SCHEDULE 1

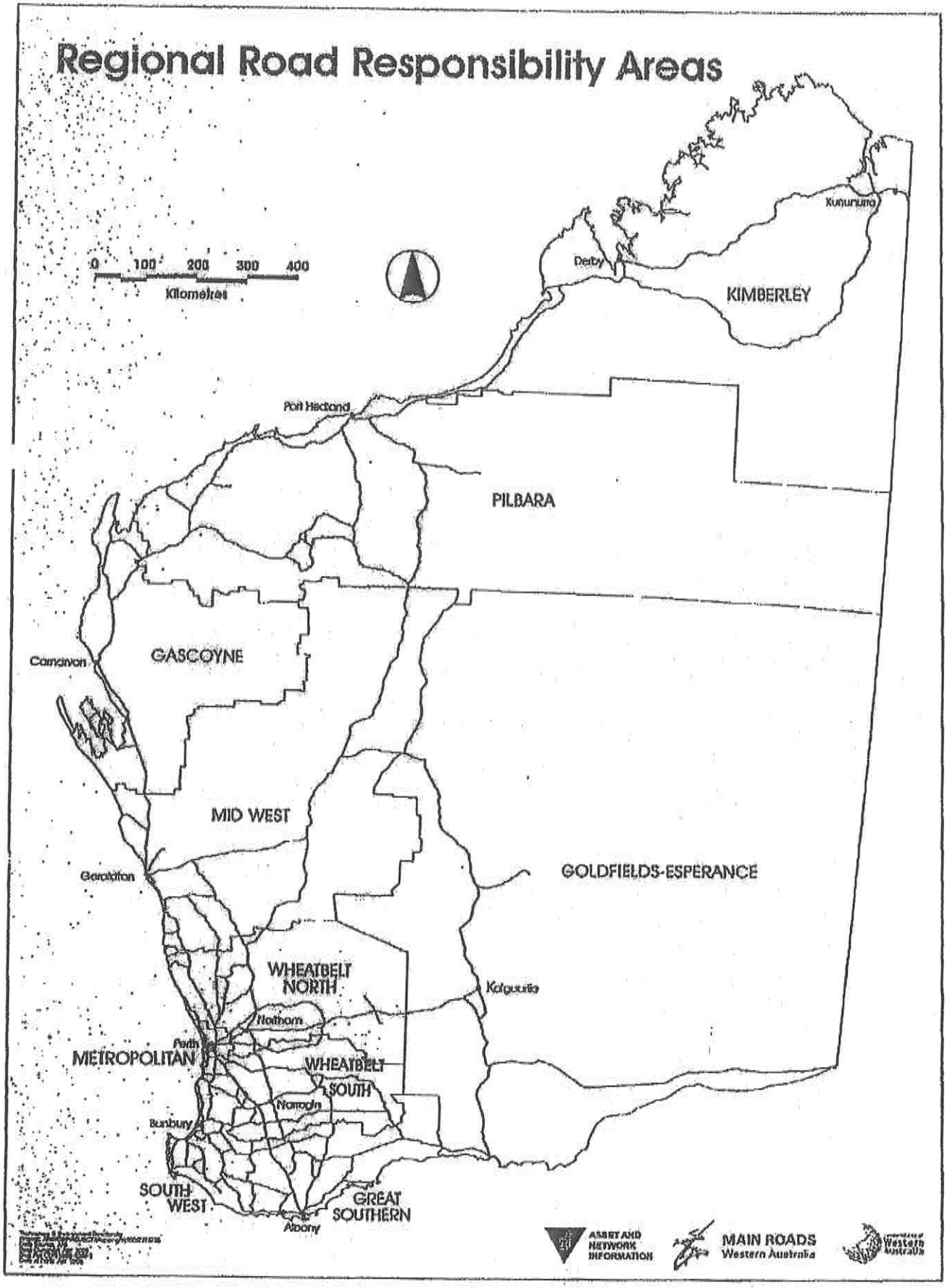
Optimal Timing for Seeding and Planting

Region	Optimal Timing	
	Seeding	**Planting**
Gascoyne	May in south of *region*; November-December in north of *region*.	No *planting* without irrigation.
Goldfields – Esperance	April-May. Earlier in south than in north.	No *planting* without irrigation.
Great Southern	April-May throughout *region*. Seeding during September-October within 30km of the coast can also be successful due to warm temperatures and spring coastal showers.	May-June.
Kimberley	October-December, preferably just before rain.	No *planting* without irrigation.
Metropolitan	April-June.	May-July.
Midwest	April-May in south of *region*; November-December in extreme north of *region*.	May-June in southern part of *region* only.
Pilbara	November-December but preferably just before rain.	No *planting* without irrigation.
South West	April-June.	May-June.
Wheatbelt North	May – June.	June- July.
Wheatbelt South	April-June.	May-June.

SCHEDULE 2

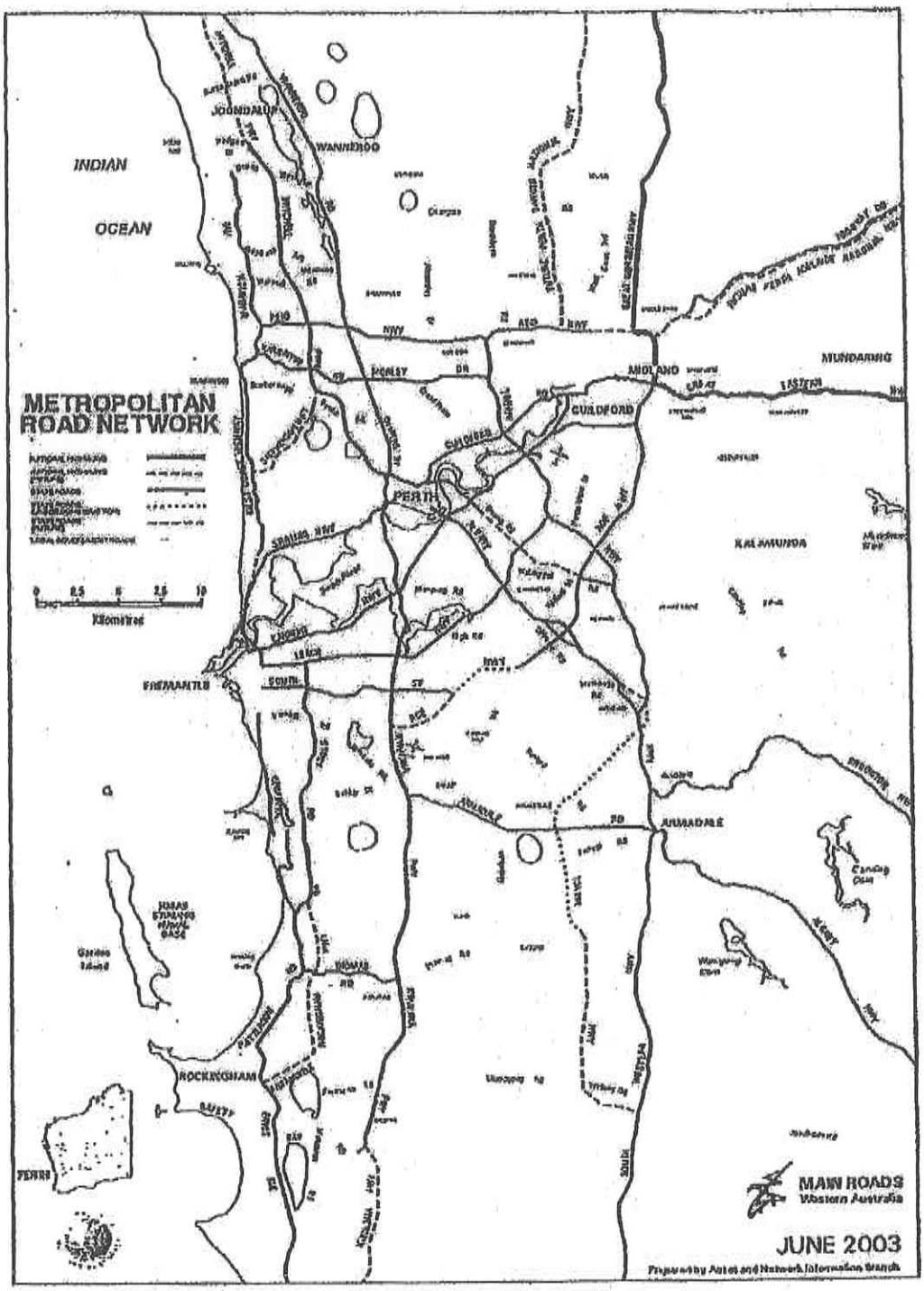
Regional Maps

Regional Road Responsibility Areas



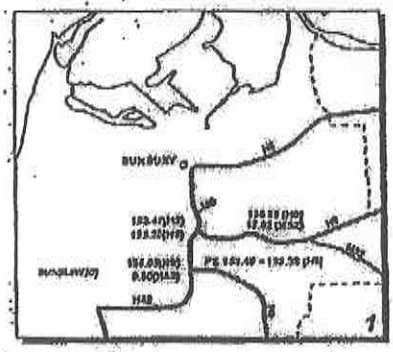
Schedule 3A: Metropolitan Region Map

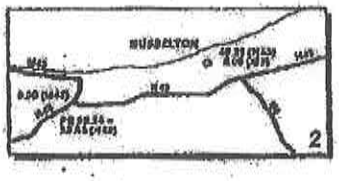
Map of Western Australian Metropolitan Road Network



Schedule 3B: South West Region Map

South West Region





SEE INSET 1

SEE INSET 2

MANAGED BY WHEATBELT SOUTH REGION (NARROGIN)

MANAGED BY GREAT SOUTHERN REGION (ALBANY)

DECLARED ROADS

H2	PERTH-BUNBURY HIGHWAY
H10	SOUTH WESTERN HIGHWAY
H13	BUSSELL HIGHWAY
H16	COALFIELDS HIGHWAY
M5	KARRIDALE-MARRADONG
M6	KINGSTON-BOYUP BROOK
M8	VASSE
M12	DONNYBROOK-KOJONUP
M23	PINJARRA
M24	MURRAY
M27	BROCKMAN
M36	PEMBERTON-NORTHCLIFFE
M37	COLLIE-LAKE KING
M42	DODDWOOD
M43	CAVES
M46	COLLIE-MUMBALLUP
M52	BOYUP-PIOTOR
M53	PINJARRA-WILLIAMS
M81	BOYANUP-CAPEL
M90	STEPHENS
M91	MUIR

LEGEND

- Highway (National)
- Highway (State)
- Main Road
- 152.08 SLK on Road
- Route Markers
- Regional Boundary
- Local Government Boundary
- Town / Site

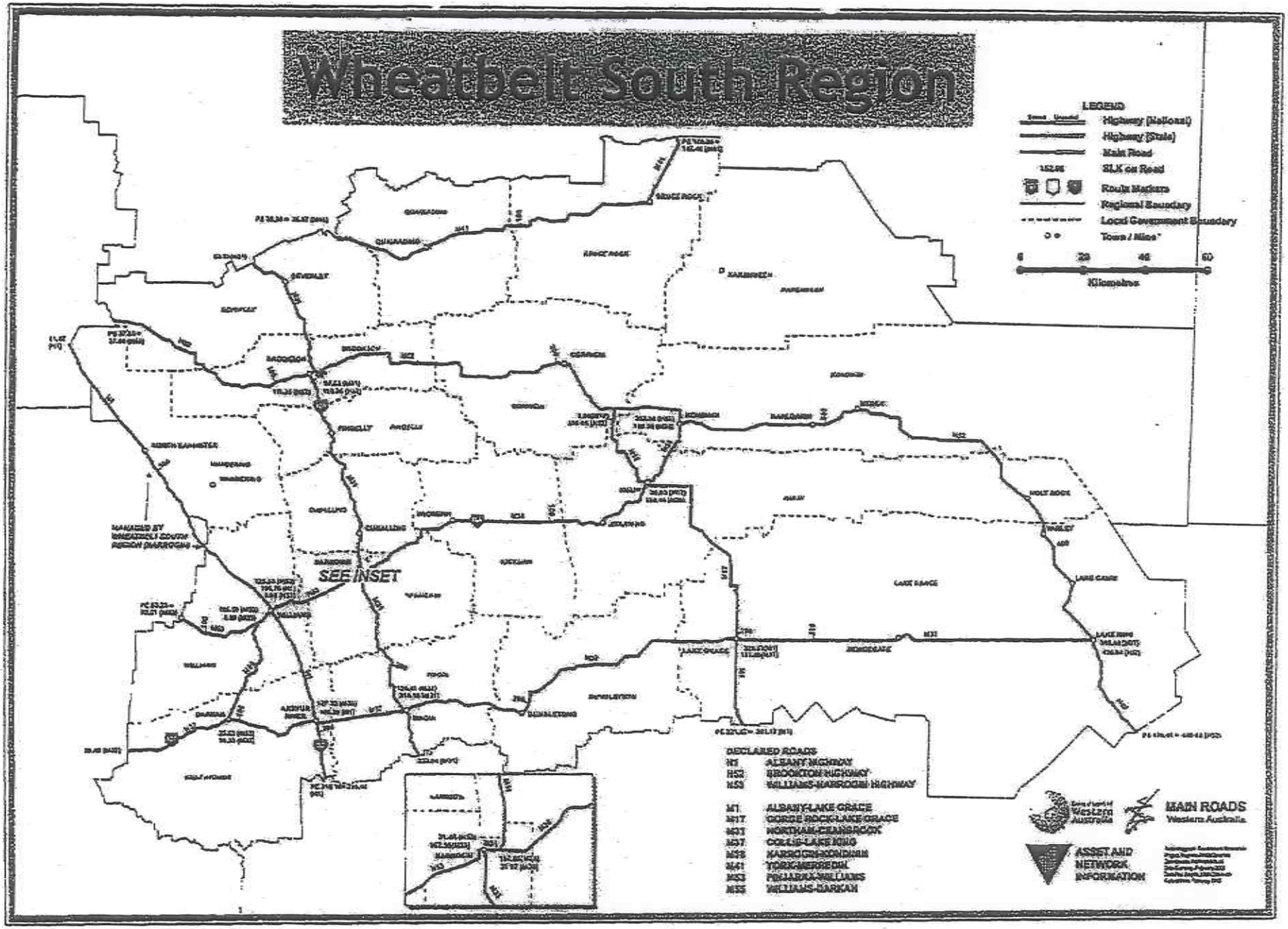
0 20 40 60 Kilometres

Government of Western Australia

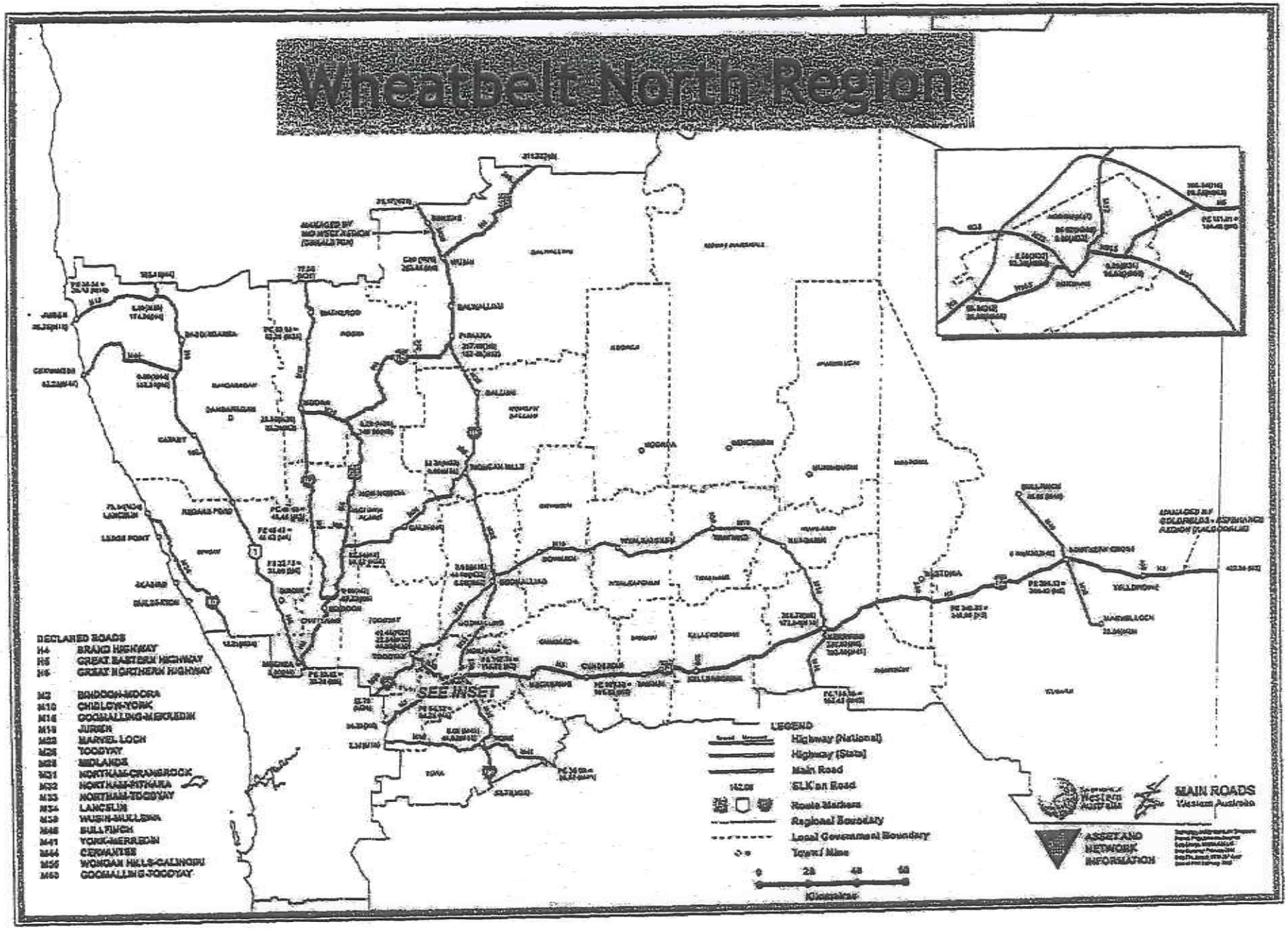
MAIN ROADS Western Australia

ASSET AND NETWORK INFORMATION

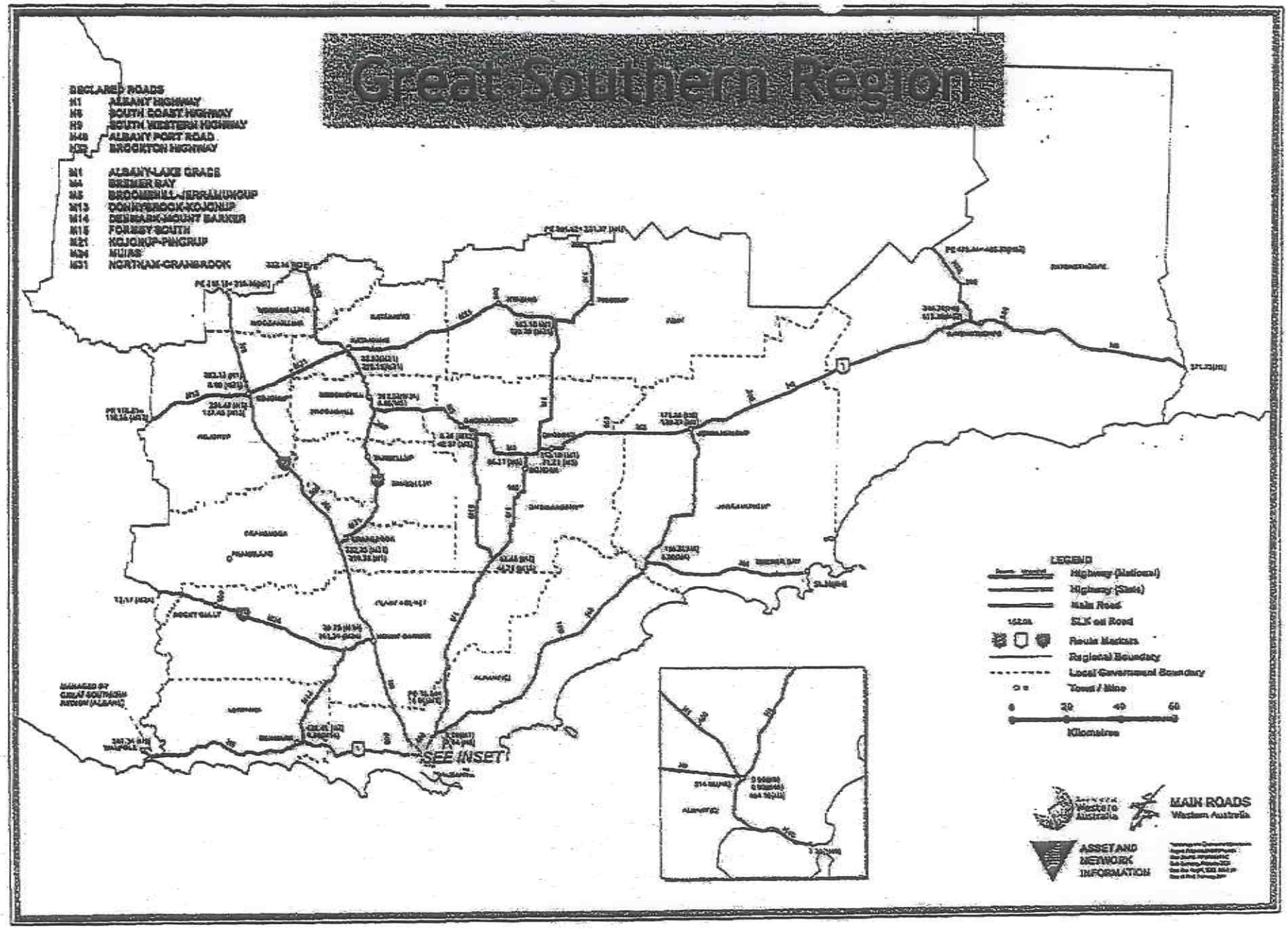
Schedule 3C: Wheatbelt South Region Map


Wheatbelt South Region
LEGEND
Highway (National)
Highway (State)
Main Road
SLK on Road
Route Markers
Regional Boundary
Local Government Boundary
Town / Mine
0
20
40
60
Kilometres
SEE INSET
MANAGED BY WHEATBELT SOUTH REGION (NARROGIN)
DECLARED ROADS
N1 ALBANY HIGHWAY
N52 BROOKTON HIGHWAY
N53 WILLIAMS-NARROGIN HIGHWAY
M1 ALBANY-LAKE GRACE
M17 GORGE ROCK-LAKE GRACE
M31 NORTHAM-CRANBROOK
M37 COLLIE-LAKE KING
M39 NARROGIN-KONDININ
M41 YORK-MERREDIN
M53 POLLARIA-WILLIAMS
M55 WILLIAMS-DARKAN
MAIN ROADS
Western Australia
ASSET AND NETWORK INFORMATION

Schedule 3D: Wheatbelt North Region Map

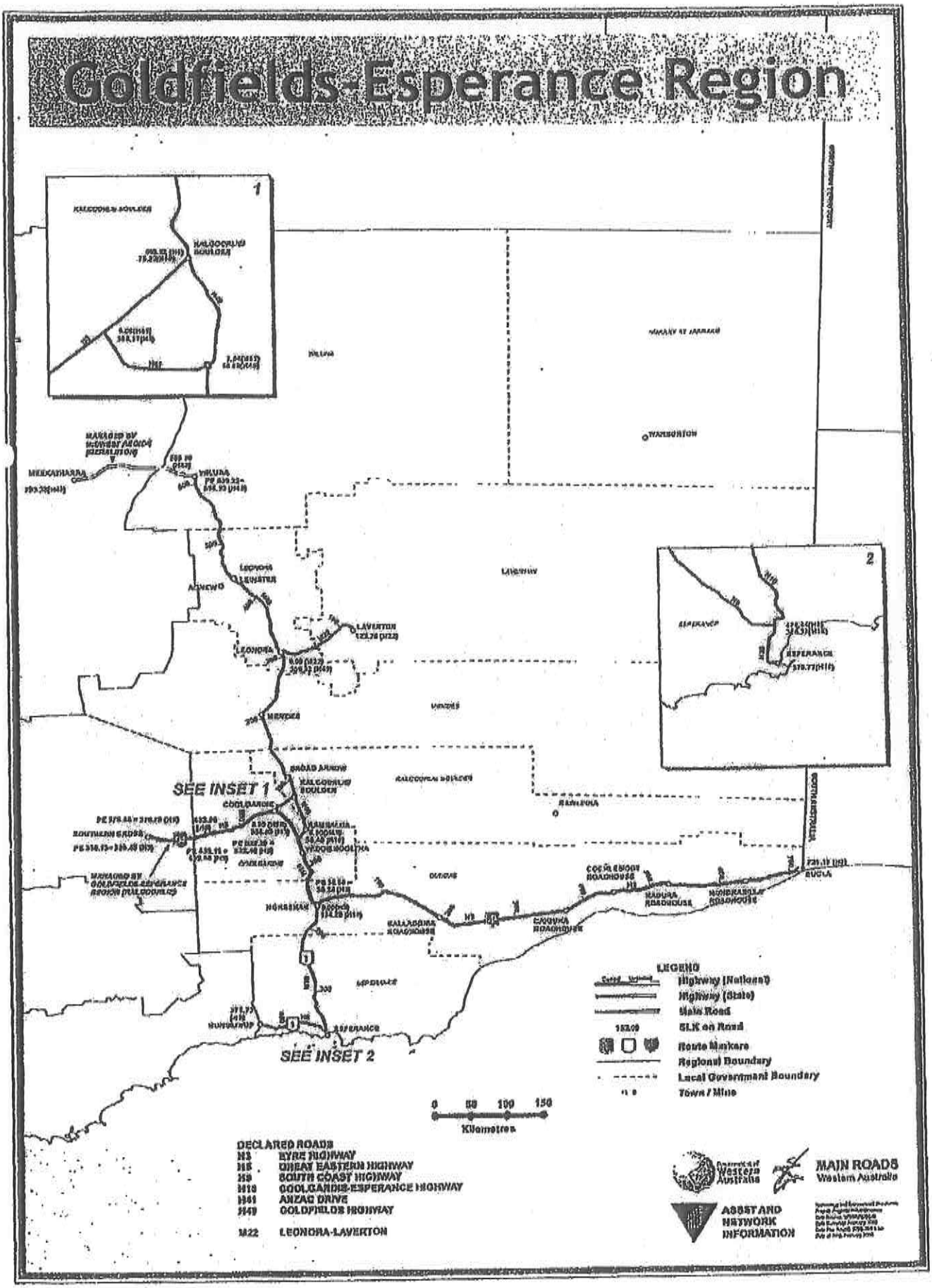

Wheatbelt North Region
SEE INSET
DECLARED ROADS
H4 BRAND HIGHWAY
H5 GREAT EASTERN HIGHWAY
H6 GREAT NORTHERN HIGHWAY
M2 BINDOON-MOORA
M10 CHIDLOW-YORK
M16 GOOMALLING-MERREDIN
M19 JURIEN
M22 MARVEL LOCH
M26 TOODYAY
M28 MIDLAND
M31 NORTHAM-CRANBROOK
M32 NORTHAM-PITHARA
M33 NORTHAM-TOODYAY
M34 LANCELIN
M39 MUKINBUDIN
M48 BULLFINCH
M49 YORK-MERREDIN
M54 CERVANTES
M56 WONGAN HILLS-CALINGIRI
M60 GOOMALLING-TOODYAY
LEGEND
Highway (National)
Highway (State)
Main Road
SLK on Road
Route Markers
Regional Boundary
Local Government Boundary
Town / Mine
0 20 40 60
Kilometres
MAIN ROADS
Western Australia
ASSET AND NETWORK INFORMATION

Schedule 3E: Great Southern Region Map

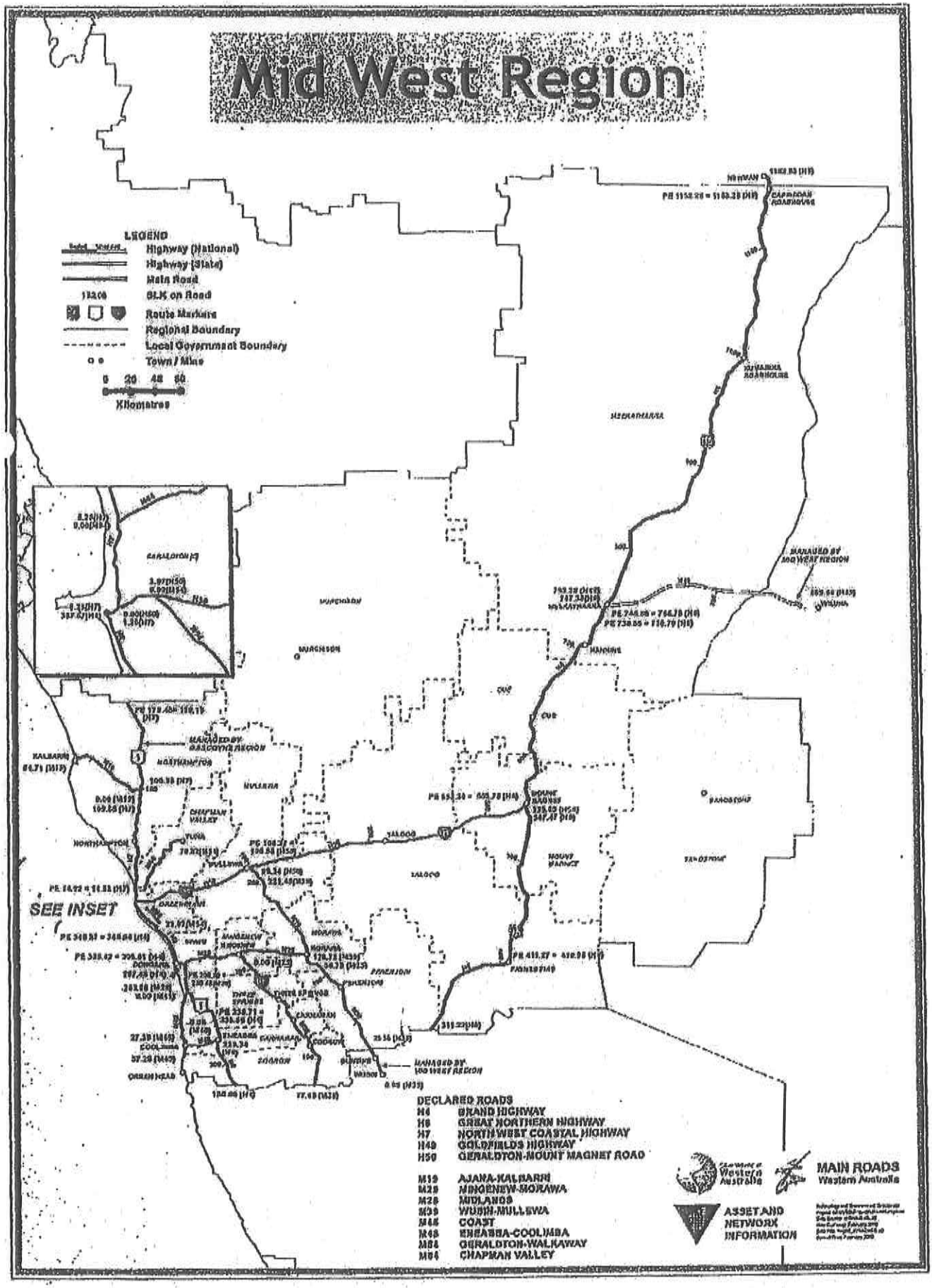

Great Southern Region
DECLARED ROADS
H1 ALBANY HIGHWAY
H5 SOUTH COAST HIGHWAY
H9 SOUTH WESTERN HIGHWAY
H48 ALBANY PORT ROAD
H58 BROOKTON HIGHWAY
M1 ALBANY-LAKE GRACE
M4 BREMER BAY
M5 BROOMEHILL-JERRAMUNGUP
M13 DONNYBROOK-KOJONUP
M14 DENMARK-MOUNT BARKER
M15 FORDBY SOUTH
M21 KOJONUP-PINGRUP
M24 MUIRS
M51 NORTHAM-CRANBROOK
SEE INSET
LEGEND
Highway (National)
Highway (State)
Main Road
SLK on Road
Route Markers
Regional Boundary
Local Government Boundary
Town / Mine
0 20 40 60
Kilometres
MAIN ROADS
Western Australia
ASSET AND NETWORK INFORMATION

Schedule 3F: Goldfields-Esperance Region Map

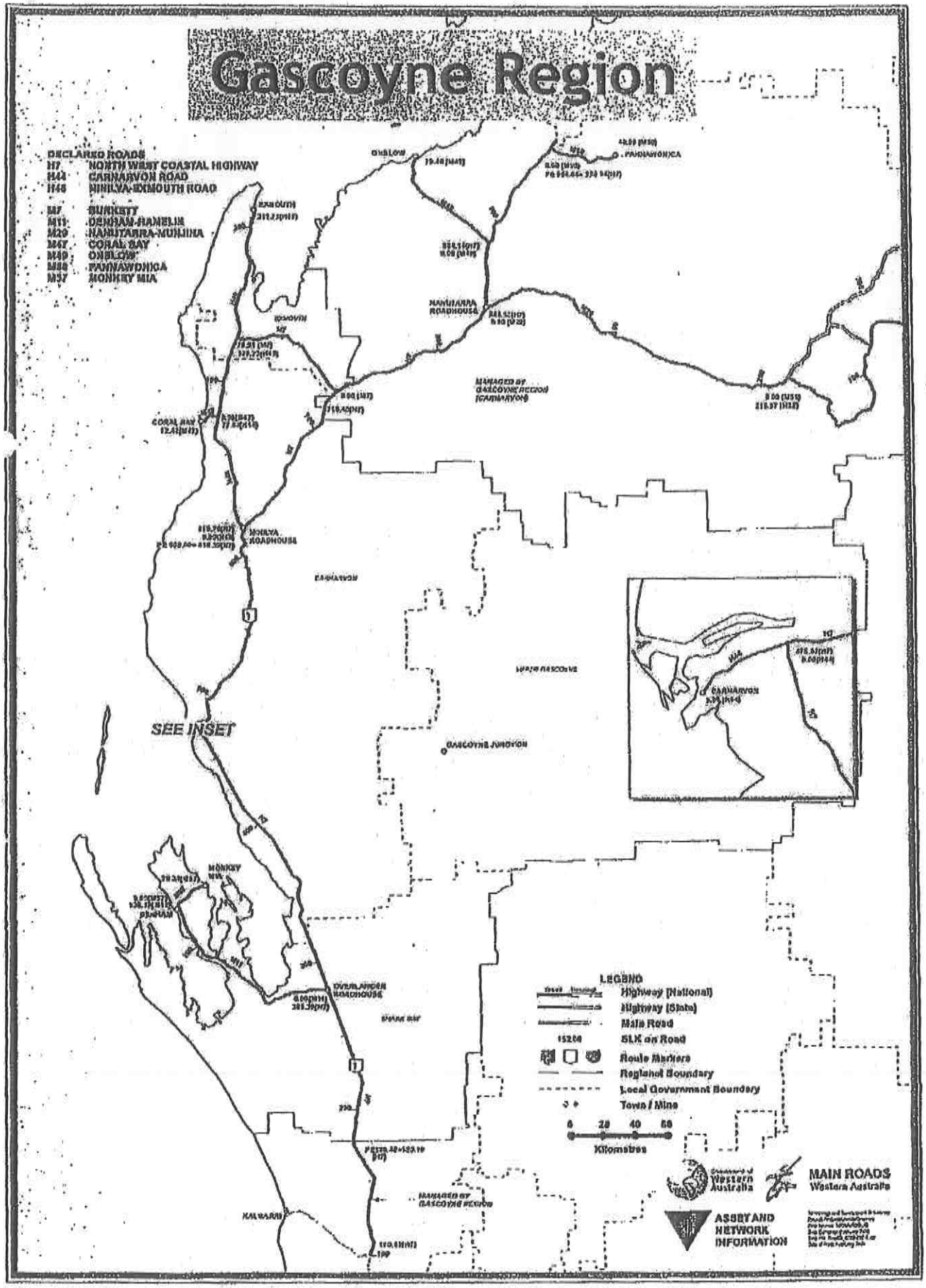
Goldfields-Esperance Region



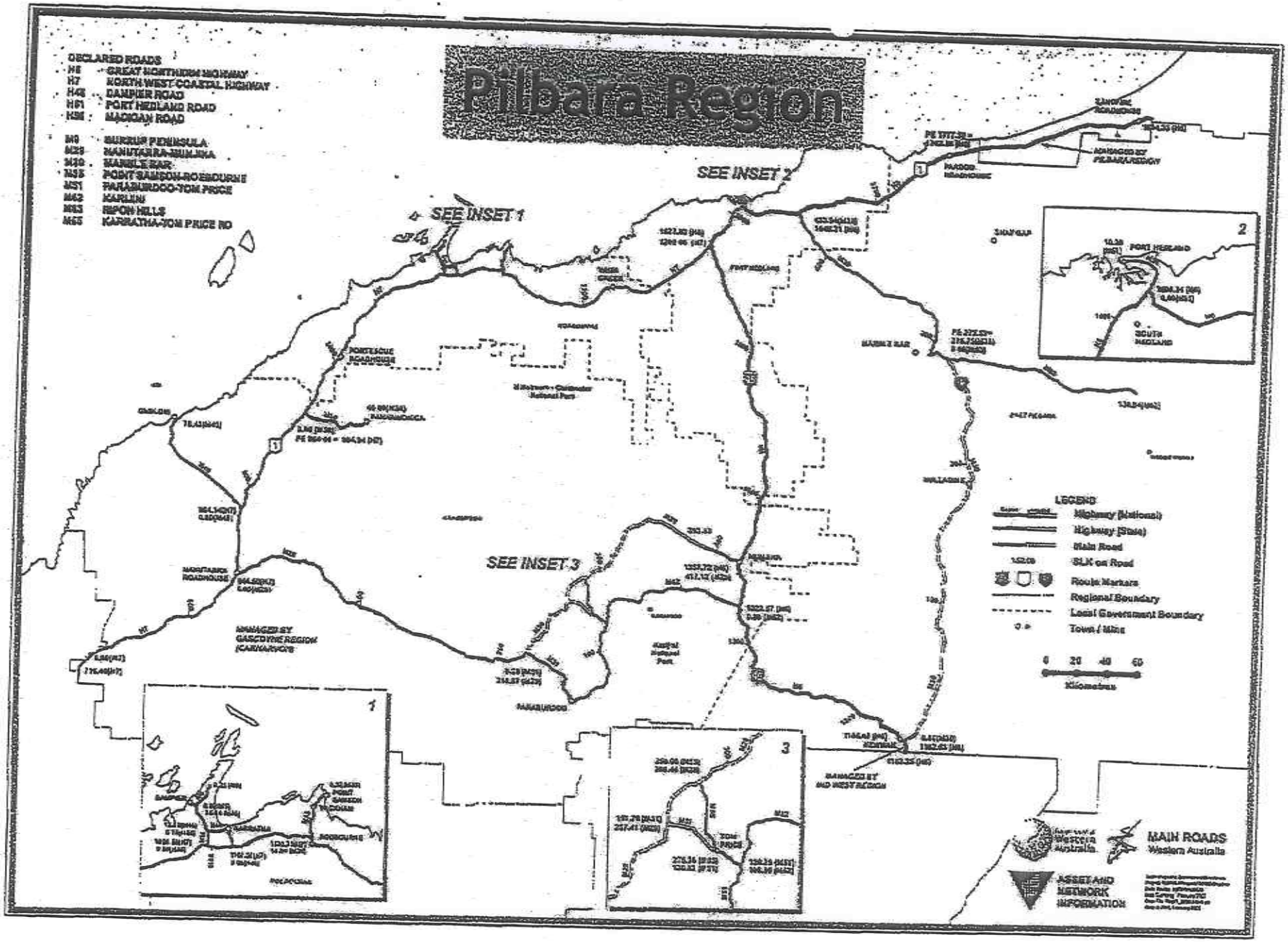
Schedule 3G: Midwest Region Map


Mid West Region
LEGEND
Highway (National)
Highway (State)
Main Road
SLK on Road
Route Markers
Regional Boundary
Local Government Boundary
Town / Mine
0 20 40 60
Kilometres
SEE INSET
MANAGED BY MID WEST REGION
MANAGED BY GASCOYNE REGION
DECLARED ROADS
H4 BRAND HIGHWAY
H6 GREAT NORTHERN HIGHWAY
H7 NORTH WEST COASTAL HIGHWAY
H40 GOLDFIELDS HIGHWAY
H50 GERALDTON-MOUNT MAGNET ROAD
M19 AJANA-KALBARRI
M20 MINGENEW-MORAWA
M28 MIDLANDS
M39 WUBIN-MULLEWA
M45 COAST
M48 EneabbA-COOLIMBA
M84 GERALDTON-WALKAWAY
M94 CHAPMAN VALLEY
Government of Western Australia
MAIN ROADS Western Australia
ASSET AND NETWORK INFORMATION

Schedule 3H: Gascoyne Region Map

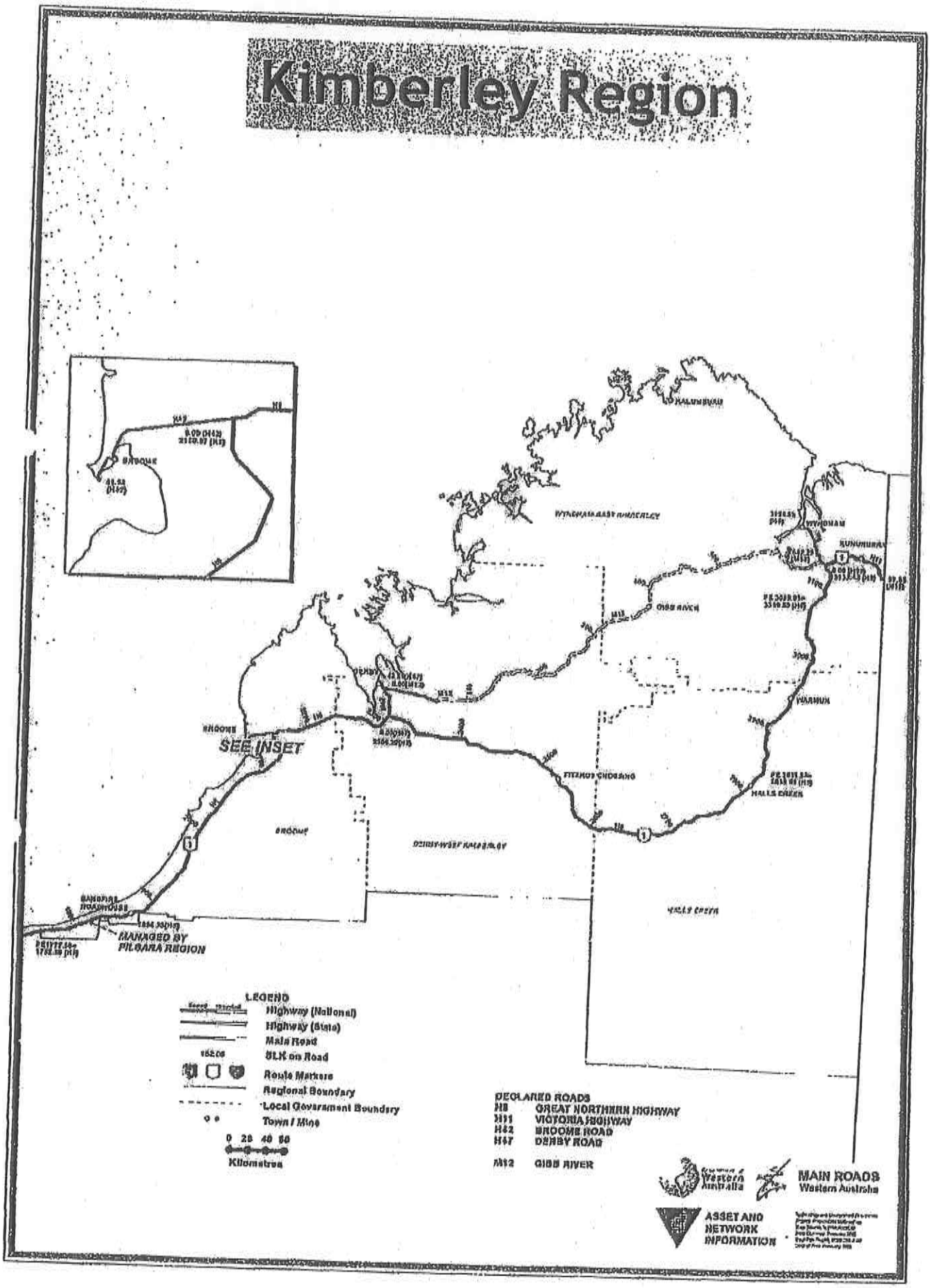

Gascoyne Region
DECLARED ROADS
N7 NORTH WEST COASTAL HIGHWAY
N43 CARNARVON ROAD
N48 MINILYA-EXMOUTH ROAD
M7 BURKETT
M11 DENHAM-HAMELIN
M20 NANUTARRA-MUNJINA
M47 CORAL BAY
M49 ONSLOW
M88 PANNAWONICA
M97 MONKEY MIA
SEE INSET
LEGEND
Highway (National)
Highway (State)
Main Road
SLK on Road
Route Markers
Regional Boundary
Local Government Boundary
Town / Mine
0 20 40 60
Kilometres
MAIN ROADS
Western Australia
ASSET AND NETWORK INFORMATION

Schedule 3I: Pilbara Region Map


Pilbara Region
DECLARED ROADS
H5 GREAT NORTHERN HIGHWAY
H7 NORTH WEST COASTAL HIGHWAY
H45 DAMPIER ROAD
H51 PORT HEDLAND ROAD
H56 MADIGAN ROAD
M6 BURRUP PENINSULA
M29 MANUWARRA-MUKUNA
M30 MARBLE BAR
M55 PORT SAMSON-ROEBOURNE
M61 PARABURDOO-TOM PRICE
M62 KARLINI
M63 RIPON HILLS
M65 KARRATHA-TOM PRICE RD
SEE INSET 1
SEE INSET 2
SEE INSET 3
MANAGED BY GASCOYNE REGION (CARNARVON)
MANAGED BY MID WEST REGION
MANAGED BY PILBARA REGION
LEGEND
Highway (National)
Highway (State)
Main Road
SLK on Road
Route Markers
Regional Boundary
Local Government Boundary
Town / Mine
0 20 40 60
Kilometres
MAIN ROADS Western Australia
ASSET AND NETWORK INFORMATION

Schedule 3J: Kimberley Region Map

Kimberley Region



ANNEXURE 1

Environmental Standard Brief: Preliminary Environmental Impact Assessment

DOC11529

MAIN ROADS
Western Australia

Document No. 6707/012 **Issue Date 31/10/2005**

CORPORATE PROCEDURE

Environmental Standard Brief

PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

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Enquiries should be directed to the delegated custodian, Manager Environment.

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REVISION STATUS RECORD

Revision No.	Revision Date	Description of Key Changes	Sections
1		Clearing permit conditions Salinity Acid Sulfate Soils Deliverables	3 3 3 6

ABOUT THIS STANDARD BRIEF

Environmental standard briefs provide the basic technical specification for engagement of suitable consultants, and will require editing to meet the requirements of a particular road project or task.

Advisory comments may be included within this standard brief and are shown in *red italics*.

For assistance in finalising this brief for a particular application, please contact the Environment Branch.

Application

This standard brief applies to road infrastructure projects at either the alignment definition or project development stage. It provides for preliminary examination of environmental aspects and would not generally involve field studies or public consultation.

In cases where field investigations are required, Sections 2 and 4 will need significant amendment.

Related Environmental Guidelines

The scope of this brief relates to requirements contained in Main Roads environmental guideline *Environmental Assessment and Approval.*

Related Environmental Standard Briefs

Environmental Impact Assessment and Environmental Management Plan (Internal), to be used for preparing a brief for environmental consultants to complete Environmental Impact Assessment (EIA) and Environmental Management Plans for internal use.

Environmental Impact Assessment (for Statutory Referral - ARI, EPS), to be used for an EIA for a proposal that will need to be referred to the EPA or Commonwealth Minister for the Environment.

Statutory Environmental Report (PER, ERMP), to be used for preparing a document for a proposal that has received statutory assessment at a level of Public Environmental Review (PER) or Environmental Review Management Program (ERMP) and is about to go through the statutory public consultation process.

PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

1. INTRODUCTION

1.1 Purpose

Briefly describe proposed project (eg. new road, dualling, widening, bridge construction etc.) and location (road, section, suburb/town, SLK start and finish, local government authority).

Main Roads Western Australia (Main Roads) requires a Preliminary Environmental Impact Assessment (PEIA) for the above project. This report will be used in the environmental assessment and approvals process and will assist in identifying the need for, and scope of, field investigations. The report will also provide a basis for discussion with environmental agencies about the need to refer the proposal for statutory approval.

1.2 Background

Briefly describe project planning context, concurrent work on non-environmental aspects of alignment definition or project development, staging of the project, status of work on other sections of the road.

Mention any previous environmental assessment work (by Main Roads or others) of which the Project Manager is aware.

If the EPA has already provided informal advice on this project under Section 16 of the Environmental Protection Act 1986, then include a copy of that advice in an Appendix to the brief.

1.3 Study Area

The location and boundaries of the study area are shown on Figure 1 and include the following features:

Describe the full extent of the proposed road works including access tracks, materials pits, connecting roads, pedestrian and cycle ways, etc.

2. SCOPE

The consultant will undertake a desktop EIA of the proposed project, including the following items:

- identify and review any existing relevant environmental reports;
- conduct an initial assessment to determine the key environmental aspects for the road proposal;
- assess all environmental aspects likely to require referral of the project and advise whether the project should be referred to the Environmental Protection Authority (EPA);
- assess all matters of National Environmental Significance likely to require referral of the project and advise whether the project should be referred to the Commonwealth Department of the Environment and Heritage (DEH);
- consult with relevant government agencies as required;
- determine (but do not apply for) clearances required under other legislative provisions, including (but not limited to) those required under the following Acts:
  - *Conservation and Land Management Act* 1984;
  - *Wildlife Conservation Act* 1950;
  - *Environmental Protection Act 1986;*
  - *Rights in Water and Irrigation Act 1914;*
  - *Heritage of Western Australia Act* 1990;
  - *Aboriginal Heritage Act* 1972; and
  - *Swan River Trust Act* 1988.
- provide a concise report on the findings.

List any other specific exclusions

3. DESKTOP INVESTIGATION

The consultant will consider all aspects relevant to the proposed project. This is to include, but is not limited to: *Customise list as required*

- Air quality;
- Dust;
- Fauna;
- Vegetation - threatened species and communities;
- Vegetation – associations, representativeness and clearing (see Section 3.1);
- Vegetation - dieback and other diseases or pathogens;
- European cultural heritage;
- Aboriginal heritage;
- Surface waters / drainage (watercourses, stormwater disposal, water quality, proclaimed waterways);
- Groundwater;
- Wetlands;
- Salinity;
- Acid Sulphate Soils;
- Noise and vibration;
- Visual amenity;
- Public safety and risk (industrial plant, gas pipeline, unexploded ordinance);
- Contaminated sites;
- Reserves and conservation areas; and

- Other project-specific aspects not covered elsewhere in this list. Examples include environmentally significant landforms, coastal and mangrove areas.

Clearing of Native Vegetation

The consultant is required to;
- confirm whether the clearing of native vegetation will occur;
- advise what permits or exemption apply or are required;
- confirm whether the project occurs within an ESA;
- assess the project against the 10 principles of clearing, as outlined in Schedule 5 of the Environmental Protection Act 1986, see Appendix A,
- report on the outcome of the above assessment; and
- seek advice from all relevant agencies.

Each principle shall be properly assessed in accordance with the DoE's *Guideline to Assessment – Clearing of Native Vegetation*.

4. CONSULTATION AND LIAISON

The consultant will liaise with government regulatory authorities as required to obtain the information required to undertake the study and will meet with the EPA for a discussion on the likely need to refer this proposal.

If required the consultant will assist Main Roads with obtaining advice under Section 16 of the *Environmental Protection Act* 1986.

No public consultation is to be undertaken by the consultant.

5. REPORT

The PEIA report will contain the following text components:
1. Summary of statutory approvals likely to be required;
2. Introduction, including background and scope of the report;
3. Brief description of the proposal;
4. Environmental aspects. Identification of key environmental aspects and desktop assessment of potential impacts under each of the following categories. (This section should include a description of the existing environment):
    - area of assessment;
    - method of evaluation;
    - extent of potential impact;
    - relevant standards / regulations / policies; and
    - further specific environmental investigations likely to be needed.
5. Approvals required;
6. Agencies / organisations consulted and outcomes;
7. Other information; and
8. References.

The Section 4 of the report on environmental aspects should include a list of:
- all environmental aspects considered in determining the scope of the EIA;
- aspects not considered relevant, with a brief explanation (one paragraph); and
- aspects considered relevant and requiring desktop investigation as part of the preliminary EIA.

Information is to be presented in tabular format where possible.

The consultant will include the following figures in the report as a minimum:

- general location map (local government boundaries, road centrelines, townsites, major watercourses, reserves and conservation areas);
- study boundaries (proposed road reserve, off-road sites, cadastre);
- map showing location of key environmental constraints (must include extent of native vegetation to be cleared and hydrological features including wetlands, watercourses, creek lines, seasonal creeks and artificial drainage); and
- aerial photography of the proposal area.
- *Insert other figures considered necessary*

All figures are to include: title, number, north point, scale, data source and currency, key/legend, adequate labelling, use of colour as appropriate.

The consultant is to submit a draft report to the Project Manager for comment. Comments are to be incorporated in the final report to the satisfaction of the Project Manager.

6. DELIVERABLES

The consultant will present the PEIA report to meet the following requirements.

Report	Bound hard copies	Unbound hard copies	Electronic copies
Draft	2	0	1
Final	6	1	1

Customise number of reports as required

Complete copies of the reports are to be provided in both Microsoft Word and PDF formats and maps are also to be provided in ESRI Arcview GIS 3.2 format.

7. SCHEDULE

The consultant will attend the following meetings and undertake the works in accordance with the following timetable:
Amend as required

- Start up meeting (onsite if required) — within 1 week of award.
- Progress meeting — as required.
- Meeting with EPA — at a date to be confirmed.
- Present draft report — 4 weeks from award.
- Submit final report — 1 week from receipt of Main Roads' comments.
- *Insert any other meetings required.*

Meetings will be held at the *nominated office*, and the consultant will provide minutes of the meetings to all participants within one week of the date of the meeting, or as otherwise agreed with the Project Manager.

8. INFORMATION TO BE PROVIDED BY MAIN ROADS

The following information will be made available to the successful consultant:

- Main Roads environmental guideline *Environmental Assessment and Approval*;
- *List any previous environmental reports available;* and
- *List any other plans or reports or electronic data to be made available to the consultant.*
- *Nominate whether information is to be returned at the completion of the study.*

Appendix A

Ten Clearing Principles, as outlined in Schedule 5 of the *Environmental Protection Act 1986*

1. Does the area to be cleared comprise a high level of biological diversity?
2. Does the area to be cleared comprise the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia?
3. Does the area to be cleared include, or is necessary for the continued existence of, rare flora?
4. Does the area to be cleared comprise the whole or a part of, or is necessary for the maintenance of, a threatened ecological community?
5. Is the area to be cleared significant as a remnant of native vegetation in an area that has been extensively cleared?
6. Does the area to be cleared within, or in association with, an environment associated with a watercourse or wetland?
7. Is the clearing of the vegetation likely to cause appreciable land degradation?
8. Is the clearing of the vegetation likely to have an impact on the environmental values of any adjacent or nearby conservation area?
9. Is the clearing of the vegetation likely to cause deterioration in the quality of surface or underground water?
10. Is the clearing of the vegetation likely to cause, or exacerbate, the incidence or intensity of flooding?

ANNEXURE 2

Environmental Standard Brief: Environmental Impact Assessment and Environmental Management Plan (Internal)

DOC115 19

MAIN ROADS
Western Australia

Document No. 6707/013 **Issue Date 31/10/2004**

CORPORATE PROCEDURE

Environmental Standard Brief

ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN (INTERNAL)

This document is owned and authorised by Executive Director Technology and Environment. Enquiries should be directed to the delegated custodian, Manager Environment.

Printed copies are uncontrolled unless marked otherwise

REVISION STATUS RECORD

Revision No.	Revision Date	Description of Key Changes	Sections
1	15/10/04	Clearing permits Consultant's Obligations Acid sulphate soils Biological Survey guideline reference Community Consultation Deliverables Agency name changes	2 4 4 4 5 7 Throughout
2	31/10/05	Clearing permit conditions	4

ABOUT THIS STANDARD BRIEF

Environmental standard briefs provide the basic technical specification for engagement of suitable consultants, and will require editing to meet the requirements of a particular road project or task.

Advisory comments may be included within this standard brief and are shown in *red italics*.

For assistance in finalising this brief for a particular application, please contact the Environment Branch.

Application

This standard brief applies to road infrastructure proposals at either the alignment definition or project development stage. It provides for an environmental impact assessment (EIA) and an environmental management plan (EMP) for a proposal that will not need to be referred to either the EPA or the Department of the Environment and Heritage (DEH), i.e. the environmental process will be purely an internal process.

In cases where the EIA report and EMP are to be combined into one report, Section 8 will need significant editing.

Related Environmental Guidelines

The scope of this brief relates to requirements contained in Main Roads environmental guidelines:

- *Supplementary Guidance on Environmental Impact Assessment;* and
- *Environmental Assessment and Approval.*

Related Environmental Standard Briefs

Preliminary Environmental Impact Assessment, to be used for preliminary examination of environmental aspects, and would not generally include field studies.

Environmental Impact Assessment (for Statutory Referral – ARI, EPS), to be used for an EIA for a proposal that will need to be referred to the EPA or Commonwealth Minister for the Environment.

Statutory Environmental Report (PER, ERMP), to be used for preparing a document for a proposal that has received statutory assessment at a level of Public Environmental Review (PER) or Environmental Review and Management Plan (ERMP), and is about to go through the statutory public consultation process.

Environmental Management Plan (Statutory), to be used for preparation of an EMP for a proposal that has received statutory assessment at a level of an Assessment on Referral Information (ARI), Environmental Protection Statement (EPS), PER or ERMP.

ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN (INTERNAL)

1. INTRODUCTION

This brief is to be used for projects that will NOT be referred to the EPA.

1.1 Purpose

Briefly describe proposed project (eg. new road, dualling, widening, bridge construction etc) and location (road, section, suburb/town, SLK start and finish, local government authority).

Main Roads Western Australia (Main Roads) requires an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP) for the above project. These documents will be used to assess and manage the environmental impacts of the project. The project is not expected to require referral to the Environmental Protection Authority (EPA) or the Department of the Environment and Heritage (DEH).

The need to prepare the EIA and EMP documents relates to requirements contained within Main Roads environmental guideline *Environment Assessment and Approval.*

1.2 Background

Briefly describe project planning context, concurrent work on non-environmental aspects of alignment definition or project development, staging of the project, status of work on other sections of the road.

Main Roads has already completed a desktop Preliminary Environmental Impact Assessment (PEIA) report.

Mention any other available environmental reports.

If the EPA has already provided informal advice on this project under Section 16 of the Environmental Protection Act 1986, then include that advice in an Appendix to the brief.

1.3 Study Area

The location and boundaries of the study area are shown on Figure 1 and include the following features:

Describe the full extent of the proposed road works including access tracks, materials pits, connecting roads, pedestrian and cycle ways, etc.

2. SCOPE

The environmental consultant will undertake an EIA of the proposed project, including the following items:

- determine the key environmental aspects to be considered and the scope of investigations required;
- assessment to confirm that no significant environmental impacts will occur and that referral to either the EPA or DEH is not required;
- description and assessment of the existing environment, including physical, biological, social aesthetic, heritage, noise, and site contamination;
- field investigations in accordance with Section 4;
- impact assessment that describes the proposed works and their potential impact on the existing environment, with reference to all features of the project including road and bridgeworks, materials pits, access tracks and spoil sites;
- consultation with regulatory stakeholders to determine requirements;
- provide all necessary information to obtain, and assist the Project Manager in applying for clearances required under legislative provisions, including (but not limited to) those required under the following Acts and regulations:
  - *Environmental Protection (Clearing of Native Vegetation) Regulations 2004;*
  - *Rights in Water and Irrigation Act 1914:*
  - *Conservation and Land Management Act* 1984;
  - *Wildlife Conservation Act* 1950;
  - *Heritage of Western Australia Act* 1990; and
  - *Swan River Trust Act* 1988.
- provide environmental management actions suitable for inclusion in the tender documentation for project implementation;
- provide a concise report on the results of environmental investigations and clearances obtained; and
- provide complete and sufficient information to prepare the EMP for construction.

An Aboriginal heritage study may be included in this work or under a separate contract (refer to Main Roads standard brief Aboriginal Heritage Study).

The consultant will also prepare an EMP for the identified impacts, including the following items:

- planning that minimises the environmental impacts of the works and identifies those responsible for implementation;
- monitoring and maintenance program which assesses the implementation;
- list of commitments identifying management requirements; and
- provide environmental management actions in accordance with results of EIA report.

3. METHODOLOGY

The consultant is to consider all environmental aspects relevant to the proposed project, including but not limited to those listed in the Main Roads environmental guideline *Supplementary Guidance on Environmental Impact Assessment* except: *List any specific exclusions*

In addition to this list the consultant is also to consider: List any additional components as required.

In addition an initial assessment is to be undertaken to determine the key environmental factors to be considered. This assessment is to be incorporated into the EIA report, and will include items listed in Main Roads environmental guideline *Supplementary Guidance on Environmental Impact Assessment.*

4. FIELD INVESTIGATIONS

Include additional surveys as required.
Edit field investigation requirements to suit using the results of the PEIA (if it exists).
As a minimum, field investigations shall be undertaken for the following environmental aspects *(develop survey list in accordance with PEIA recommendations)*:

1. *Biological flora survey;Dieback survey (including other diseases or pathogens);*
3. *Acid Sulphate Soils;*
4. *Biological fauna survey (opportunistic only);*
5. *Cultural heritage survey;*
6. *Noise survey;*
7. *Wetland field assessment; and*
8. *Contaminated site assessment.*
9. *Insert other aspects as required.*

Note that the biological survey should be conducted in Spring for optimal results

The consultant is to be fully aware of the obligations and implications of all relevant legislation including EPA policies and positions and of all legislation and regulations relating to flora and fauna collection, permits and access requirements. Field investigations and surveys are to be conducted in accordance with the requirements set out in Main Roads environmental guidelines *Biological Survey* and *Supplementary Guidance on Environmental Impact Assessment* except: *List any specific exclusions.*

Clearing of Native Vegetation

The consultant is required to;

- confirm whether the clearing of native vegetation will occur;
- advise what permits or exemption apply or are required;
- confirm whether the project occurs within an Environmentally Sensitive Area;
- assess the project against the 10 principles of clearing, as outlined in Schedule 5 of the *Environmental Protection Act 1986*, see Appendix A;
- report on the outcome of the above assessment; and
- seek advice from all relevant agencies.

Each principle shall be properly assessed in accordance with the DoE's *Guideline to Assessment – Clearing of Native Vegetation.*

5. CONSULTATION AND LIAISON

The consultant will liaise with government regulatory authorities as required to obtain the information necessary to complete the scope of work.

Provide details of public consultation requirements if applicable. Community and environmental groups will need to be considered.

6. REPORTS

The EIA report will include all components listed in Main Roads environmental guideline *Supplementary Guidance on Environmental Impact Assessment* and will be written in accordance with the guideline.

The consultant should develop the EMP in consultation with relevant Main Roads' tender document specifications.

The EMP is to be set out in accordance with the following:

1. Summary of management plan, including summary of commitments table. This table will form the basis of auditing the compliance of Main Roads, and subsequently the contractor.
2. Brief background of the project and reason for implementation. Also need to include a list of responsible parties.
3. Scope of the project, and of the EMP.
4. Brief description of existing environment.
5. Principal activities of the project.
6. Key issues. Summary to highlight the key environmental issues. Issues will reflect those identified in the Environmental Impact Assessment report.
7. Environmental management measures. These will expand upon the management strategies briefly set out in the Main Roads Environmental Impact Assessment. Management measures will be specified for each stage of the project, including detailed design (if applicable), pre-construction, construction and post-construction. The Main Roads EMP will contain a tabulated list of actions detailing:
   - action;
   - objective;
   - location (broad);
   - timing (project stage);
   - responsible party (Main Roads, contractor); and
   - requirements/consultation/acceptance criteria (eg Department of Indigenous Affairs).
8. Commitments Table.
9. Reference documents.

The EIA report and EMP may be combined into a single report in agreement with the Project Manager.

7. DELIVERABLES

The consultant will present the EIA report and EMP to meet the following requirements.

Report	Bound Colour hard copies	Unbound Colour hard copies	Electronic copies
Draft	2	0	1
Final	10	1	1

Customise number of reports as required

Complete copies of the reports are to be provided in both Microsoft Word and PDF formats and maps are also to be provided in ESRI Arcview GIS 3.2 format.

8. SCHEDULE

The consultant will attend the following meetings and undertake the works in accordance with the following timetable: *Amend as required*

- Start up meeting on site — within 1 week of award.
- Progress meeting — when required.
- Present draft report on EIA component — 4 months from award.
- Submit final EIA report *(or combined report)* — 1 week from receipt of Main Roads' comments.
- Presentation of draft EMP *(or combined report)*.
- Submit final EMP report *(or combine report)*.
- Project completion meeting.
- *Insert any other meetings required.*

Meetings will be held at the *nominated office*, and the consultant will provide minutes of the meetings to all participants within one week of the date of the meeting, or as otherwise agreed with the Project Manager.

9. INFORMATION TO BE PROVIDED BY MAIN ROADS

The following information will be made available to the successful consultant:

- Main Roads environmental guideline *Environmental Assessment and Approval*;
- PEIA Report;
- *List any previous environmental reports available; and*
- *List any other plans or reports or electronic data to be made available to the consultant.*

Nominate whether information is to be returned at the completion of the study.

Appendix A

Ten Clearing Principles, as outlined in Schedule 5 of the *Environmental Protection Act 1986*

1. Does the area to be cleared comprise a high level of biological diversity?
2. Does the area to be cleared comprise the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia?
3. Does the area to be cleared include, or is necessary for the continued existence of, rare flora?
4. Does the area to be cleared comprise the whole or a part of, or is necessary for the maintenance of, a threatened ecological community?
5. Is the area to be cleared significant as a remnant of native vegetation in an area that has been extensively cleared?
6. Does the area to be cleared within, or in association with, an environment associated with a watercourse or wetland?
7. Is the clearing of the vegetation likely to cause appreciable land degradation?
8. Is the clearing of the vegetation likely to have an impact on the environmental values of any adjacent or nearby conservation area?
9. Is the clearing of the vegetation likely to cause deterioration in the quality of surface or underground water?
10. Is the clearing of the vegetation likely to cause, or exacerbate, the incidence or intensity of flooding?

ANNEXURE 3

Environmental Guideline: Supplementary Guidance on Environmental Impact Assessment

DOC 115 20

MAIN ROADS
Western Australia

Document No. 6707/003 **Issue Date 31/10/05**

CORPORATE PROCEDURE

Environmental Guideline

SUPPLEMENTARY GUIDANCE ON ENVIRONMENTAL IMPACT ASSESSMENT

This document is owned and authorised by Executive Director Technology and Environment. Enquiries should be directed to the delegated custodian, Manager Environment.

Printed copies are uncontrolled unless marked otherwise

CONTENTS

REVISION STATUS RECORD

Rev. No.	Rev. Date	Description of Key Changes	Section
1	31/10/05	Update Figure 2 Clearing of Native Vegetation	1 Appendix A

1. INTRODUCTION

1.1 PURPOSE

This document provides supplementary guidance on environmental impact assessment (EIA), in the form of detailed requirements of field investigations, liaison and reporting.

The need for an EIA will have been identified previously in accordance with Main Roads environmental guideline *Environmental Assessment and Approval*, which guides the overall environmental process.

1.2 Application

1.2.1 When should I use this document?

When Main Roads environmental guideline *Environmental Assessment and Approval* requires an EIA to be undertaken, this supplementary guidance document should also be used.

1.2.2 Why should I use this document?

Use of this document will:

- assist in understanding what is involved in an EIA and the standard of report required;
- assist in management of the process;
- facilitate management of consultants involved in the assessment; and
- provide the basis for environmental management for a project.

1.2.3 What does this document apply to?

This document applies to a road project at alignment definition or project development stage that has been identified as needing an EIA. A preliminary (desktop) EIA is likely to have been completed previously.

Figures 1 and 2 have been taken from *Environmental Assessment and Approval* and indicate where an EIA fits into the environmental assessment and approval process.

This document applies to projects that will be managed internally (ie not needing referral to the EPA or the Commonwealth Department of the Environment and Heritage (DEH)), and also to projects that will be referred to the EPA for an expected level of assessment of "Assessment on Referral Information" (ARI) or "Environmental Protection Statement" (EPS). On completion of the EIA, the user will need to revert to the *Environmental Assessment and Approval* guideline in order to continue managing the overall environmental process.

This document is **not** to be used for:

- Comparative environmental assessment of route options (ie alignment selection);
- a Preliminary EIA; or
- a project that will be referred to the EPA for an expected level of assessment of "Public Environmental Review" (PER) or "Environmental Review and Management Program" (ERMP).

1.2.4 How do I use this document?

This document provides a guide and background information on investigations, and the format and content of an EIA report. It should be used in conjunction with the appropriate standard brief when engaging an environmental consultant to carry out an EIA (Section 1.2.5).

1.2.5 Associated corporate documents

The following Main Roads documents should be used in conjunction with this guideline:

- environmental guideline *Environmental Assessment and Approval*;
- environmental guideline *Referral to Commonwealth Government for Environmental Approval*;
- environmental guideline *Aboriginal Heritage*;
- environmental standard brief *Environmental Impact Assessment and Environmental Management Plan (Internal)*; and
- environmental standard brief *Environmental Impact Assessment (for Statutory Referral – ARI, EPS)*.

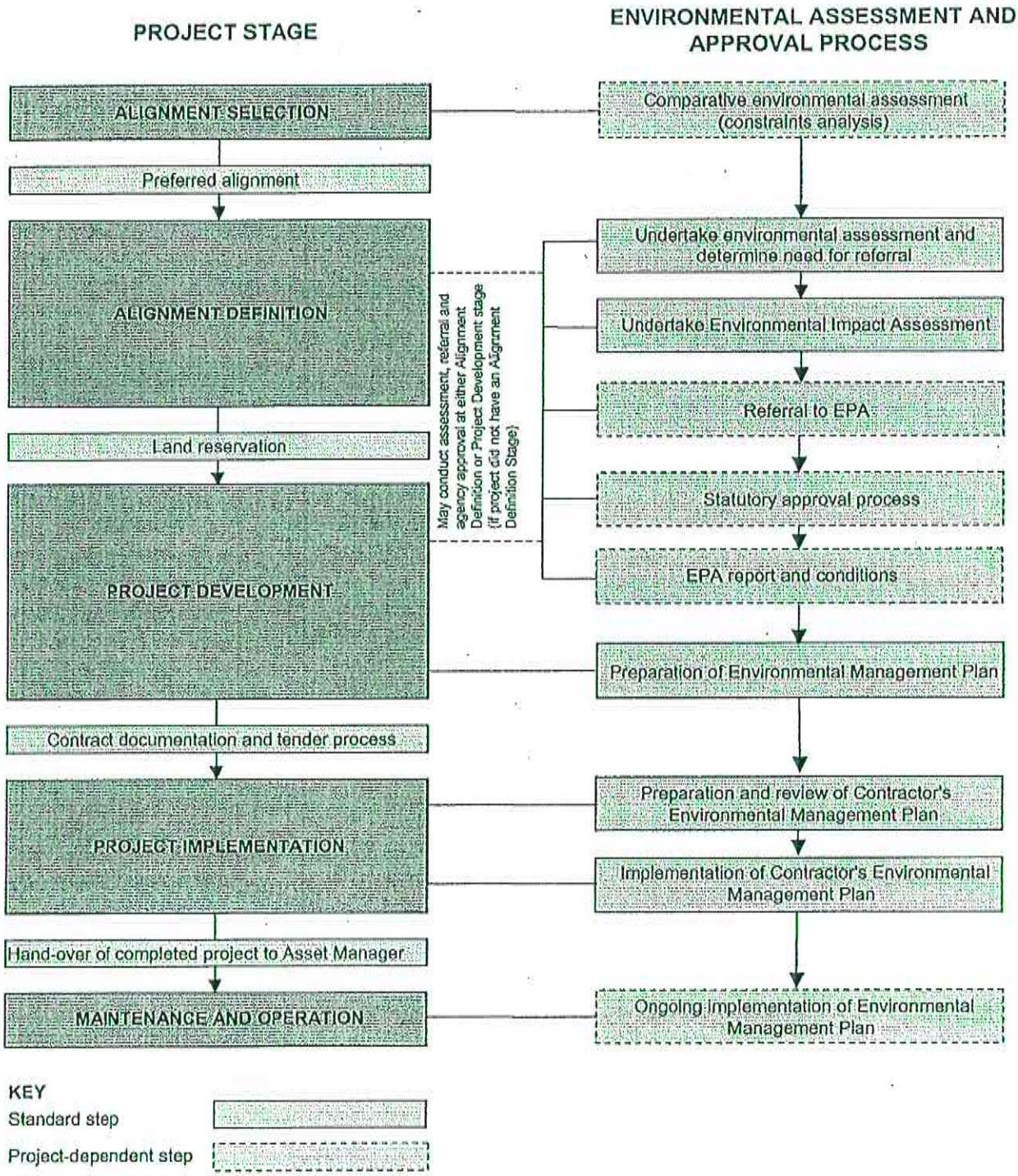


Figure 1 – Chart of Project Stage and Environmental Process

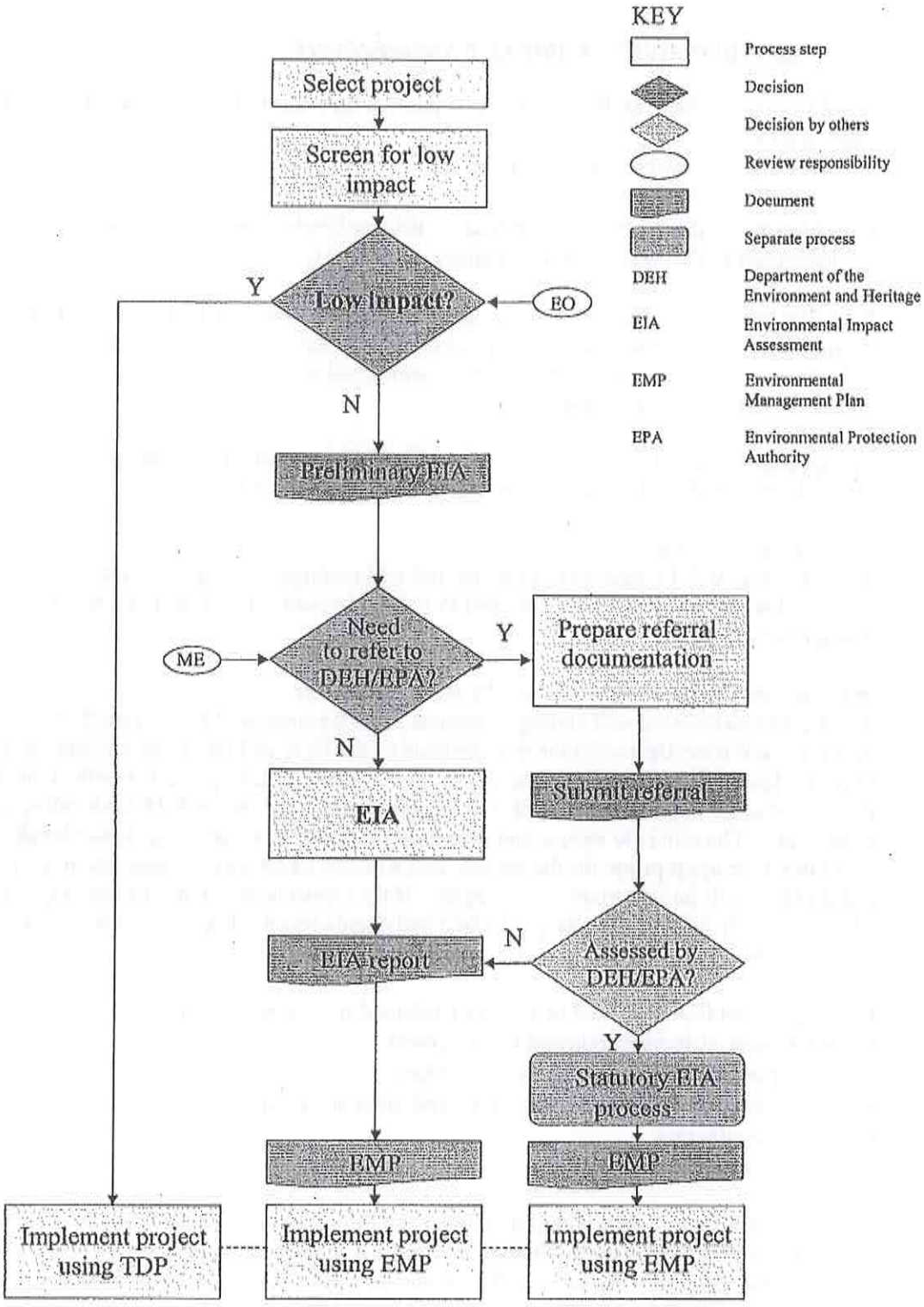


Figure 2 – Flowchart of Environmental Management for Road Projects

2. ENVIRONMENTAL IMPACT ASSESSMENT

The key steps in the overall environmental process that normally would have been undertaken prior to an EIA are:

- screening for low environmental impact;
- preliminary EIA (PEIA);
- decision whether to refer the proposal to EPA or Environment Australia; and
- indication of the likely level of statutory assessment.

If an EIA has been undertaken at some stage in the past then the EIA report must be comprehensively reviewed to ensure it meets current statutory requirements. If the review indicates it is lacking in some respects, then additional work must be carried out to bring the document to the required standard.

The approach to an EIA and its scope of work will depend on whether the proposal is to be referred and the likely level of assessment to be set eg ARI or EPS.

Projects Not Referred
These projects will be managed internally and will undergo adequate impact assessment to confirm that referral is not necessary and to enable preparation of a suitable environmental management plan.

Projects referred with likely ARI or EPS level assessment
A project to be referred will undergo adequate impact assessment to confirm that referral is necessary and meet the particular requirements of the EPA and Environment Australia for the expected level of assessment. Liaison with the EPA should take place to confirm the scope of the EIA because the EIA report will be a key document used by the EPA in deciding a level of assessment. The aim is to ensure that the report demonstrates that these 'lower levels' of assessment are appropriate for the project, and a record of adequate consultation with stakeholders will be important in this regard. If the report is deficient in some way then the EPA may apply the precautionary principle and decide to set a higher level of assessment, ie a PER or ERMP.

Key steps of an EIA are listed below and explained in following sections:

- assessment of impacts relevant to the project
- assessment of factors associated with referral
- liaison and consultation with agencies and other stakeholders
- field investigation
- preparation of EIA report

Projects which require referral to DEH under the *Environmental Protection and Biodiversity Conservation Act* 1999 have additional requirements and must comply with Main Roads environmental guideline *Referral to the Commonwealth Government for Environmental Approval.*

2.1 Assessment of Impacts Relevant to the Project.

At this stage of a project a PEIA should have been completed and indicate relevant environmental aspects (Appendix A) and possible impacts in broad terms. The preliminary report will assist in preparing a scope for further EIA work and engagement of a consultant.

The scope of investigations required for each environmental aspect is mainly dependent on the individual project, and may vary from nil, to a cursory desktop assessment, to a detailed field investigation. The scope of work required also partially reflects whether the project will be referred to the EPA.

Due to the public nature of the EIA report, projects that are to be referred must include environmental investigation of all relevant aspects rather than only those aspects requiring referral. The possible scope of investigations for each factor is listed in Appendix A.

2.2 Assessment of Factors Associated with Referral

Appendix B lists the environmental factors that require referral of a project to the EPA.

Environmental assessment of the potential impacts on any matters of National Environmental Significance will require investigation according to the Main Roads environmental guideline *Referral to Commonwealth Government for Environmental Approval.*

2.3 Liaison and Consultation with Agencies and Other Stakeholders

The aim of liaison is to ensure that EIA investigation and reporting addresses stakeholder concerns, and therefore reduces the potential for project delays at a future stage. Stakeholders include:

- State government departments
- local government
- landowners
- community and business groups

Projects that are to be referred to the EPA must include consultation with relevant regulatory agencies (eg. Department of Conservation and Land Management, Department of Environment), prior to referral to discuss the proposed scope of works in order to meet their requirements.

Concerns expressed by stakeholders will need to be adequately addressed, especially for projects that will be referred to the EPA. Failure to do so may result in the EPA setting a higher level of assessment with associated lengthy public review.

Projects with matters of National Environmental Significance will require liaison with Environment Australia.

2.4 Field Investigation

Field investigations will be carried out as follows for the two EIA processes:

- EIA for internal purposes – in accordance with the requirements provided in Appendix C
- EIA for referral purposes – in accordance with the requirements of Appendix C, the EPA and other regulatory agencies.

Field investigations will be undertaken for the relevant environmental aspects listed in Appendices A and B as a minimum. It should be noted that this is not an exhaustive list and additional surveys should be undertaken as required to suit the project requirements. Some investigations have specific timing requirements, eg a springtime flora survey, that will need to be considered when scheduling environmental impact assessment.

Investigations described in this guideline do not include Aboriginal heritage and Native Title considerations. However, Aboriginal heritage must be considered for a proposal in accordance with Main Roads environmental guideline *Aboriginal Heritage.*

2.5 Preparation of an Environmental Impact Assessment Report

The EIA report is a key document in the environmental assessment and approval process and will guide environmental management for a project. The EIA report is to include the components listed in Appendix D. In summary the EIA report is to include:

- Summary;
- Introduction;
- Description of the proposal;
- Existing environment;
- Environmental aspects;
- Environmental management;
- Environmental management commitments;
- Public consultation;
- Consultation with regulatory stakeholders; and
- Recommendations.

The environmental management section of the EIA report only needs to describe the principle management actions. A detailed description of the specific management actions will be provided later, in the Environmental Management Plan..

The environmental aspects section of the EIA report should list all aspects considered in determining the scope of the EIA and an explanation of why any aspects were considered not relevant to the project (using the checklist in Appendix E). Clearing of native vegetation is of particular interest and reporting must include an assessment of the clearing impacts based on the Ten Clearing Principles, as outlined in Schedule 5 of the Environmental Protection Act 1986, see Appendix G.

If a project is to be referred to the EPA or Environment Australia the EIA will form the base information of the referral documentation (see Appendix E of *Environmental Assessment and Approval*, and *Referral to the Commonwealth Government for Environmental Approval*).

A checklist is available (Appendix F) to assist a Project Manager review a draft EIA report, and the Environment Branch is able to assist in the review. For a project that is to be referred and is likely to be assessed at a level of an ARI or EPS, the draft EIA report should also be reviewed by the EPA before the official step of referral (the EIA report is to be reviewed by Manager Environment prior to referral to the EPA and/or Environment Australia.).

A copy or the final report is to be sent to the Main Roads librarian.

When EIA activity is complete the Project Manager will need to refer back to *Environmental Assessment and Approval* to continue with the overall environmental process.

Appendix A
Environmental Aspects To Be Considered During Environmental Impact Assessment

This Appendix provides a list of environmental aspects to be considered by an environmental consultant. It should be noted that this is **not** an exhaustive list and should be added to, to suit the project.

Air quality
Factor mostly applies to urban areas; information on regional air quality and historical data is usually sufficient. Preliminary assessment indicates whether further work is required for high traffic flows or sensitive areas; work includes modelling and/or baseline and post-construction air quality monitoring.

Dust
Mainly a construction impact dealt within the environmental management plan to protect residences. Sensitive receivers (nearby residences, some vegetation), high or ongoing dust generation potential may require air quality environmental impact assessments, as above.

Fauna
Impacts on mammals, birds, herpetofauna (reptiles and frogs) or invertebrates are usually associated with habitat loss (clearing) and restriction of movement. Scheduled or priority fauna are key aspects. Assessment is usually either desktop or opportunistic spotting during vegetation survey. Detailed investigations may include specific observations, trapping or sampling.

Vegetation - threatened species and communities
Impacts on declared rare or priority flora, or threatened ecological communities, may occur during clearing for roads or associated works. Conduct initial database check and discuss with the WA Threatened Species and Communities Unit at the Department of Conservation and Land Management. Most projects will also require a field vegetation survey and mapping to determine local and regional significance. Surveys are best conducted in spring, particularly for rare flora. Survey and mapping detail should be agreed with EPA if the project is to be referred.

Vegetation – clearing
Quantify the area of native vegetation to be cleared and consider local land degradation effects (extent of regional remnant vegetation, erosion, dust). Identify vegetation in parks or reserves, including Bush Forever sites in the metropolitan area and Regional Forest Agreement areas. Assess the clearing of native vegetation against the Ten Clearing Principles, as outlined in Schedule 5 of the Environmental Protection Act 1986, see Appendix G. Each principle shall be properly assessed in accordance with the DoE's Guideline to Assessment – Clearing of Native Vegetation.

Vegetation – dieback and other diseases or pathogens
Perform a desktop survey to determine general susceptibility and previous occurrence. Field observations during vegetation survey, focussed on indicator species. Carry out a detailed survey with soil sampling for critical areas. Assess significance with regard to vegetation quality.

Vegetation –weeds
Department of Agriculture can provide advice on weed prevalence. Field observation during vegetation survey. Focus on declared and environmental (nuisance) weeds.

Aboriginal heritage
Refer to Main Roads environmental guideline *Aboriginal Heritage*. May be limited to desktop survey, which will indicate the need for further work. Usually, projects require field surveys for ethnographic (cultural/religious) and archaeological (artefacts) sites including consultation with all groups associated with the area.

European cultural heritage
See *Cultural Heritage Assessment And Approval Process* (Main Roads, 2001). Desktop survey using Heritage Council of WA central database, plus check with local government(s). Built-up areas should also have a 'windscreen' check for buildings over 60 years old. Heritage sites potentially impacted require field assessments to be carried out to the Heritage Council of WA standard.

Surface waters / drainage (watercourses, erosion, stormwater disposal, water quality, salinity)
Impacts on surface hydrology, including flooding, channel form and alignment, should be investigated to Main Roads Senior Waterways Engineer's requirements. Desktop study of the environmental impact of erosion, stormwater disposal and potential impacts on riparian vegetation and faunal movement. Desktop information on water quality and expected impacts is usually sufficient. Baseline water quality monitoring may be required for sensitive areas.

Public drinking water source areas
Pubic drinking water source areas are underground water pollution control areas, catchment areas and water reserves. Detailed risk assessment for all project stages is required to demonstrate the necessity for roads through these areas.

Groundwater
Typical groundwater impacts are due to runoff and dewatering. Desktop information on water quality and expected impacts is usually sufficient. Dewatering environmental impact assessment may include disposal impacts, hydrogeological (desktop or field) investigations and dilapidation surveys.

Wetlands
Perform a desktop search using Department of Environmental Protection information, with ground truthing of sites. 'C' and 'R' management category wetlands may require field assessment for vegetation, fauna habitat as above and desktop assessment of hydrological and social functions.

Noise and vibration
Potential impact on residential areas usually requires modelling and field measurements. Dilapidation surveys and desktop geological studies may be required to assess vibration impacts for major construction activity in built-up areas. Other areas would require nil or generic desktop vibration EIA.

Visual impacts
Factor important for new major roads or significant upgrades. Carry out a desktop study using photography along alignment and master plan to identify visual changes. Investigate the degree of visual intrusion and loss of visual amenity.

Public safety and risk (industrial plant, gas pipeline, unexploded ordinance)
Factor only considered for facilities such as high-pressure gas or electricity lines, Department of Defence land (UXO's, operations), adjacent hazardous industrial plant, fuel or chemical storage. Road proposals only require desktop investigations and liaison with appropriate authorities

Contaminated sites
All projects on previously developed land require desktop study to assess properties for past and present activities. This is most important for new properties or construction in cut. Adjacent commercial or industrial activity should also be assessed. Properties at risk should be sampled (broad scale, then intensive) for shallow soil and or groundwater contamination.

Use of hazardous substances
Factor refers to impact of storage and transport of fuel and chemicals during both construction and operation. Usually dismissed due to low traffic flows and standard management during construction. Desktop studies using crash statistics and previous risk analyses for sensitive areas. Project-specific risk analysis if very significant.

Reserves and conservation areas
Examine the cadastral maps. Determine the significance of reserves of conservation areas. Consult with the Department of Land Administration to determine vesting, purpose of reserve, area of reserve and any information on its significance.

Other
Project-specific aspects not covered elsewhere in this list. Examples include karstic landforms (see fauna habitat, visual amenity), mangrove areas (see surface hydrology, water quality, vegetation, fauna habitat) and waste disposal.

Appendix B
Environmental Factors Associated with Referral to the EPA

B.1 TYPES OF ENVIRONMENTAL FACTORS

As agreed with the Department of Environmental Protection, where a proposal has the potential for adverse impact on environmental factors listed in this Appendix, the project will be referred to the EPA under Section 38 of the Environmental Protection Act.

Regardless of the presence of the listed factors, a project will be referred if:

- it is likely to have a significant effect on the environment;
- there is a high level of public interest; or
- a new road or a major realignment is involved.

Factor	Description	Sources of information
Native remnant vegetation	Areas recommended for protection in the System's 'Red Book' reports in non-Perth metropolitan regions.	'Red Book' reports
	Areas identified in Bush Forever, which supersedes the System's 'Red Book' reports in areas of overlap.	Bush Forever
	Land vested in the National Parks and Nature Conservation Authority for the purpose of Conservation of Flora and Fauna, National Park or Conservation Park.	Department of Conservation and Land Management
	Areas recommended by the Department of Conservation and Land Management and endorsed by Government for inclusion in Department of Conservation and Land Management's Estate.	Department of Conservation and Land Management
	Land reserved as "Parks and Recreation" under the Metropolitan Region Scheme.	Ministry for Planning
	Areas managed for multiple uses where conservation is a defined use.	Local government Ministry for Planning
	Land reserved under the Regional Forest Agreement CAR reserve system	Department of Conservation and Land Management
	Areas with rare vegetation communities, or assemblages considered by the EPA not adequately represented in secure conservation reserves (including Threatened Ecological Communities).	Bush Forever Gibson et al (1994) Department of Conservation and Land Management
	Land containing declared rare flora and fauna and the habitats of declared rare fauna.	Department of Conservation and Land Management
	Vegetation in regional areas where there is less than 20% remnant vegetation remaining within the local authority area.	Department of Agriculture EPA
	Vegetation in regional areas which is considered to poorly represented according to definitions within the Environmental Protection Authority Position Statement No.2 "Environmental Protection of Native Vegetation in Western Australia"	EPA
	Vegetation which includes species of declared rare and priority flora where specific clearance has not been obtained from Department of Conservation and Land Management for the clearing of this vegetation.	Department of Conservation and Land Management

Table B.1 Biophysical Factors

Factor	Description	Sources of Information
Wetlands	Lakes nominated for protection in the Environmental Protection (Swan Coastal Plain Lakes) Policy gazetted in December 1992.	EPA
	Conservation and Resource Management category wetlands.	Water and Rivers Commission
	Wetlands nominated for protection in the Draft Environmental Protection Policy for Lakes and Swamps of the South West Agricultural Zone.	EPA
	Wetland areas recommended for protection in the System's 'Red Book' reports not within the area covered by Bushplan.	'Red Book' reports
	Conservation wetlands identified in Bush Forever, which supersedes the System's 'Red Book' reports in areas of overlap.	Bush Forever
	Wetlands on land vested in the National Parks and Nature Conservation Authority for the purpose of Conservation of Flora and Fauna, National Park or Conservation Park, or areas recommended, and endorsed by Government, for inclusion in Department of Conservation and Land Management estate for conservation purposes.	National Parks and Nature Conservation Authority Department of Conservation and Land Management
	Wetlands in areas reserved as "Parks and Recreation" under the Metropolitan Region Scheme.	Ministry for Planning
	Wetlands with rare vegetation communities considered by the EPA not adequately represented in secure conservation areas, or rare flora and fauna (and their habitats) especially east of the Swan Coastal Plain.	Bush Forever Department of Environmental Protection
	Wetlands recognised by international agreement because of their importance primarily for waterbirds and their habitats. (eg: RAMSAR, JAMBA, CAMBA).	Department of Conservation and Land Management Environment Australia
Watercourses and rivers	Watercourses recommended for protection in the System's 'Red Book' reports not within the area covered by Bushplan.	'Red Book' reports
	Watercourse wetlands identified in Bush Forever, which supersedes the System's 'Red Book' reports in areas of overlap.	Bush Forever
	Watercourses containing lakes protected under the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992.	EPA
	Watercourses on land vested in the National Parks and Nature Conservation Authority for the purpose of Conservation of Flora and Fauna, National Park or Conservation Park or areas recommended, and endorsed by Government, for inclusion in the Department of Conservation and Land Management estate for conservation purposes.	National Parks and Nature Conservation Authority Department of Conservation and Land Management
	Watercourses in areas reserved as "Parks and Recreation" under the Metropolitan Region Scheme.	Ministry for Planning
	Watercourses with rare vegetation communities considered by the EPA not adequately represented in secure conservation areas, or rare flora and fauna (and their habitats).	Bush Forever Gibson et al (1994) Department of Conservation and Land Management

Table B.1 Biophysical Factors cont ...

Factor	Description	Sources of Information
Estuaries and inlets Coastlines and near shore marine areas	In general, all estuaries are of interest to the EPA, however, certain estuaries have specific management agencies which have statutory and advisory roles to play in their protection. These include the: • Peel Inlet - Harvey Estuary, • Leschenault Inlet, • Albany and Princess Royal Harbour, • Wilson Inlet, and • Swan - Canning Estuary.	Department of Environmental Protection
	Areas recommended for protection in the Systems 'Red Books' reports.	'Red Book' reports
	Coastline containing mangroves.	Ministry for Planning Department of Conservation and Land Management EPA
	Areas identified by the Department of Conservation and Land Management for inclusion on the List of Wetlands of International Importance (RAMSAR Convention).	Department of Conservation and Land Management
	Coastline areas (including marine areas) recommended by Department of Conservation and Land Management, and endorsed by Government for inclusion in Department of Conservation and Land Management's estate for conservation purposes.	Department of Conservation and Land Management
	Coastline in areas reserved for "Parks and Recreation" under the Metropolitan Region Scheme.	Ministry for Planning
	Coastline areas with rare vegetation communities considered by the EPA not adequately represented in secure conservation areas, or rare flora and fauna (and their habitats).	Bush Forever Gibson et al (1994) Department of Conservation and Land Management
	Coastline where recreational use is high, such as beaches in the metropolitan region.	Ministry for Planning
	Significant landforms including Beach Ridge Plain, Coastal Dunes (generally within 100 m of the shore) and Karst landforms.	EPA
Catchments with special requirements	Lake Clifton	EPA Department of Environmental Protection
	Western Swamp Tortoise Habitat	EPA Department of Environmental Protection Department of Conservation and Land Management
	Forrestdale Lakes	EPA Department of Environmental Protection
	Wetlands and their associated environmental management areas, associated with Jandakot and Gnangara Mounds.	EPA Department of Environmental Protection

Table B.1 Biophysical Factors cont ...

Factor	Description	Sources of Information
Contaminated soils	Existing areas of soil contamination that may be disturbed by future construction of road transport infrastructure.	Local government EPA
Noise and Vibration	Potential impacts on residential areas due to the relationship between the location of road transport infrastructure with respect to residential areas or other sensitive facilities such as hospitals and the like.	EPA
Public water source areas - groundwater and surface water	Priority 1 & 2, Gnangara Mound.	Department of Environmental Protection Water Corporation
	Priority 1 & 2, Jandakot Mound.	Department of Environmental Protection Water Corporation
	Water & Rivers Commission gazetted groundwater areas outside the Perth metropolitan area.	Department of Environmental Protection Water Corporation
	All surface catchments where water is collected for public water supply purposes.	Department of Environmental Protection Water Corporation

Table B.2 Pollution Prevention Factors

Factor	Description	Sources of Information
Aboriginal heritage	Sites of Aboriginal significance due to ethnographic or archaeological issues.	Department of Aboriginal Affairs
European Heritage	Sites listed by the Australian Heritage Commission or the Register of Heritage Places.	Australian Heritage Commission
Adjacent land uses	Land uses and zonings, which could be affected by road proposals.	Ministry for Planning Local government

Table B.3 Social Surroundings Factors

B.2 REFERENCES

Bush Forever — Western Australian Planning Commission, Ministry for Planning, Environmental Protection Authority, Department of Environmental Protection, National Parks and Nature Conservation Authority, Department of Conservation and Land Management, Water and Rivers Commission Board, Water and Rivers Commission (1998). *Perth's Bushplan*. Published by the Department of Environmental Protection, Perth, December 1998.

Gibson et al (1994) — Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H. and Lyons, M.N. (1994) *A Floristic Survey of the Southern Coastal Plain*. Unpublished report for the Australian Heritage Commission, Prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc.), Western Australia.

'Red Book' reports — Department of Conservation and Environment Western Australia (1983) *Conservation reserves for Western Australia as recommended by the Environmental Protection Authority - 1983. The Darling System - System 6.* Report 13, October 1983.

Appendix C
Field Investigation Survey Requirements

The environmental impact assessment field investigations are to be undertaken for the following environmental aspects, as a minimum.

1. Biological flora survey:
   - In accordance with the EPA requirements for the referral EPA;
   - a description and summary of climatic data;
   - soil descriptions and relationship to topography and plant communities;
   - an inventory of the vascular plant species in the survey area;
   - general physical characteristics of plants and flowering times;
   - a review of native plant species considered to be rare and endangered;
   - a review of threatened ecological communities (TEC);
   - an inventory of exotic plants, including declared and environmental weeds;
   - a description and location, including mapping, of roadside plant communities, particularly TECs;
   - a review of local and regional significance of the plant communities;
   - summary of the extent of clearing;
   - a description of existing surface drainage patterns with respect to topography, and to flora and fauna communities;
   - an assessment of the relationships between vertebrates and plant communities present in the roadside, and identify any habitats of significance;
   - consultation with Department of Conservation and Land Management and Department of Environment (DoE);
   - an assessment of the project against the Ten Clearing Principles, as outlined in Schedule 5 of the Environmental Protection Act 1986, see Appendix G;
   - information directed towards practical management techniques for improving the value of roadsides for conservation of flora species known to exist within the survey area; and
   - the system of soil classification shall be in accordance with the description as set out by Northcote *et al.* 1975. *A Description of Australian Soils*. CSIRO, Australia.
2. Dieback survey (including other diseases or pathogens).
3. Biological fauna survey:
   - in accordance with EPA for referral EIA;
   - opportunistic only for internal EIA;
   - an inventory of the vertebrate fauna species in the survey area;
   - a review of the fauna species considered to be rare and endangered;
   - a review of pest, declared or vermin animals;
   - a review of fauna species in need of special consideration;
   - a review of the zoogeographic region as a whole and an assessment of the regional and local conservation status of the roadside fauna;
   - an assessment of the value of the roadside in providing habitat and facilitating movement between conservation areas; and
   - information directed towards practical management techniques for improving the value of roadsides for conservation of fauna species known to exist within, or use, the survey area.
4. Cultural heritage survey:
   - in accordance with the requirements of the Heritage Council of WA.
5. Noise survey and modelling:
   - in accordance with the EPA requirements for referral EIA; and
   - in accordance with Main Roads requirements.

6. Wetland field assessment:
   - an inventory of wetlands and their management category, type, suite, vegetation community, protection status (eg. Environmental Protection Policy, RAMSAR);
   - consultation with the Department of Environment; and
   - functional assessment in accordance with EPA Bulletin 686 (or rural equivalent as agreed with Department of Environment).
7. Contaminated site assessment:
   - preparation of site history;
   - consultation with regulatory authorities and local government;
   - strategic soil and/or groundwater sampling;
   - identification of constraints; and
   - nomination of further work required.
8. Air quality modelling (EIA referral only):
   - in accordance with Main Roads requirements.

Appendix D
Components of an Environmental Impact Assessment Report

The Environmental Impact Assessment report should contain the following components:

1. Executive Summary: Including tabulated management commitments.
2. Introduction, including background and scope of the report.
3. Description of the proposal:
   - Location (address and certificate of the title details where relevant for referral only);
   - justification and objectives;
   - legal framework;
   - alternative designs;
   - key project characteristics table;
   - plans, specifications, charts; and
   - timing and staging of project.
4. Existing environment: A definition of significant environmental aspects and a list of pre-existing commitments and/or clearances. This section should summarise the general environmental context (eg. climate, geology, geomorphology, hydrology, landforms) and may also describe the existing environment in terms of the environmental aspects.
5. Environmental aspects: Identification of key environmental aspects and analysis of potential impacts under each of the following categories. (This section may include a description of the existing environment if not included previously):
   - area of assessment;
   - extent of impact;
   - broader environmental / ecological context;
   - relevant standards / regulations / policies;
   - environmental evaluation;
   - summary table of environmental aspects; and
   - further specific environmental investigations required.
6. Environmental management. A description of the principle management actions and how the opportunities for preservation, conservation and enhancement will be utilised during the design of the project.
7. Environmental management commitments, structured as follows (presented in a tabular format):
   - commitment;
   - action;
   - objective;
   - location;
   - timing;
   - responsible / implementing party (ie Main Roads, Contractor); and
   - requirements/consultation.
9. Public consultation.
10. Consultation with regulatory stakeholders and approvals obtained.
11. Recommendations. Include the need to refer the project to the EPA and/or Environment Australia indicating the environmental factor(s) from Appendix B that require referral. Also list other agency approval(s) required and associated environmental factor(s).
12. Other information.

If the EIA is to be part of the referral documentation to the EPA, then the following additional items should be included:

- Proponent information (name, address, contact person); and
- EPA objectives in the environmental aspect section.

All EIA's will include the following figures as a minimum:

- locality plan (including proposed road alignment, local government boundaries, existing roads, major urban centres, wetlands and watercourses, reserves, conservation areas, remnant native vegetation, adjoining land uses, aerial photography etc.);
- site plan – proposal details (including road reserve, bridges, materials pits if known, cadastral boundaries);
- aerial photography of the proposal area;
- maps showing location of key environmental constraints in a regional context and in a local context (must include extent of native vegetation to be cleared and hydrological features including wetlands, adjacent land uses, watercourses, creek lines, seasonal creeks and artificial drainage); and
- map showing location of key environmental management measures (eg. declared rare flora site to be protected, location of temporary drainage structure, noise-sensitive residences).

All figures are to show: title, number, contours, north point, scale, grid co-ordinates, data source and currency, key/legend, adequate labelling, use of colour as appropriate. If the data is overlaid on an aerial photo then the date of the aerial photo will be shown.

D.1 EXPLANATION OF COMPONENTS OF EIA REPORT

This section explains some of the components of the EIA report.

D.1.1 Justification and alternatives

- justification and objectives for the proposed development;
- the legal framework, including existing zoning and environmental approvals;
- decision making authorities and involved agencies; and
- consideration of alternative options.

D.1.2 Key project characteristics

The EIA documentation will include a description of the components of the proposal, including the nature and extent of works proposed. This information must be summarised in the form of a table as indicate in Table D.1 below.

Element	Description
Road dimensions	Approximately 40km long by 40m wide including drainage swales.
Road description	Four lane dual carriage-way. Bridges over Swan River and Ellen Brook.
Vegetation cleared	4 ha of degraded Community type 19c

Table D.1 Key characteristics (example only)

D.1.3 Other

Other issues that are relevant include:

- timing and staging of project; and
- ownership and liability for waste during transport, disposal operations and long-term disposal (if appropriate to the proposal).

D.1.3.1 Environmental aspects

The EIA will focus on the environmental aspects relevant to the proposal.
Items that will be discussed under each environmental factor are:

- a clear definition of the area of assessment for this factor;
- the EPA objective for this facto (EIA referral only);
- a description of what is being affected - why this factor is relevant to the proposal;
- a description of how this factor is being affected by the proposal - the predicted extent of impact;
- a description of where this factor fits into the broader environmental / ecological context (only if relevant - this may not be applicable to all aspects);
- a straightforward description or explanation of any relevant standards / regulations / policy;
- environmental evaluation - does the proposal meet the EPA's objective as defined above (EIA referral only);
- if not, environmental management proposed to ensure the EPA's objective is met (EIA referral only); and
- the predicted outcome.

Provide a summary table of the above information for all environmental aspects, under the three categories of biophysical, pollution management and social surroundings:

Environmental Factor	EPA Objective	Existing environment	Potential impact	Environmental management	Predicted outcome
BIOPHYSICAL					
vegetation community types 3b and 20b	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation community types 3b and 20b	Reserve 34587 contains 45 ha of community type 20b and 34 ha of community type 3b	Proposal avoids all areas of community types 20b and 3b	Surrounding area will be fully rehabilitated following construction	Community types 20b and 3b will remain untouched Area surrounding will be revegetated with seed stock of 20b and 3b community types
POLLUTION MANAGEMENT					
Dust	Ensure that the dust levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards	Light industrial area - three other dust producing industries in close vicinity Nearest residential area is 800 metres	Proposal may generate dust on two days of each working week.	Dust Control Plan will be implemented	Dust can be managed to meet EPA's objective
SOCIAL SURROUNDINGS					
Visual amenity	Visual amenity of the area adjacent to the project should not be unduly affected by the proposal	Area already built-up	This proposal will contribute negligibly to the overall visual amenity of the area	Bridge will be in 'forest colours' and screening trees will be planted on road	Proposal will blend well with existing visual amenity and the EPA's objective can be met

Table D.2 Environmental aspects and management

D.1.3.2 Environmental management commitments

All environmental management commitments will be consolidated in the EIA report in a list (usually in an Appendix). A commitment needs to contain most (if not all) of the following elements to be auditable:

- who (e.g. Main Roads);
- will do what (e.g. prepare a plan, take action);
- why (to meet an environmental objective);
- where / how (detail the action and where it applies);
- when (in which phase, e.g. before construction starts);
- to what standard (recognised standard or agency to be satisfied); and
- on advice from (agency to be consulted).

Examples of the preferred format for typical commitments are shown in Table D.3.

Who / What Commitment	When plan prepared Timing	Why Objective	How / Where Action	Whose advice expert consulted	Evidence Standard Compliance criteria
1. The Proponent will develop and implement a rehabilitation plan	before construction commences	to protect the abundance, species diversity, geographic distribution and productivity of the vegetation community types 3b and 20b (fig 3.1, Environmental Management Plan)	by limiting construction to 10 ha of Reserve 34587 and rehabilitating the area	on advice of Department of Conservation and Land Management .	similarity rating of rehabilitated area consistent with vegetation community types 3b and 20b.
2. The Proponent will prepare and implement a dust control plan	before the start of construction	to minimise dust generation and impact on nearby land owners	by measures such as watering roads and monitoring wind direction	preparation of the plan on advice of EPA.	1000mg/m3/1 hr average (EPA Dust Control Criteria)

Table D.3 Summary of proponent's commitments (example only)

Commitments should preferably be written in tabular format, preferably with some specification of ways in which the commitment can be measured, or how compliance can be demonstrated.

D.1.3.3 Public consultation

A description will be provided of the public participation and consultation activities undertaken by Main Roads. It will describe the activities undertaken, the dates, the groups / individuals involved and the objectives of the activities. Cross-reference will be made with the description of environmental management of the aspects, which will clearly indicate how community concerns have been addressed.

D.1.3.4 Other information

Additional detail and description of the proposal, if provided, will go in a separate section.

Appendix E
Checklist - Environmental Aspects Considered

This checklist is for use by environmental consultants. When completed it is to be included in the EIA report.

Environmental Aspect	Relevant		Comments
	Yes	No	
Air quality			
Dust			
Fauna			
Vegetation – threatened species and communities			
Vegetation – clearing			
Vegetation – dieback and other diseases or pathogens			
Vegetation – weeds			
European cultural heritage			
Surface waters / drainage (watercourses, erosion, stormwater, disposal, water quality, salinity)			
Public drinking water source areas			
Groundwater			
Wetlands			
Noise and vibration			
Visual impacts			
Public safety and risk			
Contaminated sites			
Use of hazardous substances			
Reserves and conservation areas			
Others....			

Appendix F
Checklist - Review of an EIA Report

This checklist is for use by Project Managers when reviewing a draft Environmental Impact Assessment report.

	EIA process	Completed		Comments
		Yes	No	
General Items				
Risk assessment	Both			
Checklist for review of environmental issues	Both			
Others....				
Surveys Completed				
Biological flora survey	Both			
Dieback survey	Both			
Biological fauna survey	Both			
Cultural heritage survey	Both			
Noise survey and modelling	Both			
Wetland field assessment	Both			
Contaminated site assessment	Both			
Air quality modelling	Referral			
Others....				
Specific report items				
Documentation associated with liaison with key agencies and community stakeholders	Both			
Approvals obtained	Both			
Description of the proposal	Both			
Existing environment	Both			
Ten Clearing Principles	Both			
Environmental aspects	Both			
Environmental Management	Both			
Environmental management commitments	Both			
Public consultation	Both			
Approvals required	Both			
Others....				
Figures				
Locality plan	Both			
Site plan	Both			
Aerial photography of the proposal area	Both			
Map showing location of key environmental constraints	Both			
Map showing location of key environmental management measures	Both			
Others....				

ANNEXURE 4

Environmental Guideline: Revegetation Planning and Techniques

DOC 11518

MAIN ROADS
Western Australia

Document No. 6707/031 **Issue Date 25/05/2004**

CORPORATE PROCEDURE

Environmental Guideline

REVEGETATION PLANNING AND TECHNIQUES

This document is owned and authorised by Executive Director Technology and Environment.
Enquiries should be directed to the delegated custodian, Manager Environment.

Printed copies are uncontrolled unless marked otherwise

CONTENTS

APPENDICES

REVISION STATUS RECORD

Revision No.	Revision Date	Description of Key Changes

1. INTRODUCTION

1.1 Purpose

Main Roads Western Australia ("Main Roads") has a policy aim to "protect and enhance the environmental values of road reserves". In the process of establishing new roads and upgrading existing roads, there is often a need to undertake revegetation of road reserves or other affected areas. Additionally, there may be parts of the road reserve that are degraded and would benefit from revegetation.

This document provides guidance on planning and implementing revegetation within road reserves and other areas for which Main Roads is responsible. It is designed to guide project managers on the steps involved and is intended to support, but not replace, specialist advice on revegetation projects.

1.2 Scope

This document addresses the following areas:

- Definition of what revegetation is and why it is necessary;
- Key issues affecting the planning, implementation and ultimate success of revegetation works;
- Outline of the steps involved in project management of revegetation works, and
- Supporting technical information about revegetation techniques.

The Guideline mainly relates to the establishment of native vegetation on roadsides and other areas. Landscaping techniques (eg transplanting, grassing and turf establishment, irrigation) and the ongoing maintenance of existing roadside vegetation are not covered in this Guideline. Specialist advice on landscaping works and ongoing maintenance of vegetation is available from Main Roads' Environment Branch.

1.3 Application

1.3.1 Who should use this document?

Those involved with the planning and implementation of revegetation works, including, but not limited to:

- Project Managers;
- Environment Officers; and
- Asset and Contract Managers.

1.3.2 Responsibilities

Project Managers are responsible for ensuring that Main Roads' statutory and corporate obligations are met with regard to completion and handover of revegetation works for their projects.

Asset Managers and Maintenance Contract Managers are responsible for ensuring that Main Roads' statutory and corporate obligations are met with regard to the identification of revegetation requirements and with the ongoing management of roadside vegetation.

1.3.3 Why should I use this document?

The use of this document helps to manage corporate risk by providing guidance to:

- Ensure revegetation works are planned and conducted to an acceptable standard;
- Minimise the risk of cost over-runs due to failure of revegetation works; and
- Manage consultants and contractors involved in revegetation works.

1.3.4 How do I use this document?

- Use the information in Sections 2 and 3 for background on revegetation works.
- Apply the project management procedures, Section 4, to ensure compliance with statutory and corporate obligations.
- As needed, use the supporting technical information, checklists and suggested contents for documentation given in the appendices.

1.3.5 Related documents

Documents to be used in conjunction with this document include, but are not necessarily limited to:

- Main Roads *Environmental Policy Statement*

Related Environmental Guidelines

- Main Roads environmental guideline *Vegetation Placement within the Road Reserve (Doc. No. 6707/022)*
- Main Roads environmental guideline *Vegetation Control (in preparation).*

Related Environmental Briefs

- Main Roads environmental brief *Project Revegetation Plan (in preparation).*
- Main Roads environmental brief *Revegetation Design (in preparation).*
- Main Roads environmental brief *Landscape Design (Doc. No. 6707/021).*

Related Specifications

- Specification clauses that relate to revegetation works can be found within the following Main Roads' Tender Document Process (TDP) standard contract specifications:
  - Clearing (301),
  - Earthworks (302),
  - Borrow pits (303) and
  - Revegetation and landscaping (304).

1.4 Contacts for more information

Additional support and guidance on revegetation is available from the regional Environment Officer or from the Environment Branch, Don Aitken Centre.

2. REVEGETATION

2.1 What is revegetation?

Vegetation (a plant cover of trees, shrubs, herbs or grass) of some type occurs within the road reserve across all regions of the state. This varies from forests in the South West to the scrublands and spinifex grasslands of the pastoral regions.

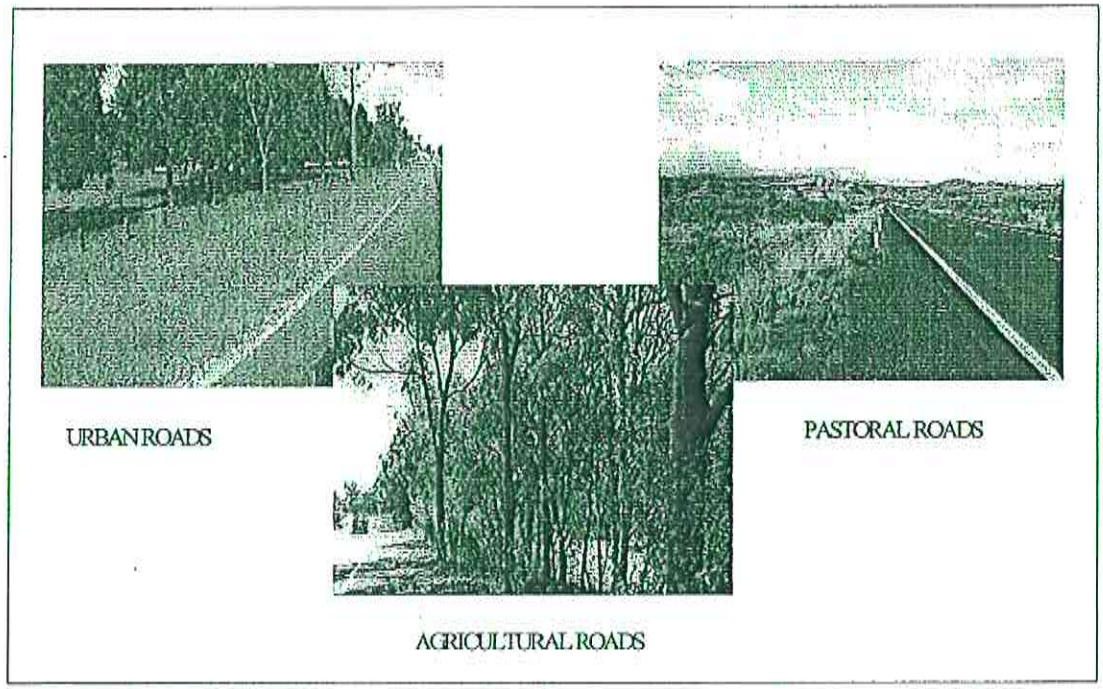


Figure 1 Typical examples of roadside vegetation across the State Road Network.

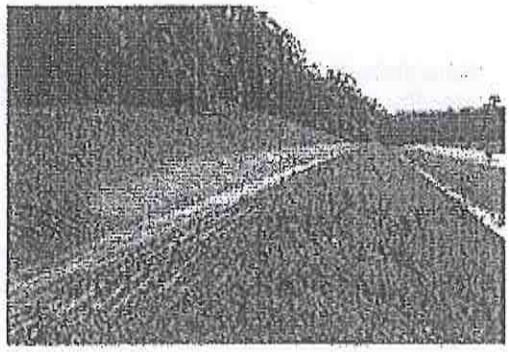
Revegetation refers to the re-establishment of a cover of vegetation suited to the location. This usually means a cover of local native plants and involves regeneration, direct seeding, and/or planting methods. Definitions of terms associated with revegetation are given in section 5.

Revegetation involves:

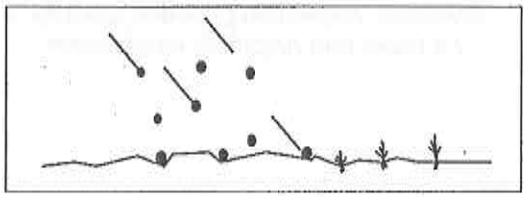
Preparation of finished soil surfaces, eg by ripping or tilling the soil surface and respreading site topsoil and chipped vegetation, to assist regeneration to occur naturally.

Regeneration of vegetation can occur through the seed existing within the site topsoil if this is stripped and respread during the earthworks, or from the seed that is carried in the cleared site vegetation that is chipped and respread over the soil.

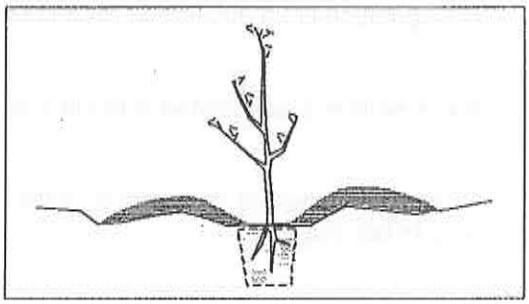
In many locations, the **additional seeding and planting of vegetation** may be necessary within the project area.



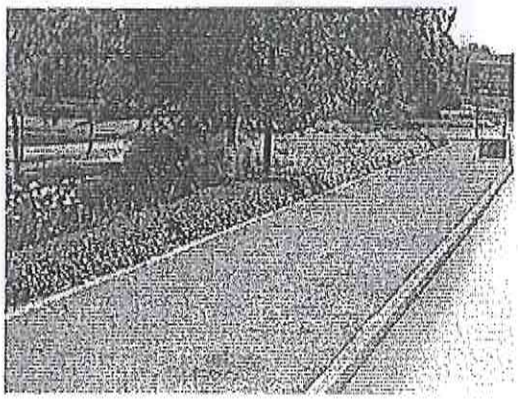
Seeding refers to the direct broadcast (by hand or machine) of plant seed onto the prepared soil surface.



Planting refers to the placement of nursery grown plants (in pots or small tubes – "tubestock") into the soil by hand or machine.

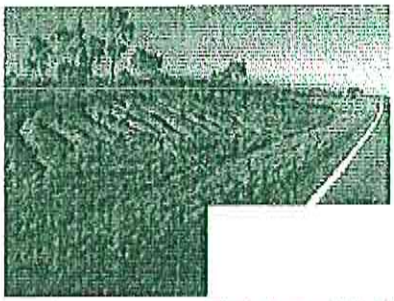


Landscaping refers to revegetation or additional works like grassing and irrigated planting beds, feature paving etc undertaken for functional and amenity objectives, for example at key locations along urban roads and town entries.

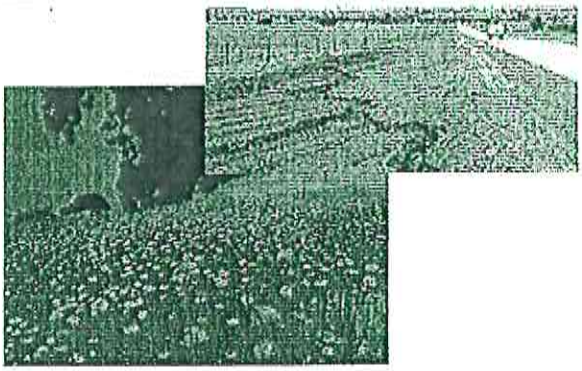


2.2 Why is revegetation necessary?

Establishing a vegetation cover helps to prevent soil erosion by rainfall impact and surface water flows.



Established vegetation help maintain the stability of the roadside and road formation.



Roadwork project commitments may include revegetation to meet environmental objectives or to meet ministerial conditions of approval for the project.

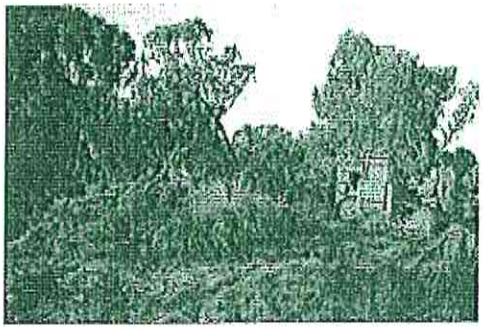
Roadside vegetation provides amenity for road users and adjoining landholders.

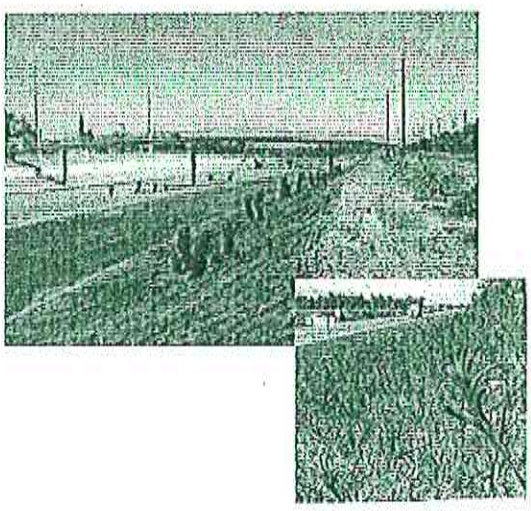
2.3 Where does revegetation occur?

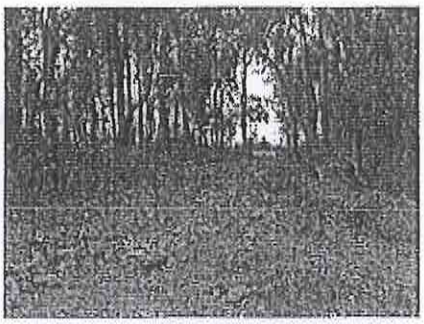
Revegetation is an accepted part and practice of roadwork projects.

Revegetation is associated with the following areas:

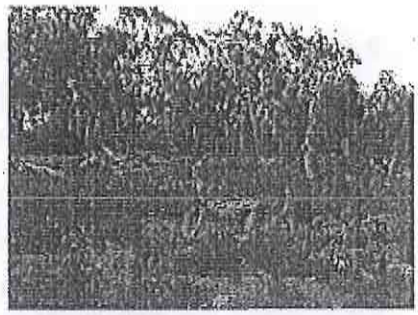
Cleared areas within roadwork projects (e.g. batter slopes).







Side tracks and access tracks.

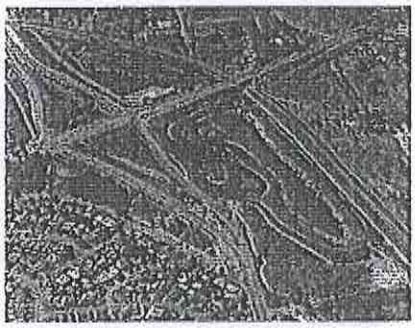


Borrow and spoil pits

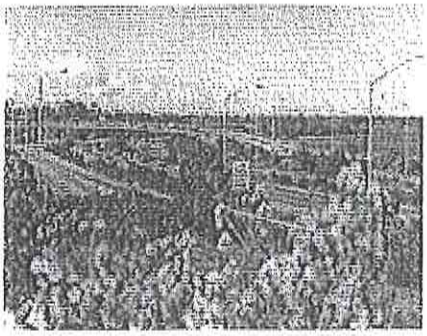
Stockpile areas.

Redundant pavement areas.

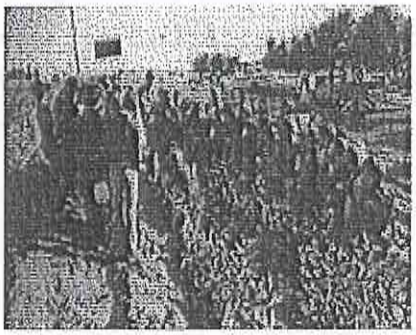
Acquired land adjoining road reserves.



Drainage basins (batters and surrounds).



Urban roadsides and medians.



Other designated areas (e.g. community or memorial roadside plantings).

Vacant gazetted road reserve.

Existing roadsides in agricultural and pastoral regions
(eg with degraded remnant vegetation or abutting good quality native vegetation).

2.4 What is involved in revegetation?

Effective revegetation practices help to accelerate the natural processes that occur following the clearing of vegetated areas and soil disturbance.

Revegetation requires the prior establishment of soil conditions suitable for plant growth through effective management of topsoil and the control of weeds and other site factors.

All plants require water to establish and grow. For most locations this means that revegetation, like agricultural cropping, is dependent on the annual rainfall.

Extent of works

Revegetation works may be limited to spreading site mulch (chipped vegetation cleared from the site) to protect an exposed batter surface, or require extensive seeding and planting. Some projects (eg in urban areas) may require landscaping with irrigated planting beds and grassing.

The methods and techniques used and the management approach will vary with the project size, the timing of the works, the site location, and other specifics of the site.

Management of the existing site topsoil and preparation of the finished soil surface is the accepted basic practice for revegetation across the State, but this is often supplemented by direct seeding and planting timed to occur with the seasonal rains.

Planning

Most importantly, however, successful revegetation requires some level of planning well in advance of any physical activities. Effective revegetation means identifying and responding to the site constraints and project commitments. It also involves making the best use of the materials available on site by not wasting the existing soil and vegetation resources.

Some level of community consultation or involvement of stakeholders will often be associated with revegetation works.

Section 3 discusses the key issues to consider and factors for success in planning revegetation works. The key steps in the revegetation process are summarised below.

- Set objective and budget for the revegetation.
- Prepare a site-specific plan.
- Manage the works (and establish the vegetation).
- Handover the works for ongoing maintenance.

3. KEY ISSUES TO CONSIDER AND FACTORS FOR SUCCESS

Failure of revegetation works is often attributed to externalities, such as 'lack of rain', or wildfire. While these externalities may be factors, poor revegetation outcomes can sometimes be traced to lack of planning and inadequate implementation.

The main reasons for the failure of revegetation works are associated with:

- Lack of early planning for revegetation works in the project process,
- Lack of expertise available within the project management and superintendence of the contract works,
- Failure to co-ordinate the revegetation with the clearing and earthworks,
- Inadequate provision for soil preparation and weed control,
- Poor timing of the revegetation works, and
- No follow up care to establish the vegetation.

This section discusses some of the key factors, which determine the success of a revegetation program. These issues and others are covered more fully in Appendix C (Recommended Revegetation Methods and Techniques).

3.1 Setting objectives

The level of treatment must be determined on a project-specific basis. Site issues are defined in the site Revegetation Plan (see Section 4). As a minimum, revegetation should achieve roadside stability and minimise on-going maintenance. In certain circumstances, additional objectives may be relevant, as summarised in Appendix A (Roadside Vegetation – Management Objectives).

For larger road projects that have been subject to statutory assessment by the Environmental Protection Authority, specific objectives will be set. Environmental constraints may apply on plant species selection, seed collection and propagation. The Asset Manager may also set revegetation objectives. Goals and targets for revegetation must be realistic for the location and project.

In pastoral regions basic topsoil management and weed control would be the expected minimum level of treatment. In agricultural regions some level of seeding and/or planting and weed control would be the expected minimum level of treatment. In urban areas a higher standard of revegetation/landscaping is the expected minimum level of treatment.

Direct seeding or regeneration from topsoil is the preferred approach for all regions of the state where re-establishment of 'natural' vegetation is the objective. This may be supplemented by some planting. Planting alone is not the preferred approach except to achieve roadside stability and amenity objectives for example in urban areas.

The measure of the success of the revegetation is based on monitoring the completion criteria as defined in the project plan. Examples of completion criteria are provided in Appendix G (Examples of Monitoring Programs for Revegetation Works).

3.2 Preparing budgets

Costs vary with the methods used and the overall size of the project. Project requirements may vary in size (from hectares to square metres), in the complexity of materials used and in the number of plant species used.

As a guide for large road projects (>$50 M) ~ 3% of the total cost estimate may be considered reasonable, depending on the specific project location and project commitments. In urban areas at least ~ 5% of the total cost estimate is used for initial estimating purposes in smaller projects.

Some typical costs for revegetation projects from around Australia are given, as benchmark costs, in Appendix D1 (Revegetation Projects – Benchmark Costs). They range from $2300 - $4200/ha for small areas to $600 - $2200/ha for large areas. These costs, however, do not include significant earthworks such as topsoil stripping and replacement.

Historical costs for Main Roads' revegetation work are not currently available but anecdotal information suggests they are higher than these values due to higher site costs when earthworks, formal monitoring and maintenance costs are considered.

A preliminary cost estimate, based on the total area and the type of revegetation works, is determined during the project planning stage. Appendix D2 provides a sample Bill of Quantities for revegetation works.

Local knowledge and experience in the region must be used where possible to determine the minimum level of treatment and for estimating costs.

Refer to Main Roads' Environment Branch for advice on estimating costs for revegetation works.

3.3 Planning

Once the need for revegetation work has been identified and a project objective set (see Appendix A), preliminary planning can be carried out. The checklists shown in Appendix B for site assessment should be used as a basis for preliminary planning but other issues could emerge.

The accepted approach for Main Roads' revegetation works is to accelerate the natural processes that occur following clearing of vegetation areas and soil disturbance. This means that successful revegetation projects require careful planning, with the timing of particular activities being critical. Taking into account the various activities involved in planning and undertaking revegetation, an example timeline for a revegetation project involving planting or direct seeding is given in Figure 2.

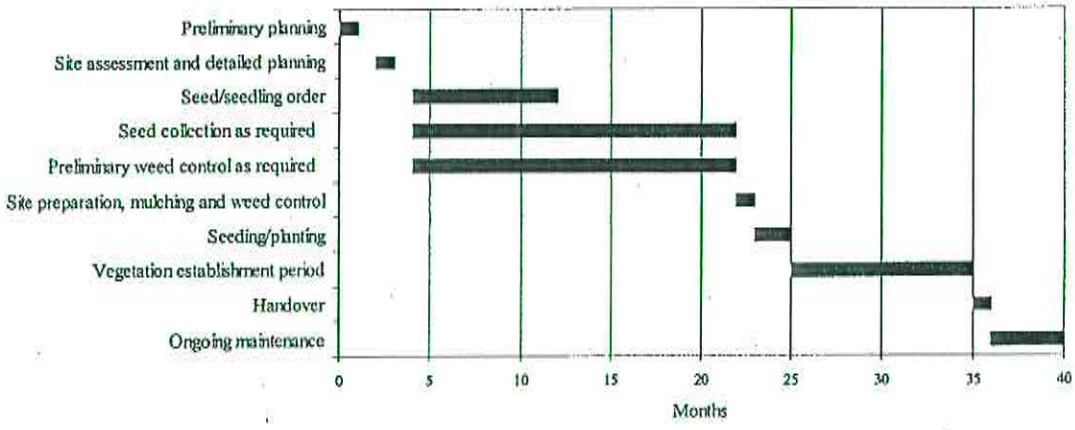


Figure 2 Suggested timeline of revegetation work involving seeding or planting – planning, implementation and subsequent monitoring.

Note that:

- Seed collection from site may need to be conducted over an extended period as the seeds of different species mature at different times. In a year with poor rainfall, seed set may be limited and collection may need to be conducted in the following year;
- Where seed other than that occurring on site is required, seed collectors may require significant advance notice in order to meet the specifications; and

- Several rounds of weed control may be necessary to adequately control the new growth of weed species (from the weed seeds existing in the soil) and reduce the competition on site for the planting or seeding. Weed control is most effective at particular times of the year.
- Where establishment of self-sustaining native vegetation is the aim, planting is used to supplement direct seeding. Planting alone does not achieve the required diversity of species and plant forms.

3.4 Timing of seeding or planting

Seeding or planting should occur when the likelihood of survival and establishment is greatest. This would normally be immediately prior to or at the 'break of season' as shown in Table 1. For example, in jarrah forest rehabilitation after bauxite mining, the best results are achieved when soil preparation and direct seeding both occur by April, with no cultivation occurring after the break of season. If the earthworks occur later, the soil surface disturbance may potentially kill any germinating seeds present in the topsoil.

Late seeding can reduce the amount of moisture available to germinating seeds and can ultimately lead to failure of seeding. There is anecdotal evidence that seeding as the first 'break of season' rains occur can be very successful.

Main Roads Region	Optimal Timing	
	Seeding	Planting
Gascoyne	May in south of region; November-December in north of region.	No planting without irrigation.
Goldfields-Esperance	April-May. Earlier in south than in north.	No planting without irrigation.
Great Southern	April-May throughout region. Seeding during September-October within 30 km of the coast can also be successful due to warm temperatures and spring coastal showers.	May-June.
Kimberley	October-December, preferably just before rain.	No planting without irrigation.
Metropolitan	April-June.	May-July.
Midwest	April-May in south of region; November-December in extreme north of region.	May-June in southern part of region only.
Pilbara	November-December but preferably just before rain.	No planting without irrigation.
South West	April-June.	May-June.
Wheatbelt North	May-June.	June-July.
Wheatbelt South	April-June.	May-June.

Table 1 Optimal seeding and planting times for each Main Roads region.

Planting should be conducted slightly later than seeding, when there is sufficient moisture in the ground to sustain the young plant but not so late that there would be insufficient moisture for establishment. In wet areas, seeding and planting can be delayed to late spring.

3.5 Regional differences

Climate is an important determinant of the methods used across the state. Not only does climate determine the timing of activities (see section 3.4) but it can also determine the method used. Historically in the more arid areas, (i.e. where the *rainfall variability* is moderate to high) the most cost effective method has proven to be topsoil management along with some direct seeding and allowing natural regeneration to occur over time.

Planting and seeding is generally limited to the Southwest corner of the State where the annual rainfall is reliable (see Figure 3) i.e. where the *rainfall variability* is low to moderate.

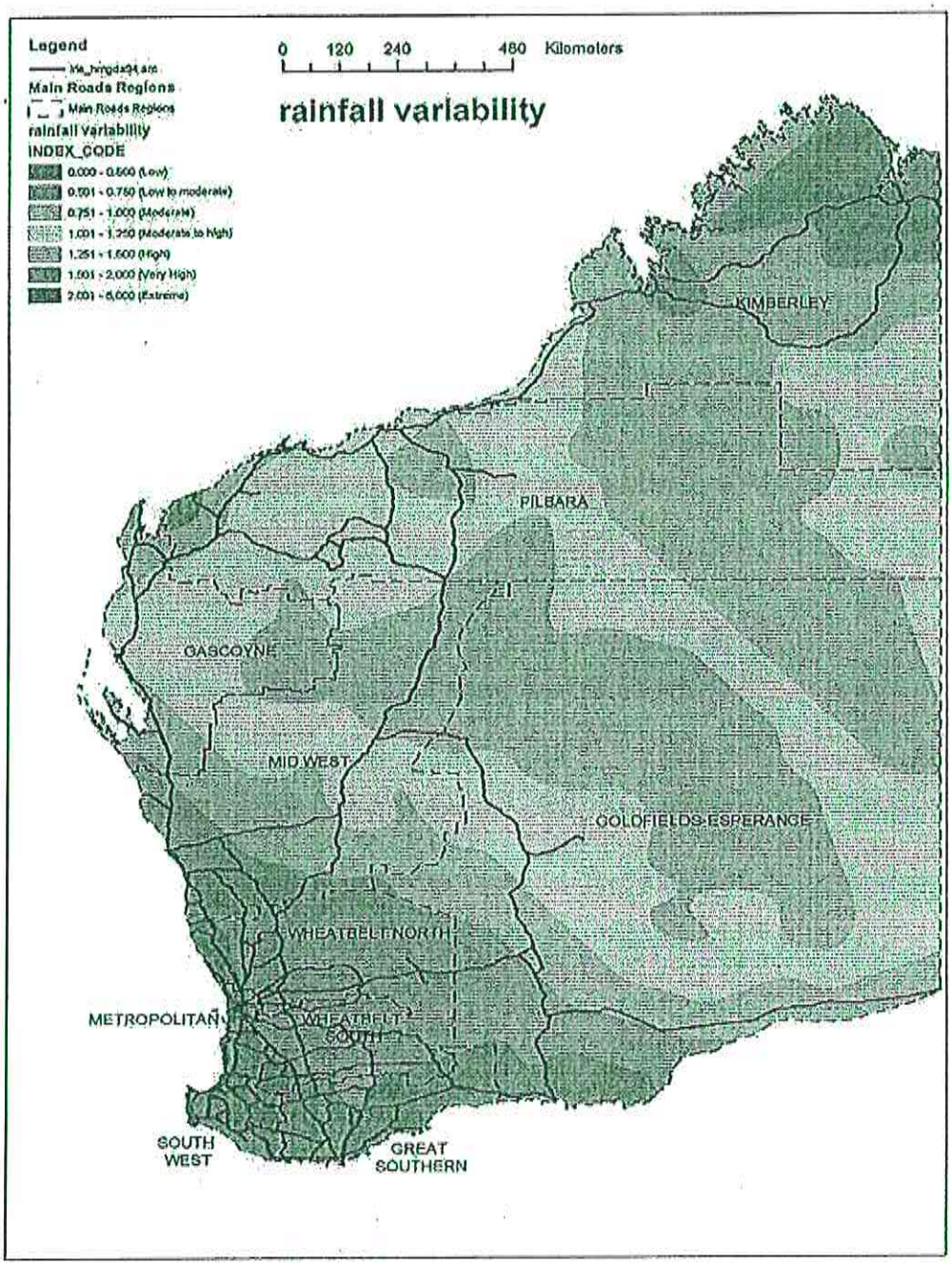


Figure 3 **Main Roads network and variability of annual rainfall**

(derived from http://www.bom.gov.au/).

Where the rainfall is very low or not reliable, then additional watering is required for any planting. Planting during the year, other than with the seasonal rains, is limited to locations where irrigation (from scheme water, bore or by tanker) is available to establish the vegetation.

3.6 Site implementation

3.6.1 Site preparation

The success of a revegetation program will hinge upon the correct preparation of the soil conditions for seeding or planting (see Appendix C, section 2). Adverse factors for plant establishment must be recognised and the appropriate steps taken to ameliorate their effects. Examples of seed or planting bed preparation include deep ripping to alleviate soil compaction and mounding to alleviate the potential effects of waterlogging. In some cases soil amendments (such as adding nutrients) may be necessary.

3.6.2 Weed control

Seeding or planting of native plants in weed-affected areas, such as former agricultural land and in urban areas, is unlikely to be successful without careful planning for weed control. Competition from weed species is a major cause in the failure of revegetation projects.

Weeds once established in the soil may inhibit the establishment of native plant species. Successful weed control may require action at several stages of the project until weed numbers (a store of seed is retained in the topsoil) are reduced to levels that allow native plant seedlings to grow and establish successfully.

3.6.3 Seed and Planting

Any seed or seedlings used in revegetation work should be of a known quality. There are steps that can be taken to reduce the risk of obtaining poor stock. These are discussed in Appendix C and involve certification of the viability of seed and adherence to certain industry standards for the production of seedlings.

There is evidence that different seeding methods can produce markedly different results. Following consultation with industry personnel and researchers, this appears to be related to seed burial, with seed that is buried too deeply unable to establish. Small-seeded species are at greater risk of loss through burial than large-seeded species. Excessive seed burial appears to occur only with some mechanical methods, with hand seeding producing satisfactory results. If mechanical seeding is to be used, advice should be obtained on this aspect.

3.7 Vegetation establishment period

The revegetation works may only be partially successful in the first year. Replacement and infill revegetation works may be required for unsuccessful areas within the project area. Once the initial seeding and planting works have been completed, the new vegetation must also be allowed to establish and grow. It is essential to allow for a vegetation establishment period with adequate funding, to ensure that follow up works (replacement or infill) are identified and will occur in subsequent years.

Key activities during the vegetation establishment period include regular inspection to monitor the success of the revegetation, to assess need for weed and pest control and to assess the need for follow up revegetation work. Inspection may highlight losses of seedlings and, indeed, some losses are inevitable. Control of site factors such as pest infestations may be necessary. Replacement of seedlings or reseeding of bare areas can be undertaken in the following planting season. Losses of seedlings will be reduced if a weed-

free zone is maintained around them. Control of any dry or herbaceous weeds is highly desirable as they represent a fire threat, which could kill young plants. Signage helps to prevent unauthorised access and assists in the promotion of revegetation work.

A minimum Vegetation Establishment Period of at least two summers, following the Practical Completion of the works, is essential to achieve the project objectives, prior to a handover of the revegetation works for ongoing routine roadside maintenance activities.

Contract arrangements must be defined as part of the project planning, to cover the establishment of the new vegetation and any remedial works that may become necessary.

3.8 Provision for remedial revegetation works

Revegetation work that does not meet the expected standards at Final Completion will have to be redone.

For all projects, contractual arrangement should be in place to protect Main Roads' investment. Generally, the application of retention monies is not favoured, as it is believed to be inequitable due to the long lead-time of some projects. The preferred option is a bank guarantee (as a performance bond), which allows the principal to call upon some funds to undertake remedial work if it is necessary and where the contractor is unwilling or unable to undertake the work. However, this is normally set at only a small proportion of the cost of the revegetation component of a project and would not cover catastrophic failure where major remedial work was necessary.

It is recommended that the provision of a bank guarantee, from 10% to full reinstatement costs of the revegetation works, be based on the Project Manager's assessment of the risks associated with the project.

3.9 Expertise

Like any road construction activities, the use of appropriate skills and advice is necessary. This will ensure the critical factors for the specific project are identified and considered in the planning, design and implementation of the revegetation works. If sufficient expertise is not available from within Main Roads, outside assistance should be sought. Local experience is particularly valuable.

3.10 Handover of the revegetation works

Once the objectives of the revegetation are achieved, it is important that the handover, from the Project Manager to the Asset Manager, is formalised to ensure that on-going maintenance activities occur. The site may also need to be monitored for a period after the handover of the contract works to meet ministerial conditions of approval.

3.11 Ongoing maintenance of established vegetation

In practical terms the ongoing maintenance of established roadside vegetation is limited to the clearing zone (along the roadway) and the maintenance zone (along the road reserve boundary). Refer to figure A1, Appendix A.

Maintenance activities outside these zones are limited to selective noxious weed control, and the removal of dead wood and vegetation growth that is hazardous. Any infill or replacement plantings that are identified as necessary by the Asset Manager are undertaken as Minor Improvement Works. This may occur within the regional Term Network Contract (TNC) or via the use of landscape contractors.

4. PROJECT MANAGEMENT OF REVEGETATION WORKS

4.1 General approach

Revegetation works occur as part of the project management process. To be cost effective, revegetation must be based on:

- A project-specific assessment of site conditions, issues and risk factors;
- Timely and appropriate decision-making; and
- The use of appropriate skills and advice.

The details will vary between regions and projects, but the general approach to undertaking revegetation works involves the steps shown in Table 2.

Stage	Key Points	Reference
Planning and documentation	Dependent on size and complexity of works Need to clearly identify objective(s) and key factors Specialist assistance may be required	App. A (objectives) App. B (site assessment) App. C (techniques) App. D (benchmark costs) App. E1-3 (documentation) App. F (seed quantity calculation worksheet) Standard Contract Specifications Brief for revegetation plan. Brief for revegetation design.
Implementation	Correct timing and surveillance essential Decision support may be required	App. C (techniques)
Vegetation establishment	Monitor progress and rectify defects after Practical Completion	App. C (techniques) App. G (examples of monitoring programs)
Handover	Handover to include recommended maintenance program	App. E4 (handover report)

Table 2 General approach to project management of revegetation works.

4.2 Processes

Revegetation may occur as part of a standard roadwork's project, a design and construct roadwork's project or as stand-alone revegetation works not directly associated with any roadwork project. The key steps to ensure successful outcomes in each of the three project management types are summarised as diagrams and guidance notes in the following sections:

- Section 4.3 - Process for **stand alone revegetation works** project (Figure 4);
- Section 4.4 - Process for **revegetation works within Design and Construct projects** (Figure 5); and
- Section 4.5 - Process for **revegetation works within other roadworks projects** (Figure 6).

4.3 Process for Stand Alone Revegetation Works

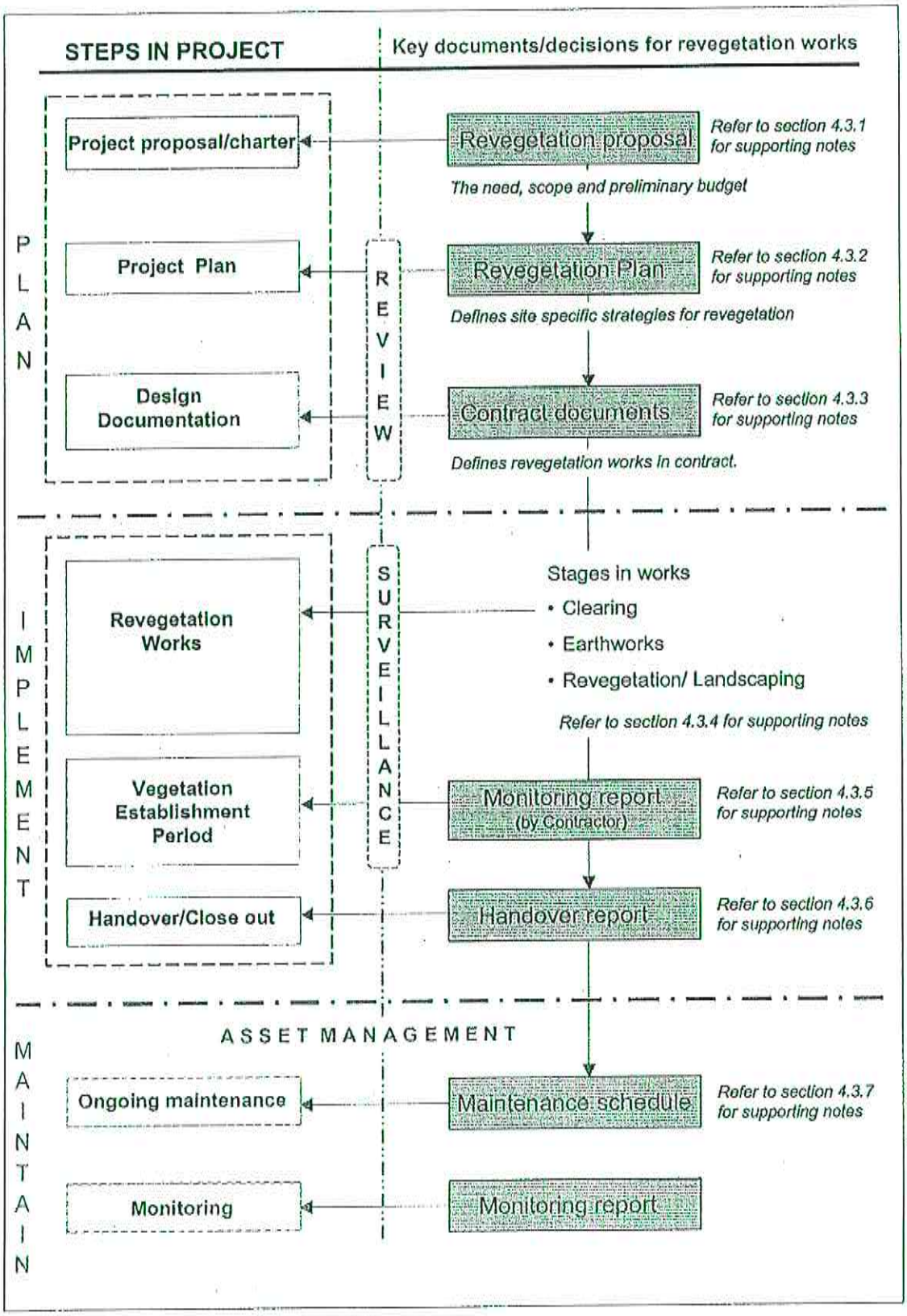


Figure 4 Steps in recommended process for stand alone revegetation works projects.

4.3.1 Project proposal

The project proposal shall include a concise statement of key information (e.g. need/purpose of the revegetation works, objectives, budget and timeframe) to gain approval to proceed with the works. The need for the works may be based on external pressures for improvements (e.g. public complaints), the project approval conditions, Main Roads' environmental policy objectives (refer to Corporate Objectives and Targets), or the Asset Management planning process. Some level of site assessment is necessary, but the requirements are not defined in detail. An Environment Officer, Asset Management Officer or the nominated Project Manager may prepare the proposal or a consultant may be engaged, if necessary, on an hourly basis (indicative cost < $2 000). In the absence of other information, a preliminary budget can be determined using the most appropriate benchmark costs given in Appendix D plus a 20% contingency.

4.3.2 Project Plan

The project plan shall include a Revegetation Plan, which defines the scope and extent of the works; staging and the methods to cost effectively deliver the works. An assessment of the site conditions is necessary to define relevant site constraints and opportunities. The level of planning and documentation required for the revegetation is dependent on the size and complexity of the works. The Revegetation Plan may be simply a clear statement of objectives in the project proposal and the use of Main Roads' standard specifications or a stand-alone assessment and report prepared for the purpose.

Ideally, the Revegetation Plan should be prepared at least two years before the proposed works are to be undertaken. An Environment Officer, Asset Management Officer or the nominated Project Manager may prepare the document. The Project Manager may seek to engage a specialist consultant (indicative cost < $5000) to assess the site issues and prepare the Revegetation Plan. *Refer to Main Roads' Environment Branch intranet web site for a template of a plan brief.* A brief for the detailed revegetation design may also be prepared at this stage.

Procurement options may include a design and construct package, separate design and construct contracts or by direct Main Roads' management of contractors. At this stage, contract arrangements should be decided to cover establishment of the new vegetation and any remedial works. Options are discussed below in section 4.3.4. It is also critical to clarify the handover process and ongoing maintenance for the site revegetation works.

4.3.3 Design and Contract Documentation

The extent of the revegetation works shall be clearly defined by a design and documentation process prior to finalising the contract documents. The detailed design specifies the requirements to achieve the revegetation objectives and defines completion criteria. For small projects the detailed requirements can be defined simply from the project plan (e.g. SLK location, plan of area, species list, and standard specification clauses etc). As the scale and complexity of the revegetation works increases, a stand-alone detailed site assessment and set of documents (drawings, specifications, design report) will be necessary. This stage includes:

- A detailed site assessment,
- The design process (decision making on the specific site requirements and revegetation techniques to be used),
- Documentation of the works to be undertaken in the contract (drawings and specifications),
- A review of design documents (Environment Officer or Environment Branch can provide support), and
- Tender documentation.

A specialist consultant may be engaged for the purpose. It is critical that the consultant is conversant with the recommended methods and techniques outlined in Appendix C and can demonstrate competency in the design and documentation of revegetation works. *Refer to Main Roads' Environment Branch intranet web site for a template of a design brief.*

The documents will include the drawings, specifications and design reports as per the brief requirements. If the necessary expertise is not available within the contract management team to review and evaluate the documents (at preliminary and final design) then a consultant is engaged for the purpose. The specifications for the works shall be based on Main Roads' standard specifications.

The project manager must ensure that the revegetation/landscaping strategies are translated into design decisions and documentation for the works. It is recommended that the same consultant be also engaged to provide design support and advice to the Superintendent during the works.

4.3.4 Contract Arrangements

Contract arrangements shall cover the establishment of the new vegetation and any remedial works that may become necessary; to assure the project objectives will be met. The specific arrangements must be based on the Project Manager's assessment of the risks associated with the project.

If the Project Manager decides to include a Vegetation Establishment Period as part of the initial contract, then contractual arrangements (monitoring, inspections and financial incentives) shall be in place to ensure any required follow up works are undertaken prior to the date of Final Completion.

If the Project Manager decides not to include a Vegetation Establishment Period as part of the initial revegetation contract, then a limited defects period of 13 weeks shall be nominated to consolidate the initial work prior to the date of Final Completion (along with defined completion criteria and inspections and financial incentives). The establishment of the new vegetation may then be handled as a separate minor works contract or undertaken via a minor improvement works order to the regional TNC.

In some locations, covered under a delegation agreement with the Local Government Authority (LGA), the vegetation establishment may be included in the agreement for the handover of the site to the LGA for ongoing maintenance.

4.3.5 Construction stage

The revegetation works may contain some or all of the following components.

- Seed collection and plant supply.
- Clearing and stockpiling of vegetation.
- Chipping and re-spreading of vegetation.
- Protection of retained vegetation.
- Weed control.
- Topsoil (strip, stockpile and re-spread).
- Erosion control and batter protection.
- Soil preparation.
- Seeding and planting.
- Maintenance during contract period.

Seed collection and plant supply must be arranged well in advance of any works to allow for the necessary lead-time to collect seed and/or propagate plants. An exception exists for small-scale landscaping works using plants that are readily available commercially. Surveillance is essential for the cost effective implementation of the works to ensure that the Contractor employs good industry practices. It is important that surveillance occurs at key

points during the works as identified in the standard specifications. Often site conditions require decision making by the Superintendent and expert advice required on the implications of necessary changes e.g. plant substitutions, weed control measures, changes to specified materials. The necessary expertise is provided by the local knowledge and experience of the Main Roads' Representative or a consultant engaged for the purpose.

Contract requirements must be enforced to ensure compliance and provide value for Main Roads' investment in revegetation.

4.3.6 Vegetation Establishment Period

All new vegetation requires a period of several years to establish and grow. For example, plant roots may dry out due to poor planting technique, due to lack of follow up rains or due to physical damage. Failure to establish the new vegetation means a loss of the investment made in the project. A minimum Vegetation Establishment Period of at least two summers, following the Practical Completion of the works, is recommended for most projects. Key tasks may include:

- Weed control as necessary.
- Replacement of failed planting/seeding, and
- In some cases watering by the contractor.
- Limiting erosion of soil surfaces.
- Limiting access to the areas of revegetation.

During this period, the Contractor must undertake all necessary works to establish the vegetation as nominated in the contract specifications. This includes monitoring of the works.

An evaluation of the completed works (compared to the contract completion criteria) must occur prior to the issue of the Final Certificate of Completion. If the necessary expertise is not available within the contract management team, a consultant should be engaged for the purpose.

It is not unusual for the current Superintendent's Representative, Project Manager and other contract staff to move onto other projects before Final Completion of the works. It is therefore important to document the status and progress of the works to allow continuity in the administration of the contract revegetation works.

4.3.7 Handover

Prior to Final Completion it is important to document the completed works. This provides the basis for the Asset Manager to set the ongoing maintenance program. The Superintendent's Representative should prepare a final handover report or engage a consultant for the purpose. This includes the contract documents, warranties and any outstanding tasks to be completed.

4.3.8 Ongoing Maintenance

Following handover of the contract works, the Asset Manager will transfer the site for ongoing maintenance as per the regional TNC contract requirements. The handover of relevant documents should include a maintenance schedule for the site, based on the final handover report and identify any outstanding or additional works to be completed. The Asset Manager shall prepare the maintenance schedule or engage a consultant for the purpose. It is also recommended that the Asset Manager initiate a monitoring program for the site at this time to record the effectiveness of the revegetation works and the need for any further remedial works.

4.4 Process for Design and Construct Projects

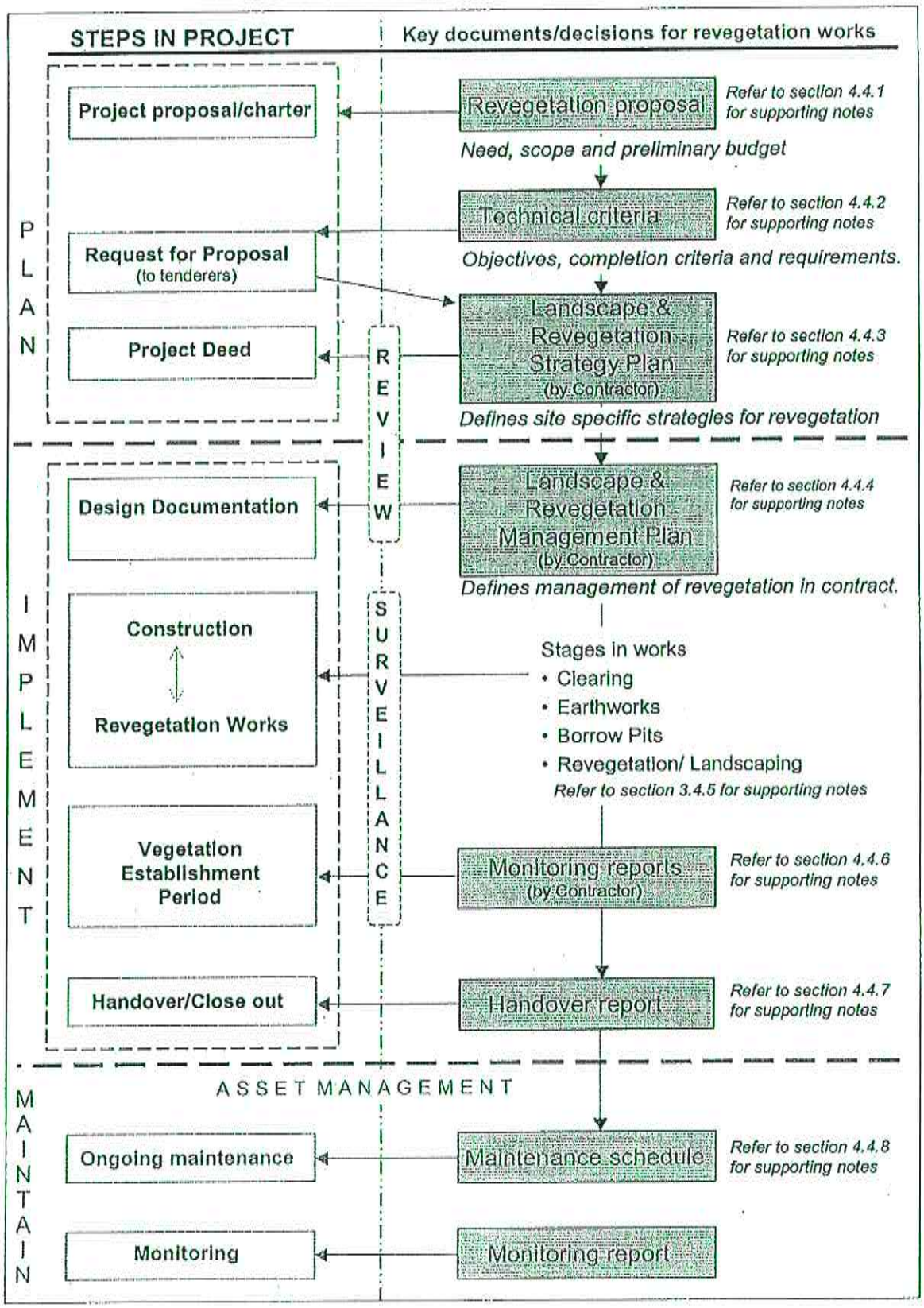


Figure 5 Steps in recommended process for design and construct road projects.

The process followed for Design and Construct projects is distinct in the terminology used and the required documentation, the steps in the planning phase and the Contractor's responsibility for both design and construction of the works. *Refer to Major Projects Directorate for examples and templates.* A summary of the required documentation is summarised below as Table 3.

Document	Timing
Landscape & Revegetation Strategy Plan	Request for Proposals stage
Landscape & Revegetation Management Plan	Project design stage
Landscape monitoring program reports	Defects Correction Period
Landscape works hand-over report	Handover/Close out stage

Table 3. Major Project Directorate - Landscaping and revegetation documentation summary.

4.4.1 Project proposal

The project charter shall identify the need, scope, extent and preliminary estimate for revegetation and landscaping works in the project. All relevant project commitments related to revegetation of the project area, as documented in the project Environmental Assessment and Approval Process (EAAP), are included as well as any concept plan(s). *Refer to Major Projects Directorate for more details on the content.*

4.4.2 Request for Proposal

Technical criteria and requirements for the revegetation/landscaping works form part of the Request for Proposal documents provided to the tenderers. This includes revegetation objectives, completion criteria and general and specific requirements.

A Landscape & Revegetation Strategy Plan is prepared by the Contractor (as tenderer) during the Request for Proposals stage in response to the Technical criteria and requirements and submitted as part of the tender.

4.4.3 Project Deed

Once the successful tender is accepted the Landscape & Revegetation Strategy Plan forms part of the Project Deed. The plan defines the site-specific strategies that the contractor will employ to design and construct the revegetation/landscaping works to achieve the revegetation objectives and completion criteria for the project. The strategy must be more than a general statement of intent. An assessment of the site conditions is necessary to define relevant site constraints and opportunities. The actions proposed must be site specific, realistic and relate to the timing of the works. This provides some quality assurance for the Main Roads' Representative and a basis for any independent review. If the necessary expertise is not available within the contract management team to review and evaluate the revegetation/ landscaping strategy plan, then a consultant is engaged for the purpose.

4.4.4 Design Documentation

The contractor must ensure that the revegetation/landscaping strategies are translated into design decisions and documentation for the works. At the design and documentation stage the Contractor is required to prepare a Landscape & Revegetation Management Plan. The set of documents are to specify the revegetation works in detail and advise how the Contractor will manage the site works to achieve the revegetation objectives and completion criteria for the project.

The document set includes the drawings, specifications and design reports as per the contract requirements. If the necessary expertise is not available within the contract management team to review and evaluate the documents (at preliminary and final design) then a consultant is engaged for the purpose.

Key decisions regarding the site management of the works have major implications for the effectiveness and success of the revegetation. Integration of the revegetation into the relevant design and specifications of the road, bridge and other components of the works is important to increase the likely success during the construction stage.

4.4.5 Construction stage

The revegetation/landscaping works will contain some or all of the following components:

- Seed collection and plant supply.
- Clearing and stockpiling of vegetation.
- Chipping and re-spreading of vegetation.
- Protection of retained vegetation.
- Weed control.
- Topsoil (strip, stockpile and re-spread).
- Erosion control and batter protection.
- Soil preparation.
- Seeding and Planting, and
- Maintenance during contract period.

Seed collection and plant supply must be arranged well in advance of any works to allow for the necessary lead-time to collect seed (at the appropriate time of year) and or propagate plants. An exception exists for small-scale landscaping works using plant materials that are readily available commercially.

The Project Manager may decide (based on the revegetation strategy) to undertake seed collection separately and prior to the main contract. Issues relate to storage and processing of the seed material. Transplanting or relocation of selected plant species on site may also form part of the initial works arranged by the Project Manager. If the necessary expertise is not available within the project management team, a consultant is engaged for the purpose.

Surveillance is essential for the cost effective implementation of the works to ensure that the Contractor employs good industry practices. It is important that surveillance occurs at key points during the works as identified in the standard specifications. Often site conditions require decision making by the Superintendent and expert advice is required on the implications of necessary changes, eg plant substitutions, weed control measures, and changes to specified materials.

The necessary expertise is provided by the local knowledge and experience of the Main Roads' Representative, Surveillance Officers, or the regional Main Roads' Environment Officer. A consultant(s) is engaged for the purpose if the expertise is not available within the contract management team.

Contract arrangements must be enforced to ensure compliance and achieve value for Main Roads' investment in revegetation.

4.4.6 Vegetation Establishment Period

All new vegetation requires an establishment period to achieve the defined completion criteria. A Vegetation Establishment Period of at least three years following the Practical Completion of the works is recommended for most Design and Construct projects.

During the Vegetation Establishment Period the Contractor must undertake all necessary works to establish the vegetation as nominated in the specifications. This includes monitoring of the works by the Contractor. Monitoring reports prepared by the contractor provide some quality assurance for the Superintendent and a basis for any independent review.

It is not unusual for the current Main Roads' Representative, Project Manager and other contract management staff to move onto other projects before Final Completion of the works. It is therefore important to document the status and progress of the works to allow continuity in the administration of the contract revegetation works.

4.4.7 Handover

Prior to Final Completion it is important to document the completed works. This provides the basis for the Asset Manager to set the ongoing maintenance program. A final handover report should be prepared by the Main Roads' Representative or consultant engaged for the purpose. This includes the contract documents, warranties and any outstanding tasks to be completed.

4.4.8 Ongoing Maintenance

Following handover of the site works, the Asset Manager will transfer on-going maintenance of the site to the regional Maintenance Program as per the TNC contract requirements. Any outstanding works or additional works must be identified in the handover of relevant documents. The Asset Manager should prepare the maintenance schedule for the site or engage a consultant for the purpose. The maintenance schedule is based on the final handover report.

It is recommended that the Asset Manager, initiate a monitoring program for the site at this time, to record the effectiveness of the works and the need for any further remedial works.

4.5 Process for Standard Roadwork Projects

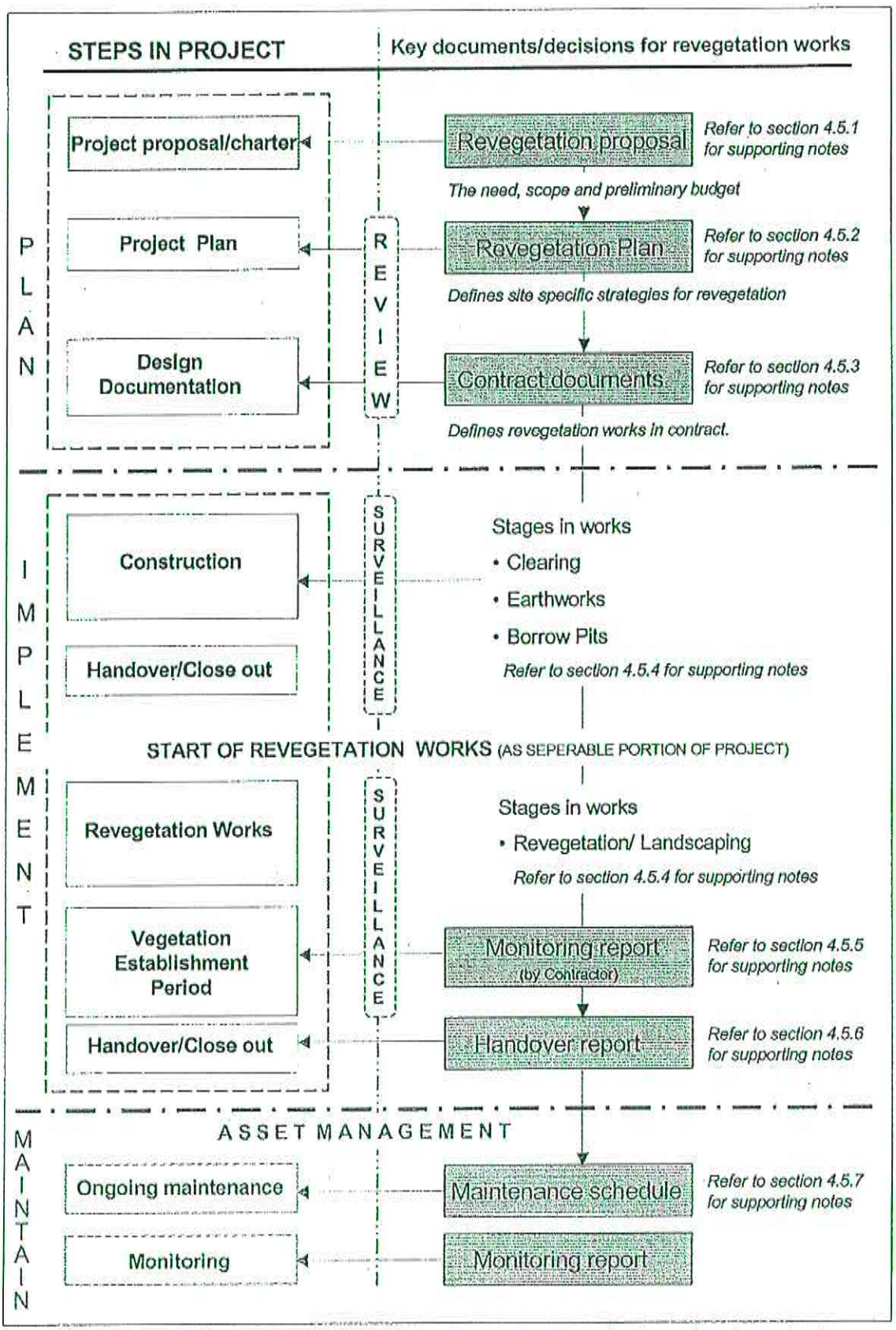


Figure 6 Steps in recommended process for standard roadwork projects.

4.5.1 Project proposal

The project proposal shall identify the need, scope, extent and preliminary estimate for revegetation and landscaping works in the project. All relevant project commitments related to revegetation of the project area (as documented in the project Environmental Assessment) is included as well as any concept plans. Other issues will include stakeholder consultation, TNC handover and maintenance. Some level of site assessment is necessary, but the requirements are not defined in detail. The nominated Project Manager (with advice from the regional Environment Officer as required) prepares the proposal. A consultant, if necessary, may be engaged on an hourly basis to prepare the proposal (indicative cost < $2 000). In the absence of other information, a preliminary budget can be determined using the most appropriate benchmark costs given in Appendix D plus a 20% contingency.

4.5.2 Project Plan

The project plan shall include a Revegetation Plan, which defines the scope and extent of the works; staging and methods to cost effectively deliver the works. An assessment of the site conditions is necessary to define relevant site constraints and opportunities. The level of planning and documentation required for the revegetation is dependent on the size and complexity of the works. The Revegetation Plan may be simply a clear statement of objectives in the project proposal and the use of Main Roads' standard specifications or a stand-alone assessment and report prepared for the purpose.

Ideally, the Revegetation Plan should be prepared at least two years before the proposed works are to be undertaken. An Environment Officer, Asset Management Officer or the nominated Project Manager may prepare the document. The Project Manager may seek to engage a specialist consultant (indicative cost < $5 000) to assess the site issues and prepare the Revegetation Plan. *Refer to Main Roads' Environment Branch Intranet web site for a template of a plan brief.* A brief for the detailed revegetation design may also be prepared at this stage.

The Revegetation Plan must include provision for appropriate measures to stabilise batters and exposed soil surfaces, if there is likely to be a transition period (more than two months) at the end of the earthworks before the seeding or planting can occur. Control of the on-site surface drainage is important to minimise potential erosion (eg due to rainstorms).

Procurement of the revegetation works shall be completed as a separable potion of the main works contract or as a separate stand-alone contract. The preferred option is dependant on the specific requirements for the project, the expected timing for the completion of the earthworks and the capability of the main contract tenderers. It is often practical to complete the seeding and planting (if required) as a separate stand-alone contract.

At this stage, contract arrangements should be decided to cover establishment of the new vegetation and any remedial works. Options are discussed below in section 4.5.4. It is also critical to clarify the handover process and ongoing maintenance for the site revegetation works.

4.5.3 Design Documentation

The extent of the revegetation works shall be clearly defined by a design and documentation process prior to finalising the contract documents. The detailed design specifies the requirements to achieve the revegetation objectives and defines completion criteria for the works.

For small projects the detailed requirements can be defined simply from the site revegetation plan (e.g. SLK location, plan of area, species list, and standard specification clauses etc).

As the scale and complexity of the revegetation works increases a stand alone detailed site assessment and set of documents (drawings, specifications, design report) will be necessary. This stage includes:

- A detailed site assessment.
- The design process (decision making on the specific site requirements and revegetation techniques to be used).
- Documentation of the works to be undertaken in the contract (drawings and specifications).
- A review of design documents (Environment Officer or Environment Branch will provide support).
- Tender documentation.

A specialist consultant may be engaged for the purpose. *Refer to Main Roads' Environment Branch Intranet site for a template of a design brief.* The specifications for the works shall be based on Main Roads' standard specifications.

The documents will include drawings, specifications and design reports as per the contract requirements. If the necessary expertise is not available within the contract management team to review and evaluate the documents (at preliminary and final design) then a consultant is engaged for the purpose. The project manager must ensure that the revegetation/landscaping strategies are translated into design decisions and documentation for the works.

Key decisions regarding the site management of the works have major implications for the effectiveness and success of the revegetation. Integration of the revegetation into the relevant design and specifications of the road, bridge and other components of the works is important to increase the likely success during the construction stage.

It is recommended that the consultant used for the Site Revegetation Plan also be engaged to provide design support and advice to the Superintendent during the works.

4.5.4 Contract Arrangements

Contract arrangements shall cover the establishment of the new vegetation and any remedial works that may become necessary to assure the project objectives will be met. The specific arrangements must be based on the Project Manager's assessment of the risks associated with the project.

If the Project Manager decides to include a Vegetation Establishment Period as part of the initial contract, then contractual arrangements (monitoring, inspections and financial incentives) shall be in place to ensure any required follow up works are undertaken prior to the date of Final Completion.

If the Project Manager decides not to include a Vegetation Establishment Period as part of the initial revegetation contract, then a limited defects period of 13 weeks shall be nominated to consolidate the initial work prior to the date of Final Completion (along with defined completion criteria and inspections and financial incentives). The establishment of the new vegetation may then be handled as a separate minor works contract or undertaken via a minor improvement works order to the regional TNC.

In some locations, covered under a delegation agreement with the Local Government Authority (LGA), the vegetation establishment may be included in the agreement for the handover of the site to the LGA for ongoing maintenance.

4.5.5 Construction stage

The main roadworks contract will contain some or all of the following components.

- Clearing and stockpiling of vegetation
- Chipping and re-spreading of vegetation.
- Protection of retained vegetation.
- Weed control.
- Topsoil (strip, stockpile and respread).
- Erosion control and batter protection.
- Soil preparation, and
- Maintenance during contract period.

The separable portion of the contract (revegetation) will contain some or all of the following:

- Seed collection and plant supply.
- Protection of retained vegetation.
- Weed control.
- Soil preparation.
- Seeding and planting, and
- Maintenance during the contract period.

Seed collection and plant supply must be arranged well in advance of any works to allow for the necessary lead-time to collect seed and or propagate plants. An exception exists for small-scale works landscaping works using plant materials that are readily available commercially. The Project Manager may decide (based on the site revegetation plan) to undertake the seed collection and plant supply separately and prior to the main contract. Issues relate to storage and processing of the seed material. Transplanting or relocation of selected plant species on site may also form part of the initial works arranged by the Project Manager.

If the necessary expertise is not available within the project management team, a consultant is engaged for the purpose.

Surveillance is essential for the cost effective implementation of the works to ensure that the Contractor employs good industry practices. It is important that surveillance occurs at key points during the works as identified in the standard specifications. Often site conditions require decision making by the Superintendent and expert advice required on the implications of necessary changes e.g. plant substitutions, weed control measures or changes to specified materials. The necessary expertise is provided by the local knowledge and experience of the Superintendent's Representative, Surveillance Officers, Main Roads' regional Environment Officer, or a consultant engaged for the purpose.

Contract requirements must be enforced to ensure compliance and provide value for Main Roads' investment in revegetation.

4.5.6 Vegetation Establishment Period

All new vegetation requires a period of several years to establish and grow. For example, plant roots may dry out due to poor planting technique, lack of follow up rains or physical damage. Failure to establish the new vegetation means a loss of the investment in the project. A minimum Vegetation Establishment Period of at least two summers, following the Practical Completion of the works, is recommended for most projects. Key tasks may include:

- Weed control as necessary.
- Replacement of failed planting/seeding.
- In some cases watering by the contractor.
- Limiting erosion of soil surfaces.
- Limiting access to the areas of revegetation.

During this period the Contractor must undertake all necessary works to establish the vegetation as nominated in the contract specifications. This includes monitoring of the works.

An evaluation of the completed works (compared to the contract completion criteria) must occur prior to the issue of the Final Certificate of Completion. If the necessary expertise is not available within the contract a consultant should be engaged for the purpose.

It is not unusual for the current Superintendent's Representative, Project Manager and other contract staff to move onto other projects before Final Completion of the works. It is therefore important to document the status and progress of the works to allow continuity in the administration of the contract works.

4.5.7 Handover

Prior to Final Completion it is important to document the completed works. This provides the basis for the Asset Manager to set the ongoing maintenance program. A final handover report should be prepared by the Superintendent's Representative or consultant engaged for the purpose. This includes the contract documents, warranties and any outstanding tasks to be completed. *Appendix E4 provides a table of headings as an example.*

4.5.8 Ongoing Maintenance

Following handover of the contract works, the Asset Manager will transfer the site for ongoing maintenance as per the regional TNC contract requirements. The handover of relevant documents should include a maintenance schedule for the site, based on the final handover report and identify any outstanding or additional works to be completed. The Asset Manager shall prepare the maintenance schedule or engage a consultant for the purpose.

It is also recommended that the Asset Manager initiate a monitoring program for the site at this time to record the effectiveness of the revegetation works and the need for any further remedial works.

5. DEFINITION OF TERMS

Revegetation refers to the re-establishment of a cover of vegetation suited to the location. This usually means a cover of local native plants and involves regeneration, direct seeding, and/or planting methods.

Rehabilitation refers to earthworks associated with revegetation work and includes removal and replacement of topsoil. In this document, the term 'revegetation' is used to cover both the establishment of vegetation and the preceding physical processes.

Regeneration describes situations where vegetation can be established from *in situ* seed banks contained within either topsoil or seed-bearing mulch. Regeneration is a revegetation technique that can be used in isolation or with other techniques. If used in isolation, it is usually in the more remote areas where other methods may not be suitable.

Landscaping refers to the establishment of special roadside treatments to meet functional or aesthetic objectives, which may include native or non-native vegetation (including grass turf) as well as other surface treatments or built elements. In most cases, this vegetation will be irrigated and will have establishment and maintenance requirements (e.g. mowing and pruning) well above those associated with most roadsides. Landscaping is generally limited to urban areas. This guideline does not cover landscaping *per se*.

Restoration refers to the return of an area to a state that is, in form and composition, as similar as practicable to its pristine condition. It is not covered in this Guideline and specialist advice would be required where restoration is an objective.

Direct seeding is a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of the desired species. Seeding can be either by mechanical means using agricultural equipment or by hand. It is used in many parts of the State as a means of establishing a wide range of species.

Planting refers to the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species. It may or may not involve irrigation. Without irrigation, it is used only in those areas where there is sufficient reliable rainfall and where an outcome is required that cannot be achieved by other means. The required outcome may relate to particular visual objectives, or may involve the establishment of species for which sufficient seed for direct seeding is not readily available.

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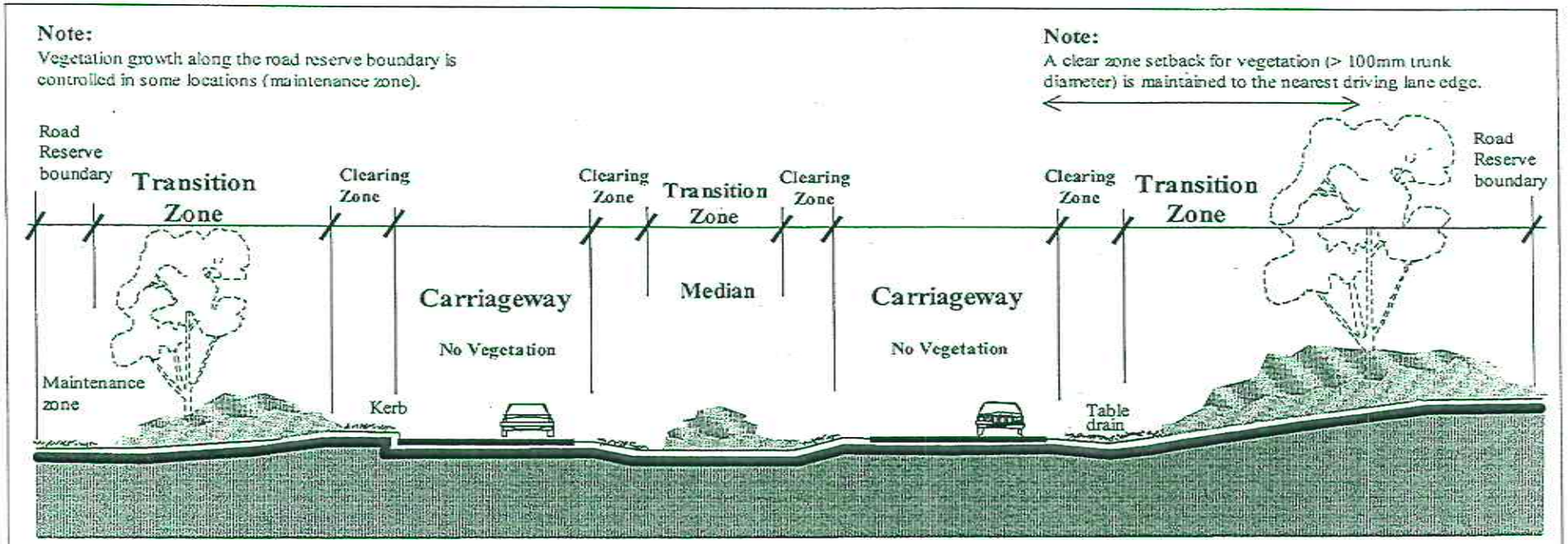
APPENDIX A

Roadside Vegetation – Management Objectives

Objective	Applicability	Comments
Roadside stability and maintenance minimisation.	All roadsides.	Established vegetation helps to maintain the stability of the roadside and road formation. The vegetation cover helps to prevent soil erosion by rainfall impact and surface water flows. Roadside vegetation should meet Main Roads' requirements in respect of lateral clearances and other requirements (see Figure A1 and refer to Main Roads' environmental guideline *Vegetation Placement Within the Road Reserve (Doc. No. 6707/022)*. Roadside vegetation should be similar in structure and content to comparable naturally occurring vegetation in the local area. Exceptions occur in urban areas, where non-native species can be used for particular purposes. Vegetation cover should be such that it discourages the establishment of weeds, which in turn, reduces costs associated with the verge maintenance.
Conservation and biodiversity.	Where local conservation values are high (eg roadsides abutting conservation reserves).	Roadsides can play an important role in conserving local biodiversity values. There are numerous instances where rare native flora occurs within the road reserve. Roadsides can also act as corridors for wildlife, especially in areas where the surrounding lands are substantially cleared. In particular, they can provide a connection with otherwise isolated reserves. Where roadside vegetation has a high conservation value, project approval conditions may require revegetation as offsets for vegetation clearing. Revegetation, in these instances, should be as similar as possible in structure and content to existing local native vegetation.
Amenity and aesthetics	Case-by-case where particular roadside vegetation is deemed important for amenity or aesthetic reasons (eg urban medians, town entries).	The roadside should meet reasonable community expectations related to local amenity and aesthetics. This may include landscaping of the median and roadside, and screening of adjoining areas for visual and noise reasons. Conversely, this may include instances where revegetation excludes trees and tall shrubs to allow desirable views beyond the road reserve. Many roads are also promoted for tourism purposes (eg designated tourist drives).
Other purposes	Case-by-case basis.	Where revegetation of land outside the road reserve is required, e.g. borrow pits, objectives may be set in consultation with the landholder and, in agricultural areas, could include establishment of commercial crops or even seed banks for future revegetation work. Similarly, other authorities and organizations with an interest in the land, including the Departments of Conservation and Land Management and Agriculture, TransWA, Local Government Authorities, Catchment Groups, and Land Conservation District Committees (LCDCs) may seek input into the desired revegetation objectives.



ROAD RESERVE - VEGETATION MANAGEMENT OBJECTIVES

CARRIAGEWAY
No Vegetation

Width as necessary to meet operational needs.

- Pavement stability.
- Off road surface drainage.
- Driver visibility.
- Placement of road hardware.
- Maintained free of debris.
- Maintain and enhance visual quality.

CLEARING ZONE
Vegetation controlled

Zone width varies by location and height of vegetation is controlled to meet operational needs.

- Vehicle recovery area.
- Maintain clear clear sight distances for passing, stopping, at intersections.
- Ensure effective off road surface drainage.
- Prevent erosion.
- Control weeds.
- Control fires.
- Accommodate utilities.
- Maintain and enhance visual quality.

TRANSITION ZONE
Vegetation conserved

Width to road reserve boundary varies by location
Vegetation type and condition varies by location.
Vegetation managed as necessary to:

- Control weeds.
- Control fires.
- Remove hazardous vegetation growth.
- Accommodate utilities.
- Prevent erosion.
- Maintain and enhance visual quality.
- Conserve and enhance biodiversity.
- Conserve wetlands and water quality.
- Preserve heritage values.

Figure A1. Typical roadside and functional management zones.

APPENDIX B

Appendix B1
Annotated Checklist for Site Assessment

Physical and chemical parameters

Parameter	Details	Comments
Soil type	May range from clays to sands, with several types potentially occurring within a project area. Consider the likely benefit of soil amendments such as gypsum in clay soils or lime in acidic soils. Check if the need for soil amendments. Check the potential for the reuse of materials, including spoil, in the revegetation work.	
Soil depth	Soils may be duplex or contain a hardpan that can affect the establishment and survival of plants.	
Soil chemical and nutrient status	Consider soil acidity/alkalinity, salinity and major nutrients such as nitrogen and phosphorus.	
Soil compaction	Consider compaction and road base under median strips which may not allow root penetration.	
Soil contamination	Check for presence of any chemical or industrial contamination that may require removal or in-situ treatment before successful revegetation can occur.	
Groundwater quality and levels	Consider depth and quality of groundwater, which can be an important determinant of revegetation success. Consider seasonal changes (e.g. waterlogging in winter, or occurrence of perched water tables) and longer term trends (e.g. rising water tables in areas affected by dryland salinity).	
Prevailing winds	Consider potential impacts of wind, such as sandblasting, on establishing seedlings.	
Likely traffic impacts	Consider likely or potential traffic impacts - for example, median strips on high speed heavy haulage routes are often exposed to wind from trucks.	
Likely off-site erosion	Consider potential for wind and water erosion from adjacent agricultural or other land.	
Site drainage	Consider whether the areas to be revegetated are water-shedding or water-accumulating.	
Climate	Consider average temperature and rainfall patterns for likely significant impacts on revegetation program.	
Other	Presence of outcropping rocks, stumps and other site characteristics likely to affect earthworks.	

Biological parameters

Parameter	Details	Comments
Existing flora and vegetation	Consider the condition and content of any existing vegetation. It is particularly important, through careful planning, to optimise the preservation of any existing native vegetation where realignments are being considered. Take note of any unusual local varieties of plants for which locally collected seed should be used. Semi-quantitative data on numbers of plants per unit area will assist with designing revegetation programs.	
Existence of any Threatened Flora	These include Declared Rare Flora (DRF), Priority Flora and Threatened Ecological Communities (TEC's) and are common in some regions. Work undertaken should protect and enhance these populations and communities.	
Desirable species	Consider which species should be included in any direct seedling or planting work proposed. Species selection should consider the objective of the work (see Appendix A) and practical considerations such as the availability of seed.	
Weed status	Consider existing weed status, especially the presence of Declared Plants and those weeds that are going to seriously impact remaining native vegetation and revegetation efforts. Estimate the likely weed seed bank in topsoil and determine whether weed emergence will require control. Be aware that some weeds may not be evident at certain times of the year but are still present. If control is required and the weed seed bank is significant, consider whether scalping is a better control option than herbicide control. Also consider the likelihood of invasion of weeds from adjoining land.	
Pest status	Consider the likely pressure on establishing vegetation from insect and vertebrate pests and what control mechanisms may be necessary throughout the revegetation project.	
Conservation value of adjoining land	Ensure revegetation work complements, in both form and function, nearby or adjacent land of conservation value. It is particularly important when considering species selection and seed source.	
Significant trees	Identify any existing objects, such as trees, which are of historical or habitat significance (e.g. trees with nesting hollows present) and ensure revegetation work complements the trees. Also, identify any trees of special significance e.g. grasstrees, that could be salvaged ahead of clearing for transplantation to revegetated sites.	
Likely dieback status	Consider the likely status of the soil with respect to dieback disease and consider what, if any, precautions with topsoil management or species selection might be required.	

Other parameters

Parameter	Details	Comments
Land status	Consider the status of the area to be revegetated and any future maintenance requirements. For example, revegetation of borrow pits may be purpose-specific and entail future management by a private landholder. Check width of road reserve.	
Local land use	Consider local land uses (e.g. agricultural, water catchment area) and how they may impact the establishment and future management of the vegetation.	
Acquisitions required	For revegetation work to be effective it may need to be preceded by acquisition of adjoining land.	
Site infrastructure	Identify services eg power lines (overhead or buried), and other underground services that could be affected by earthworks.	
Heritage values	Consider any Aboriginal or European heritage values that may be affected by the revegetation work.	
Views and vistas	Consider any particular views or vistas that the road may have and take into account when planning revegetation work to ensure that outstanding views or vistas are enhanced and not screened.	
Consultation and community involvement	Consider the value of conducting consultation about the proposed revegetation project and taking into account community opinion. Consultation could include local authorities and other relevant land managers, such as the Department of Conservation and Land Management. Consider opportunities for community involvement and / or integration of the project with plans developed by local landcare groups or other interested parties (while maintaining Main Roads' own objectives).	
Main Roads guidelines	Refer to guidelines that dictate parameters such as setbacks and sightlines. Identify areas not to be revegetated e.g. around bridge abutments.	
Landscaping	Identify need for any additional landscaping works e.g. grassing.	
Irrigation	Consider availability of water source if irrigation is likely to be a requirement.	

Appendix B2
Checklist for Site Assessment

Physical and chemical parameters

- ☐ Soil type
- ☐ Soil depth
- ☐ Soil chemical and nutrient status
- ☐ Soil compaction
- ☐ Soil contamination
- ☐ Groundwater quality and levels
- ☐ Prevailing winds
- ☐ Likely traffic impacts
- ☐ Likely off-site erosion
- ☐ Site drainage
- ☐ Climate
- ☐ Other

Biological parameters

- ☐ Existing flora and vegetation
- ☐ Existence of any Threatened Flora
- ☐ Desirable species
- ☐ Weed status
- ☐ Pest status
- ☐ Conservation value of adjoining land
- ☐ Significant trees
- ☐ Likely dieback status

Other parameters

- ☐ Land status
- ☐ Local land use
- ☐ Acquisitions required
- ☐ Site infrastructure
- ☐ Heritage values
- ☐ Views and vistas
- ☐ Consultation and community involvement
- ☐ Main Roads guidelines
- ☐ Landscaping
- ☐ Irrigation

APPENDIX C

RECOMMENDED REVEGETATION METHODS AND TECHNIQUES

C.1 KEY REVEGETATION METHODS

C.1.1 Regeneration from topsoil

In some instances, establishment of a satisfactory revegetation outcome can be achieved through management of existing seed banks or the use of seed banks contained within topsoil 'grafted' from elsewhere. *In situ* seed banks can be used where the topsoil is largely intact and weed seed numbers are low. Regeneration can be encouraged by scarification of the soil. This method may be particularly suitable for very small areas.

Where regeneration from existing topsoil alone will be inadequate, there may be the opportunity to apply a fresh topsoil containing seed of target plant species. Within reason, topsoil can be spread more thinly when reapplied to cover a larger area than originally stripped.

Be aware of the potential for dieback infection when handling soils (see section C.2.10).

C.1.2 Regeneration from seed-bearing mulch

Where vegetation has been stripped and mulched, the returned material can be an important source of seed and organic material. If cleared vegetation is to be used as a source of seed, it must be mulched immediately. Only those species that carry their seed in the canopy (bradysporous species) can be re-established in this manner.

Laying of freshly-cut brush ('brushing') can be used to introduce bradysporous species without mulching. The sand mining industry has obtained good results with this method. It is not the same as brushwood layering where stems are encouraged to take root. Western Australian species are not amenable to layering.

Caution should be taken when collected or applying mulch to ensure weeds are excluded.

C.1.3 Direct seeding

Direct seeding involves distributing seed directly onto sites that have been suitably prepared to encourage germination and growth. In the past, Main Roads has had considerable success with revegetating areas using direct seeding. In the more arid parts of the State, successful establishment can be expected to take longer and be less reliable.

C.1.4 Planting

While direct seeding can be carried out in any part of the State, tree and shrub planting is only likely to be successful in those areas that experience reliable rainfall (see Figure 1). This restricts planting without irrigation to the south-west corner of the State.

Where establishment of self-sustaining native vegetation is the aim, planting is only used to supplement direct seeding. For example in some locations, tree species may be planted and the understorey layer direct seeded. Spacing of plantings varies between projects and species but should reflect naturally-occurring densities in the local area.

Planting alone is usually limited to urban roads and streets to achieve amenity and roadside stability objectives.

C.1.5 Selection of technique

Each of the above techniques has its advantages and disadvantages. Key factors to consider are outlined in Table C.1.

Method	Advantages	Disadvantages
Regeneration from topsoil	• Low cost • Can be used in addition to other methods • Reliable source of local species and provenance seed if topsoil is in good condition.	• Limited to species in soil seed bank. • Topsoil must be fresh or only stored for a short time for best results. • Can result in the spread of weed seed.
Application of seed-bearing mulch	• Low cost if suitable equipment available. • Will contribute more species than topsoil alone if seed stored in canopy.	• Can only be used where native vegetation with low weed content is present. • Cannot be stockpiled. • Poor availability of equipment in some regions. • Only some species carry seed in canopy.
Direct seeding	• Costs less than planting. • Seed is easier to handle than seedlings. • Seed mixtures give a more 'natural' distribution of plants. • More species available as seed. • Better root growth than plantings and therefore potentially better survival. • Higher diversity and similarity to local native plant communities.	• Higher cost than regeneration from topsoil or mulch application. • Less reliable establishment on low rainfall sites. • Results less reliable on sandy sites due to sand blasting and drying of the soil profile. • Weed management can be labour-intensive and timing may be critical. • More time required than planting to determine if successful.
Planting	• Immediate visual result. • Complete control over what occurs where. • Most suitable method to establish amenity plants. • Water can be applied if necessary to enhance survival. • Best method to establish plants for which seed is hard to get or difficult to germinate.	• Only suitable in south-western corner of State (without irrigation). • Probably the most expensive approach but depends on species selected. • Labour intensive and slower than direct seeding (4 ha/day versus up to 50 ha/day) • Mature plants may be susceptible to wind blow.

Table C.1 Advantages and disadvantages of the various revegetation techniques.[1]

[1] Information drawn from consultation within Main Roads and Holt (1998).

C.2 SITE PREPARATION

C.2.1 Preliminary Earthworks

C.2.1.1 Setting out

Within any given site earmarked for revegetation work, there may be a number of distinct areas which are planned to receive different physical treatments or seed mixes, used for temporary topsoil storage, or have some other particular requirement. It will often be necessary to physically peg sites to ensure activities proceed in line with those planned.

C.2.1.2 Topsoil management

Where revegetation is not being conducted on in situ soils, soil profiles can be created from stockpiled materials. Topsoil, in particular, is very valuable both as a seed source (see Section C.1.1) and as a suitable seed bed for establishing new plants.

If topsoil is relatively weed-free, the two major factors that affect its utility in revegetation work are depth of stripping and duration of storage. Shallow (<100 mm) stripping of topsoil leads to better seedling recruitment than deeper (300 mm) stripping as the seed bank is diluted with non-seed bearing soil. As the seed bank is usually contained within the top few centimetres, it is only this material which will yield new seedlings. If the aim of the project is to optimise recruitment of seedlings from the seed bank, there is a distinct advantage in separate stripping, storage and re-use of the soil containing the seed bank and the underlying topsoil and subsoil.

While fresh topsoil is clearly preferable to optimise revegetation outcomes, temporary stockpiling of topsoil may be unavoidable. Researchers have found that stockpiling of topsoil leads to a significant decline in seedling recruitment over time. Immediate re-use is always desirable. When stockpiling is necessary, windrows up to 1m in height is the preferred method. Stabilisation of stockpiles with mulch or vegetation should be considered if the stockpiles are expected to be required for more than a few months before reuse.

Timing is also important in topsoil management. For jarrah forest rehabilitation, topsoil was collected in summer, when the seed bank is at its highest. Soils are best handled when dry and stripping and spreading topsoil in winter in the south-west depresses seedling recruitment compared with autumn.

'Scalping' of soils may be necessary where weeds are a problem (see Section C.2.8.2).

C.2.2 Erosion Control and Water Harvesting

Uncontrolled erosion has the potential to damage revegetation work and requires expensive remedial works. Most revegetation work will require preparation of a seed bed and this would normally involve ripping along the contour.

Grader formation of level banks can be used to harvest water in some situations. Caution should be taken to ensure dispersive (sodic) materials are not used to construct banks or contours as breakthroughs can readily occur.

C.2.3 Steep Slopes and Batters

Cuttings and batters in the south west of the State are often gravelled rather than topsoiled. This gives batters more stability while still allowing revegetation. There are some successful examples, however, where topsoil has been used and its success is probably dependent on the length of slope, aspect and other environmental variables. Where rocky material is

present, an option is to leave steps with natural ledges and projections and topsoil lightly for revegetation.

On steep sandy slopes through cuttings or around flyovers, gravel and mulch, including hydromulch, can be used to stabilise the surface. Mulch should be incorporated into the soil to provide resistance to erosion.

C.2.4 Existing Pavements and Gravel Road Surfaces

Where disused pavements and gravel roads occur, good revegetation has been established when the material has been deep ripped but otherwise left in situ. The 'rocky' surface appears to act as a moisture trap and promotes seedling establishment. This practice may not be acceptable in some situations where there is high visibility and stakeholder interest.

C.2.5 Waterlogged or Saline Soils

Rising water tables are a serious issue with implications for roadside revegetation. Where roadside vegetation occurs in areas that are salt-affected or prone to waterlogging, mounding can be used. Mounding usually consists of producing a raised strip of soil in a 'M' shape into which seedlings can be planted or seed sown. In loamy or heavy soils, mounding should be carried out immediately prior to revegetation. Earlier preparation may allow salts to accumulate at the surface.

Mounds can be constructed using a grader but specially constructed mounders and ripper/mounders are available.

C.2.6 Soil Amendments

During the site assessment process, the need for soil amendments may be identified. These can be incorporated into the soil during the site preparation.

There can be significant costs associated with soil amendments and the benefits should be justified. This can only be done on a case-by-case basis. Additionally, caution should be exercised over the use of soil amendments that will significantly alter native soils, potentially impeding the establishment of local native vegetation and encouraging weed species.

C.2.6.1 Mulch

Mulching with organic matter, wood chips or rocks slows the movement of water across the soil surface and reduces evaporation. Research has shown that surface mulch will improve the establishment of plants from seed but only if the mulch application is not too thick (< 3 cm) and if seeding is conducted prior to mulching. Mulch that is too thick and has seed applied over the top of mulch will reduce seedling recruitment.

If the mulch is to be incorporated into the soil, however, seeding can be conducted after mulching. Indeed, mulching is most effective on slopes if incorporated into the soil, especially sandy soils, rather than laid across the surface. Incorporation can be readily achieved using a rotary hoe.

The costs and benefits of mulching vegetation on site compared with the importation of mulch from elsewhere should be considered. While mulching vegetation on site may be more expensive, if it contains seed-bearing material it may assist with the establishment of local native vegetation. Again, the relative costs and benefits should be considered.

Brush thatching can be also used on steep banks to control erosion, protect seedlings and reduce evaporation. A stone mulch has been used in the Pilbara to stabilise soils and retain

moisture. Where high pH clays occur, mulching has been used to create a more favourable environment for planting seedlings.

Mulch can be also be used to improve the survival of seedlings. Drought stress has been found to be a major cause of poor performance in woody plants in sandy loam soils and recommended incorporation of 'compost' into soils to improve survival.

If freshly mulched material needs to be stockpiled, it should not be stockpiled to heights greater than 750 mm due to the risk of ignition.

Generally, straw mulches are not used by Main Roads. Some mulches, such as shredded karri bark, can be a fire hazard and should be used with caution. Most Main Roads' contracts require mulching for embankments greater than 3m in height.

Application of mulch material by hydromulching is commonly used to help provide short term stabilisation of slopes and other erosion-prone areas. The mulch can contain seed, usually grass seed which forms a rapid but temporary cover. It is probably not suitable for application of fine native plant seed. Paper-based mulches can have an adverse impact on soil moisture content, particularly in sandy soils, as they form a seal over the surface.

C.2.6.2 Fertiliser

Fertiliser can be used with caution to improve revegetation outcomes. Fertiliser can improve the establishment of native plants, especially in very low nutrient environments such as borrow pits or deep sands, but incorrect types and quantities can encourage weed growth and adversely affect native plants. High phosphorous fertilisers should be avoided and slow release is preferred. Nitrogenous fertiliser has been shown to delay successional processes (see Section C.8) by allowing the dominance of annuals for a longer period. Mulched soils, however, can experience a nitrogen shortage as organic material breaks down. Fertiliser requirements, therefore, will need to be assessed on a case-by-case basis but, in the absence of other information, the suggested usage is shown in Table C.2.

Revegetation Method	Previous Land Use	Suggested Fertiliser Usage
Topsoil regeneration only	Pastoral / native vegetation	Nil
Direct seeding	Native vegetation	100-200 kg/ha of slow release NPK with trace elements.
	Agriculture	Nil
Tree planting	Native vegetation	1 x 10-20g slow release NPK tablet per tree
	Agriculture	Nil

Table C.2 Suggested fertiliser usage for revegetation projects.

Care needs to be taken around waterways as fertiliser runoff may impact the water quality.

C.2.6.3 Gypsum

Gypsum is commonly used to improve water infiltration in hard-setting heavy clay soils. Gypsum-responsive soils typically have clay contents ranging from less than 15% to more than 25%. The techniques outlined in Fosberry and Howell (1985) can be used to determine whether gypsum is likely to provide a beneficial effect. If gypsum is applied, application rates up to 2.5 t/ha are used, with no benefit from greater applications.

C.2.6.4 Gravel

Gravel can act in the same manner as a mulch in that it traps and retains moisture, reduces erosion and may also raise soil temperature. Gravel covers have been shown to promote roadside revegetation. Studies have shown, however, that their effectiveness depends on fragment size, degree of incorporation into the soil and ambient conditions. Smaller, loose fragments appear to promote water infiltration and vegetation establishment better than larger, stony material.

C.2.6.5 Clay

There have been instances where clay has been successfully used as a cover over sandy soils to improve moisture retention. However, experience has shown that it must be applied evenly and incorporated into the surface soils to be effective. Poor results have resulted where this has not been done.

C.2.6.6 Lime

Lime is a suitable amendment for acidic soils but is not commonly used within Main Roads. Some soils are naturally acidic and, if using local native plant species, amendment with lime should not be necessary.

C.2.6.7 Wetting agents

Wetting agents can be very useful in non-wetting sandy soils. They can be added prior to and at the time of planting to encourage water infiltration.

C.2.6.8 Cover crops

Cereal rye has been used successfully as a 'nurse crop' for direct-seeded native plants. A nurse crop can protect small seedlings against strong winds and can assist with soil stabilisation while perennial vegetation is establishing.

C.2.6.9 Mycorrhiza

Mycorrhiza is symbiotic soil fungi that can improve the nutrient status and survival of seedlings. They can be contained within fresh topsoil but decline under stockpile conditions. Where fresh topsoil can be retained and a mycorrhiza presence maintained, research suggests that revegetated sites may be able to progress more quickly towards a climax community. Research has been conducted over some years in Western Australia to develop an inoculum for mine soils (see www.clr.uwa.edu.au). To date, this methodology has not been used in Main Roads but the potential to use it will increase as research progresses.

C.2.6.10 Other

Various other amendments may be available locally and may warrant consideration. Examples include sewage sludge and 'red mud' (bauxite residue).

C.2.7 Ripping and Other Methods of Seed Bed Establishment

Seed bed establishment is a key element to a successful revegetation program. The methods used, however, depend on the site characteristics. For example, Table C.3 shows examples of recommended site preparation on different soil types prior to planting and highlights the different approaches to different soils.

Soil type	Ploughing / rotary hoeing	Ripping to 0.5 m	Mounding (if wet)	Furrowing (if dry)	Weed control
Deep sands	-	✓✓	✓	✓	✓✓
Sands over clay	✓	✓✓	✓	✓	✓✓
Heavy clays	✓✓	✓✓	✓✓	-	✓✓
Gravels and clays	-	✓✓	-	-	✓✓

Table C.3 Suggested preparation for different soil types prior to planting.[2] Key: ✓= advised, ✓✓ = essential.

Ripping using a single tine at intervals of 1m is a common method of alleviating compaction and creating a seedbed. The development of deep root systems may be critical to long term plant survival and soil impedance needs to be alleviated in reconstructed soils. Deep ripping of soils should be conducted to at least 400mm, more if a hardpan exists. Similarly, a fine tilth in clay soils (as opposed to 'blocky' or cloddy fragments) is important for good seed to soil contact. Winged tines have been used with success in the mining industry to alleviate soil compaction and create opportunity for lateral root growth from rip lines.

Ripping is best carried out dry to maximise the shattering effect within the soil. Ripping should occur before the break of season with seeding following immediately afterwards, allowing sufficient time for some moisture to infiltrate the rip lines. Ripping after the break of season may destroy any germinating seeds in the topsoil. A good overall coverage of ripping for seed and seedling establishment is given in Mullan and White (2002a).

Where the material is very hard, e.g. base of gravel pits, cross hatch ripping is required to encourage 360° root growth as plants with roots only along a rip line may be prone to wind damage. Ripping is less important in sandy soils but should still be conducted.

Once established, contour rip lines can act as a trap for wind-blown seed.

Rotary hoeing is also used after ripping but prior to seeding or planting in some areas. This will improve water infiltration and the ability for seedlings to establish lateral roots. Ripping may result in the establishment of furrows but specialist-furrowing equipment can be used if necessary.

C.2.8 Weed Control

Failure to control weeds during revegetation work can lead to numerous problems including ongoing maintenance costs in weed control, poor public perception of Main Roads' revegetation efforts, and the potential failure of revegetated sites and subsequent costs of reworks. Pests are less often a problem but can also have a significant impact.

C.2.8.1 Cultivation

Annual weeds can be controlled through repeated cultivation of weed-affected soils. This method is less effective for perennial weeds. A lead time of at least one year is required

[2] From Mortlock *et al* (1993).

prior to revegetation. Cultivation alone, however, is generally not recommended and needs to be used in conjunction with herbicides.

C.2.8.2 Scalping

Where soils are seriously weed-infested, a substantial weed seed bank is likely to exist and will compete with native species sown or planted. Removal and disposal of the top layer of soil ('scalping') can remove the weed seed bank and greatly reduce the competition from weeds that can occur. As an example, in the Great Southern region, scalping 50-60mm of weed-infested topsoil gave 10,000-15,000 stems/ha as opposed to 200-1,500 using herbicide and cultivation only. Scalping can also be used to treat water-repellent soils but, for whatever purpose it is conducted, it will be necessary to address the loss of organic matter and nutrients and increased potential for water and wind erosion. These issues can be addressed by undertaking scalping immediately before seedbed preparation, utilising a fast-growing cover crop and incorporating mulch into the seedbed.

Some Main Roads' guidelines have required scalping up to a depth of 120mm. The depth required will depend on local conditions. Scalped layers can be transferred to farmland borrow pits, used as a topsoil on salt scalds, or used to backfill gully erosion or otherwise buried. If these options are not available then the scalped layers can be placed in windrows and used to assist with water management but they may be an ongoing source of weed seed until revegetation is well advanced. Scalping should not be conducted too long prior to revegetation as reinfestation with weeds can occur.

Scalping may not be suitable for some soils if soil zones unfavourable to plant establishment are exposed. Chemical control is best in these circumstances.

C.2.8.3 Chemical Control

All sites apart from some supporting intact native vegetation are likely to require some chemical control of weeds prior to revegetation. When establishing seedlings, Department of Agriculture studies suggest that the best results are obtained by using a combination of knockdown and high residual herbicides. The time of application is critical and needs to be after most weed seed has germinated, but before the early germinants can flower and seed again. More than one pre-sowing or planting application may be necessary.

Selection and application of herbicides requires experienced advice. The Environmental Guideline on Vegetation Control covers this issue in detail. The site assessment data should be used to determine the most appropriate methods of control.

C.2.8.4 Information about Weed Control

Other than the Main Roads' environmental guideline for Vegetation Control, there is a large amount of information available on weeds and their management. The information can be located through a number of useful websites, of which the following are the most directly applicable:

- Department of Agriculture (http://agspsrv38.agric.wa.gov.au/)
- Environmental Weeds Action Network (http://members.iinet.net.au/~ewan/)
- Plant Protection Society of Western Australia (http://members.iinet.net.au/~weeds/)
- Bay of Plenty Regional Council, Weeds in New Zealand (http://www.boprc.govt.nz/Weeds/Weed-Index.asp).

C.2.9 Pest Control

Redlegged earth mite (*Halotydeus destructor*) can be a problem in agricultural soils where they can eat germinating seedlings. In Western Australia, the presence of capeweed is an

indicator of when they may be present. Le-Mat® is used for control. More information can be found at the following website:

- Department of Agriculture (http://agspsrv38.agric.wa.gov.au/)

Wingless grasshoppers can be a problem on the coastal sandplains if grasslands are present. If the surrounding vegetation is predominantly native they will probably not occur in numbers. Control is by a diesel/pyrethrum mix. Snails can also be a problem on the coastal sandplains. In the Kimberley's, ants may eat or bury seed. Control can be achieved by not sowing too far in advance of significant rain.

In several Main Roads' regions, rabbits were recorded as a pest that will damage young plants. Baiting can be conducted with which the Department of Agriculture may assist. Plant/tree guards are regularly used in urban locations as a control measure. Other vertebrate pests that can significantly impact on revegetation are goats, restricted to parts of the pastoral regions, and kangaroos.

C.2.10 Disease Control

Many road projects and revegetation works will involve the movement of soils materials. In some areas, this can lead to the risk of spread of dieback and is an important consideration in undertaking revegetation work. Where this risk exists, Main Roads uses a document by the Dieback Working Group (2000) as a key reference and management guideline.

C.2.10.1 Phytophthora - background

Dieback is the common term used to describe the effect of *Phytophthora* spp. on our native flora. *Phytophthora* are introduced soil-borne pathogens (water mould) that kill a wide selection of plant species of the south west of Western Australia. The most common and aggressive *Phytophthora* that causes disease in the native vegetation of the south west of Western Australia is *Phytophthora cinnamomi*, however there are eight different species of *Phytophthora* that have the potential to impact on our native vegetation and over two hundred that have been identified throughout the world.

In Western Australia, *P. cinnamomi* will establish and spread under favourable environmental conditions as outlined in Table C.4.

As a general rule of thumb, dieback-susceptible areas can be regarded as being south of a line from Geraldton to Esperance but infections can occur elsewhere.

Factor	Favourable Conditions	Unfavourable Conditions
Temperature	15-30°C	< 0°C and > 35°C
Soil type	pH 5-6 (most forested areas), siliceous sands in water gaining flats, infertile soils with texture allowing good lateral movement of water.	Alkaline pH, coastal calcareous sands.
Annual Rainfall	> 800 mm	< 600 mm (unless in areas where water is concentrated)

Table C.4 Conditions favourable and unfavourable to the establishment and spread of the soil pathogen *Phytophthora cinnamomi*.

Some of the affected native plant species are useful indicators for the early detection of *P. cinnamomi* infections and some key indicator species are also shown in Table C.5. Other key indicator species include grass trees (*Xanthorrhoea* spp.). A full list of known indicator species is given within Department of Conservation and Land Management (2003).

Plant Family	Species Susceptibility (%)	Key Indicator Species
Heaths (Epacridaceae)	80	Beard heaths (*Leucopogon* spp.).
Banksias (Proteaceae)	92	Banksias (especially *B. grandis*, *B. littoralis* and *B. attenuata*).
Peas (Papilionaceae)	57	*Bossiaea aquifolium*
Eucalypts (Myrtaceae)	16	Jarrah (*Eucalyptus marginata*).

Table C.5 Plant families with high levels of susceptibility to infestation by *Phytophthora cinnamomi* and key indicator species.

While many plant species are adversely affected by *Phytophthora*, some species, e.g. prickly moses (*Acacia pulchella*), are believed to exude chemicals that may suppress it.

C.2.10.2 Management of Phytophthora

Detection of *Phytophthora* within susceptible sites is best achieved through the observation of indicator species health and patterns within susceptible vegetation communities that can be associated with *Phytophthora* disease.

Soil and root tissue samples can be taken from suspect sites and processed in any of a small number of laboratory facilities that specialise in the isolation of *Phytophthora* from such a medium. This is routinely done for major road projects in susceptible areas and in forest areas is managed in consultation with the Department of Conservation and Land Management (refer to Dieback Working Group (2000) guidelines).

C.2.10.3 Other plant diseases

Another pathogen affecting native tree and shrub species is Mundulla Yellows. As the name suggests, it causes yellowing and loss of foliage. Mundulla Yellows occurs extensively in South Australia and has spread to Western Australia in recent years having been observed along the Mitchell Freeway. The mechanisms by which the pathogen spreads are not well understood yet but it is apparently not soil-borne so will have different control mechanisms to those required for *Phytophthora* spp.

C.3 SPECIES SELECTION

C.3.1 General Approach

Whether using direct seeding or planting methods, great care must be taken over species selection. The decisions made at this stage are likely to be apparent for many years to come. The species selected should be consistent with the objective(s) determined and should match the soil and other conditions identified in the site assessment. In some instances, species selection may be subject to statutory requirements. A number of different seed mixes may be required for any one project.

Species selection for a direct seeding program will depend on the objective of the program. Where an outcome similar in structure and function to the original vegetation is sought, forty

or more species may be selected for use, depending on the target community and the degree to which it is sought to replicate it. As a minimum, it would include the most common local trees and shrubs matched with soil type. In the revegetation of areas of conservation importance, the project may seek to establish as many of the locally-occurring species as possible. Species numbers can be reduced if, for example, revegetation of a narrow strip as a windbreak or screen is being attempted. In this case, only 8-10 species may be appropriate.

The biology of individual species may have an impact on the ability to collect and sow seeds in revegetation programs. In the banksias, for example, some species are killed by fire and can only reproduce from seed while other species can resprout after fire. Species killed by fire tend to set significant amounts of seed while 'resprouters' set less seed.

C.3.2 Use of locally-occurring species

C.3.2.1 Background

Most species used in revegetation work will be locally-occurring provenance native plants. Native plants, and particularly locally-occurring species, are preferable over other species because of:

- their generally better survival and growth in the local environment,
- reduced likelihood to become invasive,
- their indirect and direct biodiversity value, and
- their contribution to a local 'sense of place'.

Particular species can be identified from site-specific flora surveys or from various other sources including:

- local knowledge of revegetation contractors and botanists, and regional staff within the Departments of Agriculture, and Conservation and Land Management (CALM),
- various databases, including
  REX (Revegetation Expert - available from the Department of Agriculture), and
  Floradata (from the Australian Centre for Mining Environmental Research),
  CALM Florabase (http://www.calm.wa.gov.au/florabase/index.html) and
- published information (e.g. Wheatbelt vegetation data that covers over twenty Shires).

In considering the objectives of roadside revegetation, however, there is scope for the use of non-local, and indeed non-native plants, and many are used for specific purposes. These purposes include erosion control, maintenance of sight distances, and visual amenity. If non-local or non-native plants are to be used, care must be taken to ensure they can survive without excessive intervention and, equally, that they do not have the capacity to become invasive.

C.3.2.2 Defining provenance

A number of contracts for road projects have required that provenance seed only be used in revegetation work. This objective may arise from within Main Roads itself or from environmental conditions placed on it by statutory authorities. Provenance refers to:

> *"seed collected from a natural population.....and is also used to describe patterns of genetic variation exhibited by a species over its geographic range. These patterns are often closely associated with the ecological conditions in which the species has evolved. When a number of provenances of a species are planted out at the same site it is usual to find differences in survival and growth performance (and possibly other characteristics) between provenances. Because the patterns of genetic diversity can be*

difficult to quantify and delineate, provenance is difficult to define in a precise geographical way" (Mortlock *et al*, 1999).

While provenance, therefore, cannot be defined in a purely geographical sense, the best way to ensure provenance requirements are met is to use seed collected in the local area. Where this is not possible, Watson (1991) recommends the use of "climate, habitat matching and common sense" as ways of delineating provenance. In other words, provenance requirements could be met by using:

- plants occurring within the same biogeographic region (see Figure C.1), and
- with no other obvious differences (from locally-occurring plants) noticeable in the field.

Note that if local variants occur, they must be used ahead of collections from elsewhere.

The following definitions are used:

Provenance seed is seed collected from within the same biogeographic region as the project area and from a similar habitat. It has been collected from plants that contain no obvious differences to locally-occurring plants of the same species.

Locally-occurring seed is provenance seed collected from the project area or from similar habitat occurring nearby.

C.3.2.3 Drawbacks of local seed collections

Unbending adherence to a tight geographic definition of provenance for seed collection purposes could lead to unsustainable levels of seed collections from local populations. Furthermore, sourcing locally-collected species may be very difficult in heavily cleared areas. Where a local seed supply is required but is very limited in availability, production of tubestock from seed may be a better option than using the seed for direct seeding.

C.3.2.4 Guideline for use of local provenance seed and seedlings

The objective of a revegetation project is the major factor in determining the source of seed and seedlings to be used. Table C.6 provides a guideline as to the extent to which locally-occurring and provenance seed should be used.

For example, for projects seeking to achieve roadside stability and maintenance minimisation, at least 90% of the seed used should be provenance, of which at least 20% should be locally-occurring.

It is appreciated that in some areas that have been heavily cleared, such as parts of the Wheatbelt, it may be difficult to rigorously apply these guidelines. Alternatives may need to be sought or seed collections spread over a number of years.

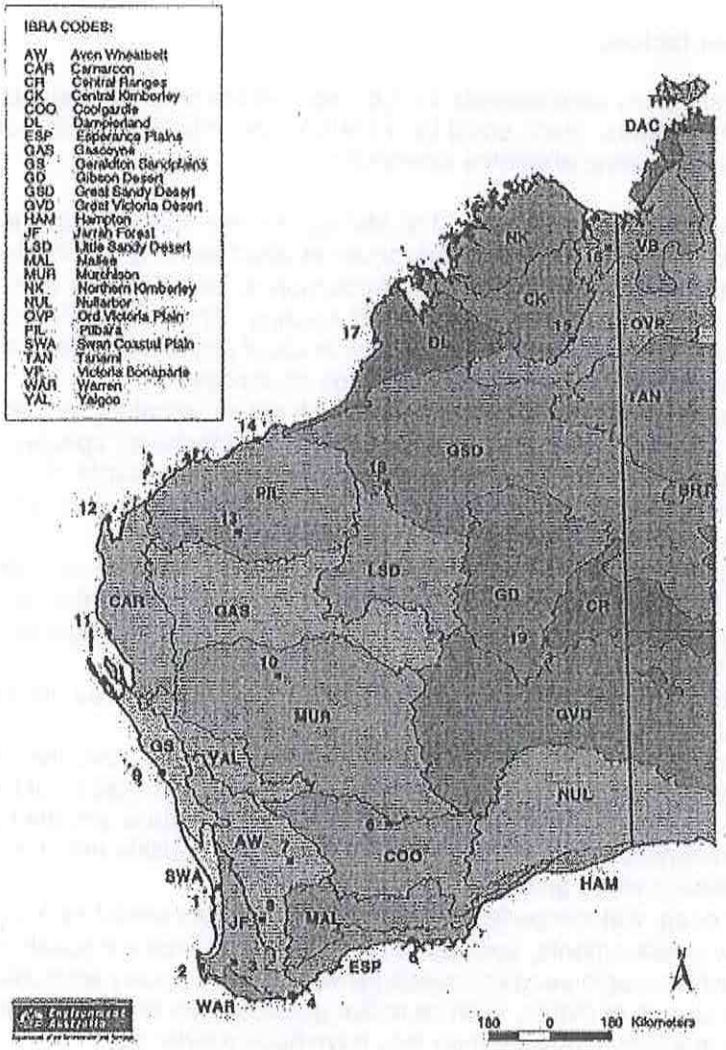


Figure C.1 Western Australian biogeographical regions (from http://www.ea.gov.au/).

Objective	Proportion of provenance seed (%)	Proportion of seed collected locally (%)	Proportion of seed from other sources (%)
Roadside stability and maintenance minimisation	≥ 90	≥ 20	≤ 10
Conservation and biodiversity	100	≥ 50	0
Amenity and aesthetics	≥ 80	≥ 20	≤ 20
Other purposes	Provenance seed preferred but decided on a case-by-case basis.		

Table C.6 Guideline for use of locally-occurring and provenance seed in revegetation projects.

C.3.3 Other factors

Having satisfied any requirements for local occurrence and provenance, there is a wide range of other issues, which could be a basis for the selection, or omission, of particular species. The following are some examples:

- Availability of viable seed. The biology of some species may mean germinable seed is not readily available, either for use in direct seeding or for raising seedlings.
- Early successional species. It is desirable to include some early successional species within a seed mix for direct seeding. These species may not be apparent in local mature vegetation. Local advice about suitable species should be obtained. See section C.8 for further discussion on succession.
- It has been observed that many, though not all, eucalypt species establish better and are less prone to insect attack if sown with understorey species. Therefore, a program with the aim of establishing eucalypts should include understorey species. Understorey plants are also important for erosion control as erosion can occur between established trees.
- Future maintenance requirements, e.g. pruning, must be considered. Species that are likely to require future pruning or particular maintenance should be avoided.
- Fire tolerance – in certain circumstances, species having greater fire tolerance might be a priority.
- Price and availability – having identified certain species as desirable, they may not be available or may be prohibitively expensive.
- Some species may have allelopathic qualities, that is, they inhibit the establishment of other species in their immediate vicinity through the release of root or leaf exudates. Where specific species are known to have this feature and they meet other requirements, they could be used to minimise roadside maintenance requirements be restricting weed growth.
- For deep, water-repellent sands, acacias are very useful as a colonising species.
- New developments, such as tissue culture, may make it possible to establish plants for which viable seeds or seedlings were not previously available. Similarly, research into groups of plants, such as native grasses, may result in them being more commercially available than they have been previously.

C.4 SOURCING SEED AND PLANT MATERIAL

C.4.1 Seedlings

Seedlings must be of good quality to produce a reliable result. The nursery industry now has an accreditation system under which nurseries agree to adhere to best practice guidelines for nursery management and plant production (although there are no specific product quality standards specified). The accreditation is operated under the Nursery Industry Accreditation Scheme, Australia (NIASA) (http://www.ngia.com.au/). As at September 2003, about thirty Western Australian nurseries were accredited. They are listed at the above website.

It is desirable for Main Roads to obtain their plants from accredited nurseries only. Where this is not possible, adherence to NIASA best practice guidelines can be made a contractual requirement. If supply problems still exist, exceptions can be made on a case-by-case basis.

The acquisition of stock from an accredited nursery does not preclude the need for their careful inspection prior to planting. Seedlings should:

- be 10-15 cm high,
- have a well-developed root system,

- be 'hardened' (exposed to full sun and a reduced watering regime for at least one month), and
- be of a generally healthy appearance and free of pests and diseases.

Useful further reading on assessing quality in seedlings occurs in Mullan and White (2002b).

Some thought should be given to the delivery arrangements so that it coincides as close as possible to the time of planting. This will avoid any problems associated with the temporary storage and maintenance of the seedlings.

C.4.2 Seeds

C.4.2.1 Supply

No formal system of ensuring seed quality exists. As a minimum, however, seed merchants should be able to supply the following:

- A current Commercial Purposes Licence issued under the *Wildlife Conservation Act 1950*.
- Confirmation that their collection, handling and storage methods are in accordance with good industry practice.
- Details of the origin of the seed (date and area collected).
- Proof of current seed germinability through viability testing.

Potential problems can be minimised through the use of established, well-known seed merchants with a record of success in revegetation projects. It is also important to verify that the seed ordered matches that used for the task.

Procedures related to seed handling can be optimised by reference to guidelines provided by Florabank (see Table C.7). While these guidelines are aimed at community-based rather than commercial activities, they do provide sound guidance to the basic level of management that can be expected.

The website (http://www.florabank.org.au/) also includes a model code of practice.

Guideline	Subject
1	Native seed storage for revegetation
2	Basic methods for drying, extraction and cleaning native plant seed
3	Improving on basic native seed storage
4	Keeping records on native seed
5	Seed collection from woody plants for local revegetation
6	Native seed collection methods
7	Seed production areas for woody native plant species
8	Basic germination and viability tests for native plant seed
9	Using native grass seed in revegetation
10	Seed collection ranges for revegetation

Table C.7 Florabank guidelines for handling of native seed (http://www.florabank.org.au/).

Note that stored seed will lose viability over time. Florabank suggest that, with good storage practices, a storage period of five years is achievable without significant loss of viability but this will vary between species. If seed is to be purchased in advance for a future project then sound storage practices are essential and evidence that viability has been maintained should be provided.

It is desirable to develop a seed list for a project in consultation with the chosen supplier. This will avoid problems when requesting amounts of seed or seed of particular species that are very difficult to collect and will therefore be very costly.

The names of reputable seed suppliers can be obtained from regional offices of the Departments of Conservation and Land Management, and Agriculture. On no account should imported seed be used, regardless of whether it is of a native species or not.

C.4.2.2 Seed Pre-treatment

Many seeds require some form of pre-treatment to promote germination. Failure to provide this pre-treatment in advance of sowing will result in failure to germinate although, in most cases, the seed may remain in the seed bank and could potentially germinate when dormancy has been broken. Those seeds remaining in the seed bank, however, may be subject to insect predation or other degrading mechanisms.

Table C.8 shows a summary of some well-known seed pre-treatments. Of the pre-treatment shown, boiled water/heat and smoke-related chemicals are readily applied to commercial quantities of seed and seed treated in this manner can usually be obtained upon request.

Other pre-treatments are more specialised and are more likely to be undertaken on a case-by-case basis.

Smoke treatment, in particular, has been shown to reduce seed dormancy in a wide range of species and is a very valuable method of establishing a much wider range of species than was previously possible. While research on the effects of smoke on seed dormancy tends to be restricted to species from the Swan Coastal Plain and Jarrah forest, smoke treatment of seed has not been shown to have a negative impact on germination in any species. Furthermore, it may reduce seed predation in the field.

Of the above, **boiled water and smoke treatments are recommended as standard treatments** for the relevant species. The other treatments should be considered on a case-by-case basis.

In the past, some practitioners have applied boiled water or scarification treatments to only a portion of the seed to be broadcast and have left the remainder untreated. In theory, this provides a back-up seed bank in case, for some reason, the treated seed fails. As seed mixes are designed to achieve a certain level of germination and not to simply create a seed bank, this approach is not recommended as standard practice. It may, however, warrant consideration in some areas where the rainfall is unpredictable. Local advice should be obtained about the value of this practice.

Pre-treatment	Comments
Aging and after-ripening	Some seeds require further aging after reaching full development to obtain full germinability. Long term storage improves germinability in some native grass seed and enzymes can be used to simulate the aging process in some seeds. Storage, however, reduces germinability in many other species.
Boiled water and heat	Immersion in boiled water promotes germination in most *Acacia* and *Oxylobium* seeds but can damage some other hard seeds with thinner coats (*Kennedia*, *Senna*). These seeds can still be treated but water must be cooler and the duration of exposure reduced. Seed merchants should be able to advise on the most suitable treatment for each species.
Leaching or washing	Germinability promoted by the removal of water-soluble inhibitory chemicals in *Eremophila*.
Aerosol smoke / water-based smoke chemicals	Smoke and water–based smoke chemicals has been shown to alleviate dormancy in a wide range of seeds. Commonly specified as a pre-treatment for Main Roads' revegetation work.
Scarification	Removal of part of the testa (seed coat) or fruit can alleviate physical dormancy but often needs to be at a particular location on the seed to be effective ('precision' scarification'). Achieves a similar result to immersion in boiled water. Some Main Roads' contracts have required only a portion of the seed (e.g. 60%) of particular species be scarified.
Priming	Exposure of the seed to non-toxic osmotic concentrations prior to broadcasting can accelerate germination in the field. Has been used with mixed results for improving establishment in eucalypts.
Removal of ancillary structures	Removal of the palea and lemma on native grass seed promotes germinability and also allows the bare seed (naked caryopsis) to be broadcast through agricultural seeders.

Table C.8 Summary of some well known seed pre-treatments.

C.5 SEEDING RATES AND PLANTING DENSITIES

C.5.1 Determining Seed Quantities

Having determined the species required, it is necessary to calculate the amounts of seed required. As seed can be very expensive and some species may be difficult to collect, a methodical approach is required to determine the correct amount required. These amounts can be calculated using the following formula:

Sowing rate (g/ha) = A / (B x C), where:
- A = No. of plants desired/ha
- B = Expected establishment of plants from seed (%)
- C = Expected no. of germinable seeds/g.

Variable A is based on the expected outcome of the revegetation program and is likely to reflect values occurring in mature vegetation. Bear in mind, however, that some species used in the seed mix will be early successional and will not appear in mature vegetation (see Section C.8).

Of the seeds sown, only a portion will survive to produce a mature plant. This surviving portion is Variable B. It can be difficult to estimate but, as a general rule of thumb, 0.5% establishment for small-seeded species and 5% establishment for large-seeded species can be used in the absence of other information. As experience is gained with revegetation work, these values can be adjusted.

Variable C equates with seed viability and should include allowance for non-seed material e.g. the 'frass' associated with eucalypt seed. Seed suppliers should be able to provide a good estimate of Variable C.

As a general rule, seed quantities do not usually exceed 5 kg/ha but it will depend on the particular program developed.

Likely recruitment of seedlings from the seed bank in topsoil, if present, should also be considered. Allowance for early successional species, which will give way to other species, should also be made. These early successional species include acacias and other species common after disturbance. Seeding should accommodate changes to the composition of the revegetation that will occur over time (see comments on succession in Section C.8).

A spreadsheet for calculating seed quantities is given in Appendix F.

C.5.2 Planting densities

Planting densities may be specified within the contract. The densities should approximate the expected density when the plants are mature, with some allowance for losses.

C.6 SEEDING METHODS

C.6.1 Seed application

Having determined the species and quantities of seed, and prepared a suitable seed bed, the seed needs to be broadcast. The method by which this is done can be by hand (for small areas only) or by a wide range of agricultural equipment, including niche seeders. Mechanical seeding equipment is readily available in the agricultural regions but elsewhere seeding is predominantly carried out by hand. Where mechanical seeders are used, they usually have seed boxes that can be adjusted to accommodate small-seeded native species. Depending on the seeding mechanism, several passes with different sized seed may be necessary.

Vermiculite is commonly used as the seed carrier but sand, sawdust and fertiliser have also been used. Seeding should be conducted when wind speeds are less than 10 km/h to avoid losses.

C.6.2 Seed burial

Seed burial appears to be a critical factor in revegetation success. Agricultural equipment such as harrows can be used to ensure there is good seed-to-soil contact for larger seed but, in the absence of this equipment, seed burial can occur through the action of wind and water. Use of harrows may bury some fine seed too deeply and adequate burial has been achieved through dragging chaff bags over them. Research suggests that burial to less than 1 mm may give the best results in species with small seeds and that, as a general rule of thumb, **all seed should be buried to a depth no greater than the diameter of the seed.** Seeds buried more deeply are unlikely to result in seedlings. There is evidence that this is a common reason for failure of direct seeding projects.

C.7 PLANTING METHODS

C.7.1 Planting

Planting can be undertaken by hand or by using a mechanical planter (for larger projects in the higher rainfall areas).

Survival will be enhanced by the minimisation of transplant stress and the creation of favourable conditions wherever possible. Experience suggests that, where practicable, holes should be dug and well watered a week prior to planting and watered again at planting. This will provide a reservoir of moisture for the plant as it adjusts to field conditions although it not practicable for mechanical planting. Plantings on slopes should encourage some runoff into the shallow basin around the seedling.

For hand planting projects in some areas, it may not be practical to establish holes and water in advance. Good survival may still be achievable with a reduced watering regime. Local advice should be sought.

When planting the seedling, any tangled roots should be loosened and good soil to plant contact made. Figure C.2 shows some of the common errors made when planting seedlings.

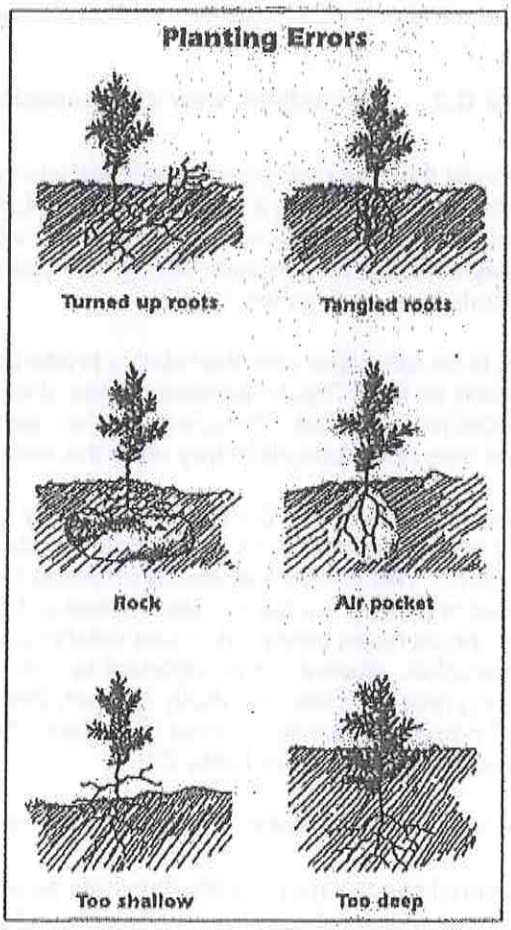


Figure C.2 Common planting errors (from Norman *et al*, 1997).

A success rate of 60-80% can normally be expected. Provision needs to be made for the replacement of failures.

C.7.2 Protection and maintenance of plants

Polyethylene tree guards can be used for protection against high winds (especially passing trucks in roadside plantings) and rabbits. The humid atmosphere within the guards can encourage early rapid growth but should be removed before summer. Fencing may be necessary in some circumstances to prevent grazing by larger animals.

A weed-free zone should be maintained around seedlings to reduce competition from other plants. Tree guards can interfere with weed control – if this is the case, the guards should be removed.

C.8 SUCCESSION IN REVEGETATED AREAS

Succession is defined as the sequential development of changes within an ecosystem as it progresses towards a self-perpetuating climax community. There is a wide range of models and theories on succession but they generally follow the process shown in Figure C.3.

Figure C.3 Generalised view of successional processes.

It is generally recognised that that roadside revegetation work will pass through a series of successional, or 'seral', stages to reach a stable, or climax, form. Often, this will be in the form of an early dominance of certain species, e.g. acacias, which, in due course, give way to other species. They establish a seed bank during their period of dominance, which can be utilised if a major disturbance, such as fire, occurs.

Some caution needs to be exercised over the relative proportion of early successional species such as acacias as Main Roads' experience has shown if they are too dominant they may suppress other desirable species. Thus, what initially appears to be a satisfactory revegetation outcome may prove unsatisfactory once the early successional species decline.

Despite the fact that some species can dominate in the early stages of revegetation, accepted practice for revegetation projects within Main Roads is *accelerated climax community development*. This is where all species desired for the mature vegetation community are seeded or planted 'up front'. Recent research into breaking dormancy in many native species should mean earlier and more reliable progress towards climax communities in revegetation. However, it is important to make allowances for successional processes in monitoring programs where, initially at least, there may be short-term dominance of a small number of species. Some important differences between early and late successional species are outlined in Table C.9.

Important aspects of succession in revegetated areas for project managers to note are:

- Early successional species may initially dominate some revegetated areas,
- Late successional species should become more dominant over time, and
- Disturbances such as fire may create a feedback loop where succession is retarded.

Characteristic	Early Successional Plants	Late Successional Plants
Seed numbers	Many	Few
Seed size	Small	Large
Longevity	Short	Long
Growth rate	Rapid	Slow
Root-to-shoot ratio	Low	High
Size	Small	Large

Table C.9 Comparative features of early and late successional plants.

In some situations, sowing a cover crop as an initial step can stabilise soils and provide organic material for use by later successional species. For example, cereal rye (at rates of 50-150 kg/ha) has been used as a short-lived cover crop to provide short term erosion protection in the south-west of the State and sorghum has been used for a similar purpose in the Kimberley's. This is most often done when the potential for significant erosion exists.

C.9 MONITORING

C.9.1 Overview

In the past, Main Roads has employed a variety of methods to assess the success of revegetation work. The methods used are summarised in Table C.10 and are generally dictated by the size and location of the project, when it was undertaken and whether an external organisation, such as the Environmental Protection Authority, has a role in determining what the target outcomes shall be.

Larger projects tend to involve more sophisticated monitoring methods, both to satisfy community demand and to allow for intervention and remedial work should it be required. Smaller projects, where the cost of a failure may not be as great, may have very little monitoring conducted. Overall, however, monitoring methods are becoming more sophisticated and detailed with the passage of time as more assurance is sought about revegetation outcomes than has been in the past.

C.9.2 Criteria

The simplest form of monitoring comprises the use of **input criteria**. Essentially, this involves ensuring that the revegetation works have been implemented as planned. This is no more than basic project management and may be the only monitoring required for some revegetation work.

Many revegetation projects, however, will warrant monitoring involving the use of **output criteria**. These will be some predetermined parameters used to assess whether the works have achieved what was intended. This criteria may be quantitative or semi quantitative (ranking on some predetermined scale). Examples of suggested indicators are shown in Table C.11 and Appendix G. Note that it is entirely appropriate to devise and implement project-specific indicators linked to the objective of the project. Any one indicator may also have a number of 'milestones' to assess at an early stage whether the desired indicator is likely to be achieved (see Appendix G).

Historically, Main Roads has used **attribute-based** monitoring where some attribute of the site, such as vegetation cover, is assessed. All of the indicators shown in Table C.11 and Appendix G are attribute-based. It is also possible to used indicators of **function** that determine whether the desired ecological processes are being achieved.

Ecosystem Function Analysis (EFA), as developed by CSIRO, is an example of function-based monitoring. Function-based indicators, with repeated measurements, give a trajectory towards a sustainable ecosystem while attribute-based indicators are defined 'end-points'. The two types of indicators can also be used in conjunction with one another.

Monitoring / Assessment Methods	Comments
A. Input criteria	Involves checking that work has been done, e.g. ripping and seeding actually conducted, without any follow up monitoring.
B. Input criteria with informal assessment	Method A method plus monitoring involving an informal visual assessment. May involve photographic records.
C. Input criteria with semi-quantitative outcome criteria	Method A plus some outcomes, e.g. seedling survival, plant cover, weed cover etc., may be ranked on a predetermined scale. Usually includes photographic records. Minimum performance levels may be stated in contractual documentation.
D. Input criteria with quantitative outcome criteria.	Method A plus quantitative monitoring at various intervals of predetermined key success criteria. Criteria may include plant cover, species richness, seedling survival, weed cover and/or surface stability. Usually includes photographic records. Minimum performance levels usually stated in contractual documentation. Success criteria may be set by external bodies e.g. Environmental Protection Authority.

Table C.10 Summary of various methods used within Main Roads for monitoring and assessing revegetation success.

C.9.3 Design of monitoring programs

Many revegetation projects will have formal monitoring requirements. The results of monitoring will have significant implications for contract managers and contractors alike. This being the case, it is critical all monitoring programs should be designed in a manner that is consistent with good scientific and statistical practices so that the results of the monitoring program will be sound and reproducible. The following are some of the key issues that must be considered:

Sample size – the sample size, in terms of both the size and number of sample plots, must be adequate. The requirements will vary from site to site but, essentially, the sample plot size should be appropriate to size and distribution of the units being measured. When additional sampling produces little or no additional information, then the number of sample plots is adequate.

Stratified sampling – it is critical to recognise distinctly different variables at the site and to design the monitoring program accordingly. For example, there may be differences in topography (slopes vs. flat areas), soil types, and revegetation treatments (e.g. seed mixes), each of which potentially produces a different outcome. Sampling should consider each of these individual areas with sample sizes in proportion to the size of the overall area. If this is correctly done, it will help identify the areas in which there are problems and distinguish them from other areas that are progressing satisfactorily.

Random sampling – all plots should be placed at random. Random number tables are usually used for this purpose. This will remove any bias the sampler may have in selecting the location of sample plots.

All formal monitoring reports should outline and justify the methodology used.

Criterion	Indicator	Values	Target
Input	Site preparation completed as per Revegetation Plan	Yes/No	Yes
	Seed mix applied as per Revegetation Plan	Yes/No	Yes
	Seedlings planted as per Revegetation Plan	Yes/No	Yes
Output (Informal)	Visual inspection	Progress acceptable/ not acceptable	Acceptable
	Photographic records	Progress acceptable/ not acceptable	Acceptable
Output (Semi-quantitative)	Mean foliage cover excluding weeds	0-5	≥4
	Mean foliage cover – weeds	0-5	≤1
	Plant health	0-5	≥4
Output (Quantitative)	Mean foliage cover excluding weeds	%	Site specific
	Mean foliage cover – weeds	%	Site specific
	Mean no. of individual plants/ m^2	n	Site specific
	Mean no. of individual plants of key species/ m^2	n	Site specific
	Species richness	n	Site specific
	No. of bare areas > 100 m^2	n	Site specific
	No. of erosion gullies > 200 mm in depth	n	Site specific
	Seedling survival	%	80 (or as otherwise agreed)

Table C.11 Suggested revegetation project monitoring indicators.

C.10 REFERENCES

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Schirmer, J. and Field, J. (2000). The Cost of Revegetation - Final Report. ANU Forestry and Greening Australia.

Watson, R. (1991). How local is local? In "Proceedings of Growback '91: a forum for the exchange of information and ideas relating to managing remnant vegetation and re-establishing native vegetation in the Australian landscape". Growback Publications, Fitzroy, Victoria.

APPENDIX D 1

Revegetation Projects – Benchmark Costs

No.	Revegetation Project Type	Total Cost/ha ($)		
		1 ha	10 ha	50 ha
1	Assisted natural regeneration in a warm moist temperate region	2300	900	600
2	Direct seeding on ex-pasture site in warm moist temperate region	3200	1500	1200
3	Speedlings[3] with same fencing, stocking etc. as tubestock project 4	2400	1500	1300
4	Tubestock[4] in semi-arid region	2600	1900	1700
5	Speedlings on ex-pasture in warm moist temperate region with contract planting and fertiliser	4200	2500	2200

Table D1 Indicative costs of revegetation projects.

Note:

1. Based on a range of Australian projects reviewed by Schirmer and Field (2000) from costs incurred in 1999. Dollar values have been rounded to aid comparisons.
2. The costs include ripping and seedbed establishment but do not include earthmoving costs, such as topsoil stripping and replacement, and significant site drainage works.
3. These costs are based mainly on revegetation carried out on farms. Main Roads' personnel advise that the costs associated with roadside revegetation are generally higher. If using this data as a basis for cost estimation, the addition of a 20% contingency is recommended.

[3] 'Speedlings' are small seedlings grown in cells in a tray as opposed to seedlings in individual pots. If available, they are usually cheaper per unit than seedlings.
[4] 'Tubestock' refers to seedlings grown in individual pots.

Appendix D2

Revegetation - Sample Bill of Quantities

Item					
1.0	Design and Pre-order	Unit	Qty	Unit Rate	Value
1.1	Complete Landscape Design / Scope	Item			
1.2	Additional services - eg drawings	Item			
2.0	***Supply and Application of Native Seed***	Unit	Qty	Unit Rate	Value
2.1	Supply and Pre-treatment of Native Seeds	kg/grms			
2.2	Initial herbicide application by boom spray	ha			
2.3	Site preparation - ripping, scarifying, rotary hoeing	ha			
2.4	Hand broadcasting of seed	m2			
2.5	Manual application of mulch 50 - 80 mm deep to site	m2			
2.6	Mechanical broadcasting of seed	m2			
2.7	Mechanical application of mulch 50 - 80 mm deep to site	m2			
2.8	Supply and application of Fertiliser	ha			
2.9	Secondary herbicide application including selective herbicide	Ha			
2.10	Maintenance herbicide application by boom spray	Ha			
2.11	Labour rate for manual works	hr			
3.0	***Supply and Plant Seedlings***	Unit	Qty	Unit Rate	Value
3.1	Supply Seedlings - rate 1 Seeded	ea			
3.2	Supply Seedlings - rate 2 Cuttings	ea			
3.3	Supply Seedlings - rate 3 - Banksia etc	ea			
3.4	Initial herbicide application by boom spray	Ha			
3.5	Prepare mound for seedling planting (Includes ripping and rotary hoeing)	m			
3.6	Preparation of individual augered planting sites	ea			
3.7	Mechanical application of mulch 50 - 80 mm deep on the mounded area	m2			
3.8	Manual application of mulch 50 - 80 mm deep to site	m2			
3.9	Secondary herbicide application including residual herbicide	Ha			
3.10	Hand planting of seedlings (Includes setting out)	ea			
3.11	Supply and placement of 20grm fertiliser tablets for each seedling	ea			
3.13	Supply and placement of plastic tree cover and three stakes	ea			
3.14	Labour rate for manual works	hr			
4.00	***Additional Items***	Unit	Qty	Unit Rate	Value
4.1	Control of pests (Rabbits / Fox / Declared Plants material supply	item			
4.2	Control of pests (Rabbits / Fox / Declared Plants in the sites - implementation	hr			
4.3	Preparation of additional mounds as per specification	ea			
4.4	Additional Herbicide application to mounded sites	ea			
4.5	Additional Herbicide application to augered sites	ea			
5.0	Provisional Sum	PS			
	Works as agreed with Superintendent				

Note: Above example was prepared for a South West road location. The cost items will vary by region and road location.

APPENDIX E

Typical Documents- Suggested Tables of Contents

Appendix E1
Revegetation Proposal- Suggested Table of Contents

1. BACKGROUND (rationale for project, objective)
2. DESCRIPTION OF AREA (location by SLK, summary of preliminary site assessment)
3. STAKEHOLDERS
4. REQUIREMENT FOR REVEGETATION (preliminary review of key factors, likely methods, desirable species)
5. LIKELY TIMING AND RESOURCING
6. PRELIMINARY BUDGET

Appendix E2
Revegetation Plan – Suggested Table of Contents

EXECUTIVE SUMMARY (inc. recommended actions and budget)

1. PROJECT OUTLINE
2. RELEVANT ISSUES
3. KEY SITE BIOPHYSICAL FACTORS (soil, vegetation etc)
4. REVEGETATION PLAN (objectives, methods, contract arrangements etc)
5. ESTIMATE OF PROBABLE COSTS
6. SUCCESS CRITERIA
7. IMPLEMENTATION ISSUES
8. VEGETATION ESTABLISHMENT
9. MONITORING
10. RECOMMENDED MANAGEMENT ACTIONS

ATTACHMENTS

Refer to the Main Roads Environment Branch intranet web site for a template of a plan brief.

Refer to the Main Roads Environment Branch intranet site for a template of a design brief.

Appendix E3

Weed Management Plan - Suggested Table of Contents

Components of weed management for a project are:

- Weed Assessment (description and distribution of weeds on site)
- Control Program (the control work to be undertaken)
- Monitoring (effectiveness of control and need for follow up).

A Weed Management Plan should include the following:

- Project site plan with all road verges broken into conservation value (1 to 5 degraded to intact native vegetation).
- Complete description of weeds on site and summary of distribution.
- Any declared weeds and control recommendations.
- Areas for priority treatment.
- Topsoil management recommendations for the project that take into account, declared weeds, pest weeds, normal weeds and conserved vegetation.
- Control program with total areas (ha), chemical types, application methods, safety data sheets, application timing, and application rates, complete with an estimate of cost to deliver the required control program. Program timeframes and number of applications required.
- Monitoring program.

Appendix E4

Revegetation Handover Report - Suggested Table of Contents

1. PROJECT OUTLINE
1.1 Background
1.2 Description of area
1.3 Stakeholders
1.4 Objectives
1.5 Key Factors
1.6 Timing of works

2. SUMMARY OF WORKS
2.1 Site preparation
2.2 Revegetation method(s)
2.3 Species and quantities used

3. MONITORING
3.1 Details to date
3.2 Future monitoring

4. RECOMMENDED ONGOING MAINTENANCE ACTIONS

APPENDIX F

Revegetation Programs - Seed Quantity Calculation Worksheet

Species	Target coverage (stems ha^{-1})[1]	Seed Requirement for Revegetation						
		Expected recruitment from topsoil (stems ha^{-1})[2]	Recruitment required from seed (stems ha^{-1})	Expected establishment from seed (%)[3]	Expected no. of germinants (seeds g^{-1})[4]	Sowing rate (g ha^{-1})	Area to be Revegetated (ha)	Total Seed Requirement (g)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			(2) – (3)			(4) / ((5) x (6))		(7) x (8)
Example 1 (*Acacia acuminata*)	1,000	200	800	5	65	246.2	6.7	1649.2
Example 2 (*Anigozanthos manglesii*)	500	0	500	1	480	104.2	6.7	697.9

[1] Estimate based on naturally-occurring native vegetation to be provided in Revegetation Plan.
[2] Estimate to be provided in Revegetation Plan.
[3] As for 2. If not known, the following default values can be used: large-seeded species e.g. acacias (5%), small-seeded species, e.g. eucalypts (0.5%).
[4] From seed supplier.

APPENDIX G

Examples of Monitoring Programs for Revegetation Works

Example 1

Objective: Roadside stability and maintenance minimisation.
Targets: Based on adjacent undisturbed vegetation.
Revegetation method: Regeneration from topsoil.
Monitoring method: Visual assessment.

Criterion	Target	After three months	After one year	After three years
Mean vegetation foliage cover (%) excluding weeds	>75	NA	50	60
Mean weed foliage cover (%)	<10	<10	<10	<10
Species richness (n)	5	3	4	5
No. of bare areas > 100m^2	0	0	0	0
No. of erosion gullies greater than 200 mm in depth	0	0	0	0

Example 2

Objective: Conservation and biodiversity.
Targets: Based on vegetation in adjoining conservation reserve. Key species is dominant tree species in reserve.
Revegetation method: Direct seeding.
Monitoring method: Quantitative by quadrats.

Criterion	Target	After three months	After one year	After three years
Mean vegetation foliage cover (%) excluding weeds	>75	NA	50	60
Mean weed foliage cover (%)	<10	<10	<10	<10
Mean no. of individual plants/m^2 (n)	4	6	4	4
Mean no. of individual plants of key species/m^2 (n)	0.25	0.25	0.25	0.25
Species richness (n) excluding weeds	40	20	30	35
No. of weed species (n)	<3	<5	<5	<3
No. of bare areas > 100m^2	0	0	0	0
No. of erosion gullies greater than 200 mm in depth	0	0	0	0

Example 3

Objective: Amenity and aesthetics.
Targets: Based on local community expectations.
Revegetation method: Planting.
Monitoring method: Quantitative and semi-quantitative by quadrat.

Criterion	Target	After three months	After one year	After three years
Mean vegetation foliage cover (%) excluding weeds	>50	NA	30	50
Mean weed foliage cover (%)	<10	<10	<10	<10
Plant survival (%)	85	90	85	85
Plant health (1-4)[6]	85% at 3 or better	90% at 3 or better	90% at 3 or better	85% at 3 or better
Species richness (n)	8	8	8	8
No. of bare areas > 100m^2	0	0	0	0
No. of erosion gullies greater than 200 mm in depth	0	0	0	0

[6] Based on a semi-quantitative score where 1 = poor and 4 = healthy.

ANNEXURE 5

Guidelines for Assessment: Clearing of Native Vegetation under the *Environmental Protection Act 1986*

GUIDE TO ASSESSMENT CLEARING OF NATIVE VEGETATION

under the Environmental Protection Act 1986

Purpose of these guidelines

Under the Part V Division 2 of the *Environmental Protection Act 1986* (*EP Act*) clearing of native vegetation must be done under the authority of a clearing permit, unless subject to an exemption. The Chief Executive Officer of the Department of Environment and Conservation (CEO) must have regard to the clearing principles outlined in Schedule 5 of the *EP Act*, approved policies, planning instruments, and other matters, that the CEO considers are relevant in deciding whether or not to issue a permit.

This guideline has been prepared to provide guidance regarding how to assess clearing of native vegetation against the clearing principles and to take into account any other relevant information. It is intended to assist proponents, consultants and assessors to:

- understand how assessment occurs;
- plan to undertake appropriate studies for projects that involve clearing; and
- provide advice and recommendations to the CEO.

Persons who intend to undertake activities that may involve clearing are advised to consult the actual legislation and seek advice, including legal advice, where necessary. Whilst the Department has endeavoured to ensure the accuracy of the contents of this document, it accepts no responsibility for any inaccuracies and persons relying on this document do so at their own risk.

Process to assess the environmental impacts of clearing of native vegetation

1 Assessment Methodology

Native vegetation in Western Australia cannot be cleared unless a permit has been granted, or the activity is subject to an exemption. Further details on exemptions are provided in Guidelines.

Clearing applications are assessed against a number of factors including principles outlined in Schedule 5 of the *EP Act*. If a proposal is also likely to have a significant environmental impact, the proposal could be subject to assessment by the Environmental Protection Authority (EPA). The Department of Environment and Conservation (DEC) would then provide specialist advice to the Environmental Protection Authority on the impacts of the clearing.

The CEO makes decisions on clearing applications and must consider a range of factors in making the decision. In practice, the CEO will use advice and recommendations from assessors in reaching a decision.

It is recognised that some of the principles are difficult to address through desktop study and brief site visit only, especially where existing information for the area is limited. Guidance is therefore given as to which principles can reasonably be addressed through desktop study and site visit alone, and those principles for which additional studies may be required to determine whether the principles apply.

The assessor should consider each of the principles, and note the extent to which they have been addressed, including methodologies used; the limitations that apply to the assessment; and the relevance of the principle to the current clearing proposal. Other factors and planning matters also need to be considered. The results of the assessment should be documented in an assessment report. A proforma assessment report is provided which outlines the form and content expected of this report.

Assessment techniques should take into account EPA standards and policies for environmental impact assessment as outlined in Guidance Statements and Position Statements. Relevant Guidance Statements and Position Statements are detailed in relation to each principle.

> The assessment is a judgement against the principles and other matters. These guidelines and listed tools are intended to assist assessors in making that judgement.

Firstly, assessments should be conducted at the level of a **desktop study**.

A **desktop study** involves a literature review, including a map-based information search of all current and relevant literature sources and databases.

In some circumstances further work may be required, such as a **site visit** by qualified personnel to:
verify desktop survey information;
(a) delineate key flora, fauna, soil, and groundwater and surface water values and potential sensitivity to impact; and
(b) undertake broad-scale vegetation and vegetation condition mapping based on selected sites rather than regular gridding.

Note that a site visit may involve more than one agency to identify the multiple environmental values of an area.

A secondary assessment may be required whenever there is insufficient information to make an informed decision on an application.

The methodology of this handbook is designed to make recommendations according to the best available information.

2 Clearing Principles and Guidelines

(a) Native vegetation should not be cleared if it comprises a high level of biological diversity.

Guidelines

This principle protects areas of outstanding biodiversity. This principle also protects intact natural systems with naturally occurring species diversity, ecosystem diversity or genetic diversity and natural systems that may be degraded but contain high levels of species diversity, ecosystem diversity or genetic diversity compared with the remaining native vegetation of that ecological community.

Measures of plant species diversity include:
- total vascular plant taxa (species, subspecies and varieties) diversity; and
- vascular plant taxa diversity for each ecological community.

Measures of fauna species diversity include:
- total vertebrate and invertebrate fauna taxa (genera, species and subspecies) diversity.

Measures of ecosystem diversity include:
- number of ecological communities (plant communities);
- number of ecological communities (fauna communities (assemblages));
- macrohabitat diversity;
- microhabitat diversity in each macro-habitat;
- a variety of soil types or geological formations; and
- micro topographical diversity and edaphic variation.

Assessment of biodiversity is complex because of the huge number of species, genetic variation within species and associations of species that exist within Western Australian ecosystems. In general, there are only reasonable data on the diversity and distribution of vertebrates, limited data on the diversity and distribution of vascular plants, few data on invertebrates and negligible information on micro-organism diversity.

It is recognised that this principle may concentrate on vascular flora as information on vascular plant biodiversity is relatively easy to collect and there are sufficient regional datasets available to allow for the comparisons that are inherent in the principle. This focus does not exclude other measures of biological diversity.

The EPA has noted that ecosystem diversity is harder to measure than species or genetic diversity because the boundaries of communities (i.e. variety of unique assemblages of plants and animals and ecosystems) are hard to define. As long as a consistent set of criteria is used to define communities and ecosystems, their number and distribution can be measured. Even using a relatively simplified measure, any given area contributes to biodiversity in at least two different ways: through its richness in numbers of species and through the endemism (geographical uniqueness) of these species. The relative importance of these two factors changes at different geographical scales (EPA Position Statement No.3).

It is recognised that genetic diversity is poorly understood and that adequate information to assess this aspect is difficult to obtain. Taxon diversity (species, subspecies, variety and forms) should be used to address this issue where data is not available.

An adequate assessment of this principle is possible as part of a desktop assessment and the assessor should use existing site and regional studies for comparative purposes. The assessor will need to have skills in assessing vegetation condition, and in determining floral species diversity and plant ecological community diversity to enable such comparisons to be made.

Tools used by proponents and assessors

EPA Position Statement No.3 outlines the EPA's principles in respect of environmental impact assessment of biodiversity. The EPA sees the proper understanding of the requirements of adequate surveys as central to achieving a sound assessment of biodiversity.

Some key factors in using surveys to assess biodiversity include:

- The methodology used should be consistent with the approaches recommended in the EPA Guidance Statement;
- The timing and time allocated should be determined by the natural cycles of the region (such as growth and flowering);
- The intensity of the sampling (number of sites, their spacing, and their area) should be based on the complexity of the flora, vegetation and faunal assemblages of the permit application area;
- The level of effort should be commensurate with the existing data for that area (i.e. where less existing information is available, a greater survey effort would be required).

(b) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.

Guidelines

This principle aims to maintain indigenous fauna species and assemblages of species in their local natural habitat and to ensure that fauna are not further threatened.

Fauna plays an important role in maintaining ecosystems and the life-supporting services provided by ecosystems by:

- cycling of material, through the browsing of flora, predation, digging, the consumption of organic matter generally, excretion, death and decay;
- the pollination, fertilisation and germination of plants; and
- maintaining the dynamic "balance" in ecosystems. The balance between assemblages of plants, animals and diseases, and environmental elements such as fire, soil structure and chemistry, can be destabilised by changes to any of the ecosystem components.

The ecological relationships between fauna, vegetation and their physical environment are affected by habitat decline and a consequent loss of ecological functions and processes. These may include:

- increasing edge to area ratios of native vegetation, which reduce the width of a remnant and increase its perimeter;
- loss of corridors, stepping stones (ecological linkages) and buffering vegetation;
- loss of large intact areas of native vegetation capable of supporting breeding populations of species with limited dispersal;
- loss of vegetation areas that support meta-populations;
- the loss of key habitat requirements, e.g. loss of tree hollows and fallen trees and branches that may be used for breeding or sheltering sites, the loss of proximity of the required combination of habitat types, e.g. Carnaby's Cockatoo is threatened because it requires a combination of woodland for breeding and heath habitat for feeding (both habitat types have been extensively cleared);
- increased probability of weed invasion due to external influences such as nutrient enrichment, drainage water or wind blown material;
- increased risk of disease entry and subsequent reduction in habitat values; and
- adjacent land uses which may impact adversely on habitat values.

In extensively cleared landscapes habitat specialist fauna species have declined as a result of habitat loss and in many cases are declining further as a result of natural attrition and an inability to recruit. For example, specialist bird species of heathlands and specialist bird species of woodlands in the wheatbelt and Swan Coastal Plain have declined at least in proportion to the loss of those habitats.

Fauna species may be resource-limited, dispersal-limited or area-limited. Significant habitat is habitat which provides resources (breeding, sheltering and feeding), connectivity or habitat area for a species or community that is critical for its survival.

It may be necessary to identify, from the total pool of faunal species present, the species that would become more vulnerable if a habitat was lost. For example, in the fragmented habitats of the WA wheatbelt Lambeck (1997) found that birds were useful indicators of habitats.

To identify which species or communities may be vulnerable to local extinction, consideration should include whether:

- the breeding, sheltering and feeding sites within the subject land were lost or reduced;
- the subject land provided an important linkage; or
- the habitat area was reduced so that a breeding pair or functioning social group could not survive.

Tools used by proponents and assessors

To determine the likelihood of significant fauna species, populations, ecological communities or their habitat within the site or its vicinity, the following considerations should be addressed.

1. Consult fauna references and/or key agencies (DEC, WA Museum) to determine whether any Threatened Fauna, Other Specially Protected Fauna, Priority-listed Fauna or fauna otherwise of significance occurs within the geographic range of the land. Compile a field list of each of these species, and their habitat requirements.

2. Note the presence or absence of each of the specific habitat elements required by field list species. Identify relevant areas on the property map.

3. Determine if any of the following habitats are present in the area where significant fauna species or populations may exist:
   - foraging areas (food sources). Studies need to record species that may be only present on a seasonal basis and rely on the vegetation in that season, eg nest hollows or an autumn food source;
   - trees with hollows;
   - abundance of ground cover and/or fallen trees;
   - caves, rock outcrops, overhangs or crevices;
   - permanent or intermittent waterways or water bodies; and/or
   - other (describe).

4. Is the habitat part of either an ecological linkage or does it form a large area of intact vegetation which may support meta-populations of fauna?

5. Note any signs of fauna presence, including distinctive scratches, nests, diggings, scats, pellets, calls, burrows, bones, etc. Record any sightings of fauna, including the habitat in which they were seen.

The scope of the assessment will be determined on a case-by-case basis, but would be consistent with EPA Guidance Statement No. 56. In marine environments, EPA Guidance Statement No. 29, *Benthic Primary Producer Habitat Protection for Western Australia's Marine Environments*, provides a set of principles to be applied when considering proposals that may result in removal or destruction of, or damage to, marine benthic primary producer communities or the habitats which support them.

(c) Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.

Guidelines

This principle aims to provide for the continuing *in situ* existence of Declared Rare Flora (DRF), other significant flora and significant habitat for priority-listed flora. The intent is to also protect habitat necessary for the maintenance of DRF and significant flora.

The assessment should consider the flora themselves and the buffer necessary to protect the flora from deleterious impacts by maintaining ecological processes and functions within the habitat of the DRF and significant flora. Buffer areas are measured from location of the flora, or in the case of more than one individual, from the outermost individual(s). To ensure an ongoing and viable area remains to protect the flora and ecological processes and functions, the minimum buffer radius recommended is 200m. This should be ideally determined on a case by case basis and is related to the characteristics of the species being protected, and the surrounding land uses.

Significant flora may include habitats of rare, uncommon or restricted flora species and/or species outside of or at the limit of their range.

Studies must be undertaken by suitably qualified people of a timing, duration and extent necessary for the adequate identification of rare flora, other significant flora and priority flora species.

Note that DRF are protected under the *Wildlife Conservation Act 1950* and may not be taken except with the written permission of the Minister for the Environment. Taking includes "includes to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means" and includes activities such as burning and grazing.

Flora listed as other significant flora such as rare, uncommon or restricted flora species and/or species outside of or at the limit of their range may not be cleared under these criteria.

Buffers necessary to maintain ecological processes and functions for DRF and significant flora may not be cleared under these criteria. The value of the subject land for the ongoing maintenance of Declared Rare, significant and priority flora species should be determined.

Tools used by proponents and assessors

The highest level of knowledge should be used.

1. Refer to DEC databases for the presence of known populations of DRF, and priority flora species. Refer to DEC database for the presence of known populations of other significant flora.

2. Refer to FloraBase website and any appropriate region or area-specific studies to determine whether habitats likely to support DRF, significant or priority-lised flora are present.

If the results of the assessment show the potential for DRF, a more detailed assessment of flora habitats and values may need to be undertaken.

GIS themes

DEC DRF and priority-listed flora

(d) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a threatened ecological community.

Guidelines

An ecological community is a naturally occurring biological assemblage that occurs in a particular type of habitat.

The aim of this principle is to provide for the continuing *in situ* existence of threatened ecological communities (TECs) under the *Environment Protection and Biodiversity Conservation Act 1999*, priority ecological communities (PECs) and other significant ecological communities as listed by DEC. This principle also aims to protect habitat necessary for the maintenance of these communities.

Vegetation that has a bioregional conservation status of depleted or worse (<50% representation) is more likely to contain TECs or other significant ecological communities.

The assessment should consider the ecological communities themselves and the buffer necessary to protect the communities from deleterious impacts by maintaining ecological processes and functions within these habitats. Buffer areas are measured from the outermost edge of the community. To ensure an ongoing and viable area remains to protect the ecological communities and ecological processes and functions, the minimum buffer radius recommended is 200m. This should be ideally determined on a case-by-case basis and is related to the characteristics of the communities being protected, and the surrounding land uses.

Tools used by proponents and assessors

The highest level of knowledge should be used.

1) Refer to DEC database for known sites of TECs listed in the *Environment Protection and Biodiversity Conservation Act 1999*.

2) Refer to DEC database for known sites of PECs or other significant ecological communities.

3) Refer to any appropriate region or area-specific studies to determine whether areas likely to support TECs, PECs or other significant ecological communities are present.

GIS Themes

DEC TECs / PECs

(e) Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.

Guidelines

This principle aims to maintain sufficient native vegetation in the landscape for the maintenance of ecological values. It also recognises the need to protect ecological communities that have been extensively cleared and to retain a representation of each ecological community in local areas throughout its pre-European range.

The *National Objectives and Targets for Biodiversity Conservation 2001-2005* (Commonwealth of Australia 2001a) recognise that the retention of 30%, or more, of the pre-clearing extent of each ecological community is necessary if Australia's biological diversity is to be protected. This level of recognition is in keeping with the targets recommended in the review of the *National Strategy for the Conservation of Australia's Biological Diversity* (ANZECC 2000) and in the EPA's Position Statement No.2 on environmental protection of native vegetation in Western Australia (EPA 2000).

A typical pattern of vegetation clearing in highly fragmented landscapes (e.g. from analysis of vegetation in the Greater Bunbury Scheme study area) shows that relatively few large remnants remain, and the vast majority of remnant areas are small, mostly less than 5 ha. In these fragmented landscapes, larger remnants should be retained as a priority as they provide core habitat areas necessary to support populations of species that are unable to survive in smaller areas of native vegetation.

The best available knowledge should be used in determining the ecological communities in an area. In terms of these criteria, vegetation complexes, which are mapped for the entire extent of the Swan Coastal Plain in the System 6 and System 1 Region (Heddle *et al.* 1980; Mattiske and Havel 1998) and the area covered by the Regional Forest Agreement, which includes the Jarrah Forest Bioregion within System 6 (Mattiske and Havel 1998; Havel 2000), are used as the base mapping of ecological communities. On the Swan Coastal Plain this should be supplemented by information on floristic community types (Gibson *et al.*, 1994, Department of Environmental Protection, 1996). Outside of these areas, vegetation types as defined by Beard (1990) are used as the base mapping of ecological communities.

In considering ecological values consider the vegetation type/complex and floristic community type at IBRA region, subregion scale and the local area of that type.

In recognition of past land use planning decisions, constrained areas have been identified on the Swan Coastal Plain of the Greater Bunbury Region Scheme and within the Bush Forever study. Within these constrained areas, criteria may be varied to "at least 10%". However, other principles and criteria do apply within these constrained areas, subject to exemptions for assessed schemes and deemed works of subdivisions under Schedule 6. This includes the need to recognise locally significant bushland.

Tools used by proponents and assessors

Percentage remaining criteria provide absolute minimum figures but reliable statistics may be difficult to obtain.

1. Determine the ecological communities on the subject land. The highest level of knowledge should be used, i.e. regional studies and/or area-specific studies.

2. Determine the percentage remaining of these types within the bioregion, subregion (Arc View tables) and local area (DEP_CAT).

3. Determine if the area is constrained land (including urban, urban deferred or industrial) within the Bush Forever study area or the Great Bunbury Region Scheme. Apply a benchmark of at least 10% for these areas. For other areas, consider planning instruments and other factors to achieve a greater percentage of protection of remnant vegetation.

GIS themes and tools

NLWRA (Beard/Hopkins) vegetation mapping
NLWRA remnant vegetation extent
Heddle
RFA
IBRA regions and subregions
DEP_CAT (calculates representation at local area scale)
Vegetation trends 88-00

(f) Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.

Guidelines

This principle aims to conserve all vegetated watercourses and wetlands.

The principle must consider both the area identified as watercourse or wetland and an appropriate buffer required to maintain the hydrological and ecological values of the watercourse or wetland. The watercourse or wetland buffer is defined in an area outside of vegetation dependent on waterlogged soil.

Under this principle, vegetation dependent on waterlogged soils would be protected e.g. damplands and floodplains.

Watercourses are an integral part of our heritage, have diverse ecological functions and support a wide range of activities including agriculture and tourism. In our predominantly dry landscape, watercourses are a focus for recreational activities such as swimming, boating, picnicking and bushwalking. Watercourses provide important linkages between landforms.

Wetlands are widely recognised as important wildlife habitats and as being among the most biologically productive and biologically diverse habitats on the planet. They directly and indirectly supply food to a broad range of animals including microorganisms, invertebrates, fish, birds, mammals and reptiles. Wetlands also serve to purify water by removing suspended matter (settling of particles), reducing numbers of faecal microorganisms and using dissolved nitrogen and phosphorus for plant growth.

Buffers are designed to protect watercourse and wetland vegetation from potential deleterious impacts from adjacent or surrounding land uses and associated impacts. For wetland and watercourse ecosystems, the buffers are measured from the edge of the boundary, which encompasses both waterlogged and inundated areas and the wetland-dependant vegetation, to the outside edge of any proposed development or activity.

EPA Position Statement No.4 *Environmental Protection of Wetlands* has as a goal no net loss of wetland values and functions. The EPA has noted that a lack of understanding of or interest in wetlands in the past has contributed to a focus on their economic benefits rather on a broader understanding of all their environmental values.

Tools used by proponents and assessors

1) Identify watercourses and wetlands including their associated riparian zones, wetland dependent vegetation and appropriate buffers.

2) Determine whether the watercourse or wetland is listed as significant.

   Sources of information that will aid in the identification of significant watercourses and wetlands include:
   - Swan Coastal Plain wetland mapping north of Bunbury is available through the Geomorphic Wetlands Database; and
   - Swan Coastal Plain wetland mapping south of Bunbury is available in Hill *et al.*, (1996) Wetlands of the Swan Coastal Plain Volume 2B: Wetland Mapping, Classification and Evaluation. Wetland Atlas.

   Significant watercourses and wetlands include those listed as:
   - Environmental Protection Authority (1992). *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992.* Western Australian Government Gazette, 24 December , 1992, pp 6287-93;
   - Environmental Protection Authority (1998). *Environmental Protection (South West Wetlands) Policy 1998;*
   - Conservation Category Wetlands as identified by the Water and Rivers Commission;
   - Significant wetlands of the South Coast Region;
   - RAMSAR wetlands;
   - A Directory of Important Wetlands in Australia (ANCA);
   - Freshwater wetlands in the Agricultural Zone;
   - Wild rivers;
   - Significant watercourses and wetlands as identified by the Water and Rivers Commission; and
   - Watercourses and wetlands listed in EPA Systems 1-12.

3) Determine appropriate buffers (where necessary) for watercourses and wetlands.

   Additional information that may aid in the application of buffers to watercourses and wetlands:
   - Water and Rivers Commission (2001) Determining Foreshore Reserves. Water and Rivers Commission River Restoration Report No. RR16, Perth;
   - Water and Rivers Commission Position Statement: Wetlands; and
   - Guide to Water and Rivers Commission Foreshore Policy 1: Identifying the Foreshore Area.

For a guide to the Commission's wetland buffer requirements for a range of land uses on the Swan Coastal Plain (Davies and Lane 1995) refer to the table in Position Statement No.4.

GIS Themes

Geomorphic Wetlands Dataset (includes conservation category wetlands)
South Coast Wetlands
Rivers at 1:250,000
Rivers at 1:1,000,000
Hydrography, Linear Features
ANCA wetlands
Wild rivers
Lakes at 1:1,000,000
EPP Lakes
South west Wetlands EPP when available
Ramsar wetlands

(g) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

Guidelines

Native vegetation should not be cleared if it is likely to cause land degradation. This includes soil erosion, salinity, nutrient export, acidification, waterlogging and flooding that affects the present or future use of land.

The assessment of land degradation risk takes into consideration a number of often interacting factors including soil type, landform and slopes, rainfall zone and intended land use. Low pH soils are usually those below 4 while high pH soils are those above 9.

Salinity risk assessment is site specific taking into account site and catchment information and the intended use of the land post clearing. Assessment of salinity risk should consider the average annual rainfall soil types, landform, underlying geology and hydrology of the site and its subcatchment. Clearing is unlikely to be approved where the clearing and subsequent use of the land is likely to increase ground water recharge resulting in rising saline ground water tables.

Tools used by proponents and assessors

Land evaluation Standards for Land Resource Mapping. Department of Agriculture, Technical Report 181.

Rapid Catchment Appraisal process - estimates current and predicted areas of secondary salinity in catchments.

AgMaps (CD)

Land degradation is assessed with reference to the Land Capability Class of the area where applicable.

Soil landscape mapping and land degradation quality data - contact Dennis Van Gool Department of Agriculture.

The Department of Agriculture has developed land capability classes. In general, Classes IV and V should not be cleared.

Land capability classes

Capability Class	General Description
I	Very high capability for the proposed activity or use. Very few physical limitations present which are easily overcome. Risk of land degradation is negligible.
II	High capability. Some physical limitations affecting either productive land use or risk of land degradation. Limitations overcome by careful planning.
III	Fair capability. Moderate physical limitations significantly affecting productive land use or risk of land degradation. Careful planning and conservation measures required.
IV	Low capability. High degree of physical limitations not easily overcome by standard development techniques and/or resulting in a high risk of land degradation. Extensive conservation requirements.
V	Very low capability. Severity of physical limitations is such that its use is usually prohibitive in terms of either development costs or the associated risk of land degradation.

Guidelines developed by the Department of Agriculture are used to assess the likelihood of other land degradation hazards occurring as a result of clearing. These guidelines are summarised in the tables below.

Soil erosion - determine land capability classes for water and wind-generated soil erosion.

Water erosion

Agricultural region	Soil surface texture	Land Capability Class				
		I	II	III	IV	V
		% slope				
South West	Sand	0-2	3-4	5-8	9-15	>15
	Sandy Loam and Loams	0-2 0-1	3-5 2	6-8 3-8	9-20 9-25	>20 >25
	Clay Loams and heavier					
Northern	Sand	0-2	3-4	5-8	9-15	>15
	Sandy Loams	0-2	3-5	6-8	9-20	>15
	Clay Loams and heavier	0-1	2	3-8	9	>9
South Coast	Sand	0-2	3-4	5-8	9	>9
	Sandy Loam and Loams	0-2 0-1	3-5 2	6-8 3-8	9-15 9	>15 >12
	Clay Loams and heavier					
Great Southern	Sand	0-2	3-4	5-8	9	>9
	Sandy Loam and Loams	0-1 0-1	2 2	3-8 3-8	9-15 9	>15 >9
	Clay Loams and heavier					
Central	Sand	0-2	3-4	5-8	9	>9
	Sandy Loam and Loams	0-1 0-1	2 2	3-8 3-8	9 9	>15 >9
	Clay Loams and heavier					

Class IV and V lands should generally not be cleared.

Wind erosion

The process to follow for the assessment of wind erosion hazard is as follows:

1. Determine the strength of the soil in terms of consistency (McDonald *et al.* Australia Soil and Land Survey - Field Handbook p. 115-116). Strength is determined by the force just sufficient to break or deform a 20mm diameter piece of dry soil when a compressive shearing force is applied between thumb and forefinger.

Force	Description		Hazard "rating"
0	Loose	No force required. Separate particles as found in loose sands	6
1	Very weak	Very small forces, almost nil	5
2	Moderately weak	Small but significant force	4
3	Moderately firm	Moderate to firm force	2
	Very firm to rigid	Disregard as wind erosion hazard, if particles are >2mm	1

2. Determine the particle or ped size: if the majority of sizes are less than 2 mm it should be regarded as a wind erosion hazard.

Particle or ped size	Hazard rating
< 1 mm	6*
1-2 mm	5
2-5 mm	3

3. Relief and aspect is also important. This can be combined to give ratings on the following landforms:

Landform	Hazard rating
Dune system	6
Exposed flat plain	5
Undulating country	4
Hilly terrain	2
Depressions	1

4. Add totals from 1-3 to determine the land capability class for wind erosion hazard.

Added points	Land capability class	Comments
18	V	No clearing
16-16	IV	Clearing with wind protection left
<16	1-III	Normal district practice

Determine soil pH and heavy metal levels.

Soil acidity
(Central and Northern agricultural regions only)

Soil acidity should be tested on yellow or pale yellow sandplain supporting Wodgil vegetation (*Acacia* spp.) or where naturally acidic soils are suspected.

1. Identify areas of uniform vegetation (sandplain vegetation).

2. Soil sampling (subsoil 15-20 cm). Take one sample per hectare systematically across the unit, with a minimum of 30 samples within a sandplain unit. Then bulk each 30 samples and take a subsample for soil testing.

3. pH test on subsample (1:5 0.01M $CaCl_2$)

   pH ≥ 4.5 Not highly acidic, no clearing restrictions
   pH < 4.5 Proceed to 4

4. Al test on subsample (1:5 0.05M KCl extract)

   <20 µmol Al Not highly acidic, no clearing restrictions
   ≥20 µmol Al Do not clear

   These levels of Aluminium significantly reduce plant growth resulting in an increased wind erosion risk and increased groundwater recharge.

Determine land capability class for water logging.

Waterlogging

Agricultural region	Soil surface texture	Land Capability Class				
		I	II	III	IV	V
		% slope				
South West	Drainage Landform element Soil type Soil depth Mottling Inundation risk	Well-drained Undulating S >1.0 m 0-10% Nil	Moderately drained Undulating SL 0.5-1.0 m 10-20% Low	Imperfectly drained Plain SCL duplex soils 0.2-0.5 m 20-30% Medium	Poorly drained Valley floor C <0.2 m 30-70% High	V. poorly drained Swamp C <0.2 m Gleyed Very high
Northern	Drainage Landform element Soil type Soil depth Mottling Inundation risk	Well-drained Undulating S >1.0 m 0-10% Nil	Moderately drained Undulating SL 0.5-1.0 m 10-20% Low	Imperfectly drained Plain SCL duplex soils 0.2-0.5 m 20-30% Medium	Poorly drained Valley floor C <0.2 m 30-70% High	V. poorly drained Swamp C <0.2 m Gleyed Very high
South Coast	Drainage Landform element Soil type Soil depth Mottling Inundation risk	Well-drained Undulating S >1.0 m 0-10% Nil	Moderately drained Undulating SL 0.5-1.0 m 10-20% Low	Imperfectly drained Plain SCL duplex soils 0.2-0.5 m 20-30% Medium	Poorly drained Valley floor C <0.2 m 30-70% High	V. poorly drained Swamp C <0.2 m Gleyed Very high
Note: low-lying depressions with poorly drained soils should not be cleared						
Great Southern	Slope Depth to clay Soil type % gleyed Site drainage Landform Drainage capacity	>5% >1 m deep S 0-10% 1	5-3% > 1m SL 10-20% 2	3-1% 0.5-1.0 m SC 20-30% 3 plain/platea u capable	1-0.1% 0.5-0.15 m LC 30-70% 4 valley floor uneven	0% <0.15 m HC >70% 5 swamps incapable
Central	Drainage Landform element Soil type Soil depth Mottling Inundation risk	Well-drained Undulating S >1.0 m 0-10% Nil	Moderately drained Undulating SL 0.5-1.0 m 10-20% Low	Imperfectly drained Plain SCL duplex soils 0.2-0.5 m 20-30% Medium	Poorly drained Valley floor C <0.2 m 30-70% High	V. poorly drained Swamp C <0.2 m Gleyed Very high

Soils classified as Class IV or V should generally not be cleared.

Determine if water logging is a problem on adjacent land and whether clearing is likely to increase the problem.

Determine the status of salinity on the land and in the region, determine the current rate of water table rise. Determine if the rate of rise is likely to be increased and if this is likely to lead to increased salinisation or earlier onset of salinisation.

GIS themes

Salinity Mapping (Land Monitor)
Salinity Monitoring (Land Monitor)
Salinity Risk (Land Monitor)
Groundwater Salinity, Confined Aquifers
Groundwater Salinity, Superficial Aquifers
Acid sulphate soil risk on Swan Coastal Plain

(h) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

Guidelines

Habitat fragmentation poses one of the greatest threats to biodiversity. When core habitat reserves are isolated from one another by human land uses, the diversity of native species generally declines and the probability of species extinction increases. This process of ecosystem decay has been well-documented in fragmented landscapes throughout the world.

Ecological linkages and buffers in the context of this principle contribute to the functioning and viability of existing conservation estate by:

- establishing connectivity between conservation areas and other areas of native vegetation;
- contributing to the maintenance or restorability of one or more key ecological processes required to sustain the conservation areas; and
- expanding the functional size of an existing conservation area or partially compensating for less than ideal shape.

The only way in which many of the basic ecological functions of smaller, remnant natural areas can be maintained is by maintaining connectivity with the broader natural landscape.

Native vegetation adjacent to or near conservation reserves improves the viability and conservation values of the reserve by providing larger core areas, buffering the reserve from edge effects, consolidating boundaries or adding plant communities and habitats not represented or under represented in the reserve. The size of an effective buffer will depend on the vegetation types present and their resilience.

Ecological linkages of vegetation between larger areas of conservation value are important for enabling fauna to continue to move through the landscape and between reserves. This is vital both for species that are nomadic and for maintaining populations of less mobile species that may otherwise become locally extinct in individual reserves.

Remnant patches within the vicinity of large contiguous areas of native vegetation (outliers) are more likely to support wildlife than more isolated patches - with greater separation distances fewer and fewer species will have the mobility necessary to maintain access.

Tools used by proponents and assessors

Determine if land held or managed for conservation is present. Need to refer to:

- land status maps for existing reserves and DEC region plans / EPA System 1-12 reports and Bush Forever for proposed reserves and protected areas;
- may need to access DOLA data for reserves that have a dual purpose (e.g. recreation and conservation) and are not managed by DEC;
- check with LGA for Shire reserves that may have a dual purpose;
- check with DEC for covenants, Land for Wildlife sites, World Heritage areas, biosphere reserves;
- check with National Trust of Australia (WA) for covenanted and Bush bank sites;
- check with World Wildlife Fund for Woodland Watch sites;
- wetlands identified under principle (f); and
- Perth Biodiversity Project Local Biodiversity Guidelines and subsequent Local Biodiversity Plans for regional and local ecological linkages and Local Biodiversity Areas with high priority for retention and protection (i.e. Local Conservation Areas).

Determine whether the land provides a buffer, ecological linkage or outlier to a conservation area. These may include areas that provide large, regional connections to conservation areas to facilitate animal movements and other essential flows between different sections of the landscape, and buffer the conservation area from adverse impacts. Alternatively, a narrow, disjunct, impacted, or otherwise tenuous habitat linkage connecting to conservation areas may exist. These are essential to maintain landscape-level connectivity, but are particularly in danger of losing connectivity function. An example is a narrow peninsula of habitat, surrounded by human-dominated land uses, that connects larger habitat blocks. See South Coast Region Macrocorridor project.

Factors to consider in determining whether an area has a function as an ecological linkage or buffer, or contributes significantly to the environmental values of a conservation area, include:

- distance to the conservation area and between other possible ecological linkages;
- size and shape of the ecological linkage or buffer;
- types of habitats (riparian, coastal, woodland, etc.) present within the linkage or buffer and key focal species and ecological processes that may be present that would indicate connectivity;
- types of land cover (eg. natural vegetation, pastoral/grazing, cropland/irrigated agricultural, low density residential, etc.) within and immediately adjacent to the linkage;
- primary barriers that are impediments to faunal movement, gene flow and ecological processes, and features that facilitate these within linkage. For example, watercourse, riparian habitat, dirt road, continual habitat coverage, underpasses/bridges, agriculture, urban areas; and
- any studies that exist to demonstrate the use and functions of the linkage or buffer, including any anecdotal evidence or field studies conducted on this particular linkage or buffer.

GIS themes

DEC-managed Estate
WRC Estate
EPA System boundaries and areas
Bush Forever areas
Register of the National Estate

(i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.

Guidelines

This principle considers biological, chemical and physical parameters, and water quantity as far as these affect overall environmental quality.

This principle aims to ensure that the quality of water supplies are not reduced, that levels of nutrients in water bodies and discharge water, salinity or pH levels are not significantly altered by land clearing, and that water regimes and environmental water provisions are not adversely affected.

The assessment should consider both onsite and offsite impacts, so that problems are not transferred from the cleared site to another part of the catchment or aquifer.

Native vegetation should be retained if clearing is likely to lead to sedimentation entering water bodies.

Native vegetation should be retained if impacts on it are likely to contribute to increased nutrient levels in the catchment. Soils with low and very low phosphorous retention ability should not be cleared.

Native vegetation should be retained if there is potential for low pH waters and/or acid sulphate soils to form as a result of clearing.

Within the north-west of the State, mangrove areas and tidal flats provide the main indicator of conditions that may potentially result in acid sulfate soils and low pH waters.

Acid sulfate potential has been mapped for the Swan Coastal Plain but not for the remainder of the southwest. The Acid Sulfate Soils Guideline Series provide further information on this issue.

Within Public Drinking Water Supply Catchments (PDWSA), the impacts of the land use and clearing must be compatible with the PDWSA guidelines and Water Source Protection Plans.

On Water Reserves under the Country Areas Water Supply Act (CAWS), clearing controls are in place. In these areas, the CAWS Clearing Guidelines should be consulted to identify additional water quality considerations. Clearing may be restricted through compensation payments or due to location in the catchment and salinity risk.

Biological communities associated with groundwater dependent ecosystems (GDEs), such as wetlands, groundwater-dependent terrestrial vegetation, cave streams and springs, have adapted to existing water regimes. Clearing of relatively substantial areas of vegetation can alter these regimes and cause degradation of existing biological communities. On the Swan Coastal Plain, GDEs most likely to be affected by a rising water table are those in areas with a depth to groundwater of 0 to 6 metres.

Native vegetation should be retained if clearing is likely to lead to changes in water regimes of GDEs on or off site and subsequent degradation of the biological communities associated with these systems. Degradation could entail local extinction of vegetation species, loss of diversity of fauna, loss of habitat diversity, etc.

In areas where Environmental Water Provisions (EWPs) have been set for groundwater-dependent ecosystems, the clearing of native vegetation should not result in breaches of EWPs.

Tools used by proponents and assessors

General

- Environmental Geology Series (Department of Industry and Resources) - identifies soil types, land use suitability and geomorphology.

Groundwater

- Estimate depth to water table and identify existing water quality readings from Water Information Network (WIN) sites and drilling project reports.
- Consult salinity risk mapping series to identify if salinity (electrical conductivity) is rising in the area (south west only). If it is, then obtain all water quality monitoring parameters from WIN and look at the long term trend, focusing on pH and electrical conductivity.
- On Swan Coastal Plain, consult the acid sulphate soil GIS data to identify whether the area is in area of moderate or high risk.
- In other areas, determine whether soil types have the potential to generate acid sulphate soils. Consult the Acid Sulfate Soils Guideline Series for information on this. Consider any previous studies carried out in the area.
- Any increase in rate of water table rise in catchments affected by or likely to be affected by salinity or changes in pH of discharge groundwater is unacceptable.
- Hydrogeologic modelling and assessment to determine the likely spatial and temporal extent and magnitude of impact on the water table of clearing, particularly where large areas of vegetation are proposed to be cleared.
- Where GDEs are likely to be affected by water table rises, assessment of the Ecological Water Requirements (EWRs) of groundwater-dependent ecosystems and setting of maximum water level criteria (generally by qualified ecologists) may be required. Hydrogeologic modelling can then be employed to ensure that the proposed clearing of native vegetation does not breach the water level criteria.

Surface water

- Identify the nearest gauging station and view historical pH, electrical conductivity and nitrogen and phosphorus readings. The Phosphorus Retention Index (PRI) may be useful to determine the nutrient capacity of the soils. If there is a trend then obtain all WIN readings for the area and consider long term trends.
- Determine nutrient trends for wetlands in the catchment. Determine soils in the catchment and their risk of erosion and nutrient holding capacity.

- Determine likely impact of clearing on nutrient levels from leaching of nutrients or from erosion carrying nutrient rich soil particles. No increase in nutrient levels is acceptable in systems with a trend towards elevated nutrient levels.

GIS Themes

Salinity Risk (SW only)
Salinity Mapping (SW only)
Salinity Monitoring (SW only)
PDWSA Policy Area
Acid Sulphate Soil Potential for Swan Coastal Plain
Soil Mapping Series - show PRI - but don't cover much of the state.
WIN database - provides water quality information from monitoring bores and gauging stations throughout WA

(j) Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

Guidelines

Consideration of this principle may require extensive modelling of the whole catchment and should only be considered for large clearing proposals.

For smaller proposals, clearing should not cause water logging (localised flooding). This is already considered under principle (g) (land degradation). Flooding and/or water logging may also exacerbate criteria under principle (i) such as salinity, sedimentation, low pH waters or eutrophication or result in unacceptable changes in water regimes or environmental water provisions, both on and offsite.

Tools used by proponents and assessors

Hydrological modelling may be required.

Indicators of possible water logging problems:

- soil compaction and infiltration
- soil profile depth
- soil drainage/recharge rates
- perched water tables - groundwater contours and monitoring well water levels could be considered
- water logging observed on adjacent properties

Floodplain mapping for major towns (1 in 100 year flood levels).

GIS themes

Perth Basin Hydrogeology, Base Superficial formation
Aquifer theme from DWAID

3 Planning Instruments

The *EP Act* requires that the CEO shall have regard to the clearing principles, so far as they are relevant to the matter under consideration. The *EP Act* also prescribes that in considering a clearing matter the CEO shall have regard to any planning instrument, or other matter that the CEO considers relevant.

Planning instruments are defined in the *EP Act* as:
(a) a scheme or a strategy, policy or plan made or adopted under a scheme;
(b) a State planning policy approved under section 29 of the *Planning and Development Act 2005* and published in the *Gazette;* or
(c) a local planning strategy made under the *Planning and Development Act 2005.*

Local and regional level planning strategies, by-laws and policies should be considered as part of the recommendations to the CEO and decision-making. Examples of these include Local Biodiversity Guidelines and related Local Biodiversity Plans prepared by Local Government, or regional planning strategies dealing with public infrastructure.

4 Other Matters

The other factors which can be taking into account by the CEO in considering a clearing application are not defined in the EP Act, and consequently are any matters the CEO considers relevant. As a matter of policy, these matters should be detailed in the assessment and decision reports. Generally, other factors could include such matters as:

- research undertakings;
- social inputs;
- community infrastructure needs;
- transportation requirements;
- listing of property and provisions undertakings; and
- matters of public interest.

These matters should be considered in the context of discussions with proponents, through submissions related to application advertising, or in response to direct interest letters.

Any other matters for consideration in decision-making should be detailed in that section of the assessment and decision reports.

Glossary

Biological diversity
The variety of life forms: the different plants, animals and microorganisms, the genes they contain, and the ecosystems they form. It is usually considered at three levels: genetic diversity, species diversity and ecosystem diversity. It is also referred to as *biodiversity*.

Bioregion
IBRA regions represent a landscape-based approach to classifying the land surface. Specialist ecological knowledge, combined with regional and continental scale data on climate, geomorphology, landform, lithology and characteristic flora and fauna were interpreted to describe these patterns. The resulting integrated regions were ascribed the term biogeographic regions. The Interim Biogeographic Regionalisation for Australia (IBRA) was developed in 1993-94 under the coordination of Environment Australia by the States and Territories as a basis for developing priorities for the Commonwealth in funding additions to the reserve system under the National Reserve System Cooperative Program. It has been subsequently revised in the light of new knowledge.

Bioregional Conservation Status of Ecological Vegetation Classes

Presumed extinct	Probably no longer present in the bioregion
Endangered*	<10% of pre-European extent remains
Vulnerable*	10-30% of pre-European extent exists
Depleted*	>30% and up to 50% of pre-European extent exists
Least concern	>50% pre-European extent exists and subject to little or no degradation over a majority of this area

* or a combination of depletion, loss of quality, current threats and rarity gives a comparable status (Department of Natural Resources and Environment 2002)

Buffer
Area designed to protect significant environmental values, including significant flora, significant ecological communities, and wetlands and watercourses, from deleterious impacts by maintaining ecological processes and functions in the habitat.

Clearing
(a) the killing or destruction of;
(b) the removal of;
(c) the severing or ringbarking of trunks or stems of; or
(d) the doing of any other substantial damage to,
some or all of the native vegetation in an area, and includes the draining or flooding of land, the burning of vegetation, the grazing of stock, or any other act or activity that causes -
(e) the killing or destruction of;
(f) the severing of trunks or stems of; or
(g) any other substantial damage to,
some or all of the native vegetation in the area.

Condition
Condition is a rating given to vegetation to categorise disturbance related to human activities. This rating refers to the degree of change in the structure, density and species present in vegetation in relation to undisturbed vegetation of the same type.

The most widely used condition system is that of Keighery (1994):
1. Pristine: no obvious signs of disturbance.
2. Excellent: vegetation structure intact; disturbance affecting individual species and weeds are non-aggressive.
3. Very Good: vegetation structure altered; obvious signs of disturbance.
4. Good: Vegetation structure significantly altered by obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it.
5. Degraded: Basic vegetation structure severely impacted by disturbance. Scope for regeneration of vegetation structure, but not to a state approaching good condition without intensive management.
6. Completely Degraded: The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

Other condition ratings used commonly are described in Government of WA 2000.

Conservation area
A conservation park, national park, nature reserve, marine nature reserve, marine park or marine management area within the meaning of the *Conservation and Land Management Act 1984* or any other land or waters reserved or managed for the purpose of, or purposes including, nature conservation.

Constrained Area
An identified area within the Swan Coastal Plain portion of the Greater Bunbury Region Scheme and the Bush Forever Study area where there is a reasonable expectation that development will be able to proceed. This may include areas zoned urban, urban deferred or industrial zoned land or land with existing development approvals.

Declared Rare Flora
Species protected under the *Wildlife Conservation Act 1950* as identified in the current listing.

Depleted
Refer to Bioregional Conservation Status of Ecological Vegetation Classes.

Ecological community
A naturally occurring biological assemblage that occurs in a particular type of habitat (English and Blythe, 1997; 1999). The scale at which ecological communities are defined will depend on the level of detail in the information source, therefore no particular scale is specified.

Ecological linkage
Are a network of native vegetation that maintain some ecological functions of natural areas and counter the effects of habitat fragmentation.

Ecosystem Diversity
Ecosystems are the critical biological/ecological operating units in nature. Ecosystem diversity is the diversity of all living organisms and non-living components within a given area and their relationships. Ecosystems include abiotic components, being partly determined by soil, parent material and climate. Ecological system diversity is the variety of habitats, biotic communities and ecological processes in a given area.

Ecological processes are the interactions, changes or evolutionary development processes of the ecosystem over time.

Fauna that is otherwise significant
These are defined as:

- Threatened fauna as endorsed by the Minister;
- fauna species that are habitat specialists;
- wide-ranging fauna species with reduced populations in the Bioregion;
- short-range endemic species;
- fauna species that have few populations in the Bioregion;
- fauna species which have reduced ranges or few recent records in the Bioregion; and
- internationally-listed migratory species.

Foreshore reserve
Where the foreshore area or watercourse buffer is to be set aside as a reserve under planning legislation, it is generally known as a foreshore reserve.

Fringing or riparian vegetation
Vegetation adjacent to the water body and directly dependent on the proximity of the watercourse or wetland. Riparian vegetation may include both wetland and dryland vegetation. Wetland vegetation can tolerate some period of inundation and is typically found below the high water mark or within the floodway, for example flooded gums and paperbarks, and submerged and emergent species like rushes. Dryland vegetation is not tolerant of permanently or seasonally waterlogged conditions. Riparian vegetation provides many important functions including habitat for many aquatic and terrestrial species, stabilisation of the banks, energy dissipation, ecological linkages, and sediment and nutrient retention; it assists in maintaining the integrity of the watercourse or wetland in a number of ways.

Genetic Diversity
Variation of genes/genetic information contained in all individual plants, animals and microorganisms both within and between populations of organisms that comprise individual species as well as between species. Genetic diversity represents the heritable variation within and between populations of organisms. There are so many genes and different possible combinations of genes that for most types of organism every individual, population and species is genetically distinct.

Landscape
Made up of basic elements - climate, geology, topography, vegetation, fauna and humans - biophysical characteristics that can be used to identify differences between different landscapes.

Local area
Varies with region and indicates the distance across which there is little change in a vegetation community. For example in the mallee region of the south-west a local area is typically a radius of 15 km from the subject land. For ecological communities where there is rapid change over distance such as the Lesueur and Fitzgerald River areas a distance of 5 km is more appropriate. In the Eremaean Province a distance of 50km is recommended. This will need to be determined on a region and vegetation specific basis.

Meta-population
A population of populations. A defined set of geographically separate populations with at least some exchange of individuals between the separate populations - in other words, systems of local populations connected by dispersing individuals.

Native vegetation
Indigenous aquatic or terrestrial vegetation but does not include vegetation that was intentionally sown, planted or propagated unless:
(a) that vegetation was sown, planted or propagated as required under this Act or another written law; or
(b) that vegetation is of a class declared by regulation to be included in this definition,
and includes dead vegetation unless that dead vegetation is of a class declared by regulation to be excluded.
Note that this includes non-vascular plants (e.g. mosses, fungi, algae) and marine plants (seagrass, macroalgae/seaweed).

Priority Flora
Plant taxa, lists of which are maintained by the Department of Conservation and Land Management, that are either under consideration as threatened flora but are in need of further survey to adequately determine their status, are adequately known but require ongoing monitoring to ensure their security does not decline, or are conservation dependent, that is they require active management to maintain their status.

Priority Fauna
Conservation significant animal species listed by DEC's Threatened Species Consultative Committee but which are not currently listed under Section 14(2)(ba) of the *Wildlife Conservation Act 1950* as Specially Protected Fauna.

Protected area
An area of land especially dedicated to the protection and maintenance of biological diversity and managed through legal and other effective means (ICUN 1994).

Representativeness
The extent to which areas selected for inclusion in the national reserves system are capable of reflecting the known biological diversity and ecological patterns and processes of the ecological community or ecosystem concerned (Commonwealth of Australia 1996).

Significant ecological community
- DEC threatened ecological communities (TECs) as listed through an existing Ministerial approval process;
- Priority ecological communities as listed by DEC - under consideration as TECs but need further survey; and
- Geographically Restricted Ecological Communities.

Significant flora
- Species that are confined to a specific area (ie endemic to the Bioregion) or otherwise geographically restricted;
- distinctive local forms that have not been recognised taxonomically (not a species, subspecies or variety);
- populations that are outside the main geographic range (ie disjunct populations)
- populations at the end of the plant's geographic range;
- populations that represent a significant number of the known individuals of the taxon in the bioregion; and
- Priority one to four flora as listed by DEC - taxa that are under consideration as DRF but are in need of further survey or continued monitoring.

Significant habitat

Habitat that provides resources (breeding, resting and feeding), connectivity or habitat area for a species or community that is critical for its survival.

Specially Protected Fauna
Species protected under the Wildlife Conservation Act 1950. The latest listing is Wildlife Conservation (Specially Protected Fauna) Notice 2001 (Government of Western Australia 2001b).

Species Diversity
This can be considered as the variety of individual species within a given area, such as a region. While such diversity can be measured in many ways, the number of species (species richness) is most often used. A more precise measurement of taxonomic diversity also considers the relationship of species to each other. The greater the difference between one species and another species, the greater its contribution to any overall measure of biological diversity. The ecological importance of a species can have a direct effect on community structure and thus on overall biodiversity. The variety of species increases with genetic change and evolutionary processes.

Threatened ecological communities
Those (ecological communities) that have been assessed through a procedure (coordinated by DEC) and assigned to one of the following categories related to the status of the threat to the community. The categories are "Presumed Totally Destroyed", "Critically Endangered", "Endangered" or "Vulnerable" (English and Blyth 1997, 1999). One of the criteria used to determine the categories is an estimate of the geographic range and/or the total area occupied and/or the number of discrete occurrences reduced since European settlement, where $\leq$10% is Critically Endangered and $\leq$30% is Endangered.

Vegetation complex
As defined by Heddle et al. (1980) and Mattiske and Havel (1998). The vegetation complexes are based on the pattern of vegetation at a regional scale as it reflects the underlying key determining factors of landforms, soils and climate.

Vegetation Type
Vegetation types as defined by Beard (1990) are based on three principal characteristics of vegetation.

1. Floristic Composition: the species of plants which comprise vegetation.
2. Vegetation Structure: the height of plants in layers, their shape and their spacing
3. Growth-form: the morphological characteristics of the component plants, such as woody or herbaceous, annual or perennial, thorny or succulent, evergreen or deciduous, and leaves of a certain texture, size and shape.
4. Plant Association: the component species, with particular dominants, of a given area. If the vegetation of another area has the same dominants it is in the same association. The association is the basic unit of vegetation.
5. Plant Formation: a vegetation unit that considers plant associations that have a similar physiognomy (a combination of vegetation structure and growth-form), independent of specific floristic composition.

Watercourse
(a) Any river, creek, stream or brook in which water flows;
(b) any collection of water (including a reservoir) into, through or out of which any thing coming within paragraph (a) flows;
(c) any place where water flows that is prescribed by local by-laws to be a watercourse, and includes the bed and banks of any thing referred to in paragraph (a), (b) or (c).

For the purposes of the definition: a flow or collection of water comes within that definition even though it is only intermittent or occasional; a river, creek, stream or brook includes a conduit that wholly or partially diverts it from its natural course and forms part of the river, creek, stream or brook; and it is immaterial that a river, creek, stream or brook or a natural collection of water may have been artificially improved or altered.

Watercourse or wetland buffer
Land adjoining, or directly influencing a watercourse or wetland that is managed to protect watercourse and wetland values, including any riparian areas. It is basically an area outside a watercourse or wetland where clearing and certain activities are inappropriate. The size of the buffer area should take into account watercourse or wetland values, condition, pressures and responses to pressures.

Wetland
Areas of seasonally, intermittently or permanently waterlogged soils or inundated land whether natural or otherwise, including lakes, swamps, marshes, springs, damplands, intertidal flats, mangroves and estuaries.

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