

Conservation Commission

Forest Management Plan Performance Assessment

**Wungong Catchment Environment and Water Management
Project (Wungong catchment trial/Wungong catchment thinning
trial) – Performance Assessment PART A**
Performance Assessment Number FMPPA 01/08



Conservation Commission
of Western Australia



Conservation Commission performance assessments are undertaken primarily to fulfil the functions described in S 19(g) of the Conservation and Land Management Act 1984. That is to “assess and audit the performance of the Department and the Forest Products Commission in carrying out and complying with the management plans”. They will also help inform its policy development function and its responsibility to advise the Minister on conservation and management of biodiversity components throughout the State.

This performance assessment was undertaken in accord with the “*Conservation Commission policy and guidelines for the performance assessment of conservation reserve and forest management plans and biodiversity management in WA*”. Further details are available at www.conservation.wa.gov.au.

In the compilation of this report the information is presented as at the time of the assessment in 2008. Some additions have been made to the document in the intervening period to assist in the interpretation of the key findings. The use of Department of Environment and Conservation (DEC) data for the production of maps in this report is acknowledged.

Presented at Conservation Commission meeting – 11th May 2009

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EXECUTIVE SUMMARY

This Forest Management Plan Performance Assessment (FMPPA) reviewed the implementation of the Water Corporation's 'Wungong Catchment Environment and Water Management Project'. The assessment commenced in 2008 and this report (Part A) assesses the context and planning of the project at the time of the assessment and interviews (2008). Part B of this assessment, which is in preparation, will focus upon the operational activities associated with implementation of the project.

In summary, this assessment (Part A) identified the following:-

- The Water Corporation has provided a four-yearly review of the trial to the Conservation Commission;
- The Water Corporation has commissioned a review by CSIRO of the project's research program and produced numerous planning documents in relation to the trial including the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)*;
- The *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)* contains variations to *Silviculture Guideline 1 (2004)*. Some of these variations are inconsistent with the documentation provided at the proposal stage of the project and this planning aspect of the project is considered to be inconsistent with the *Forest Management Plan 2004-2013*;
- The Conservation Commission's position on adaptive management is that adaptive management trials under the *Wungong Catchment Environment and Water Management Project 2005* could allow for variations to thinning prescriptions above those parameters indicated in the proposal documentation and not below. Advice at the proposal stage of the project from the Conservation Commission did not support thinning to a lower target basal area than proposed. Thinning proposals that vary from the parameters which were indicated in the *Wungong Catchment Environment and Water Management Project 2005* (and subsequently endorsed by the Conservation Commission) should still be consistent with *Silviculture Guideline 1 (2004)*;
- There have been critical delays regarding important biodiversity research projects such as FORESTCHECK, which are of fundamental importance to the commitments given by the Water Corporation in relation to the delivery of biodiversity research outputs.

Six key findings are outlined in the document and these are listed below. The full response from the Water Corporation to each of the key findings has been included in Appendix 4 of this report with discussion of the key findings in the body of the report.

Key Finding 1

There are significant variations between the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* and the standard practice undertaken through *Silviculture Guideline 1 (2004)* and this planning aspect of the project is considered to be inconsistent with the *Forest Management Plan 2004-2013* (see full background to this finding on page 16 of the report).

Key Finding 2

There are gaps in the research program and critical delays on important biodiversity research projects, such as FORESTCHECK, which are of fundamental importance to the delivery of biodiversity research outputs. This appears to be an important deviation from the commitment which was given at the proposal stage of the Wungong trial (see full background to this finding on page 19 of the report - the Water Corporation have indicated in their response to this finding that the funds are available to implement FORESTCHECK but it has continued to be deferred due to the limited availability of FORESTCHECK research expertise).

Key Finding 3

The draft Memorandum of Understanding (MOU) between the Water Corporation and DEC has not been signed-off and there is no binding agreement in relation to the

project responsibilities (see full background to this finding on page 20 of the report – the Water Corporation have indicated in their response to this finding that the MOU was subsequently signed in 2009).

Key Finding 4

The contents of the Project Implementation Management Plan (PIMP) deliver little detailed guidance for undertaking an audit, and in general the PIMP does not seem to fulfil the other EPA recommendations, particularly at an operational scale (see full background to this finding on page 21 of the report - the Water Corporation has indicated that it will include operational detail for the PIMP in line with the EPA recommendations).

Key Finding 5

It is unclear what the goal of maintaining fuel to less than 8 tonnes per hectare will practically mean in relation to prescribed fire frequency and intensity for the Wungong Catchment trial area (see full background to this finding on page 23 of the report).

Key Finding 6

Clarification is required in relation to the origin and status of the datasets used to derive the isohyets which are then used for setting parameters in the silvicultural prescriptions of the trial (see full background to this finding on page 24 of the report).

Overall, there appears to be important deviations from the indications and commitments which were given at the proposal stage of the Wungong trial. After consideration of the responses to the key findings from the Water Corporation, the Conservation Commission has made several recommendations in response which are summarized as follows:-

- the Water Corporation establish FORESTCHECK biodiversity monitoring sites and implement pre-treatment monitoring on future treatment areas;
- the Water Corporation consult with DEC and amend *Appendix 4: Jarrah Thinning Intensity (Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007))*;
- the Water Corporation consult with DEC and remove reference to the use of prescribed burning as a ‘Follow-up Treatment’ in the document *Jarrah Thinning Intensity (Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007))* and include detail on prescribed burning in the PIMP;
- Present for consideration by the Conservation Commission proposed silvicultural guidelines for the Wungong Catchment Thinning Trial.

Part B of this assessment will assess the operational activities associated with implementation of the project, in particular the application of the documents described in this report (Part A). While there have been recommendations to alter the planning documentation through this report (Part A), the possibility exists that further planning documentation changes will be recommended through information gathered during Part B of the assessment. There is provision in the ‘*Wungong Catchment Environment and Water Management Project*’ for annual auditing by the Conservation Commission and priorities for ongoing assessments will be derived from Part A and Part B of this initial assessment.

INTRODUCTION

This Forest Management Plan Performance Assessment (FMPPA) reviewed the implementation of the *Wungong Catchment Environment and Water Management Project* (Wungong Project). The project is an experimental trial designed to both enhance water production and to be consistent with the objectives and intent of the Forest Management Plan 2004-2013 (FMP). The proponent for the project is the Water Corporation.

The primary objective of this assessment was to audit Wungong Project activities against the objectives and actions of the FMP. The audit process forms part of the basis for the decision by the Environmental Protection Authority (EPA) to forgo the setting of binding conditions on the Water Corporation through Part IV of the *Environmental Protection Act 1986*.

The main emphasis of this assessment is upon the native forest areas subject to commercial logging and non-commercial thinning. The assessment commenced in 2008 and this report (Part A) assesses the context and planning of the project at the time of the assessment and interviews (2008). The assessment has been divided into two parts with Part A) focused on the context and planning associated with the native forest areas of the trial. Part B of this assessment will be drafted separately and will focus upon the operational activities associated with implementation of the project in native forest areas. Evidence was derived from records, documents, interviews and observations. Wherever possible, documents and records were verified with observations and interviews (and vice versa).

There is provision for the *Wungong Catchment Environment and Water Management Project* to be audited annually by the Conservation Commission and this assessment can be used to establish priorities for further assessments by the Commission. Other areas of activity such as silvicultural¹ treatment of exotic mine rehabilitation areas may be assessed in the future.

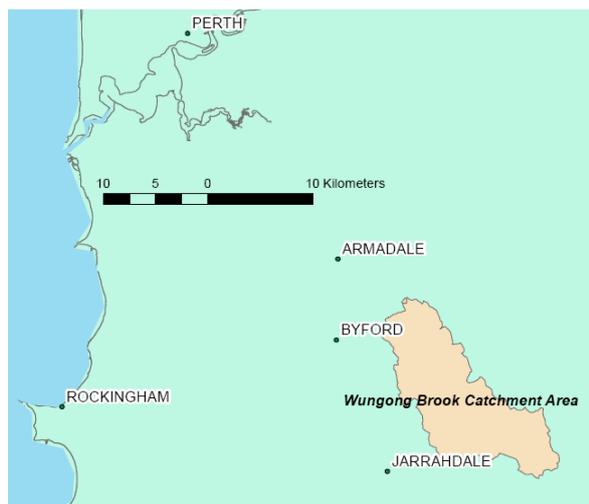
The assessment process is summarised in Appendix 1.

BACKGROUND

The Wungong Catchment is a gazetted drinking water catchment located one hour's drive south-east of Perth in Western Australia (WA) (Figure 1). The Wungong catchment covers an area of 12,845 ha. The aim of the Wungong Project as outlined in the planning documentation is to increase stream flow through silvicultural treatments (thinning and burning regimes) in selected areas of the catchment. Silvicultural work began in the last quarter of 2006.

¹ Silviculture is the theory and practice of managing forest establishment, composition and growth to achieve specified management objectives. Also see glossary of terminology in Appendix 3.

Figure 1. Location of the Wungong Catchment



A background summary is provided below of the key planning documentation which has been referenced in this assessment.

Brief description of key project related documents

1. Forest Management Plan 2004-2013 (FMP) (Conservation Commission 2004)

A key objective of the FMP is to maintain productivity of the forest and seek to regenerate or rehabilitate disturbed forest so as to maintain the productive capacity, flora composition and structural attributes of that forest in the long term (Section 15). In line with this objective, the FMP requires the following actions in relation to silvicultural operations:-

(Extract from FMP section 6.2)

6.2 The Forest Products Commission and its agents will conduct its silvicultural operations:

6.2.1 in accordance with the Department's Silviculture Guidelines (see Glossary for definition of silviculture); and

6.2.2 prior to the formal incorporation of the amendments identified in Appendix 5 into those Guidelines, in a manner that is consistent with those amendments.

The objectives and actions for regeneration and rehabilitation of disturbed forest are detailed in Section 15.1 of the FMP.

The amendments to the *Silvicultural Guidelines* outlined above relate to the reduced impact of silvicultural operations on flora diversity and abundance, the retention of marri due to a reduction in the chipwood market, and other key changes to existing jarrah and karri guidelines.

The Forest Management Plan allows for adaptive management through the conduct of trials of improvements to silviculture (Section 33) and subsequently incorporating changes to jarrah silviculture in the silviculture guidelines of the FMP.

2. Silvicultural Practice in the Jarrah Forest (Department of Conservation and Environment SFM Guideline No.1 2004)

Changes to silviculture under the FMP Appendix 5 were incorporated into *SFM Guideline No.1* which was then approved for implementation under the FMP.

3. **Wungong Catchment Environment and Water Management Project² (Water Corporation 2005)**

The key features of the project as outlined in this document include the thinning (see Glossary for definition) of native regrowth jarrah forest, the thinning of native trees in rehabilitated bauxite mining areas and the gradual conversion of exotic trees to native species in rehabilitated bauxite mining areas.³ Thinning in regrowth jarrah was scheduled to be undertaken to a target of 15-18m² per hectare over the first stage of the project, with small trees culled (using herbicide) and more mature and larger trees retained. Ongoing treatment was considered necessary to maintain enhanced water yield over time. This would involve follow-up treatments of coppice and young Banksia and Allocasuarina trees whilst retaining key components of the understorey according to jarrah silvicultural guidelines. Thinning was to be supplemented by a range of environmental projects in the catchment such as feral animal control and flora and fauna recovery plans.

The project incorporates an undertaking to be consistent with the objectives and actions of the *Forest Management Plan 2004-2013*. Support for regular auditing by the Conservation Commission, regular monitoring of environmental parameters and research in key areas of risk (that provide data for assessment against the key performance indicators (KPIs) in the FMP) constitute part of this undertaking.

4. **Forest Management Intensity Analysis (Water Corporation 2004)**

This report was prepared for the Conservation Commission to determine the silvicultural intensity of the Wungong proposal compared to past and future silviculture. The report states that '*it appears the Wungong proposal is similar to or less intensive than past or future silviculture*' and that '*Compared to the expected silviculture under the Forest Management Plan 2004-2013, the Wungong proposal will treat more area per year than a single harvest area, but uses treatments that retain more trees (or higher basal area- see glossary for definition)*'.

The *Forest Management Intensity Analysis* report presents the following table for the purposes of comparison:-

Table 1. Extract of Table 2 (Forest management intensity analysis 2004) Average post treatment basal areas for different treatments and silvicultural regimes

Treatment	Basal area (m ² /ha) post treatment		
	1990-2001 Silviculture	Current Forest Management Plan	Wungong Proposal
1. Thinning	15	15	16.5

The table shows that the predicted post-thinning basal area of the Wungong trial (16.5m²/ha) would be marginally higher than thinning under the FMP (15m²/ha).

5. **Water Corporation response to submissions from 2005 public review (Water Corporation 2005)**

The Water Corporation undertook a public review in 2005 of the proposal outlined in the document *Wungong Catchment Environment and Water Management Project*. The submissions are summarised in the *Water Corporation response to public submissions* as Issues (posed as questions), Submission quotes, Summary of issues, Response (by Water Corporation) and Answer (by Water Corporation). A number of commitments are given in the

² Water Corporation (2005) *Wungong Catchment Environment and Water Management Project: Sustainable management of water services to make Western Australia a great place to live and invest*. Perth: Water Corporation.

³ (along with the potential conversion of pine plantations).

responses to the issues raised. For example, some of the Water Corporation responses to queries are listed as follows:-

- In relation to vegetation retention:- *Some submissions have incorrectly stated the project will kill balga, banksia and sheoak – the focus is on thinning the overstorey species (jarrah and marri) and will keep key understorey species (with some treatment only if they regenerate out of a natural balance (Section 2.19)).*
- In relation to community involvement in the project:- *There will be numerous communication streams including a project web site, presentations, workshops and field trips, and potential participation in research and on-ground work.*
- In relation to dieback:- *The project will adhere to current management requirements in the Forest Management Plan including implementing dieback mapping, forest hygiene, operations in dry soil using light-weight vehicles and foot access and vehicle wash-down if required to minimise this risk.*
- In relation to thinning proposals:- *Within the Wungong Catchment up to 62% of the catchment will be thinned to increase the spacing between trees from 3–4 m to 5–6 m, with a retained basal area of 15–18 m²/ha..... In particular some have assumed incorrectly the forest will be kept permanently at a basal area of 15–18 m²/ha, when in fact it will on average increase its basal area in time as it moves towards a more mature structure (Section 2.22).*

6. Advice of the Environmental Protection Authority to the Minister for the Environment under Section 16 of the Environmental Protection Act 1986 (EPA Bulletin 1196) (Environmental Protection Authority 2005)

The project proposal was subject to a process of review by the public, the Conservation Commission and the Department of Environment and Conservation, with advice to the Environmental Protection Authority (EPA). The project was considered by the Conservation Commission and DEC to be consistent with the *Forest Management Plan 2004-2013* and in line with the FMP's intention for adaptive management (see Glossary for definition) through the conduct of trials of improvements to silviculture (Section 33).

The EPA elected to forgo the setting of binding conditions on the Water Corporation through Part IV of the *Environmental Protection Act 1986* (WA) in view of the advice received from the Conservation Commission and DEC that the project (as documented and committed to at the time) is consistent with the FMP.

In its advice to the Minister, the EPA made several recommendations in relation to biodiversity, water quality, research needs, adaptive management and implementation in areas of regrowth jarrah. In particular, these relate to:

- A need to confirm environmental benefits of the project that had been predicted, along with the need for research that addresses the ecological uncertainties of the thinning process and the concerns expressed by the community;
- A need for the monitoring and protection of water quality;
- A need for an interagency agreement that defines the responsibilities and process;
- A need for a formal Project Implementation Management Plan (PIMP) to be prepared by the Corporation, which provides information on research, interagency structure and consultation and also key operational matters including project objectives and indicators, schedules, collection of baseline data, monitoring proposals, an outline of adaptive management at the operational scale and information on reviews and audits;

- A need for variations to thinning prescriptions and target basal areas to be undertaken, for example, where effects exceeded expectation, as well as to provide more knowledge for future application.
- It also recommended that the Corporation's first four-yearly project review would be submitted to the Commission in 2008 so that it could be incorporated in the Commission's mid-term audit on the implementation of the FMP. This four-year review was received, however it was received too-late in 2008 to be incorporated into the mid-term audit of the FMP.

7. Department of Environment and Conservation 2007, Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment

The *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* was published by DEC on a trial basis subject to review in 2008. Formal approval of the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* was not sought or received from the Conservation Commission. According to the Water Corporation these interim guidelines:-

“will be used to guide operational practice for an initial trial period. After this initial trial period, the Water Corporation and DEC will undertake review of these guidelines. As part of the review, a public submission process will be initiated dependant on the completion date of the trial period. Following this review and taking into account public submissions, the guidelines may be amended and then submitted to the Conservation Commission for advice and subsequent approval as a final guideline by the Minister for the Environment.”

A list of variations in the interim guideline to the current silviculture in jarrah forest is outlined in the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* and included below:-

Extract from page 7 of *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* (2007)

“This guideline varies from Silvicultural Practice in the Jarrah Forest (SFM Guideline No1, 2004) in the following respects.

2.1 Thinning

All culls in excess of the nominated crop tree density are treated, compared to only those within 4 m of a crop tree. Culls within 5 m of a habitat tree are still retained.

2.2 Gaps and Shelterwood

□ Remove all culls up to 20 m²/ha to create a gap or shelterwood as appropriate (the standard guideline is 12 m²/ha)

□ Where there are more than 20 m²/ha of culls:

□ Retain a thinning density and cull the remainder (80% of area); or

□ Remove culls to create a gap or a shelterwood (20% of the area). These areas would previously have been treated to result in a selective cut.

□ Regeneration in gaps would be considered for thinning to 350 spha at 10-15 years of age. (note that spha refers to stems per hectare)

2.3 Follow-up Treatment

□ Stump coppice (see Glossary for definition) will be treated with herbicide (foliar spray) following harvesting.

□ Sapling regrowth and some regrowth of secondary species will be treated with herbicide on a regular (10 yearly?) basis.

□ Prescribed burning will be conducted with the object of maintaining a fuel load of <8 tonnes/ha.”

Significant variations include removing all 'culls'⁴ in excess of the trees which have been marked for retention. In normal practice removals only take place within 4 m of a tree marked for retention. Another significant variation is considered to be the application of follow-up treatments of coppicing and return thinning which are not normally undertaken in silvicultural thinning of jarrah.

8. Research Program (ongoing)

An integral part of the development of the Wungong Project was the design and implementation of a research program to monitor environmental parameters so that the effects of forest thinning might be understood. The research program developed by the Water Corporation in relation to the Wungong trial incorporates 20 projects broadly categorized in the areas of water, land and biodiversity. The conservation of biodiversity is one of the foremost objectives of the FMP. In its advice on the project, the Conservation Commission highlighted the need to understand the impacts of disturbance on terrestrial and aquatic biodiversity elements. The importance of research designed to understand the impacts on biodiversity was reiterated in EPA advice to the Minister.

9. Project Implementation Management Plan (2008)

The EPA recommended a need for a formal Project Implementation Management Plan (PIMP) to be prepared by the Water Corporation. Details in relation to the EPA recommendations for the PIMP from *EPA Bulletin 1196* are included below as an extract:-

It is also understood that a project management plan may be prepared by the Corporation to manage the implementation of the project. Due to the level of public interest and the complexity of the project, the EPA recommends that a more formal Project Implementation Management Plan (PIMP) be prepared by the Corporation prior to or during the early stages of the project's implementation. The recommended PIMP should consolidate information from a number of areas of the project and clearly describe how the various commitments in the project document will be fulfilled. The PIMP should be in a form that can be accessed by the community and stakeholders, and be updated regularly as new information about the project becomes available.

It is recommended that the following matters to be included in the PIMP:

- *information on research proposals and environmental projects - specifically how they will be further scoped, funded and implemented etc;*
- *the development of the interagency structure and process as recommended by CALM; and*
- *a consultation strategy.*

At an operational scale the following matters may be included:

- *project objectives and key performance indicators;*
- *schedules and timelines for staged on-ground implementation;*
- *collection of baseline ecological data;*
- *monitoring proposals, including for example: an expanded water quality monitoring program which incorporates the advice of the DoE; and biodiversity monitoring, including some based on the ForestCheck system and integrated with groundwater monitoring, as advised by CC (note CC refers to Conservation Commission);*
- *demonstration of how adaptive management will occur at an operational scale. For example, information on how decisions on the implementation of the project will be guided by the results and outcomes of ongoing monitoring and research; and*
- *information on reviews and audits.*

4 Culling is the deliberate felling, poisoning or pushing down of unwanted overstorey or understorey species, usually to reduce competition to retained crop trees or for establishing regeneration.

In addition to CALM's role in ensuring that the project is undertaken in a manner consistent with the FMP, it is noted that CC would conduct audits of the activities in accordance with the FMP. The recommended PIMP could provide a basis for such audits."

A Project Implementation Management Plan was produced by the Water Corporation in 2008 and provided for this assessment. Further discussion and findings in relation to the contents of the PIMP are included in this document under Key Finding 4.

10. *Wungong trial draft review of research program (CSIRO 2008)*

The Water Corporation has also commissioned a review of the research program by CSIRO and a draft of the CSIRO commissioned research program review was provided for this assessment (see summary table in Appendix 2 - Research projects according to CSIRO assessment, ranked according to relevance, indicating status and relationship to FMP KPIs). The CSIRO review is referenced in this assessment report and the Conservation Commission acknowledges this Water Corporation initiative to monitor the progress of the research program.

11. *Wungong trial – Four-yearly review for the Conservation Commission of Western Australia (Water Corporation 2008)*

The Water Corporation has provided a four-yearly review of the trial to the Conservation Commission. Details in relation to the EPA recommendations for the first project review from *EPA Bulletin 1196* are included below as an extract:-

With respect to reporting, it is also recommended that the Corporation's first project review (proposed to occur every 4 years) be brought forward and be submitted to the CC in 2008. This would enable the Corporation's first project review to be incorporated with the CC's midterm audit performance report on the implementation of the FMP, which under the Ministerial Conditions for the FMP (Condition 2-2 of Ministerial Statement 641), is required to be submitted by 31 December 2008. This is followed by the EPA undertaking a review of CC's audit findings and the preparation of a publicly available report to the Minister for the Environment on CC's compliance with the Conditions.

The four-year review was received from the Water Corporation however it was received too late in 2008 to be incorporated into the mid-term audit of the FMP. This first project review essentially combines the previously published documentation (most of which is referred to above) and presents the 16 Key Performance Indicators (KPIs) for the trial however, apart from some discussion in relation to hydrology, there is little information available to-date in relation to the KPI performance measures. In terms of hydrology and the aim for improved runoff the Water Corporation has indicated in this document that *'a further 1-2 years of accurate streamflow data from Chandler Road and Cobiac stream gauging stations are needed to establish whether there has been an improvement in catchment runoff'*. The Water Corporation has reiterated in this review document that it continues to manage and support this trial project and that the trial is necessary to test the overall hypothesis that thinning regrowth forest in water catchment areas can provide environment and water benefits under a drying climate.

PERFORMANCE ASSESSMENT FINDINGS

The assessment results are presented under the World Commission on Protected Areas Performance Assessment Framework headings of Context, Planning, Inputs, Management Systems, Outputs and Outcomes. As the project is scheduled to run for 12 years, and it is in its early stages, the main focus of this report (PART A) is upon the context and planning outputs related to the project. PART B of the report will analyse the inputs and management systems in greater detail. There is provision for the project to be audited annually by the Conservation Commission, and it is expected that over time more information on outputs and

outcomes will become available from the program which can then be reported upon. The assessment observations are documented as either a 'Finding' or a 'Key Finding'. Where a 'Key Finding' has been identified it is accompanied by a management response developed following provision of the draft to the Water Corporation and the Department of Environment and Conservation (DEC) and consideration of their response by the Conservation Commission.

CONTEXT

Understanding the "context" of the area: - including its values; the threats that it faces and opportunities available; its stakeholders; and the management environment.

The majority of the Wungong catchment area is State forest, vested in the Conservation Commission and managed by DEC. The area is reserved for the purposes of conservation, recreation, timber production on a sustained yield basis, water catchment protection and other purposes prescribed in regulations. The Wungong Catchment is gazetted as a drinking water catchment. A Special Mining Lease exists over the Crown land in the catchment, enabling Alcoa World Alumina Australia to extract bauxite. The Jarrahdale mine site is now closed and no mining activity has occurred within the catchment since 1998. Other management of the catchment area includes forest and plantation management, such as timber harvesting, fire management and recreation. Approximately fifty percent of the catchment is dieback affected.

Western Australia, and specifically the Perth metropolitan area, has experienced unprecedented population expansion, and this combined with decreasing rainfall and the effects of climate change mean that pressure on the State's drinking water supply has increased.

Consistency of the planning and implementation of the project with the Forest Management Plan 2004-2013

At the project approval stage the Wungong project was considered by the Conservation Commission and DEC to be consistent with the FMP and in line with the Plan's intention for adaptive management through the conduct of trials of improvements to silviculture (Section 33). However this assessment has identified significant variations between the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* (2007) and the standard practice undertaken through *Silviculture Guideline 1* (2004). The extent to which these variations could be considered consistent with the original project proposals and the FMP are discussed here.

Implementation of the original proposal: Basal Area

In numerous references including the Water Corporation's *Response to Public Submissions* and *Forest Management Intensity Analysis (2004)*, and *EPA Bulletin 1196*, there is clear indication that the project proposal was to undertake thinning to a target basal area⁵ of 15-18 m² per hectare. The document *Forest Management Intensity Analysis (2004)* was prepared for the Conservation Commission to determine the silvicultural intensity of the Wungong proposal compared to past and future silviculture, and in turn assist in the decision-making relating to whether the proposal was consistent with the FMP. This report states that '*it appears the Wungong proposal is similar to or less intensive than past or future silviculture*' and that

⁵ Basal area measurements are the sum of the cross-sectional areas of trees in a given stand measured at 1.3 metres above the ground. It is usually expressed as square metres per hectare.

'Compared to the expected silviculture under the Forest Management Plan 2004-2013, the Wungong proposal will treat more area per year than a single harvest area, but uses treatments that retain more trees (or higher basal area). The comparisons in the Forest Management Intensity Analysis (2004) indicate a predicted basal area post treatment of 16.5 m²/ha. However, the Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment indicates a target success criterion of an average area marked from 12 to 16 m² per hectare. These targets appear to be at variance with the original project proposal to thin to a target basal area of 15-18 m² per hectare and the Forest Management Intensity Analysis (2004) which compared a thinning proposal for Wungong as 16.5 m²/ha versus 15 m²/ha under the Forest Management Plan 2004-2013. It is acknowledged that the marked basal area may differ from the final residual basal area figure due to missed stems and notching inefficiencies, however, it is unclear whether the planning target for basal area retention is still 15-18 m² per hectare as detailed in the proposal documentation.

Adaptive management and variations to silvicultural prescriptions

In 2007 the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* was implemented in the catchment. Under section 2 there are a list of variations to the standard jarrah silviculture prescription (*Silviculture Guideline 1 (2004)*). One of the listed variations is as follows;

All culls in excess of the nominated crop tree density are treated, compared to only those within 4 m of a crop tree. Culls within 5 m of a habitat tree are still retained.

Other variations not listed elsewhere have been identified in this assessment such as:- Appendix 4 of the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* and Appendix 4 of *Silviculture Guideline 1 (2004)*. This relates to the thinning regimes to be applied to different crop tree sizes. In particular crop tree sizes above 40cm at which size class the intention under the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* is to treemark a basal area to 12 m² per hectare (plus 2-3 m² per hectare of habitat trees), whereas under *Silviculture Guideline 1 (2004)* the schedule at the 40 cm size class is 18 m² per hectare and at the 50cm size class 20 m² per hectare. This detail of the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* is not consistent with the advice given through *Water Corporation response to submissions from 2005 public review* (Water Corporation 2005) which detailed the following:-

In particular some have assumed incorrectly the forest will be kept permanently at a basal area of 15–18 m²/ha, when in fact it will on average increase its basal area in time as it moves towards a more mature structure (Section 2.22).

Another variation in the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* is the variation of retention parameters for the intermediate rainfall zone⁶ of 12 m² per hectare (plus 2-3 m² per hectare of habitat trees) under the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* whereas under *Silviculture Guideline 1 (2004)* the guiding retention levels for the intermediate rainfall zone is 15 m² per hectare. Part of the Wungong catchment is in the intermediate rainfall zone and the basal area retention rate in the intermediate rainfall zone would need to be higher if the interim guideline were consistent with standard jarrah silviculture.

As outlined in section 2 of the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* there is also a variation to the standard jarrah silviculture prescription (*Silviculture Guideline 1 (2004)*) in relation to burning:-

⁶ Intermediate rainfall zone - Areas where the average annual rainfall is between 900 and 1100 millimetres per year.

Prescribed burning will be conducted with the object of maintaining a fuel load of <8 tonnes/ha

In the proposal document *Wungong Catchment Environment and Water Management Project (Water Corporation 2005)* the following statement is detailed in relation to burning (in this extract CALM is the Department of Conservation and Land Management (now DEC)):-

It is expected that CALM will continue with standard prescribed burning operations on this catchment for hazard reduction and for protection of life and of key property assets

This is a variation from the content of *Silviculture Guideline 1 (2004)*, and the use of fire as a follow-up treatment is not indicated in the proposal documentation. See further detail in relation to burning under Key Finding 5.

EPA Bulletin 1196 and Conservation Commission advice

The variations discussed here might be seen as acceptable within an adaptive management framework, and this possibility is discussed here. In *EPA Bulletin 1196* the following statement is made in relation to adaptive management and the Wungong project:-

“In the context of adaptive management, the EPA considers that it will be important for the project to include a capacity to vary thinning prescriptions and target basal areas during the implementation of the project. For example, variations to prescriptions and target basal areas should be undertaken by the Corporation where monitoring and research shows that environmental impacts are greater than expected.....The EPA expects that further details in relation to how adaptive management will occur with respect to prescriptions and basal areas and the decision making process to support this will be developed through the technical reference group and documented in the PIMP.”

The PIMP referred to above is the Project Implementation Management Plan produced in 2008 which does not contain details in relation to variations to prescriptions and the decision making process to support this (see Key Finding 4).

EPA Bulletin 1196 goes on to reference the advice received from the Conservation Commission (referred to as CC in the following extract) in relation to the project as follows:-

“...there is very limited trialling of a range of different thinning and management prescriptions. The CC is of the view that there is an opportunity to undertake adaptive management on a more experimental basis generating more knowledge for future application although perhaps leading to a lower increase in water yield. For example the proposal appears to be designed to only test one thinning regime over all available areas in most of the catchment (to 15 m²/ha basal area) against a control area in a small sub-catchment. The testing of a range of thinning options would be appropriate in a properly designed adaptive management trial.”

The Conservation Commission position in relation to the intent of this wording was outlined to the Water Corporation in correspondence on a separate proposal to reduce the retained basal area to 8m²/ha in the Cobiac catchment of the Wungong Catchment as follows:-

“The intention of this advice was that there would be merit in thinning to a higher target area to increase the value of the trial for future application through adaptive management. The Commission was not supporting thinning to a lower target. Subsequently the EPA noted in Bulletin 1196 that, “For example, variations to prescriptions and target basal areas may be required where monitoring and research shows that environmental impacts are greater than expected”. Both of these matters do not support a greater thinning regime as proposed.....It should also be noted that

the Conservation Commission in 2005 advised the EPA that the 'Wungong Catchment Environment and Water Management Proposal' was consistent with the objectives and actions of the Forest Management Plan 2004-2013. This was a fundamental requirement of the Wungong Trial. Following this advice and other factors such as the stakeholder group involvement in drafting the proposal it was considered by the EPA that formal assessment under the Environmental Protection Act was not necessary.....The Conservation Commission considers that thinning proposals in the Wungong catchment should be consistent with the jarrah silviculture guidelines which are specified in Appendix 5 of the Forest Management Plan 2004-2013 and the subsidiary document 'Silvicultural Practice in the Jarrah Forest (SFM Guideline No. 1 - 2004)'.

The Conservation Commission requested that the Water Corporation provide the *Forest Management Intensity Analysis* report in order to confirm unequivocally that the intensity of the proposed thinning will be consistent with the FMP. This report states that *'it appears the Wungong proposal is similar to or less intensive than past or future silviculture'* and that *'Compared to the expected silviculture under the Forest Management Plan 2004-2013, the Wungong proposal will treat more area per year than a single harvest area, but uses treatments that retain more trees (or higher basal area)*. In keeping with this advice the Conservation Commission advised the EPA that the proposal was *'consistent with the objectives and actions of the Forest Management Plan 2004-2013'*. However, this assessment has identified significant variations between the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)* and *Silviculture Guideline 1 (2004)*.

In summary the stated position of the Conservation Commission is that adaptive management trials under the *Wungong Catchment Environment and Water Management Project* could allow for variations to thinning prescriptions above those parameters indicated in the proposal documentation and not below; and that thinning proposals that vary from the parameters which were indicated in the *Wungong Catchment Environment and Water Management Project (2005)* should still be consistent with *Silviculture Guideline 1 (2004)*.

Key Finding 1

There are significant variations between the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* and the standard practice undertaken through *Silviculture Guideline 1 (2004)* and this planning aspect of the project is considered to be inconsistent with the FMP.

Water Corporation response (the full detail of the response is included as Appendix 4 with the perceived intent of the response summarised below in the following sentences)

The Wungong Project Team believes there are no significant variations between the Interim Guideline (SFM 1-2007) and the standard SFM Guideline for Silvicultural Practice (SFM 1-2004). The Team also believes that planning for development and approval of the Interim Guideline is consistent with the FMP.

.....

Basal Area – The target basal area for marking and the residual basal area after treatment will always be higher than that marked. This is due to some stems being missed during notching and other stems being notched but not dying.

The Water Corporation is aware that target basal areas for thinning in the Forest Management Plan 2004-2013 (Conservation Commission of Western Australia, 2004) are dependent on tree size and range from 10-12 m²/ha for 20-30 and 30-40cm respectively. There is also a requirement to leave at least 5 habitat trees/hectare. These add about 2-3m²/ha, depending on their size. Thus a retained basal area of 12-15 m²/ha is acceptable under the FMP within native forest. Practical experience shows that not all cull trees are notched and not all notched trees die. This is why water yield calculations to achieve a final basal area of between 15 and 18m²/ha were

conservatively based in the Water Corporation's initial documents. Should the final basal areas actually achieved in practice be between the FMPs acceptable limits of 12 and 15 m²/ha – this result would be very acceptable to the Water Corporation.

The Interim Guidelines sets out the success criteria by which the forest treatments will be measured (section 6.10.4; SFM 1-2007). These are general and aim to ensure that the project objectives are met without exceeding the parameters set out within related documents. The Interim Guidelines note success criteria including that 80% of the treatment areas will fall between a basal area of 12 and 16m².

The 'retained' basal areas after treatment were in fact 15.3 and 17.6 m²/ha, due to misses of 1.8 and 2m²/ha and notching inefficiencies of 92% and 86% respectively. These data were all made available during the operation audit, however it is anticipated that a more informed understanding of this process will be outlined in Part B of this review. (See Appendix 4 for further information provided in response to this finding by the Water Corporation).

Conservation Commission response

- The Conservation Commission were given to understand at the proposal stage of the project that under normal jarrah silviculture target basal areas are not commonly achieved due to the retention of 'cull trees'; and
- That the intent was to implement (under the Wungong proposal) essentially what is the current practice but actually achieve the proposed target basal areas (albeit at slightly higher retained basal area (15-18 m²/ha) than under normal jarrah silviculture (see page 8 of this report – extract from *Forest management intensity analysis (2004)*);
- It is considered that Appendix 4 of the Wungong interim guideline is not consistent with the original project proposal documentation (see Attachment 1 - *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment – Appendix 4 (DEC 2007)* for instance:-
 - A basal area level of 10 m²/ha (for thinning size classes 20-30 cm diameter) plus 2-3 m²/ha of habitat trees, results in a figure of 12-13 m²/ha (not 15-18 m²/ha);
 - A basal area level of 12 m²/ha (for thinning size classes over 30 cm diameter) plus 2-3 m²/ha of habitat trees, results in a figure of 14-15 m²/ha (not 15-18 m²/ha);
 - It is not specified in the proposal (or planning) documentation that the tree marking parameters of the trial would be below the level specified at the proposal stage to allow for 'missed trees and trees that were notched and did not die' as stated by the Water Corporation in their response (and this is considered an unacceptable approach). The Conservation Commission's view is that the guideline should specify the total basal area to be marked in the field for retention, and the parameters should be consistent with the original project proposal documentation;
- Aspects of the interim guideline are also not consistent with Appendix 4 of the FMP's *Silviculture Guideline 1* for instance:-
 - The project proposal documentation states that the thinned forest '*will on average increase its basal area in time as it moves towards a more mature structure*', whereas the Wungong interim guideline indicates that the thinned forest will in fact be kept at a constant basal area (12 m²/ha plus 2-3 m²/ha of habitat trees) for size classes above 30cm diameter (Attachment 1 - *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment – Appendix 4 (DEC 2007)*);
 - Appendix 4 of the FMP's *Silviculture Guideline 1* clearly shows an increase in basal area over time as the size classes increase (see Attachment 2 - appendix 4 from *Silvicultural Practice in the Jarrah Forest (DEC-SFM Guideline No.1 2004)*). This aspect of the interim guideline is not consistent with the proposal details (see Attachment 3 – *Water Corporation response to 2005 public review of Wungong project (Water Corporation 2005)*, and as it is also not consistent with the current silvicultural guideline, and the Conservation Commission view is that this variation is not consistent with the Forest Management Plan 2004-2013;

- In Appendix 4 of the Wungong interim guideline, a figure of 12 m²/ha (plus 2-3 m²/ha of habitat trees) is specified for size classes below 30 cm diameter (Attachment 1 - *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* – Appendix 4 (DEC 2007));
- If the similar table in Appendix 4 of *Silviculture Guideline 1* is read in the same manner, it indicates that crop tree basal area in the intermediate zone is intended to be 15 m²/ha (plus 2-3 m²/ha of habitat trees) for size classes below 30 cm diameter (see Attachment 2 - appendix 4 from *Silvicultural Practice in the Jarrah Forest (DEC-SFM Guideline No.1 2004)*). It should follow that the relative retention parameters (higher) for the intermediate rainfall zone would apply;
- Consistency with the Forest Management Plan 2004-2013 was the premise for the project not requiring assessment under the Environmental Protection Act.

The Conservation Commission recommends that the Water Corporation undertake the following measures:-

- The Water Corporation consult with DEC and amend Appendix 4: Jarrah Thinning Intensity (*Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)*) to specify the total basal area to be marked in the field for retention with parameters that are consistent with the original project proposal documentation;
- The Water Corporation consult with DEC and amend Appendix 4: Jarrah Thinning Intensity (*Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)*) to conform with the commitments given in the document *Water Corporation response to submissions from 2005 public review (Water Corporation 2005)*;
- Following the amendment of the thinning schedule in Appendix 4: Jarrah Thinning Intensity (*Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)*) the Water Corporation consult with DEC and include the relative retention parameters for the intermediate rainfall zone in the Appendix 4: Jarrah Thinning Intensity (*Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)*);
- Present for consideration by the Conservation Commission proposed silvicultural guidelines for the Wungong Catchment Thinning Trial.

The research program

An integral part of the development of the Wungong Project was the design and implementation of a research program to monitor environmental parameters so that the effects of forest thinning might be understood. The research program developed by the Water Corporation in relation to the Wungong trial incorporates 20 projects broadly categorized in the areas of water, land and biodiversity.

The conservation of biodiversity is one of the foremost objectives of the Forest Management Plan (FMP). In its advice on the project, the Conservation Commission highlighted the need to understand the impacts of disturbance on biodiversity elements. The importance of research designed to understand the impacts on biodiversity was reiterated in EPA advice to the Minister.

The provision of data against the key performance indicators in the FMP constitutes part of the responsibility for the project to be consistent with the objectives and actions of the plan. The individual research projects are designed to address these, along with project indicators (developed by the Water Corporation).

As part of this performance assessment the Conservation Commission requested that the Water Corporation provide relevant documentation. The Water Corporation provided documents pertaining to aquatic biodiversity, fauna, vegetation, birds, demonstration sites and forest. The Water Corporation has also commissioned a review of the research program by CSIRO and a draft of the CSIRO commissioned research program review was also provided for this assessment (see summary table in Appendix 2 - Research projects according to CSIRO assessment, ranked according to relevance, indicating status and relationship to FMP KPIs).

From the CSIRO review, and information collected for this performance assessment, the following points are highlighted:-

- Baseline data has been collected for monitoring parameters such as seasonal groundwater levels, botanical biodiversity and fauna including aquatic fauna and birds.
- The review of the research program by CSIRO found, for example, that the study of fungi did not cover treated and non-treated areas to the extent that changes could be related to thinning; similarly, it found that there is no clear correlation between the surveys and thinning work in the project on cockatoos, other avifauna and small ground vertebrates.
- There have been delays regarding important projects such as FORESTCHECK⁷ and Ecosystem response to thinning. The establishment of the FORESTCHECK project has been delayed until at least 2012.
- There is also a gap in research in the area of productive capacity. The research trials do not appear to include a study of the effects of varied thinning criteria on the long-term productive capacity of the forest. It is considered that information in relation to potential changes in woodflow⁸ from the Wungong trial would need to be determined in conjunction with the other factors of ecologically sustainable forest management when the outcomes of the trial are assessed.
- Project indicators have not been developed beyond the stage of naming the Key Performance Indicator (KPI) titles.

The delay in FORESTCHECK monitoring is of particular significance. Vital outputs from FORESTCHECK include measures of species richness, composition and abundance, invasion by exotic plant species, understorey structure and cover, overstorey composition and density (including tree basal area figures). The Conservation Commission considers that monitoring forms the basis for adaptive management and that monitoring is a fundamental component of ecologically sustainable forest management (ESFM). Furthermore the Conservation Commission specifically requested that the trial incorporate the FORESTCHECK monitoring program and EPA advice on the project was based in part on a commitment by the Water Corporation to include FORESTCHECK monitoring. This has implications especially for the viability of the biodiversity component of the research and the generation of a knowledge-base on which the adaptive management process is dependent.

Key Finding 2

There are gaps in the research program and critical delays on important biodiversity research projects, such as FORESTCHECK, which are of fundamental importance to the delivery of biodiversity research outputs. This is an important deviation from the commitment which was given at the proposal stage of the Wungong trial.

Water Corporation response

The Water Corporation identified 'gaps' in the research program and subsequently commissioned the CSIRO review. Copies of the review were provided to the Project's Technical Reference Group and the Auditor and made readily available through the Project website and by contacting the Water Corporation. The Water Corporation accepted the findings in the review and welcomes constructive input from all stakeholders, particularly the State's scientific community. In addition the research program will be adapted as per the CSIRO's recommendations.

⁷ FORESTCHECK is an integrated monitoring system developed by DEC to provide information to forest managers about any changes and trends in key elements of forest biodiversity associated with a variety of forest management activities.

⁸ Woodflow is the projected annual supply of timber arising from scheduling the area of forest available and the sequence of harvesting operations over an extended period of time.

It should be recognised that interim results of the research work being done during the 12-year trial have already been published and updates will continue to be uploaded to the website. In addition, the Water Corporation has undertaken to communicate final results on the completion of the trial. The table of research projects as described in the FMPPA Appendix 2 does not correctly reflect the status of all the projects at the time of audit. (See Appendix 4 for further information provided in response to this finding by the Water Corporation).

Conservation Commission response

The Conservation Commission acknowledges the Water Corporation initiative to identify potential gaps in biodiversity knowledge and looks forward to the outcomes of this process. In addition, the Conservation Commission recommends that the Water Corporation consult with DEC on research to include a study of the effects of varied thinning criteria on the long-term productive capacity of the forest.

In relation to the lack of implementation of FORESTCHECK, the original intent for integration is consistent with the *EPA Bulletin 1196* which states, “-the Corporation has agreed to undertake biological monitoring, including monitoring based on CALM’s ForestCheck system and integrated with groundwater monitoring, as recommended by the CC.” (See Attachment 4 – extract from EPA Bulletin 1196 (Environmental Protection Authority 2005). The Water Corporation have indicated in their response to this finding that the funds are available to implement FORESTCHECK but it has continued to be deferred due to the limited availability of FORESTCHECK research expertise

The Conservation Commission specifically requested that the trial incorporate the FORESTCHECK monitoring program and EPA advice on the project was based in part on a commitment by the Water Corporation to include FORESTCHECK monitoring. This is an important deviation from the commitment which was given at the proposal stage of the Wungong trial. The Conservation Commission recommends that the Water Corporation establish FORESTCHECK biodiversity monitoring sites and implement pre-treatment monitoring on future treatment areas.

PLANNING

Through "planning":- establishing vision, goals, objectives and strategies to conserve values and reduce threats.

Memorandum of Understanding

The need for an interagency agreement that defines the responsibilities and process of the Wungong Project was outlined in *EPA Bulletin 1196*. There is a draft Memorandum of Understanding between DEC and the Water Corporation however the document has not been formally signed-off by the two agencies. Therefore there is no binding agreement for the responsibilities for implementation of the project.

Key Finding 3

The draft Memorandum of Understanding between the Water Corporation and DEC has not been signed-off and there is no binding agreement in relation to the project responsibilities.

Water Corporation response

The draft Memorandum of Understanding (MOU) has been continuously reviewed by Water Corporation and DEC officers and successful working arrangements undertaken since 2005. The MOU was formalised by signatories being the CEO Water Corporation and Executive Director DEC early in 2009.

Conservation Commission response

The Conservation Commission acknowledges this Water Corporation advice.

Project Implementation Management Plan

The EPA highlighted the need for a formal Project Implementation Management Plan (PIMP), to be prepared by the Water Corporation. The EPA outlined the series of matters to be included in the PIMP, such as information on research, interagency structure and consultation and also key operational matters including project objectives and indicators, schedules, collection of baseline data, monitoring proposals, an outline of adaptive management at the operational scale and information on reviews and audits. With regard to reporting and auditing responsibilities, the EPA stated that the recommended PIMP could provide the basis for Conservation Commission audits of the activities in accordance with the FMP. The Water Corporation produced a PIMP in May 2008.

This assessment has highlighted that key elements of the PIMP lack operational planning details, such as;

- detail relating to the various silvicultural objectives (shelterwood, gap, thinning) for treatment areas;
- how adaptive management will occur with respect to prescriptions and basal areas and the decision making process to support this;
- schedules for dieback interpretation;
- details of proposed applications of fire by treatment area, where this is to be applied, objectives and timing;
- details of the types of thinning and follow-up controls to be undertaken in different silvicultural treatment areas, e.g details on the application of foliar spray and ensuring that adequate regeneration levels are maintained along with the protection of understorey species;
- schedules for thinning activities, follow-up controls and the objectives and timing for return thinning;
- detail in relation to the types and frequency of supervision monitoring activities which will be applied and the parties responsible for undertaking these activities;
- reference to the induction and training of persons who will be undertaking thinning activities in the catchment and the types of activities which will be undertaken by low-skilled workers.

Key Finding 4

The contents of the PIMP deliver little detailed guidance for undertaking an audit, and in general the PIMP does not fulfil the other EPA recommendations, particularly at an operational scale.

Water Corporation response

The Project Implementation Management Plan (PIMP) content and presentation is consistent with Water Corporation standard used in all project management. The status of operational work is shown in separate detailed maps within the PIMP and regularly updated and distributed to members of the Technical Reference Group and on request to the Corporation's CEO and Board. The PIMP has also been published on the Project's website. (See Appendix 4 for further information provided in response to this finding by the Water Corporation).

Conservation Commission response

The Conservation Commission notes that in its full response to this key finding the Water Corporation has indicated that it will include operational detail for the PIMP in line with the EPA recommendations.

Fire

An overall aim of the FMP is to seek to sustain or enhance forest ecosystem health and vitality. With respect to fire, the FMP states that a competent fire management, suppression and response capability must be maintained, along with the preparation and maintenance of a fire management plan and smoke management guidelines. An annual prescribed burning program is to be maintained and executed in a manner that is in accordance with the fire management plan, the smoke management guidelines and the Goals for Understorey Structural Diversity (referred to in Action 4.1 of the FMP). Consideration is to be given to any special vulnerability of fauna and flora known to exist in a particular area to burning in that area.

In the proposal document *Wungong Catchment Environment and Water Management Project (Water Corporation 2005)* the following statement is detailed in relation to burning:-

It is expected that CALM will continue with standard prescribed burning operations on this catchment for hazard reduction and for protection of life and of key property assets

The stated strategy in the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* is detailed as follows:-

“Understorey is expected to increase in density following thinning and this will have an adverse impact on water yield. In order to reduce the average period over which understorey transpires strongly and to reduce rainfall interception by heavy litter, a burning frequency aimed at maintaining fuel loads of <8 tonnes per hectare is the objective.”

During interviews for this assessment, DEC staff indicated that the buildup of fuel from logging/thinning activities will substantially increase the fire risk for managing affected areas particularly when no advanced burning (i.e. before the thinning activities) has taken place. It was indicated by DEC that it would be difficult to achieve a mosaic burn unless prescribed burning was undertaken prior to the logging/thinning operation. According to DEC a fuel load measure of approximately 8.5 tonnes per hectare is considered to be the fuel point above which direct attack in a wildfire situation is considered unsafe. Apart from this information derived from the interviews, in this assessment the Conservation Commission was unable to find previous reference to the use of this prescribed burning parameter (less than 8 tonnes per hectare of fuel) in the silvicultural guidelines (no reference was located in *Silviculture Guideline 1 (2004)* or *Silvicultural Guideline 1/97 - fire as a silvicultural tool in the jarrah forest*).

A range of options have been proposed for managing this build up of fuel loading in the thinned areas; however, it is unclear from the planning documentation how this will be managed operationally through prescribed burning (also see Key Finding 4 on Project Implementation Management Plan). In particular there is a lack of detail relating to prescribed burning frequency. It is also noted in the research and monitoring program that there will be a project in the adjacent 39 Mile Brook Catchment to “*evaluate the effect of frequent prescribed burning on stream water quantity and quality*”. The method of this related research trial is to apply four to six yearly prescribed burning and monitor the results. It is unclear whether the intention then would be to control burn the Wungong thinning areas at the same frequency and treat the 39 Mile Brook Catchment as a controlled study area, and if so, how this would deliver information on the combined effects of logging/thinning and burning.

Key Finding 5

It is unclear what the goal of maintaining fuel to less than 8 tonnes per hectare will practically mean in relation to prescribed fire frequency and intensity for the Wungong Catchment trial area.

Water Corporation response

The DEC has responsibility for planning and implementing a fuel reduction programme in the Wungong catchment. As stated in the FMPPA (pp 17), DEC Fire Management Services consider that a fuel load measure of about 8.5 tonnes per hectare is considered as the point above which direct attack in a wildfire situation is considered unsafe.

The review fails to recognise that the majority of TA 1 [Treatment Area 1] was advance burnt by DEC prior to commencing any treatment (this work being financed by the Water Corporation). The demonstration site and surrounding native forest which was commercially harvested by FPC had a post follow-up burn in 2007. This area is considered much larger than the 'small demonstration plot' as stated in the Audit. The areas that were not advance burnt in Treatment Area 2 were commercially logged by FPC, not by the Water Corporation. (See Appendix 4 for further information provided in response to this finding by the Water Corporation).

Conservation Commission response

The Conservation Commission queries the inclusion of prescribed burning as a "Follow-up Treatment" as referenced on page 7 of the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)*. This is a variation from the content of *Silviculture Guideline 1 (2004)*, and the use of fire as a follow-up treatment is not indicated in the proposal documentation (also see discussion preceding Key Finding 1). The following aspects in relation to fire are noted:-

- A fuel-load figure of less than 8 tonnes per hectare is vague and would potentially allow maintenance of any fuel loading below a figure of 8 tonnes;
- The FMP's *Silviculture Guideline 1* does not refer to the use of fire as a 'follow-up' treatment (it is included in the Wungong interim guideline under section 6.10 'Additional Follow-up Treatment' - see Attachment 5 extract from *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (DEC 2007)*);
- The Conservation Commission noted in the report that it was indicated by DEC that it would be difficult to achieve a mosaic burn unless prescribed burning was undertaken prior to the logging/thinning operation;
- It is unclear from the Wungong interim guideline (or the PIMP) how fire will be applied and scheduled i.e., pre-thinning, post-thinning and tops disposal and how these operations might interrelate with higher than normal fuel-loads as a result of thinning activities.

The Conservation Commission recommends consulting with DEC, removing reference to the use of prescribed burning as a "Follow-up Treatment" and including detail on prescribed burning in the PIMP (also see discussion preceding Key Finding 4).

In relation to the Water Corporation response on the lack of recognition in the report relating to advance burning activities, the related wording in the assessment report has been amended as the operational implementation of the trial will be examined through Part B of this assessment.

Rainfall levels

The *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment* lists isohyets (rainfall averages represented in a mapped isoline⁹) which are used as a guide for certain silvicultural purposes. The main use of isohyets in the Wungong Silvicultural Prescription relates to Appendix 4 which stipulates the different thinning intensities to be applied with a reference to different basal area retention in the intermediate rainfall zone. According to the DEC corporate dataset, the years which have been included in the isohyets calculations are 1987 to 1994. Other references to the isohyets layer such as the Water Corporations *Forest management intensity analysis (2004)* refer to the isohyets being based upon rainfall for the years 1961-1981; EPA Bulletin 1196 refers to the high rainfall zone 'based on the 30 years to 1980'. All referenced datasets are considered to be a narrow span to utilise for averages, and it is unclear if these datasets are subject to periodic updating. There are questions in relation to their origin and basis. The isohyets dataset could be expected to be updated at some point in the future, which may change the relative position of the rainfall zones and therefore the variations in the prescription to be applied. Clarification on the use and background of the isohyet dataset for silvicultural activities is required.

The use and update of this corporate dataset may also have broader implications for management outside the Wungong Catchment in relation to a changing climate. See below extract from the Silviculture Guideline 1 (2004):-

While the impact of climate change is unlikely to be significant in the short term, the change in rainfall and its seasonal distribution is expected to affect the biological diversity, productive capacity, ecosystem health and hydrology of the jarrah forest. This may change the notional representation of the 900 mm isohyet, and increase the area that needs to be treated as eastern jarrah forest. Monitoring climate change will be important in ensuring that the planning and management of these stands are able to be adapted in a timely manner.

Key Finding 6

Clarification is required in relation to the origin and status of the datasets used to derive the isohyets which are then used for setting parameters in the silvicultural prescriptions of the trial.

Water Corporation response

The rainfall isohyets used in all mapping for the Wungong Trial are consistent with historic rainfall dataset and is identified as: "Average annual rainfall isohyets (1926-1979,1980,1981) (Based on Public Works Department, Water Resources Investigations Technical Note 78 & Branch Report WRB 3 & WRB 35 & WRB 79)". Originally defined at a scale of 1 : 250 000. These are the same parameters used by DEC operations within the forest areas and the Wungong project is not proposing to vary from current protocols. (See Appendix 4 for further information provided in response to this finding by the Water Corporation).

Conservation Commission response

It is noted from the Water Corporation response that the historical isohyets boundaries correspond well with groundwater salinity and they are used for a specific purpose. As this is a long-term project and there are conflicting references and other rainfall isohyet datasets in use within DEC, it is suggested that these historical isohyets lines are referenced in a way that will clearly identify the dataset and its special purpose from other isohyet datasets (which may have different geographical distributions now or be altered in the future).

⁹ Isolines - a line on a map or chart along which there is a constant value (as of temperature or rainfall).

It should also be noted that the information provided above has emphasized that the various documentation sources list different datasets and that this latest information remains at odds with the details from the various documentation sources e.g. Figure 11 on page 27 of the document *Wungong Catchment Environment and Water Management Project (Water Corporation 2005)* states the following:- 'Figure 11 Wungong Catchment monitoring locations (note: isohyets are based on 30 years to 1981, and are used for salt risk assessment)'.

CONCLUSION

This Conservation Commission performance assessment reviewed the context and planning elements of the Water Corporations '*Wungong Catchment Environment and Water Management Project*'. In summary the following should be noted:-

- The Water Corporation has commissioned a review by CSIRO of the project's research program and produced numerous planning documents in relation to the trial including the *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)*;
- The *Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007)* contains variations to *Silviculture Guideline 1 (2004)*. Some of these variations are inconsistent with the documentation provided at the proposal stage of the project and this planning aspect of the project is considered to be inconsistent with the *Forest Management Plan 2004-2013*;
- The Conservation Commission's position on adaptive management is that adaptive management trials under the *Wungong Catchment Environment and Water Management Project* could allow for variations to thinning prescriptions above those parameters indicated in the proposal documentation and not below. Advice at the proposal stage of the project from the Conservation Commission was not supporting thinning to a lower target basal area than proposed. Thinning proposals that vary from the parameters which were indicated in the *Wungong Catchment Environment and Water Management Project 2005* should still be consistent with *Silviculture Guideline 1 (2004)*;
- There are critical delays on important biodiversity research projects, such as FORESTCHECK.

Overall, there appears to be important deviations from the indications and commitments which were given at the proposal stage of the Wungong trial.

After consideration of the responses to the key findings from the Water Corporation, the Conservation Commission has made several recommendations in its response which are summarized as follows:-

- the Water Corporation establish FORESTCHECK biodiversity monitoring sites and implement pre-treatment monitoring on future treatment areas;
- the Water Corporation consult with DEC and amend *Appendix 4: Jarrah Thinning Intensity (Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007))*;
- the Water Corporation consult with DEC and remove reference to the use of prescribed burning as a 'Follow-up Treatment' in the document *Jarrah Thinning Intensity (Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment (2007))* and include detail on prescribed burning in the PIMP;
- Present for consideration by the Conservation Commission proposed silvicultural guidelines for the Wungong Catchment Thinning Trial.

Part B of this assessment will assess the operational activities associated with implementation of the project, in particular the application of the documents described in this report (Part A). While there have been recommendations to alter the planning documentation through this

report (Part A), the possibility exists that further planning documentation changes will be recommended through information gathered during Part B of the assessment. There is provision in the '*Wungong Catchment Environment and Water Management Project*' for annual auditing by the Conservation Commission and priorities for ongoing assessments will be derived from Part A and Part B of this initial assessment.

APPENDIX 1 - Assessment Process Summary

- Performance Assessment Plan sent to Water Corporation in June 2008;
- Interviews and assessments undertaken September/October 2008;
- Water Corporation response to Key Findings received 21 April 2009;
- Final version presented at Conservation Commission meeting on May 11th 2009, with delegation to the Chairman for final approval of suggested changes;
- Due to an extended delay this report was reviewed in 2010 with minor updates due to the passage of time;
- Copy sent to the Water Corporation in July 2010 to provide an opportunity for a review of their initial (2009) response, with some minor changes made;
- Published August 2010.

APPENDIX 2: Research projects according to CSIRO assessment (2008), ranked according to relevance, indicating status and relationship to FMP KPIs.

	Project description	Addressing FMP objectives (KPIs)	Status
1	Monitor rainfall, streamflow and water quality	22 water production 28 adaptive mangt 19 stream salinity trends	Indicates that data has been collected and analysed but does not indicate findings.
2	Analyse streamflow data and validate LUCICAT model for hydrological simulation	22 water production 28 adaptive mangt 19 stream salinity trends	Initial results for calibrating and validating model described as encouraging; no report on streamflow
3	Collect data and validate WEC-C model for predicting of interflow in bauxite mining pits	22 water production	-
4	Measure seasonal groundwater levels and analyse trends to better understand impacts of a drying climate on land-use changes on levels	22 water production 19 stream salinity trends	Baseline data
5	Evaluate effectiveness of frequent prescribed burning on stream water quality and quantity	22 water production 28 adaptive mangt	-
6	Monitor effects of wildfire on water, vegetation and biodiversity	22 water production	Shows early deposits in streams but soil stabilizes after a year. Runoff increases in first 2 years but then becomes less than before burn. Habitat damage; ecosystem less diverse.
7	Monitor vegetation dynamics and water yield under changing climate and management	22 water production 28 adaptive mangt	Change in health indicated

8	Monitor changes in vegetation structure and health	6 9 10 12 18 21 31	Rehab areas have higher LAI so expect less runoff
9	Monitor changes in leaf area index due to catchment thinning, dieback and vegetation stress	31	-
10	Assess impact of forest thinning on public perceptions of recreational value and ecosystem health	26	-
11	Establish demonstration/information sites to facilitate community understanding of the project	26	-
12	Sapflow measurements to determine transpiration rates	22 28 31 33	-
13	Vegetation monitoring to measure effect of trials on botanical biodiversity	31 33 10 28 Also 2, 3, 9, 10, 17, 18	Baseline monitoring completed
14	Fauna monitoring	2, 3, 31, 33, 28	Too early to define trends in data collected
15	Community-based study of fungi aimed at raising awareness of fungi in catchment	Potential for 31, 33, 10, 28 and also 17, 18, 29 (but not in current form)	-
16	Monitor biodiversity in jarrah forest using FORESTCHECK	2, 3, 10, 17, 18, 20, 21, 31, 33, 28	Project deferred may not proceed until 2012
17	Monitoring dieback	2, 3, 10, 18, 28, 31,	-

		33	
18	Monitoring cockatoos, avifauna and small ground vertebrates	2, 3, 10, 24, 31, 33, 28	Draft report for avifauna and cockatoos prepared
19	Aquatic fauna biodiversity assessment	2, 3, 19, 20, 31, 33, 28	Initial monitoring results available in report
20	Ecosystem response to thinning	2, 3, 9, 10, 17, 20, 21, 22, 31, 33, 28	Delayed

APPENDIX 3

Glossary

Adaptive management	A process of responding positively to change. The term adaptive management is used to describe an approach to managing complex natural systems that builds on common sense and learning from experience, experimenting, monitoring, and adjusting practices based on what was learned.
Advance growth	Young trees that have established themselves in openings in the forest, or under the forest cover, before regeneration harvesting is undertaken.
Basal area	The sum of the cross-sectional areas of trees in a given stand measured at 1.3 metres above the ground. It is usually expressed as square metres per hectare.
Biological diversity (Biodiversity) (described in CALM Act)	The variability among living biological entities and the ecosystems and ecological complexes of which those entities are a part and includes: (a) diversity within native species and between native species; (b) diversity of ecosystems; and (c) diversity of other biodiversity components.
Biological diversity component (described in CALM Act)	Includes habitats, ecological communities, genes and ecological processes A named administrative subdivision of the forest, varying in size from about 3,000 to 8,000 hectares.
Bole	The tree trunk from the ground to the crown break. The bole does not include the major branches supporting the crown.
Bole sawlog	The bole of the felled tree but docked at each end so that there is a minimum of one second grade sawlog.
Buffer strip	A strip of vegetation retained on the edge of a feature such as a stream or rock outcrop. Buffer strips can serve a variety of purposes in the landscape, including protection of the feature from a disturbing activity, and provide flora and fauna habitat and aesthetic values.
Catchment	The surface area from which water runs off to a river or any other collecting reservoir.
Clearfelling	A silvicultural system in which the trees are removed at one time to allow regeneration to establish and develop as an even-aged stand.
Coppice	A shoot (or shoots) arising from adventitious buds at the base of a woody plant that has been cut near the ground or burnt back.

Criterion	A category of conditions or processes by which sustainable forest management may be assessed. A criterion is characterised by a set of related indicators that are monitored periodically to assess change.
Culling	The deliberate felling, poisoning or pushing down of unwanted overstorey or understorey species, usually to reduce competition to retained crop trees or for establishing regeneration.
Critically endangered	A taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.
Dieback	In the south-west of Western Australia, a disease of plants caused by infection by the soil-borne organisms of the genus <i>Phytophthora</i> .
Disturbance	Any range of conditions affecting the condition of a natural area. Disturbance may be natural (e.g. fire) or human induced (e.g. timber harvesting).
Ecological community	An integrated assemblage of species that inhabit a particular area.
Ecologically sustainable forest management (ESFM)	Forest management and use consistent with the principles described in section 19(2) of the CALM Act.
Ecosystem	A community or an assemblage of communities of organisms, interacting with one another and the environment in which they live.
Endangered	A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the near future.
Environmental Management System	A framework for the systematic management of an organisation's environmental obligations and targets. Often conforming to a standard, the most popular being AS/NZS ISO 14001.
Epicormic	Vegetative shoots arising on the bole or branches of a tree as a consequence of damage to its crown.
Exotic species	Any species growing or living outside its natural range of occurrence. Normally this refers to species purposely or accidentally introduced into countries or regions where they do not historically occur.
Fauna	<p>The animals inhabiting an area; including mammals, birds, reptiles, amphibians and invertebrates. Usually restricted to animals occurring naturally and excluding feral or introduced animals.</p> <p>With respect to the Wildlife Conservation Act, fauna is:</p> <p>(a) any animal indigenous to any State or Territory of the Commonwealth or the territorial waters of the Commonwealth;</p> <p>(b) any animal that periodically migrates to and lives in any State or Territory of the Commonwealth or the territorial waters of the Commonwealth; and</p> <p>(c) any animal declared as fauna pursuant to subsection (2),</p>

and includes in relation to any such animal –

(d) any class or individual member thereof;

(e) the eggs, larvae or semen;

(f) the carcass, skin, plumage or fur thereof, but does not include any prescribed animal or prescribed class of animal.

Feral	<u>An introduced or domestic animal now living in the wild.</u>
Fire regime	<u>The combination of season, intensity, interval, extent and patchiness of fire in a given area over a period of time.</u>
Flora	<p>The plants growing in an area; including flowering and non-flowering plants, ferns, mosses, lichens, algae and fungi. Usually restricted to species occurring naturally and excluding weeds.</p> <p><u>With respect to the Wildlife Conservation Act flora is any plant (including any wildflower, palm, shrub, tree, fern, creeper or vine) which is: (a) native to the State or (b) declared to be flora pursuant to subsection (4), and includes any part of flora and all seeds and spores thereof.</u></p>
Forest	An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding two metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20 per cent.
Forest ecosystem	An indigenous ecosystem with an overstorey of trees that are greater than 20 per cent crown cover. These ecosystems should normally be discriminated at a resolution requiring a map-standard scale of 1:100,000. Preferably these units should be defined in terms of floristic composition in combination with substrate and position within the landscape.
Forest operations	Work activities undertaken in the forest to achieve the management objectives for that forest.
Forest produce	For the purposes of the CALM Act includes trees, parts of trees, timber, sawdust, chips, firewood, charcoal, gum, kino, resin, sap, honey, seed, bees-wax, rocks, stone and soil but, subject to the foregoing, does not in Division 1 of Part VIII include minerals within the meaning of the Mining Act 1978.
Forest products	For the purposes of the CALM Act and the Forest Products Act: (1) Subject to subsection (2) trees or parts of trees; timber, sawdust or chips; charcoal, gum, resin, kino or sap; and firewood. If they are located on public land or sharefarmed land. (2) When something referred to in subsection (1) has been removed under contract or arrangement entered into by the Commission, any residues

	that remain are not forest products for the purposes of this (FP Act) Act.
Forest regeneration	The renewal of a forest arising from planting or from seed or the young plants on a site. The process by which a forest is renewed.
Gap	A discrete opening in the overstorey canopy created to reduce competition to allow seedlings to become established and or develop.
Guideline	Principles, standards and practices for meeting goals that have been established as desirable outcomes for management. They can be quantitative or qualitative.
Habitat	A component of an ecosystem providing food and shelter to a particular organism.
Heritage	Something inherited from past generations that is valued.
High rainfall zone	Areas where the average annual rainfall exceeds 1100 millimetres per year.
Hygiene – in relation to dieback	Actions that decrease the risk of the pathogen being introduced spread or intensified.
Indicator	A measure (measurement) of an aspect of a criterion. A quantitative or qualitative variable that can be measured or described and that, when observed periodically, demonstrates trends.
Intermediate rainfall zone	Areas where the average annual rainfall is between 900 and 1100 millimetres per year.
Lignotuber	A woody swelling formed at the base of some eucalypts that has the ability to produce new shoots when the existing ones are destroyed.
Low rainfall zone	Areas where the average annual rainfall is less than 900 millimetres per year.
Monitoring	Regular assessment of a management program and of the resources being managed, checking that desired outcomes are achieved, and adjusting the new plan where necessary.
National estate	Those elements of the natural environment, the Aboriginal environment and the historic environment which are of special value to the Australian community, present and future.
Non-bole log	Timber from the branches of a tree above the crown break on the bole. Non-bole material is not included in inventory and is additional to the sustained yield.
Old-growth forest	Ecologically mature forest where the effects of unnatural disturbance are now negligible. The definition focuses on forest in which the upper stratum or overstorey is in a late mature to senescent growth stage.
Patch	A group of trees resulting from a natural regeneration event or a past management activity such as gap creation and regeneration.
Performance measure	Qualitative or quantitative measures developed to assess progress toward attainment of an objective.
Pest	Troublesome or destructive animals including insects, either introduced or native.
Plantation	State forest and timber reserve planted with exotic species.

Plantation management area	The total area within a defined management boundary that includes all of the areas planted with exotic species.
Prescribed burning	The planned application of fire under selected fuel and weather conditions to a defined area to achieve specific management objectives.
Prescription	A detailed specification of the objectives, area, procedures and standards for a task to be undertaken.
Policy	The course of action to be followed to achieve an organisation's objectives.
Rare species	Taxa which are uncommon, not widely distributed, or occurring sparsely across their range.
Recovery plan	A plan that describes the actions required to achieve the recovery of threatened species or ecological community from the current threat of extinction or destruction.
Rehabilitation	The process necessary to return disturbed land to a predetermined surface, vegetational cover, land-use or productivity.
Reserve – conservation	An area set aside primarily for the conservation of natural ecosystems but which may allow a level of recreation consistent with the proper maintenance and restoration of the natural environment.
Reserve – formal	One of the land category categories of national park, nature reserve, conservation park, or CALM Act sections 5(1)(g) or 5(1)(h) reserves for the purpose of conservation.
Reserve – informal	An area set aside for conservation under an approved management plan; has had opportunity for the public to comment on changes to reserve boundaries; able to be accurately defined on a map; and is of an area and design sufficient to sustain the values it seeks to protect.
Riparian	Pertaining to the banks of streams, rivers or lakes.
Rotation	The planned number of years between the establishment of a crop and its felling.
Second grade sawlog jarrah	A log cut from the bole of a jarrah tree that is a minimum of 2.1 metres in length, has a minimum under bark diameter of 250 mm and has a minimum of 30% millable timber on the worst end face.
Second grade sawlog karri	A log cut from the bole of a karri tree that is a minimum of 2.4 metres in length, has a minimum under bark diameter of 300 mm and has a minimum of 30% millable timber on the worst end face.
Shelterwood system	A jarrah silvicultural system that involves a partial removal from the overstorey of some mature trees and action to establish regeneration under the remaining mature trees. When the regeneration is sufficiently established most of the remaining mature trees are removed to allow the regeneration to develop.
Silviculture	The theory and practice of managing forest establishment, composition and growth to achieve specified management objectives.
Snig track	A track along which logs are pulled from the felling point to a landing or point of loading.
Soil Dryness Index	A predictor of the deficiency of soil moisture in a hypothetical soil profile having 200 mm capacity. The predictor uses rainfall input, run-off, evaporation and transpiration by plants. The measure is zero when soils are at field capacity and 2000 when completely dry.

Specially protected	Those species declared under the Wildlife Conservation Act to be specially protected because they are deemed otherwise in need of special protection.
Stand	A group of trees or patch of forest that can be distinguished from other groups on the basis of size, age, species composition, condition or other attribute.
Structure	When applied to a forest is the vertical and spatial distribution of the vegetation.
Sustained yield	The yield that a forest can produce continuously at a given intensity of management.
Thinning	A felling made in an immature stand for the purpose of improving the growth of trees that remain without permanently breaking the canopy and encouraging regeneration.
Threatening process	Those processes which may result in the long-term reduction of biodiversity. Examples include predation and habitat change by introduced animals; competition and displacement by introduced plants and destruction and modification of habitat.
Threatened taxa	Taxa that are vulnerable, endangered, critically endangered or presumed extinct. Taxa which are naturally rare or geographically restricted, or have become so as a result of human activities, and are in danger of declining further, or becoming extinct, unless adverse factors acting on them can be identified and ameliorated.
Timber harvesting	The cutting, felling, and gathering of forest timber undertaken as part of a planned sequence of silvicultural activities including the regeneration of the forest.
Treemarking	The silvicultural system in which trees are marked for retention prior to harvesting in a forest.
Turbidity	Discolouration of water due to suspended silt or organic matter.
Vegetation complex	A combination of distinct site vegetation types, usually associated with a particular geomorphic, climatic, floristic and vegetation structural association.
Vulnerable taxa	A taxon is vulnerable when not critically endangered or endangered, but facing a high risk of extinction in the wild in the medium term.
Weed	A plant, often a self-sown exotic, growing where it is not wanted.
Weed – environmental	A naturalised non-indigenous plant species outside the agricultural context that adversely affects the survival or regeneration of indigenous species in natural vegetation communities.
Woodflows	Projected annual supply of timber arising from scheduling the area of forest available and the sequence of harvesting operations over an extended period of time.
Yield	The amount of product produced from the forest by a particular management strategy.
Yield regulation	The process by which the yield of any product is controlled to achieve the stipulated levels in a management plan.

Water Corporation Response to the Conservation Commission's Performance Assessment of the Wungong Catchment Trial PART A: Number 01/08

This document is presented in response to the above assessment which has identified six Key Findings. A general response to each Key Finding is provided and where deemed necessary, more specific information follows.

Key Finding 1

There are significant variations between the Interim Guideline for Silvicultural Practice in the Jarrah Forest of the Wungong Catchment and the standard practice undertaken through Silviculture Guideline 1 (2004) and this planning aspect of the project is considered to be inconsistent with the Forest Management Plan 2004-2013 (FMP).

Water Corporation response

The Interim Guidelines were specifically developed to overcome what were seen to be impediments to water production either in the standard guideline or in standard practice. The Wungong Project Team believes that these variations are consistent with the intent and objectives of the FMP. The Team also believes that the planning for development and approval of the Interim Guideline is consistent with the FMP. The following detail provides information to clarify perceived differences.

Specific information

The Conservation Commission's Performance Assessment Part A 01/08 notes two significant variations from those listed within the Interim Guideline (SFM 1-2007). The two variations that the Commission has noted as significant are:

“removing all ‘culls’ in excess of the trees which have been marked for retention” and “the application of the follow-up treatments of coppicing and return thinning which are not normally undertaken in silvicultural thinning of Jarrah”.

Removal of cull trees

The project does not believe that the removal of the additional culls is a significant variation due to the standard guideline and the FMP (Conservation Commission 2004, pp100) requiring culls to be removed from “*within 4 m of a crop tree*” (unless within 5 m of a habitat tree). Treatment is not limited to 4 metres. The intent of this clause in the original guideline was to avoid unnecessary expenditure to thin around non-crop trees which would not have a future timber product and this is acknowledged in section 5.2 of SFM 1-2004.

In a stand fully stocked with crop trees, the 4 m culling would link up, resulting in all culls being removed. In the interim guideline ‘crop’ trees are fully marked to the required basal area as stated in Appendix 2 and all culls (except those within 5 m of a habitat tree and 1 m of a crop tree) are available to be removed. This was clearly illustrated in the original report (Water Corporation 2005 Figure 29). This conforms to what is ‘allowable’ under the standard guideline but is more intense than generally occurs in practice under the timber objective.

Treatment of Coppice

The treatment of coppice is a technique to maximise productivity of retained crop trees as well as water availability outcomes. Where trees are felled as part of a commercial operation there is no treatment of the stump allowing significant stump coppicing from these. This also impacts on the productivity of the forest in the future

and although control of coppice is desirable from this standpoint it has not been practiced because of cost.

Return Thinning

Return thinning will be required in the future to retain the forest at the target basal areas to retain good productivity in relation to timber and water. This will be done under normal commercial operations where they are commercially viable or under non-commercial treatments where additional cull removal is required. Although it is not stated in SFM 1-2004 return thinning is the normal expectation for timber production and is explicitly included in yield determination (Ferguson *et al.* 2003).

Planning

The Interim Guideline (SFM 1-2007) was developed over a period of two years with continual liaison between DEC staff and members of the Project team. Drafts of the Interim Guideline were directly based on the approved Guideline (CALM 2004).

The Interim Guidelines were reviewed and implemented in line with the Communications Plan developed for the Wungong Catchment Trial Project (the Trial). These allow for trials to be undertaken prior to further public consultation.

The Interim Guidelines have been made available to the Technical Reference Group (whose members include the Conservation Commission and conservation groups) and through the Wungong website to the wider community. The release of these documents has been publicised extensively by the Water Corporation.

In relation to suggested variations between the 2004 and 2007 guidelines Section 2 of the Interim Guidelines (DEC 2007) states the differences between the Wungong trial and the standard guideline and practice (CALM 2004). These are consistent with the strategies outlined in the original proposals for the Trial and consistent with the process of adaptive management aimed at increasing water yield (Water Corporation March 2005).

Specific information

Implementation of original proposal

Basal area

The *target* basal area for marking and the *residual* basal area after treatment will **always** be higher than that marked. This is due to some stems being missed during notching and other stems being notched but not dying.

The Water Corporation is aware that the target basal areas for thinning in the *Forest Management Plan 2004-2013* (Conservation Commission of Western Australia, 2004) are dependent on tree size and range from 10–12 m²/ha for 20–30 and 30–40 cm respectively. This variation was based on optimising timber yield, not for environmental reasons. There is also a requirement to leave at least 5 habitat trees/hectare. These add about 2–3 m²/ha, depending on their size. Thus a **retained** basal area of 12–15 m²/ha is acceptable under the FMP within native forest. Practical experience shows that not all cull trees are notched and that not all notched trees die. This is why water yield calculations to achieve a final basal area of between 15 and 18 m²/ha were conservatively based in the Water Corporation's initial documents. Should the final basal areas actually achieved in practice be between the FMPs acceptable limits of 12 and 15 m²/ha — this result would be very acceptable to the Water Corporation.

The Interim Guideline sets out the success criteria by which the forest treatments will be measured (section 6.10.4; SFM 1-2007). These are general and aim to ensure that the project objectives are met without exceeding the parameters set out within related documents. The Interim Guidelines note success criteria including that 80% of the treatment areas will fall between a basal area of 12 and 16 m².

The 'retained' basal areas after treatment were in fact 15.3 and 17.6 m²/ha, due to misses of 1.8 and 2 m²/ha and notching efficiencies of 92% and 86% respectively. These data were all made available during the operation audit however it is anticipated that a more informed understanding of this process will be outlined in Part B of this review.

The **Interim Guideline** in fact **retains a higher basal area** of crop and habitat trees than the standard guideline for stems up to 40 cm diameter when compared with Appendix 4 of the standard prescription.

Retention in the intermediate rainfall zone

Guidelines applying to different rainfall zones are shown in Table 2 of the standard guideline. Retained density for trees >25 cm dbh is the same in both guidelines. Most of the Wungong catchment is in the high rainfall zone.

Adaptive management

The intention of the Trial has always been to thin more heavily than was normal practice in order to increase water yield over that which results from normal operations. The FMP provided for adaptive management trials to be carried out. The Commission argues that the project does not comply with the FMP because the interim guideline is not the same as the standard guideline.

In the Environmental Protection Authority's Bulletin 1196 (EPA 2005) the Commission appears to support 'adaptive management' and the *"testing of a range of thinning options would be appropriate in a properly designed **adaptive management trial**"*.

The Commission's recently published Annual Report, 2008 states:

*"A particular issue is to **determine an appropriate response to the impact of climate change on forest management**...."*

*"An issue that falls under the same heading is that of the **relationship between forest management, a drying climate and water supply**" and*

*"The Conservation Commission recognises its **special role in producing effective and adaptive management plans** in light of the challenges that **climate change** presents."*

Despite the Commission requesting a 'range' of thinning intensity, this was interpreted as a range with retention rates higher than the normal density. Therefore, meaning that a lower density does not qualify as 'a range' despite adaptive management statements. The retention of higher basal area and the prevention of coppice control would result in the same or higher density of vegetation than currently occurs in practice. The Water Corporation would see no value in continuing the Trial under this interpretation.

Key Finding 2

There are gaps in the research program and critical delays on important biodiversity research projects, such as FORESTCHECK, which are of fundamental importance to the delivery of biodiversity research outputs. This appears to be an important deviation from the commitment which was given at the proposal stage of the Wungong trial.

Water Corporation response

The Water Corporation approached DEC to set up FORESTCHECK sites within the Wungong Catchment to be funded by the Water Corporation. DEC staff visited the catchment to select suitable sites.

It is understood that DEC researchers are under pressure with maintaining FORESTCHECK as well as other research programs and the establishment of these six sites has continued to be deferred. In view of these delays, the Water Corporation suggested that contractors be considered to assist DEC.

To ensure that required biodiversity data was available, the Water Corporation promptly engaged Matiske and Associates and Kabay and Associates to establish transects in the Wungong Catchment to monitor biodiversity from control areas and areas to be treated in lieu of FORESTCHECK. Baseline data was collected prior to the start of thinning. The monitoring will be continued until the completion of the project. While not identical to FORESTCHECK, the monitoring is comprehensive and the plots were established prior to treatment and have been remeasured.

Data have been collected on flora, forest structure, composition, coarse woody debris, litter, birds, mammals, bats, reptiles, ants and some invertebrates groups. The Water Corporation has also funded extensive surveys by UWA on aquatic biodiversity, by the Museum on black cockatoo, on birds and small mammals. The Corporation also assisted the Naturalist Club in carrying out an initial survey of fungi.

General response

The Water Corporation identified 'gaps' in the research program and subsequently commissioned the CSIRO review. Copies of the review were provided to the Project's Technical Reference Group and the Auditor and made readily available through the Project website and by contacting the Water Corporation. The Water Corporation accepted the findings in the review and welcomes constructive input from all stakeholders, particularly the State's scientific community. The research program was adapted as per the CSIRO's recommendations.

It should be recognised that interim results of the research work being done during the 12-year trial have already been published and updates will continue to be uploaded to the website. In addition, the Water Corporation has undertaken to communicate final results on completion of the trial. The table of research projects as described in the FMPPA Appendix 2 does not correctly reflect the status of all the projects at the time of audit.

For example, the status of research program 20 (FMPPA p. 23) is described as 'delayed'. In support of an ARC Linkage proposal researchers are continuing this important project work under a collaborative agreement between Water Corporation and Murdoch University. A report of work completed in 2008 is in preparation.

Rainfall and streamflow monitoring data are readily available via the Department of Water's website.

APPENDIX 4 – Water Corporation response

The Water Corporation and DEC will continue to review constraints with the implementation of FORESTCHECK within the Trial area. The Corporation will if necessary increase the scope of the existing flora and fauna consultants to provide any important biodiversity information that would have been gained through FORESTCHECK.

It is understood that DEC has a number of other FORESTCHECK plots that are being monitored as per CALM 2004 Guidelines.

As recommended in the CSIRO Review, the project has convened a group of scientists in the biodiversity field to review the current monitoring program, identify any gaps in knowledge and make recommends. The outcome and recommendations from this group will be presented to the TRG and included in the Trial's Research reports.

Key Finding 3

The draft Memorandum of Understanding between the Water Corporation and DEC has not been signed-off and there is no binding agreement in relation to the project responsibilities.

Water Corporation response

The draft Memorandum of Understanding (MOU) has been continuously reviewed by Water Corporation and DEC officers and successful working arrangements undertaken since 2005. The MOU was formalised by signatories being the CEO Water Corporation and Executive Director DEC early in 2009.

Key Finding 4

The contents of the Project Implementation Management Plan (PIMP) deliver little detailed guidance for undertaking an audit, and in general the PIMP does not seem to fulfil the other EPA recommendations, particularly on an operation scale.

Water Corporation response

The Project Implementation Management Plan (PIMP) content and presentation is consistent with Water Corporation standard used in all project management. The status of operational work is shown in separate detailed maps within the PIMP and regularly updated and distributed to members of the Technical Reference Group and on request to the Corporation's CEO and Board. The PIMP has also been published on the Project's website.

Specific information

Operational planning details such as schedules for dieback interpretation, burning and thinning as well as induction, training and supervisory monitoring are carried out by DEC on behalf of the Water Corporation. These day-to-day activities are documented and available to members of the TRG and wider community on request from the Project group. However as suggested in the audit review, they will be built into future annual reviews of the PIMP together with details in relation to any variations.

Key Finding 5

It is unclear what the goal of maintaining fuel to less than 8 tonnes per hectare will practically mean in relation to prescribed fire frequency and intensity for the Wungong Catchment trial area.

Water Corporation response

The DEC has responsibility for planning and implementing a fuel reduction programme in the Wungong catchment. As stated in the FMPPA (pp 17), DEC Fire Management Services consider that a fuel load measure of about 8.5 tonnes per hectare is considered as the point above which direct attack in a wildfire situation is considered unsafe and unlikely to succeed.

The review fails to recognise that the majority of TA 1 was advanced burnt by DEC prior to commencing any treatment (this work being financed by the Water Corporation). The demonstration site and surrounding native forest which was commercially harvested by FPC had a post follow-up burn in 2007. This area is considered much larger than the 'small demonstration plot' as stated in the Audit. The areas that were not advanced burnt in Treatment Area 2 were commercially logged by FPC, not by the Water Corporation.

Specific information

The preferred method of operation would be to burn in advance of thinning followed by a tops disposal burn. However it is virtually impossible to manage the advance burn without conflicting with dieback mapping. Because of that, advance burning of jarrah forest is rarely done in normal FPC operations.

Maintaining the fuel load at less than 8 tonnes per hectare is based on the 5-year-old fuel load of the 'Standard' northern jarrah forest fuel type. It ranges for 7.6 tonnes to 8.5 tonnes per hectare for a stand with 60% crown cover. It is the basis for the Rate of Spread Index. This means that a fuel load of 8 tonnes /ha will occur at about 5 years under a 60% canopy. With a canopy of 20% it will take 11 years to reach 8 tonnes. This information is derived from Sneeuwjagt and Peet (1985 pp 8, 9, 40), commonly referred to as the Red Book, the guiding tables for fire behaviour in Western Australian forests. Litter accumulation, interception and fire frequency are therefore responsive to the changing canopy cover that occurs with thinning operations. This level is consistent with accepted parameters for manageable fire behaviour. This is also consistent with Department of Environment and Conservation policy to maintain a negative exponential distribution of time since fire. Currently 60% of the jarrah forest has been burnt in the last 10 years (Conservation Commission 2008).

Key Finding 6

Clarification is required in relation to the origin and status of the datasets used to derive isohyets which are then used for setting parameters in the silvicultural prescriptions of the trial.

Water Corporation response

The rainfall isohyets used in all mapping for the Wungong Trial are consistent with historic rainfall data set and is identified as:

"Average annual rainfall isohyets (1926 -1979, 1980, 1981) (Based on Public Works Department, Water Resources Investigations Technical Note 78 & Branch Report WRB 3 & WRB 35 & WRB 79)". Originally defined at a scale of 1 : 250 000

This is the set of isohyets utilised to define the Intermediate Rainfall Zone in the Forest Management Plan. This set of isohyets is utilised widely, including by CSIRO, Department of Water and DEC, and the Wungong project is not proposing to vary from current protocols.

Specific information

During the 1970s and 1990s there was a large research effort into the study of salinity. Research was carried out by CSIRO, as well as many government agencies — Geological Survey, Public Works Department, Metropolitan Water Board, Forests Department and Alcoa. In excess of 150 bores were drilled, the soil content of the profile analysed and the groundwater depths and salinities recorded. This was an expensive program with each bore costing several thousand dollars. It was decided that a more practical way of estimating salinity risk was required. The data showed that, as one progresses from West to East in the forest, the groundwater salinity increases, the depth to groundwater increases and the stored salts also increase. When all these data were examined and plotted it was obvious that there was a good relationship with the Isohyets developed by the Public Works Department Water Resources Branch from historical rainfall data available to 1980.

The Low, Intermediate and High salinity risk zones corresponded well with the > 1100, 900 to 1100 and < 900 mm Historical Isohyets and these have since been used as a guide. The best test of whether there is a salinity risk in an area is data on the depth to and salinity of groundwater tables. In the Cobiac catchment which is at the boundary of High and Intermediate zones, there are over 100 boreholes drilled by Alcoa. Data show that salinities are invariably < 1000 mg/l, in many cases a lot lower than this. Based on these data, the Water Corporation is confident that thinning the forest in the Wungong Catchment will not lead to a rise in stream salinity.

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APPENDIX 4 – Water Corporation response

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Appendix 4: Jarrah Thinning Intensity

Mean DBHOB of best 150 Stems/ha at first thinning	Crop* tree basal area (m ² /ha) [^]	Crop* tree density (spha)	Crop* tree spacing (m) (rounded)
<20cm		350	5
20-30cm	#10m ² /ha	320 to 145	6 to 8
30 - 40 cm	12 m ² /ha	145 to 80	8 to 11
>40 cm	12 m ² /ha	<80	>11

* “crop” tree in this context means marked trees that conform to the standards in Appendix 3 as well as those ‘non-crop’ trees that may be marked to maintain a minimum density as described in Sections 5.2.6 and 6.6.

[^] Habitat trees are expected to contribute 2-3 m²/ha of additional basal area

In the Intermediate Rainfall Zone - 12 m²/ha

Appendix 4: Jarrah Thinning Intensity

Mean DBHOB of best 150 Stems/ha at first thinning	Crop tree basal area (m ² /ha)	Schedule
Less than 20cm	N/A	Release 200 jarrah stems/ha from overtopping and crown abrasion. The objective is to maintain healthy crown development on future jarrah crop trees without promoting a permanent low crown break.
20-25cm	#*10m ² /ha	This will usually be a non-commercial thinning. It will leave more than 150 stems/ha but ensures that the stand is not left understocked. A further thinning will be required before the crop trees reach 50cm dbhob
25-30cm	#*10m ² /ha	This is likely to be both a commercial and non-commercial thinning. The remaining trees are capable of reaching 50cm dbhob without the stand becoming overstocked (50 years). More conservative thinning in the future will maximise sawlog volume/ha
40cm	18m ² /ha	Thin again when crop trees reach 50cm dbhob. Above comments apply
50cm	20m ² /ha	

* An additional 5m²/ha of the following may be retained:

Trees within 5cm of becoming a power transmission pole or sawlog

Sheoak crop trees

Second grade sawlogs in areas which will have follow-up non-commercial thinning.

#	In the Intermediate Rainfall Zone	-	15m ² /ha
	In the Low (<900mm) Rainfall Zone	-	15m ² /ha - 30% TEAS
		-	10m ² /ha - 70%

Last updated: 5 November 2004

Custodian: Manager, Policy and Practices Branch

Approved by: Director Sustainable Forest Management

2.1 Project document

Issue	Was the project document adequate in explaining the Wungong project and what will happen after the project?
Submission quotes	<p>“I found it very interesting and of professional standard, though there are some minor errors, such as Xanthorrhoea preissh (preisii?) on p 38 and these taxon (taxa?) on p 65.” “... omissions of some relevant references, in particular those relating to catchment management, photocopies of which I include.”</p> <p>“it is beautifully put together and very informative, but lengthy!”</p> <p>“We acknowledge that you have produced a very well researched report in favour of this project”</p>
Summary of issue	<ul style="list-style-type: none"> Although large, the project document was of a high standard with only minor typographical errors.
Response	<p>Catchment management is complex and the length of the project document illustrates the number of issues that need explanation. A 6-page summary of the main document was produced and used in the public review, but submissions were directed appropriately at the main document. Future communications related to the project will continue to provide information at several levels of detail from thirty second television advertisements to scientific journal papers.</p> <p>The project document was adequate in explaining the project, but in just focusing on the 12-year project it did not provide enough information about the long-term vision for the forests in the Wungong Catchment. In the absence of this information some submissions have made incorrect assumptions. In particular some have assumed incorrectly the forest will be kept permanently at a basal area of 15–18 m²/ha, when in fact it will on average increase its basal area in time as it moves towards a more mature structure (Section 2.22).</p>
Answer	Document was adequate and the public review process provided an opportunity to clarify some points of uncertainty.

particularly the notion of 'improving the forest' through thinning. In view of the observed and projected decrease in reservoir inflows, an experimental trial which includes research and monitoring to elucidate the potential environmental benefits is considered to be appropriate.

Based on a precautionary approach, the EPA emphasises the need for the proposed monitoring and research to focus on confirming the predicted environmental impacts from this trial project and for results of this work to be made publicly available. The results of research and monitoring in relation to the predicted environmental impacts will assist the Corporation and the relevant project stakeholders in determining the environmental costs and benefits of the project and whether catchment thinning for water production should be applied more widely to other catchment areas.

Project research needs

While the use of thinning to increase stream flow is well validated in research, there is limited information available in relation to the ecological effects of thinning, particularly on the scale, duration and frequency that is proposed as part of the Wungong project. For example, in its advice on the project, the CC highlighted that the impacts of more frequent disturbances on biodiversity elements (such as reptiles and fungi) are unclear.

The Corporation has acknowledged the uncertainties of the project and committed to undertaking and funding appropriate research and monitoring programs in a number of areas to gain a better understanding of the effects of thinning and to build on the existing knowledge in relation to the impact of silvicultural practices on biodiversity. With respect to monitoring, the Corporation has agreed to undertake biological monitoring, including monitoring based on CALM's ForestCheck system and integrated with groundwater monitoring, as recommended by the CC.

It is noted that research proposed as part of this project would be progressed through a technical reference group to include various Government agencies, universities and research organisations such as the CSIRO. As such, the *Monitoring and Research* section of the project document (Section 5.6.3) is very broad in scope with limited information on research projects and priorities for research and monitoring.

From the issues and questions raised during the consultation to date, there appears to be a need for research to focus on the proposed silvicultural prescriptions and management practices and their impacts on biodiversity elements of the forest such as the understorey, fungi, fauna and also fire and dieback risk and how they relate to modified forest structure and water regime. The research will also need to focus on testing the predicted environmental benefits of the project.

In summary the EPA:

- **considers that information to be collected from this project trial, through research and monitoring, along with information from untreated control catchments should aim to confirm the predicted environmental impacts of this project. It is recommended that this information be made available to the community, relevant stakeholders and Government agencies and be available for peer review; and**
- **recommends that, in developing research proposals in consultation with the relevant agencies and research organisations, priority be given to research proposals which**

6.10.2 Control of stump coppice and regrowth in thinned stands

Coppice and regrowth developing in thinned stands will negate the positive impact of thinning on water yield within about 10 years. To maintain the value of thinning for water production thinned stands will require follow-up to control stump coppice and regrowth either by the use of herbicides or by mechanical means. It will enhance timber production as well as water production.

Initial practice will involve a tops disposal burn in the first or second summer after treatment, followed by foliar spray of stump coppice before it reach 0.5 - 1m in height. This would be followed by notching of sapling regrowth and any surviving stump coppice within 5-10 years of the thinning. Control of regrowth at the sapling stage ensures that a lignotuber pool can continue to develop and be available for regeneration release when required. Field trials of alternative methods will be developed as the need becomes apparent.

Understorey is expected to increase in density following thinning and this will also have an adverse impact on water yield. Secondary tree species (*Banksia* and *Allocasuarina*) will require herbicide application to control regrowth and coppice. This can be controlled at the same time and by the same technique as eucalypt regrowth control. The requirements of Section 5.4, aimed at ensuring continued representation of second storey species will apply.

It is not possible to predict at this time how often regrowth control will be necessary but it may be in the order of once a decade. The ecological impact of these practices will be monitored.

A second thinning of crop trees will be required in about 20 years time.

Regrowth control cannot be continued indefinitely without compromising the long term capacity for renewing the forest. This is safeguarded by the provisions of the current guidelines i.e. when stands are considered unsuited to thinning and require regeneration, they cannot be cut to a gap until there is adequate ground coppice available to regenerate it. The process described above should ensure that there is an adequate lignotuber pool available when required. Long term thinning to the proposed densities also serves a similar role to shelterwood by providing a seed source and level of competition from the overstorey that should allow seedlings to establish.

The requirements of Section 6.4, aimed at managing the risks to understorey vegetation from regrowth control operations will apply.

6.10.3 Routine prescribed burning

Understorey is expected to increase in density following thinning and this will have an adverse impact on water yield. In order to reduce the average period over which understorey transpires strongly and to reduce rainfall interception by heavy litter, a burning frequency aimed at maintaining fuel loads of <8 tonnes/ha is the objective. The exception to this is where a longer period is required to protect regeneration that has been released.

6.10.4 Monitoring of forest density

Areas thinned for water and timber production will be monitored using variable radius plots on a coupe basis. Success criteria will be as follows: