

# Wungong Catchment Trial

Review of Research Program  
September 2008



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- 2 Richard Boykett and Tony Smith, Department of Environment and Conservation;
- 3 Frank Batini, consultant: and
- 4 Members of the Wungong Technical Reference Group who carried out a critical review of a draft report.

While all of the suggested changes made by members of the Wungong Technical Reference Group have been considered, not all have been incorporated in the conclusions and recommendations. Reasons for non inclusion include some being conflicting and others being beyond the terms of reference of the review. However many suggested changes have been included, comments have been added as footnotes where they help guide future directions and the quality of the final report was improved significantly as a result.

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## EXECUTIVE SUMMARY

The Water Corporation is undertaking a major trial of forest thinning in an effort to increase water yields into the Wungong Reservoir to try to offset the effects of a drying climate and catchment management practices, and the consequent reduced inflows. The trial is expected to have additional environmental benefits (eg more mature trees; improved aquatic environments) and may also result in improved timber yields and quality. However there are risks to biodiversity, water quality, soil protection, forest structure and disease spread associated with thinning that need to be understood and managed.

As part of the trial the Corporation has supported 20 research projects in the areas of water, land and biodiversity<sup>1</sup>. Through reports and published commitments it has also undertaken to develop a series of Key Performance Indicators (KPIs) to assess its performance in these areas during the thinning trial.

This report summarises how the 20 research projects contribute to meeting the KPIs and identifies gaps in the program<sup>2</sup>. It also provides advice on reporting to the Conservation Commission of Western Australia, Environmental Protection Authority and the Board of the Water Corporation.

Detailed recommendations can be found in Section 9. However in summary it is suggested that additional KPIs be made in the areas of millable timber yields (or another economic measure of woody biomass production) and the social acceptability and cost effectiveness of thinning. Consideration should also be given to developing a KPI on overstorey composition (as there is for understorey). It is also recommended that there be a fourth grouping of KPIs entitled “Socio-economic”. All KPIs need to be fully defined with the Technical Reference Group with several KPIs needing to be based on those in the Forest Management Plan 2004 – 2013.

The field operations program could be converted into a research project so that KPIs for the safe handling of herbicides, the efficacy of herbicide treatment and soil protection are also covered by the research program. Currently these KPIs are addressed through operational programs. This new project may also assist meet those for the achievement of retained basal areas and level of damage in retained stems. If new KPIs are developed for millable timber / woody biomass and the social acceptability and cost effectiveness of thinning then these will also require definition.

A constraint in all projects is the ability to examine thinning and other management practices in stream and reservoir buffers. In a drying climate these areas are now drier and any impacts of treating upslope areas may be offset by a dense stream or reservoir buffer which is usually prescribed for protecting water quality<sup>3</sup>. If the thinning trial were

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<sup>1</sup> A fourth area – Climate Change – with KPIs for greenhouse gas emissions and carbon storage has been suggested by Jael Johnstone, TRG member

<sup>2</sup> The use of the degraded, logged and burnt forest within the Wungong Catchment as the control for the treatment has been questioned by some members of the TRG. However the possibility of conducting the trial in more pristine forest could raise other issues.

<sup>3</sup> Whether hydrological data could be collected upslope of the buffers has been suggested as an alternative approach by Jael Johnstone, TRG member.

to be extended into the buffers permission would be required from the Conservation Commission and the Water Source Protection Branch within the Department of Water. Additional measurements of the impacts on stream water quality may also be required as well as on in-stream biodiversity.

Summary details are provided for all 20 projects along with the trial KPIs, FMP and EPA recommendations they help to meet. From this analysis it was found that a number were weakly aligned at present (fungi biodiversity; hydrological processes; prescribed fire and stream quantity and quality; monitoring the effect of wildfire on water, vegetation and biodiversity; and the monitoring cockatoo, avifauna and ground vertebrates projects. To include some/more measurements in both the thinned and unthinned treatments would be required to improve several of these projects (not the wildfire one however). The information provided for the review is not detailed for some projects and some may also be out-of-date. Therefore the lack of alignment may not be as bad as appears to be the case. It is hoped that collating this project data together will prove to be a useful communication initiative.

A number of projects are measuring similar components or using related methods but have little or no evidence of data and expertise sharing. Meetings of groups involved in remote sensing, hydrological modelling, leaf area index work and systems modelling are recommended to improve the linkages.

There are annual information sharing seminars to report these projects but given that there are 20 to cover in one day there is often insufficient time to assimilate the overall results. It is therefore suggested that a half day workshop be added to provide an opportunity for synthesis between result areas, and also between researchers and managers. This workshop would be smaller in size than the full day of presentations.

Finally, while no report is required to be made to the EPA it is recommended that a program of informal briefings be established and maintained in case a formal assessment is required in future. Reporting to the Conservation Commission needs to address the Forest Management Plan (FMP) KPIs identified for each project and emphasise the likely consequences of “doing nothing different” in a drying climate on aquatic ecosystems. Information prepared for the submission to thin the 31 Mile Brook Catchment may assist in this regard. If an alignment is made between the Wungong and FMP KPI definitions then reporting will be relatively straightforward.

The report to the Board of the Water Corporation requires a detailed business case to be made of costs and likely benefits over time and most projects are not assembling these data in a systematic way. The proposed new project to meet the KPI on the cost efficacy of thinning could be aligned to help meet this requirement.

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## **1 Introduction**

In early 2008 CSIRO were contracted to provide professional independent advice to the Water Corporation on its Wungong thinning trial, specifically:

- 1 Advise whether the Wungong research and monitoring program is able to meet the publicly-stated commitments made by the Water Corporation (especially the KPIs on pages 73-74 of the Water Corporation's response to the 2005 public review); and if not
- 2 Advise what additional work would need to be done to fill any gaps.

This work entailed a high level audit of the 20 research projects currently funded (Appendix 1) and their relationship with these KPIs.

In addition, high level advice was required on how best to report on the Wungong project to the Conservation Commission of Western Australia, Environmental Protection Authority (EPA) and Water Corporation Board.

Deliverables were to produce a report for comment by the end of April 2008 and a final report by the end of May 2008.

This report is the final deliverable. The deadline was extended to enable input to be made by members of the Wungong Technical Reference Group (TRG).

## **2 Review of publicly-stated commitments**

### ***2.1 Water Corporation Response to the 2005 Public Review***

In August 2005 the Water Corporation made commitments to develop two stages of Key Performance Indicators (KPIs).

#### **A. Concurrent with silvicultural practices in each activity area the KPIs are to target:**

- 1 water quality and quantity criteria;
- 2 safe handling of herbicides;
- 3 achievements of retained basal areas;
- 4 efficacy of herbicide treatment;
- 5 level of damage in retained stems; and
- 6 efficacy of burn prescriptions.

#### **B Within 12 months of starting silvicultural work the KPIs are to target:**

- 1 changes in stream invertebrates;
- 2 soil protection;
- 3 dieback;
- 4 changes in indicator fauna species;

- 5 changes in understorey; and
- 6 consultation and communication.

Silvicultural work began in the last quarter of 2006 (M. Loh pers. comm.)

In December 2007, the following Project Success Criteria (PSC) and KPIs were circulated to the Wungong Technical Reference Group for comment (Michael Loh, pers. comm. 2007).

**Project Success Criteria.** The criteria that will be used to evaluate the overall success of the Wungong Catchment Trial include:

**Water:** A 20% - 25% increase in runoff following the approved silviculture treatment.

**Land:** Sustainable uses of the forest remain viable following the approved silviculture treatment.

**Biodiversity:** No adverse impact on ecosystem functions following the approved silviculture treatment.

**Project KPIs**

There were also 12 Key Performance Indicators (KPI) proposed to be used to determine the success of monitoring and research programs as stated in the *Water Corporation's response to submissions from 2005 public review, 2007* (Water Corporation project commitments pp 73-74). They are listed in the table below under the categories of **Water, Land and Biodiversity.**

**Table 1 KPIs grouped according to the three Project Success Criteria (Michael Loh, pers. comm. December 2007)**

WATER	LAND	BIODIVERSITY
1. water quality and quantity criteria.	4. achievement of retained basal areas.	9. changes in stream invertebrates.
2. safe handling of herbicides.	5. level of damage in retained stems.	10. changes in indicator fauna species.
3. efficacy of herbicide treatment	6. efficacy of burn prescriptions.	11. changes in understorey
	7. soil protection	12. consultation and communication.
	8. dieback	

## Suggested changes

Following discussion of a first draft of this report, the following changes were recommended by the Wungong Project Team on 12<sup>th</sup> May 2008.

### Project Success Criteria<sup>4</sup>

- *The social acceptability and cost effectiveness<sup>5</sup> of thinning hills catchments to improve water yields relative to the do nothing different case will be sufficiently well known to enable a decision to be made whether to continue treatment of the Wungong Catchment, and to extend it to other catchments<sup>6</sup>.*
- *A 20%<sup>7</sup> increase in runoff in the Wungong Catchment following the approved silvicultural treatment relative to the “do nothing different” case.*
- *Stakeholder acceptance<sup>8</sup> of the forest structure after the approved silvicultural treatment.*
- *No significant adverse impact on terrestrial and in-stream ecosystem functions following the approved silvicultural treatment relative to the “do nothing different” case.*
- *Impact on ecosystems’ ability to adapt to climate change improved as a result of the approved silvicultural treatment.*

### Project KPIs

At this meeting it was also suggested that there be 16 Key Performance Indicators (KPIs) to determine the success of monitoring and research programs as stated in the *Water Corporation’s response to submissions from 2005 public review, 2007*. These KPIs (names only and headings may change when they are developed in detail) are:

1. Stream water quality and quantity
2. Safe handling of herbicides
3. Efficacy of herbicide treatment
4. Achievement of retained basal areas
5. Level of damage in retained stems

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<sup>4</sup> A sixth PSC has been proposed by Jael Johnstone: **Climate Change contributions:** *All greenhouse gas contributions from the project including vehicle miles associated with thinning and research, loss of overall forest canopy and burning, etc be calculated, included in all financial assessments of the project and be made publicly available.*

<sup>5</sup> Suggested change to “Community awareness of costs and benefits” instead of “social acceptability and cost-effectiveness” – Beth Schultz pers. comm.

<sup>6</sup> An alternative has been proposed by Jael Johnstone: **Public Opinion:** *The informed community response and cost effectiveness of thinning hills catchments to improve water yields relative to the ‘do nothing different’ case will be sufficiently well known to enable a decision to be made whether to continue treatment of the Wungong Catchment. It might also provide useful data to assist consideration of whether or not future projects on catchment thinning in other catchments should proceed*

<sup>7</sup> The earlier PSC had a range (20-25%) which is imprecise so a final figure needs to be decided

<sup>8</sup> Suggested change to “Informed stakeholder response” from Stakeholder acceptance” Beth Schulz pers. comm.



6. Efficacy of burn prescriptions
7. Soil protection
8. Growth rates of commercial species and timber yields
9. Dieback
10. Changes in stream invertebrates
11. Changes in indicator fauna species
12. Changes in understorey
13. Changes in overstorey
14. Consultation and communications
15. Social acceptability of catchment thinning
16. Cost effectiveness of catchment thinning

It was suggested to consider a KPI on “forest health” which may incorporate an element of its ability to adapt to climate change (resilience).

The effect of forest thinning on stored carbon has been raised as an issue that may need to be considered. Replacing many smaller trees with fewer but larger trees and the associated root system may or may not increase overall carbon amounts and liability.

## **2.2 EPA Bulletin 1196**

Under s16 of the *Environmental Protection Act 1986* the EPA provided the following main advice and recommendations in regards to the Water Corporation’s project proposal as described in Water Corporation (March 2005)<sup>9</sup>:

- 1 Information collected from the project should:
  - a. aim to confirm predicted environmental benefits;
  - b. give priority to research projects that address ecological uncertainties;
  - c. address concerns and questions raised in the public review;
  - d. be made readily available;
  - e. assist consideration of whether future projects on catchment thinning for water production should proceed; and
  - f. contribute to policies and guidelines for catchment thinning in other catchments.
- 2 The Corporation needs to continue to work with the Water Source Protection Branch in the DoW on:
  - a. the standard and level of water quality monitoring before, during and after on-

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<sup>9</sup> The recommendations have been summarised and numbered so that they can be more easily referenced against the Wungong research projects. Items 1 a to f are a summary of Recommendation 3a and b; Item 2 is a summary of Recommendation 3c; Item 3 summarises Recommendation 3d and Item 4 summarises Recommendation 3e.

- ground works; and
- b. catchment management practices and strategies, especially those in Reservoir Protection Zones.
- 3 The project's first project review should be submitted to the Conservation Commission in 2008 so that the findings may be incorporated into the Commission's mid-term audit report of the Forest Management Plan which is due at the end of 2008.
  - 4 Consideration is given to testing a range of thinning options in both native regrowth forests and rehabilitated bauxite mined areas.

### ***2.3 Forest Management Plan 2004 - 2013***

The Forest Management Plan 2004 – 2013 (Conservation Commission of WA 2004) includes 33 KPIs, some of which may be used as a model for KPIs in the Wungong Catchment as the Conservation Commission needs to approve any forest thinning operations that are carried out. Not all of the KPIs were considered relevant to the Wungong catchment (eg those related to critically endangered species) and others are the responsibility of agencies such as DEC, Forest Products Commission (FPC) and the Commission itself. Some TRG members believed that many more, if not all of the FMP recommendations are relevant to Wungong but it was decided that the project should concentrate on those twelve with most relevance

These KPIs are summarised In Table 2 below:

**Table 2 Summary of KPIs in the Forest Management Plan 2004 - 2013 which are of relevance<sup>10</sup> to the Wungong Catchment (in approximate decreasing order of relevance)**

<b>KPI Indicator</b>	<b>Performance Measure</b>	<b>Performance Target</b>	<b>Reporting / Response</b>
22. Water production	Stream flow in selected forest streams	Streamflow to be maintained	DEC and others to identify reasons for any trend and report to CC and the Minister. The Conservation Commission (CC) to evaluate the need for revision of management practices in consultation with DEC
20 Percentage of water bodies with significant variance in biodiversity from historic range of variability	Diversity of aquatic macro-invertebrate fauna at a selected number of monitoring sites	No sites with fauna significantly different from the reference condition	DEC to investigate cause and report to CC and Minister. CC to evaluate the need for revision of management practices in consultation with DEC
12 The achievement of early thinning schedules that underpin future yields	Achieve thinning versus that prescribed in silviculture schedules	All stands thinned at the prescribed stand development stage	Two yearly reporting. FPC and CC to investigate the cause and report to CC. The CC to evaluate the need to revise management practices
28 Adaptive Management	The number and topic of formal adaptive management trials (Stream zones in informal reserves; improvements to silviculture and fire management practices)	Within 5 years trials will have been held into at least two separate issues detailed in the plan's action statement	DEC to report to CC and the Minister for the Environment
31 Development of scientific understanding of ecosystem characteristics and functions	Expenditure on R&D related to ecologically sustainable forest management. Person years of research. Number of peer review articles published on ecologically sustainable forest management	None	Annually the CC to review the scientific effort in forests in relation to total DEC effort and discuss priorities with DEC
21 The level of soil damage resulting from timber harvesting	Soil damage by risk category as measured by survey	Soil damage not to exceed prescribed maximum levels	DEC to investigate the cause and report to the CC and the Minister for Environment. CC to evaluate the need to revise management practices
26 Number, range and use of recreation/ tourism activities available by proposed land category in plan area	The number of visits to selected recreational areas. The satisfaction that visitors express with their experience	Visitor satisfaction maintained at high levels	Annually. DEC to investigate cause and report to CC and Minister for Environment. CC to evaluate the need to revise management practices in consultation with DEC

<sup>10</sup> Other FMP KPIs that may be considered include: 2 the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing); 3 (the status of selected threatened or conservation dependent) species that are the subject of management actions to protect them); 7 (the removal of non-sawlog timber); 11 (forecast strategic timber yield versus actual timber yield); 17 (the severity status of weeds and pests as determined by subjective survey); and 24 (consultation and involvement of Aboriginal people in forest management)

<b>KPI Indicator</b>	<b>Performance Measure</b>	<b>Performance Target</b>	<b>Reporting / Response</b>
18 The effectiveness of dieback hygiene	The number of sampled areas uninfested by <i>Phytophthora cinnamomi</i> that remain uninfested following an operation with an approved hygiene management plan	No uninfested protectable areas to become infested as a result of management actions	Every 5 years. DEC to investigate cause and report to CC and Minister for Environment. CC to evaluate the need to revise management practices in consultation with DEC
19 The annual flow weighted mean salinity and the trend for streams in fully forested catchments	Annual flow weighted mean salinity and the trend for streams in fully forested catchments	Salinity trends to be neutral	Every 5 years (DoW). DEC to investigate cause and report to the CC and Minister for Environment. The Commission to evaluate the need to revise management practices in consultation with DEC
5 Annual removal of wood products compared to the sustained yield determined by the plan	Cumulative removals of jarrah first and second grade logs compared to average annual sustainable yield; annual removal of jarrah sawlogs below first and second grade; annual removal of all logs	No more than 10% average annual yield of first and second grade logs to be removed in any one year Volumes set for each species (see plan for details)	FPC to advise CC how it will manage removals to be under the end of plan target. CC to evaluate the need to revise harvesting levels in consultation with DEC.
10 Effectiveness of regeneration of native forest and plantation	Proportion of sampled annual regeneration release program that doesn't meet the stocking standard	No more than 5% of the area regenerated requiring remedial action	Annually. FPC to notify DEC how it will rectify the shortfall. DEC to determine the need to revise management practices in consultation with CC
33 Operational control	The extent to which guidance documents have been prepared / reviewed and management modified to improve ecologically sustainable forest management	All guidance documents to be prepared / reviewed by mid term (2009)	DEC to investigate the cause and report to CC and the Minister of the Environment. CC to evaluate the need to revise management practices in consultation with DEC

### **3 Criteria used for reviewing the Research and Monitoring Program**

It is most important that the Research and Development projects meet the Wungong thinning project KPIs as reported in Water Corporation (August 2005) as it is assumed that these were developed in response to the advice and recommendations within EPA Bulletin 1196 and overall constraints and joint-assessment opportunities contained within the Forest Management Plan 2004-2013.

As the project has developed a lot has been learnt since its initiation and care will need to be taken not to focus too closely on earlier documentation such that work essential to meeting the project's overall objective is not carried out. For time-dependent data it is better to collect some that may subsequently prove not to be needed

As at February 2008 the project KPIs are just headings so there remains scope to ensure that they do meet these earlier commitments.

For reporting purposes the projects have been assessed against the:

- 16 project KPIs (P1, P2, etc);
- EPA Advise and recommendations (1a, 1b., 2a, 2b etc); and
- Forest Management Plan KPIs (F1, F2, etc).

The assessment will use the notation shown above.

The notation may be useful in reports to the EPA and Conservation Commission of Western Australia.

After the project-by-project assessment, gaps and opportunities for further work are considered (Section 5) and integration between projects is considered (Section 6).

## **4 Brief assessment of each research / monitoring project**

The 20 research projects are reviewed in the order shown in Appendix 1 (Bishnu Devkota pers. comm.). The first seven projects have a water theme, the next five a land theme, and the last eight, a biodiversity theme, although many projects have aspects of all themes within them. The review was based on the information provided and some analyses were restricted by limited or out-of-date data.

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### **1 Project Title:** Hydrographic measurements

**Project Researcher(s):** Kelvin Baldock (Hydro-SMART); Department of Water, hydrographic team Welshpool (Kim Richardson, Glenn Biggens); Keith Barrett

**Objectives:** To monitor and report on rainfall, streamflow and water quality in the Wungong (thinning), Mundaring (January 2005 wildfire) and nearby control or comparison catchments.

**Methods:**

Use hydrologic information being collected in the region by the Department of Water, Alcoa and Bureau of Meteorology and enhance the monitoring network as necessary to ensure the needs of this project are covered.

Maintain and operate gauged catchments monitoring rainfall, streamflow and water quality at:

1. Mundaring Catchment – Little Darkin, Hairpin Bend; Pickering Brook, Slavery Lane;
2. Wungong Catchment – Cobiac, Vardi Road, Chandler Road;
3. Canning River Catchment (comparison) – 31 Mile Brook, Canning River at Glen Eagle and Millar’s Road
4. Serpentine Catchment - 39 Mile Brook Jack Rocks – impact of more frequent prescribed burning without thinning; and
5. North Dandalup, North Road - long record in the region for comparison with Wungong.

For each gauged catchment a reliable streamflow record is obtained by continuously recording the water level at a control structure and developing a relationship between water level and flow.

Four catchment rainfall pluviometers have been established and are operating at the Hairpin Bend, Slavery Lane, Cobiac and Jack Rocks stream gauging sites and at Mt Dale (Mundaring), Hakea and Eagle Hill, adjacent to Wungong, and Millar's Road, Metro Road and Omeo Road (in the Canning Catchment), Herald Road in 39 Mile Brook catchment and Rampe in the North Dandalup catchment. Three pluviometers funded by Alcoa for Bauxite research at Gardens, More Seldom Seen and Waterfall Gully are within the Wungong Catchment.

For evaporation, an automated Class A evaporimeter with recorder is currently being installed near the boundary of the Wungong and 31 Mile Brook catchments.

Maintain and operate six automatic pumping samplers at Hairpin Bend, Vardi Road (2), Chandler Road and Cobiac (2). The automatic pumping samplers may be relocated depending on the results obtained and new needs identified as the project proceeds

To assist in identifying changes in groundwater flow following silvicultural treatment, continuous conductivity monitoring has been added at the Cobiac and 31 Mile Brook gauging stations.

Manual sampling and in-situ observations of temperature, pH and electrical conductivity are made at all sites.

Validation, processing and management are also undertaken of all data collected. Hydstra is the software that will primarily be used.

#### **Results / status:**

The hydrographic data have already been used to analyse trends in streamflows and the effect of the Mundaring Catchment fire on streamflows and water quality (Barrett 2007). There has also been an Honours thesis that has used the data, and analyses have been made by Frank Batini and other researchers.

Streamflow and rainfall records are available for viewing on the Department of Water web page as monthly data at;

<http://kumina.water.wa.gov.au/waterinformation/wrdata/wrdata.cfm>

Daily and more detailed data can be requested from the Department of Water (see Web page for instructions).

#### **Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 1 (stream water quality and quantity), 7 (soil protection) and 14 (social acceptability and cost effectiveness of catchment thinning). It is also important for KPI 10 (change in stream invertebrates) in that it provides overall information on the stream habitat under different catchment practices and climate change.

#### **Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (confirm predicted

environmental benefits), 1c (address issues raised in the public review), 1d (be made publicly available) 1e (enable an assessment of future catchment thinning), 2a (DOW standards of water quality monitoring, and catchment management practices and strategies) and 4 (testing a range of thinning options in native forest and bauxite mined areas).

### **Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 22 (water production), 28 (adaptive management) and 19 (stream salinity trends)

Hydrographic activity for the Wungong Project is being carried out by Hydro-SMART and Department of Water staff based at Welshpool.

Other hydrological measurements are made in the catchments funded by the Department of Water and Alcoa.

### **Overall assessment**

The project provides essential data that underpin much of the other work in the catchments. Measurements from the Mundaring, Canning, Serpentine and North Dandalup Catchments allow the Wungong streamflow results to be compared and placed in context. Other measurements in Darling Range Catchments, particular work supported by Alcoa, will also be of value in interpreting the results of forest thinning.

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## **2 Project Title:** Hydrological analysis and modelling

**Project Researcher(s):** Dr. Bishnu Devkota (Water Corporation) and Dr. Mohammad Bari (Department of Water)

### **Objectives:**

To analyse streamflow data and to validate the LUCICAT model for hydrological simulation.

### **Methods:**

Application of the Land Use Change Integrated Catchment (LUCICAT) model for long term hydrological simulation and improved understanding of the hydrologic impacts (particularly changes in streamflow and salinity) caused by thinning. The model will also be used to extend the result to other selected IWSS water supply catchments.

The LUCICAT model was developed by Dr Mohammad Bari (DoW). It comprises three main modules –LUCICAT\_Geopro (satellite, DEM, soils and photographic data); LUCICAT\_Rain (response units, rain and ET) and LUCICAT\_Main (observed streamflow and salinity data). As such it has the potential to share data with other research projects (eg 1, 4, 7 and 20). This model has already been applied to Collie, Warren, Denmark and Stirling Catchments.

The model subdivides catchments into a number of response units and the hydrologic responses of each unit can be examined. The model uses Leaf Area Index (LAI) as input data that relates to impacts caused by thinning and land-use changes. The groundwater component in the model is conceptual only. The advantage of this model is that it can handle both land-use and climate change impacts and it can simulate catchment hydrology over the long term.

**Results / status:**

The initial calibration and validation of the model using the observed rainfall and constant LAI data has given encouraging results. The model validation using the updated rainfall and LAI data and addition of more response units is progressing to validate the model against the measured stream flow, salinity and groundwater levels.

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 1 (stream water quality and quantity) and 14 (social acceptability and cost effectiveness of catchment thinning).

**Relationship with EPA Bulletin 1196**

The project is important for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1c (address issues raised in the public review), 1d (be made publically available), 1e (enable an assessment of future catchment thinning) and 4 (testing a range of thinning options in native forest and bauxite mined areas).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 22 (water production), 28 (adaptive management) and 19 (stream salinity trends).

**Overall assessment**

The project has strong links with Project 7 (Vegetation dynamics and hydrology) and needs to have links with project 3 (Hydrological processes) especially to understand the hydrological processes in bauxite mining pits with in the Wungong.

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**3 Project Title:** Hydrological processes

**Project Researcher(s):** Amanda Reed (Alcoa)

**Objectives:**

To collect field data and to validate WEC-C model for predicting of interflow in bauxite mining pits. It will provide an improved understanding of the impacts of bauxite mining and rehabilitation on runoff generation.

**Methods:**

Application of the WEC-C model to better understand sub-surface runoff generation processes in bauxite mining pits. The work is located outside the Wungong Catchment but still relevant.

**Results / status:**

Bauxite mining rehabilitation impacts on 19% of soils in the Wungong Catchment and has been implicated in reducing streamflow because of dense vegetation in rehabilitation areas, bunding to reduce the possible spread of dieback and the removal of the lateritic caprock that may assist in interflow mechanisms.

**Relationship with the (new, proposed) Project KPIs:**

The project is important for assessing KPI 1 (stream water quality and quantity) as it will elucidate processes in rehabilitated mined areas.



**Relationship with EPA Bulletin 1196:**

The project is important for assessing advice and recommendation 4 (testing a range of thinning options in native forest and bauxite mined areas) as it concentrates on the 19% of the catchment that has been mined.

**Relationship with Forest Management Plan 2004 – 2013:**

The project helps meet KPIs 22 (water production).

**Overall assessment**

It is hard to assess this project without any details but if it can elucidate the important hydrological processes that occur in the 19% of the catchment that has been mined then this will be important. How these areas will respond to catchment thinning is being addressed by Alcoa's thin/burn research within the Warren and Bennett's research catchments (Amanda Reed, pers. comm.).

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**4 Project Title:** Groundwater monitoring and analysis

**Project Researcher(s):** Dr. Bishnu Devkota (Water Corporation) and ND Mining Services (contractor)

**Objectives:**

To measure seasonal groundwater levels and analyse the trends to better understand the impacts of a drying climate and land-use changes (thinning and forest structure) on levels.

**Methods:**

Field measurements of groundwater levels are taken once every three months.

Alcoa has installed approx 180 bores in Wungong (Cobiac) and has monitored monthly groundwater levels from 1992 to 1998 and some to 2006. Since late 2006, Water Corporation commissioned N.D Mining services to continue monitoring the levels on a seasonal basis.

This project will analyse the data to see the trends and spatial and temporal variation of groundwater levels. Alcoa has calibrated the WEC-C model for the Cobiac Catchment. This groundwater level monitoring data will be used to calibrate the WEC-C and LUCICAT models.

**Results / status:**

Analyses have shown that groundwater level in Cobiac have declined by an average of 4m over the last 10 years. The near-stream groundwater levels have fallen by up to 2 m and the upslope levels has fallen by up to 6 m (Devkota, 2008). As 2007 was a relatively wet year, the rate of fall in groundwater levels has decreased.

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 1 (stream water quality and quantity), 15 (informed community response) and 16 (cost effectiveness of catchment thinning).

### **Relationship with EPA Bulletin 1196**

The project is important for assessing advice and recommendations 1d (be made publicly available) and 1e (enable an assessment of future catchment thinning) and 4 (testing a range of thinning options in native regrowth forests and rehabilitated bauxite mined areas).

### **Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 22 (water production) and 19 (stream salinity trends).

### **Overall assessment**

Given the importance of groundwater in determining rainfall - runoff responses these data are crucial to understanding the likelihood of thinning being effective and will also provide data for a number of the other projects (eg 2, 7 and 20). More monitoring may be required to assess the impacts of non-commercial thinning, FORESTCHECK sites where the watertable is close to the ground surface and to assess the impact of treatments on buffers (eg if the additional water generated by thinning results in increased buffer vegetation growth and a subsequent loss of water yield).

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## **5 Project Title: Prescribed fire and stream quantity and quality**

**Project Researcher(s):** Rick Sneeuwjagt, DEC

### **Objectives:**

To evaluate the effect of frequent prescribed burning on stream water quantity and quality.

### **Methods:**

Apply 4 to 6 yearly prescribed burning in the 39 Mile Brook Catchment (5,500 ha gauged at Jack Rocks) which is part of the Serpentine Catchment and monitor the resultant streamflow, water quality and some ecology. The frequency of burning is about twice that of normal practice and the trial may take 20 years to yield the required results. Earlier work in a wetter jarrah-marri catchment has shown a >20% increase in runoff for two years after each burn.

Gauging station and two pluviometers were re-established in 2006 after a gap of 8 years. Stream fauna monitoring is being done in the region by Dr Andrew Storey (UWA) and quokka monitoring is being undertaken at Frollet Swamp. Burn and fuel load statistics will also be collected.

### **Results / status:**

Draft agreement prepared in August 2007.

### **Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 6 (Efficacy of burn prescriptions) and is important for KPI 10 (Change in stream invertebrates).

### **Relationship with EPA Bulletin 1196**

The project is important for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1c (address issues raised in the public review), and 1d (be made

publicly available – data will be stored on the Department of Water’s WIN database) and 1e (assist consideration of whether future projects on catchment thinning for water production should proceed).

### **Relationship with Forest Management Plan 2004 – 2013<sup>11</sup>**

The project helps meet KPIs 22 (water production) and 28 (adaptive management) with the latter requiring formal adaptive management trials on improvements to fire management practices.

### **Overall assessment**

This project will help answer the questions of whether climate change impacts on runoff can be partly offset by increased fire frequencies, and whether some of the reduction in streamflows in recent years has been the result of changed fire management practices. However, determining the combined impacts of “water-prescription” forest thinning and increased fire frequency on runoff and ecology will not be able to be precisely estimated, or the management implications of increased burning of these thinned forests, unless some of these trials are in thinned catchments. The forest will receive the standard pre-fire monitoring carried out by DEC (eg quokka habitat) for which there is an operations checklist.

The project may need to also look at the effect of burning on groundwater levels to be able to better understand runoff mechanisms (eg wetter profile versus an increase in soil water repellence) if realistic control sites can be established. Concerns have been raised by some TRG members about:

- public acceptance, the apparent lack of a control area and its links to the thinning trial (Jan Starr).
- There are other Project KPIs that are relevant to very frequent prescribed burning: 7 Soil protection; 9 Phytophthora dieback and other pathogens; 12 Changes in understorey; 13 Changes in overstorey; and 14 Consultation and communication (Beth Schultz pers. comm.).

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<sup>11</sup> According to Beth Schulz (pers. comm.) the project is also relevant to FMP KPIs: 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing); 3 (the status of selected threatened or conservation dependent) species that are the subject of management actions to protect them); 9 (time to regenerate harvested areas); 10 (effectiveness of regeneration of native forest and plantations); 16 (the risk to conservation, life, property and other forest values posed by wildfire); 17 (the severity status of weeds and pests as determined by subjective survey); 18 (effectiveness of dieback hygiene); 19 (the annual plow weighted mean salinity and the trend for streams in fully forested catchments); 20 (percentage of water bodies with significant variance in biodiversity from historic range of variability); 21 (the level of soil damage resulting from timber harvesting); 26 (number, range and use of recreation/ tourism activities available by proposed land category in plan are); 31 (development of scientific understanding of ecosystem characteristics and functions). The current structure of the project doesn’t address many of these issues.

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**6 Project Title:** Monitoring the effects of wildfire on water, vegetation and biodiversity

**Project Researcher(s):** Frank Batini (forester) and Keith Barrett (hydrologist)

**Objectives:**

To monitor streamflow, water quality and vegetation in Little Darkin Catchment (burnt) in comparison with the adjacent Pickering Brook Catchment (unburnt)

**Methods:**

The project monitors the hydrological and vegetative responses to an intense wildfire in the Little Darkin Catchment in January 2005. Stream gauges were recommissioned following the fire and recorded rainfall, runoff and water quality. Monitoring is expected to continue for 5 to 8 years.

**Results / status:**

Very large quantities of soil, silt and ash were deposited within stream beds and pools in 2005 but soils were stable by 2006. Water yields were about 2.2 times expected amounts (when compared with Pickering Brook flows) in 2005 and 2006 (an exceptionally dry year with little runoff). In 2007 the increase was only 40% and runoff is expected to become less than the “no wildfire” state within the next couple of years (due to regrowth). Many habitat trees were killed and others were damaged. The terrestrial ecosystem is more simplistic and less diverse. More details can be found in Jackson (2006).

**Relationship with the (new, proposed) Project KPIs:**

The project will provide useful information for assessing KPI 6 (efficacy of burn prescriptions) and assist with catchment modelling of the impacts of wildfires on hydrology and forest structure if this is a future risk in thinned catchments.

**Relationship with EPA Bulletin 1196**

The project is not related to thinned catchments and therefore there has limited connection with the bulletin.

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 22 (water production).

**Overall assessment**

This project will help assess the long term impacts of wildfire on stream yields in a drying climate. It is illustrative that the complete removal of vegetative cover resulted in just a 2.2 fold increase in water yield compared with a fully vegetated state. This reflects the lower groundwater levels in recent years and the inability to develop a wetted area near the streamlines to yield water. Reducing LAIs through forest thinning is another way to reduce evapotranspiration rates but this event has provided a measure of the impact of complete removal over the entire catchment. It may therefore be useful for model calibrations (Projects 2 and 7).

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**7 Project Title:** Vegetation dynamics and water yield under changing climate and management

**Project Researcher(s):** Dr Richard Silberstein, Dr Eddy Campbell (CSIRO)

**Objectives:**

- a. Derive broad-scale relationships between streamflow, climate and vegetation change, using multi-variate statistical analyses on temporal sequences of Landsat- derived vegetation indices, catchment digital elevation models, long-term climate and stream flow records.
- b. Measure the relationship between water balance and density and structure of managed jarrah forest stands, undertaken in two climate zones.
- c. Develop or adapt a predictive model coupling forest structure and water yield in response to climate and management (fire and thinning), and test it on hillslope, catchment and regional datasets.
- d. Forecast the water yield and forest structure of selected catchments under a range of future climate and forest management scenarios.
- e. Encapsulate the learning in the Final Report that can be updated as better information becomes available in future.
- f. Scope a whole of system catchment modeling framework for later development.

**Methods:**

1. Assemble spatial and temporal datasets for forested catchments and seek statistically sound relationships between catchment properties, condition and response
2. Select three Experimental Catchments, based on an analysis of gauging and experimental history and continuity of record
  - Control – a catchment where no logging or forest thinning has occurred for more than 10 years prior to the commencement of the project, and is not undertaken during the course of the project (Bates Catchment)
  - Previously Thinned – a catchment treated with logging or thinning at least five years prior to the project commencement (Cobiac Catchment within Wungong)
  - Treated – a catchment that will be treated (by controlled thinning) in year 2 of the project, and whose previous history is similar to the control catchment (31 Mile Brook Catchment)
3. Select appropriate techniques for experimental design and purchase instruments
4. Instrument catchments and establish monitoring sites for forest structure and density measurements, groundwater and stream flow and chemistry monitoring.

**Results / status:**

The Premier's Water Foundation and partners have accepted the project proposal and a detailed plan is being developed. Drilling has been carried out in the Cobiac Catchment. Permission to thin the 31 Mile Brook Catchment was granted by the Conservation Commission in March 2008 subject to ecological monitoring.

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 1 (stream water quality and quantity), 12 (changes in understorey) and 15 (social acceptability) and 15 (cost effectiveness of catchment thinning). This project could establish a model that would enable other manipulation options to be simulated in Wungong, and to extend results to other catchments.

**Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (aim to confirm predicted environmental benefits), 1b (give priority to research projects that address ecological uncertainties), 1c (address issues raised in the public review), 1d (be made publicly available), 1e (enable an assessment of future catchment thinning) and 4 (testing a range of thinning options in native regrowth forest and rehabilitated bauxite mined areas).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 22 (water production), 28 (adaptive management), 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control) and 19 (stream salinity trends).

**Overall assessment**

This project will establish a model that would enable other manipulation options to be simulated in Wungong, and to extend results to other catchments. A major limitation is that the PWF funding needs to be expended by July 2010 which will not enable the full impacts of thinning the 31 Mile Brook Catchment from being evaluated unless monitoring continues after this data (assuming that the Conservation Commission of WA approve this treatment).

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**8 Project Title: Remote sensing to monitor changes in forested catchments**

**Project Researcher(s): Frank Batini, Consultant),** Mike Canci, Water Corporation; Andrew Malcolm and Frank Honey – SpecTerra

**Objectives:**

Monitor changes in vegetation structure and health as a result of catchment operations and compare field-based estimates of crown cover with those derived from the imagery.

**Methods:**

Initial baseline (spring 2005) capture of the entire Wungong catchment has been followed by annual acquisition of digital multi-spectral (4 band) imagery (Digital Multi Spectral Video or DMSI) at a spatial resolution is 0.5m over small selected sub-areas of the catchment. SpecTerra delivers ortho-rectified imagery along with processed change detection products.

**Results / status:**

High level of correlation between the crown cover estimates. Field verification confirmed change in vegetation health as indicated by comparison of multi-date imagery.

**Relationship with the (new, proposed) Project KPIs:**

The project is relevant to Project KPIs 3 (efficacy of herbicide treatments); 4 (achievement of retained basal areas); 6 (efficacy of burn prescriptions); 9 (dieback); 12 (changes in understorey); and 13 (changes in overstorey).

**Relationship with EPA Bulletin 1196**

The project is important for assessing advice and recommendations 1a (aim to confirm predicted environmental benefits); 1b (give priority to research projects that address ecological uncertainties); 1c (address concerns and questions raised in the public review); 1d (be made readily available); 1e (assist consideration of whether future projects on catchment thinning for water production should proceed); and 1f (contribute to policies and guidelines for catchment thinning in other catchments).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet FMP KPIs: 6 (area of forest cut annually); 9 (time to regenerate harvested areas); 10 (effectiveness of regeneration of native forest and plantations); 12 (the achievement of early thinning schedules that underpin future yields); 18 (effectiveness of dieback hygiene); 21 (the level of soil damage resulting from timber harvesting); and 31 (development of scientific understanding of ecosystem characteristics and functions).

**Overall assessment**

Digital aerial photography is also being captured of Wungong with a spatial resolution of 0.3m (red-blue-green-infrared) and 0.1m (black and white) as part of the Urban Monitor consortium. Images have been collected in autumn 2007 and autumn 2008.

Significant processing is required by the data providers before the information is suitable for analysis. As at July 2008 this processing has not been completed.

Hyper-spectral data (2.4m pixel) have also been collected in part of the Wungong Catchment and compared with the SpecTerra DMSV (0.5m pixel) by Dr Ian Lau (2008). The draft report is inconclusive on their applicability but it is likely that the images are not of sufficient quality to be of use (swaths rather than overlapping vertical images; low sun angles).

In summary the SpecTerra data have been shown to provide quality information that can be used to monitor both the effectiveness of the catchment operations along with change in vegetation health and structure. SpecTerra provides fast mobilisation of equipment and quick turn-around in delivery of data products.

Dr Peter Hick has developed a biodiversity decision support system for the Peel Harvey Catchment Council ([www.peel-harvey.org.au](http://www.peel-harvey.org.au)) based on collaboration with Land Monitor (Jan Starr pers. comm.).

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**9 Project Title:** Leaf Area Index (LAI)

**Project Researcher(s):** Dr. Bishnu Devkota (Water Corporation) and Geoff Mauger (Consultant)

**Objectives:**

To analyse Landsat data to map annual changes in LAI as a result of catchment thinning, dieback and vegetation stress.

**Methods:**

Application of GIS methods will be used to examine spatial and temporal variations in LAI in the catchment. Excel will be used to calculate the LAI of each response units and gauged catchments. Correlation analyses will assess relationships between LAI data, runoff and groundwater levels.

**Results / status:**

A spatial LAI variation map of Wungong has been developed using LAI data from 2005. It was found that the rehab area had higher LAI values than other areas. It is also found that the higher the LAI, the less the runoff coefficient (Devkota, 2008). Vardi Road, which encompasses 80% of the Wungong catchment area, had the highest LAI value of 2.2 and the smallest runoff coefficient.

**Relationship with the (new, proposed) Project KPIs:**

This project supports other projects by mapping the changes in vegetation. The project may provide some insights help to explain KPI 12 (changes in understorey) and 13 (changes in overstorey).

**Relationship with EPA Bulletin 1196**

The project can provide essential information for 1e (enable an assessment of future catchment thinning) and 4 (testing a range of thinning options in native forest and bauxite mined areas).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPI 31 ((development of scientific understanding of ecosystem characteristics and functions).

**Overall assessment**

This will provide knowledge on the temporal and spatial variation of LAI and is an input data set to LUCICAT modelling and may help explain changes in groundwater levels and streamflows.



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**10 Project Title:** The impact of forest thinning techniques on perceptions of recreational value and ecosystem health

**Project Researcher(s):** Jo Ann Beckwith (Beckwith Environmental Planning Pty Ltd) and Susan Moore (Murdoch University)

**Objectives:**

What is the impact of the different forest thinning techniques tested in the Wungong Catchment on perceptions of (a) recreation value and (b) ecosystem health ?

- Do social values and affiliations affect people's acceptance of tree thinning options ?
- What is the relationship between scenic beauty and perceptions of ecosystem health and management ?
- What is the relationship between perceptions of aesthetic value and satisfaction with nature-based recreational activities ?
- What impact does providing information and the consequences of the thinning techniques have on the acceptability of the options ?

**Methods:**

Photo simulations of forests after 1, 5, 25, 50 and 70 years of five thinning treatments will be shown to three target populations – off-road cyclists, bushwalkers and forest managers.

Their perceptions of the recreational value and ecosystem health of each treatment will be recorded and analysed.

**Results / status:**

A detailed proposal has been developed (March 2008) which is based on an initial July / November 2006 proposal.

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing 15 (Social acceptability) and 16 (cost effectiveness of catchment thinning) and important for KPI 14 (Consultation and communication) because it will help establishment how different forest users view the altered forest.

**Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1c (address issues raised in the public review), 1d (be made publicly available), 1e (assist consideration of future projects on catchment thinning), 1f (contribute to policies and guidelines for catchment thinning in other catchments and 4 (testing a range of thinning options in native regrowth forest and rehabilitated bauxite mined areas).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 26 (recreation / tourism activities).

## **Overall assessment**

This is the only social science study and as such it provides essential information as to public perceptions and ultimate response to forest thinning. It is possible that the public will like the end result but show some antipathy to the interim stages. It has been noted that the impact of the treatments may not be apparent for hundreds of years (Beth Schulz pers. comm.).

Keith Barrett (pers. comm. 2008) has raised an important perspective in that any antipathy may be offset were the public also to be asked about their preference to streams that were dry (unthinned) or flowing (thinned) assuming that thinning will help return streams more like their previous wet condition. This limitation needs to be mentioned when results are discussed if it is not feasible to include similar assessments.

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## **11 Project Title: Demonstration / Information sites**

**Project Researcher(s):** Marg Wilke, Frank Batini and Richard Boykett, DEC, Bentley

**Objectives:** To establish demonstration / information areas in native regrowth forest and in a post 1998 rehabilitation bauxite mine pit along Jarrahdale Road to provide accessible examples of thinned forest types.

### **Methods:**

Establish a forest site of eight plots each at least 1 ha (native forest) and another eight plots each at least 0.5 ha (mine rehabilitation pit) in accessible sites along Jarrahdale Road to act as demonstration / information sites of various treatment options for the larger catchment.

### **Results / status:**

The plots have been established.

### **Relationship with the (new, proposed) Project KPIs:**

The project is essential for KPI 14 (Consultation and communication) and important for assessing KPI 15 (Social acceptability) and 16 (cost effectiveness of catchment thinning) because it will help establishment how different forest users view the altered forest.

### **Relationship with EPA Bulletin 1196:**

The project is essential for assessing advice and recommendation numbers 1c (address concerns and questions raised in the public review), 1d (be made readily available), 1e (assist consideration of whether future projects on catchment thinning for water production should proceed), and 1f (contribute to policies and guidelines for catchment thinning in other catchments).

### **Relationship with Forest Management Plan 2004 – 2013:**

The project helps meet KPIs 26 (recreation / tourism activities).

## **Overall assessment**

Such demonstration sites may be effective in increasing community understanding of the concept as people become familiar with the various forest forms.

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**12 Project Title:** Sapflow measurements to answer tree water use questions

**Project Researcher(s):** Richard Silberstein, Craig Macfarlane and Don White, CSIRO, Floreat

**Objectives:**

To determine whether:

- stands of large, old jarrah trees transpire less than younger stands containing smaller trees, and quantify the differences; and
- transpiration by other species, including marri and Bull Banksia is a significant component of the stand water balance in regrowth jarrah forest. Currently not funded but strong interest in these measurements has been expressed by partners.

**Methods:**

The work will involve sapflow measurements of selected jarrah, marri and Banksia trees as well as water potential measurements using stem hygrometers. It will supplement other stand and catchment scale measurements made in PWF project 7.

**Results / status:**

Details of the work on old jarrah trees are still under discussion. A decision needs to be made as to whether the additional measurements are worthwhile.

**Relationship with the (new, proposed) Project KPIs:**

The project is important for assessing KPI 1 (stream water quality and quantity), 12 (changes in understorey), 15 (social acceptability) and 16 (cost effectiveness of catchment thinning).

**Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1d (be made publicly available) and 1e (enable an assessment of future catchment thinning).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 22 (water production), 28 (adaptive management), 31 (development of scientific understanding of ecosystem characteristics and functions) and 33 (operational control).

**Overall assessment:**

This work will provide direct measurements of the reduction in transpiration on old jarrah trees that have been inferred from streamflow measurements, in addition to assessing the relative importance of other forest species. Species-specific measurements are required to understand what each forest species contributes to the overall water balance components. She-oak should be included in the measurements according to Jan Starr (pers. comm.)

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**13 Project Title:** Vegetation monitoring program

**Project Researcher(s):** Libby Mattiske, Mattiske Consulting Pty Ltd

**Objectives:**

To establish a vegetation monitoring program to measure the effect of the proposed thinning trials on the botanical biodiversity values in the catchment.

**Methods:**

**Stage 1A Transects across the creeklines** to monitor the indirect impacts of logging in the sub-catchments in the botanical biodiversity value

**Stage 1B Plots and quadrats in Stage 1 logging regime** to monitor the indirect impacts of logging in the sub-catchments in the botanical biodiversity value

**Stage 1C Design longer-term monitoring program 2006 to 2015** for assessing the potential impacts of the proposed thinning of the understorey species in the Wungong Catchment.

**Results / status:**

Baseline monitoring for four flora transects and six plots overlapping with fauna plots is completed. A draft report has been received.

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 12 (changes in understorey) and important for assessing KPI 5 (level of damage in retained stems), 15 (social acceptability) and 16 (cost effectiveness of catchment thinning). It is also relevant to Project KPIs 5 (dieback) and 15 (changes in overstorey).

**Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1c (address concerns and questions raised in the public review), 1d (be made publicly available), 1e (enable an assessment of future catchment thinning), 1f (contribute to policies and guidelines for catchment thinning) and 2b (catchment management practices and strategies, especially those in Reservoir Protection Zones).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control), 10 (effectiveness of regeneration of native forest and plantations) and 28 (adaptive management). It is also relevant to FMP KPIs 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing); 3 (the status of selected threatened or conservation dependent) species that are the subject of management actions to protect them); 9 (time to regenerate harvested areas); 10 (effectiveness of regeneration of native forest and plantations); 17 (the severity status of weeds and pests as determined by subjective survey); and 18 (effectiveness of dieback hygiene).

## **Overall assessment**

This project will provide essential data for a number of KPIs and help meet the reporting requirements. It builds on extensive monitoring from other catchments and therefore the relatively modest budget will be well worthwhile as the results will be able to be put into a wide context. If the FORESTCHECK work is reduced or omitted altogether then this monitoring may need to be expanded.

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### **14 Project Title:** Fauna monitoring plots and fauna monitoring programs

**Project Researcher(s):** Dave Kabay – Kabay Consultants Pty Ltd

#### **Objectives:**

To establish an additional six fauna monitoring plots in the Wungong Catchment (to complement the Alcoa World Alumina plots) and conduct fauna monitoring programs at these plots so as to assess the effect of thinning practices on defined fauna.

#### **Methods:**

Two plots will be established each in:

- Non-commercial thinning area;
- Commercial logging followed by non-commercial thinning (higher impact); and
- Control plots in the SE (proposed National Park).

Fauna monitoring will be carried out at establishment and at four yearly intervals – ie in years 1, 5 and 9

#### **Results / status:**

Early design and data are reported in Kabay (2007a; 2007b). It is too early to define any trends in the data. Spring and summer measurements and the final report on baseline monitoring have been completed.

#### **Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 11 (changes in indicator fauna species) and important for assessing KPI 15 (social acceptability) and 16 (cost effectiveness of catchment thinning).

#### **Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1 c (address concerns and questions raised in the public review), 1d (be made publicly available), 1e (enable an assessment of future catchment thinning), 1f (contribute to policies and guidelines for catchment thinning) and 2b (catchment management practices and strategies, especially those in Reservoir Protection Zones).

#### **Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing), 3 (the status of selected threatened or conservation dependent)

species that are the subject of management actions to protect them), 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control) and 28 (adaptive management).

**Overall assessment:**

Like Project 13, this project will provide essential data for biological KPIs and help meet the reporting requirements. It builds on monitoring from other catchments (DEC, mining companies) and therefore the Wungong results will be able to be put into a wide context.

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**15 Project Title:** Community-based study of fungi biodiversity in the Wungong Region

**Project Researcher(s):** Roz Hart (Perth Urban Bushland Fungi Project), Dr Neal Bougher (Mycologist, DEC) and Margaret Larke (Western Australian Naturalist Club Inc).

**Objectives:**

- To foster public participation, awareness and education about fungal biodiversity and the role of fungi for the long-term health of Wungong Catchment.

**Methods:**

An initial one-season study is proposed between April and December 2008 involving a weekend fungi workshop followed up by processing of the fungi collected and a report. At least five years of survey is recommended to establish the main fungi in an area. It is understood that both thinned and unthinned catchment areas will be surveyed (Frank Batini per. comm.) although the initial submission did not indicate this.

**Results / status:**

One field survey of fungi in the Wungong Catchment has been completed. This did not compare treated and non-treated parts of the forest and the members are uneasy about their measurements being used for thinning decision purposes.

**Relationship with the (new, proposed) Project KPIs:**

The project may be useful for KPIs 9 (dieback), 11 (changes in indicator fauna<sup>12</sup> species) and 12 (changes in understorey).

**Relationship with EPA Bulletin 1196**

If the work does survey thinned and unthinned areas the project may be useful for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1c (address concerns and questions raised in the public review), 1d (be made publicly available), 1e (enable an assessment of future catchment thinning), 1f (contribute to policies and guidelines for catchment thinning) and 2b (catchment management practices and strategies, especially those in Reservoir Protection Zones).

**Relationship with Forest Management Plan 2004 – 2013**

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<sup>12</sup> The fungi are more closely related to animals than plants yet the discipline of mycology often falls under a branch of botany

If the work covers both treated and untreated areas, the project could help meet KPIs 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control), 10 (effectiveness of regeneration of native forest and plantations) and 28 (adaptive management). It is also relevant to FMP KPIs 17 (the severity status of weeds and pests as determined by subjective survey) and 18 (effectiveness of dieback hygiene). This project may also help meet KPI 29 (provide for public involvement activities and public education, awareness and extension programs and make available forest-related information).

**Overall assessment:**

Currently this project is not aligned with the forest thinning work unless both treated and non-treated areas are covered in a sufficiently detailed way to be able to feel confident that any changes in fungal occurrence and amounts were significant enough as to be due to the treatment. The surveys may need to be longer (more than a single weekend), targeted to treatment and non-treatment areas and capture data over a long period (given the variability in longitudinal data from other studies) for it to be definitive.

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**16 Project Title:** FORESTCHECK – monitoring biodiversity in jarrah forest managed for sustainable forestry

**Project Researcher(s):** Dr Richard Robinson and Dr Lachie McCaw, DEC

**Objectives:**

Use FORESTCHECK to monitor changes and trends in key elements of forest biodiversity associated with forest management activities in Wungong and compare with other FORESTCHECK sites in the forest.

**Methods:**

Depending on resources, establish sites in both the Murray 1 vegetation type and in the Dwellingup 2 vegetation type (Mattiske and Havel 1988) within Treatment Area 3.

**Results / status:**

The initial timetable was:

- Site to be chosen in July 2007
- Site establishment and pre-treatment monitoring 2008
- Treatment in autumn / winter 2009
- Report in 2009
- Sites are monitored on a 5 year rotation.

Currently (July 2008) the project has been deferred depending upon resource availability and may not proceed until 2012.

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 11 (changes in indicator fauna species) and 12 (changes in understorey) and important for assessing KPI 15 (social acceptability) and 16 (forest-related information).

(cost effectiveness of catchment thinning). It is also relevant to Project KPIs 9 (dieback) and 10 (changes in stream invertebrates).

### **Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1b (give priority to projects that address ecological uncertainties), 1c (address concerns and questions raised in the public review), 1d (be made publically available), 1e (enable an assessment of future catchment thinning), 1f (contribute to policies and guidelines for catchment thinning) and 2b (catchment management practices and strategies, especially those in Reservoir Protection Zones).

### **Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing), 3 (the status of selected threatened or conservation dependent) species that are the subject of management actions to protect them), 9 (time to regenerate harvested areas), 10 (effectiveness of regeneration of native forest and plantations), 17 (the severity status of weeds and pests as determined by subjective survey), 18 (effectiveness of dieback hygiene), 20 (percentage of water bodies with significant variance in biodiversity from historic range of variability), 21 (the level of soil damage resulting from timber harvesting), 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control) and 28 (adaptive management).

### **Overall assessment**

This project could assist in measuring biodiversity changes in an area undergoing thinning and making credible comparisons with other forest areas. It will help separate changes due to thinning from other changes such as climate change, other logging practices, dieback and fire.

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## **17 Project Title: Monitoring dieback in the Wungong Catchment<sup>13</sup>**

**Project Researcher(s):** Mike Stukely and Greg Strelein (DEC)

### **Objectives:**

To determine whether thinning will change dieback introduction, spread or impact.

### **Methods:**

**Vectored spread** – Map occurrence prior to operations, conduct operations using hygiene measures and assess the success by remapping a sample of areas.

**Autonomous spread** - Establish about 20 transects to measure spread over 5 or more, sample thinned and unthinned forest on comparable slopes, vegetation site types /

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<sup>13</sup> Details from “Aspects of dieback behaviour relevant to the formation of jarrah silviculture guidelines” were sent as background for this project but they are unaligned because they are not relevant to the Wungong or thinning in any appreciable way.



complexes and determine the rate of spread and simulate future spread.

**Results / status:**

The project is part of a broader DEC program and is carried out at a regional (operational) scale rather than at a research scale.

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPI 9 (dieback). It is also relevant to Project KPIs 6 (efficacy of burn prescriptions); 8 (growth rates of commercial species and timber yields); 11 (changes in indicator fauna species); 12 (changes in understorey); 13 (changes in overstorey); 15 (social acceptability) and 16 (cost effectiveness of catchment thinning).

**Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1b (give priority to projects that address ecological uncertainties), 1c (address concerns and questions raised in the public review), 1d (be made publicly available), 1e (enable an assessment of future catchment thinning), 1f (contribute to policies and guidelines for catchment thinning) and 2b (catchment management practices and strategies, especially those in Reservoir Protection Zones).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing), 3 (the status of selected threatened or conservation dependent) species that are the subject of management actions to protect them), 10 (effectiveness of regeneration of native forest and plantations), 18 (the effectiveness of dieback hygiene), 28 (adaptive management), 31 (development of scientific understanding of ecosystem characteristics and functions), and 33 (operational control).

**Overall assessment**

This project is the only one that addresses KPI 9 (dieback) so is essential. By examining vectored and autonomous spread it also will assess both dieback spread risk issues associated with thinning. It has been suggested by Amanda Reed (pers. comm.) that the methods should use Alcoa's method which re-monitors the dieback lines to search for new spots as they are unsure how impact is assessed using the transect method.

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**18 Project Title:** Monitoring Cockatoo, Avifauna and Ground Vertebrates

**Project Researcher(s):** Ron Johnstone and Tony Kirkby, WA Museum

**Objectives:**

**Cockatoo Project**

Monitor and document breeding, feeding and roosting sites for the Forest Red-tailed Black Cockatoo, Carnaby's Cockatoo and Baudin's Cockatoo within Wungong Catchment, Bungendore Park and the Canning and Serpentine Dam Catchments. The project will help estimate the effects of forest fragmentation, predators, fire and processes that alter habitat characteristics on these threatened populations.

### **Avifauna in the Wungong Catchment**

To provide information on the distribution, status, relative abundance, habitat preference, breeding and migration and movement of all species of birds inhabiting or visiting the Wungong Catchment.

### **Survey of Small Ground Vertebrates**

To continue and expand documenting ground vertebrate fauna of Bungendore Park (1992 to 2006) as a comparison of sites being monitored in the Wungong Catchment.

#### **Methods:**

Cockatoo Project – continue to monitor 59 nests of Forest Red-tailed Black Cockatoo, 14 of Carnaby's Cockatoo and 2 of Baudin's Cockatoo, including monitoring banded individuals and threats such as the impact of the European honey bee.

Avifauna in the Wungong Catchment – evaluate data in the Storr – Johnstone Bird Data Bank and interpret changes in distribution, abundance etc

Survey of Small Ground Vertebrates - continue the study beyond 2006 and survey species such as Carpet Python, King Skink and the Quokka.

#### **Results / status:**

A draft report for Cockatoo and Avifauna is prepared and is under review. The ground vertebrates' survey is progressed.

#### **Relationship with the (new, proposed) Project KPIs:**

The project is important for assessing KPI 11 (changes in indicator fauna species) and KPI 15 (social acceptability) and 16 (cost effectiveness of catchment thinning).

#### **Relationship with EPA Bulletin 1196**

The project is important for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1b (give priority to projects that address ecological uncertainties), 1c (address concerns and questions raised in the public review) and 1d (be made publically available).

#### **Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing), 3 (the status of selected threatened or conservation dependent) species that are the subject of management actions to protect them), 10 (effectiveness of regeneration of native forest and plantations), 24 (consultation and involvement of Aboriginal people in forest management), 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control) and 28 (adaptive management).

#### **Overall assessment**

It is not clear whether the cockatoo and vertebrates work was going to continue anyway. There is no clear correlation between the surveys and the thinning work in the current proposal. The bird measurements could contribute to a KPI (Jan Starr pers. comm.).

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**19 Project Title:** Aquatic fauna biodiversity assessment

**Project Researcher(s):** Andrew Storey, Aquatic Research Laboratory (ARL), UWA

**Objectives:**

To assess the effects of the Wungong Catchment Environment and Water Management project on the biodiversity of aquatic fauna, principally aquatic macroinvertebrates and fish, in tributary streams of the Wungong catchment.

**Methods:**

Compare macroinvertebrates and fish communities of streams in sub-catchments to be manipulated to streams of subcatchments that will remain untouched. Two approaches will be done – a Before-After-Control-Impact (BACI) study and a multivariate analysis of change in community structure.

At least three streams would be selected, one being in the Wungong and two in nearby streams previously sampled by the ARL.

**Results / status:**

Three sites exposed to thinning, Treatment Area 1, Treatment Area 2 and Vardi Road and three reference sites, Waterfall Gully, 31 Mile Brook and Foster Brook were monitored in December 2005 and October 2006.

For 2007 a new control (as 31 Mile Brook was now to be treated) was established on Wilson Brook and 39 Mile Brook Jack Rocks was added. The eight sites were again monitored in spring 2007.

The 2005 and 2006 monitoring is discussed in a report for the Water Corporation titled “Wungong Catchment Environment and Water Management Project, Aquatic Fauna Biodiversity Assessment October 2006” by Aquatic Research Laboratory, University of Western Australia

**Relationship with the (new, proposed) Project KPIs:**

The project is essential for assessing KPIs 10 (changes in stream invertebrates) and 11 (changes in indicator fauna species) and important for assessing KPIs 15 (community acceptance) and 16 (cost effectiveness of catchment thinning).

**Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1b (give priority to projects that address ecological uncertainties), 1c (address concerns and questions raised in the public review), 1d (be made publicly available), 1e (enable an assessment of future catchment thinning), 1f (contribute to policies and guidelines for catchment thinning) and 2b (catchment management practices and strategies, especially those in Reservoir Protection Zones).

**Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities

as determined by listing), 3 (the status of selected threatened or conservation dependent species that are the subject of management actions to protect them), 19 (the annual flow weighted mean salinity and the trend for streams in fully forested catchments), 20 (percentage of water bodies with significant variance in biodiversity from historic range of variability), 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control) and 28 (adaptive management).

### **Overall assessment**

The project will provide quantitative information on the ability of catchment thinning to retain aquatic fauna in the face of climate change. There could develop useful links with Projects 1, 2, 3, 4 and 7.

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**20 Project Title:** Balancing water quality and ecosystem health with water yield – ecosystem response to thinning in Wungong Catchment

**Project Researcher(s):** Richard Bell and Qui Song, Murdoch University

### **Objectives:**

The project is trying to answer the following four research questions (RQs)

1. How are thinning impacts reflected in the ecosystem composition, structure and function during transition to a new stable state ?
2. What are the underling processes regulating post-thinning vegetation change and ecosystem dynamics ?
3. How do catchment dynamics after thinning impinge on stream water quality ?
4. Can post-thinning successional trajectories be predicted ?

### **Methods:**

RQ1 and 2 will be addressed in Sub-project 1 by monitoring 15 sites with controls and landscape-scale thinning. The sub-project will also include a field plot experiment to test the effect of thinning method (stem injection, commercial harvest) and intensity (basal area reduction %) on nutrient cycling and biological response.

RQ3 will be addressed in Sub-project 2 whereby transects will be carried away from streamlines in areas undergoing either stem injection or commercial harvest treatments. Runoff plots and groundwater bores will be established along each transect.

RQ4 will be addressed by studying ecosystem structure and compositional properties in previously thinned jarrah forest within or near the Wungong catchment.

### **Results / status:**

Failure to appoint an APAI Scholarship student has delayed progress. Shortlisting of sites commenced in February 2006 using spatial data from Water Corporation and DEC. Three sites have been selected (thinned after burning; burnt but not thinned and not thinned or burnt) and some meteorological measurement and litter fall have been made. Equipment has been purchased. Thinned burn areas had the highest litter all with the lowest litterfall in the unburnt and unthinned sites.

### **Relationship with the (new, proposed) Project KPIs:**

The project is important for assessing KPI 1 (water quality and quantity criteria), KPI 11 (changes in indicator fauna species) and KPI 12 (changes in understorey), and may be important for assessing KPI 15 (social acceptability) and 16 (cost effectiveness of catchment thinning). It is also relevant to Project KPIs 6 (efficacy of burn prescriptions); 7 (soil protection); 10 (changes in stream invertebrates); 12 (changes in understorey) and 13 (changes in overstorey).

### **Relationship with EPA Bulletin 1196**

The project is essential for assessing advice and recommendations 1a (confirm predicted environmental benefits), 1b (give priority to projects that address ecological uncertainties), 1c (address concerns and questions raised in the public review), 1d (be made publicly available), 1e (enable an assessment of future catchment thinning), 1f (contribute to policies and guidelines for catchment thinning) and 2b (catchment management practices and strategies, especially those in Reservoir Protection Zones).

### **Relationship with Forest Management Plan 2004 – 2013**

The project helps meet KPIs 2 (the status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing), 3 (the status of selected threatened or conservation dependent) species that are the subject of management actions to protect them), 9 (time to regenerate harvested areas), 10 (effectiveness of regeneration of native forest and plantations), 17 (the severity status of weeds and pests as determined by subjective survey), 18 (effectiveness of dieback hygiene), 20 (percentage of water bodies with significant variance in biodiversity from historic range of variability), 21 (the level of soil damage resulting from timber harvesting), 22 (water production), 31 (development of scientific understanding of ecosystem characteristics and functions), 33 (operational control) and 28 (adaptive management).

### **Overall assessment**

Like Project 7 this has the potential to integrate a lot of related data and also leverage significant resources and skills. Synergies between these two integrative projects should be sought.

## **5 Research Gaps**

The project KPIs that are not addressed at all by the current 20 projects are:

- No 2 - safe handling of herbicides; and
- No 3 – efficacy of herbicide treatment.

Project KPIs that may or may not be met (according to whether the projects can be better aligned) are:

- No 4 – achievement of retained basal areas;
- No 5 – level of damage to retained stems; and
- No 7 – soil protection.

There is a need for an operational research project (Number 21) that applies the currently-

collected monitoring and operational data to assess the most cost effective ways to thin the forest, prevent regrowth and address safety and environmental damage risks. ALCOA agree with this need as they have had to retreat the rehabilitation in Bennett's catchment (Amanda Reed, pers. comm.).

If the thinning process is not efficient the on-going cost of maintaining the required basal areas may become prohibitive. It is presumed that maintenance costs decrease over time as the mature trees take over the available light, water and nutrients. However it is not clear whether any current project will estimate these transition cost at the same time as estimating ecological transitions (Projects 7, 20).

A possible research project on soil health (KPI 7) may need to be considered as current measurements mainly cover soil disturbance as a result of mechanical operations. The thinning operation is non-mechanical but will result in changes to soil temperatures, light penetration and moisture levels. This may extend to the health of mining (disturbed) sites as well as un-mined areas.

Another research gap is the impact on stream flows of leaving stream buffers untreated as these are now the main runoff generating parts of the catchments in a drying climate and falling groundwater levels. These buffers have been protected for many years for water quality purposes but their impact on reducing flows which may cause ecological damage is unclear. The trade-off between water quality risks and reduced flows is an important consideration that needs to be evaluated in a project, a conclusion that is supported by ALCOA (Amanda Reed pers. comm.).

When developing the detailed KPIs, Geoff Stoneman (pers. comm.) believes that consideration should be given to:

- impacts on biodiversity elements considered to be at high risk;
- the long term impacts on the sustainable yields from both native forests and rehabilitation (instead of millable timber yields); and
- the effectiveness in reducing weeds, especially in association with rehabilitation areas.

The detailed KPIs also need to be "SMARTened"<sup>14</sup> (Jan Starr pers. comm.)

Some projects could be better aligned with the treatments to achieve a more cost effective and thorough outcome as indicated below:

#### **Projects that are currently weakly aligned to catchment thinning**

- No 15 – Community based study of fungi biodiversity in the Wungong Catchment. It is hard to see how the data collected from this study can be used to assess the impact of catchment thinning in the Wungong Catchment unless it is sufficiently comprehensive to provide a confident assessment of the impact of the treatment on fungal occurrence and intensity. As described the project will produce a list of fungi present at the time of the survey. It is possible however that the project has since been better aligned so that it targets the questions than need to be addressed.

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<sup>14</sup> Specific, measurable, achievable, realistic and time-bound or timely.

- No 3 - Hydrological processes - unless this project also addresses bauxite mine pits that have been thinned (unclear as the project details are lacking). According to Amanda Reed (pers. comm.) This project should still provide value, irrespective of whether thinning occurs.
- No 5 – Prescribed fire and stream quantity and quality – unless a burnt area is also thinned.
- No 6 – Monitoring the effect of wildfire on water, vegetation and biodiversity – although the work may enable the effect of extreme vegetation removal to be understood and included in hydrological models. According to Amanda Reed (pers. comm.) we still need data on “streamflow versus time since fire”; how fast streamflow returns to normal; how much variation and do we understand the reasons ?
- No 18 – Monitoring Cockatoo, Avifauna and Ground Vertebrates – unless the surveying were better related to forest thinning.

#### **Projects that provide essential support information to others and help meet KPIs**

- No 1 – Hydrographic measurements
- No 4 – Groundwater monitoring
- No 8 – Remote sensing
- No 9 – Leaf Area Index

#### **Completely aligned projects**

Nos 2, 7, 10, 11, 12, 13, 14, 16, 17, 19 and 20 are completely aligned with the work in the Wungong Catchment.

## **6 Opportunities for better integration**

It is recommended that small groups involved in related projects get together and explore possible integration or sharing of data or survey sites so that the work may be more cost effective. There appears to be scope to better link the following work areas

**Remote sensing** components in Projects 7, 8, 9 and 17. Most of these projects are using Landsat TM and there are likely to be opportunities for collaboration and the avoidance of conflicting results.

**Hydrological modelling** in Projects 2, 3 and 7. Three different models are proposed – LUCICAT, WEC-C and MIKE-SHE, each with their own strengths and weaknesses. The researchers have a history of collaboration so there should not be any issues in getting close collaboration. Interactions with modelling in project 20 also need to be explored.

**Leaf area index** work in Projects 7, 9 and 16. Different methods are proposed to assess aspects of LAI – Echidna, Landsat TM and observations of forest composition, structure and developmental stage. The more detailed methods may enable others to be more accurately calibrated.

**Integrative systems research** in Projects 7 and 20; and a new project on millable timber yields if funded. These two projects are very complex as they integrate a large amount of data and build predictive methods of what will happen under future conditions. They

involve external skills and funds (Premiers Water Foundation, Australian Research Council Linkage) and may provide a measure of independence that the other projects lack due to their being commissioned studies or consultancies by the Water Corporation. Both projects are ambitious and timelines are likely to be stretched (as they have already).

Getting the various **flora and fauna monitoring groups** together may also be beneficial (Mattiske Consulting; Kabay Consultants; WA Museum; UWA; DEC; Murdoch University; WA Naturalists Club) to see whether the datasets can be improved through common database linkages and sharing. According to Amanda Reed (pers. comm.) this is an important issue and an aquatic fauna working group would be beneficial.

There are annual information sharing seminars to report these projects but given that there are 20 to cover in one day there is often insufficient time to assimilate the overall results. It is therefore suggested that a second half day workshop be added to provide an opportunity for synthesis between results, and between researchers and managers.

## **7 Reporting**

A general recommendation is that the reports reflect back to the regulators their written concerns so that they can see that the Wungong project has taken their issues and recommendations seriously. Appendix 2 relates the 20 individual projects to EPA Bulletin 1196 and the Forest Management Plan, as well as the Trial's own KPIs.

Rather than write three separate reports it is recommended that a common format be adopted with specific sections being used to address each specific need.

### **7.1 Conservation Commission**

The Commission has recently been briefed on the advantages and disadvantages of forest thinning through the submission by CSIRO to thin the 31 Mile Brook Catchment (Silverstein 2008). This application is likely to raise issues that the Commission would like the broader trial to address over time. Importantly the case was made that "doing nothing different" in the face of climate change may result in the loss of important aquatic ecosystems and that catchment thinning may "pre-condition" the forest and make it more adaptable to a drier and hotter future climate. However this may be viewed by some members as a courageous intervention and carry its own risks.

The other consideration is how the Wungong Trial can help the Commission address its own needs to report on the Forest Management Plan 2004 – 2013. No project by itself will address the KPIs but they can assist DEC, the FPC and the Commission in meeting their reporting needs.

### **7.2 EPA**

The EPA's advice and recommendations are very broad and therefore the assessment of how each project addresses each requirement can only be subjective. EPA requirement 3 is that the Projects' first review needs to be submitted to the Conservation Commission by 2008. There is no requirement for on-going reporting to the EPA, only to take account of the s16e advice. However it is advisable to provide periodic (biannual ?) briefings to the EPA as it expressed an interest in what the trial would mean for the future management of



water catchments under a drying climate (p 11).

### **7.3 Water Corporation Board**

A new KPI (number 16) was added to address the need of the Water Corporation Board to be able to determine the social acceptability and cost effectiveness of catchment thinning as both criteria will need to be met if the treatment is to proceed beyond the reviews in 2008 and 2012. This KPI will also help meet the EPA recommendation that the trial assist consideration of whether future projects on catchment thinning for water production should proceed.

It is possible that the treatment could prove as beneficial from an aquatic environment and/or millable timber perspective as it does from considerations of increased water production and possibly more so. This may enable multiple parties to contribute to the on-going cost of maintaining low basal areas or encourage the introduction of a Community Service Obligation payment for the practice to be subsidised. Multiple benefits need to be anticipated and assessed so that a full appreciation of who benefits is understood.

The Water Corporation Board will be mainly interested in the business case of forest thinning in terms of the amount and reliability of catchment yields, the on-going costs of treatment (hopefully reducing as the large trees take over) and the unit cost on new water as compared with other sources. The fact that the dams are all connected to the Integrated Water Supply System, require no filtration and provide water under gravity makes any additional yield of high value compared with other sources that lack these advantages. Therefore the advantage of having these expensive assets more fully utilised needs to be considered in any comparative assessment. Any long-term monitoring commitments that may be made by the Water Corporation in the course of the investigation also need to be considered as this could result in monitoring costs continuing after the trial has been completed even if a decision is subsequently made not to continue with the treatment.

The ability of the current 20 research projects to generate the numbers required to build a business case for consideration by the Board needs to be assessed by the Infrastructure Planning (Graeme Hughes) and/or Pricing and Evaluation Branches (Lloyd Werner) at an early stage. None of the projects is currently assessing the cost of establishing and maintaining low basal areas under operational conditions. Several projects are however measuring and/or modelling streamflows as a result of the treatments and estimating how these may change under future catchment and climate conditions. The trial may also be more effective in southern catchments that have not dried to the same extent as the Wungong so consideration to estimating catchment responses in the Harvey, Samson and Logue Catchment may need to be given<sup>15</sup>.

## **8 Conclusions**

The 20 research projects reviewed in this report are a mixture of small consultancies, internal (Water Corporation) projects; aligned industry projects (eg Alcoa) and externally funded integrated research that the Corporation is supporting.

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<sup>15</sup> This suggestion is considered by Jan Starr to be naïve as climate change is moving to these catchments as well.

Currently there are 12 KPIs that the 20 projects are meant to provide data for monitoring performance. It is recommended that the KPIs be increased by two – one on millable timber yields and another on the social acceptability and cost effectiveness of catchment thinning. Another KPI on upper story composition may also be considered as the composition of the forest is important for both timber production and the environment.

If this recommendation is accepted then the main gaps are a project on safe handling of herbicides and the efficacy of herbicide treatments, associated with work on the most cost-effective methods of attaining and maintaining basal areas over time. This project may also help with KPIs on the level of damage to retained stems and soil protection which are poorly addressed in the current research program.

One research project is completely unaligned with the thinning treatment (fungi biodiversity) and several could be improved were they better aligned (hydrological processes which appears confined to unthinned bauxite regrowth areas; prescribed fire and stream quality and quantity; bird and invertebrate monitoring; and possibly the dieback project).

The information made available on a number of these projects is limited so it is possible that the projects are better aligned than is stated in this report.

Four areas lend themselves to better integration – remote sensing, hydrological modelling, leaf area index measurement and integrated systems research.

Reporting to the Conservation Commission is required in 2008 and to the Board of the Water Corporation in 2009. A less formal reporting to the EPA is recommended. The Conservation Commission report needs to address the Forest Management Plan recommendations but also the issues that may arise out of the request to thin the 31 Mile Brook Catchment.

The Board of the Water Corporation require details on the cost effectiveness of the proposal and a good appreciation of its social acceptability. Currently the projects are limited in the economic data that they will assemble and this lack needs to be met by the proposed project that meets the operational KPIs that are currently not being addressed.

The KPIs are currently just headings (eg soil protection; changes in understory) and need to be converted to statements that can be objectively reported against. The type of KPI contained in the Forest Management Plan could be a guide for their form.

## **9 Recommendations**

### ***9.1 Change the Project Success Criteria to that shown below:***

#### **Project Success Criteria**

- *The social acceptability and cost effectiveness<sup>16</sup> of thinning hills catchments to improve water yields relative to the do nothing different case will be sufficiently well known to enable a decision to be made whether to continue treatment of the Wungong Catchment, and to extend it to other catchments.*

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<sup>16</sup> Suggested change to “Community awareness of costs and benefits” instead of “social acceptability and cost-effectiveness” – Beth Schultz pers. comm.

- *A 20% increase in runoff in the Wungong Catchment following the approved silvicultural treatment relative to the “do nothing different” case.*
- *Stakeholder acceptance<sup>17</sup> of the forest structure after the approved silvicultural treatment.*
- *No significant adverse impact on terrestrial and in-stream ecosystem functions following the approved silviculture treatment relative to the “do nothing different” case.*
- *Impact on ecosystems’ ability to adapt to climate change improved as a result of the approved silvicultural treatment.*

All KPIs will need to be met to meet the first Project Success Criteria.

## **9.2 Project KPIs**

It is suggested that there be 16 Key Performance Indicators (KPIs) to determine the success of monitoring and research programs as stated in the *Water Corporation’s response to submissions from 2005 public review, 2007*.

1. Stream water quality and quantity
2. Safe handling of herbicides
3. Efficacy of herbicide treatment
4. Achievement of retained basal areas
5. Level of damage in retained stems
6. Efficacy of burn prescriptions
7. Soil protection
8. Growth rates of commercial species and timber yields
9. Dieback
10. Changes in stream invertebrates
11. Changes in indicator fauna species
12. Changes in understorey
13. Changes in overstorey
14. Consultation and communications
15. Social acceptability of catchment thinning
16. Cost effectiveness of catchment thinning

KPIs that assess whether the ecosystem’s ability to adapt to climate change has been improved as a result of the silvicultural treatment (i.e. resilience) and the forest’s capacity to sequester carbon have also been suggested by Jan Starr (pers. comm.).

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<sup>17</sup> Suggested change to “Informed stakeholder response” from Stakeholder acceptance” Beth Schulz pers. comm.

Currently these KPIs are headings only and their names may change as a result of developing the measures (e.g. Beth Schulz has suggested changing “social acceptability” to “Community understanding of catchment thinning”). KPIs on Greenhouse gas emissions and stored carbon have also been suggested by Jael Johnstone.

### **9.3 *New project***

Establish a new project to address research gaps to meet KPIs 2 (safe handling of herbicides), 3 (efficacy of herbicide treatment), 4 achievement of basal areas), 5 (level of damage in retained stems) and 6 (soil protection) while at the same time assembling data on the costs over time of the treatments (KPI 16).

### **9.4 *Project alignment with Program needs***

Renegotiate unaligned and poorly aligned projects to better assess the thinning treatments for projects on fungi biodiversity; hydrological processes; prescribed fire and stream quantity and quality; cockatoos, avifauna and invertebrates.

### **9.5 *Project integration***

Convene separate meetings of researchers working on remote sensing (Projects 7, 8, 9 and 17); hydrological monitoring (2, 3 and 7); leaf area indices (7, 9 and 16) and integrated systems modelling (7, 20) to seek better sharing of skills and data. Explore a similar opportunity for flora and fauna monitoring groups.

Consider holding a half day workshop between the leaders of all 20 research groups after the annual seminar day to improve linkages and develop an integrated overview of findings and how they relate to the program’s KPIs.

### **9.6 *Reporting***

Look for synergies in reporting to the Conservation Commission and Board of the Water Corporation. Seek informal methods of briefing the EPA on a less regular basis.

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11. APPENDIX 1. Wungong Catchment Trial Project: Key Areas of Research and Monitoring (Draft November 2007) Source: Bishnu Devkota

No.	Issue	Done By	Objectives/Methods	Research question/expected outcome	Synergy/ Integration with	Status (May 2008)	FMP KPI
1	Hydrographic measurements	Hydrosmart/DoW	To monitor the stream flow and water quality at gauging stations in exposed (thinned) and controlled catchments	Impacts of thinning on stream flow and water quality and comparison between the thinned and controlled catchments	Murdoch, CSIRO, stream biodiversity	On going	19, 22
2	Hydrological analysis and modelling	Water Corporation	To analyse stream flow data and to validate the LUCICAT model for hydrological simulation	Better understanding on the increase in stream flow due to thinning and apply the LUCICAT model to other high rainfall zone catchments	CSIRO, Murdoch	Work in progress	31
3	Hydrological processes	Alcoa and others	To collect field data and to validation of WEC-C model for prediction of interflow in bauxite mining pits	Improved understanding of the impacts of bauxite mining and rehabilitation on runoff generation	CSIRO, Stream flow	Work in progress	31
4	Ground water monitoring	Water Corporation	To measure seasonal groundwater levels and analysis of the data	Better understanding of the g/w level trends in the forest and to predict the impacts of drying climate and forest structure on ground water	Murdoch, CSIRO, stream biodiversity	On going and extending beyond the Cobiac catchment	31, EPA's Advice
5	Fire and water (external to Wungong project)	DEC/Water Corporation	To apply more frequent (mosaic) burning in Jack Rocks (in Serpentine) and to monitor the impacts on stream flow, water quality and ecology and eco	Understanding the impacts of fires on water production (quantity and quality) and ecology and to separate the impacts of thinning and fire in Wungong	Mosaic Burning, Wungong thinning	Under development	31
6	Wild-fire impacts on runoff, water quality and vegetation	Water Corporation	To monitor stream flow, water quality and vegetation recovery in Little Darkin (Mundaring)	Better understanding the impacts of wild fires on water quantity, quality and recovery of vegetation after wild fire	Mosaic Burning, Wungong thinning, fire water project	On going monitoring and one honours thesis completed by UWA student	31
7	Vegetation dynamics and hydrology	CSIRO	To quantify the impacts of land use and climate change on stream flow and field measurement (Wungong project and the PWF will be implemented in a Co-ordinated manner)	Better understanding on the impacts of vegetation and climate on hydrology	Murdoch, stream flow, hydrologic modelling, LAI	research sites are selected and drilling to continuously monitor the g/w level and the soil moisture completed	22, 31
8	Remote sensing	Water Corporation	Remote sensing with 0.5 m resolution with 4-bands, taken by flying a plane over the area, and image processing	Change in forest biomass, dieback and vegetation stress	dieback/forest health	first image in Nov 2005 and taking second images in selected part of the catchment is underway, data analysis and comparison will be started	31
9	Leaf Area Index (LAI)	Water Corporation	To analyse Landsat data to see annual changes in LAI and after thinning	Relationship between the changes in LAI, rainfall and the stream flow	Sap flow, Murdoch, Hydrologic modelling	Ongoing	31
10	Recreational values and ecosystem health	Beckwith Environmental Planning/Murdoch	Survey, focus groups, site visit and photographs	public opinion on thinning by balancing the visual impacts and ecological health	Demo plots, thinning techniques	Under development	29, 31
11	Demonstration Plots	Water Corporation/DEC	To establish of plots to show outcomes of different thinning techniques	Comparison of the impacts of different thinning techniques on bio-diversity and visual values	visual impacts and ecosystem health, thinning methods	Field work completed and DEC contracted to produce interpretation signage	29
12	Sap Flow	CSIRO	To monitor and quantify the tree water use	Better understanding on tree water use and transpiration	Murdoch, CSIRO, hydrologic modelling	Proposal being developed	31
13	Flora and Vegetation Values	Mattiske Consulting Pty Ltd	4 stream transects across the creek lines to measure flora (change in over and understorey species by monitoring diversity, abundance) revolving every 4-5 years; upslope quadrants and design long term program. 6 plots overlapping with fauna plots to integrate flora and fauna monitoring	Understanding on the potential shifts in the vegetation in response to local changes in hydrological conditions. Compare findings between the respective sites (in relation to topography, land forms, soils and proximity to seasonally wet/moist soils)	Fauna, Forestcheck	Field monitoring of all 4 transects and 6 plots is completed and a draft report is received in early March 2007.	2
14	Fauna	Kabay Consultant Pty Ltd	Establishment of 6 plots (3000 m) with traps for measurements of mammals, reptiles, invertebrates and threatened species (if trapped), and counting birds. Plots established covering severity of thinning (high and medium reduction in basal area)	Impacts of thinning on terrestrial fauna including endangered species and integration of flora fauna data	Flora, Forestcheck	Baseline monitoring (for both summer and winter period) completed	3
15	Fungi	WA Naturist Club	Community group to carry out fungi survey (on Forestcheck plots, demo plots) followed by and workshop to identify the fungi and to prepare reports	Identification and impacts of thinning on fungi, and community involvement	Flora, Forestcheck	under development	2, 29
16	FORESTCHECK	DEC	Establishment 6 grids as per DEC's FORESTCHECK protocols to measure forest attributes and bio-diversity values (forest structure and regeneration, foliar and soil nutrients, soil disturbance, coarse woody debris and litter) and bio-diversity values (macro-fungi, cryptogams, vascular plants, invertebrates, birds, mammals and herpetofauna)	Impacts of thinning on soil damage, fungi, change in understorey species, and invertebrates	flora, fauna, Murdoch and Museum	Site selected and monitoring will commence Spring 2008.	33, EPA Advice
17	Forest health/dieback	DEC	Mapping the occurrence and establish transects to monitor die-back spread and catchment scale remote sensing and plot based monitoring for forest health. Integrate with FORESTCHECK, inventory or other plots for vegetation composition change.	Modes of spread of dieback and impacts of thinning on forest health and dieback	Soil damage guideline; best management practices	Dieback demarcation is completed in Treatment Area 1 (TA1) and TA2. Forest health/dieback research (an idea)	18
18	Cockatoos, historical bird data and ground vertebrates	Museum	Monitoring breeding, feeding and roosting sites for Cockatoos (Forest Red-tailed, Black, Carnaby and Baudin) within the Wungong Catchment and adjacent areas--Analysis of historical bird data (since 1959)-- field observations of mammals and reptiles	Information on birds since 1959 and continue to document breeding, feeding and roosting sites for Cockatoos in and ground vertebrate fauna	Fauna, Forestcheck, FHZ	Being Implemented	3
19	Stream biodiversity	UWA	Establishment of 6 sites (three sites each, exposed and control) for measuring base line condition. Measurement will be taken every 2 to 5 years, and a comparison made with historical records	Change in macro-invertebrates and fish, and measurement of channel parameters	Murdoch, Stream flow	Spring 2006 sampling and analysis completed building on 2005. Monitoring extended to two more plots	20
20	Balancing water quantity, quality and thinning	ARC Linkage Project: Murdoch University	Establishment of transects covering different rainfall zones to study balance between water quality, water yield, thinning and forest health	Understand and predict transient and longer term responses to thinning (vegetation change and ecosystem dynamics)	CSIRO, Forestcheck, Stream bio-diversity	Initial monitoring and site selection started	10, 22, 31

12. APPENDIX 2. Wungong Catchment Trial Projects in relation to KPIs, EPA Bulletin 1196 and Forest Management Plan KPIs

No.	Issue	Project KPI	EPA Bulletin 1196	Forest Management Plan KPIs	Overall Comment
1	Hydrographic measurements	Essential 1, 14 Important 7, 10	1a, 1c, 1d, 1e, 2a, 4	22, 28, 19	Essential component of a number of projects. Need to assess whether enough sites are being measured to meet all needs
2	Hydrological analysis and modelling	Essential 1, 14	1a, 1c, 1d, 1e, 4	22, 28, 19	Links need to be clear with Projects 3, 7 and 20 which also involve modelling
3	Hydrological processes	Essential 1, 14	1d, 1e, 4 (bauxite areas)	22	Unclear whether thinned bauxite pits will be modelled. This work is at no cost to the Water Corporation but consideration should be given to modifying it
4	Groundwater monitoring	Important 1, 14	1b, 1d, 1e	22, 19	More details of program are needed. Data are essential to understand runoff processes under climate change and management
5	Fire and water (external to Wungong)	Essential 6 Important 14	1a, 1d, 1e	22, 28	Links to thinning treatment are unclear, if not completely lacking. Need to seek better alignment if possible.
6	Wildfire impacts on runoff, water quality and vegetation	Important 1, 6	None	22, 28	Useful as it assesses the extreme case of complete destruction of vegetation and its recovery after wildfire
7	Vegetation dynamics and hydrology	Essential 1, 12, 14	1a, 1b, 1c, 1d, 1e, 1f, 4	22, 28, 31, 33, 19	The most integrative project in the program but has time constraints due to external funding deadlines
8	Remote sensing	Important 13, 14	1c, 1d, 4	Unknown	Details are lacking on this project. Links with Project 7 and "Urban Monitor" need to be clarified
9	Leaf Area Index (LAI)	Unknown	Unknown	10, 12	Links with Project 7, 8 and 20 need to be established
10	Recreational values and ecosystem health	Essential 14 Important 13	1c, 1d, 1e, 1f, 4	26	This is the only social acceptance project so it fills an important gap. Could be linked to demonstration sites and include stream condition acceptability
11	Demonstration Plots	Essential 13 Important 14	1f	26	Could be very effective in gaining public understanding and potentially acceptance
12	Sap Flow	Important 1 (understanding tree water use)	1a, 1b, 1d, 1e	22, 28, 31	Fills data gaps in other projects (7, 20) in a direct manner
13	Flora and Vegetation Values	Essential 12 Important 5, 14	1a, 1c, 1d, 1e, 1f, 2b	31, 10, 28	Along with Projects 1 and 14, this provides an essential data set
14	Fauna	Essential 11 Important 14	1a, 1b, 1c, 1d, 1e, 1f, 2b	31, 10, 28	Along with Projects 1 and 13, this provides an essential data set
15	Fungi	None unless aligned to treatment areas	None unless aligned to treatment areas	None unless aligned to treatment areas	This project could augment the data in Project 14 if better aligned to thinned and unthinned catchment areas
16	FORESTCHECK	Essential 11, 12 Important 14	1a, 1b, 1c, 1d, 1e, 1f, 2b	31, 10, 28	Comprehensive measure of biodiversity that enables a comparison with other parts of the jarrah forest. It will help separate thinning impacts from climate change, logging, dieback and fire
17	Forest health/dieback	Essential 9	1b, 1c, 1d, 1e, 1f, 4	18	Need clarification of the nature of the research project as several versions have been received
18	Cockatoos, historical bird data and ground vertebrates	Important 11, 14	1a, 1b, 1c, 1d, 1e, 1f	31, 33, 28	It is not clear how or if the cockatoo and invertebrate work aligns with the thinning treatments.
19	Stream bio-diversity	Essential 10 Important 14	1a, 1b, 1c, 1d, 1e, 1f, 2b	31	Important as it builds on a long history of stream biodiversity measurements and may enable the impacts of thinning on streamflows to be assessed in terms of biodiversity
20	Balancing water quantity, quality and thinning	Essential 1, 11, 12 Important 14	1a, 1b, 2c, 1d, 1e, 1f, 2b	31, 33	An important project as (like Project 7) it integrates data, entrains external skills and resources while providing an independent assessment of forest thinning