Wungong Catchment Trial

Streamflow and groundwater enhancement in native forest within Treatment Area 4

2012

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Acknowledgement

The advice and expertise of the following people who assisted in the preparation of this supporting document which is gratefully appreciated include *Bob Hagan, Danielle Wiseman, Steve Raper, Ian Freeman and Frank Bailey (DEC), Michael Loh, Keith Barrett and Amanda Reed (Water Corporation) and consultants Frank Batini, Jack Bradshaw, and Marg Wilke.* Advice on cockatoos was prepared with assistance from *Ron Johnstone,* Curator of Ornithology, WA Museum.

Introduction

The Wungong Catchment lies between Albany and South-West highways with the reservoir situated just south of Bedfordale and the Wungong Regional Park. The catchment is located approximately 60 km from Perth (Fig 1).

Figure 1. The Wungong Catchment

This Catchment has been studied extensively over many years by scientists and researchers from several universities, government agencies and industry (eg. ALCOA). Since 2005 the Water Corporation's Wungong catchment trial has collected valuable data on ecosystem processes in this part of the Northern Jarrah Forest.

Currently, there are many research projects being funded through the trial. The results of these projects are well documented and widely published and can be accessed at www.watercorporation.com.au/wungong

Hydrological process modelling, that is based on the 2001–2010 rainfall sequence, indicates that more intense and more frequent thinning than that previously envisaged by the trial, will be required to restore streamflow and groundwater levels (Fig 2).

A new draft Silvicultural guideline proposed for this trial within Treatment Area 4 (TA4) of the Wungong catchment is based on this knowledge.

It involves actively managing a trial forested water catchment area to reduce water use by vegetation and increase water availability to the remaining plants, animals, soils and streams, as outlined in Soil and Water Conservation Guideline SFM Guideline No. 5 (DEC 2009).

In particular it provides the opportunity to implement Guiding principle 5: *Silvicultural treatments and fire regimes may be used to enhance the quantity of surface and groundwater reservoirs* (pp 23).

Also as a consequence of reduced rainfall over several decades, a number of species of plant and animal that are found in this catchment are under threat.

This is recently discussed in *Dry Times in the Jarrah Forest*, Landscope Vol 27 no 2 Summer 2011–2012 (Batini 2011).

Threats to forest health, biodiversity and water production will be better understood through this study and management of vegetation density.

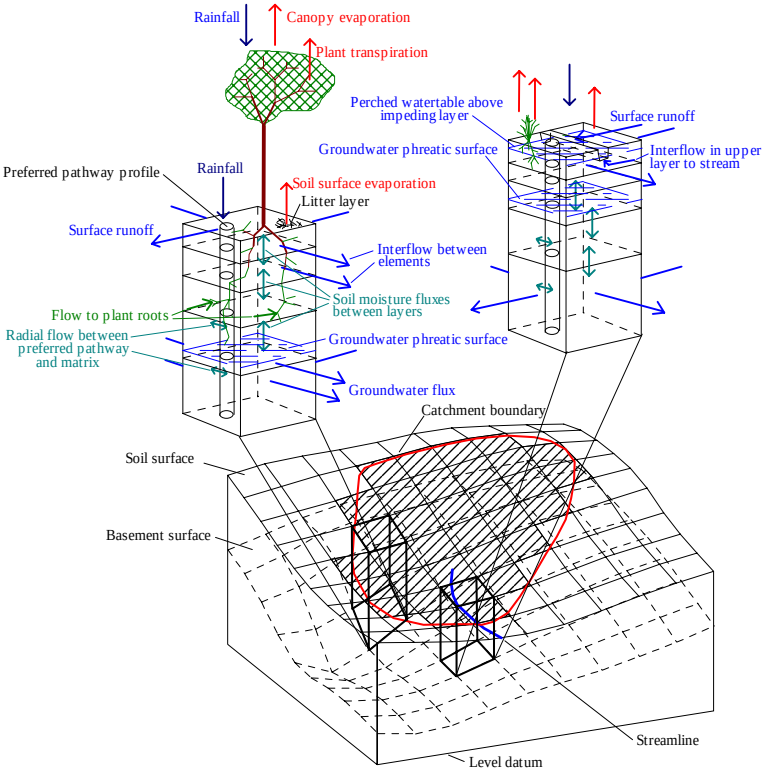
This document provides additional information to support the new draft Silvicultural guideline.

A demonstration plot showing the outcome achieved by applying the strategies as described in this document

Taken on 17 September 2010 by Keith Barrett

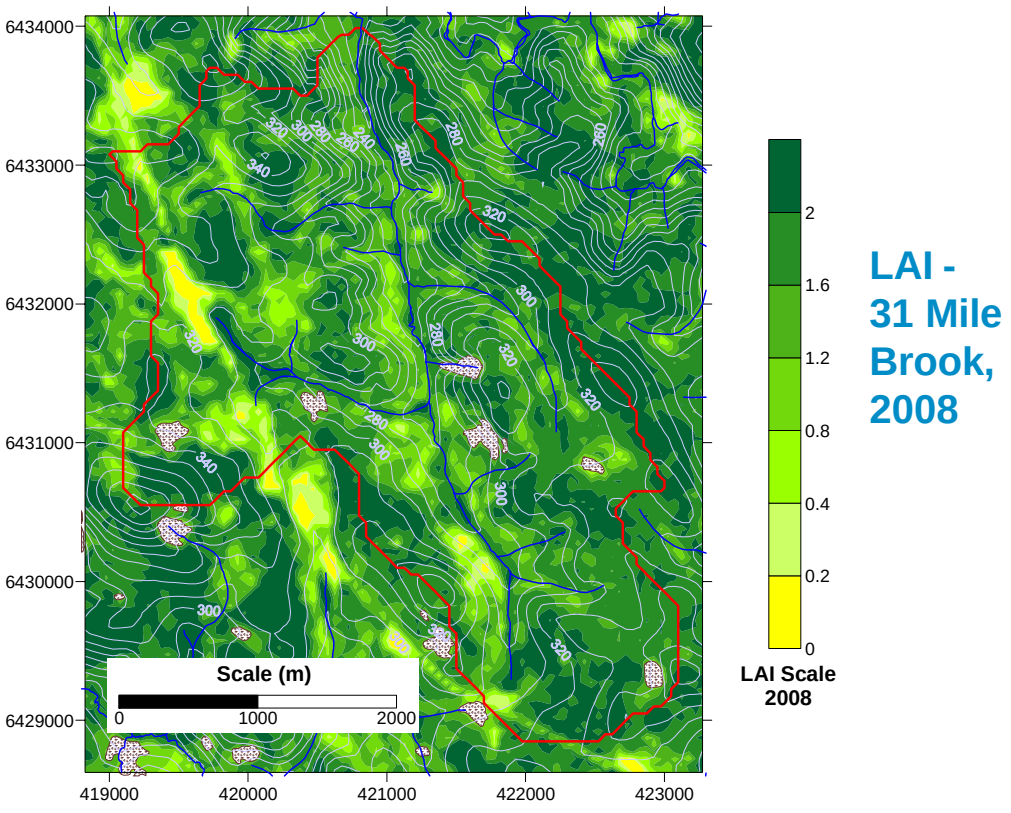
The WEC-C Model

WEC–C is a complex, distributed, deterministic model that simulates water and solute fluxes in a three-dimensional framework. It includes all major processes and dual continua.



WEC-C has a series of inputs – rainfall, evaporation, and land use.

Land use is represented by leaf area index (LAI), with each grid cell in the model having it's own LAI value.



LAI - 31 Mile Brook, 2008

Figure 2. Hydological process modelling - WEC-C

Background

Since the Wungong trial's development and implementation in 2005, the south west region of Western Australia has continued to experience poor rainfall, most notably during 2006 and 2010.

This rainfall pattern on the 31 Mile Brook catchment has resulted in a two-thirds reduction in streamflow with the average from 1986–1998 being ~150mm and from 2006–2010 the average being only ~50mm.

Recent hydrological modelling undertaken by Croton (2010) as part of the Wungong trial, shows that under this rainfall regime groundwater levels have diminished to such a degree that the original proposal by the Water Corporation (Water Corporation 2005a) will no longer recover groundwater levels high enough to impact streamflows.

In this trial, the aim of the draft Silviculture guideline is to recover soil moisture storage back to the level of the 1990s.

This will result in enough groundwater contribution to elevate streamflows to about 70 per cent of the 1990–2000 flows — a level that makes this proposal a viable option for the Water Corporation.

The modelled future scenarios assume a continuation of the 2001–2010 rainfall pattern. This is similar to the rainfall reductions to 2030 expected by climate change modelling for the south west of Western Australia (CSIRO 2007).

Using the modelling results from 31 Mile Brook catchment several treatment options have been reviewed.

The figures show that the treatments in the draft Silvicultural guideline result in the recovery of soil moisture storage (Fig 3) and streamflow (Fig 4) to the target levels.

The benefit of the treatment on riparian vegetation is shown in the groundwater level maps (Fig 5).

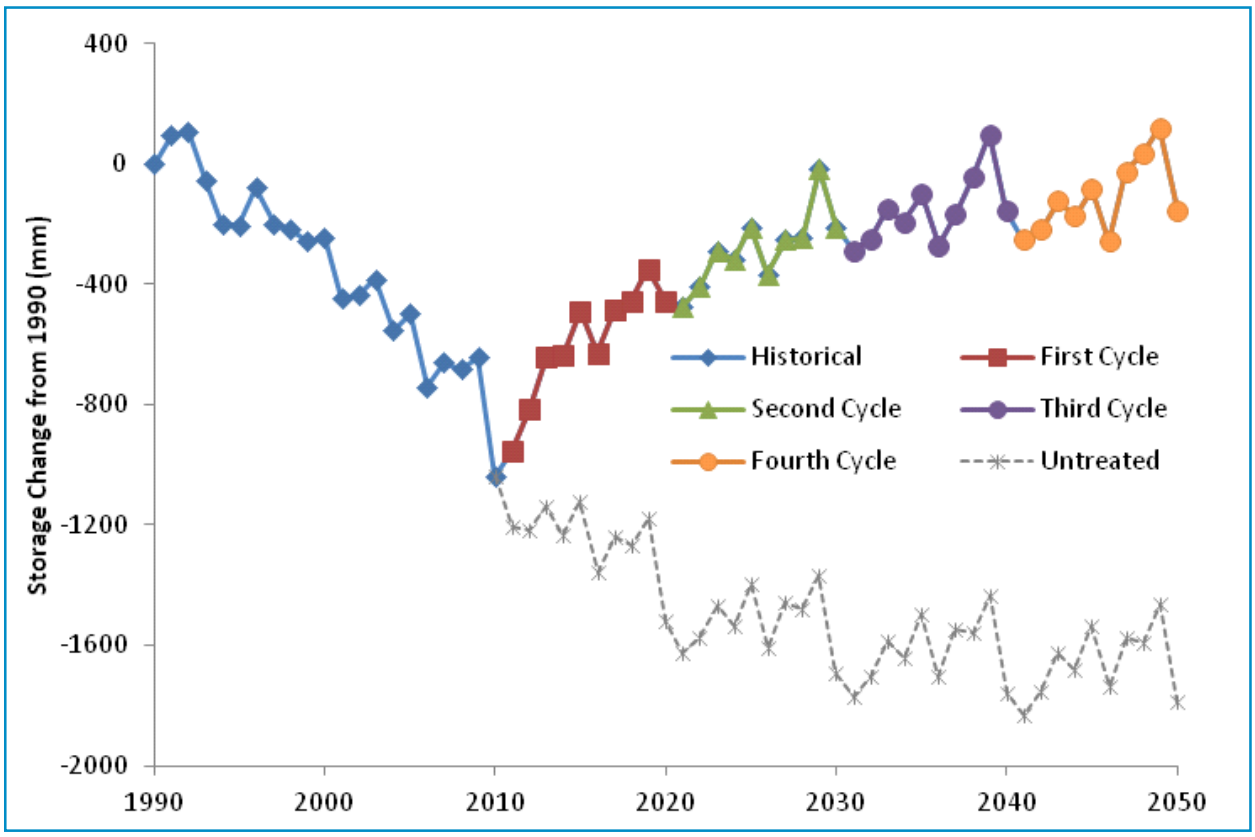


Figure 3. Predicted recovery of soil moisture storage using the draft Silviculture guideline

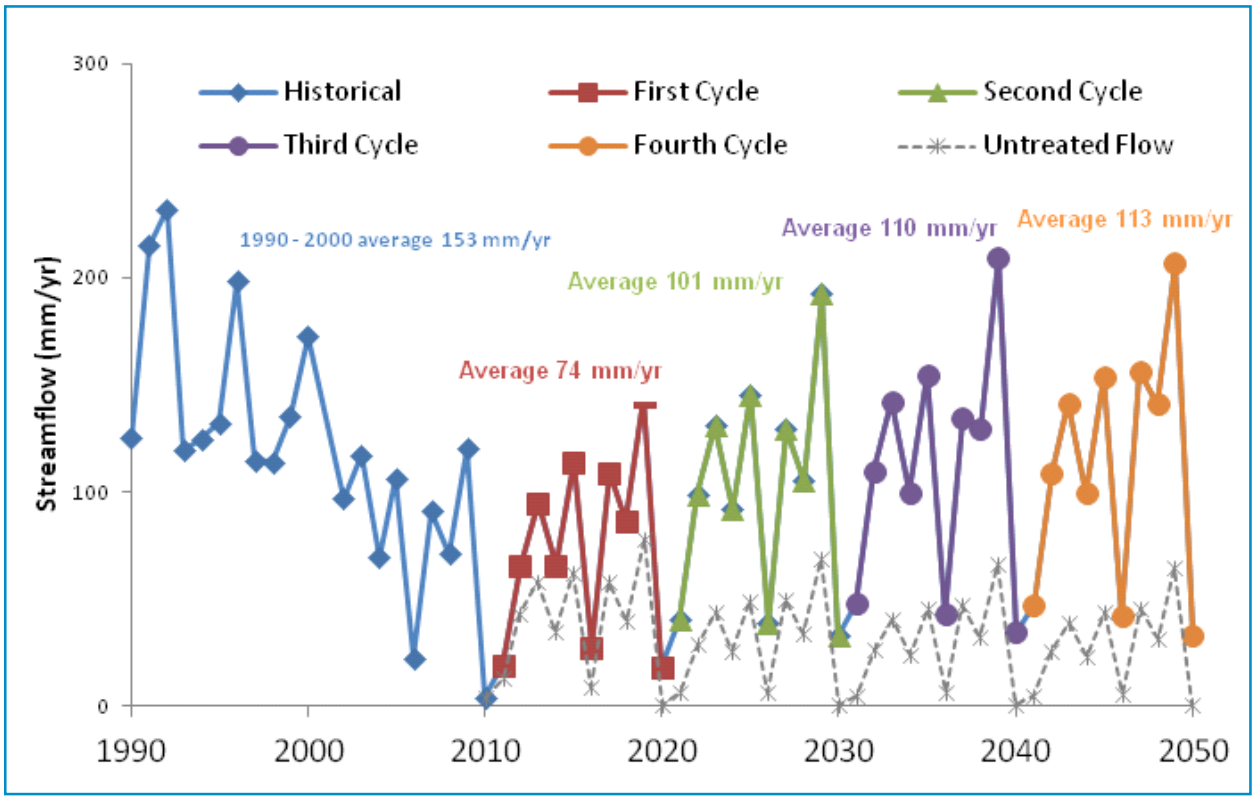
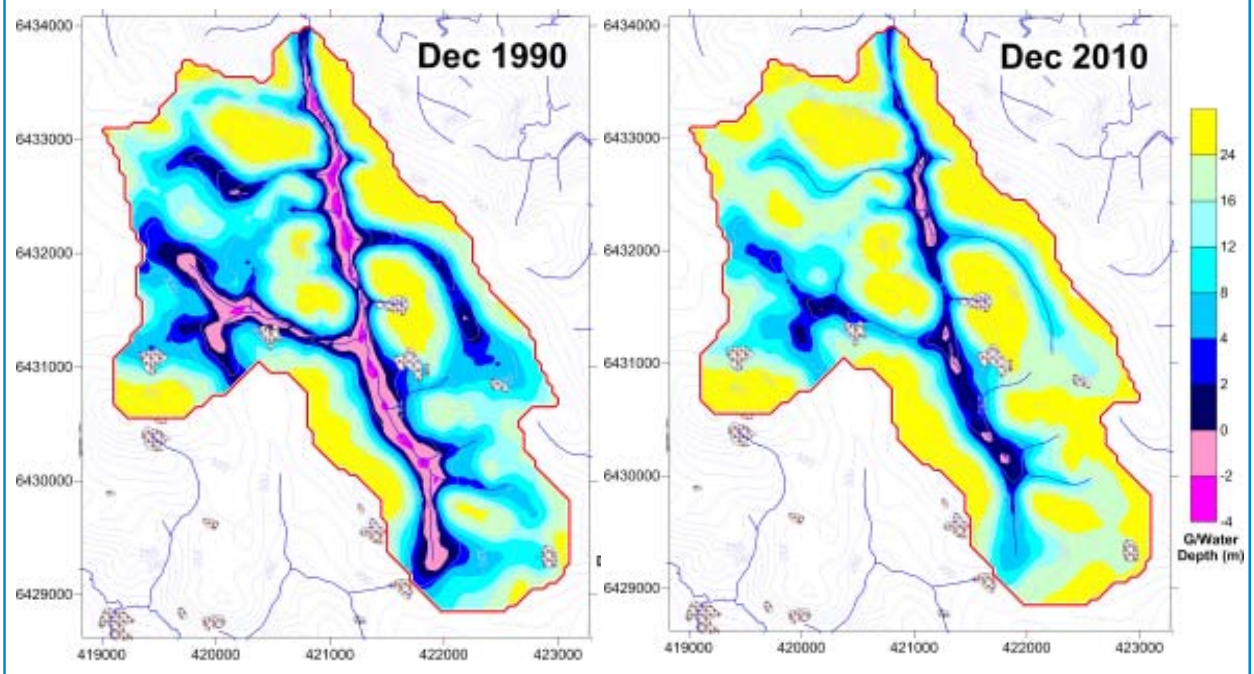
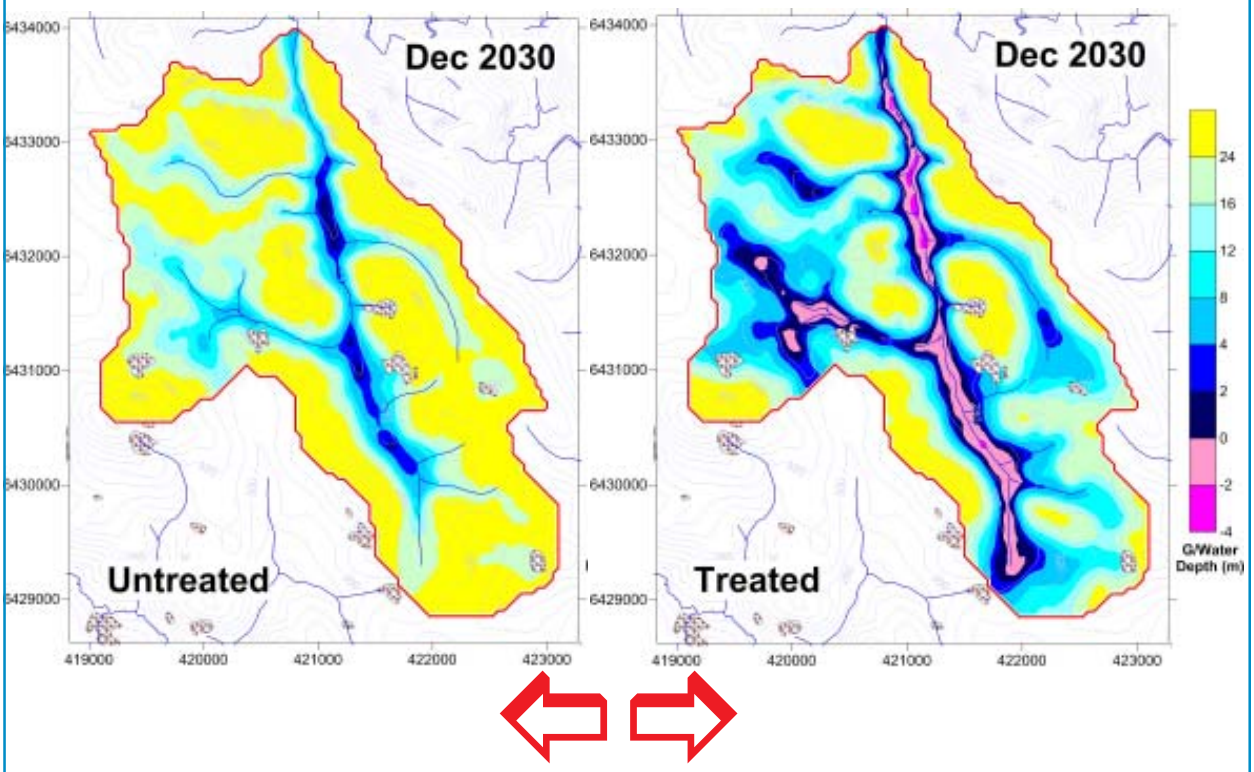


Figure 4. Predicted recovery of streamflow using the draft Silviculture guideline

Groundwater level modelling and treatment scenarios — 31 Mile Brook gauged-catchment



Groundwater levels in 1990 and the **decline already** being observed in 2010



Groundwater levels in 2030 if the catchment is left **untreated** compared with the levels in 2030 with **silviculture treatment**

Figure 5. Effect of groundwater levels on riparian vegetation in the catchment

Objectives

The main objectives of this trial are to:

1. restore soil moisture, groundwater levels and streamflow duration to that prevailing in the 1990s;

2. recover streamflow volume to more than 70 per cent of the flows for the 1990–2000 period. (*In the context of long term streamflow this represents flow volumes that are less than half those of the pre-1975 period)*;

3. maintain or recover biodiversity values;

4. improve forest health and vigour; and

5. maintain the capacity for continued timber production.

Strategies

- Reduce total stand density to a Leaf Area Index (LAI) of 0.6 (approximately 8–10 m^2/ha basal area over bark) with an emphasis on retaining larger trees.

- Control coppice and dynamic shoot development as and when required after thinning to ensure that it contributes an average of no more than 0.05 LAI (~1 m^2/ha).

- Re-thin within one year from when the average LAI since thinning reaches 0.99.

- Prescribe burn after thinning and thereafter at intervals to reduce interception, maximize species richness and reduce the risk of damage by wildfire.

Scope

The area proposed to be treated under the draft Silviculture guideline is less than 2000 ha (<15 per cent) of the Wungong catchment. Figure 6 shows the entire boundary of TA4. The area that the Silviculture guideline will apply to is within this boundary. Formal and informal reserves, fauna habitat zones and other areas excluded from timber harvesting under the Forest Management Plan 2004-2013 will not be subjected to commercial or non-commercial thinning. These areas will be confirmed with the DEC and defined on site.

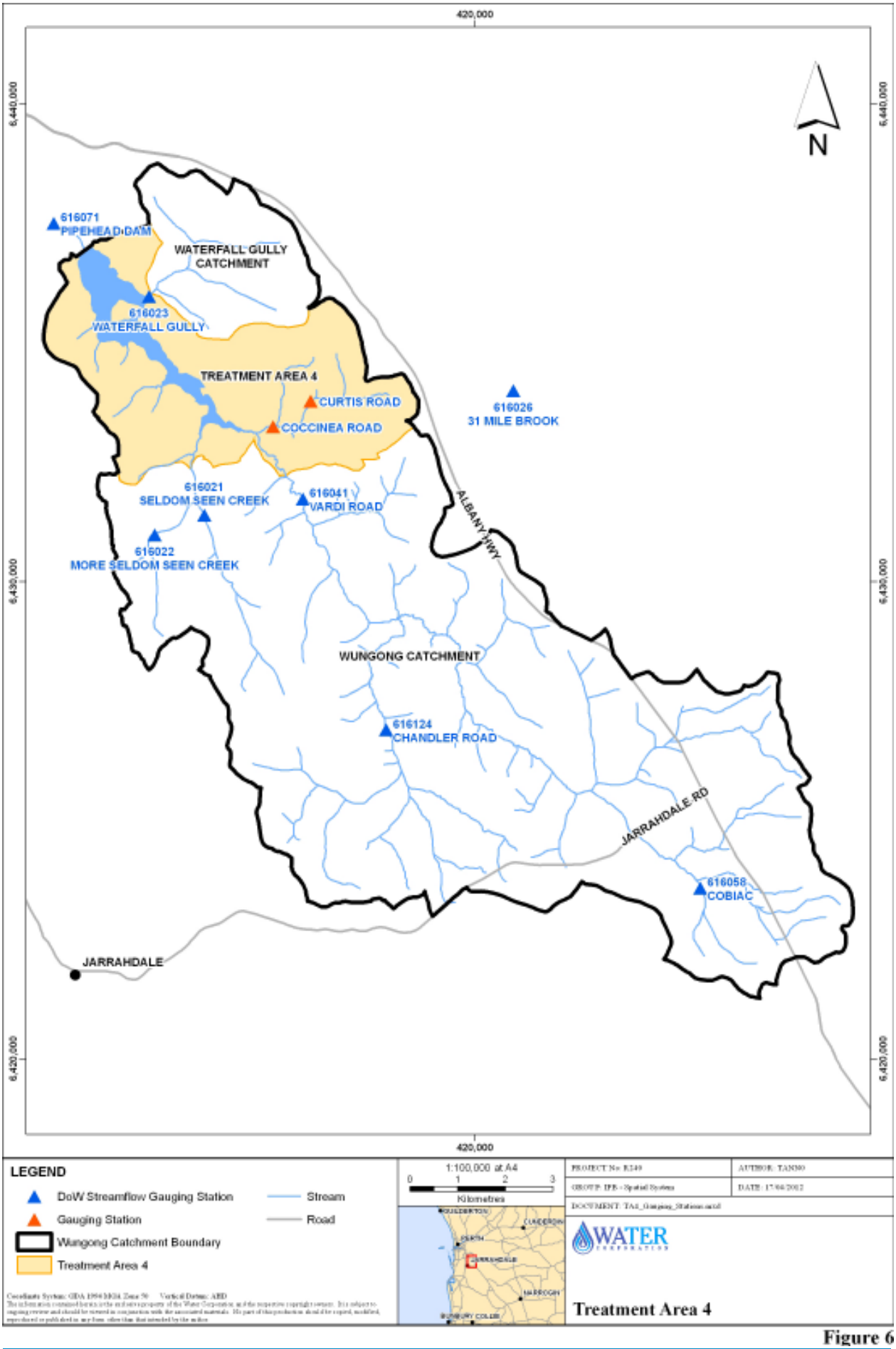


Figure 6

Figure 6. Treatment Area 4 (TA4)

Operations

All operations will comply with the amended draft Silviculture guideline and will be approved by DEC staff following the normal approval processes.DEC will monitor all silvicultural aspects of the trial including:

- Prescribed burning
- Adequacy of marking;
- Notching success; and
- Dieback mapping and demarcation

The area west of the reservoir was burnt by DEC in spring 2009 and much of the eastern part during spring 2011 (Fig 7).

The area to be thinned has been mapped for the presence of Phytophthora dieback by trained DEC interpreters. About two thirds of the area was mapped as infected (Fig 8).

Coppice and regrowth will be managed in accordance with the amended Silviculture guideline (pg 7). Glyphosate use will comply with PSC 88 and follow DEC requirements.

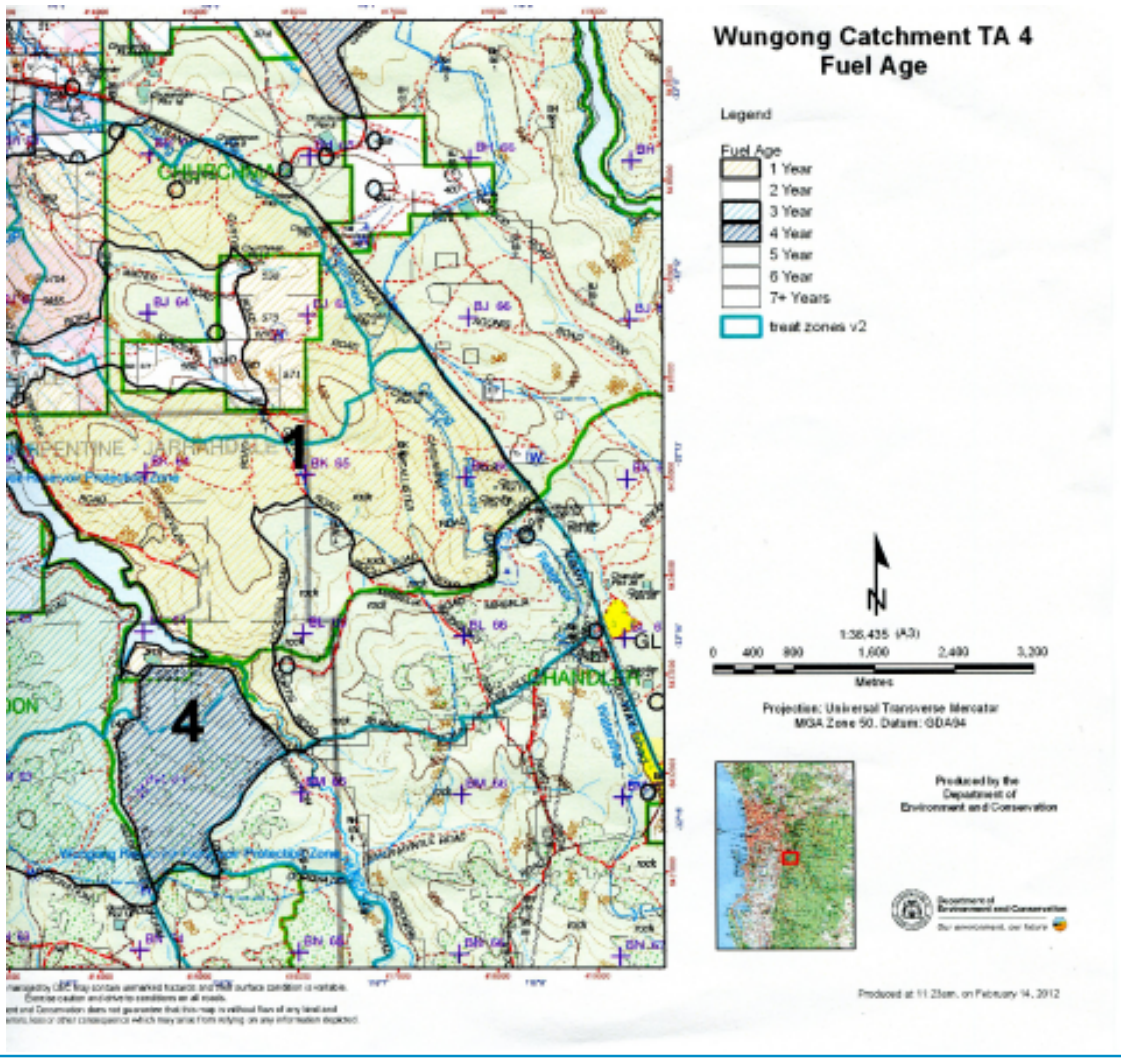


Figure 7. The area within TA4 burnt in 2009 and 2011

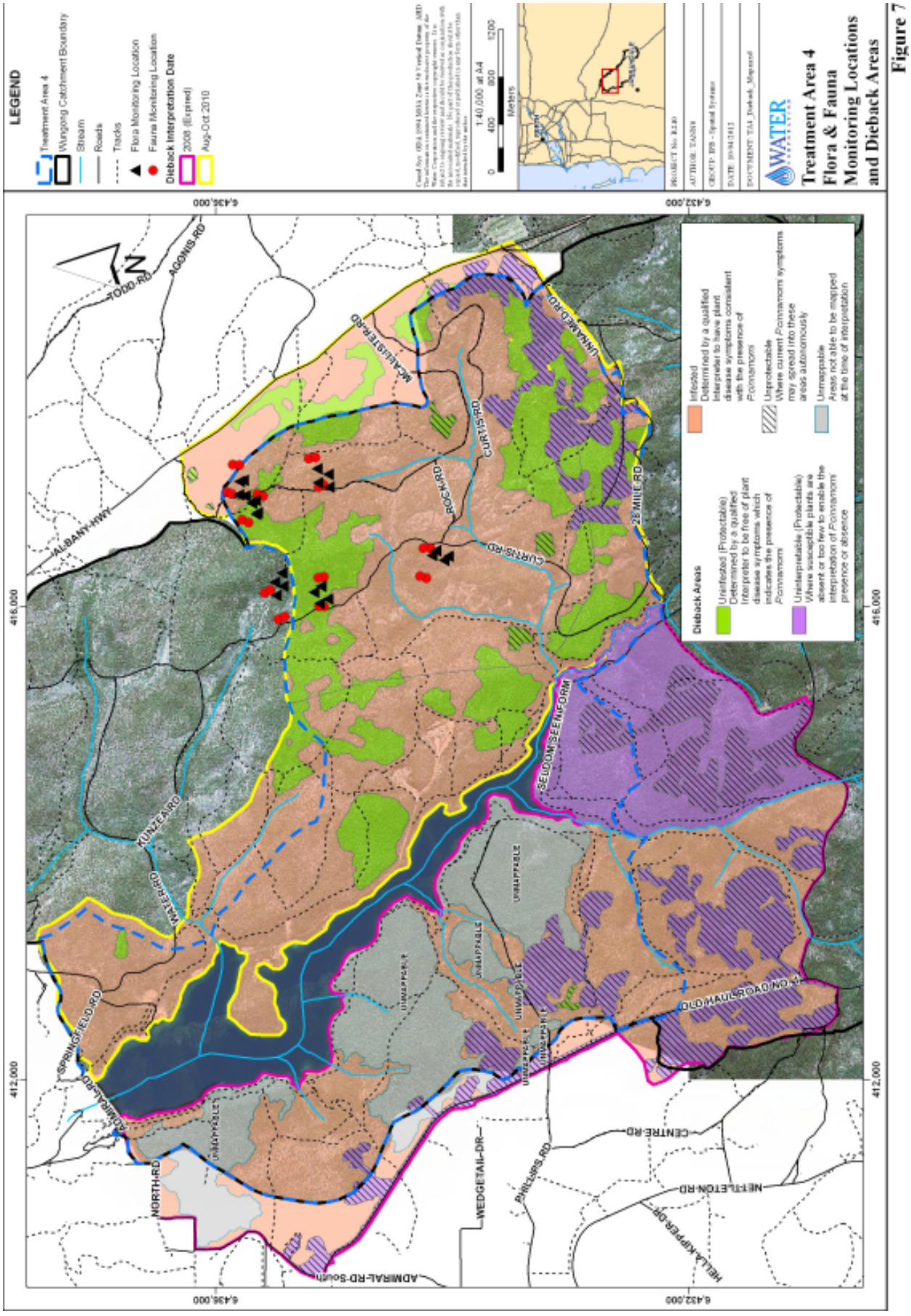


Figure 8. Phytophthora dieback in TA4

Research and monitoring

Research and monitoring projects that are relevant to this thinning trial have been undertaken to support the Water Corporation's Wungong catchment trial (2005 a, b). This work is well documented and all reports can be accessed at www.watercorporation.com.au/wungong

Additional monitoring programs proposed for this trial are outlined below, with further reports to be made available to stakeholders and the wider community via the above website.

Hydrology

Two new stream gauging stations and a pluviometer have been established within TA4 at Coccinea and Curtis roads (Fig 6). These gauging stations monitor flows before and after treatment. Regular manual water quality monitoring at Coccinea road has been enhanced by continuous turbidity monitoring.

The nearby long-term 31 Mile Brook and Waterfall Gully gauged catchments will provide very valuable comparative data. In addition, a network of pluviometers will support this study.

Each year a clear sky January LANDSAT image will be analysed to track LAI changes across TA4.

The hydrological process catchment model, WEC-C (Fig 1), will be utilised to build on knowledge gained from the above stations. This modelling analysis will show the soil-water/groundwater response to the drying climate and the thinning treatment.

Through this integrated hydrology, the volume of flow, period of flow, and modelled soil-water/groundwater changes will be tracked and changes resulting from treatment quantified.

All streamflow and rainfall data will be readily available through the Department of Water website.

Groundwater

Depth to groundwater and the rate of groundwater recharge following winter rainfall is important to both streamflow generation and duration.

In general, steep hillslopes with incised valleys have groundwater near the surface, and a fast rate of groundwater recharge. In turn, this results in streams that have a quick response to rainfall and that flow for much, if not all, of the year. These locations, including sections of TA4, will also have the best response to thinning.

Detailed monitoring from the Cobiac research catchment, indicates that even in drier locations with deeper groundwater, thinning does result in measurable increases in groundwater recharge (Fig 9).

Figure 9 shows a comparison between the depth to groundwater measured from two mid-slope piezometers located within the Cobiac catchment. The piezometer labelled as control is in a position in the catchment where no treatment has occurred, while the other is located within a treated area. There has been a clear response to the treatment undertaken in early 2008.

While the depth to water at mid-slope locations within Cobiac is quite deep, groundwater at the streamzone is generally very shallow. Figure 10 shows depth to water at a bore located close to the gauging station. The shallower depth to groundwater post-treatment, especially in 2009, has resulted in increased streamflow measured at the gauging station.

In TA4 it is expected that the closer proximity of groundwater to the surface beyond the streamzone and the higher intensity of the initial treatment will result in the necessary groundwater level rises required to generate the targeted streamflow.

Unlike much of the Wungong catchment, TA4 has no existing piezometers located within it. Ideally, a groundwater monitoring network should be installed to provide the longest possible length of pre-treatment data record — preferably five years or more, with a minimum requirement of three years.

Since there is no piezometer network within TA4 the groundwater levels within the Catchment will be inferred through analysis of the streamflow record from gauging stations at Waterfall Gully, Coccinea and Curtis roads.

As mentioned previously, the WEC-C model will also provide modelled groundwater and soil moisture data.

Aquatic biodiversity

The current annual monitoring program has been in place for six years. It is extensive and covers a wide range of sites, including the catchment adjacent to TA4 — Waterfall Gully.

The streams in TA4 are small (first/second order) and no additional monitoring is proposed.

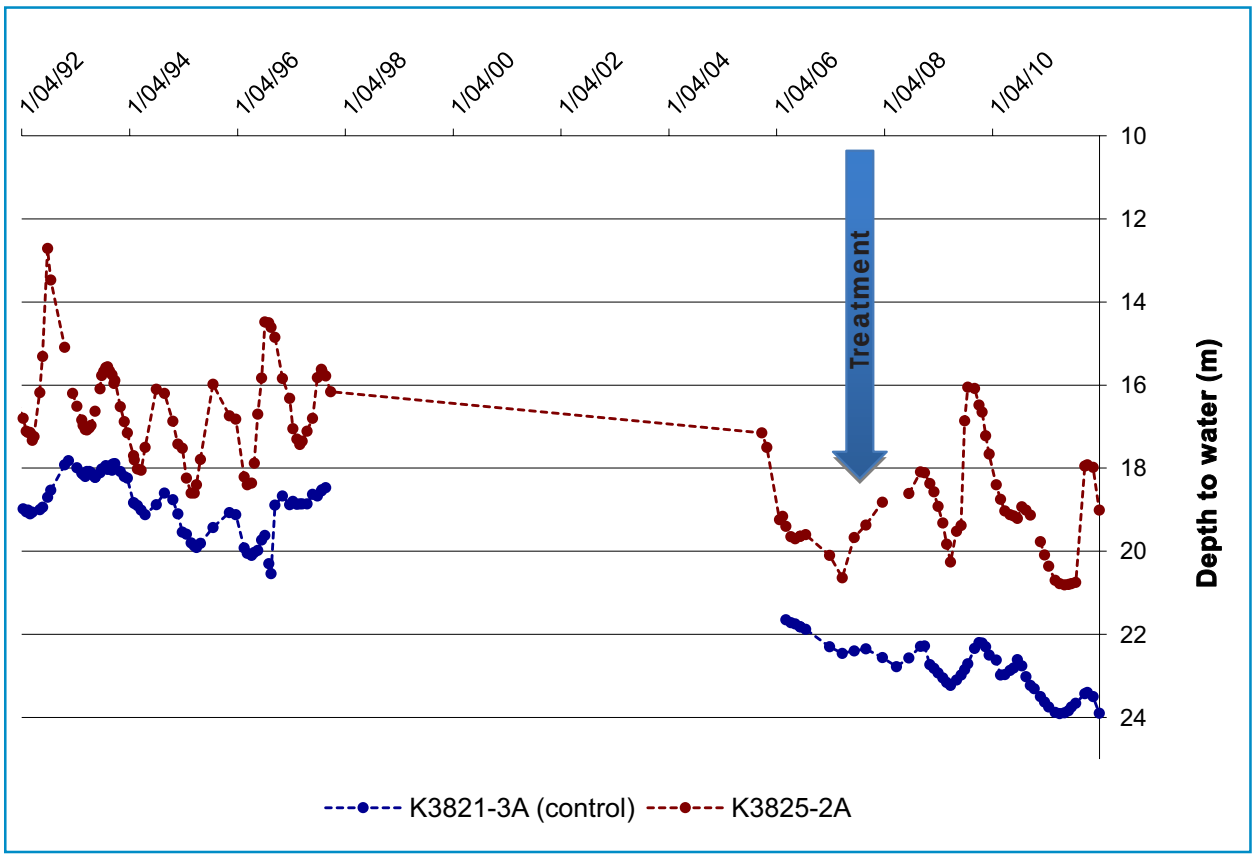


Figure 9. Depth to groundwater from piezometers in Cobiac catchment – with and without treatment

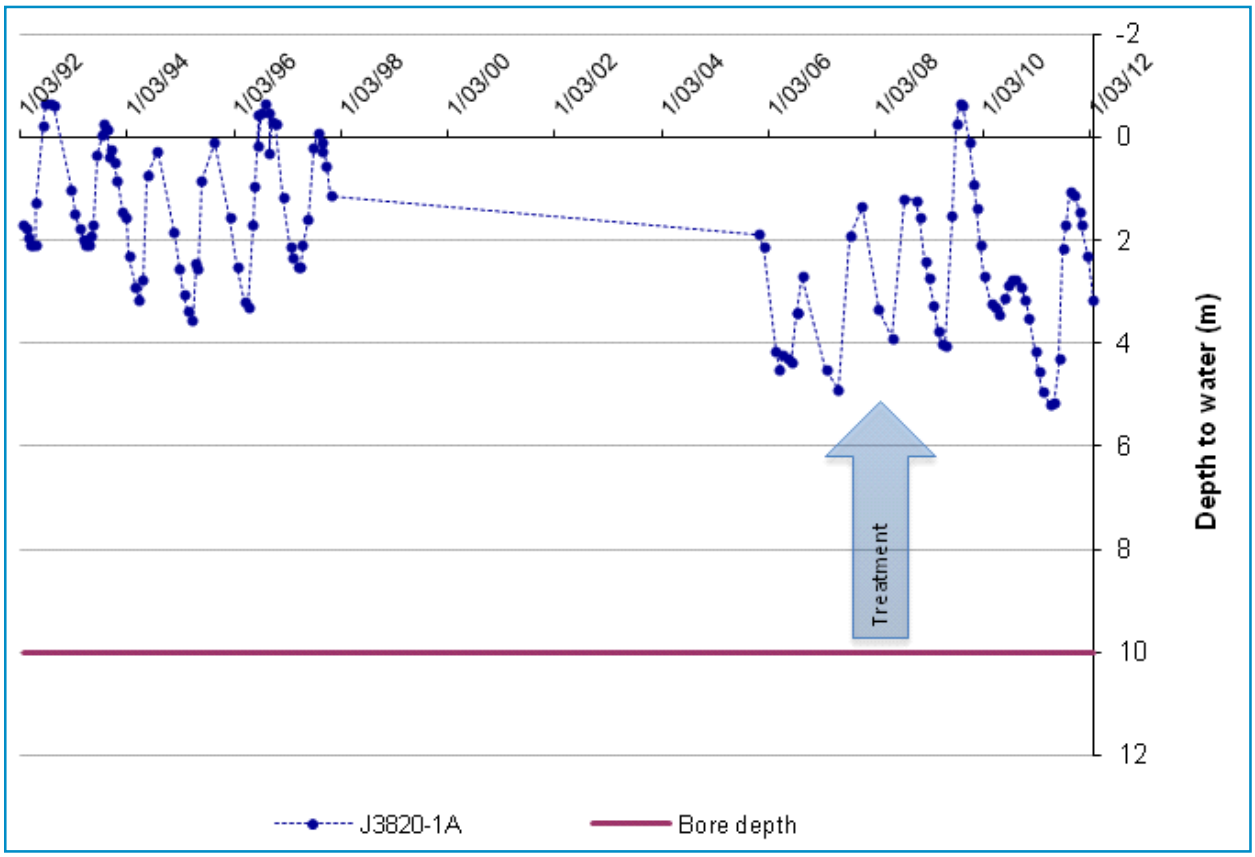


Figure 10. Depth to groundwater close to the gauging station in Cobiac catchment – with and without treatment

Fauna

Twelve transects, each 250 m in length, have been established prior to treatment. Six are located in healthy forest and six in areas mapped by DEC staff as dieback affected (Fig 11). It is proposed that eight transects will be treated by thinning, with four remaining as control. Monitoring includes pit traps, cage and Elliot traps, bird calls and visual sightings and analysis of bat calls.

Data are collected on mammals and bats, reptiles, birds, ants and some invertebrate fauna as captured in pit traps.

Monitoring is carried out at different seasons — spring, summer and autumn. A pre-treatment report is not available until sampling is completed. Re-measurements at 3–5 year intervals are proposed.

Flora

Understorey

Twelve transects each 120 m in length were established prior to treatment to measure understorey cover, species richness and species diversity. Six are located in healthy forest and six in areas mapped by DEC staff as dieback affected (Fig 11). It is proposed that eight transects will be treated by thinning, with four remaining as control. Along these transects, understorey data are collected on 2m x 2m quadrats located every 5m along each transect.

A pre-treatment report has been prepared (Mattiske and Associates February 2011, www.watercorporation.com.au/wungong). The data show that the species richness is statistically lower in the dieback-affected plots. Re-measurements at 3–5 year intervals are proposed.

Trees

Twelve transects each 120 m in length by 10 m wide were established prior to treatment. Six are located in healthy forest and six in areas mapped by DEC staff as dieback affected. It is proposed that eight transects will be treated by thinning, with four remaining as control. Along these twelve transects, all trees taller than 1.3 m are tagged and data are collected on tree species, diameter at breast height (dobh), height and health class (healthy, slightly stressed, stressed, very stressed, recently dead and older death.

A pre-treatment report has been prepared (Mattiske and Associates February 2011). The data show that while the numbers of stems per hectare are similar on both dieback-affected and dieback-free, the basal areas are lower in the dieback-affected plots. Tree health on all sites was rated as stressed to slightly-stressed. Re-measurements at 3–5 year intervals are proposed.

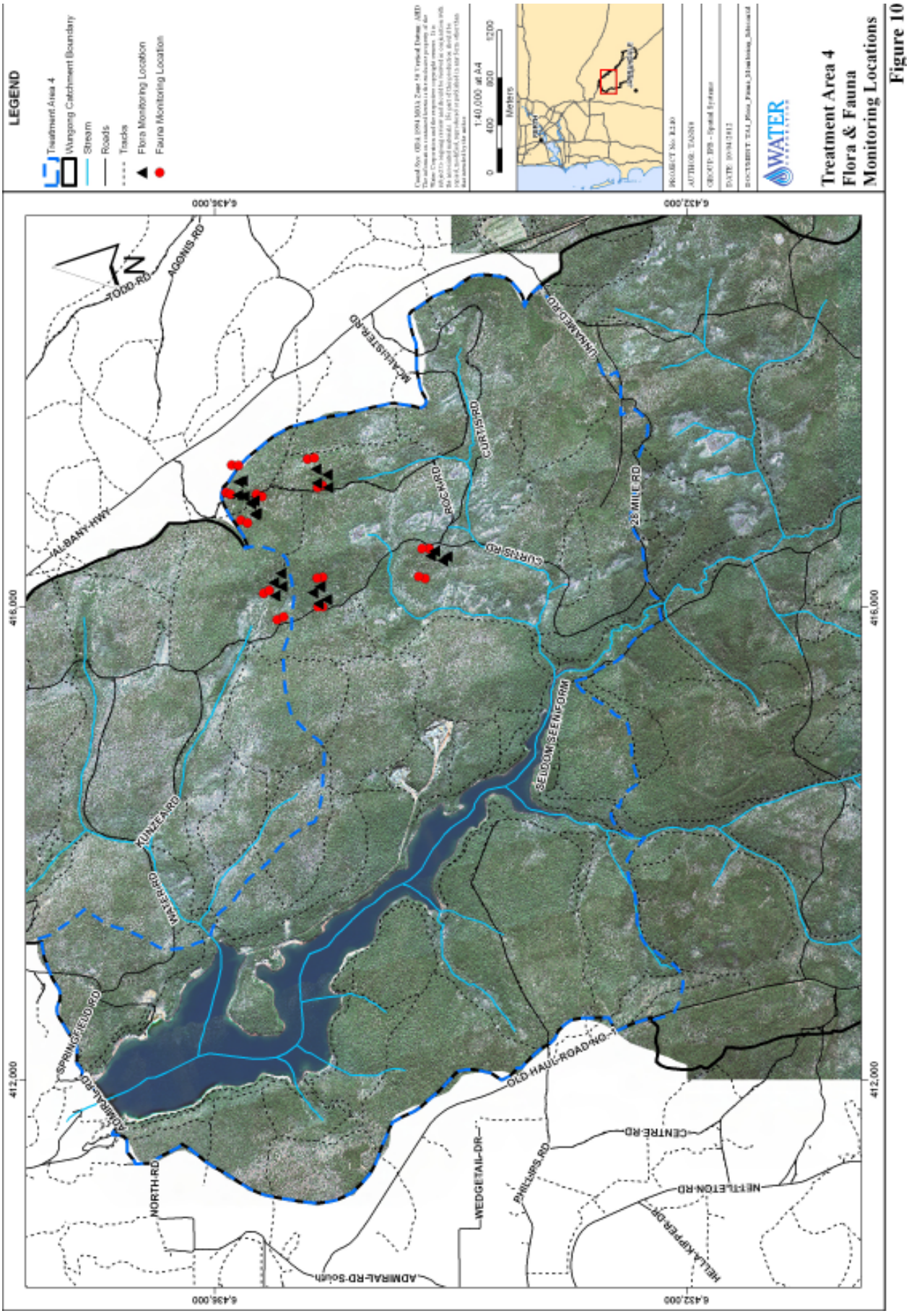


Figure 11. Fauna and flora monitoring sites within TA4

Ecosystem health

Re-measurement of the flora and fauna transects in 3–5 years time will provide an indication of ecosystem response to thinning treatment in both healthy forest and areas mapped by DEC staff as dieback affected.

Data will be available on how tree health, understorey criteria and fauna respond, and whether this response is affected by the presence or absence of Phytophthora on the site. *This is the first time that these factors have been tested in a replicated and monitored trial*.

Data on crown cover, plant cell density and tree health will also be collected by remote sensing to supplement these field measurements. The combination of all these data will indicate whether less precautionary settings for dieback-affected areas are effective.

Tree health – *a project summary*

Crown health was assessed on 370 trees, four years after thinning the Cobiac experimental catchment. One hundred and four trees were in the thinned, dieback-free site; 162 in thinned, dieback-affected and 104 in the un-thinned control strip. Tree crowns were classified as very healthy, healthy, average, poor, very poor and recently dead.

Thinning has substantially increased crown health of the remaining trees.

Crown health was expressed as the ratio of the number of above average (very good/good) to below average (very poor/poor/recently dead) crowns. In both the dieback-affected and dieback-free transects, this ratio was 3:1, indicating that most crowns were healthy, irrespective of the dieback status. In contrast, within the un-thinned control strip this ratio was 0.7:1, with more poor crowns as well as several recently dead trees.

This result is quite contrary to statements that thinning in dieback-affected forest will result in the death of most of the retained trees.

The current prescriptions which require that at least 15 m^2/ha of basal area be retained in dieback-affected sites were derived empirically rather than being based on research data.

Aesthetics

A comprehensive survey of public attitudes to thinning and notching has recently been done by Beckwith and Associates in conjunction with Murdoch University. The report is available at www.watercorporation.com.au/wungong. As a result, no additional work is proposed for this small-scale operation.

Post thinning forest structure

Thinning alters the existing forest structure by predominantly removing the smaller trees and selectively favouring the retention of the larger jarrah and marri.

Monitoring of this treatment on structure and species composition will therefore be necessary, to ensure that all species and age classes are still represented.

It is proposed to do this by establishing randomly selected strip lines 20 m wide within thinned areas some 2–3 months after thinning and to record the health status of the remaining species by 10 cm size classes, as follows: 10–20, 20–30, 30–40, 40–50, 50–60, >60 cm. Post-thinning surveys of Cobiac catchment trial show that adequate numbers of stems have been retained in all these size classes.

Other relevant monitoring

An additional set of twelve transects were also established some years ago in Treatment Area 1 (four transects, notched), Treatment area 2 (four transects, logged by FPC) and the Monadnocks Conservation Park (four transects, as controls). Data are collected on fauna, understorey flora, trees and ecosystem health, as described above and reports have been posted on the website.

These twelve transects have also been mapped for dieback disease by DEC interpreters and will provide additional information on the effects of thinning on tree health, understorey criteria and fauna, and whether the response is affected by the presence or absence of Phytophthora on the site.

Cockatoos – *a project summary*

Between 2007 and 2011 the Water Corporation funded a cockatoo research program by Ron Johnstone, Curator of Ornithology at the Western Australian Museum within the Wungong Catchment. Three species of cockatoo — baudins, carnaby's and the forest red-tailed black cockatoo are found in the Wungong catchment (Johnstone and Kirkby 2009).

Baudin's cockatoo *(Calyptorhynchus baudinii)*

Carnaby's cockatoo *(Calyptorhynchus latirostris)*

Red-tailed black cockatoo *(Calyptorhynchus banksii naso)*

The main aim of this project was to document areas of critical habitat (breeding, roosting and feeding sites) within the catchment and to monitor changes in populations due to impacts of clearing, vegetation thinning, fire and climate change. All three species use the catchment and surrounding areas to:

- **feed** — primarily on marri and jarrah, but also on several understorey species
- **nest** (within catchment region — currently monitoring of 78 nests of the forest red-tail, six of carnaby's cockatoo and two of baudin's cockatoo, most nests are located primarily in large, old marri trees), and
- **roost** (monitoring a total of 23 roost sites).

Some large roost sites for baudin's are also found just north of the Wungong Reservoir within Bungendore Park (Johnstone and Kirkby 2008). Up to 700

individuals of baudin's cockatoo have been recorded at a traditional roost site and flocks of up to 99 forest red-tails have been counted during survey. All three species require access to permanent water, are classified as endangered and are protected by State and Federal legislation.

The Wungong catchment is therefore an important area for cockatoos and for additional research on the effects of climate change and forest management on cockatoos.

The three species have survived in a catchment that has been logged three to four times since 1900 (though some patches of older trees were left on steep slopes and ridges), that has been prescribed burnt regularly since the 1960s, that has been extensively affected by Phytophthora dieback disease (~60 per cent) and that has been extensively mined for bauxite (~30 per cent).

Flowering and seeding of jarrah and marri is intermittent, dependent on rainfall, with some years much better than others. Also, the larger trees with big, healthy crowns produce most of the available seed (Abbott and Loneragan 1986). After thinning, the trees are less water-stressed and produce large healthy crowns (see frontispiece photograph and Fig 12).

In summer 2011, many drought deaths were observed in un-thinned forest within Wungong but none in areas that had been thinned in 2008 (Batini pers. com). See photo on the back page.

The proposal to thin parts of TA 4 will not target known nest sites (mainly veteran marri trees) or roosting areas (often large trees near streams) as determined after survey by museum staff, the silvicultural prescription will select the bigger trees for retention and habitat trees will also be retained.

The trial thinning proposed for TA4 will enhance soil moisture, water tables, streamflow and tree health and is likely to benefit the survival, crown health and seed production by jarrah and marri.

The proposed silvicultural activity may well increase the availability of food and access to water in pools for resident cockatoos.

The trial will also provide an opportunity for further research into the effects of climate change and forest management on cockatoo species.

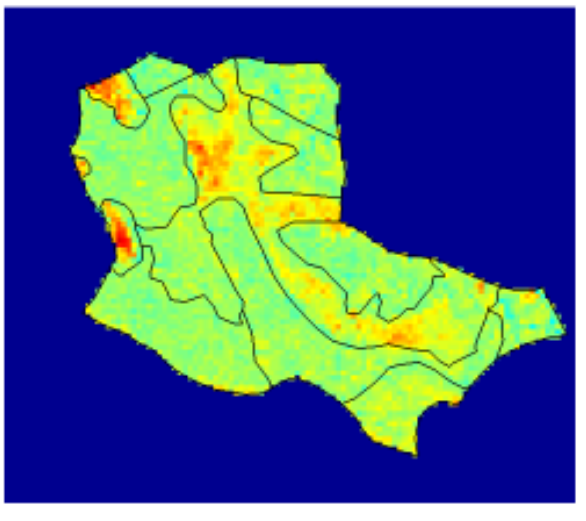


Figure 12. Change in canopy cover in Cobiac catchment, Jan 2010 – March 2011 ***(Dr MacFarlane, CSIRO)***

Reporting and evaluation

All reports on this Trial will be made available on the Water Corporation's website. In addition, the Wungong Project Manager will provide hard copies of these reports to the Manager, Forest Policy and Practices Branch, DEC.

Any concerns raised by these reports will be addressed by members of the Wungong catchment project team in consultation with appropriate DEC staff.

The study will be evaluated against the five objectives by members of the Wungong Project Team and the Manager, Forest Policy and Practices Branch, DEC.

Results will be published at www.watercorporation.com.au/wungong when 3–5 years post thinning data are available.

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