Research Agreement between CSIRO (Division of Forestry and Forest Products and Forest Products)

and

Department of Conservation and Land Management (CALM), WA

Australian Fire Authorities Council Inc (AFAC)

Parties	**Commonwealth Scientific & Industrial Research Organisation** a body corporate established under the Science and Industry Research Act 1949 and having its Head Office at Limestone Avenue, Campbell in the Australian Capital Territory (**'CSIRO'**), through its Division of Forestry and Forest Products (**"Division"**). **Department of Conservation and Land Management ("CALM")** Hackett Drive, CRAWLEY WA **Australian Fire Authorities Council ("AFAC")** 1st Floor, 312 Stephensons Road, Mount Waverley, Victoria, 3149.
Project	**Vesta**: The prediction of high-intensity fire behaviour in dry eucalypt forest
Liaison Officers	**CSIRO**: N P Cheney, Senior Principal Research Scientist **CALM:** Dr N Burrows, Director - Scientific and Fire Information Division **AFAC**: I G Lavelle, Chief Executive Officer
CSIRO Key Personnel	**N P Cheney** **J S Gould**
CALM Key Personnel	**L McCaw**
AFAC Key Personnel	**R Sneeuwjagt**

This Research Agreement comprises each of the following ticked items which must be **ATTACHED** to this Cover Sheet and initialled on each page by each party:

- ❑ This Cover Sheet
- ❑ Project description
- ❑ Project Plan *(including full description of tasks of each party, deliverables, work sites and payments)*
- ❑ Terms of Collaborative Research

Executed as an Agreement **Dated/ /**

Signed for and on behalf of CSIRO by an authorised officer

.....	.....	.....	.....
Signature of authorised officer	Name of authorised officer	Signature of witness	Name of witness

Signed for and on behalf of CALM by an authorised officer

.....	.....	.....	.....
Signature of authorised officer	Name of authorised officer	Signature of witness	Name of witness

Signed for and on behalf of AFAC by an authorised officer

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Signature of authorised officer	Name of authorised officer	Signature of witness	Name of witness

PROJECT VESTA

Project Description

Project Description (Purpose)

This project will revise algorithms required to predict fire behaviour in dry eucalypt forest.

The functional relationships which require specific attention and which are currently believed to under-estimate forest fire behaviour are between:

- rate of forward spread and
  - fuel load
  - fuel age
  - fuel structure
- rate of forward spread and in forest wind speed
- in forest wind speed and open windspeed @ 10 m

This research will enable the development of a National Forest Fire Behaviour Prediction system capable of providing reliable predictions of high-intensity bushfire behaviour in dry forests with fuels of different structure and of different age.

PROJECT VESTA

Project Plan

Objective:

To determine new algorithms to predict high-intensity fire spread in dry eucalypt forests which have wide application to different fuel types.

Research Hypothesis:

This study will test the following hypotheses.

That -

- the rate of spread of surface fires is independent of fuel load;
- the increase in spread rate of surface fires with increasing wind speed is best described by a direct linear relationship above a defined threshold wind speed;
- flame dimensions are dependent on fuel load and on fire rate of spread (i.e. fire intensity);
- the length of time that fuel reduction burning reduces fire behaviour characteristics depends on the re-development of fuel structure at different ages not on the re-accumulation of fuel mass.

Collaboration

This project will undertaken by scientists from CSIRO Division of Forestry and Forest Products (DFFP) and the Science and Information Division, CALM Western Australia as a collaborative research project.

Principal Investigators:	N P Cheney	-	Senior Principal Research Scientist
	J S Gould	-	Senior Experimental Scientist CSIRO DFFP, Canberra
	L McCaw	-	Senior Research Scientist SID CALM, Western Australia
Project Co-ordinator:	J S Gould	-	CSIRO DFFP

The fire research groups of CSIRO and CALM have expertise in the measurement and analysis of forest fire behaviour which is recognised internationally as amongst the best in the world - it will bring together an outstanding combination of skills capable of resolving difficult experimental problems. The team has access to expertise in specialised scientific fields (eg wind profile measurement and modelling) in other divisions of CSIRO and to practical fire management through the CALM Fire Management Branch.

The project has been made possible by CALM scheduling their prescribed burning program to provide a range of fuel loads on suitable experimental forests. Initial funding was received from the Australian IDNDR (International Decade for Natural Disaster Reduction) National Committee for analysis of high intensity fire data to examine the relationship between head-fire width and fire spread during the 1995-96 financial year. This analysis showed that existing fire behaviour under-predict fire spread under certain conditions and has assisted in the selection of suitable site and the experimental design of the project.

Funding

The total cost of the project will $4.44 million over 6 years. The contribution from CSIRO can be up to 70% of the total cost for collaborative projects supported by stakeholders. Direct financial support will be required from the State forest and land management agencies, State fire authorities, and research funding agencies over the next 5 years. Additional collaborative arrangements with State land management agencies could be made to extend the fuel sampling to a wider range of forest fuel types. An estimate of the funds required is:-

Contributor	$,000
CSIRO DFFP	2358.9
CALM WA	783.9
IDNDR(grant*)	42.5
External funds required **	1254.2
	4439.5

* Received in 1995-96.

The annual cost of the project and the funds required from each agency is summarised in Attachment 1. A full breakdown of project costs is set out in Attachment 2. The proportion to be contributed by CSIRO, CALM and external funds required each year is illustrated in Figure 1.

External funds will be sought from Australian Fire Authorities co-ordinated through the Australian Fire Authorities Council (AFAC).

CSIRO and CALM have invested a considerable effort in high-intensity fire behaviour research and have assessed the feasibility of the project with external funding assistance from the Australian Committee for the International Decade for Natural Disaster Reduction during 1995/6. CALM Fire Management Branch have scheduled previous operational burning to provide a suitable range of age classes for the experiments in 1998. If this opportunity is missed the project will face increased costs to prepare specific sites and delays until a suitable range of fuels accumulate. The results from analysis of existing data will be limited without information on the effects of fuel load and structure on fire spread and scientists may be directed to seek funding for projects on other problems.

Aims:

1. Fuel characterisation

   - Develop applied field-based techniques for measuring and describing fuel characteristics to predict fire behaviour.

   - Establish the statistical significance of the load and structural attributes of the fuel bed at different times after prescribed burning.

2. Fire behaviour

   - Develop statistical models to describe the relationships between fire behaviour descriptors (e.g. rate of spread, flame dimensions) and fuel characteristics (e.g. structure, composition and load).

   - Quantify the changes in the behaviour of fires with the characteristics of high intensity summer wildfires as the fuels in dry eucalypt forests develop with age.

   - Develop a new algorithm to describe the relationship between fire spread and wind speed both within and above the forest.

3. Wind speed measurement

   - Develop characteristic wind speed profiles within the dry eucalypt forests that are related to a range of over-storey height, canopy density and understorey structure.

   - Test models designed to predict variation of wind speed and direction over variable terrain and canopy height.

Experimental Site

Two experimental sites are needed. One site is in the McCorkhill block, Nannup District a second site east of Harvey has been selected.

These sites have been selected for the following reasons:

- they represents a dry sclerophyll forest fuel type;
- there is a range of suitable fuel ages;
- experimental fires can be contained with existing fuel reduced buffer strips;
- there is an existing network of roads and tracks;
- reasonable proximity to support services and suppression resources; and,
- there already exists considerable fuel, fire behaviour and terrain data from previous experimental studies.

The vegetation and fuels of the McCorkhill block are considered reasonably representative of dry eucalypt forests with a low understorey shrub component. Jarrah (*Eucalyptus marginata*)

is commonly associated with marri (*E. calophylla*) forming the overstorey of 40 to 60 percent canopy cover with a top height of 25 - 30 m. Under-canopy trees consist of primarily casuarina and banksia species. The understorey scrub height ranges from 0.2 - 2 m and the cover ranges from sparse to near-continuous (10 to 70 percent). Topography is gently undulating.

The study site has fuels of five ages which by 1998 will be:

1. 2 year old - burnt Spring 1995,
2. 4 year old - burnt in March 1994,
3. 7 year old - burnt in November 1991,
4. 10 year old - burnt in November 1988,
5. 15 year old - burnt in March 1983.

On the second site in Jarrah-Marri forest east of Harvey the fuels are primarily litter with only a small proportion of shrubs. The volume of these shrubs does not increase dramatically with age after burning. The study site has 4 fuel ages in close proximity which by 1988 will be:

1. 2 year old - burnt in October 1995
2. 5 year old - burnt in spring 1993
3. 7 year old - burnt in spring 1991
4. 18 year old - burnt in spring 1970

Areas of dry eucalypt forests with various aged fuels in New South Wales and/or Victoria are being investigated to conduct fuel studies. These studies will quantify and compare the fuel components and structural attributes from the different fuel types in south-eastern Australia with the experimental sites in Western Australia. The results from the fuel component and structural survey will ensure that relationships between fire behaviour and fuel characteristics established in WA can be extended to other dry forest fuel types in Eastern Australia.

Experimental Design

a) Fuel assessment

A detailed fuel survey will be conducted to describe the fuel load, structure, composition and continuity for each age class. Fuel sampling techniques will be designed to systematically sample all fuels in a way that allows sub-division into classes that can be associated with the observed fire behaviour.

b) Fine fuels

Are defined as dead leaf twig and bark material < 6 mm thickness. The fine fuel load expressed in tonne per ha will be measured by destructive sampling. Sufficient samples will be taken on each block to obtain an estimate of the mean with a standard deviation within ± 10% of the mean.

c) Structure

The structure of the fuel complex is probably more important than the species associations which make up the complex. Different plant associations may have similar structure and the associations are often used to identify specific fuel types. The fuels consumed in low to moderate-intensity fires, typical of experimental fires, generally extend up to a height of 2 m above the ground. Some shrub types will be higher than 2 m; the need to sample these higher fuels will depend on the structure of the fuel type and the anticipated burning conditions.

The fuel will be stratified into the following layers:

(i) *elevated fuels* - shrubs and juvenile overstorey plants to a height of at least 2 m. This layer includes the low portions of understorey. The individual fuel components generally have an upright orientation and the spatial variability of elevated fuels is high.
Bark may be a special category of elevated fuels to be estimated separately.

(ii) *near-surface fuels* - grasses, low shrubs and heath sometimes containing suspended fuel components of leaves, bark and twigs from the overstorey. The height of this layer can vary from just centimetres to over a metre above the ground. The orientation of the fuel components is mostly upright. The layer may be continuous or discontinuous. Where it is well developed and continuous, this is the layer most important in propagating the fire.

(iii) *surface fuels* - leaf, twig and bark litter of the overstorey and understorey plants. The fuel components are generally horizontally layered. This layer usually makes up the bulk of the fuel load and determines the flame depth of a surface fire.

(iv) *duff fuels* - decomposing plant material which is tightly compacted and is in close contact with the soil. When soils are dry, it is difficult to sample the duff layer without collecting attached soil and samples should be ashed in a muffle furnace to determine the fraction of organic matter. Because the lower duff layer contributes only to smouldering combustion well after the flame front passes (if it burns at all), it is recommended that only that fraction of duff which can be easily separated from the soil be collected when sampling for fire behaviour experiments.

In some fuel types, all of the fuel layers may not be present or only present in small quantities. Sampling techniques for quantitatively measuring fuel structure will need to be designed and tested.

Fuel plots representative of each fuel type need to be established and be measured after burning to establish the fuel consumed.

d) Fire behaviour

Fuels of different ages will be burnt simultaneously in 200 x 200 m or 200 x 100 m plots. Twelve plots per age group are planned depending on area and uniformity of canopy cover and vegetation. There will be twelve combinations of the four age groups to be burnt simultaneously under range of wind conditions as shown in Table 1.

Table 1. Proposed windspeeds, replicates, and plot size for each fuel age.

Open windspeeds at 30m (km h^{-1})	Number of Replicates	Plot Size
Light (7 - 10)	2	200 m x 100 m
Moderate (12-18)	5	200 m x 200 m
Strong (20-25)	5	200 m x 200 m

It will be desirable to burn all 4 ages at the same time and it is planned to burn only one set per day requiring 12 burning days.

Recent research on high-intensity fires in grasslands and woodlands in northern Australia has shown that the potential rate of spread of a fire is dependent on the length of the fire ignition line and, as the fire develops, it also depends on the width of the head fire and the wind speed. At moderate wind speeds of 25-30 km h^{-1} fires may not reach a quasi-steady rate of spread until the fire front is more than 150 m wide.

From preliminary analysis of line and coalescing fires (IDNDR Project 4/95) it appears that a similar relationship also holds true for fires in jarrah forest fuels. All fires will be lit in a line ignition at right angles to the prevailing winds (if possible) at a constant length of 100 m. Although fires may not achieve the potential rate of spread within the plot they are expected burn at a quasi-steady rate which will be satisfactory to establish relationships between rate of spread, wind speed and fuel characteristics.

For experimental fires to maintain forward spread in a consistent direction, wind speed in the forest must be above 2 km h^{-1}. The range of suitable fire weather conditions and expected fire spread are as follows:

Temperature	25 - 35°C
Relative humidity	15 - 45%
Surface fuel moisture content	4 - 10%
In-forest wind speed (1.5 m)	2 - 8 km h^{-1}
Open wind speed at 30 m (4 : 1)	8 - 32 km h^{-1}

Soil dryness index	> 500
McArthur Forest Fire Danger Index	7 - 25
Forward rate of spread (FFDM) (10 t ha^{-1})	84 - 550 m h^{-1}
Jarrah rate of spread index	30 - 480 m h^{-1}
Potential Spotting	< 1 km

The experiments will be conducted during the period of maximum burning conditions for the day when there is a relatively uniform wind field across the plots. This will mean burning under sea-breeze conditions (i.e. westerly - south westerly) between 1200 to 1500 hours at the McCorkhill site and under easterly winds between 1100 to 1400 hours at the Harvey site.

CSIRO is examining the feasibility of measuring fire spread by oblique imagery from a helicopter using a hand-held infra-red camera and the use of fire-spread markers on the ground. The infra-red camera will produce a series of thermal images of the fire front burning through the experimental plots.

One-way analysis of co-variance (ANCOVA) will be used to assess the effects of fuel age on forward rate of spread after the effects of one or more co-variates are statistically removed. Co-variates of wind speed, fine fuel moisture, slope and effective length of ignition line are likely to be chosen because of their known association with the dependent variable (forward rate of spread). The ANCOVA will answer the question: are there mean differences in the forward rate of spread associated with the fires in the four different fuel ages after adjusting for difference in wind speed, fine fuel moisture, slope etc?

e). Fire meteorology

The basic meteorological measurements necessary for fire behaviour experiments will be combined with a project which aims to test a model using terrain and vegetation information to extrapolate the wind conditions measured at a semi-remote station to the wind conditions at the location of the fire.

The basic measurements necessary for fire behaviour characterisation will be obtained using a 10 metre instrument tower on an exposed ridge. Movable towers 10 m towers will be placed on the upwind edges of the plots about to be burnt to record in-forest wind profiles.

Wind measurements from the meteorological station will be extrapolated to the fire site by use of a computer program known as **WA^{s}P**[1] and compared with the measured values. This program is operated by CSIRO Centre for Environmental Mechanics. The program will predict the wind flow over undulating terrain referenced to a wind speed measurement at one location. The terrain must be digitised at the canopy top. With suitable estimations of canopy resistance the winds at up to 16,000 points in the digitised terrain, based on the one input wind speed location, can be output. Environmental Mechanics will be contracted to produce wind maps for the range of experimental conditions of wind speed and direction. This would allow a prediction of the relative wind speeds on the two blocks scheduled for simultaneous burning.

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[1]Wind Atlas Analysis Applied Program. Riso National Laboratory Roskidle, Denmark.

Up to three permanent (for the duration of the experiments) towers of 40 metres will be erected within the canopy in the vicinity of the experimental plots, but not in a position where they could be expected to be burnt. The towers will be erected several hundred metres apart, at distances representative of the horizontal terrain scale. These towers will have intensive instrumentation which will allow a relationship between canopy-top wind and the wind at all heights below the canopy to be established. These towers should be set up several weeks before the burning experiments begin to enable good statistical evaluation of the **WA^{5}P** model and in-canopy vs overhead winds to be made before vegetation is modified by experimental fires.

The details of the measurement, tower placement and instrument design: anemometer type, vane, propeller or cup, the frequency responses; temperature sensors, humidity sensors will depend on the investigation work carried out by Environmental Mechanics in an open forest in NSW (Moga, Braidwood). It is important that our methods are complementary to studies already performed but include measurements to answer the questions unique to the fire behaviour questions.

Project Tasks

The major tasks to be carried out over the next 5 years are:

Proposal and Funding

- Prepare detailed work plans.
- Secure funding from CSIRO, State Agencies and Research Funding agencies.
- Secure approval from CALM for specific sites and draw up cooperative agreements.

Site Preparation

- Survey and locate plots on uniform terrain.
- Construct plots, firebreaks and buffer zones.
- Hazard reduce buffer areas.

Fuel Measurements

- Determine satisfactory sampling techniques to estimate fuel load, fuel height and bulk density.
- Survey selected fuel types in typical forest types in Eastern Australia.
- Detailed survey of fuels on experimental sites immediately prior to burning.
- Post-burn survey of residual fuels.

Wind Terrain Study

- Establish summer wind characteristics for experimental sites (from existing records, or after setting up meteorological stations on or near site).
- Build and evaluate instrumentation to measure wind profiles in and above forest canopy.
- Obtain WA^{5}P model and digitise terrain and canopy surfaces.
- Establish an anemometer network to evaluate wind terrain model.
- Measure wind profiles at each experimental fire.

Fire Behaviour

- Measure seasonal and diurnal trends of live shrub and dead litter moisture content.
- Carry out pilot study burns to evaluate equipment and fire measurement methods.
- Undertake simultaneous experimental fires in 4 age classes at McCorkhill and Harvey blocks (separately).

Data Analysis

- Determine quantitative measures of fuel structure in each fuel type and age class.
- Determine in forest wind profiles for forests with known structure, density and canopy cover.
- Test models that predict variation of wind velocity over the terrain.
- Determine a relationship between fire behaviour (rate of spread, flame height, spotting distance) with fuel characteristics (fuel load, height, bulk density cover) fuel moisture content and wind speed.

Reports

- Update research proposals as negotiations proceed.
- Produce working plans for major field events.
- Prepare progress reports (6 monthly).
- Prepare preliminary and final reports.
- Publish scientific findings.

The proposed work schedules follow and are illustrated in the Gantt chart shown in Figure 2.

Steering Committee

A Steering Committee comprising:

Phil Cheney	CSIRO
Lachlan McCaw	CALM
Laurie Lavelle	AFAC
Rick Sneeuwjagt	AFAC

will monitor the progress of the Project.

The management will meet in person or by teleconference at 6 monthly intervals and at other times if deemed necessary.

PROJECT VESTA

Work Schedule - July 1995 - June 1996

Activity	Date	Status
Undertake analysis of data from projects Aquarius & Narrick	July 1995 - June 1996	Completed
Investigate feasibility of project Vesta as a collaborative project with CALM	February -March 1996	Completed
Prepare Project Proposal and submit to AFAC	February 1996	Completed
Locate suitable experimental sites and gain necessary approvals	February - June 1996	Completed
Undertake preliminary trials of fuel sampling procedures	February - March 1996	Completed
Select areas for Pilot Study on South Coast of NSW	May 1996	Possible sites visited and discussed with State Forests NSW
Commence analysis of fuel sampling techniques	May-June 1996	Ongoing

Work Schedule - July 1996 - February 1997

Activity	Date	Status
Prepare final report on analysis of Projects Aquarius & Narrick data IDNDR Project 4/95. Establish need for Project Vesta	July - October 1996	Completed (See final report Prediction of Bushfire Spread IDNDR Project 4/95)
Prepare conference paper NDR-96	September-October	Completed
Assemble two weather stations for McCorkhill and DeeVee experimental sites	July-October	Completed
Undertake modelling of wind over terrain at McCorkhill using the WA^{5}P model.	July - November	Completed
Analyse preliminary fuel sampling data. Finalise fuel sampling techniques	July-January 1997	Completed. (See progress report)
Prepare conference paper on Project Vesta for 13th Conference on Fire and Forest Meteorology	October 1996	Completed. Paper submitted for publication in Conference Proceedings.
Establish and survey location of experimental plots at McCorkhill and Dee Vee	November - December 1996	Completed
Install weather stations at experimental sites	November 1996	Completed
Construct experimental plots and fire breaks	January - February 1997	Continuing
Develop proto-type anemometry to measure in-forest winds	November - January 1997	Prototype anemometer and mast developed for field testing

Activity	Date	Status
Develop techniques for instantaneous ignition of experimental fires.	January - February	Continuing
Undertake pilot study in coastal forest of SE NSW	February - March 1997	Abandoned. Pilot study burns to be conducted in WA.
Revise statistical design of fuel sampling	February 1997	Continuing
Progress report	February 1997	Completed

PROJECT VESTA

Work Schedule - March - June 1997

Activity	Proposed Dates
Draw up contracts with CALM and AFAC and finalise funding arrangements	March 18
Undertake fuel survey stage I (60% of estimated sampling number on all plots)	March 3 - April 11
Measure variability of in-forest wind profiles. Test equipment.	March 17 - April 11
Pilot study - 4 experiment test burns. Trial fire measurement techniques.	March 24 - April 11
Meeting with Bureau of Metrology WA for co-operative research	March 24 - April 11
Briefing/seminars CALM Fire and Rural Fires Board on Project Vesta objectives	March 24 - April 11
Recreation Leave	April - June
Aerial photography of plots	April - June
Deduction of fuel survey data for analysis	April - June
Reduction of wind profile data for analysis	April - June
Submit costs for 1996-97 to AFAC: Revise budget 97-98	April - June
Attend International Wildland Fire Conference, Vancouver (Cheney)	May - June

PROJECT VESTA

Work Schedule - July 1997 - June 1998

Activity	Proposed Dates
Recreation leave	July - August
Progress report	July
Data reduction for analysis - Fuel survey - Wind profiles	July - August
Participate in crown fire field studies in Canada. (Gould)	July
Preliminary analysis of fuels data-recalculation sampling density	August - September
Final design and construction/purchase of experimental equipment - anemometer - fire spread times - video equipment - fuel moisture meters - ignition devices - upper wind measurement	July - November
Run WaSP models to estimate wind over terrain at Dee Vee site	July - October
Draft experimental design for: - wind profile measurement - fire behaviour measurement	August - September
Revise work plans for: - stage II fuel sampling - experimental burning	October
Protective burning of buffer areas around experimental sites	October - November
Instal weather stations at McCorkhill and Dee Vee sites	October - November
Fuel sampling Stage II	November - December
Progress report	20 December
Experimental fires McCorkhill site	5 January - 20 February
Experimental fires Dee Vee site	21 February - 27 March

Activity	Proposed Dates
Post-fire fuel surveys	30 March - 14 April
Recreation leave	April - June
Recalibration checks of equipment	May - June
Collation and cross-checking of field data	May - June

PROJECT VESTA

Work Schedule - 1998 - 1999

Activity	Proposed Dates
Progress report	July
Revision of schedules plans for data analysis	July
Reduction of fuel survey data for analysis	July - December
Reduction of wind profile data for analysis	July - December
Analysis of stand density from aerial photographs	July - December
Progress report	January
Reduction of fire spread data for analysis	January - June
Reduction of weather station data for analysis	January - June
Preliminary analysis of fuel load and fuel structure distribution on individual experimental plots	January - June
Preparation of papers on Aquarius fire behaviour for peer review.	January - June

PROJECT VESTA

Work Schedule -1999 - 2000

Activity	Proposed Date
Progress report	July
Revise work schedules for analysis	July
Analysis of fuel data	July - September
Analysis of wind in forests with open wind, forest stand characteristics and terrain	August - December
Analysis of fire spread data with meteorologic conditions, fuel characteristics in forest winds, fuel moisture	September - June
Progress report	January
Preparation of draft papers on changes in fuel load and structure with age for peer review	September - June
Preparation of draft papers on wind structure in forests of different structure and fuel in level to undulating terrain for peer review	March - June

PROJECT VESTA

Work Schedule - 2000 - 2001

Activity	Proposed Date
Progress report	July
Revise work schedules for analysis and preparation of publications	July
Preparation of draft papers on wind structure in forests of different structure and fuel ages in level to undulating terrain	July - December
Submit papers on changes in fuel load and structure with age to peer review journal	September
Analysis of fire spread data. Preparation of algorithms describing fire spread from fuel and weather variables.	July - February
Preparation of papers on fire spread for submission to peer review journals	January - June
Preparation of final report	April - June

Attachment 1

Summary of Project Budget (1)

Contributions	1995/96 $,000	1996/97 $,000	1997/98 $,000	1998/99 $,000	1999/00 $,000	2000/01 $,000	Cost 1996-2001 $,000	Total Project Cost $,000
CSIRO Division of Forestry	327.2	365.7	476.6	352.2	401.6	421.7	**2017.8**	**2345**
WA CALM	80	156.3	267.8	169.6	63.1	47.1	**703.9**	**783.9**
Additional Support Required								
CSIRO Expenses	52.7	192.6	351.1	171.4	75.8	91.1	**882**	**934.7**
CALM Expenses	3.7	58.8	313.4				**372.2**	**375.9**
Total External Funds Required	**56.4**	**251.4**	**664.5**	**171.4**	**75.8**	**91.1**	**1254.2**	**1310.6**
TOTAL	463.6	773.4	1408.9	693.2	540.5	559.9	**3975.9**	**4439.5**

Note: (1) 1996-2001 cost are 1995/96 dollars adjusted 5 % per annum for inflation

(2) CSIRO received $42.5K grant from Austraila IDNDR committee to fund 1995/96 external requirements

Attachment 2

Proposed budget, expenses, contribution from CSIRO and CALM and grants required to fund the research project(1995-2001).

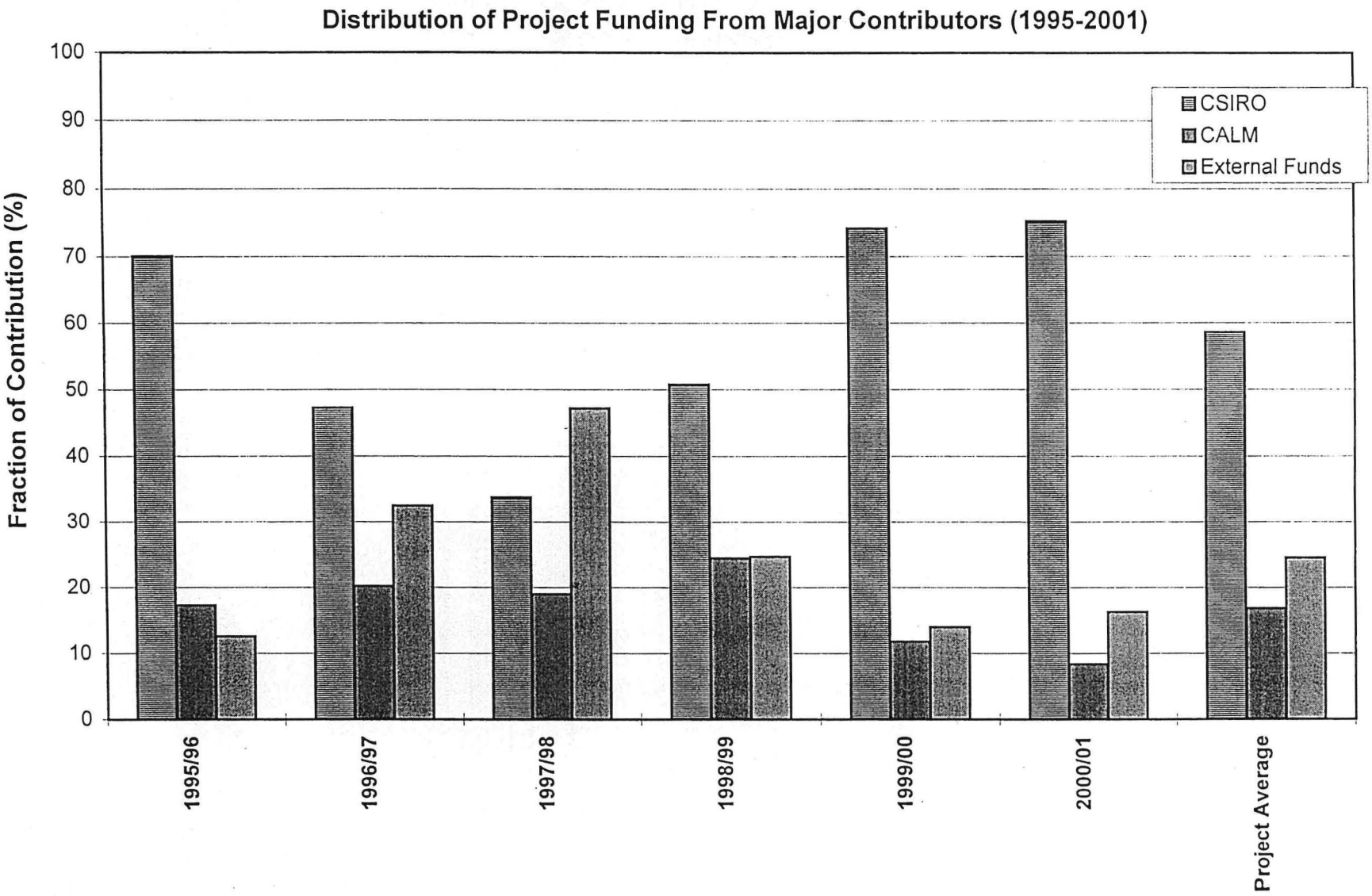
Expenses($000)	1995 / 96					1996 / 97					1997 / 98					1998 / 99				
	CSIRO	CALM	GRANTS		TOTAL	CSIRO	CALM	GRANTS		TOTAL	CSIRO	CALM	GRANTS		TOTAL	CSIRO	CALM	GRANTS		TOTAL
			CSIRO	CALM				CSIRO	CALM				CSIRO	CALM				CSIRO	CALM	
Salary																				
Direct salary	129.8	49.2	26.6		205.6	140.4	91.6	26.6		258.6	174.9	149.4	37.5		361.8	101.8	90.1	77.6		269.5
Salary on cost	37.5	6.0	7.7		51.2	40.6	11.1	7.7		59.4	50.5	18.1	10.8		79.5	29.4	10.9	22.4		62.7
Total Salary	167.3	55.2	34.3		256.8	181.0	102.7	34.3		318.0	225.4	167.5	48.3		441.3	131.2	101.0	100.0		332.2
Overheads	150.1	24.8			174.9	160.3	46.2			206.5	203.9	75.4			279.3	172.0	45.5			217.5
OHS	1.0				1.0	2.0				2.0	3.0				3.0	1.0				1.0
Operating																				
Project Proposal	8.8				8.8	5.0				5.0										
Site Preparation																				
Plot Layout								10.8		10.8										
McCorkhill Site									15.9	15.9										
Dee Vee Site									17.1	17.1										
BufferStrips																				
McCorkhill Site														14.1	14.1					
Dee Vee Site														15.7	15.7					
Fuel Sampling																				
Preliminary surveys			14.4	3.7	18.1			14.4	3.7	18.1										
Pre-burn surveys								22.9	18.5	41.4			22.9	18.5	41.4					
Post-burn surveys													36.4	12.6	49.0					
Pilot Study																				
Site Preparation								1.5		1.5										
Fuel sampling								6.0		6.0										
Experimental Fires								27.1		27.1										
Wind / Terrain Study																				
Travel													9.8		9.8					
Computing (WAsP)			4.0		4.0			3.0		3.0			4.0		4.0					
Maintenance								5.0		5.0			5.0		5.0					
Equipment								43.4		43.4			34.9		34.9					
Fire Behaviour																				
Casual Labour													15.8		15.8					
Overtime													10.0	20.0	30.0					
Travel													73.6	13.7	87.3					
Vehicles													17.8	17.9	35.7					
Maintenance								5.0		5.0			10.0	5.0	15.0					
Equipment								10.0		10.0			30.0	5.0	35.0					
Fire suppression														100.0	100.0					
Escape fire contingency														75.0	75.0					
Data Analysis																				
Travel																		18.1		18.1
Maintenance																		10.0		10.0
Equipment																		20.0		20.0
Total Operating	8.8	0.0	18.4	3.7	30.9	5.0	0.0	149.1	55.2	209.3	0.0	0.0	270.2	297.5	567.7	0.0	0.0	48.1		48.1
TOTAL	327.2	80.0	52.7	3.7	463.6	348.3	148.9	183.4	55.2	735.8	432.3	242.9	318.5	297.5	1291.3	304.2	146.5	148.1	0.0	598.8

Attachment 2

Proposed budget, expenses, contribution from CSIRO and CALM and grants required to fund the research project(1995-2001).

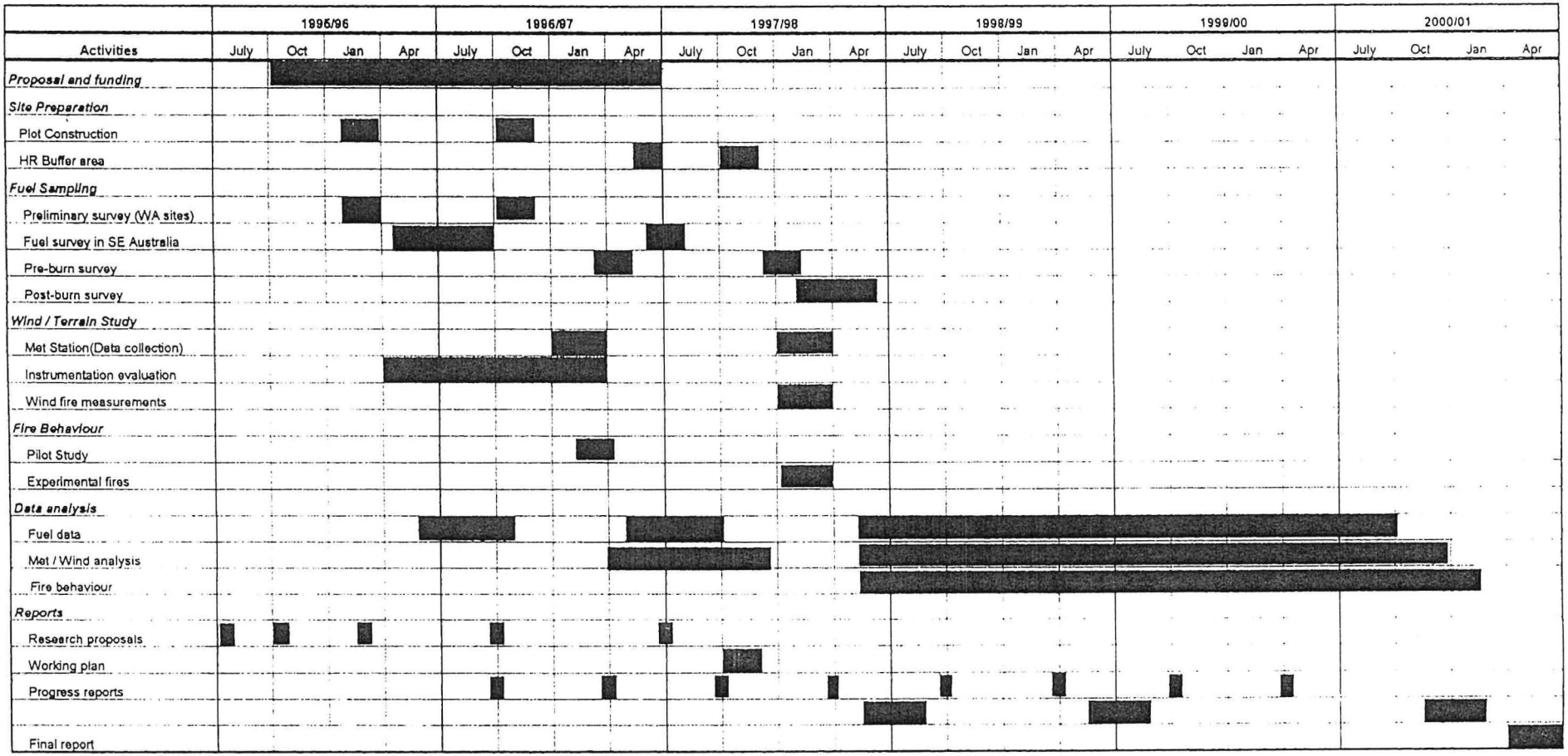
Expenses($000)	1999/00					2000/01				
	CSIRO	CALM	GRANTS		TOTAL	CSIRO	CALM	GRANTS		TOTAL
			CSIRO	CALM				CSIRO	CALM	
Salary										
Direct salary	135.3	31.9	26.6		193.8	135.3	22.7	26.6		184.6
Salary on cost	39.1	3.9	7.7		50.7	39.1	2.7	7.7		49.5
Total Salary	174.4	35.8	34.3		244.5	174.4	25.4	34.3		234.1
Overheads	155.5	16.1			171.6	155.5	11.4			166.9
OHS	0.5				0.5	0.5				0.5
Operating										
Project Proposal										
Site Preparation										
Plot Layout										
McCorkhill Site										
Dee Vee Site										
BufferStrips										
McCorkhill Site										
Dee Vee Site										
Fuel Sampling										
Preliminary surveys										
Pre-burn surveys										
Pilot Study										
Site Preparation										
Fuel sampling										
Experimental Fires										
Wind / Terrain Study										
Travel										
Computing (WAsP)										
Maintenance										
Equipment										
Fire Behaviour										
Casual Labour										
Overtime										
Travel										
Vehicles										
Maintenance										
Equipment										
Fire suppression										
Escape fire contingency										
Data Analysis										
Travel			18.1		18.1			27.0		27.0
Maintenance			5.0		5.0			5.0		5.0
Equipment			5.0		5.0			5.0		5.0
Total Operating	0.0	0.0	28.1	0.0	28.1	0.0	0.0	37.0		37.0
TOTAL	330.4	51.9	62.4	0.0	444.7	330.4	36.8	71.3	0.0	438.5

~~Attachment 2~~
FIGURE 1.



21/02/97

Table 2. Gantt Chart showing the major milestones of the research project.



Terms of Collaborative Research

Anticipated Public Domain Information Only

1. DEFINITIONS

1.1 In this Agreement

'Objectives' means the objectives of the Project, as specified in the Project Plan.

'Project Methodology' means the methodology used or generated by CSIRO (either alone or jointly with CALM or any other person) to generate the Project Results, except to the extent that generation of methodology is an Objective.

'Project Results' means all results (including but not limited to, information, discoveries, developments, inventions and software) generated by either party (whether alone or jointly with the other party or any other person) in carrying out the Tasks or in achieving or attempting to achieve the Objectives, except Project Methodology.

'Tasks' allocated to a party means the tasks allocated to that party in the Project Plan.

1.2 All other terms starting with a capital letter and used in these Terms are defined in the Cover Sheet.

2. CO-OPERATION

2.1 Each of CSIRO (only through the Division of Forestry and Forest Products) CALM and AFAC must:

(a) co-operate fully with the other party and any other persons involved in the Project;

(b) carry out the Tasks allocated to it:

(i) in accordance with the Project Plan;

(ii) to the best of its abilities and knowledge; and

(iii) in the case of CSIRO, with the active involvement of CSIRO Key Personnel; and

(c) use reasonable efforts, through the mechanism of the Project meetings, to discuss and agree on variations to any aspect of the Project.

3. DISCLOSURE AND USE OF PROJECT RESULTS

3.1 Each party must disclose all Project Results to the other party immediately after they come into the disclosing party's possession or control.

3.2 Unless the parties otherwise agree in writing, each party may use the Project Results without accounting to the other.

3.3 The parties anticipate that the Project Results will:

(a) be generated using only public domain information; and

(b) not include any material capable of protection by any form of intellectual property rights, including confidential information.

4. PROJECT MEETINGS AND REPORTING

CSIRO, CALM and AFAC will:

(a) in accordance with the Project Plan or as agreed between the parties in writing:

(i) arrange regular Project meetings to review the progress of the Project and to discuss any proposed variations to any aspect of the Project; and

(ii) prepare regular reports specifying the Project Tasks completed during the period to which the report relates; and

5. VARIATIONS TO PROJECT TASKS

5.1 Either party may suggest or request revisions (including deletions or additions) to the Project Plan ('Proposals') either:

(a) formally, by submitting a written Proposal to the other party outlining the Proposal; or

(b) informally, through the Project Meetings referred to in clause 4 (and then provide any information reasonably requested by the other party).

6. IPR AND REGISTRATION

6.1 'Intellectual Property Rights' or 'IPR' means all intellectual property rights, including but not limited to:

(a) patents, copyright, rights in circuit layouts, plant variety rights, registered designs, trade marks and any right to have confidential information kept confidential; and

(b) any application or right to apply for registration of any of the rights referred to in (a).

6.2 A party ('notifying party') may notify the other party ('receiving party') if, contrary to the parties' anticipation as set out in clause 3.3:

(a) in the notifying party's opinion Project Results include any material that may constitute IPR; and

(b) the notifying party wishes to apply for registration of any registrable IPR referred to in the notice.

6.3 If within 30 days after receiving a notice under clause 6.2 the receiving party:

(a) notifies the notifying party that it wishes to own those IPR jointly with the notifying party, the parties will (unless otherwise agreed between them) own those IPR equally and share equally the costs of applying for registration of any such IPR; or

(b) notifies the notifying party that it does not wish to own those IPR or does not notify the notifying party, the notifying party will own those IPR and may apply for registration of those IPR in its own name and at its sole cost.

6.4 Each party agrees that:

(a) clause 6.3 may result in one or more assignments or IPR;

(b) no additional documentation is necessary to complete those assignments; and

(c) it will do all things reasonably requested by the other to enable that other to assure further the IPR assigned.

7. CONFIDENTIAL INFORMATION

7.1 In this clause, 'Confidential Information' of a party means:

(a) information (including commercial information and methodology) treated by that party as confidential;

(b) information the parties agree under clause 6 (IPR) to treat as confidential.

7.2 Each party must:

(a) keep confidential and not disclose Confidential Information of the other party to any person except:

(i) its officers and employees who have a need to know (and only to the extent that each has a need to know); or

(ii) in any published article or at any conference if:

(A) both parties' Liaison Officers or a Project meeting approve the disclosure before it is made; and

(B) the disclosure will not adversely affect the commercial interests of a party;

(b) use Confidential Information of the other party only for carrying out the Tasks;

(c) establish and maintain effective security measures to safeguard Confidential Information of the other party from access or use not authorised by this Agreement;

(d) notify the other party immediately of any suspected or actual unauthorised use or disclosure of Confidential Information of the other party; and

(e) comply with any reasonable direction issued by the disclosing party from time to time regarding a suspected or actual breach.

7.3 The obligations of confidentiality under this Agreement do not apply to information that (whether before or after this Agreement is executed):

(a) is technical or scientific information, except to the extent that:

(i) the information is Project Methodology; or

(ii) the parties agree under clause 6 (IPR) to treat that information as confidential:

(b) the recipient creates (whether alone or jointly with any person) independently of the disclosing party's Confidential Information;

(c) is public knowledge (otherwise than as a result of a breach of confidentiality by the recipient);

(d) the recipient is required by law to disclose.

7.4 The obligations of confidentiality under the Agreement survive termination.

8. PERSONNEL

8.1 Each party must, if reasonably requested by the other, replace any of its personnel (other than Key Personnel) assigned to perform obligations under this Agreement.

8.2 Each party must, and must ensure that any of its personnel who attend the other party's premises, comply with that other party's usual staff and security practices while attending those premises.

9. PROPERTY

9.1 CSIRO and CALM will jointly own all equipment and other property acquired with external funds for use on the Project ('Joint Equipment'), except Equipment:

(a) already owned or purchased by either party using departmental funds; and

(b) specified at the time it is provided as being on loan only ('Loan Equipment').

9.2 On completion of the Project:

(a) Each party will return Loan Equipment; and

(b) Joint equipment will be divided between CSIRO and CALM on basis of future research needs.

10. FUNDING

10.1 CSIRO and CALM agree to contribute salaries and salary on-costs identified in Attachment 2 of the project plan as

10.2 AFAC will seek contributions from members to cover the salaries and operating costs identified as grants in Attachment 2 of the project plan as "grants."

10.3 CSIRO, on the behalf of all parties to this agreement, will manage its own contribution together with all grants money.

10.4 The steering committee will review income and expenditure against the total budget expenditure identified in Attachment 2.

10.5 The steering committee will meet in person or by teleconferencing at 6 monthly intervals or when requested by any party.

11. PUBLICITY

11.1 Neither party may make any public statements relating to the Project or CSIRO's involvement in the Project unless it has the other party's written approval to the statement, which may not be unreasonably withheld.

12. EXCLUSION AND LIMITATION OF LIABILITY

12.1 This clause does not exclude or limit the application of any provision of any law where to do so:

(a) would contravene that law; or

(b) cause any part of this clause to be void.

12.2 CSIRO excludes all:

(a) implied conditions and warranties except to the extent that any such exclusion would contravene any applicable law or cause this clause to be void ('Non-excludable Condition');

(b) liability for any damage CALM (or any person claiming through CALM) may suffer arising out of the Project Results being inaccurate or incomplete in any way or incapable of achieving any purpose; and

(c) liability for consequential damage (including lost profits and related out of pocket expenses) suffered by CALM (or any person claiming through CALM) arising out the Project.

12.3 CSIRO's liability to CALM for breach of any express provision of this Agreement or of any Non-excludable Condition (other than for any negligence of CSIRO) is limited to providing, replacing or repairing goods or providing services again.

12.4 CSIRO does not make any representation express or implied that the use or exploitation of the Project Results or the Project Methodology will not infringe any person's intellectual property rights.

13. INDEMNITY

13.1 Each party ('first party') indemnifies the other party (each an 'indemnified party') against all liabilities, expenses, losses, damages, and costs (on a solicitor and own client basis) that an indemnified party may sustain or incur as a result of:

(a) any property damage or injury to or death of any of the first party's personnel; or

(b) negligence of the first party.

14. RESOLUTION OF DISPUTES

14.1 A party must not start arbitration or court proceedings (except proceedings seeking interlocutory relief) in respect of a dispute arising out of this Agreement ('Dispute') unless it has complied with this clause.

14.2 A party claiming that a Dispute has arisen must notify the other party to the Dispute giving details of the Dispute ('Notification').

14.3 On receipt of a Notification each party must refer the Dispute for resolution by its Chief Executive Officer or the CEO's nominee.

14.4 If the Dispute is not resolved under clause 15.3 within 30 days (or longer period agreed between the parties), the parties must refer the Dispute for mediation by the Australian Commercial Dispute Centre Limited ('ACDC') for resolution in accordance with the Conciliation Rules of ACDC.

14.5 If the Dispute is not resolved under clause 15.4 within 60 days (or longer period agreed between the parties) either party may initiate proceedings in a court.

15 TERM OF PROJECT

15.1 Each party agrees that the Project will be complete when all of the Project Tasks are completed.

16. TERMINATION

16.1 A party may terminate this Agreement at any time with immediate effect by giving notice to the other party if:

(a) that other party breaches any provision of this Agreement and fails to remedy the breach with 90 days after receiving notice requiring it to do so: or

(b) any event referred to in clause 17.3 happens to that other party.

16.2 A party ('notifying party') must notify the other party immediately if:

(a) the notifying party disposes of the whole or any part of its assets, operations or business other than in the normal course of business;

(b) any step is taken to enter into any arrangement between the notifying party and its creditors;

(c) the notifying party ceases to be able to pay its debts as they become due;

(d) the notifying party ceases to carry on business;

(e) any step is taken by a mortgagee to enter into possession or dispose of the whole or any part of the notifying party's assets or business; or

(f) any step is taken to appoint a receiver, a receiver and manager, a trustee in bankruptcy, a liquidator or other like person of the whole or any part of the notifying party's assets or business.

17. AFTER TERMINATION OF AGREEMENT OR COMPLETION OF PROJECT

17.1 A party ('first party') may at any time request the other party ('requested party') to return to it all of the first party's Confidential Information (as defined in clause 7) in the requested party's possession or control, except to the extent that the information is necessary to allow:

(a) CSIRO (if it is the requested party) to use the Project Results or the Project Methodology; or

(b) CALM (if it is the requested party) to use the Project Results.

17.2 On receipt of a request under clause 18.1 the requested party must immediately at the first party's option:

(a) return to the first party;

(b) destroy and certify in writing to the first party the destruction of; or

(c) destroy and permit the other party to witness the destruction of -

all of the first party's Confidential Information in the first party's possession or control.

17.3 The obligations of confidentiality under clause 7 (Confidential Information) continue to apply to the parties to this Agreement (in addition to any assignee) after completion of the Project or termination or assignment of this Agreement.

17.4 Clauses (IPR), (Exclusion and Limitation of Liability) and (Indemnity) continue after completion of the Project or termination of this Agreement.

17.5 Termination of this Agreement will not affect any accrued rights or remedies either party may have.

17.5 Termination of this Agreement will not affect any accrued rights or remedies either party may have.

18. FORCE MAJEURE

18.1 'Force Majeure Event' affecting a party means anything outside that party's reasonable control, including but not limited to, acts or omissions of the other party, fire, storm, flood, earthquake, war, transportation embargo or failure or delay in transportation, act or omission (including laws, regulations, disapprovals or failures to approve) of any third person (including but not limited to, subcontractors, customers, governments or government agencies).

18.2 If a Force Majeure Event affecting a party precludes that party ('precluded party') partially or wholly complying with its obligations under this Agreement then:

(a) as soon as reasonably practicable after that Force Majeure Event arises, the precluded party must notify the other party of the Force Majeure Event; and

(b) to the extent and for the period that the precluded party is precluded by the Force Majeure Event from complying with its obligations under this Agreement, those obligations will be suspended.

18.3 This clause does not apply to any obligation to pay money.

19. FURTHER ACTION

19.1 Each party must do or cause to be done all things necessary or desirable to give effect to, and refrain from doing things that would hinder performance of, this Agreement.

20. ASSIGNMENT

20.1 A party must not assign or attempt to assign or otherwise transfer any right arising out of this Agreement without the written consent of the other party.

21. SEVERABILITY

21.1 If the whole or any part of any clause of this Agreement that is illegal or unenforceable, it will be severed from this Agreement and will not affect the continued operation of the remaining provisions of this Agreement.

22. WAIVER

22.1 The failure of a party at any time to insist on performance of any obligation of another party under this Agreement is not a waiver of its right:

(a) to insist on performance of, or claim damages for breach of, that obligation unless that party acknowledges in writing that the failure is a waiver; and

(b) at any other time to insist on performance of that or any other obligation of another party under this Agreement.

23. NOTICES

23.1 A party notifying or giving notice under this Agreement must give notice:

(a) in writing;

(b) addressed to the address of the recipient specified in this Agreement or as altered by notice given in accordance with this clause; and

(c) left at or sent by prepaid post or by fax to that address.

23.2 A notice given in accordance with clause 25.1 will be deemed received:

(a) if left at the recipient's address, on the date of delivers;

(b) if sent by prepaid post, 5 days after the date of posting; and

(c) if sent by fax, when the sender's facsimile system generates a message confirming successful transmission of the total number of pages of the notice.

24. HEADINGS

24.1 Headings are for ease of reference only and do not affect the construction of this Agreement

25. GOVERNING LAW

25.1 This Agreement is governed by the laws of New South Wales.

26. ENTIRE AGREEMENT

26.1 This Agreement (comprising these R&D Terms, the Cover Sheet and each of the items listed on the Cover Sheet):

(a) constitutes the entire agreement between the parties as to its subject matter and supersedes all prior representations and agreements in connection with that subject matter; and

(b) may only be altered in writing signed by both parties.