SEMINAR PAPER

REVIEW OF ROAD, RIVER AND STREAM ZONES IN THE SOUTH WEST FORESTS

Hydrological Values

Alan Walker

INTRODUCTION

In reviewing the adequacy and effectiveness of a system of buffer zones in the forest for the protection of water values, I will first look at water as a forest value, and discuss briefly the parameters of water quality used to assess impacts.

I will then outline the history of hydrology research in the forests of Western Australia with a focus on the southern forests. The salient points of this research will then be outlined in presenting recommendations for allocation of buffer zones in the future.

Finally, I will mention some of the practical considerations in the management of activities in the forest, particularly forest harvesting, important for optimising water quality.

1. Water as a Forest Value

Water derived from forested catchments is generally perceived to have two major values: as a commodity for human consumption and use, and as the medium for aquatic ecosystems and their biota.

The commodity value of water is related to its use by rural and urban communities, for personal, industrial and agricultural purposes. The quantity and quality of water available for such purposes is critical. In the south west of Western Australia water is considered to be a very important, if not the most important forest product.

The main conservation values of forest water are related to aquatic ecosystems, namely rivers, streams, creeks and wetlands found in the forests or dependent on forested catchments for their water supply. The importance of water for maintaining the conservation value of the forest ecosystem itself is generally taken for granted.

Most of you will be familiar with the hydrological cycle, however I will briefly recap. There are a number of physical and hydrological processes which determine the quantity of water flowing from a catchment. Water enters a catchment as rain, and is lost mostly through streamflow, or transpiration and evaporation to the atmosphere; over an extended period, more water is lost from forests by evapotranspiration than streamflow. Total evapotranspiration is the sum of evaporation from the stream surface, soil surface, intercepted water on the forest floor and forest canopy, and evapotranspiration from plants. Stream water is largely derived from soil surface runoff and overland flow, subsurface flow of water after rain storms, and flow of water through the ground (base flow/groundwater flow). The water quantity of a catchment is influenced by factors such as climate, soil type, catchment physiography, vegetation density, amount of litter on the soil surface, and management practices adopted in the catchment area.

A range of water quality parameters can be assessed in the hydrological system. These include levels of sediment, either suspended in the water column or deposited on or in the stream bed, turbidity, salinity, dissolved nutrients, oxygen, light availability, and organic debris. These attributes are in turn affected by factors such as flow rates of the water (especially the proportion of base flow to storm flow), groundwater levels and water temperature.

In south west forests, catchments are managed to optimise the quality of water produced. CALM land on gazetted catchments and water reserves is managed by CALM to the requirements of WAWA.

The quantity of water collected varies according to seasonal rainfall, soil storage and natural use by forests and agricultural crops. Clearing, clearfelling and forest thinning operations increase water yield.

Increased salinity is regarded as the most serious threat. In low rainfall zones, clearing for crops and pasture releases soil stored salts. Water quality in the Blackwood, Warren, Frankland, Kent and Hay Rivers which drain the southern forests, has been degraded in this way.

[show overhead of Southern Forest Region catchments and dams]

2. Hydrology Research in South West Forests

There is a sound body of information available to decision makers about the impacts of agricultural and forest activities on water quality.

For the purpose of this paper it is proposed only to consider forest harvesting and associated roading and regeneration activities and their impacts.

In 1973, following approval of the Environmental Impact Statement for commencement of a woodchipping operation in the southern part of the forests, research commenced to determine if proposed harvesting would have any impact on the hydrology of the region. Projects undertaken included:

- identification of areas vulnerable to salinity increases;
- a paired-catchment study to provide information on surface and groundwater hydrology;
- monitoring major rivers to identify large scale changes in water quality;
- monitoring of operational wood harvesting coupes for groundwater responses.

[show overhead of paired-catchment locations]

The results of this research has been reported in a series of Water Authority reports and scientific papers published from 1987 to 1989 [Borg et al (1987 a b); Borg et al (1988 a b); Borg and Stoneman (1989); Stoneman et al (1987)].

Hydrological research in the northern jarrah forest has also been extensive over the last two decades and this work was summarised by Schofield et al in 1989.

Streamflow

The paired-catchment study in Sutton Block in the southern forest provided an opportunity to compare streamflow following clearfelling in a catchment with a buffer 100 m either side of the main stream (April Road North) and a catchment with no stream buffer (March Road).

The data shows an insignificant difference in annual streamflow between the catchments despite the fact that 10% of the April Road catchment was retained unlogged.

[show overhead of March Road/April Road data]

Stream Sediment Concentration

The paired-catchment studies indicated that 100 m wide stream buffers were effective in preventing nearly all of the sediment produced as a result of clearfelling from reaching the streams.

[show overhead of sediment data]

A further study on six experimental coupes in 1985 and 1986 showed that halving the width of river and stream buffers had no effect on sediment concentrations, when logging took place in summer.

Buffers less than 30 m wide have been found to be effective in stopping sedimentation in eastern Australia (Clinnick, 1985), however factors such as soil type, slope steepness and vegetation cover are important in selecting buffer width.

Stream Salinity

The buffers kept on streams in the April Road North and Yerraminup south catchments reduced the groundwater rise in the valleys following logging. This probably moderated the associated increase in salt discharge and stream salinity, although it was not obvious from the data. It is significant that the largest increase in annual flow weighted salinities (about 150 mg/l TSS) occurred in a catchment in the intermediate rainfall zone which did not have a stream buffer.

[show overhead of salinity data]

Since the research programme began there has been particular interest in the effect of the new logging and regeneration strategies on water quality in the low rainfall zone where the soil salt storage is high. However, experimental results have shown there is no stream salinity increase in this area. This is because recharge was small and the depth to groundwater was sufficiently large that groundwater (the major source of salt) did not contribute to streamflow following harvesting and regeneration.

In the intermediate and high rainfall zones, groundwater contributed to streamflow before logging. Following logging in these zones, permanent groundwater levels rose and stream salinities increased, briefly in the order of 50 to 150 mg/L, indicating an increase in the discharge of salts from groundwater to streams. However all flow weighted salinities remained below 500 mg/L, the limit for high quality drinking water. Similarly, as groundwater levels began to fall following regeneration, stream salinities fell. It is expected that stream salinities will return to pre-logging values. This has already occurred in several of the experimental catchments.

The Water Authority reports concluded that from a regional water resource perspective, the salinity increases observed are minor and temporary. However, the low flow salinities measured at greater than 1500 mg/L, if they persist for many weeks, could cause problems with small-scale public water supply systems based on low-volume storages. This potential problem can be overcome by appropriate design of vegetative stream buffers.

Groundwater storage

Results from the southern forest projects showed that groundwater responses to logging were much less in the low rainfall (less than 900 mm per annum) zone than other zones. Stream vegetation buffers would reduce the rate of groundwater rise and should be employed where salinity risk is greatest in the intermediate zone.

In Summary [show overhead]

The presence or absence or the width of buffers is unlikely to seriously alter:

- water quantity (although increase of up to 10% of rainfall may occur for 2-3 years following harvest) or peak flow rates;
- chemical or bacteriological values.

The presence or absence or the width of buffers is likely to alter:

- sediment, especially in the high rainfall zone and if harvesting is on steep slopes, adjoining logging roads or conducted in winter (on some soils);
- salinity, especially in the intermediate rainfall zone;
- debris in streams, stream channels and the likelihood of algal blooms - if no buffer is present.

Aquatic Fauna

In their review of the impact of timber harvesting and production on streams, Campbell and Doeg (1989), concluded that major short term impacts of timber harvesting on the aquatic biota result from increased sediment input and the removal of riparian vegetation. Sediment which settles on the stream bed is of more concern than suspended sediment, and can lead to long-term deleterious changes to fish and invertebrate populations.

The provision of a network of stream buffers which prevent or minimize changes to sediment and salinity levels and protect streamside vegetation is clearly the most effective way to minimize impacts on aquatic biota.

3. Recommendations for Redistribution of Buffer Zones [show overhead]

The preferred distribution of buffers to reduce the impacts stated above is:

3.1 To reduce the width but increase the length of stream zones protected. Research suggests that a width of 30-50 m is adequate for this purpose.

3.2 The zone of least priority is the low rainfall zone.

Other factors which need to be considered are:

3.3 The understorey vegetation provides the primary protective function in reducing stream sedimentation. Some trees could be removed from buffers without increasing the risk of sedimentation provided that the understorey was not removed.

3.4 The location and construction of stream crossings can markedly influence water quality, especially sediment concentration.

3.5 The influence of road construction and drainage is significant. Logging under "sloppy" soil conditions also must be minimised.

3.6 It is difficult to keep all buffers unburnt and it may be desirable to either plan to burn some (limited research indicates that this does not affect water quality) or construct stream crossings in advance of burning.

3.7 During harvesting it is possible to implement measures that will significantly reduce the risk of sedimentation. These include the timing and method of scrub rolling, the type and method of snigging, the timing of regeneration burning as well as the proper use of erosion control measures such as cross drains or snig tracks.

3.8 Some drilling may be necessary in the intermediate rainfall zone to determine depth to water table.

[show overheads of redistribution of stream zones, according to stream order, for four forest blocks]

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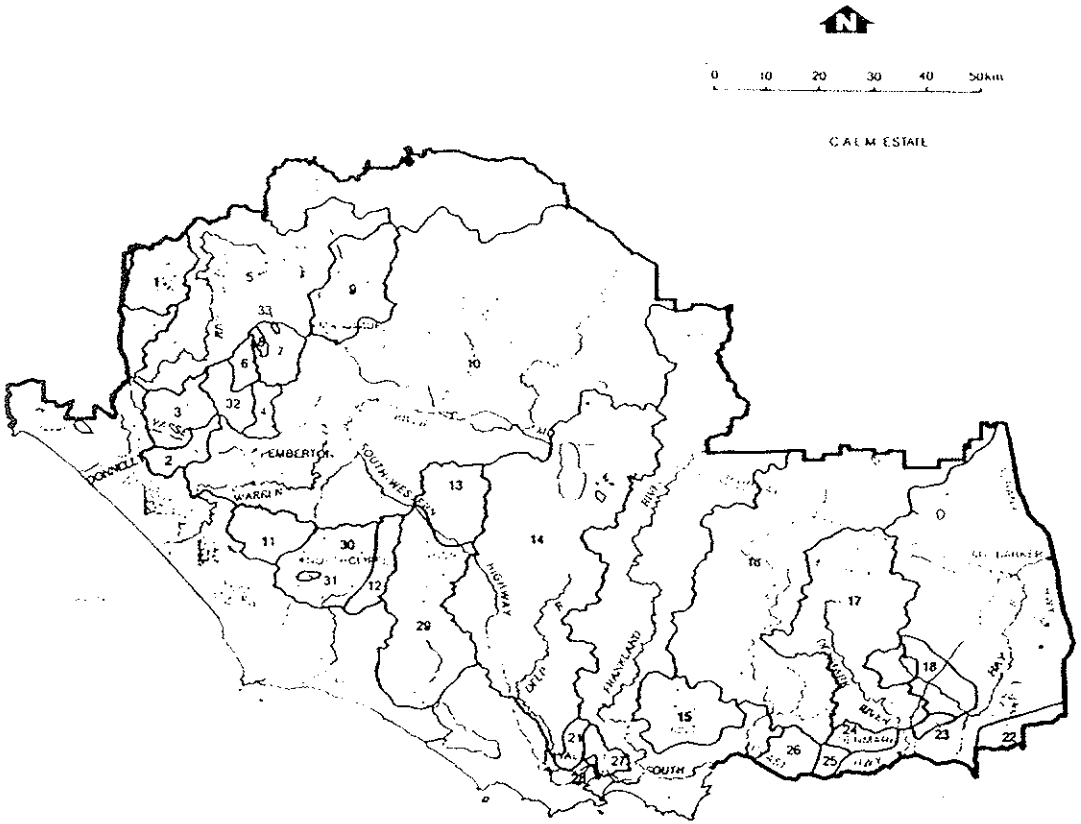
SOUTHERN FOREST REGION
CATCHMENTS AND DAMS



CATCHMENT CLASSIFICATIONS

Surface catchments and ground water management areas in the south west of the State have been classified as follows by the Water Authority for management purposes. Restrictions on recreation are indicated

Type 1a Public Water Supply Area

Type 1b Groundwater Area

Type 1c Water Reserve

Type 2a Active catchment area—domestic supply

(i) Small diversion dam. Access is only permitted, if at all, along open roads, marked walk trails, designated picnic areas, but not to the water area

(ii) Large dam. Pedestrian access within 2 km from the water area is only permitted along open roads, marked walk trails and at designated picnic areas. Pedestrian access beyond 2 km is unrestricted

Type 2b Active catchment area—irrigation. Access is permitted to all of the catchment, the water area, and to the dam wall.

Type 2c Active catchment area—domestic and irrigation. All are currently as for 2a (ii) large dams

Type 3 Water reserve. Potential water resource that has been gazetted

Type 4 Important potential surface water catchment area (not gazetted)

Other Not classified

No.	CATCHMENT	TYPE	No.	CATCHMENT	TYPE
1	UPPER BARLEE BROOK	3	17	DENMARK RIVER	2a(ii)
2	FLY BROOK	4	18	MITCHELL RIVER	4
3	CAREY BROOK	4	21	WALPOLE RIVER	2a(ii)
4	PEMBERTON	2a(ii)	22	SLEEMAN RIVER	4
5	DONNELLY RIVER	3	23	QUICKUP BROOK	4
6	FOUR MILE BROOK	2a	24	SCOTSDALE BROOK	2a(i)
7	LEFROY BROOK	2a	25	KORDABUP RIVER EAST	4
8	MANJIMUP	2a(i)	26	KORDABUP RIVER WEST	4
9	WILGARUP RIVER	3	27	COLLIER RIVER	4
10	WARREN RIVER	3	28	BUTLERS CREEK	2a(i)
11	DOMBAKER BROOK	4	29	LOWER SHANNON	4
12	GARDNER RIVER EAST	4	30	GARDNER RIVER WEST	4
13	UPPER SHANNON RIVER	4	31	NORTHCLIFFE W S	2a(i)
14	DEEP RIVER	3	32	BIG BROOK	2a
15	BOW RIVER	4	33	PHILLIPS CREEK	2a(i)
16	KENT RIVER	3			

1

From: CALM Regional Management Plan (1987)

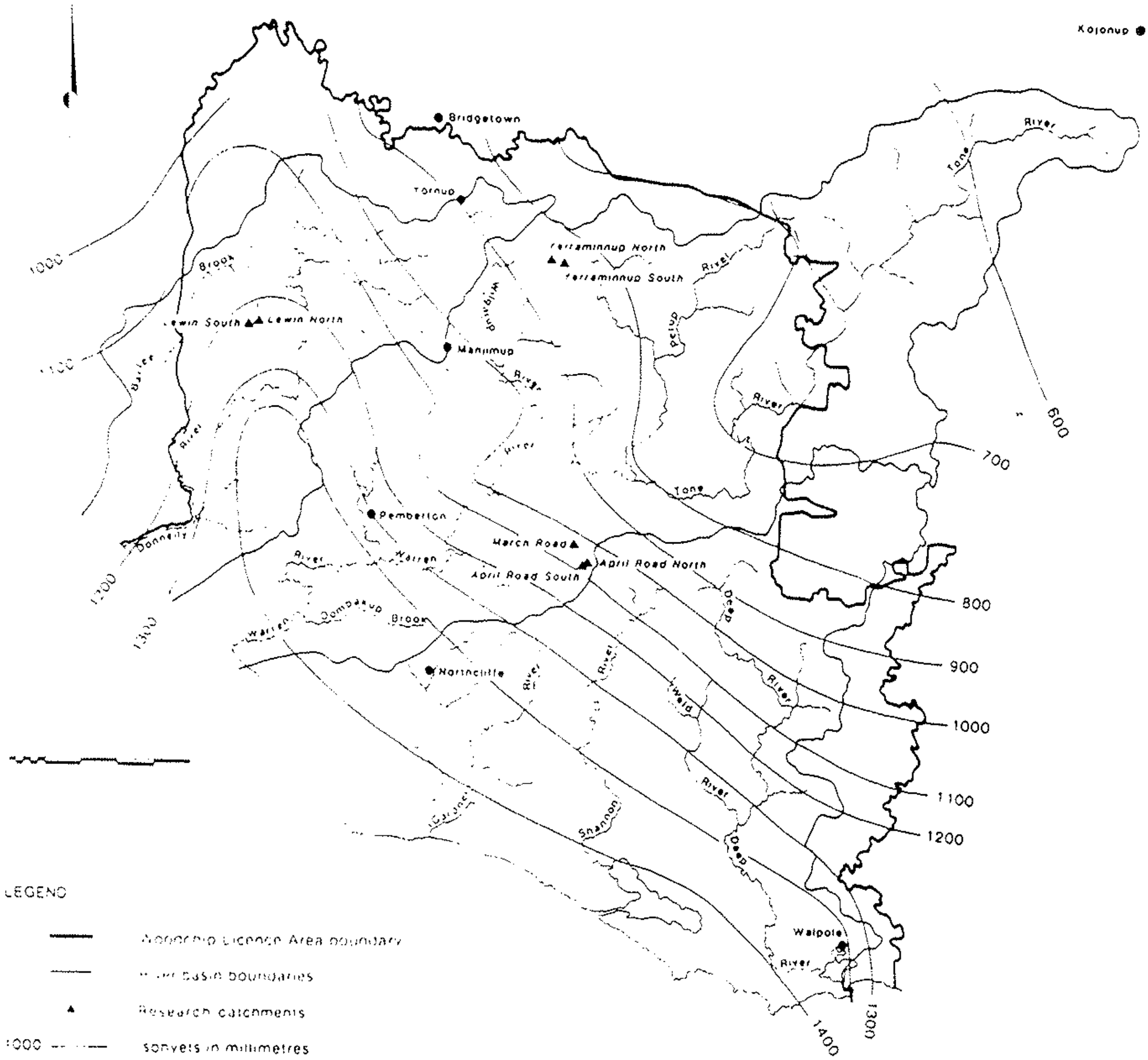
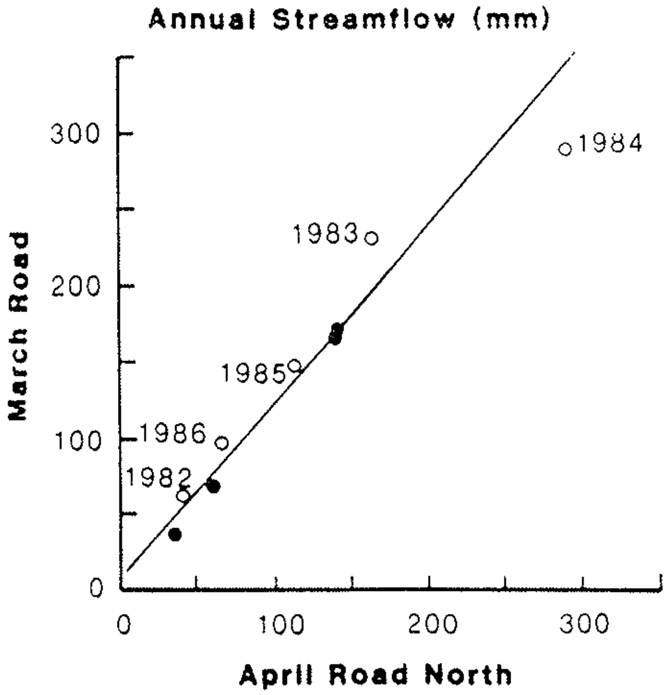


Figure 2

Mean annual rainfall in the research area. (Data from Loh and King 1978.)



y = 7.10 + 1.16x

6 data points

R^2 = 0.968

year	observed flow at March Road (mm)	predicted flow at March Road (mm)	absolute difference (mm)	relative difference (%)
1982	61	55	6	11
1983	231	199	32	16
1984	290	346	-56	-16
1985	149	140	9	6
1986	98	85	13	15
			mean = 0.4	

Figure 7

Annual streamflow at March Road (stream area logged) in relation to annual streamflow at April Road North (stream area not logged.) (The regression is based on the data from 1976 to 1981 inclusive.)

From Borg et al (1987)

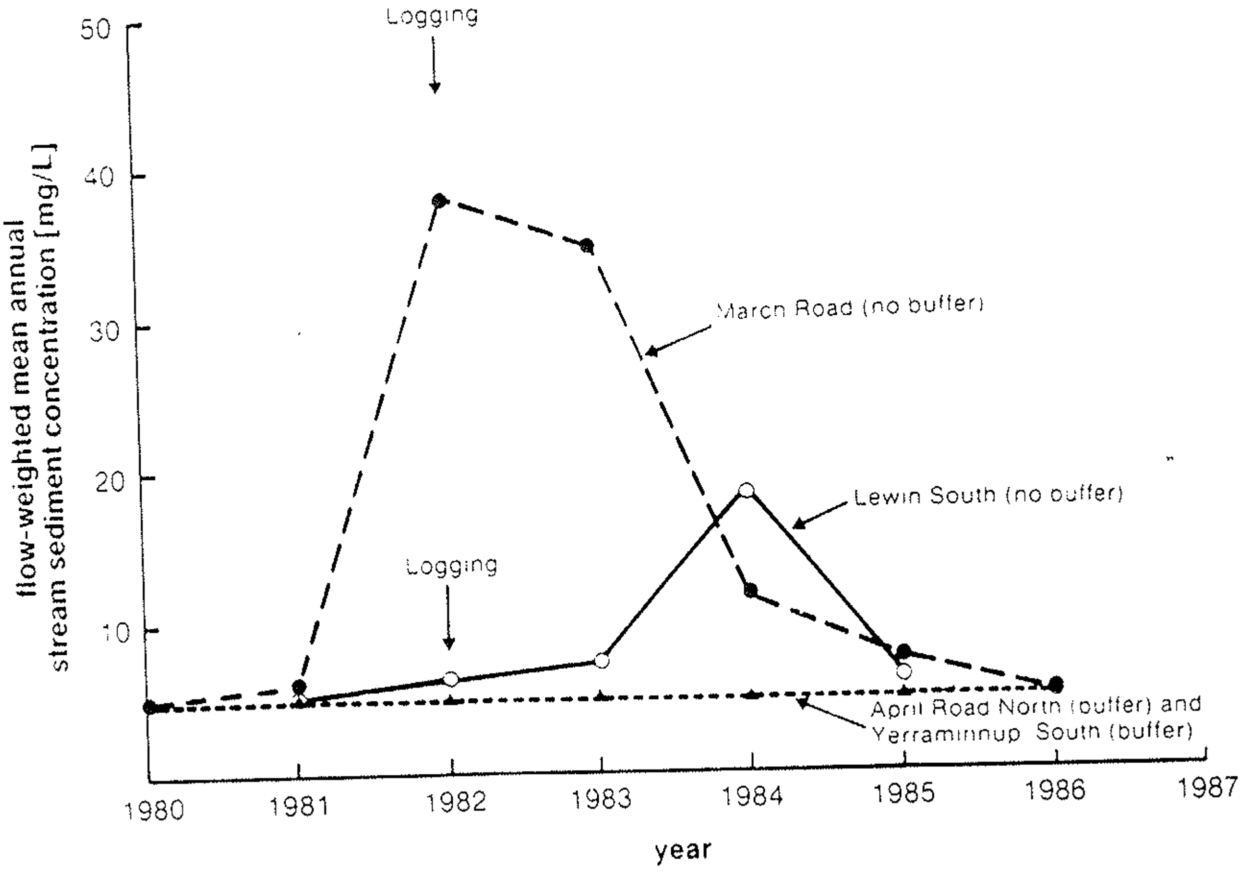


Figure 9
Changes in flow-weighted mean annual stream sediment concentration following logging

From Borg et al (1987)

Table 4
Annual flow-weighted salinities of streams draining experimental catchments before and after logging

Coupe/ Catchment	Mean Annual Rainfall (mm)	Year of Logging	**Mean TSS Before Logging (mg/L)**	**Maximum TSS After Logging (mg/L)**	**TSS in 1985 (mg/L)**
PROJECT 4					
Crowea	1380	1977	142	192 (1979)	153
Poole	1310	1977	102	196 (1979)	163
Iffley	1200	1977	352	432 (1979)	307
Mooralup	880	1977	no data	142 (1980)	no flow
PROJECT 2					
Lewin South	1220	1982	99	182 (1985)	182
March Road	1070	1982	153	314 (1985)	314
April Road North	1070	1982	101	140 (1985)	111
Yerraminnup South	850	1982	133	114 (1985)	114

Notes (1)

Values are the Toal Soluble Salts (TSS) concentration determined as the sum of major ions dissolved in the water sample. The annual flow weighted mean is effectively the concentration derived by the annual mass of solute discharged via the stream is divided by the annual volume of water discharged via the stream.

From Borg et al (1987)

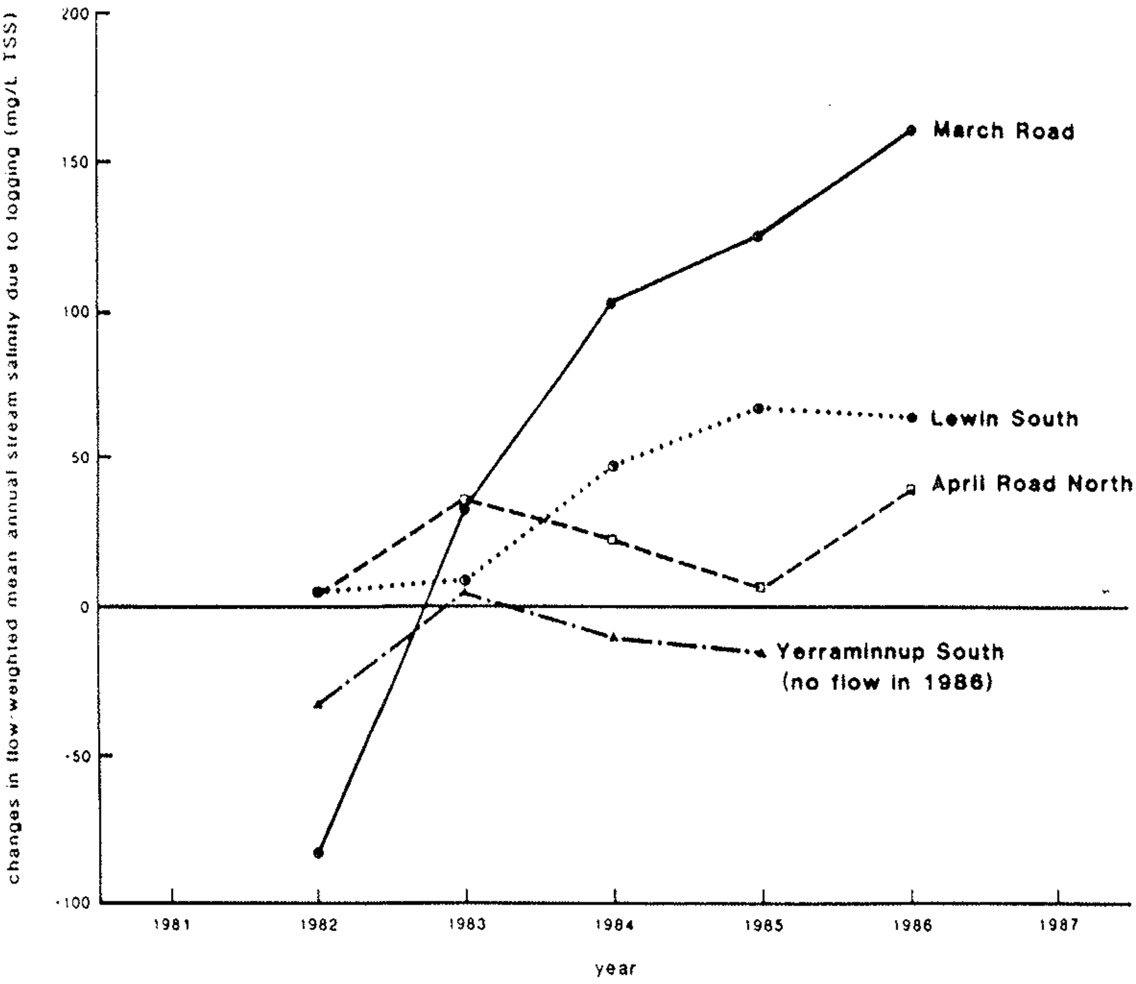


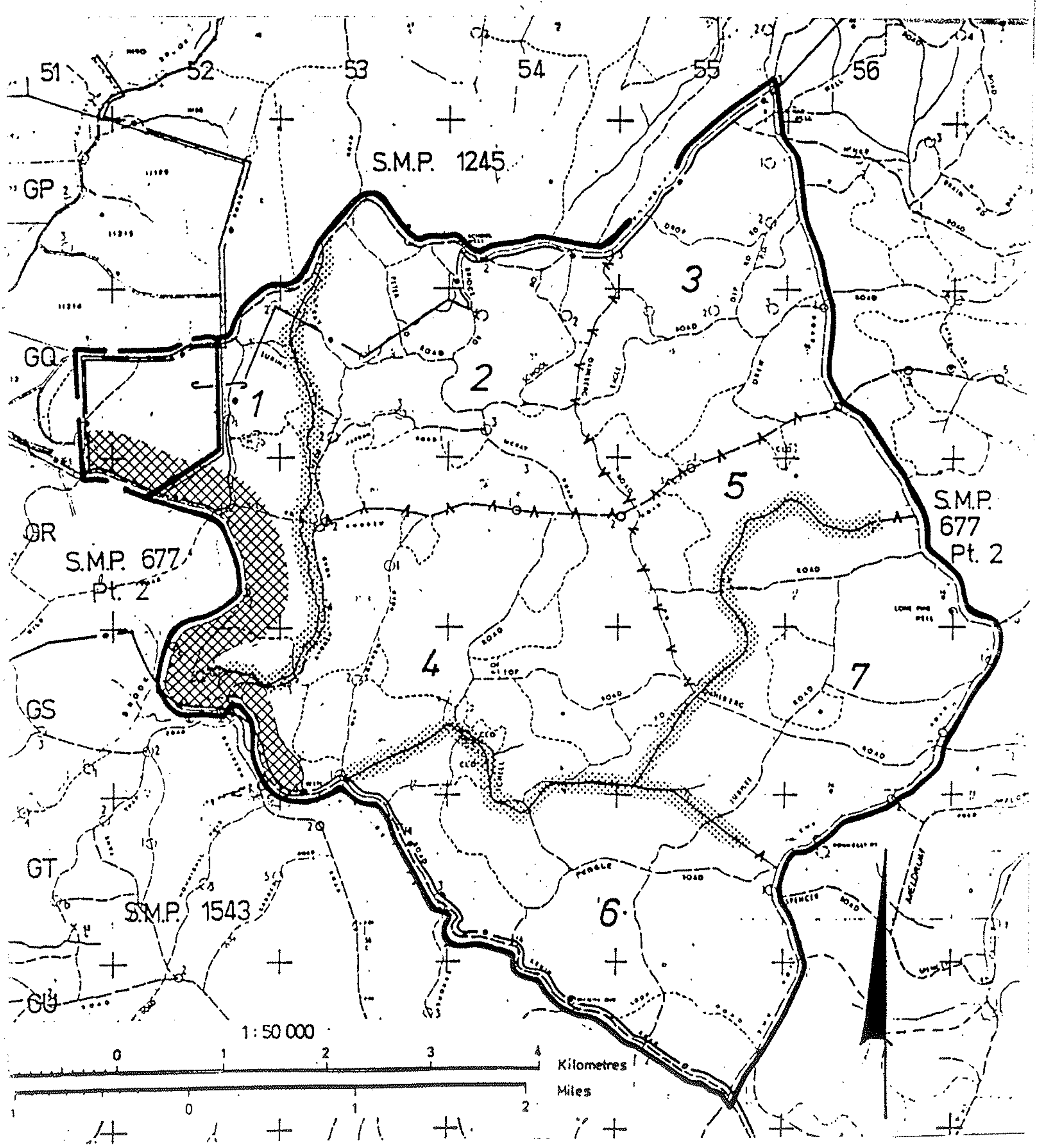
Figure 9

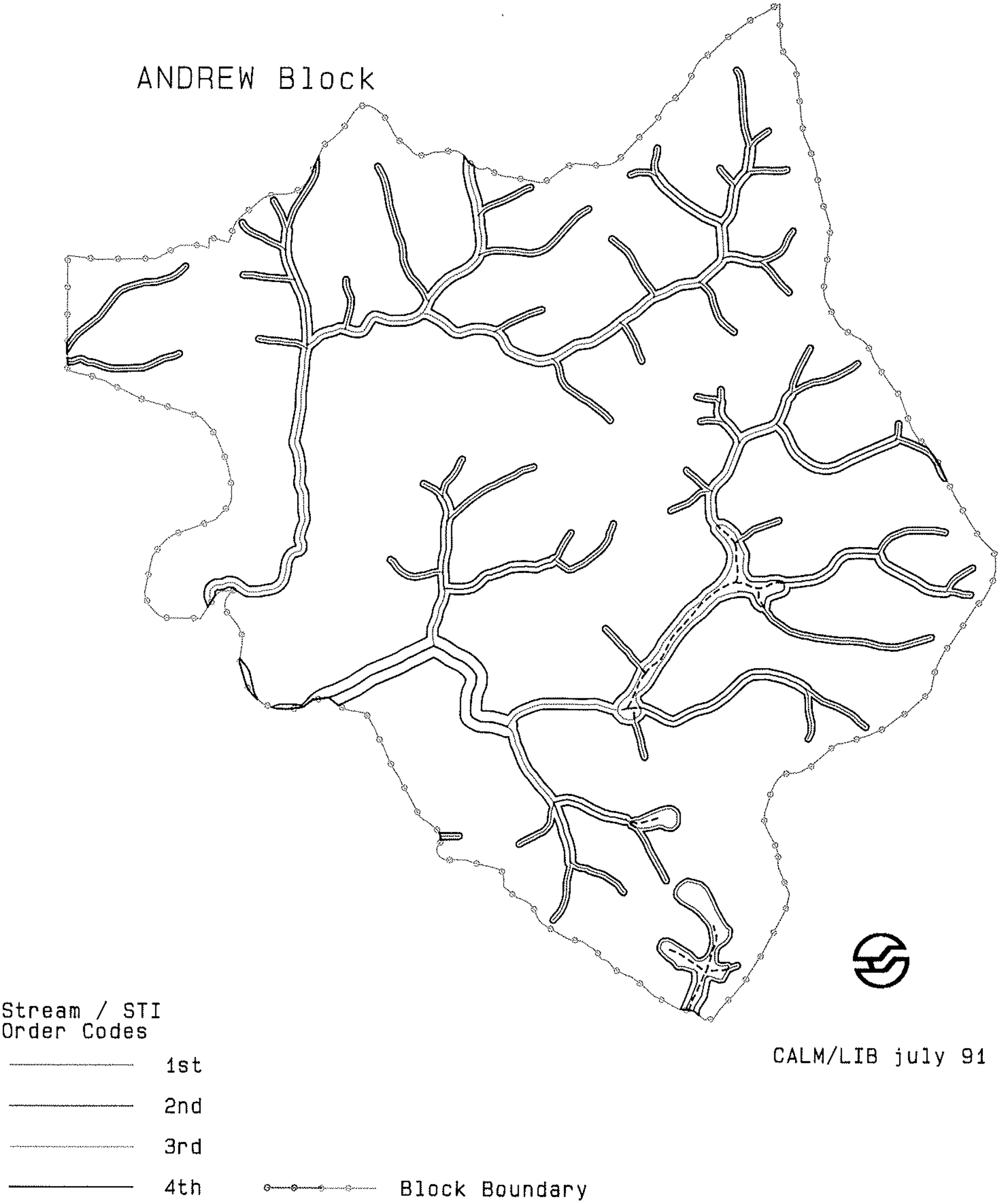
Changes in flow-weighted mean annual stream salinity in the four cut-over research catchments due to logging.

From: Borg, King and Loh (1987)

BLOCK	:	ANDREW
AREA UNDER F.D. CONTROL	:	4265 ha
AREA OF V.C.L., L.A. ∧	:	147 ha
TOTAL BLOCK	:	4412 ha

SHIRE BOUNDARIES
CATCHMENT BOUNDARIES
STREAM RESERVE
ROAD RESERVE
COUPE BOUNDARY





Possible Distribution of Riparian Zones for ANDREW Block

DIVISION : PEMBERTON

BLOCK : CHALLAR

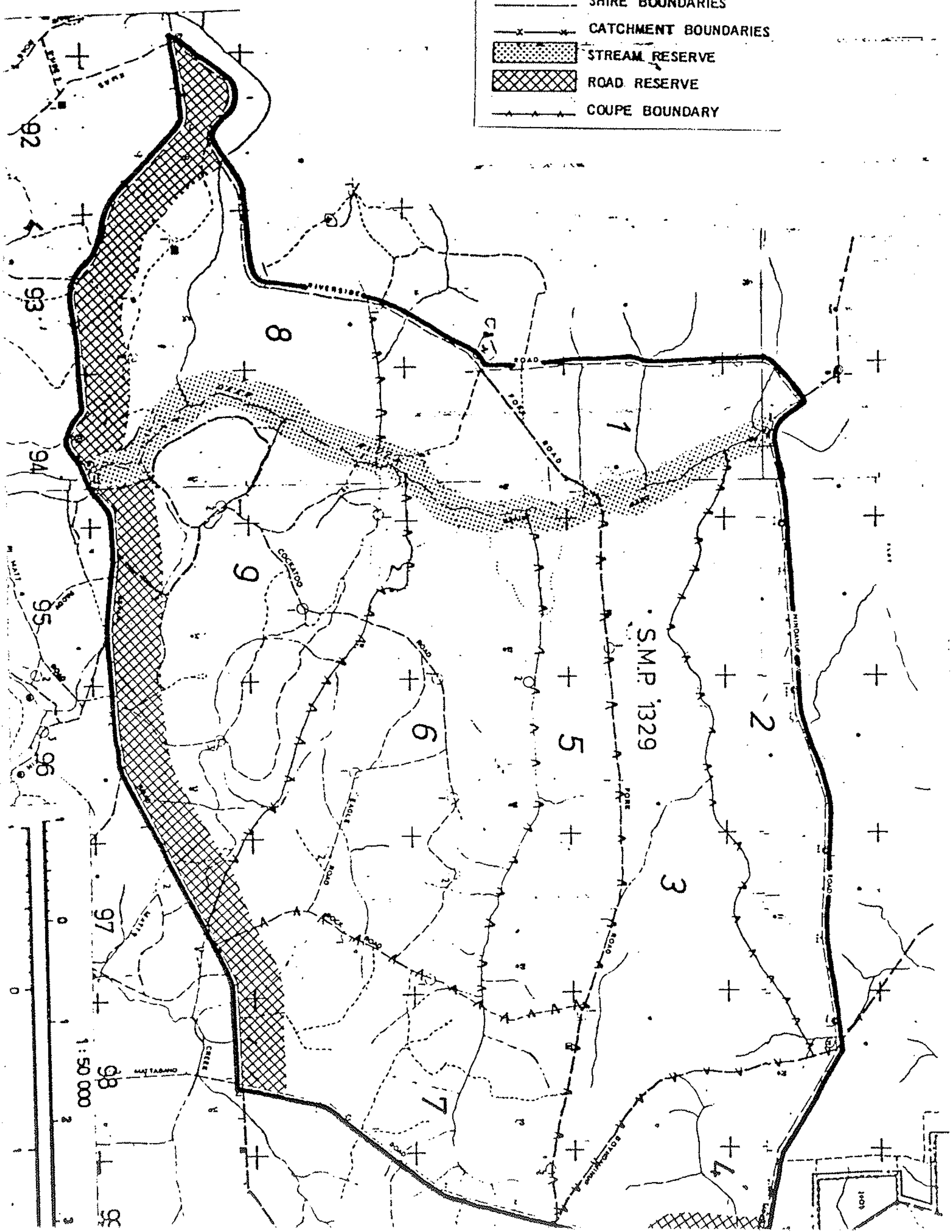
AREA UNDER F.D. CONTROL : 6048 ha

AREA OF V.C.L. :

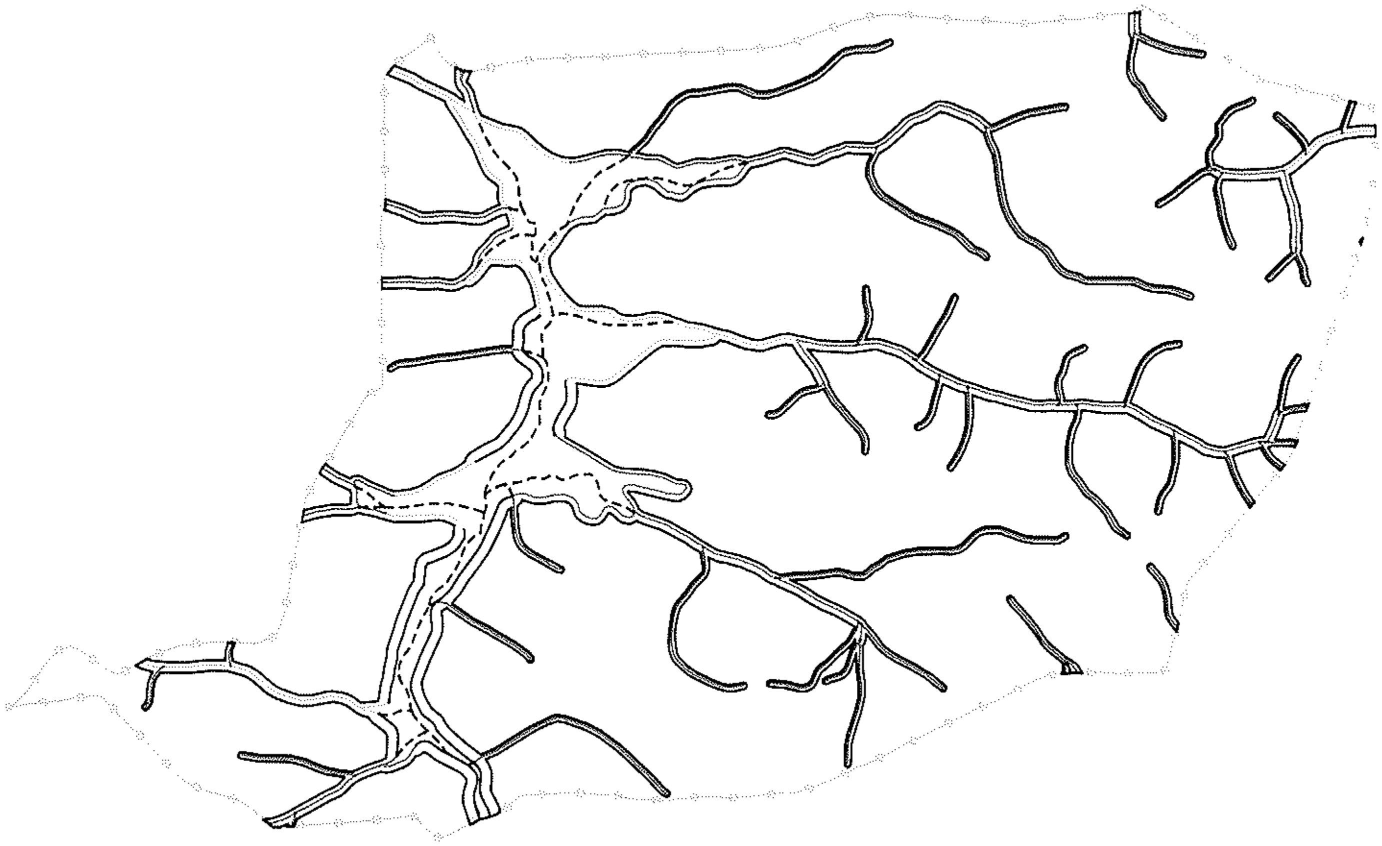
TOTAL BLOCK : 6048 ha

SHIRE MANJIMUP

CATCHMENT DEEP



CHALLAR Block



Stream / STI
Order Codes

1st

2nd

3rd

4th

Block Boundary

CALM/LIB july 91

Possible Distribution of Riparian Zones for CHALLAR Block

BLOCK : DIAMOND 1

AREA UNDER F.D. CONTROL : 1710 ha

AREA OF V.C.L. :

TOTAL BLOCK : 1710 ha

SHIRE

BASE PLAN 5

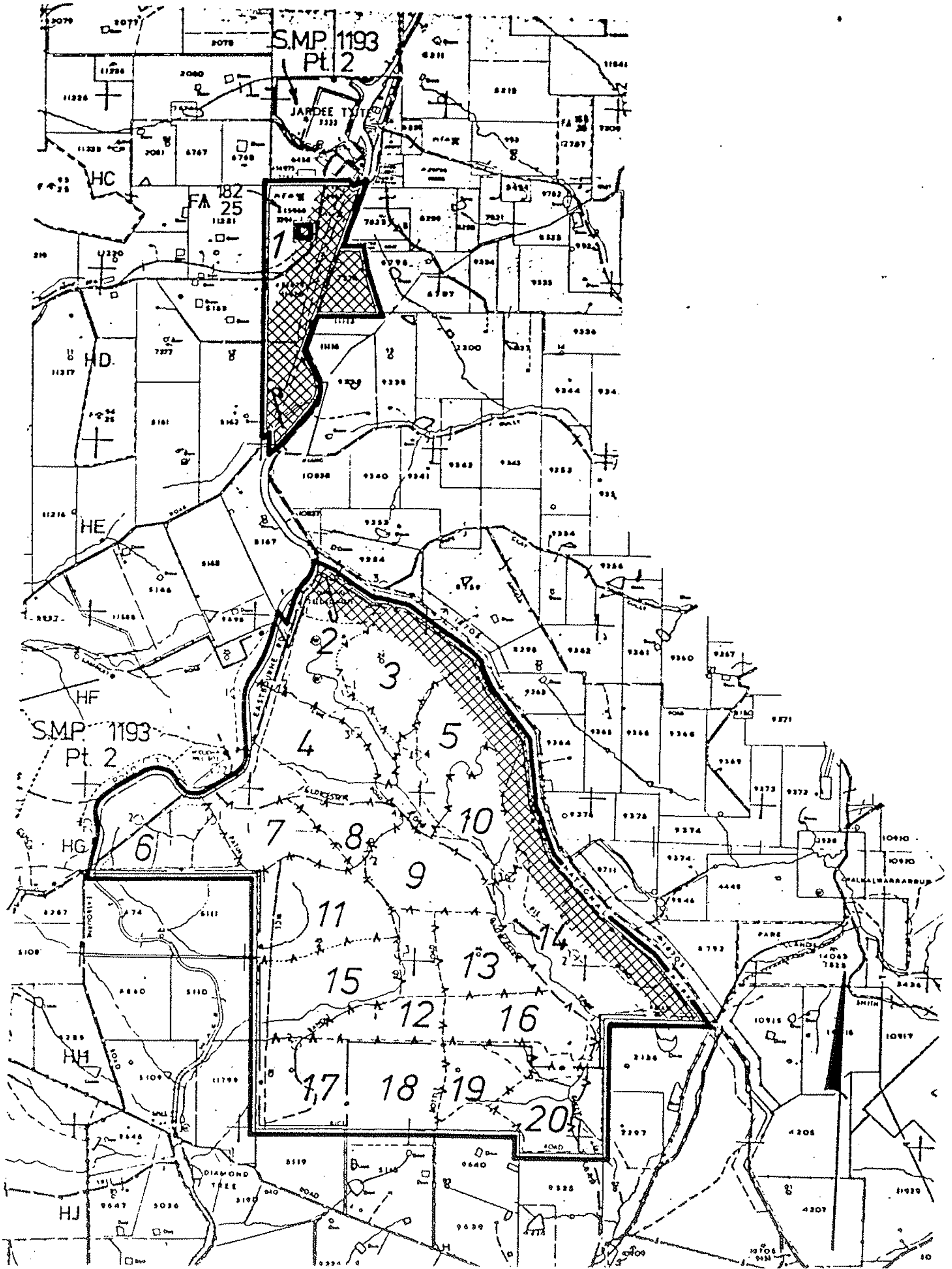
SHIRE BOUNDARIES

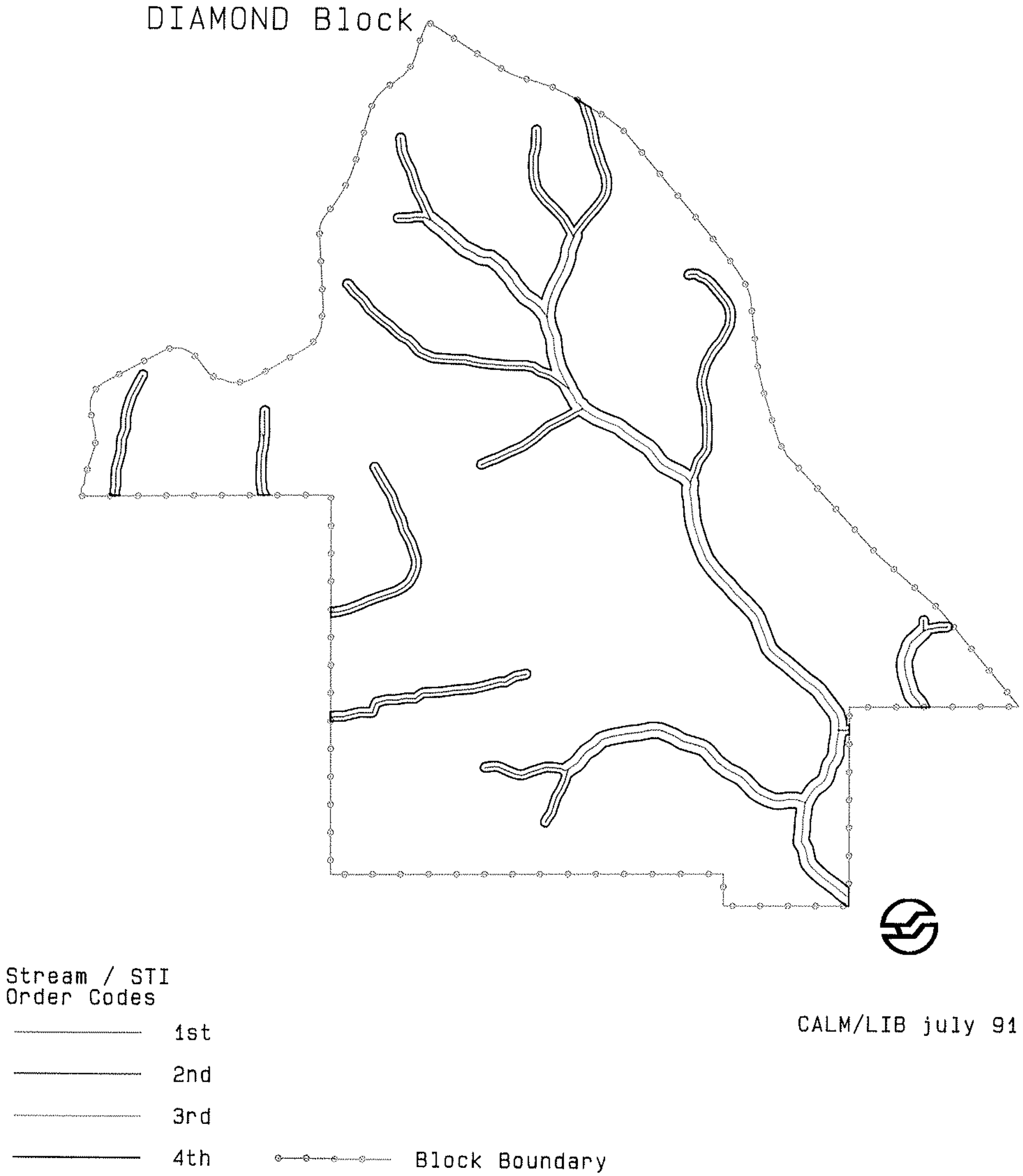
CATCHMENT BOUNDARIES

STREAM RESERVE

ROAD RESERVE

COUPE BOUNDARY



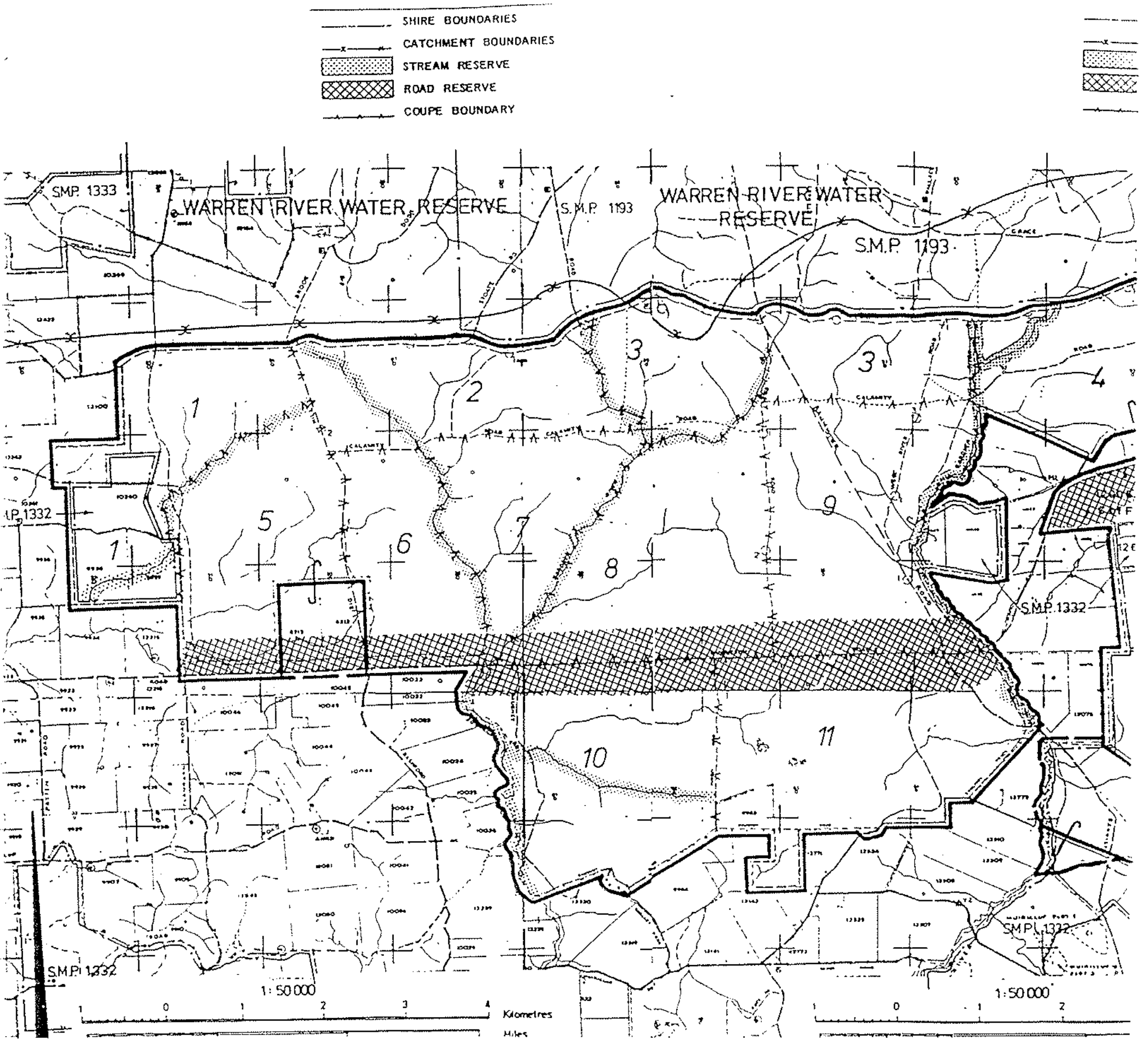


Possible Distribution of Riparian Zones for DIAMOND Block

: JANE (WEST)
UNDER F.D. CONTROL : 7082 ha
OF V.C.L. & L.A. A : 353 ha
. BLOCK : 7435 ha

CATCHMENTS SHANNON
WARREN

BLOCK
AREA UNDER F.D. CONTROL : 7082 ha
AREA OF V.C.L. & L.A. A : 353 ha
TOTAL BLOCK : 7435 ha



JANE Block

Stream / STI
Order Codes

1st

2nd

3rd

4th

Block Boundary

CALM/LIB july 91

Possible Distribution of Riparian Zones for JANE Block

PROCEEDINGS OF A SEMINAR

A REVIEW OF ROAD, RIVER AND STREAM ZONES IN SOUTH WEST FORESTS

Held at Manjimup

Tuesday, 9 July 1991

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