REFORESTATION OF CLEARED FARMLAND ON THE COLLIE RIVER CATCHMENT AS A POSSIBLE METHOD OF SALINITY CONTROL

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INTRODUCTION

Increasing salinity of rivers, developed as a result of past agricultural clearings, is a major long term water resource problem of the south-west of Western Australia (Public Works Department, 1979).

Under forested conditions the hydrological system in most catchments is in a near balanced condition with incoming and outgoing salts approximately equal. However, the removal of deep rooted forest cover has led to mobilisation of stored salts, rising groundwater tables and saline discharges (Peck, 1978).

The Collie River Catchment (Fig. 1), which embraces 1830 km^2 and is under the authority of the Public Works Department, is the most acute example of this regional salinity problem. Wellington Reservoir, on the Collie River, has an annual water yield of $102 \times 10^6 m^3$, which is used for crop irrigation and domestic supplies by thirty inland towns (Public Works Department, 1979). Until 1960 water supplied from Wellington Reservoir averaged 250 $mg \cdot l^{-1}$ Total Dissolved Solids (T.D.S.). At that stage only 9 per cent of the catchment had been cleared of forest. By 1976, when bans on clearing were introduced, 23 per cent of the catchment had been cleared. Over the last two years salinity levels have ranged from 840 to 900 $mg \cdot l^{-1}$ T.D.S. Even without further clearing, salinity levels are predicted to rise and reach 1100 $mg \cdot l^{-1}$ T.D.S. within 20 years (Public Works Department, 1979).

Reforestation of up to 40 per cent of the already cleared land has been recommended as the most suitable method for reversing the increasing salinity trend. In a ten-year reforestation programme planned for the Collie River Catchment the Public Works Department proposes planting up to 2000 ha per year on repurchased farmland. The programme is seen as an important study to provide practical experience for dealing with salinity in other catchments (Public Works Department, 1979).

Only limited data is available concerning the overall impact on salinity discharge which reforestation will make and how long it will be before any effects can be observed. Greenwood and Beresford (1979) have recently provided some useful information on transpiration of several *Eucalyptus* species in their juvenile stages. The large differences in groundwater tables beneath native forest and adjoining cleared pasture land, as revealed by the extensive transects of groundwater bores established on the repurchased farm, give some indication of the possible long term effects of reforestation (Figs. 2, 3 and 4).

In 1976, at the request of the Public Works Department, the W.A. Forests Department commenced reforestation trials on a repurchased farm on the Collie River Catchment, just east of the 800 mm annual rainfall isohyet (Fig. 5). The objectives of the planting trials were:

1) To identify and solve problems involved in establishing and maintaining tree growth on the various sites, including saline affected areas.
2) To develop socially acceptable techniques for reforestation and future management.
3) To provide base data for the assessment of the effectiveness of replanted trees in reducing groundwater tables and salt discharge.

METHOD

The trials were located in a 140 ha cleared section of the valley of the Bingham River which is a tributary of the Collie River. Clearing in the main valley was carried out in 1964 and 1965 and was extended upslope between 1968 and 1970. Two salt patches developed along the river valley about 1974 and appeared to be extending upslope.

Planting Pattern

To test whether partial reforestation was compatible with continued farming practice, reforestation was designed in a series of 40 m wide strips of trees using a 4 x 2 m spacing occupying about 20 per cent of the cleared study area (see Fig. 2) (Public Works Department, 1977). These strips were surrounded by fencing to exclude grazing animals.

The planting pattern (see Fig. 2) was based on the following considerations (Public Works Department, 1977).

1) In an endeavour to lower the water tables, thus minimising capillary rise of salts during summer and saline discharges during winter, the strips of trees were planted to encircle the salt patches.
2) Strips were then planted upslope at intervals of about 200 m on the assumption that 40 m wide strips, 200 m apart, would act as groundwater pumps and cause local groundwater reduction.
3) A strip was placed parallel to the Collie-Williams road to minimise effects of any groundwater moving from the 28 ha cleared area south of the road.

Species Selection

Fifteen species of trees (twelve eucalypts and 3 conifers) were tested to determine those most suitable for reforestation of the sites under consideration.

Establishment Techniques

Cultivation

Planting areas were cultivated with a multi-tyne chisel plough to a depth of about 25 cm. Planting rows in low lying areas were mounded with a mound plough to a height of 25 cm above the natural surface.

Weed control

The seed bearing heads of annual grasses were burnt with a running fire in late spring to reduce the number of viable grass seeds (Pearce and Holmes, 1976). Planting lines were sprayed with the weedicide Vorox A.A. just before planting the trees when grass was about 2 cm high. Vorox at the rate of 5 $kg \cdot ha^{-1}$ was used, which represents 1.6 kg of the active ingredients amitrol and atrazine.

Planting

Seven-month-old seedlings raised in 6 x 6 x 6 cm peat pots were planted using a 4 x 2 m spacing to give an initial stocking rate of 1250 plants per hectare. Fertiliser at the rate of 100 g per plant of Agras 12:52 (12 per cent nitrogen, 52 per cent phosphate) was applied shortly after planting.

Alternative Establishment Trials

Leader trials were established to test alternative techniques likely to lead to simpler and less expensive establishment. This is important in view of the large areas being considered for reforestation. Items examined were as follows.

Type of planting stock

Seedlings raised in large 6 x 6 x 6 cm peat pots have proven very reliable over many years of planting. However, considerable savings in the nursery, plant transport and the actual planting operation would be possible if smaller containers were proven reliable. Trial plantings were made using small peat pots (3 x 3 x 4 cm) and paper pots (4 x 4 x 5 cm). Open rooted eucalypts were also tested as they can be raised relatively cheaply.

Fertiliser application

Six levels of fertiliser application, including fertiliser tablets, were tested. Application rates per seedling ranged from 10 g to 200 g of N:P fertiliser.

Direct seeding

Naturally regenerated *Eucalyptus rudis* Endl. beneath shade trees on cleared farmland, particularly where grazing had been excluded, offered a viable suggestion for cheap and easy reforestation and led to direct seeding trials in 1978, when 3 plots measuring 0.75 ha each and covering the full range of topography from dry upper slopes to moist valley floors, were broadcast sown using the method described by Bartle *et al.* (1978). A seed mixture containing equal quantities of seeds of four eucalypts was used, namely *Eucalyptus wandoo,* Blakely., *E. rudis, E. camaldulensis,* Denh. and *E. calophylla* R.Br. Six weeks before sowing, the plots were sprayed with Vorox A.A. using the standard application for grass control.

RESULTS

Tree establishment in areas affected by salt scald or severe waterlogging has proven difficult. Although waterlogged sites can be ameliorated by mounding, the practice is costly. Experience has shown that by the time annual grasses have germinated, the sites are often so wet that tractors are unable to traverse the ground to apply weedicide. Currently these sites are not planted. When upslope plantings reduce the waterlogged condition, it is anticipated that planting will proceed with more chance of success. Survival rates on upslope sites have been greater than 90 per cent using stock from large peat pots. Therefore, initial planting densities on potentially favourable upslope sites have been reduced to 625 per ha.

Planting Pattern

The strip planting pattern initially established posed some problems which cast doubt on their value. It is doubtful that strips of trees 40 m wide are wide enough to cause the desirable rapid lowering of the water table. Furthermore, the high cost of fencing and gates, together with additional management problems, such as the difficulties of protection from fire and grazing animals (despite fencing some animals got in and caused damage), strips have been considered impractical and future plantings are designed in large, compact blocks (Fig. 6). A typical block planting pattern is shown for a recently purchased property (Fig. 6). The strategy is to plant in block formation, all probable intake and valley seepage sites (Fig. 7).

Species Selection

Based on the performance of the 15 species tested since reforestation commenced in 1976, six core species were selected for the programme. Table 1 summarises the selection of species in relation to topography.

TABLE 1
Planting location of core tree species

Species		Common name	Location
Eucalyptus rudis, Endl.	-	Flooded gum	Lower slopes
E. camaldulensis, Denh.	-	River red gum	Lower slopes
E. wandoo, Blakely	-	Wandoo	Mid slopes
E. calophylla, R.Br.	-	Marri	Mid slopes
E. globulus, Labill.	-	Blue gum	Upper slopes
E. accedens, W.V. Fitzg.	-	Powder bark	Upper slopes

In selecting these species the objective was to obtain a mixture of rapid growers and slower native species which could prove more reliable in the longer term. This will provide some tree cover rapidly but will guard against possible failure of some species. As more information becomes available on transpiration performance of individual species the list will be reviewed. Transpirational ability alone is unlikely to be the criterion for species selection; factors such as long term survival and fire tolerance are also important.

Establishment Techniques

Cultivation

Penetration by the tynes of a chisel plough was unreliable on compacted sites. Therefore, its use has been substituted by a single tyne subsoil ripper to rip planting lines: penetration is very even and averages 40 cm.

Weed control

Burning the grass in late spring reduced the viable seeds by only 30 per cent, thus making the use of weedicide necessary to obtain sufficient control. The cost of burning to obtain an unsatisfactory result makes it an impractical means of weed control, so that weedicide will be used as the sole weed control method in future.

Alternative Establishment Trials

Types of planting stock

Stock raised in large (6 x 6 x 6 cm) peat pots established successfully and stock raised in small peat pots is promising though it is too early to be sure at this stage.

Survival of open rooted eucalypts and seedlings raised in small paper pots was very low. Further trials with two-year-old open rooted eucalypts will be tested.

Direct seeding

Results are promising. Successful establishment at age 18 months is set out in Table 2. The seedling distribution has been arbitrarily subdivided into three topographic positions. Growth rates compare favourably with similar age seedlings in peat pots.

TABLE 2
Seedlings per ha at 18 months

Seeding rate $kg \cdot ha^{-1}$	Upper slopes	Mid slopes	Lower slopes
1.0	215	1390	545
1.5	225	1350	675
2.0	425	2850	1205

However, obtaining the required seed quantity would be a major problem if broadcast seeding was to be used on a large scale. Even if 0.5 $kg \cdot ha^{-1}$ proved to be a satisfactory seeding rate, one tonne of seed would be required each year for a 2000 ha per year programme. More efficient use of seed by way of pelleting and spot sowing may be appropriate and we propose to test these techniques.

Reduction of Water Tables

Groundwater levels in the study area are measured by the Public Works Department at approximately monthly intervals. No reductions have occurred in water tables as a result of the 1976 plantings.

CONCLUSIONS

Results from three years of reforestation trials in eastern parts of the Collie River Catchment have yielded some useful information on establishment methods. More work is required to improve techniques and also understand what is needed to maintain the new forest cover.

In 1979 an 80 ha arboretum containing 54 species and 24 provenances was established to provide useful long term information on likely species.

The scale of the reforestation programme and possible extension to other catchments could result in a new forest resource being created.

Although the primary reason for reforestation is to make maximum use of the water resource, use for other forest values is likely to follow.

ACKNOWLEDGEMENTS

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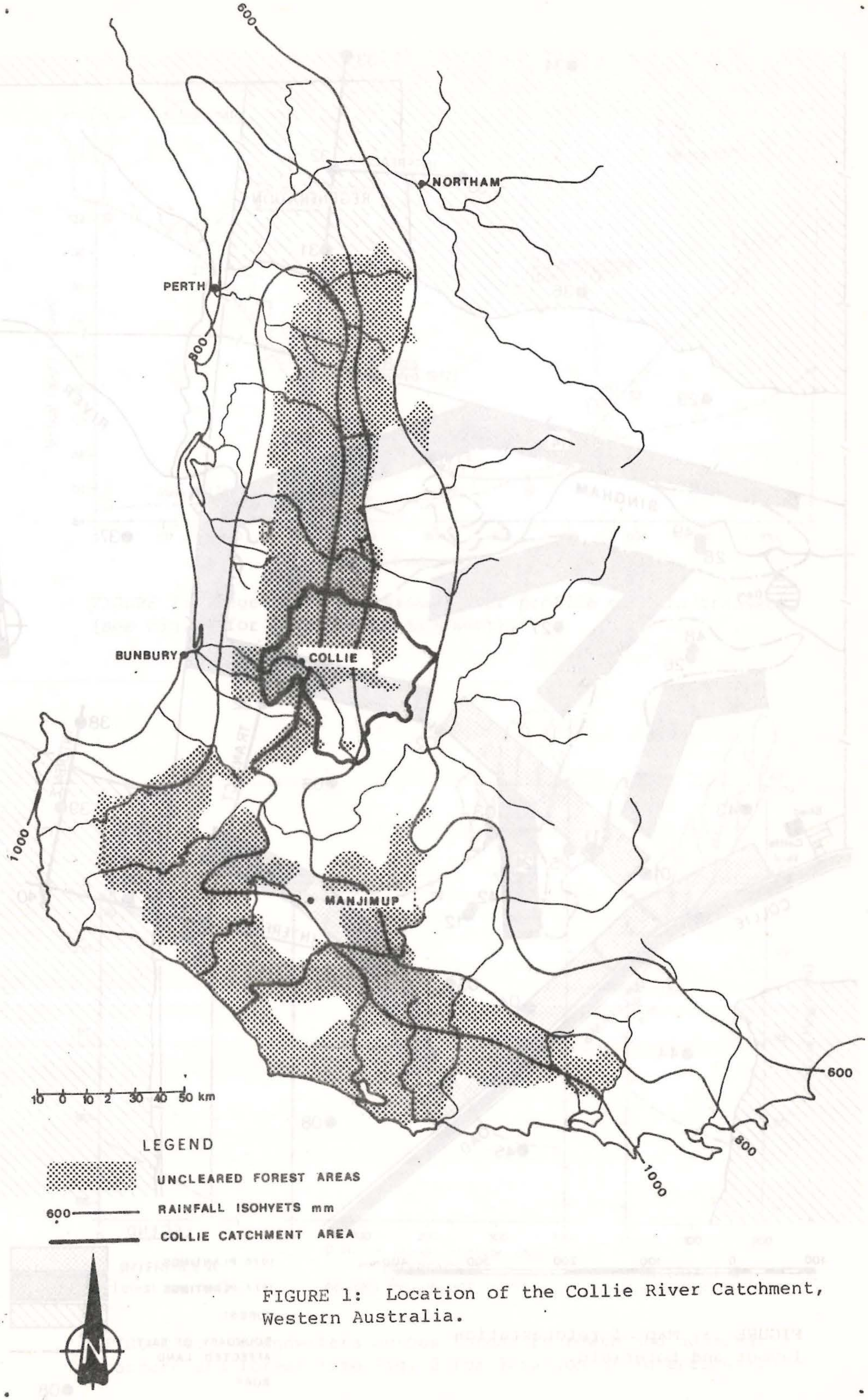

FIGURE 1: Location of the Collie River Catchment, Western Australia.

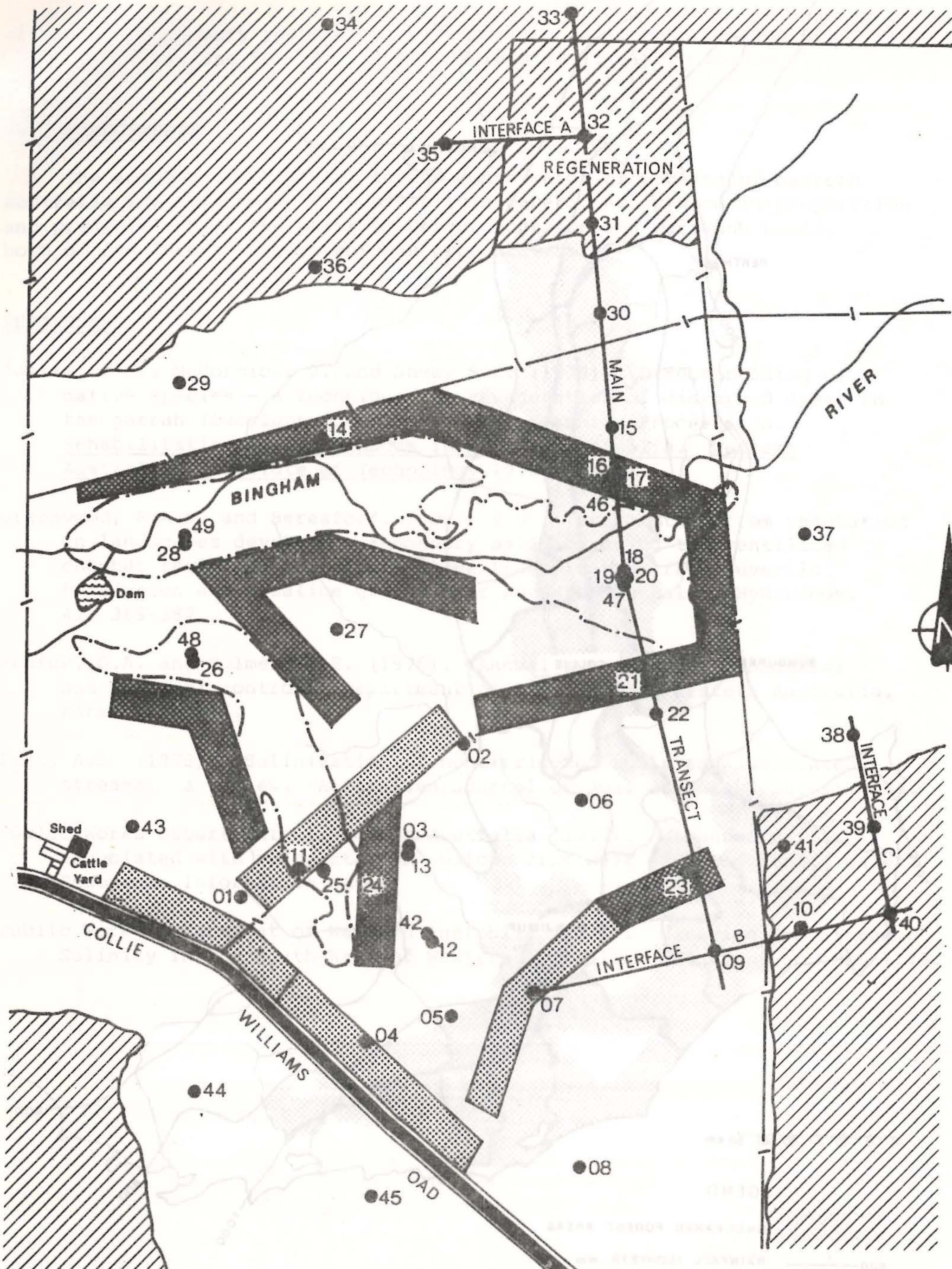

FIGURE 2: Map of reforestation layout and borefield.

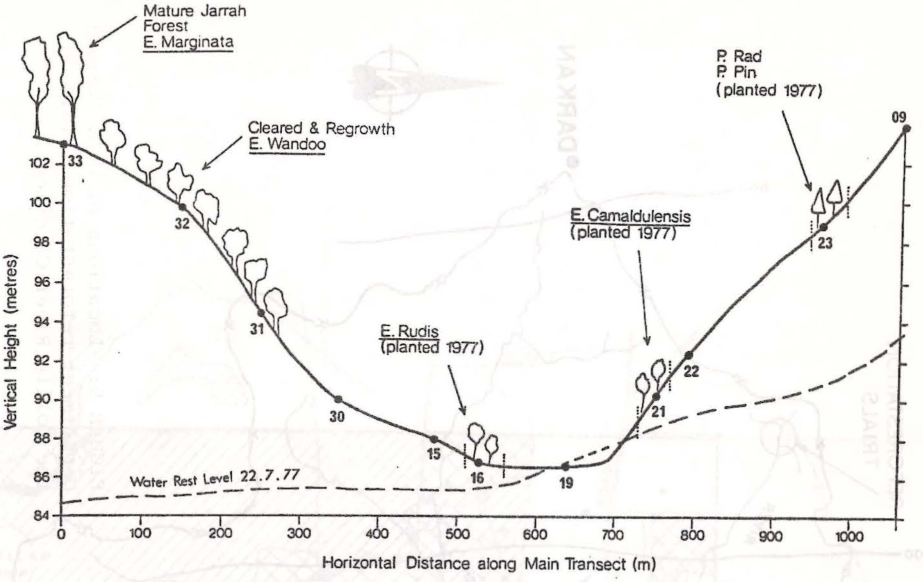

FIGURE 3: Vegetation and groundwater profile of main transect (see Fig. 2 for location of transect).

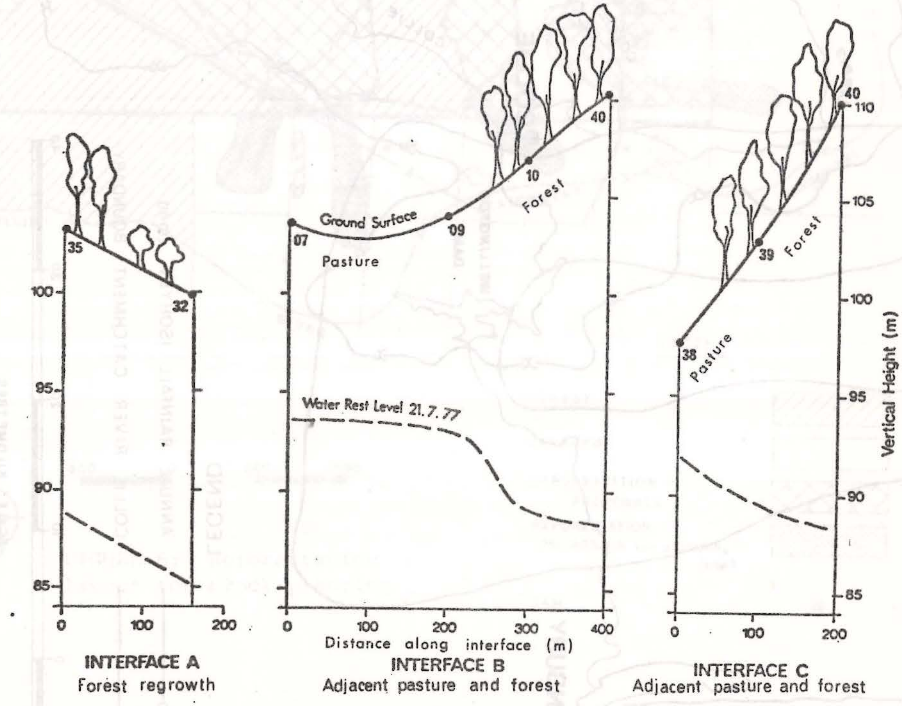

FIGURE 4: Groundwaters across forest regrowth and adjacent pasture and forest (see Fig. 2 for location of interfaces).

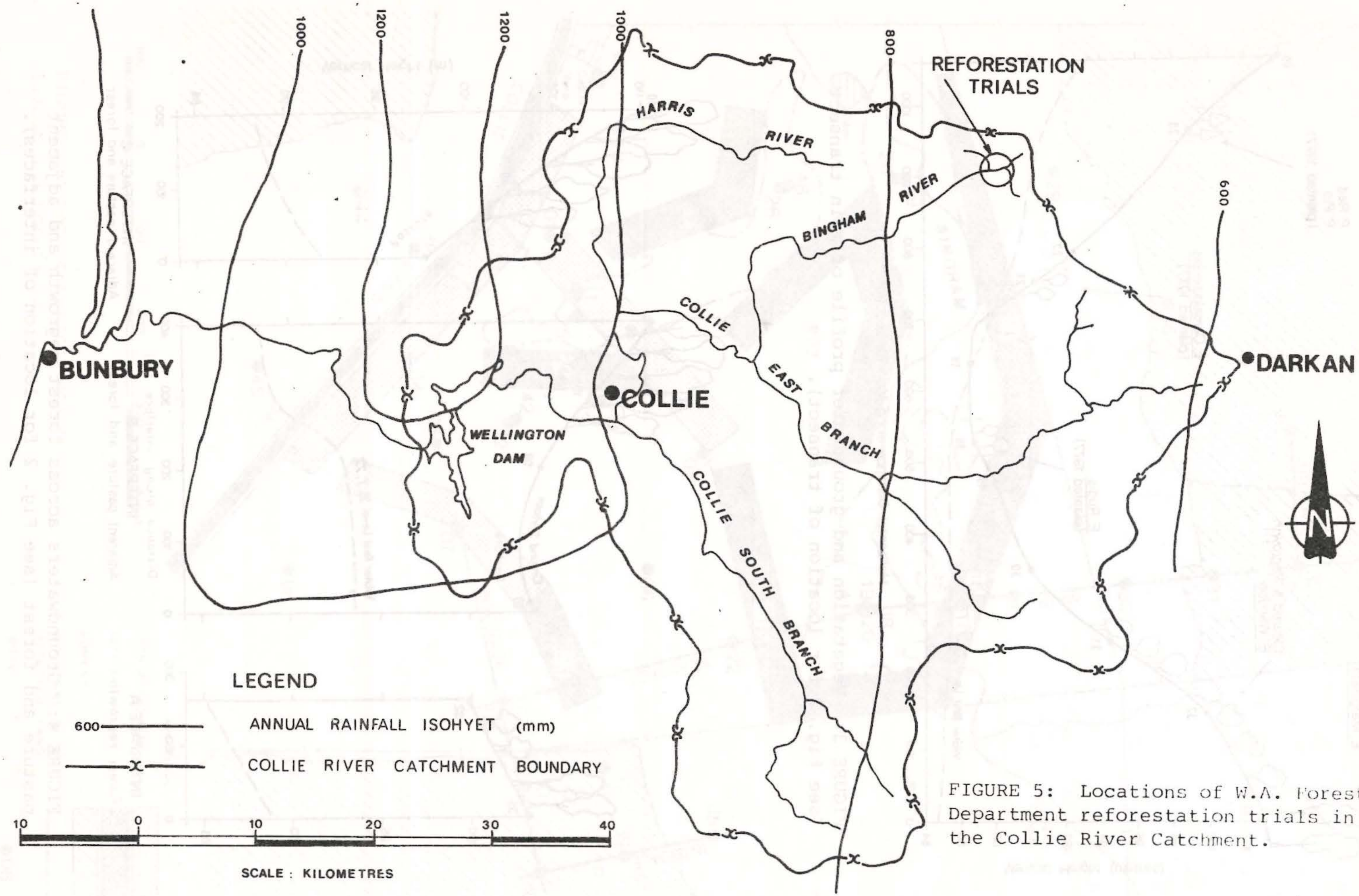

FIGURE 5: Locations of W.A. Forests Department reforestation trials in the Collie River Catchment.

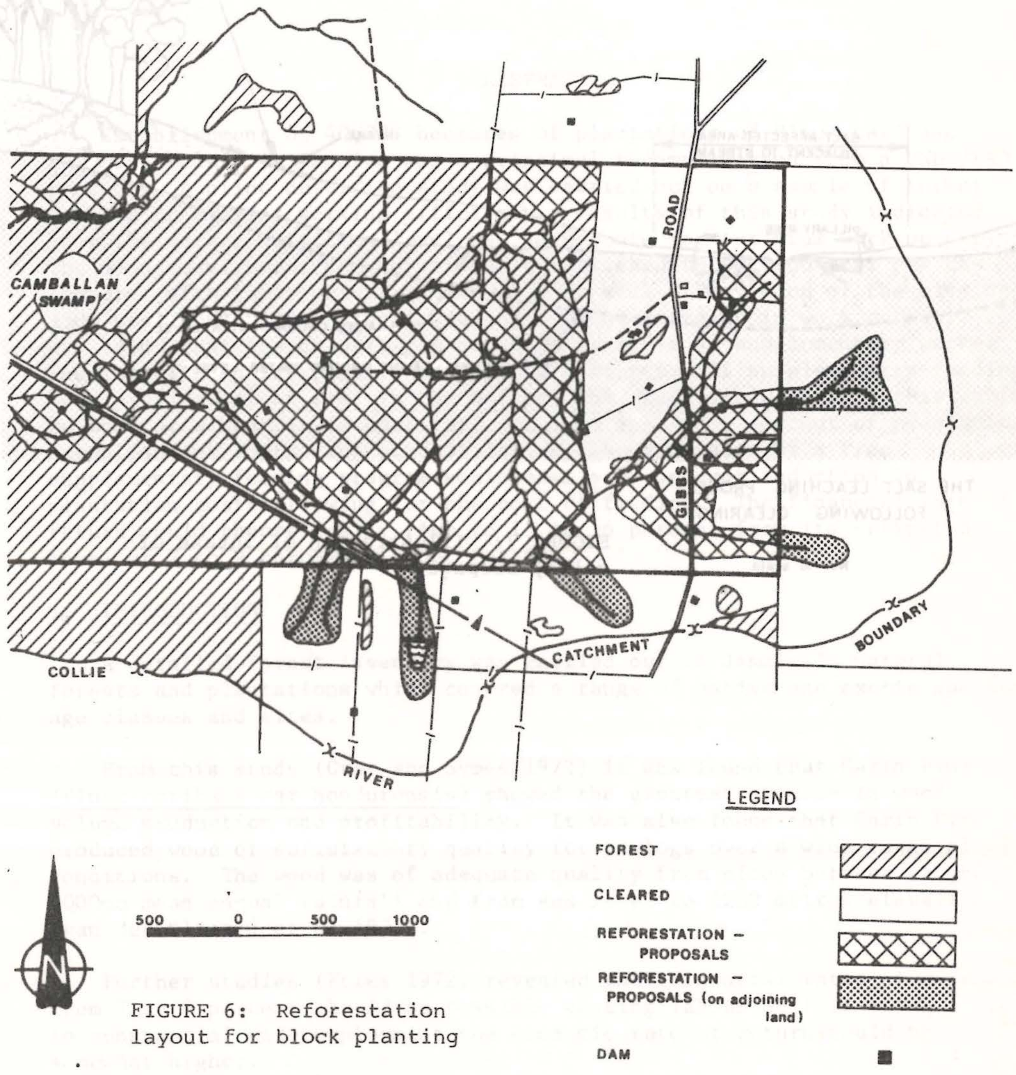

FIGURE 6: Reforestation layout for block planting

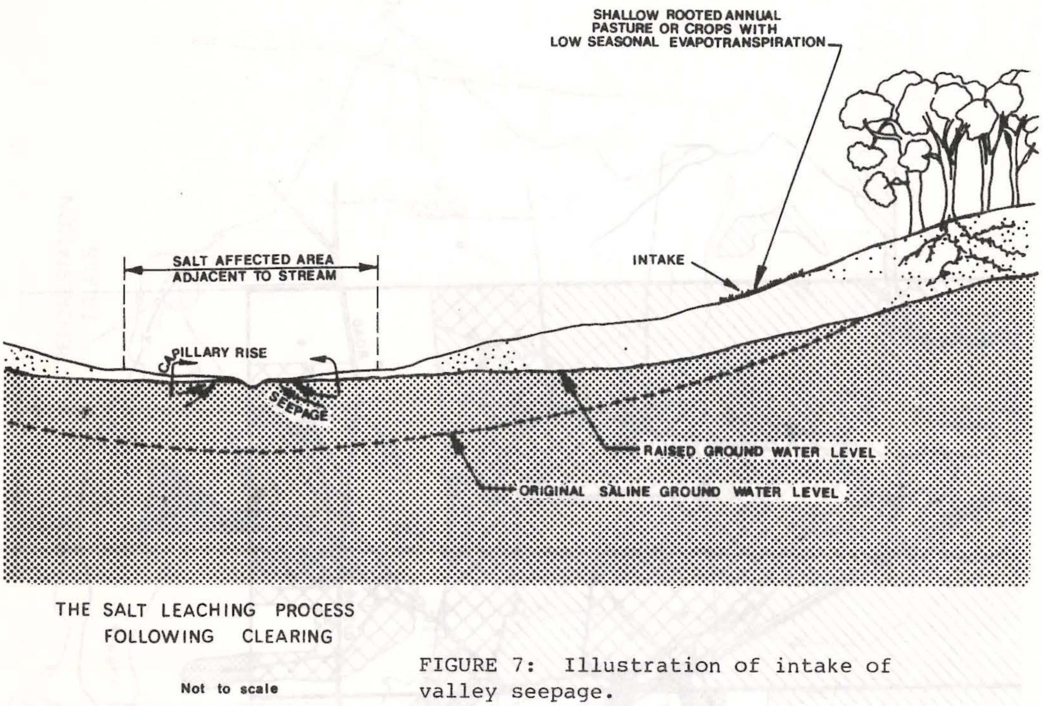

FIGURE 7: Illustration of intake of valley seepage.