# COOLILUP LAKES MULTIPLE USE PROJECT

Resource description
and
proposed land uses
for
Section A of the Ludlow plantation
including
land mined, re-filled and re-vegetated.

July, 1983

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# COOLILUP LAKES MULTIPLE USE PROJECT

## Part I - Description of the resource.

1. Background

The land which is the subject of this report carries Section A of the Ludlow pine plantation, established between 1910 and 1965.

A titanium mining company, Associated Minerals Consolidated, holds ten mineral claims over 460 hectares of the land, and a mining lease which will remain current until April, 1989. Since about 1973 mining has been proceeding after clearing of pine plantation, and that operation moved off State Forest in October, 1981. Rehabilitation measures were expected to continue over the ensuing three or four years. However the company may continue to use the area of the mining lease for any purpose connected with its operations until the expiry date.

The area of plantation cleared was about 300 hectares and the area disturbed by mining was 270 hectares. Company practice has been to replace soil from mining either back into excavations or on to unmined land to one side. It has also seen it expedient to retain an inter-connected series of excavations as lakes, for the purpose of maintaining a supply of clarified water for the primary concentration plant. Spoil surfaces have been re-contoured and stabilized by agricultural methods and to the planning of this the Forests Department has had some input. Trees have also been planted, since 1980 to Forests Department specifications.

Planning requirements laid down by the local Research and Planning officer late in 1976 were in the following terms:-

"1. Allocation of part of the area for a new rifle range, to replace the existing range in the tuart forest.

2. Possible public recreation facilities e.g. around any lakes which might be left after mining, or perhaps a golf course, etc.

3. Possible replanting of commercial pine forest, after a suitable period of rebuilding soil fertility with lupins.

4. Developed pasture land which might be used for future land exchange purposes."

The facts that the area disturbed by mining approximates half that of the forest unit, and that the remainder also exhibits a diversity of condition and potential, made it sensible to treat both as an integrated unit for planning purposes. A proposal for location of the rifle range on un-mined land was accepted in July 1977, but long-range planning for the mined area has been delayed by uncertainty as to the final characteristics of the land and water resource which the Forests Department would inherit. Abandonment of proposals first presented in January 1979 has occurred because of limitations which became evident as

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mining progressed. However the delay has had the benefit of allowing refinement of ideas and incorporation of information coming to hand from earlier rehabilitation work.

Refilling and reshaping of the mined land has now produced what will be essentially the final condition on which land use decisions will be based. Description of that condition is therefore timely.

2. The Land

The land is identified as State Forest No. 12 and is delineated on Lands Department Plan No. 413 B/40. Its northern extremity adjoins the Bussell Highway at a point 3.5 km from Capel. Its southwestern extremity is 1 km from the Ludlow district headquarters and is just under that distance from the highway. It is accessible from the Highway via the Ludlow-Ruabon road and a portion of the old highway alignment. The east boundary is a gravelled public road, and the north-west is bounded by the Boyanup-Busselton railway. The total area after a pending land exchange will be approximately 690 hectares.

The Ludlow River crosses the land in its southern part and the locality name is taken from the (ephemeral) Coolyoolup Pool where the river enters at the eastern boundary.

3. Topography

A narrow valley bottom containing the river is bounded by banks rising about five metres on the south side and to about ten metres on the north side, which takes the elevation over 20m. A.S.L. The ground on the south side of the river continues to rise slightly before sloping down again to the southern boundary, but is crossed in part by a depression tributary to the river. On the north of the river the surface continues to slope up to the crest of a ridge trending north-eastwards. In that direction this crest rises to a maximum of about 23 metres A.S.L. * just before it crosses the eastern boundary of the area, and broadens to the extent that it accomodates several shallow depressions which gain water from the surrounding surfaces. Northwestwards from this ridge the surface slopes down to the area mined which was probably at about 18m. A.S.L. * originally, and which contained swampy areas probably about 16.5m A.S.L.* These are believed to have originally drained northwards towards the Capel River. A narrow swamp zone crosses the north-eastern corner of the land from farm-land to the east.

Drainage now is intercepted by the chain of lakes, the bottoms of which are below the ground water level, and is routed via a deep ditch to the Ludlow river, after passing over an adjustable weir at the overflow from the final lake. As a consequence of the mechanical movement of soil and of retention of excavations the surrounding land is

*Estimates based on a contour plan prepared for the mining company.

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mainly at higher elevation than the original surface.

Slope grades are mainly gentle. Exceptions are the banks of the central lakes of the chain, and very localized steep berms which were formed during refilling operations near the railway line, and retained as a landscape feature. The south-eastern half of the mined strip exhibits extensive flat areas which are the surfaces of dried out silt dams.

4. Geomorphology and Soils

Soil surveys of part of the area were carried out by the Forests Department in the 1930's but plans available locally covered only small parts and no soil descriptive information accompanied them. A new reconnaissance of un-mined lands has therefore been carried out.

A small area in the north was mapped by C.S.I.R.O. workers (1, below) in 1956 and allocated to soil association later (2, below), when the development of the soils was also discussed (3, below). The soil profiles observed in the recent reconnaissance have therefore been correlated with the soils described in those publications.

The land occupied by S.F. No. 12 lies on the western edge of the local occurrence of Southern River association depicted by Bettenay, McArthur and Hingston (2, below) and overlaps on to Serpentine Association. McArthur and Bettenay (3, below) describe Southern River association as the oldest soils of the Bassendean Dune System, which itself is the oldest series of sand dunes laid down in a then coastal position (± 225 000 years ago). Serpentine association soils have developed on fine textured deposits ponded between Bassendean Dunes and the next youngest series to the west, the Spearwood Dune System.

The allocation to Southern River association is on the basis of the occurrence of Gavin sand, along with Ludlow sand and an un-named swamp soil. Gavin sand, a humus podzol, is the main series represented in the Southern River association and also in the Bassendean association. Ludlow sand was the soil developed on a strand-line deposit which contained the heavy minerals mined in this locality.

Gavin sand occurs only on a small northern portion of S.F. No. 12, however, and the area farther south is occupied by dunes which are higher and less thoroughly leached. These correlate better with the most recent members of the Bassendean association which are the Jandakot series and its local counterpart the Elgin series, hence have been mapped as Elgin sand. However parts of this dune system where the profiles show highly leached sand to the depth of investigation (900 mm) have been assigned to

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(1) Soils of the Capel-Boyanup Area W.A., W.M. McArthur and E. Bettenay, 1956.

(2) Soil Associations of the Swan Coastal Plain, W.A., E. Bettenay, W.M. McArthur and F.J. Hingston, 1960.

(3) The Development and Distribution of the Soils of the Swan Coastal Plain, W.A., W.M. McArthur and E. Bettenay, 1960.

Gavin sand although it is doubtful that a sub-surface organic horizon exists.

The interiors of these dunes have been even less leached, and where this yellow sand has been exposed by removal of the overlying more leached layer (by wind action, presumably) it has been mapped as Wonnerup sand (Karrakatta association of the Spearwood Dune System). There is no knowledge of the presence of the limestone which is a feature of Karrakatta association soils beneath these dunes, but there is a precedent for this treatment in the recording of this soil in an equivalent geographical position on the 1956 map referred to already. Profiles with less than 500 mm of overlying, moderately leached sand have also been included as Wonnerup sand and those with a greater depth have been retained as Elgin sand.

A few profiles similar to Elgin sand but with texture increasing to loam or clay loam, the latter textures with or without sand content, within the depth studied have been grouped under the name of Elgin sandy loam.

On the eastern end of the main ridge north of the river, gravel was encountered at a depth of around 800 millimetres in some profiles. Though profile descriptions do not match the type description closely, and the elevation is probably greater than for the typical profile, the name of Trigwell sand has been used in the current work. Valley sides near the river display in places loamy soils with moderate amounts of gravel and these have been mapped as Trigwell sandy loam. More massive occurrences of laterite are found in the bed of the Ludlow River and sheets of a half to one metre thickness under swampy areas in the Ludlow sand. Much of the latter however has been removed in the mining operation.

A soil type of relatively small extent in the south of the area is Boyanup loam which comprises profiles with a loamy texture at or near the surface and overlying yellowish brown clay. Other minor soil occurrences have been characterized as Abba sand (over clay) and Swamp I, while the soils adjacent to the river fall within the un-named River III type of the authors cited.

The soil materials resulting from mining fall into three classes based on particle size. These occasionally occur in a mixed state but more usually have been stratified.

Most extensive in area and by far the greatest in bulk is the sand tailings, consisting of quartz grains with slight iron staining. The sand was transported in water suspension which was sprayed on to the disposal site from a nozzle moved periodically. The land fill was therfore built up as a series of overlapping cones, on the surfaces of which gravitational sorting would be expected to occur. Consequently the upper layers can be expected to consist predominantly of the coarser particles while the finer particles will tend to be segregated at depth. Even where sand tailings have been deposited on the natural soil surface the depth is usually so great that shallow-rooted plants can not reach the natural soil and tree roots would take some time to penetrate. Where replaced in excavations the depth can be as much as eight metres of this free-draining and nutritionally useless material.

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The fine particles of the original soil ('slimes' or silt tailings) have also been pumped as a slurry into lagoons excavated usually in previously pumped sand tailings. Dewatering of the silt results in shrinkage to produce prismatic columns about 200mm to 700mm in diameter and separated by cracks up to 100mm wide at the surface but narrowing below. These cracks extend downwards probably as much as one metre. The dried material can be readily broken down into angular peds by mechanical cultivation, but the depth of the cultivated layer produced is only about 100 millimetres. The peds produced are also readily broken down by the impact of rain, and a result of this and of cultivation is the partial filling of the cracks in the deposit. However the lower parts of the cracks in the silt deposit can remain open. The margins of the silt dams are usually partly covered by sand in the process of smoothing down the surrounding banks with a bulldozer prior to cultivation, and in a few cases silt dams have been covered by sand tailings pumped later.

For a period deliberate mixing of partially de-watered silt tailings with sand tailings was practised but was terminated because of cost. One some areas casual coverage of sand with silt slurry has occurred and cultivation has resulted in mixing. The mixture of silt into the upper part of the sand deposits creates a vastly improved substrate for plant growth. It has been observed on another mining operation that presence of a silt deposit at about 900mm depth under sand also creates a favourable site for tree growth.

A further characteristic of most silt dams which may prove additionally favourable to plant growth is their content of a chemical flocculating agent (anionic polyacrylamide compound). Those dams on which this has not been done are identified on the soil plan. Chemical analyses have been carried out on three samples of the silt material. The results are presented below, with values from analysis of a loamy soil (type 5) from the Donnybrook Sunkland for comparison.

| | Mine Silt | 'Type 5' Soil |
|---|---|---|
| pH | 5.4 | 6.8 |
| Ex. Ca (m.e.%) | 0.88 | 1.31 |
| Ex. Mg (m.e.%) | 0.89 | 0.49 |
| Ex. K (m.e.%) | 0.04 | 0.06 |
| Ex. Na (m.e.%) | 0.014 | 0.07 |
| C.E.C. (m.e.%) | 19.77 | 6.22 |

The comparison appears favourable to the mine silt except that it is likely that addition of lime would be beneficial to improve the Ca/Mg ratio.

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The third type of material resulting from extraction and primary concentration of heavy mineral sands is lateritic rock and gravel. Massive boulders have occasionally been placed on top of other fill as a landscape interest feature but were usually dumped into excavations before other fill. However a considerable part of the excavation containing the final lake in the series is occupied by these and smaller fragments with little or no fine material above or within the deposit. Fragments with diameters from about fifty millimetres down have been used as road material, and predominantly small gravel has been spread on the surface of sand tailings as an anti-deflation measure and because of the associated vegetative propagules screened off with the gravel. These gravelled areas have produced quite prolific regeneration of native plant species though the number of species is low.

A summary of the soil types occurring on State Forest No. 12, their physical and chemical characteristics and the areas covered by each forms Appendix 1 to this report and their distribution is recorded on soil plan No. GSM 40/5.

## 5. Water

The lakes cover an area of approximately 32 hectares and because of the steep sides of most of them this area is not greatly affected by fluctuations of level. In one there is a delta of less than half a hectare in area which has been for some time exposed by the currently very low water level. It seems likely that in the absence of water usage by the mining company the system could be maintained at a level which would just cover the delta even in summer, because the water needs of the mining operation are at the time of writing being met by seepage from ground water into the lakes with very little augmentation from the refining plant.

The quality of the water appears to be good, if relatively hard. No analytical data are available for it but an analysis of a shoreline deposit of salts produced the following results. (Figures are percentages of dry weight):-

| | |
|---|---|
| Calcium - 12.7 | Phosphate - Nil |
| Magnesium - 1.1 | Chloride - Nil |
| Sodium - 1.8 | Other anions (probably sulphate, carbonate, or bicarbonate) not tested for. |
| Potassium - 0.2 | |

## 6. Vegetation

Native vegetation which remains on surrounding land falls within the structural classifications of woodland, low open forest and low woodland according to Smith, Dr. F.G., Vegetation Survey of Western Australia, 1973. W.A. Dept. of Agric.

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The dominant species are jarrah and banksias. Some of the jarrah trees growing on the subject area prior to clearing for pine plantation were of very large girth, although the height was not great.

A portion of the area where plantation was not successful has reverted to a quasi-natural state of woodland dominated by marri but with numerous P. pinaster and some jarrah. It also exhibits melaleuca closed scrub in patches. Elsewhere closed scrub or open shrubland dominated by hakea and grevillea species occupy wetter areas. In the region where mining and associated activities have taken place low open woodland featuring swamp banksia and paperbarks was a common vegetation type and a considerable number of the latter species have survived inundation by silt tailings on one previously swampy patch.

An area where plantation was cleared during the early 1970's without either mining or tailings deposition ensuing now carries a shrubland to low open shrubland of numerous species which is providing a seed source for regeneration of some of the species on adjoining filled land.

A check list of plant species occurring on State Forest No. 12, excluding those species introduced by cultural practises, forms part of Appendix 2 to this report. Subsidiary lists for clearly distinguishable species groupings are also provided there.

The degree of approximation of these vegetation assemblages to the original structure and species composition can be expected to vary. Those areas where plantation was not established because of site conditions are likely to be closely similar to the original condition. Areas where plantation has failed, though containing many of the original species, will have them in different abundance and some may be absent. On yet other areas where indigenous species have regenerated after clearing of plantation the species present will be either those which were able to persist under plantation or those which could regenerate from wind borne seed after exposure of the soil. These differences can be taken into account to provide a ranking of importance for preservation or management purposes.

Pine plantation remaining covers 202 hectares, almost equally shared by Llandes and Leiria strains of Pinus pinaster, and a further 10 hectares of Pinus radiata and Pinus palustris. The Llandes strain was planted between 1915 and 1925 and the Leiria strain between 1935 and 1965, following a trial established in 1929. An impression of the site qualities of the plantation is given by the plan forming Appendix 3A but is confused by the fact that data were acquired in two different years. Growth rates are explained more fully in Appendix 3B (Extract from Plantation Area Statement, 83/04/08), and displayed in Appendix 3C.

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A summary of the data is given below:-

Numbers of compartments in S.Q./species categories

| | Stratum I | Stratum II | Stratum III | Failed |
|---|---|---|---|---|
| Leiria pinaster | 6 | 11 | 1 | 1 |
| Llandes pinaster | 0 | 3 | 13 | 6 |
| Radiata | 0 | 0 | 0 | 2 |

The sub-standard compartments of P. radiata are in the valley floor and should not suffer lack of moisture, nor would one expect poor nutrition there. There may be excess moisture in winter though. There appears to be a difference in site quality indicated by different strains of P. pinaster, although the different planting periods could have led to improvements in technique which favoured the Leiria strain. However it is suggested that P. radiata may produce acceptable growth rates on current P. pinaster sites if given fertilizer and favoured by wide spacing and improvement of the soil by agricultural methods.

During the years up to 1979 the mining company's Regional Agronomist was planting out 5000 tree seedlings per annum, however the proportion of these going on State Forest is unknown. The species used would have been predominantly the following:-

Acacia decurrens

A. saligna

Agonis flexuosa

Casuarina obesa

Eucalyptus camaldulensis

E. globulus

E. gomphocephala

Melaleuca leucadendron

From 1980 on the plantings were specified as to species and site types and to a large extent as to location, by the Forests Department. The species are listed in Appendix 4A. Plantings were partially segregated by site types to which the species would be suited. Plantings by the company were mainly as landscape-orientated groups. Those by the Forests Department (approximately half of the total) took the form mainly of wide-spread informal test groups cum landscape features, though three formal experimental plots were laid out. Most of the planting by the Department occurred on the north-eastern zone of silt dams in 1980 and 1981, then on either side of the drain running between remaining pine plantation and the lakes in 1982. Continuing from this a low-lying zone just east of the internal access road was planted in 1983.

In addition to broadcast fertilizer applied to agricultural species both before and since tree-planting, each seedling received a local application of a mixed fertilizer including nitrogen about a month after planting.

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The experimental plots tested the two main site types on refilled land, viz. sand and silt tailings. Brief descriptions including results form Appendix 4B. These results and general observations of other plantings indicate that on pure sand tailings, though establishment may be satisfactory if weather conditions are favourable, persistence is poor. On silt tailings there can be deaths in the first year, possibly because of poor aeration in the slaked layer near the surface. Stability is often not good also, because of the low strength of the moist material. Once established, trees on silt grow well with the proviso that isolation of the root system by the wide cracks in the dried material lower down has probably been the cause of deaths in trees between one-and-a-half and four years after planting. Where trees are planted into sand with some admixture of silt, or close to the edge of silt dams, growth can be excellent. Shrub regeneration by natural means has been almost limited to undisturbed soil or to refilled land with an admixture of natural soil or a layer of the gravel screenings described earlier. One or two plants with seeds which can be wind-borne have also established, on silt areas mainly.

Attempts have been made by the Forests Department to establish shrubs (mainly indigenous and mainly legumes) by broadcasting seed which had been given suitable pre-germination treatment. Even though species naturally occuring on sandy soils were used, sowing on sand tailings produced negligible numbers of established plants. Where the technique was tried with suitable species on a silt dam which had not been given mechanical preparation, germination was good and survival has also been quite good. Even so the method is wasteful of seed, and for 1983 the company has purchased and sown smaller quantities of seed on lightly-raked patches, on both silt and sandy land.

No data are available on the productivity of the pastures established on filled land and the company Agronomist considers that assessment of even the longest-established would be premature. To a non-specialist observer, the first-year production of cereal and undersown legumes appears to be good on some areas, notably where there is a silty substrate but poor on some pure sand areas. Establishment and persistence of clover seems to be good only where topsoil occurs although second-year growth has seemed reasonable on tailings. On silt dams clover establishment has appeared poor. Land re-habilitated three to four years ago now seems to carry few legumes except serradella where that was used, but a high proportion of young rye-grass, plus cape-weed. The total cover seems fairly sparse.

7. 'Dieback pathogen'

Prior to mining a few deaths of Banksia littoralis were observed on the swampy area. Even had these been due to Phytopthora cinnamomi the inoculum potential is likely to have become so attenuated as a result of removal of root material and mixing of topsoil with soil from much lower down that such disease is not thought likely to be a threat to trees and shrubs which are established on refilled land.

Several deaths (referred to earlier) of Eucalyptus gomphocephala on silt and sand in one locality have occurred between the ages

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of eighteen months and four years. In early 1981 a 1 metre dead tree was pulled out and later eight dead trees averaging 1.4 metres tall and two live ones about 1.9 metres tall were washed out to allow testing for the pathogen. Plating onto selective agar of material from various parts of the root system failed to demonstrate the presence of other than a normal rhizosphere microflora.

Although the fine roots were not recoverable for testing, the morphology of the root systems of dead trees compared to those of live trees supports the assumption that Phytopthora was not responsible for the deaths. The dead root systems were typically one-sided, and pocessing only between one and five main roots with diameters greater than about 1 centimetre at the origins. The live root systems in contrast, were symmetric and consisted of five and seven such roots respectively. Thus it appears more likely that droughting resulting from incapacity to reach a sufficient soil volume was the cause of deaths.

8. Fauna

No studies of fauna on State Forest No. 12 are known except that of Davieson (1982)* into recolonization of filled land by arthropods. Dr J. Majer has provided a summary of the main finding of that study, as follows:-
"In comparison with sand mines rehabilitated to native vegetation (e.g. at Eneabba, Myall Lakes and Stradbrake Island) subsequent ant fauna at Capel was of low species richness but characterized by very high numbers of a few species. These were associated with the very high densities of grass-associated springtails and mites". It should be noted that although various invertebrates were studied Dr Majer attaches particular importance to ants as indicative of the general situation.

Incidental observation indicates that the area (including land undergoing rehabilitation) is much frequented by kangaroos, which have been responsible for damage to at least one species of tree seedling (C. obesa). The presence of the brush-tailed wallaby is suspected but not confirmed. Evidence in the form of a lower mandible indicates the presence at one time in the more natural forest formation of the ring-tailed possum.

A few birds have been particularly noted on the land. On one occasion a somewhat unusual congregation of bronze-wing pigeons was encountered in the branches of pine trees. The location was close to a variety of feeding habitats, viz. nearby farmland, pastured re-filled land and regenerated scrubland rich in leguminous plants. A small group of parrots similar in appearance to regent parrots has been seen on the pastured mine-site, and in the same locality a group of small birds which were finch-like in appearance and call note, possibly white-fronted chats. Water birds seen on the lakes have been a few swans, rarely a cormorant or heron, but at times very numerous ducks. Most of these appear to frequent the northern-most lake on State Forest, which may be due to its gently-sloping banks and underwater contours, and to its greater age.

*Davieson, G., Recolonization of invertebrates in rehabilitated sand mines at Capel, W.A.I.T. Biological Project 301-302, Report, 1982

APPENDIX 1

## Soil Types of State Forests No. 12 (Coolilup)

(After McAuthur and Bettenay, 1956, 1960)

Southern River Association - general soil type is podzol.

1. Gavin sand (ahumus podzol) - very light grey sand overlying an organic hardpan at about 900mm and an iron concretionary horizon at 1500mm depth. Where the hardpan does not occur within 1200mm of the surface the soil is mapped as a deep phase.

   The profile is moderately acid in reaction and has a very low salt content. Surface phosphorus values are less than 10 p.p.m.

2. Elgin sand (a podzol) - light yellowish grey sand with the texture rising to sandy loam by about 760mm.

   The profile is slightly acid and the salt content very low. No information is published on the surface phosphorus concentration but it may be a little higher than for Gavin sand.

3. Trigwell sand (an iron podzol) - light greyish brown becoming light brown sand with large amounts of ferruginous gravel by about 300mm, overlying light brown sandy clay with moderate amounts of ferruginous gravel at about 700mm below the surface.

   The profile is slightly acid and the salt content is low. No information is published on the surface phosphorus concentration but it will be very low.

4. Jandakot sand (an iron humus podzol) - light grey becoming very light grey sand to about 1000mm then with iron staining increasing to a horizon of yellow brown sand with rusty mottles between about 1700 and 2300mm. Colour then fades and the pale sand continues over 3300mm deep.

   The profile is slightly acid and the salt content is low. The surface phosphorus concentration is less than 10 p.p.m.

Karrakatta Association

5. Wonnerup sand (a podzolic soil) - below a slightly leached surface, yellowish brown sand grading in colour to bright yellow by 1500mm, this continuing deeper than 3000mm. There may be a few ferruginous concretions at about 3000mm and limestone occurs at a great depth.

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APPENDIX 1 CONT'D

The profile is slightly acid in reaction and the salt content is low. No information on phosphorus levels is available from soil literature but the requirement for phosphorus addition in order to grow pine has been reported by Stoate and by Bednall.

Guildford Association

6. Boyanup loam (a yellow podzolic soil) - dull brown loam becoming sandy loam to 80mm, overlying yellowish brown fine sandy clay which becomes faintly mottled by 1000mm depth. Here there is a change to a variously mottled fine clay with the mottling reducing to light grey and red by 1200mm depth.

The profile is slightly acid and the salt content is very low. Phosphorus concentration at the surface is 24 p.p.m.

Miscellaneous Soils

7. River Series III (an undifferented riverine alluvium) - greyish brown fine sandy loam becoming darker to 150mm and at that depth overlying dull yellowish brown fine sandy clay with weak mottling; at 500mm colour becomes grey mottled with yellowish brown and the profile contains slight ferruginous and manganiferous concretions down to 950mm. The profile is slightly acid at the surface trending to nearly neutral at depth. Salt content is relatively high at the surface, decreasing in the subsoil before rising again at depth greater than 1000mm. No information on phosphorus status has been published.

8. Swamp Series I - light pinkish brown sand with slight ferruginous gravel becomes light grey clayey sand lying over very light grey clay with yellow brown mottles, at 750mm depth. The profile is moderately acid at the surface tending towards neutral at depth, and the salt content although low at the surface also increases slightly with depth.

APPENDIX 2A

## Checklist of indigenous plant species on S.F. No. 12 (Coolilup)

(Species asterisked known to be introduced)

Acacia armata
A. cochlearis
A. cupularis
A. decurrens*
A. divergens
A. extensa
A. forrestiana
A. horridula
A. pulchella
A. stenoptera
Actinodium cunninghamii
Adenanthos meissneri
A. obovatus
Agonis flexuosa
A. linearifolia
Anarthria prolifera
Anigozanthos manglesii
Astartea fascicularis
Banksia attenuata
B. grandis
B. littoralis
Boronia spathulata
Bossiaea eriocarpa
Brachyloma preissii
Brachysema praemorsum
Calothamnus sanguineus
Calytrix fraseri
Cassytha racemosa
Comesperma ? virgatum
Conospermum flexuosum
Conostylis aculeata
C. setigera
Cynosurus echinata*
Dasypogon bromeliioides
Daviesia incrassata
D. polyphylla
Dianella revoluta
Dillwynia uncinata
Dryandra nivea
Eucalyptus calophylla
E. marginata
E. rudis
Gompholobium burtonioides
G. tomentosum
Grevillea commutata
G. ?vestita
Hakea preissii
H. ruscifolia
H. ?sulcata
H. varia

Hardenbergia comptoniana
Hemiandra pungens
Hibbertia hypericoides
H. pachyrhiza
H. racemosa
H. rhadinopoda
H. stellaris
H. tetrandra
H. vaginata
Hybanthus floribundus
Hypocalymma angustifolium
Hypolaena exsulca
Jacksonia horrida
J. spinosa
Juncus ? caespitosus
J. pallidus
Kennedia prostrata
Kingia australis
Kunzea micrantha
Laxmannia sessiliflora
Lepidosperma angustatum
Leptocarpus canus
Leptospermum ellipticum
Lepyrodia monoica
Leucopogan conostephoides
L. glabellus
Lindsaya linearis
Lobelia alata
Loxocarya fasciculata
Lyginia tenax
Macrozamia riedlei
Melaleuca acerosa
M. incana
M. lateritia
M. preissiana
M. rhaphiophylla
M. teretifolia
M. thymoides
Mesomelaena tetragona
Nuytsia floribunda
Patersonia occidentalis
Pelargonium capitatum
Persoonia longifolia
P. saccata
Phyllanthus calycinus
Pimelea sp.
Platytheca verticillata
Podolepis incana
Polygonum prostratum

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APPENDIX 2A CON'T

Pteridium esculentum
Ptilotus sericostachyus
Pultenaea sp.
Regelia ciliata
Scaevola striata
Stirlingia latifolia
Stylidium repens
Symphiobasis alsinoides
Synaphea?petiolaris
S. reticulata
Trymalium ledifolium
Thysanotus sp.
Typha angustifolia
Verticordia spicata
Viminaria juncea
Xanthorrhoea gracilis
X. preissii
Xylomelum occidentale

# Appendix 2B. Distribution of indigenous plant species by site types, S.F. No.12 (Coolilup).

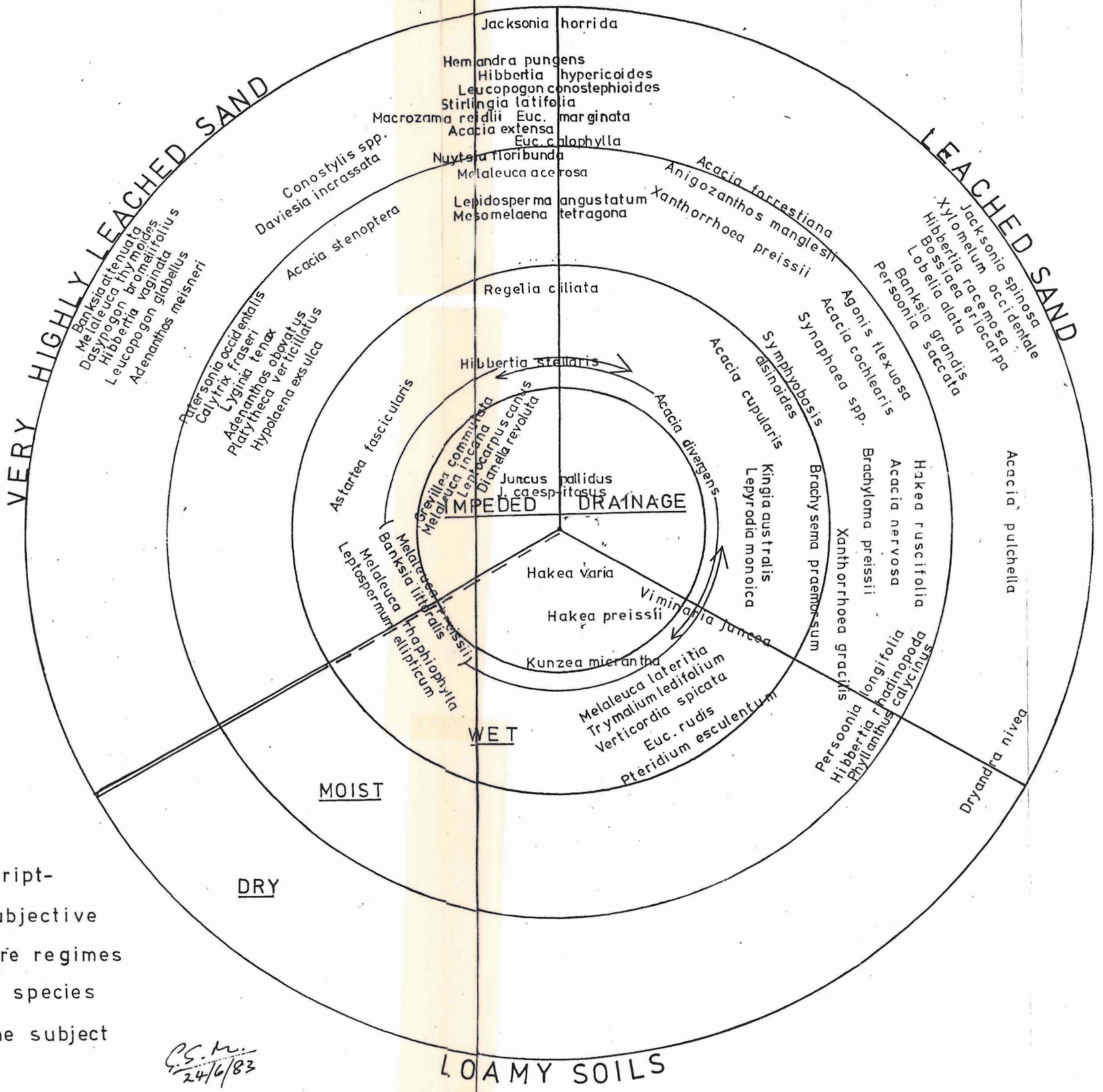


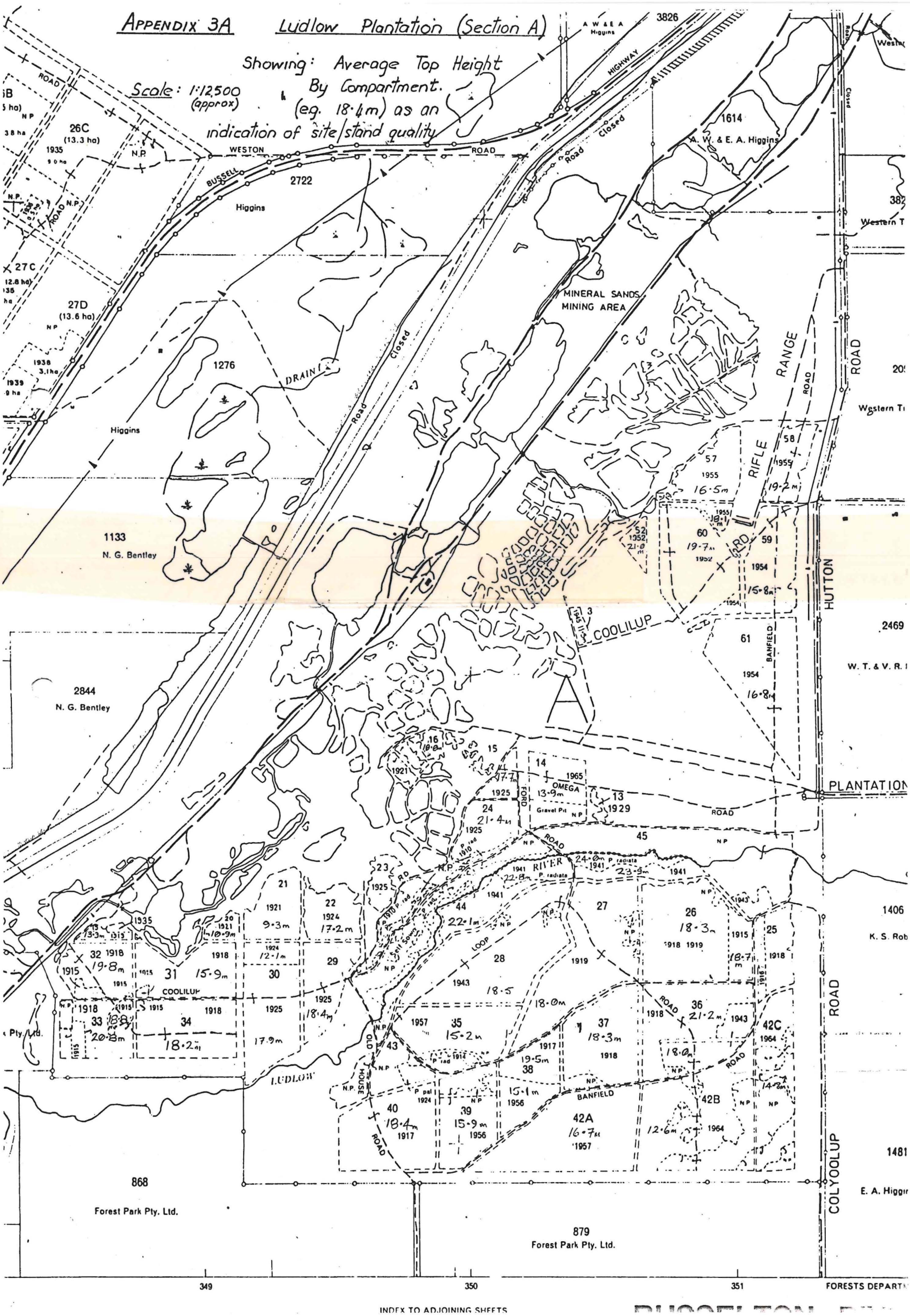

Diagram based on soil descriptions and non-systematic subjective assessment of the moisture regimes of the sites at which the species have been recorded, on the subject area and elsewhere.

G.S.M. 24/6/83

# APPENDIX 3A — Ludlow Plantation (Section A)

Showing: Average Top Height By Compartment. (eg. 18·4m) as an indication of site/stand quality

Scale: 1:12,500 (approx)



## APPENDIX 3B - Extract from Plantation Area Statement 83/04/08

Ludlow Section A

| Species | Plant Yr. | Cpt. | Area (ha) | Assess. Date | Cpt. Top Ht. | |
|---|---|---|---|---|---|---|
| | | | | | Average (m) | M.A.I.* (m/ann) |
| P.pinaster (Llandes) | 15 | 26 | 1.8 | 78/04/18 | 18.7 | 0.30 |
| " " | 15 | 31 | .2 | 78/04/18 | | |
| " " | 15 | 32 | .5 | 78/04/18 | | |
| " " | 15 | 33 | 1.2 | 78/04/18 | 18.8 | 0.30 |
| " " | 16 | 34 | .1 | 78/04/18 | | |
| " " | 16 | 25 | .9 | 78/04/18 | | |
| " " | 17 | 38 | 2.5 | 78/04/18 | 19.5 | 0.32 |
| " " | 17 | 40 | 8.1 | 78/04/18 | 18.4 | 0.30 |
| " " | 18 | 25 | 2.5 | 78/04/18 | | |
| " " | 18 | 26 | 9.7 | 78/04/18 | 18.3 | 0.31 |
| " " | 18 | 31 | 5.6 | 82/04/23 | 15.9 | 0.25 |
| " " | 18 | 32 | 3.9 | 82/04/23 | 19.8 | 0.31 |
| " " | 18 | 33 | 3.2 | 82/04/23 | 20.8 | 0.33 |
| " " | 18 | 34 | 6.6 | 78/04/18 | 18.2 | 0.30 |
| " " | 18 | 36 | 6.7 | 78/04/18 | 21.2 | 0.35 |
| " " | 18 | 37 | 7.1 | 78/04/18 | 18.3 | 0.31 |
| " " | 19 | 19 | .9 | 81/05/13 | 13.3 | 0.21 |
| " " | 19 | 27 | 11.5 | 78/04/18 | 18.6 | 0.31 |
| " " | 21 | 16 | 1.7 | 81/05/13 | 10.0 | 0.17 |
| " " | 21 | 20 | | 82/04/23 | 10.9 | 0.18 |
| " " | 21 | 21 | 3 | 81/05/13 | 9.3 | 0.16 |
| " " | 24 | 22 | | 81/05/13 | 17.2 | 0.30 |
| " " | 24 | 30 | 1.6 | 78/04/18 | 12.1 | 0.22 |
| " " | 25 | 15 | 1.7 | 81/05/13 | 17.7 | 0.32 |
| " " | 25 | 23 | 1.5 | 82/04/23 | | |
| " " | 25 | 24 | 3.3 | 82/04/23 | 21.4 | 0.38 |
| " " | 25 | 29 | 4.5 | 78/04/18 | 18.4 | 0.35 |
| " " | 25 | 30 | 6.7 | 78/04/18 | 17.9 | 0.34 |
| pinaster iria) | 29 | 13 | .4 | 82/04/23 | | |
| " " | 35 | 19 | .3 | 82/04/23 | | |
| " " | 41 | 44 | 2.9 | 78/04/18 | 22.1 | 0.60 |
| " " | 41 | 45 | 2.1 | 78/04/18 | 23.9 | 0.65 |
| " " | 43 | 28 | 13.1 | 78/04/18 | 18.5 | 0.53 |
| " " | 43 | 36 | 3.3 | 78/04/18 | 18.0 | 0.51 |
| " " | 43 | 45 | .8 | 78/04/18 | | |
| " " | 45 | 3 | .5 | 78/04/18 | 11.3 | 0.34 |
| " " | 52 | 52 | 1.1 | 81/05/13 | 21.0 | 0.72 |
| " " | 52 | 60 | 8.6 | 78/04/18 | 19.7 | 0.76 |
| " " | 54 | 59 | 6.1 | 81/05/13 | 15.8 | 0.59 |
| " " | 54 | 60 | .5 | 78/04/18 | | |
| " " | 54 | 61 | 10.9 | 78/04/18 | 16.8 | 0.70 |
| " " | 55 | 57 | 4.4 | 82/04/23 | 16.5 | 0.61 |
| " " | 55 | 58 | 3.0 | 82/04/23 | 19.2 | 0.71 |
| " " | 55 | 60 | 1.2 | 82/04/23 | 18.1 | 0.67 |
| " " | 56 | 38 | 2.4 | 78/04/18 | 15.1 | 0.69 |
| " " | 56 | 39 | 5.4 | 78/04/18 | 15.9 | 0.72 |
| " " | 57 | 35 | 6.1 | 78/04/18 | 15.2 | 0.72 |
| " " | 57 | 42A | 11.3 | 78/04/18 | 16.7 | 0.80 |
| " " | 64 | 42B | 9.1 | 78/04/18 | 12.6 | 0.90 |
| " " | 64 | 42C | 3.8 | 78/04/18 | 14.8 | 1.06 |
| " " | 65 | 14 | 3.1 | 78/04/18 | 13.9 | 1.07 |

APPENDIX 3B (Cont.)

| Species | Plant Yr. | Cpt. | Area (ha) | Assess. Date | Cpt. Top Ht. | |
|---|---|---|---|---|---|---|
| | | | | | Average (m) | M.A.I.* (m/ann) |
| P.radiata | 10 | 23 | .6 | 78/04/18 | | |
| " " | 10 | 24 | .3 | 78/04/18 | | |
| " " | 14 | 35 | .9 | 78/04/18 | | |
| " " | 41 | 44 | 6.3 | 78/04/18 | 22.8 | 0.62 |
| " " | 41 | 45 | 1.4 | 78/04/18 | 24.0 | 0.65 |
| P.palustris | 24 | 43 | .6 | 78/04/18 | | |

*This figure has been reduced by less than 1%, and that for the later planting years only, by accepting data recorded in April or May as representing complete years of growth.

APPENDIX 4A

## Coolilup mining reclamation, tree-planting co-ordinated by the Forests Department

| Species | Numbers planted in years | | | | |
|---|---|---|---|---|---|
| | 1980 | 1981 | 1982 | 1983 | Totals |
| Acacia acuminata | 64 | - | N/A | 30 | 94 |
| A. decurrens | 340 | 350 | 20 | - | 710 |
| A. saligna | 500 | 430 | 100 | 330 | 1360 |
| Agonis flexuosa | 200 | 500 | 450 | 360 | 1510 |
| Callistemon speciosus | - | - | 60 | 150 | 210 |
| Callitris columelloris | - | 50 | 15 | N/A | 65 |
| C. preissii | 18 | 50 | 60 | 120 | 248 |
| Casuarina obesa | 500 | 500 | 400 | 270 | 1670 |
| Eucalyptus botryoides | - | - | 90 | N/A | 90 |
| E. calcicola | - | - | 60 | 90 | 150 |
| E. calophylla | 230 | 500 | 630 | 550 | 1910 |
| E. camaldulensis | 900 | 500 | 270 | 290 | 1960 (others probably bought outside F.D.) |
| E. ficifolia | - | - | - | 30 | 30 |
| E. gomphocephala | N/A | 900 | 180 | - | 1080 |
| E. globulus | ±150 | These were surplus to T. Butcher's provenance trials | | | ±150 |
| E. leucoxylon var. rosea | 300 | 220 | 60 | - | 580 |
| E. marginata | 60 | 60 | 630 | 300 | 1050 |
| E. melliodora | N/A/ | 50 | 60 | - | 110 |
| E. patens | 200 | 200 | 90 | 240 | 730 |
| E. robusta | - | - | 90 | N/A | 90 |
| E. rudis | 200 | 200 | 510 | 390 | 1300 (others bought outside F.D.) |
| Melaleuca leucadendron | 300 | - | - | - | 300 (others bought outside F.D.) |
| M. preissiana | N/A | 200 | N/A | 240 | 440 |
| M. pubescens | - | - | 50 | 90 | 140 |
| Xylomelum occidentale | - | 15 | - | - | 15 |
| | 3962 | 4725 | 3825 | 3480 | 15992 |

N/A = ordered but not available from F.D. nurseries

APPENDIX 4B

## Experimental tree plots on Coolilup re-filled land

No. M5/80

**Aim:** to test potential overstorey and understorey species for creation of a woodland on a doubtful site type, with some site amelioration.

**Site Type:** sand tailings under cultivation for one year.

**Area:** 0.81 ha

**Planting date:** 13/8/80

**Layout:** a square grid pattern oriented north-south, of tuart at 15 metre intervals with a square of four rows of marri inter-planted; a smaller-scale grid of jam wattle interposed, and a few Rottnest pines at varying distances on north (sunny) and south (shaded) sides of tuarts.

**Site preparation:** for each tree, a 0.2 - 0.3 $m^3$ hole excavated by backhoe and refilled with a brown sandy topsoil (Ludlow sand). Tree planting was within a day of preparation, as a result of company default.

**Survival and Growth:** in the first two months about 8 per cent of the eucalypts were eaten by rabbits and other deaths due to drought appeared likely. Grazing of the area by cattle was commenced in spring of 1981 in spite of a verbal agreement to exclude it. Browsing by cattle has obviously restricted the growth of the older eucalypts and many have been the cause of the high losses of E. melliodora. Data representing Survival per cent/Height (cm)/Basal diameter (mm) at various ages are tabulated below.

| Species | 2 months | 9 months | 2 years | 3 years | % Browsed severe | % Browsed moderate |
|---|---|---|---|---|---|---|
| Acacia acuminata | 98/- | 70/- | - | 56/91/14 | 8 | 40 |
| Callitris preissii | 92/- | 42/- | - | 6/6/2 | - | - |
| Euc. calophylla | 96/- | 22/- | - | 21/40/7 | 0 | 40 |
| Euc. gomphocephala | 80/- | 38/- | - | 27/53/14 | 69 | 31 |
| Euc. melliodora | (refill species, 1981) | | 14/39/8 | - | 43 | 0 |

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APPENDIX 4B CON'T

## Experimental tree plots on Coolilup re-filled land

### No. M6/80

**Aim:** to test the ability of jarrah to grow on a doubtful site type, with and without some amelioration.

**Site type:** sand tailings under cultivation for one year.

**Area:** 0.16 ha

**Planting date:** 18/8/80

**Layout:** a rectangle of trees oriented north-south, at basically 7 metre intervals; even numbered east-west rows interplanted at 3.5 metre spacing; four specimens of Acacia extensa addad as the most easterly inter-plantings.

**Site preparation:** odd-numbered east-west rows had for each tree a 0.2 - 0.3 m3 hole excavated by back-hoe and refilled with a brown, sandy topsoil (Ludlow sand); even-numbered rows had no such amelioration. Tree-planting was within a day of preparation, as a result of company failure to prepare ahead.

**Survival:** over the first summer survival fell from 96% to the following figures (numbers in parenthesis are original plantings):-

| | | |
|---|---|---|
| Jarrah with site preparation | (25) | - 56% |
| Jarrah without site preparation | (35) | - 0% |
| Acacia with site preparation | (2) | - 100% |
| Acacia without site preparation | (2) | - Progressing to 0% |

However on the improved sites 35% of jarrah seedlings had become defoliated and failed to produce new leaves by late October of the planting year, and half of all trees had lost leaves but produced new ones. By the end of the second summer only one jarrah tree survived. It had made little growth but that and some losses may have been due to browsing by cattle over probably the previous six months.

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APPENDIX 4B CON'T

## Experimental tree plots on Coolilup re-filled land

### No. M1/81

**Aim:** to test a selection of tree species thought suitable for a re-filled site type, with a range of site treatments.

**Site type:** a dried out silt dam without prior agricultural re-vegetation.

**Area:** 0.25 ha

**Planting date:** 24/6/81 (Planned 1980, but site not dry enough to work).

**Layout:** a rectangular plot oriented northeast-southwest, divided into two primary treatments in that direction, with cross-treatments as surface applications randomly located; eight tree species randomly located within each treatment combination, on a 3.66 x 3.33 metre spacing.

**Treatments:**

1. Ripped to 0.5m maximum depth (1980; was specified as 1m) and deep tyne cultivated to 200mm in 1981.
2. Surface crumbling by use of an iron "drag".
3. Sand tailings applied 300mm deep across 1 & 2.
4. Topsoil applied 300mm deep across 1 & 2.
5. Lime application at 4 tonnes/ha (200kg) applied across 1 & 2, and lightly cultivated to mix in.
6. Gypsum application at 1 tonne/ha (50kg) applied across 1 & 2, and lightly cultivated to mix in.
7. Control. No treatment other than 1 & 2.

Company preparation of the site apparently did not comply with the treatments specified, to what extent is not known. However the Agronomist admitted terminating the services of the operator as a result.

A close inspection of the ground, coupled with field pH tests (Hellige indicator), carried out in 1982 has led to the following conclusions.

1. Ground limestone was probably applied to the whole area and then removed and concentrated on one strip.

   Statistical analysis of recorded pH values indicates a very high probability of differences in treatment of the sub-plots but insignificant differences between samples from within any

APPENDIX 4B CON'T

Experimental tree plots on Coolilup re-filled land

No. M1/81 Con't

sub-plot.

2. Some traces of soil materials other than silt were observed, but not on the treatment blocks which were specified.
3. Tentative deductions as to the actual locations of the treatments, based on the above observation and the pH evidence, can be made (and these are recorded on the experimental file).
4. Further tests of site conditions to elucidate the position are justified, viz. structural profile descriptions, particle size analysis, laboratory pH tests and tests for calcium and sulphate.

Tree species:

A - Acacia decurrens (20) - were over-large and consequently had suffered drought stress during holding.

B - Acacia saligna (20)

C - Agonis flexuosa (20)

D - Casuarina obesa (20)

E - Eucalyptus calophylla (10)

F - E. camaldulensis (20)

G - E. gomphocephala (60)

H - E. leucoxylon (10)

Survival: percentage survival data at various times are tabulated below.

| Species | 2 months | 12 months | 23 months |
|---|---|---|---|
| A | 95 | 95 | 90 |
| B | 80* | 85 | 85 |
| C | 100 | 95 | 90 |
| D | 85* | 95 | 95 |
| E | 100 | 100 | 100 |
| F | 85 | 75 | 75 |
| G | 97 | 87 | 82 |
| H | 100 | 90 | 90 |

*apparently premature assumption of mortality resulted from observation of poor colour and dryness.

Growth: measurements at 23 months produced the data below. Multiple stems on one tree were summed for the basal area figure and this applied particularly to species B, A and C. Data are averages for species over all treatments; analysis of effects of treatments has not yet been done.

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APPENDIX 4B CON'T

Experimental tree plots on Coolilup re-filled land

No. M1/81 Con't

| Species | Height(cm) | Basal Area($cm^2$) |
|---|---|---|
| A | 237 | 13.9 |
| B | 110 | 12.6 |
| C | 85 | 3.8 |
| D | 239 | 12.9 |
| E | 123 | 12.8 |
| F | 230 | 17.8 |
| G | 166 | 16.1 |
| H | 153 | 12.6 |
| All species | 170 | 13.4 |

COOLYOOLUP LAKES MULTIPLE USE PROJECT

PART II

Land-use options

Five options of the broadest kind are available.
These are:-

1. Continued tenure by the Forests Department.

2. Leasing to other management(s).

3. Alienation from the Crown to other management(s).

4. Transfer to another Crown agency.

5. Combinations of the above.

It will be possible to embark upon multiple use of the land in two senses, i.e. several uses on separate parts, and more than one use on the same part. The meshing of these uses, however will require one overall management. The potentialities of the land as described in Part I can therefore best be realized, and management best co-ordinated, by the first option above for the bulk of the land, with portions only treated as in 2 and 3 above.

Some portions may be not well suited to Forests Department purposes, therefore leasing offers both better land-use and a financial return at a commercial rate, and such return may be routed to assist development. A more detailed classification of potential land-uses is given in Table 1 (see Page 2).

A further value, which would be contributed to by the first five uses listed in Table 1 and by the presence of bodies of water, would be that of landscape. This aspect when developed with care, can add a recreational value even to the productive activities, and greatly augment the value of the recreational land uses.

Of the land uses listed in Table 1 all except the last four fall into activity categories for which the Forests Department would be expected and permitted to cater. However the uses numbered 14 through 23, although recreational, have the characteristics of a concentrated human impact upon an environment and a requirement for constructed facilities, generally costly. The same two characteristics render those land uses more suitable as subjects of entrepreneurial management. Such management could be achieved by leasing portions of the subject area to interested persons, but the characteristics of those land-uses would often be such as to conflict with best realization of the potential of the land-uses under direct Forests Department management on adjoining land.

The potential conflicts between possible land uses have been studied in greater detail and with an attempt at greater objectivity by quantifying the interactions between pairs of land-uses. The results are presented in Appendix III. They are basically supportive of the classification in Table 1.

TABLE 1. Classification of potential land uses.

| Land Use | | Activity category | Human impact |
|---|---|---|---|
| 1. | Flora | Conservation | |
| 2. | Fauna | | |
| 3. | Softwood | Production | Diffuse. (Constructed facilities none or very simple). |
| 4. | Hardwood | | |
| 5. | Agricultural | | |
| 6. | Quarry | | |
| 7. | Picnicking | Recreation, passive | |
| 8. | Nature Study | | |
| 9. | Walking | | |
| 10. | Fishing | | |
| 11. | Swimming | Recreation, active | |
| 12. | Canoeing | | |
| 13. | Sailing | | |
| 14. | Trail riding | | |
| 15. | 'B.M.X.' | Recreation, active and passive | Concentrated. (Constructed facilities essential and costly; minimum is sanitary facility). |
| 16. | Equestrian park | | |
| 17. | Field sports | | |
| 18. | Golfing | | |
| 19. | Horse racing | | |
| 20. | Power boating | Recreation, active and passive, mechanized | |
| 21. | Motocross | | |
| 22. | Speedway | | |
| 23. | Zoological park | Recreation, passive | |
| 24. | Caravan park or campsite | Residential | |
| 25. | Holiday camp | | |
| 26. | Housing estate | | |
| 27. | Airfield | | |

../3

Land-use allocation - general

For a large part of the area the historical use of softwood timber production should continue. The product emphasis should change after utilization of the present crop, however, towards high quality sawlogs. Partly, this should be achieved by management as an agro-forestry regime. The area would then also serve as a very accessible demonstration of the latter practice, having educational and recreational value. For some land currently under pine cover, retention as pine woodland is proposed as a landscape measure, in conjunction with a recreational zoning.

A considerable other area of land should be assigned to primary production of the pure agricultural form. Most of this will be land which has been worked over by the mining company, and for such land establishment of cover crops followed by pasture and grazing for at least five years has already been prescribed (see Appendix I).

Following (in some locations, preceding) this period of substrate improvement certain areas should be devoted to hardwood woodland as a shelter, shade and landscape resource rather than a directly productive one. Hardwood forest with an eventual productive aim may be a suitable objective for other portions and if possible these should feature local timber species.

Three portions of the subject area carry flora species but rarely found in the region because of agricultural clearing. The optimal land use for these would be assignment to flora conservation in perpetuity. At the least, they should be managed as sources of seed until the species could be established on suitable nearby land unused except as part of the recreational resource.

The presence of extensive water bodies in a region in which that resource is diminishing should automatically favour fauna conservation as a use on the area. When consideration is given to the conservation importance of the paper-bark swamp on alienated land nearby their value must be increased. According to the local officer of the Department of Fisheries and Wildlife that swamp is the habitat of forty species of birds (including all the common ducks) of which eight are known to be breeding there. Most importantly two ibises have breeding colonies. That of the straw-necked ibis (Threskiornis spinicollis) is only the second in the State known outside of the Kimberley region, and that of the White ibis (T. molucca) is the only one known outside that region. The white egret (Egretta alba) is also though to be breeding there. The value of that island habitat would be augmented if an equivalent one could be created around the lakes resulting from mining. Conversely management of water levels in those lakes could have an adverse effect on the natural swamp through underlying ground water table. This point has already been the subject of discussion between the Department of Fisheries and Wildlife and the mining company.

In addition to the potential for water-fowl habitat, water bodies are valuable for several forms of recreation, and it is proposed that some of these uses could be combined in a sympathetic way with the previous one.

../4

The philosophy which has been applied in relation to recreation is that only those activities which have a diffuse impact and low requirement for constructed facilities should be accommodated. Exceptions to these criteria would be the rifle club activities where the users are prepared to provide the required facilities, and possible equestrian sport and B.M.X. venues where a similar condition might apply. This cut-off point roughly corresponds to the upper fifty per cent of compatibility ratings as displayed in Table 2, Appendix III.

Control of recreational activity would be facilitated by arranging that access routes and facilities such as picnic sites be disposed peripherally. In particular the large through roads constructed by the mining company should be removed once mineral claims have expired. Recreational use of the more central portions assigned to that use would then be restricted to people prepared to use non-mechanical methods of getting there, except that some provision would be needed to bar all-terrain vehicles. The reasons for restricting access would be:-

1. To avoid disturbance to wildlife and livestock.

2. To minimize the incidence of shooting.

3. To limit the area on which environmental degradation and littering would be problems.

4. To reduce the chance of wildfires.

Concentration of passive recreational activity on the south-western part of the land, in combination with a varied vegetation cover and topography, would provide both heightened experience and the restriction of the intensively managed zone. However the integration of recreation with softwood production would still provide a stern test of management skills.

The land use of quarrying, normally thought of as inimical to many of the values attributable to the subject area has been judged only conditionally so, depending on its location and extent. It is proposed as a temporary land use as a self-supporting means of improving certain features of the subject area, viz.

1. Removal of undesirable roads, and provision of material for other roads.

2. Removal of piles of coarse laterite which are present to excess adjoining and in the proposed Lake Coolyoolup, and which offers slight prospect of ever adequately being revegetated.

3. Removal of regular projections into water bodies, and grading of steep banks in some places.

In the latter case a better effect could be achieved by pushing material out into lakes to create shallow-water areas, but this would involve expenditure rather than being a self-financing operation.

A summary of projected land-use allocations is presented in Table 2.

TABLE 2. Areal Allocation to Land Uses

| | Hectares |
|---|---|
| Hardwood production | 20 |
| Mixed hardwood/softwood | 25 |
| Softwood production | 61 |
| Softwood + Livestock production | 168 |
| Softwood production + Flora Conservation | 24 |
| Flora Conservation | 22 |
| Fauna Conservation and Recreation | 69 |
| Recreation | 136 |
| Agric. production + Landscape | 128 |
| Agric. production | 40 |
| | 693 |

Land-use allocation - specific areas

In this section the areas delineated by land-use boundaries and identified by number on the Coolyoolup Lakes Land Use and Landscape Plan are discussed individually.

Item 1. 22.9 ha. The rifle range firing gallery has already been established. The plantation immediately adjoining the south-western end has been thinned to a prescription based on visual amenity value, making use of a trade operation. There is an area on the west of this zone, comprising parts of Compartments 57 and 60, which has been thinned commercially. The recommendation for this is that the final timber-getting operation, whenever it may be, should retain scattered, strong trees to complement the landscape value of the inner zone already retained.

Item 2. 70.1 ha. Though the land has produced quite good oaten hay and grain crops the establishment of pasture species is not yet noticeably good. Good early growth of some tree species has been evident, but the probability of droughting on parts and the possibility of poor form resulting from winter instability on silt tailings mean that the likelihood of commercial timber production needs further assessment. Therefore a prolonged agricultural use is proposed. The tree planting to date has been located with landscape and shelter values in mind, and carried out in such a way as to enable the use of conventional agricultural machinery without damage to trees. Grain or hay crops would thus be a possibility as well as grazing.

A further use proposed for this area is an emergency landing ground, viz. a retained portion of the present access road. This is about eleven metres wide, and straight and level for 750 metres. Such use would however be conditional on removal of the power line which runs along the western side.

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The power line presents something of a problem. It is undesirable in relation to the use proposed above, and aesthetically because of constraints imposed on re-afforestation, but it would probably be more economic for the company to retain it than to arrange a new supply from the line close to where the operation now is. Also part of it could be useful for some of the agricultural activity which is proposed in a later paragraph, although this could be supplied if necessary from the extension which will have to come in from the east to the rifle club development.

Item 3. 2.2 ha. Planning for this precinct has been carried out as a subsidiary project (see Appendix II) and the lease application from the South-West Rifle Clubs Association is currently under consideration.

Item 4. 7.3 ha. The indigenous species here appear to have arisen since clearing in 1973 of plantation established in 1951 and 1955, probably from isolated specimens and possibly from seed stored in the soil. One leguminous species present appears to be a good colonizer and that especially would be a source of seed for revegetation of the disturbed land where agricultural species are to be replaced ultimately with indigenous species.

Item 5. 14.8 ha. The bulk of this zone is occupied by shrub species or by flooded gum (Eucalyptus rudis) indicating unsuitability for pine plantation. At the same time this riparian flora is probably not now well represented among the agricultural land surrounding, and so could be considered worthy of preservation.

Item 6. 24.3 ha. The partially wet area within this section carried one species (Melaleuca lateritia) which has only been observed by the author at one other location in the region round Busselton. Establishment of plantation around the wet areas in 1964 has apparently not affected the survival of the species here, therefore combination of timber production with flora conservation is proposed as the land use for this area.

Item 7. 57.8 ha. The land of this section is similar to that of item 2, being mainly refilled land with silt dams, though rising to greater elevation. It is mainly treated as a separate area because preparation of the surface and initial seeding have not yet been done for most of the silt dams, and so it will become available for use later.

The ultimate use will be as for item 2 but for trees it may be more droughty because of the greater elevation of tailings. An area at the northern end, being low lying and closely covered by relatively shallow silt dams, presents itself as suitable for horticultural practices with irrigation from the nearby lake. Suitable crops could be tree seedlings, vegetables or citrus fruits, and such high-value products could make worthwhile some physical amendment of soil conditions by incorporating sand from nearby areas and also organic material.

Item 8. 21.8 ha. The lake which is the main feature of this proposed recreational precinct is already fairly attractive by virtue of some early established trees. It is ideally located as a meal-stop for passing travellers on the Bussell Highway, and it could also serve as starting point for lakeside and woodland walk trails, or for canoe voyaging along the lake system.

With co-operation from the mining company in relation to grading of land on the west of the lake and to exclusion of cattle, development of picnic sites here could proceed almost immediately.

Item 9. 88.8 ha. This recreational area could provide for a range of more environment-oriented experiences, e.g. picnicking, walking, trail riding, nature study, fishing. At the same time by incorporating small areas of pine and hardwood plantation in the landscape it could serve an educational function. These plantations could be run as demonstrations and suitably explained by signing.

It is proposed that public access should be from west or east by the re-routed and up-graded Coolyoolup Road which would in part take over the present Banfield Road. The re-establishment of the western end, destroyed by mining, is expected to be done during the summer of 1982-83.

Preliminary tree planting for landscape purposes on the banks of Coolyoolup Lake has been carried out in 1982 by the mining company, and it is proposed to promote this activity in the next year or two. By reason of its potential shallow areas and its banks and islands this lake could prove the most interesting in terms of wild-fowl feeding and resting. The abundance of crannies in the dumped rocks could also prove to be very conducive to maintenance of a large population of marron. These are already in some of the northern lakes on company land and their distribution is being promoted through an informal arrangement by the rehabilitation officer of the company.

Water levels in the lakes will fluctuate with the seasons, and quite markedly (by about 1.2 metre) until about 1988. By that time the company should have enough storage on its land to the south-west to sustain the summer draw-down without recourse to water on State Forest.

Item 10. 49.3 ha. This area currently carries P. pinaster planted between 1915 and 1925, of the Landes strain, and much in an unthinned state. However as the soil on most of the area is of the Wonnerup series it should be an average site quality for P. radiata, hence the proposal of that species for a second rotation. In the eastern portion there are well grown specimens of P. pinaster and it is proposed that those within 30 metres of the centre of the road alignment be retained as amenity trees.

Item 11. 11.9 ha. Proposed plantation of this item will be of an experimental nature. The land has been refilled and mostly covered by silt dams but is inconveniently interlocked with portions of present plantation which have been proposed as amenity woodland. For this reason it may be impractical to fence and practice agriculture as is proposed for improving the substrate on other parts of the subject area, nor should there be any compromising of the indigenous flora resource intermingled with plantation remnants, by allowing inclusions in order to achieve straight boundaries.

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The results which might be obtained in the absence of grazing as an aid in building up soil nitrogen are problematical. Nitrogen build-up by legumes may need to be supplemented with applied fertilizer. Physical unsuitability for P. radiata may be proven, in which case P. taeda may be tried for the silt dams, with hardwoods on the sand tailings. Whatever the success or failure of softwood species the result would be an indication of the potential of ~~these~~ such refilled sites for return to timber production.

Item 12. 20.1 ha. This proposed hardwood production area will also have an important landscape and shelter value for the recreationally used environs of the lake. The production purpose may not be realizable, but that and the species which can be grown there should be more assessable from the progress of prior plantings when the land becomes available. It is suggested however that jarrah and tuart should be preferred if practicable.

Item 13. 79.7 ha. The proposal for this area accords with that of Plantation Management Officer Gilchrist in his 1979 report on the silviculture desirable for the subject area. However when the present pinaster crop has been harvested three species are now proposed for the second rotation. There is some site variability and best results should be obtained by allocating P. pinaster, P. radiata and P. taeda to grey sands, to yellow sands and loamy soils and to wet sites respectively.

Provision has been made on the area for retention of old pinaster within thirty metres of the centre line of the proposed Coolyoolup Road as landscape and shade strips. A prescription has been prepared, and implemented in conjunction with commercial thinning in Compartment 38.

A complication yet to be evaluated would be the legality of issuing a grazing lease over an area which coincides with a prior lease held by the Department of the Army.

Item 14. 25.1 ha. The western part of this item has not been planted with pine in the past, doubtless because of a large proportion of heavy to very heavy soil texture and occurrences of gravel. It is now proposed that eucalypt pole species should be grown there. A similar proposal is made for the eastern section which currently carries P. pinaster, except that interplanting of P. radiata with the eucalypt is suggested. The area would be a trial of raising poles under intensive management, the pines enabling thinning of the stand commercially once well formed pole lengths had been achieved.

The whole area would add to the recreational and educational value of the land to the west and form part of a burnable buffer, at least in later years, between the recreational zone and the high-value production zone to the east.

Item 15. 88.3 ha. This item exhibits predominantly deep grey sandy soil, some of which is extremely leached. In spite of being mainly in an elevated position, some parts are water-retaining. Indigenous vegetation has overcome P. pinaster on one area south west of Compartments 60 and 61 and some uncommon species are present. There would be a case for a further flora reserve in this area, and that could be implemented informally by exclusion from planting if the present plantation were to be replaced by a second rotation at full stocking.

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However it is proposed that the land be allocated to combined livestock and timber production for a second rotation, the tree species to be mainly P. pinaster on the dry parts with P. taeda on wet patches. This is in accord with the silvicultural prescription for the current rotation.

Item 16. 39.9 ha. This area contains fourteen hectares of land now unused (unplantable plus boundary break) and in addition parts are too wet for the current crop of P. pinaster. The current silvicultural prescription proposes grazing after thinning for at least one compartment. It is therefore proposed that land of this item should be leased for grazing till the end of the rotation, establishing pasture as thinning on different compartments allows. At rotation end leasing could be continued or the land made available for exchange; it is well suited to that purpose by reason of its location peripheral on the subject area.

Item 17. 69.1 ha. The area is proposed as wildlife refuge for several reasons. The first is the proximity to a small but very important nesting habitat nearby and the possibility of developing an addition to that resource. In addition to the lakes there are areas of near-natural swampy ground and of artificial ponds which could be made similar. The sand tailings fill which is on average about five metres deep, is a very difficult site on which to establish tree cover. Some parts, notably where gravel screenings have been spread, have produced regeneration of native shrub and ground cover species, and it seems that a shrubland may be an easier target than woodland or forest. However the former would create more suitable habitat for smaller birds and for some fauna.

The inclusion of recreation as a proposed use for a wildlife refuge is possible provided it is isolated from vehicular access and therefore difficult to get to. This characteristic is accentuated by the elongated shape of the portion of land. Thus relatively few people would use the area (compared to Item 9) and they would be following quiet pursuits. Walking or riding for enjoyment or accession to a particular point, canoeing or rowing, and fishing or marroning would be the likely uses. Even access to the lakes by powered dinghy would probably be acceptable, but would be easy to limit by physical means if disturbance were to ensue.

Inclusion of the eastern shores of the lakes in this area is proposed partly because they are mainly so steep as to be degraded if accessible to farm animals, and partly to make a greater length of shoreline accessible to people, whose effects are more controllable.

In spite of the stated potential of the lakes as wildlife habitat, achievement of that potential demands considerable modification. The banks are mostly too steep to provide good resting places at the waterline, there are few shallow areas suitable for feeding of water birds, and the shorelines are too straight and short to accomodate large numbers of resident birds. Islands which might provide ground nesting sites safe from predation are lacking.

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The mining company has been aware at least since 1978 of the desirability of the above features, and in fact has tended to leave wider and shallower lakes since about that time, but special measures such as pumping fill to grade banks and create islands have been avoided on practical and economic grounds.

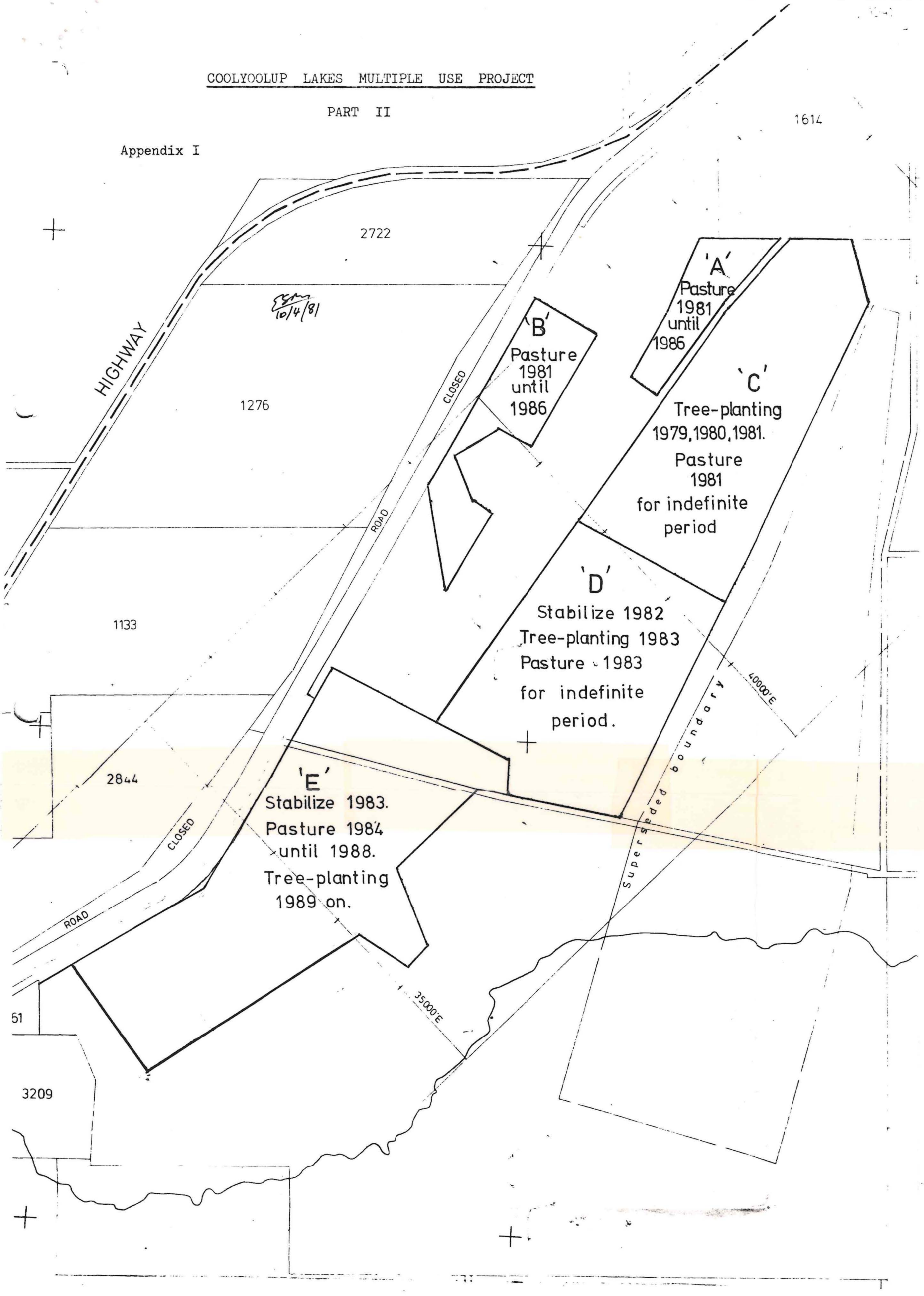
It is therefore proposed that at an early stage in management by the Forests Department the disposal of sand tailings as land-fill material should be canvassed. As consideration for supply of material to a private contractor, he should be required to carry out transport of further material into lakes to create shallow water and above-water promontaries. All operations should be planned, estimated and agreed upon before starting. This would involve loss of some stabilization and tree planting already achieved, but would be justified by the result.

G.S. McCutcheon
S.D.F.O. (Site Survey)
20/8/82

COOLYOOLUP LAKES MULTIPLE USE PROJECT

PART II

Appendix I



COOLYOOLUP LAKES MULTIPLE USE PROJECT

PART II

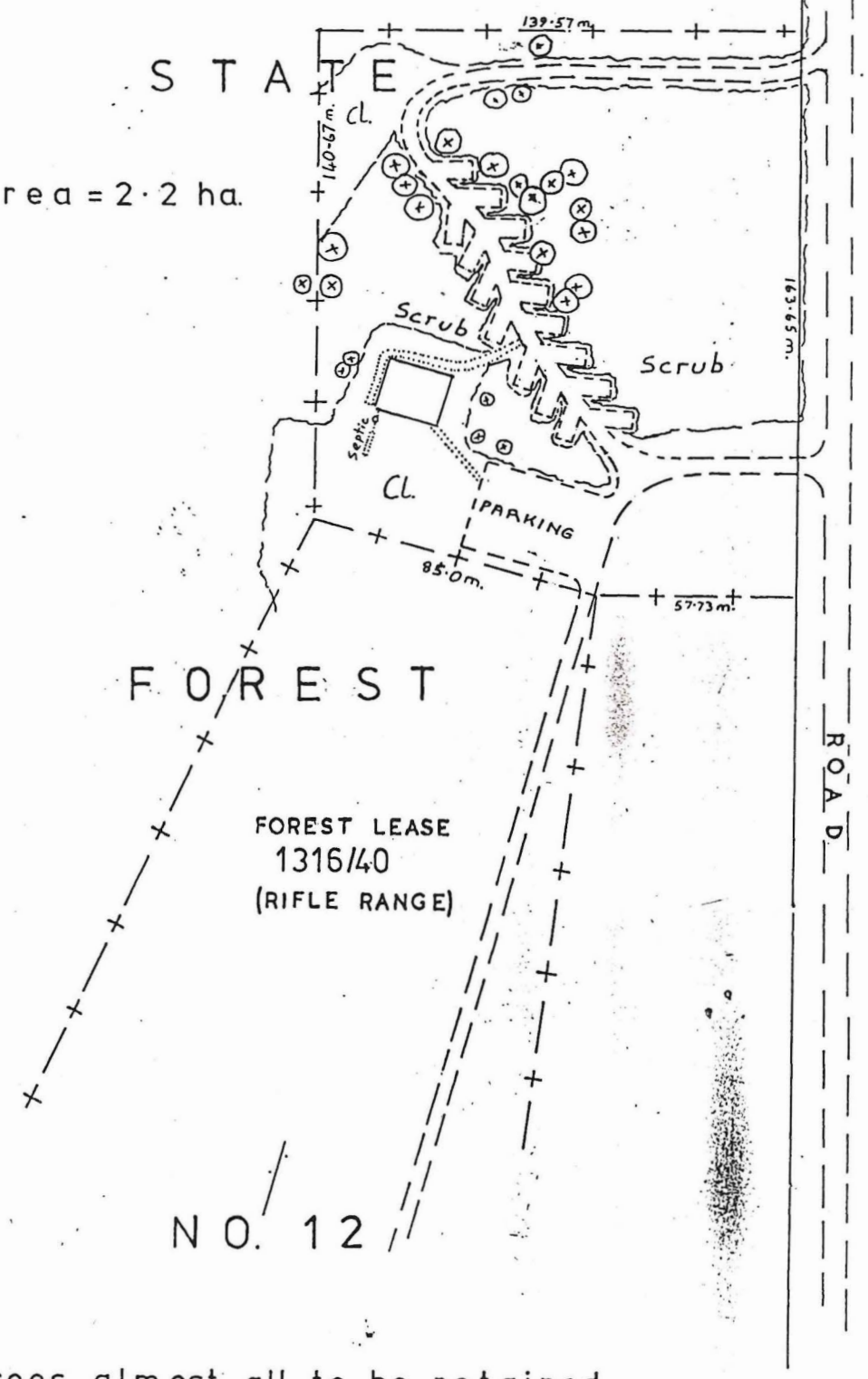
Appendix II

Loc. 1614

Proposed lease area outlined in red.

Scale: 1mm = 2 metres

Lease area = 2·2 ha.




⊗ = pine trees, almost all to be retained.

Caravan bays 5·5 X 7 m. clear of road.

Car bays 4 m. + 7m. turning space.

C.S.M.
23/6/82

# COOLYOOLUP LAKES MULTIPLE USE PROJECT

## PART II

### Appendix III

A subjective assessment of the mutual compatibility of the various land uses is provided in Table 1 herein. This was compiled by tabulating the maximum level at which a secondary use would be compatible with each primary use without imposing a reduction from the full potential of the primary use. Apart from consideration of physical deterioration which might be caused to a primary resource, detraction from the experience expected by users of the resource is also treated as a constraint. Some interactions between uses have not been treated as subject to constraint because they are highly ephemeral.

It should be noted that the two halves of this table differ. This follows from the fact that each compatibility coding depends on which land-use is assumed to have priority. For example, flora conservation is conditionally compatible with hardwood production as a priority use because some indigenous species will be able to survive, provided the propagules are present initially. However economic hardwood production (originating as plantation) is incompatible with flora conservation as a priority use.

Converting the compatibility estimates of Table 1 into rank numbers as in the key to that table, estimates of the overall compatibility with other uses and tolerance to other uses were calculated for each land use. These are listed in Table 2. There, a high Mean Compatibility Rating indicates that a land-use detracts relatively little from most other uses. A high Mean Tolerance Rating indicates that it is relatively little affected by most other uses.

In general the highest level of multiple use for a piece of land will be achieved by selection from those uses with high Mean Compatibility Ratings. However this general approach has to be modified first by consideration of the suitability for the selected uses. Again it may be modified by the historical uses of the land which may be a strong argument against change of use. A reduced list of uses arrived at by this means may be augmented by incorporating low compatibility uses on the same or adjoining precincts with high tolerance uses of the first list.

From Table 2 it will be seen that the land uses which have Compatibility Ratings from the fifth decile upwards (broadly those which are at least compatible on adjoining areas) correspond fairly well with those characterized as having diffuse impact in Table 1 in the body of Section II of the report. This support for the first classification from a semi-objective system of studying interactions does lack something however. The results would have been more reliable had they been derived from a survey of potential users.

COOLYOOLUP LAKES MULTIPLE USE PROJECT

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Appendix III

Table 1. Compatibility of Land-uses on the same or on an adjoining precinct.

Maximum level at which a secondary use (in row) would be compatible with a primary use (in column).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | = | =. | 0 | =. | =. | = | = | = | 0 | 0. | =. | =. | = | =. | =. | =. | = | =. | 0. | 0 | =. | =. | 0. | 0. | 0. | 0 |
| 2 | = | | =. | 0 | =. | =. | = | = | = | 0 | 0 | 0 | 0 | = | =. | =. | =. | = | =. | 0 | 0 | =. | =. | 0. | 0. | 0. | 0 |
| 3 | =. | =. | | =. | =. | =. | 0 | = | = | =. | =. | =. | X. | = | =. | =. | =. | =. | =. | =. | 0 | =. | 0 | =. | =. | 0. | 0. |
| 4 | =. | =. | =. | | =. | =. | = | = | = | =. | =. | =. | X. | = | =. | =. | =. | =. | =. | =. | 0 | =. | 0 | =. | =. | =. | 0. |
| 5 | =. | =. | =. | =. | | =. | =. | =. | =. | =. | 0. | =. | =. | =. | =. | 0 | =. | =. | =. | =. | =. | =. | 0 | =. | =. | =. | =. |
| 6 | =. | =. | =. | =. | =. | | 0. | =. | = | = | =. | =. | =. | 0 | 0 | =. | =. | =. | =. | =. | = | =. | =. | 0. | 0. | X. | =. |
| 7 | = | 0 | 0 | = | =. | =. | | = | = | 0 | =. | =. | =. | = | =. | 0 | 0 | =. | 0 | = | 0 | 0 | 0 | = | 0 | =. | 0 |
| 8 | = | = | = | = | =. | 0 | = | | = | = | = | =. | =. | = | =. | 0 | 0 | = | =. | 0 | =. | 0 | 0 | = | = | 0 | 0 |
| 9 | = | = | = | = | 0 | 0 | = | = | | = | =. | =. | =. | = | 0 | 0 | 0 | = | 0 | =. | =. | 0 | 0 | = | = | = | 0 |
| 10 | 0. | = | =. | =. | 0 | 0 | = | = | = | | 0 | 0 | 0 | = | =. | =. | =. | =. | =. | 0 | 0 | =. | 0 | =. | =. | =. | =. |
| 11 | 0. | 0 | =. | =. | =. | =. | =. | 0 | =. | 0 | | 0 | 0 | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0 | =. | =. | =. | =. |
| 12 | =. | = | =. | =. | =. | =. | =. | = | =. | = | = | | 0 | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0 | =. | =. | =. | =. |
| 13 | =. | = | =. | =. | =. | =. | =. | = | =. | 0 | 0 | 0 | | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0 | =. | =. | =. | =. |
| 14 | = | = | = | = | =. | 0 | =. | = | = | = | =. | =. | =. | | =. | =. | =. | =. | 0. | =. | =. | =. | =. | =. | =. | =. | 0 |
| 15 | 0. | 0. | =. | 0 | =. | 0 | 0. | 0. | =. | 0. | =. | 0. | 0. | =. | | =. | =. | 0. | =. | =. | =. | 0 | =. | =. | =. | =. | =. |
| 16 | =. | 0. | =. | =. | 0 | =. | =. | 0. | =. | =. | =. | =. | =. | =. | =. | | =. | =. | =. | =. | =. | 0 | =. | =. | =. | =. | =. |
| 17 | X. | X. | =. | =. | =. | =. | =. | 0. | =. | 0. | =. | 0. | 0. | 0. | =. | =. | | =. | =. | =. | =. | 0 | 0. | =. | =. | =. | =. |
| 18 | =. | 0. | =. | =. | =. | =. | X. | 0. | 0. | X. | X. | X. | X. | X. | X. | X. | X. | | =. | =. | =. | X. | 0. | 0. | 0. | 0. | 0. |
| 19 | 0. | 0. | =. | =. | =. | =. | 0. | 0. | =. | 0. | =. | 0. | 0. | =. | =. | 0. | =. | 0. | | =. | =. | 0 | 0. | 0. | 0. | 0. | =. |
| 20 | 0. | X. | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0. | 0. | =. | =. | 0. | =. | 0. | =. | | =. | =. | =. | 0. | 0. | 0. | =. |
| 21 | X. | X. | =. | 0 | =. | 0 | X. | 0. | X. | X. | 0. | X. | X. | X. | =. | X. | =. | X. | 0 | =. | | =. | X. | X. | X. | X. | =. |
| 22 | 0. | =. | =. | =. | =. | =. | X. | 0. | =. | 0. | 0. | X. | X. | 0. | =. | 0. | =. | 0. | 0. | =. | =. | | X. | X. | X. | X. | =. |
| 23 | =. | =. | =. | =. | =. | =. | =. | = | 0 | =. | =. | =. | =. | =. | =. | =. | =. | =. | =. | =. | =. | =. | | =. | =. | =. | =. |
| 24 | X. | X. | 0. | =. | =. | =. | 0. | 0. | =. | =. | =. | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0. | =. | X. | | =. | 0 | 0. |
| 25 | X. | X. | 0. | =. | =. | =. | 0. | X. | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0. | =. | =. | 0. | =. | X. | = | | 0 | 0. |
| 26 | X. | X. | 0. | =. | =. | =. | 0. | X. | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0. | =. | =. | 0. | =. | X. | =. | =. | | 0. |
| 27 | =. | 0. | =. | =. | =. | =. | =. | =. | 0 | =. | =. | =. | =. | 0 | =. | 0. | =. | =. | =. | =. | =. | =. | =. | =. | =. | 0 | |

Key to coding:-

| | | |
|---|---|---|
| 1 | X. | Incompatible even on adjoining precinct. |
| 2 | 0. | Conditionally compatible on adjoining precinct. |
| 3 | =. | Compatible on adjoining precinct. |
| 4 | 0 | Conditionally compatible on the same precinct. |
| 5 | = | Fully compatible on the same precinct. |

COOLYOOLUP LAKES MULTIPLE USE PROJECT

PART II

Appendix III

Table 2. Compatibility and Tolerance Ratings*

| Land-Use | Mean Compatibility Rating | Land-Use | Mean Tolerance Rating | Deciles of Range |
|---|---|---|---|---|
| Walking | 4.27 | Walking | 3.65 | |
| Nature Study | 4.23 | | | 10 |
| Picnicking | 3.96 | Hardwood Prod. | 3.46 | |
| | | Trail Riding | 3.46 | 9 |
| Fauna Cons. | 3.65 | Nature study | 3.42 | |
| Fishing | 3.65 | | | |
| Trail Riding | 3.58 | | | 8 |
| Flora Cons. | 3.42 | Fishing | 3.27 | |
| Canoeing | 3.38 | | | 7 |
| Sailing | 3.31 | Quarrying | 3.23 | |
| Hardwood Prod. | 3.27 | Motorcross | 3.19 | |
| Softwood Prod. | 3.19 | Speedway | 3.19 | |
| Swimming | 3.19 | Softwood Prod. | 3.15 | |
| Quarrying | 3.12 | Power boating | 3.15 | |
| Zoological park | 3.12 | | | 6 |
| Agriculture | 3.04 | Agriculture | 3.12 | |
| Airfield | 3.04 | Picnicking | 3.04 | |
| Equestrian park | 3.00 | Swimming | 3.04 | |
| | | Field sports | 3.04 | |
| | | Horse racing | 3.04 | 5 |
| B.M.X. | 2.81 | B.M.X. | 3.00 | |
| Field sports | 2.65 | Golf | 3.00 | |
| | | Airfield | 3.00 | |
| | | Fauna Cons. | 2.96 | 4 |
| Power boating | 2.62 | Van park & camp. | 2.92 | |
| Van park & camp. | 2.62 | Zoological park | 2.88 | |
| Holiday resort | 2.62 | Equestrian park | 2.85 | |
| Horse racing | 2.54 | | | |
| Housing | 2.50 | | | 3 |
| | | Holiday resort | 2.81 | |
| | | Flora Cons. | 2.77 | |
| | | Canoeing | 2.77 | |
| | | Housing | 2.77 | 2 |
| Speedway | 2.15 | Sailing | 2.62 | |
| Motorcross | 1.96 | | | |
| Golf | 1.92 | | | 1 |

* Means calculated from numerical rankings of Table 1 key.

# SPECIFICATION FOR AMENITY THINNING OF P. PINASTER ADJACENT TO BANFIELD ROAD AND ITS PROPOSED EXTENSION

**Amenity Zone** - to 30 metres distance on either side of the centre line of the existing road or the proposed centre-line marked with red flagging tape. This zone is to be taken as the zone whose boundaries are markedwith yellow tape.

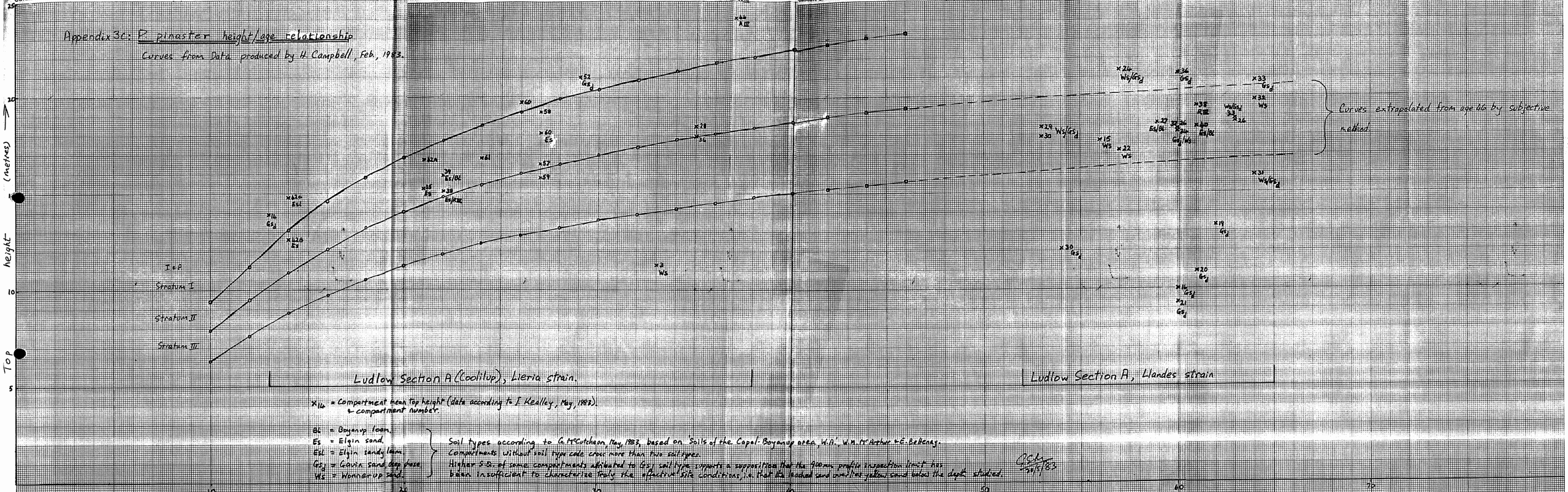
**Standard of Tr e for Retention** - co-dominant or sub-dominant trees having a relatively low ratio of crown diameter/density to d.b.h.o.b.; stem taper should be strong; moderate bole deformity and large branch size are acceptable; forked boles and kinked boles due to early cockatoo damage are to be avoided if possible.

**Spacing of Retained Trees** - distance between retained trees may vary between 5 and 7 metres on the square, i.e. within the same row or at right-angles to the row. This corresponds to diagonal distances betw en 7 and 10 metres (and stacking between 400 and 200 s.p.h.).

Standard of tree and spacing of trees may occasionally be subject to some mutual accommodation, e.g. two trees meeting the specification well may be retained close together to compensate for an excessive distance to another tree suitable for retention.

# Appendix 3C: P. pinaster height/age relationship

Curves from Data produced by H. Campbell, Feb. 1983.




Ludlow Section A (Coolilup), Lieria strain.

Ludlow Section A, Llandes strain

$X_{16}$ = Compartment mean top height (data according to F. Kealley, May, 1982).
16 = compartment number.

Bl = Boyanup loam.
Es = Elgin sand.
Esl = Elgin sandy loam.
Gs1 = Gavin sand, deep phase.
Ws = Wonnerup sand.

Soil types according to G. McCutcheon, May 1983, based on 'Soils of the Capel-Boyanup area, W.A.', W.M. McArthur & G. Bettenay.
Compartments without soil type code cross more than two soil types.
Higher S.I. of some compartments attributed to Gs1 soil type supports a supposition that the 900mm profile excavation limit has been insufficient to characterise truly the effective site conditions, i.e. that Bl is leached and overlies yellow sand below the depth studied.

J.C.K. 30/6/83