CONSULTATIVE ENVIRONMENTAL REVIEW

MINING OF AGRICULTURAL GYPSUM

from

LAKE CHINOCUP "A" CLASS NATURE RESERVE

No. A28395

PINGRUP

SHIRE OF KENT

PROPONENTS

Philip and Wendy Patterson, Gnowangerup
Paul and Diane Shiner, Pingrup

ENVIRONMENTAL CONSULTANTS

B K Masters and Associates
P O Box 315
Capel WA 6271

November, 1993

INVITATION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Consultative Environmental Review (CER) describes a proposal to mine agricultural gypsum from Lake Chinocup "A" Class Nature Reserve No. A28395, near Pingrup east of Katanning. In accordance with the Environmental Protection Act, a CER has been prepared which describes this proposal and its likely effects on the environment. **This CER is available for a public review period of 5 weeks from 2 December, 1993.**

Following receipt of comments from government agencies and the public, the EPA will prepare an assessment report with recommendations to the government, taking into account issues raised in public submissions.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions may be fully or partially utilised in compiling a summary of the issues raised or, where complex or technical issues are raised, a confidential copy of the submission (or part thereof) may be sent to the proponent. The summary of issues raised is normally included in the EPA's assessment report. Submittors would not be identified to the proponent without the submittor's permission.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may held reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues or the specific proposals discussed in this report. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in this report:

- clearly state your point of view
- indicate the source of your information or argument if this is possible
- suggest recommendations, safeguards or alternatives.

Points to keep in mind.

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues are clear. A summary of your submission is helpful.
- refer each point to the appropriate section, chapter or recommendation in the report
- if you discuss different sections of this report, keep them distinct and separate, so there is no confusion as to which section you are considering
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name
- your address, and
- the date.

The closing date for submissions is **10 January, 1994.**

Submissions should be addressed to:

Environmental Protection Authority
Westralia Square
141 St George's Terrace
Perth WA 6000

Attention: Jim Treloar

MINING OF AGRICULTURAL GYPSUM

from

LAKE CHINOCUP "A" CLASS NATURE RESERVE No. 28395

1.0 SUMMARY

The applicants for a Mining Lease over part of the Lake Chinocup Nature Reserve (80 kilometres east-north-east of Katanning) seek to quarry gypsum sand from dunes on the south-east side of the salt lake. The gypsum will be used principally for agricultural purposes, to improve salt-affected and clay-rich soils.

An extensive survey of the Pingrup\Nyabing region by the proponents has failed to locate alternative sources of suitable gypsum. Examination of 45 sites suggested by the Geological Survey of WA showed that tall dunes within the Chinocup Nature Reserve are the only economic resource of granular gypsum within a 90 kilometre radius.

A resource of some 660,000 cubic metres is indicated within tall dunes in Mining Lease 70/835 and, at an annual mining rate of up to 20,000 tonnes affecting about one hectare, a minimum minelife of 30 years is expected.

The gypsum occurs within actively growing dunes, with sand-sized particles of gypsum being blown from the bed and edge of the lake. Within the last 30 years, the gypsum dunes have increased their area and thickness significantly (area by an estimated 30%). This geological youthfulness explains the poor development of vegetation on the dunes and suggests that, once the area has been mined, natural processes will continue and recreate the pre-existing dunal landforms.

Re-establishment of pre-existing vegetation is expected to occur naturally over a five to ten year period, although appropriate commitments to full and on-going rehabilitation, including collection and spreading of seed and planting of seedlings, are given by the proponents.

The gypsum resource is wholly located within an "A class" Nature Reserve (number 28395) vested in the National Parks and Nature Conservation Authority for conservation of flora and fauna. It covers an area of about 19,825 hectares, of which some 12,500 is unvegetated salt lake.

The conservation values of the reserve are high and mining will be carried out in the following manner to ensure that environmental impacts are kept to an acceptably low level:-

* access to the proposed mining area will be along an existing track that runs along the southern side of the former Nyabing/Pingrup railway reserve (now unmade road number 8315)

* floral conservation values of all land to be affected by possible road improvements will be assessed by a botanist to ensure that siting of these works does not affect rare or unique flora.

* mining will be by front-end loader loading direct into the proponents' truck which will take product to a stockpile site to be developed on an existing gravel-covered area within the Chinocup townsite

* an Environmental Management Program will be prepared to the requirements of the Department of Minerals and Energy and the Department of Conservation and Land Management, to ensure that all aspects of mining and rehabilitation are fully detailed before mining commences.

* topsoil within the proposed mining area and all vegetation matter will be retained for spreading within mined-out areas. A 0.3 metre layer of gypsum sand will be left at the base of the mining area to maintain existing hydrological conditions and to encourage regeneration of vegetation into a substrate similar to that which exists at present. This thickness appears to be the minimum amount required for growth of those species currently growing on the dunes.

* initial approval to mine 20 hectares of gypsum dunes will be sought, after which further mining approval will be dependent upon demonstrating successful rehabilitation

* a stockpile area will be established on a gravel-covered 0.4 hectare area within the Chinocup townsite. Farmers' trucks will not have to enter the Nature Reserve to be loaded with gypsum. Only the proponents and their employees will be allowed to use the access track to enter the mining area.

* although the site is potentially susceptible to dieback, the overall risk of infection is considered low. Even so, because of the high conservation values of the Nature Reserve, dieback control measures as specified by the Department of Conservation and Land Management and Department of Minerals and Energy will be followed.

There will be no impacts on Lake Chinocup as the gypsum does not require processing prior to sale and no liquid wastes will be generated.

Gypsum occurs within some 70 hectares of the Mining Lease, representing about 1% of the vegetated portion of the Nature Reserve.

The proposed mining area does not carry habitat suitable for any of the rare faunal species known to occur within the Chinocup Nature Reserve (Western Mouse, Tammar Wallaby, Western Bristlebird, Western Whipbird).

Selective mining will be carried out to ensure that less than 100 of the estimated 1500 specimens of the Declared Rare Flora *Adenanthos pungens* ssp. *pungens* present within the Nature Reserve (800 within the Mining Lease) are removed during mining. No interference is expected to any of the other seven Declared Rare or Priority Flora populations found close to but not within the proposed mining area.

The proponents have gained approval from the Shire of Kent for up to half of the 243 hectare Chinocup Townsite reserve to be offered to the Department of Conservation and Land Management for inclusion in the nature reserve. This area of remnant vegetation contains six Declared Rare or Priority plant species and habitat suitable for the four species of rare or endangered fauna previously recorded from the Nature Reserve. The addition of this land will increase the conservation value of the Chinocup Nature Reserve.

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2.0 INTRODUCTION

2.1 Need for the Mining Proposal

Farmers in the Pingrup and Nyabing areas do not have access to a local supply of sand-sized gypsum (hydrated calcium sulphate or CaSO4.2H2O), a mineral of great value to agriculture. Gypsum is an effective source of sulphur for use on sandy soils but its use as an additive to clay-rich soils is of greater relevance to the Pingrup/Nyabing area.

Gypsum changes the chemical and physical characteristics of clay-rich soils by:-

* reducing surface water logging which then reduces salinisation of those soils see (PHOTO 1)

* increasing water uptake into the soil, preventing crops from drying out during extended dry periods during the growing season,

* increasing soil aeration, thus improving crop growth over the wetter winter months, and

* improving root growth by breaking down strongly binding clays.

Improved trafficability after gypsum application marginally reduces fuel consumption.

Gypsum-responsive clay-rich soils within the Pingrup/Nyabing area are conservatively estimated at between 5 and 15% of the total farming area (Kim Overhoi, Department of Agriculture, Jerramungup, and John Warren, Department of Agriculture, Esperance, pers. comm., 1993). Local farmers from the Ongerup to Pingrup area estimate clay-dominated soils reach 20 to 25% of the total farming area.

If these soils are improved through the addition of gypsum, the economic gains to farmers will be significant (productivity gains in the order to 100 to 400% from each gypsum responsive hectare). However, these gains may be relatively short-lived since gypsum application should form just one part of a total farm management plan.

Greater productivity from land already cleared for farming also reduces the need for landowners to clear remaining areas of bush. If farm income can be improved by applying gypsum to soils already used for agriculture, the need to spend money on clearing and developing new land is lessened.

Other benefits from gypsum use include improvements to surface water quality through lower levels of nutrient and soil run-off.

Most gypsum deposits being worked at present in WA occur more than 250 kilometres to the north, at Lakes Hillman, Cowcowing and Brown. The nearest deposit being worked is at Lake Magenta some 95 kilometres to the east.

Gypsum sells for between $7.50 and $11.00 per tonne ex-mine. Commercial haulage charges average about $0.08/tonne/kilometre, with a flat fee of $5.00 per tonne for the first 25 km. A 100 km haulage distance adds up to $11.00 to the cost of each tonne of product. Farmers using their own trucks would still pay as much as 50% of this contract rate.

Lower fuel use resulting from a shorter cartage distance will reduce emissions of greenhouse gases to the atmosphere.

The Department of Agriculture's Farmnote No. 32/85 provides cost estimates for gypsum application, using variables such as application rate, haulage distance and gypsum content in 1985 dollars (see appendix 1). Gypsum carted 100 kilometres was shown to be 70% more expensive per hectare than similar quality material transported 20 kilometres.

Most gypsum in WA occurs in four forms: coarse crystals, fine powder, sand-grain sized "seed" gypsum and cemented masses of crystalline gypsum.

Large crystals occur in the bed of many salt lakes throughout the southern parts of the state. This material is difficult to mine, is high in salt and requires several stages of processing before it can be used on farms. It is therefore the most expensive method of producing gypsum of suitable size and quality.

Powder gypsum is blown from the surface of salt lakes into dunes or lunettes around lake margins. While it is easy to mine, it is often of variable quality, can have a very high salt content and, of greatest importance, its powdery nature means that it is difficult to apply using normal farm equipment.

Sand-sized or seed gypsum is a rare commodity. The Chinocup deposit is of high quality (containing 93% or more hydrated calcium sulphate) and low in salt (less than 0.3% at the surface and averaging 0.1% at depth). Its grain size is excellent, which means that it will remain in the soil for several years and be easily applied using conventional farm equipment.

At Jurien Bay and Dongara, former marine embayments contain deposits of granular gypsum. However, the 500 haulage distance makes the use of this material uneconomic for the Pingrup/Nyabing area. The nearest possible marine deposits to Lake Chinocup are near Norseman and Esperance (see section 5.1).

2.2 The Proponents

The deposits are covered by Mining Lease 70/835, held in the names of:

Philip Gary and Wendy Diane Patterson
P.O. Box 176, Gnowangerup 6335

William Paul and Diane Margaret Shiner
40 Carrie Street, Pingrup 6343

The tenement was applied for on November 18, 1993. It covers a total of 213 hectares and, if granted, will have a life of 21 years, with potential for renewal. Upon grant, it will have a set of conditions applied to ensure that responsible mining occurs.

Mining will be carried out by Paul Shiner, with environmental advice to be provided by Anne Coates, botanist, of P.O. Box 36, Newdegate, 6355 and Bernie Masters, zoologist, of P.O. Box 315, Capel 6271.

A Miscellaneous License is also being sought by the ML applicants, to allow development of an access route along the western part of unmade road No. 8315.

2.3 History

Permission to mine gypsum within the Mining Lease has been sought on two previous occasions. In the mid 1970s, Paul Shiner applied for mineral claims over the area, but was discouraged from continuing with the application, based upon conservation concerns and the assumed presence of large tonnages of gypsum sand elsewhere in the general area.

In 1984, approval to extract gypsum from the deposit was again sought unsuccessfully from the then Department of Fisheries and Wildlife.

In 1992, the current applicants applied for and were granted Exploration License 70/1209 after having satisfied themselves that there was no other sizeable deposits of suitable gypsum within 90 kilometres of the current ML application area.

Results of a Geoscientific Survey Permit approved by DOMEWA confirmed that a large gypsum resource existed. A botanical survey of the area was then undertaken which convinced the proponents that mining could take place without unacceptable impacts on the Nature Reserve's conservation values.

The Chinocup Nature Reserve is an "A Class" reserve (No. A28395) covering some 19,825 hectares, of which approximately 12,500 hectares comprise salt lakes. It is vested in the National Parks and Nature Conservation Authority and managed by the Department of Conservation and Land Management (CALM) for the purposes of "Conservation of Flora and Fauna".

McKenzie (1973) and McKenzie and Youngson (1975) reported upon the conservation values of the area, with the former report recommending that the Chinocup townsite reserve (243 hectares) should be added to the Nature Reserve and managed by CALM for the conservation of flora and fauna.

2.4 Project Timing

The proponents wish to commence mining in early 1995, so that gypsum can be made available for application by local landowners in autumn of that year. Pre-mining site developments such as road upgrading and preparation of the stockpiling area will take several weeks. Hence, site works are hoped to commence during the summer of 1994/95.

2.5 Statutory Requirements and Approvals

For gypsum mining to proceed within the Chinocup Nature Reserve, the following approvals and statutory requirements must first be gained:-

* formal assessment as required by the Environmental Protection Act
* approval from the Minister for the Environment for mining to proceed within a Nature Reserve
* support from the Minister for the Environment for excision of the mining area from the Nature Reserve
* approval from both houses of State Parliament to allow mining within an "A" class reserve, with excision of the area covered by Mining Act tenements from the Nature Reserve

* grant of the Mining Lease and Miscellaneous License

* a detailed Environmental Management Program to be prepared by the proponents, with the plan to be accepted by DOMEWA and CALM so

* approval from the Minister for the Environment to allow the taking (removal) of rare and endangered plants and for the collection of seed and/or cuttings for revegetation purposes

3.0 DESCRIPTION OF THE PROJECT

3.1 Location

The gypsum deposit is located on the south-east edge of Lake Chinocup within Chinocup Nature Reserve No. A28395 some 25 km east of Nyabing and 10 km west of Pingrup within the Shire of Kent (see figures 1, 2 and 3). The area is located within the South West Mineral Field.

3.2 Existing Facilities

No facilities exist within the proposed mining area.

The now abandoned Nyabing to Pingrup railway reserve passes through the southern section of the Nature Reserve, immediately south of the proposed mining area. It has been reclassified into unmade Road No. 8315. Although the rail and most sleepers have been removed, the gravel foundation of the rail line remains and sections are useable by 4WD vehicles.

A bush track exists on the south side of the railway line alignment (see PHOTO 2). In summer, it is readily traversed by 4WD vehicles, although winter rains make access across creeks difficult and, on occasion, impossible.

3.3 Mining Method

Mining will involve the excavation of gypsum sand by a rubber-tyred front-end loader, loading into a multi-axle truck or semi-trailer for delivery to a stockpile area within an already cleared and gravel-covered part of the Chinocup townsite reserve. Product to be sold from the mining operation is in-situ gypsum sand and no processing is proposed or necessary.

Mining will comprise the following steps:

* collection of seed and/or cuttings from existing vegetation

* removal and stockpiling of existing vegetation or its direct placement onto mined-out areas

* removal of the surface layer (5 to 10 centimetres) of gypsum within which seed and other organic matter has accumulated and its stockpiling on the edge of the minesite or its direct placement onto mined-out areas

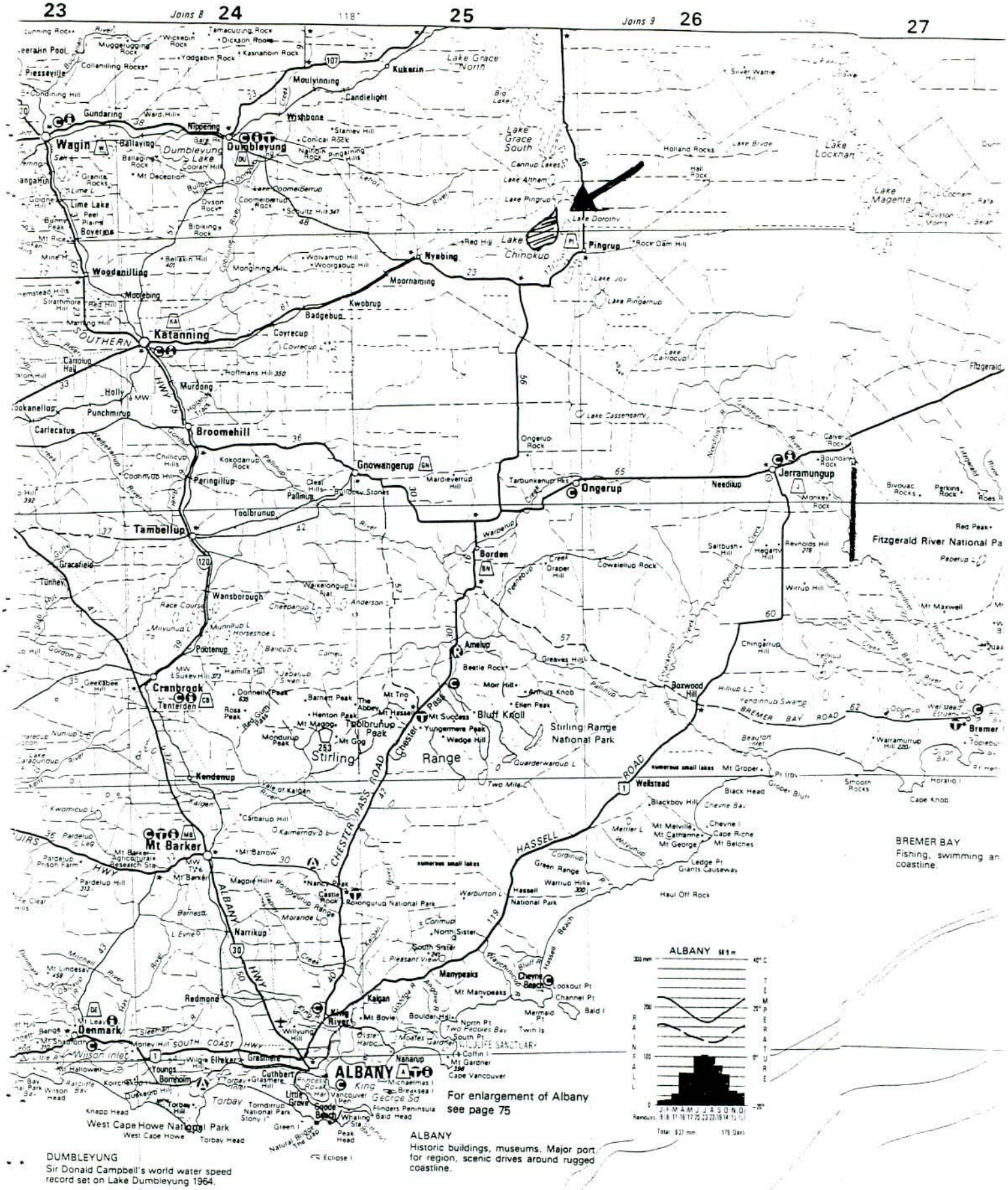


FIGURE 1
LOCATION MAP
1:1,000,000

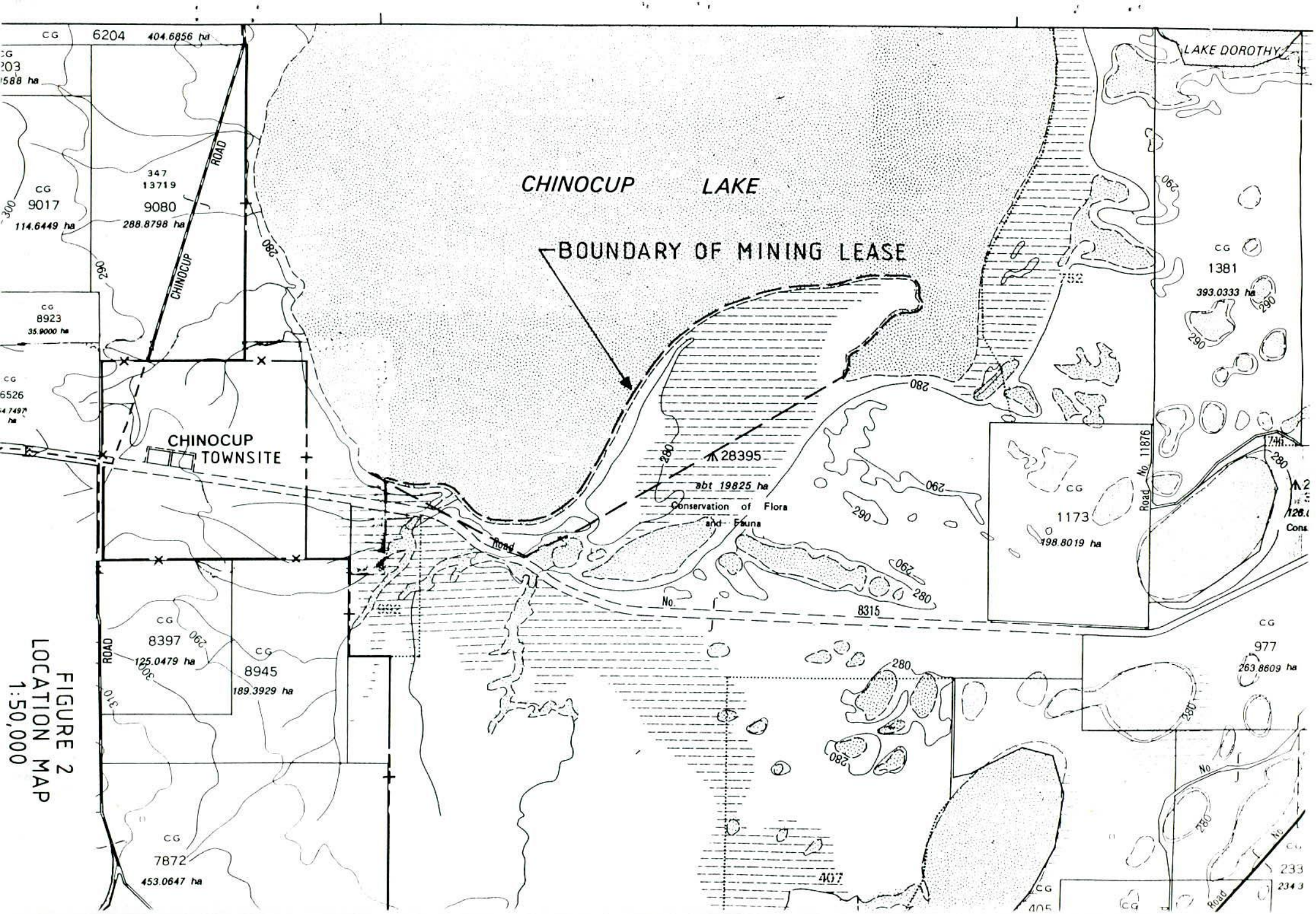


FIGURE 2
LOCATION MAP
1:50,000

FIGURE 3
Aerial Photograph of Project Area
1:16,000 approx.

* excavation of gypsum sand and loading direct into a multi-axle semi-trailer or truck operated by the proponents, using a rubber-tyred front-end loader

* recontouring of the worked-out areas, leaving 0.3 metres of gypsum sand at the base of the dunes to assist in revegetation and maintenance of pre-mining hydrology

* respreading of seed-bearing topsoil material from previously mined areas

* respreading of stockpiled vegetation matter

* seed distribution and/or planting of seedlings

* implementation of appropriate weed and feral animal (especially rabbit) controls, if necessary

* monitoring of rehabilitation success and remedial action for a minimum of five years or up to 10 years if shown to be necessary

A detailed mine path will be determined after a botanical survey has mapped those areas of denser vegetation or clumps of rare or otherwise high conservation value flora that are to be excluded from mining.

If requested by CALM, a fence will be erected around the outside of the mining area so that the mining path is clearly defined. All clumps of vegetation to be retained within the mining area will be fenced to ensure their protection against accidental disturbance.

Use of the existing gravel area at the former railway station site within the Chinocup townsite will eliminate the need to clear additional vegetation for stockpiling mined gypsum. The existing network of tracks leading to the railway station site can be readily modified to ensure a sensible traffic flows.

Use of the stockpile area within the Chinocup townsite reserve may be short-term, lasting only for the first 3 to 5 years of mining. However, upgrading of unmade road 8315 and provision of a truck loading and turning area within the Mining Lease will only occur if CALM can be satisfied that environmental impacts will be minimal and acceptable.

3.4 Ore Processing

No processing of ore will occur. It will be loaded onto farmers trucks at the stockpile area without prior washing, crushing or sizing.

3.5 Tailings Dam

No tailings will be produced during the mining operation; no water or other liquids will be used during the mining process; and a dam will not be necessary.

3.6 Areas Proposed for Clearing, Excavation and Stockpiling

Figure 4 outlines the four areas of higher gypsum dune sand which are proposed for mining in the short to medium term. Lower dunes largely covered in samphire will be sought for mining in the longer term.

As described in section 8.3, areas of dense vegetation and clumps of important plant species within these dunes will not be mined. The exact positions of these areas will be determined by a flora survey to be carried out as part of preparation of the Environmental Management Program.

The proponents are seeking formal permission to mine within 20 hectares of the taller dune areas. This will provide a mine life of between 15 and 20 years, depending upon demand and the actual thickness of recoverable gypsum.

In total, gypsum sand occurs beneath some 70 hectares of the Mining Lease, representing about a third of the Mining Lease area and 1% of the vegetation-covered section of the Chinocup Nature Reserve.

Stockpiling is proposed for the 0.4 hectares of gravel apron already existing within the Chinocup townsite. This was the former railway station loading/unloading area.

3.7 Expected Mine Life

With an estimated gypsum resource of some 660,000 tonnes contained within the taller dunes, a predicted annual mining rate of 20,000 tonnes will allow mining to last for 30 years. A similar quantity of gypsum may occur within low dunes (see figure 4) and a further 30 years of mining is possible.

3.8 Nature, Volume, Composition and Fate of Any Aqueous Discharge

No aqueous liquids will be generated on site.

3.9 Auxiliary Services

A small storage facility for diesel fuel will be needed to supply the proponents' front-end loader and truck. This will be installed in accordance with standard DOMEWA guidelines and a base and bunds of suitably impervious material will be installed.

Should toilet facilities be required on site, a simple portable unit will be purchased and installed. Disposal of wastes will be by burial at depth into underlying clay-rich sediments.

3.10 Construction Workforce and Vehicular Movements

Access from the Chinocup townsite to the mining area will use the existing track on the south side of the now abandoned railway line.

Permission to develop access from the eastern side of the Nature Reserve will not be sought unless by prior assessment and approval from the EPA.

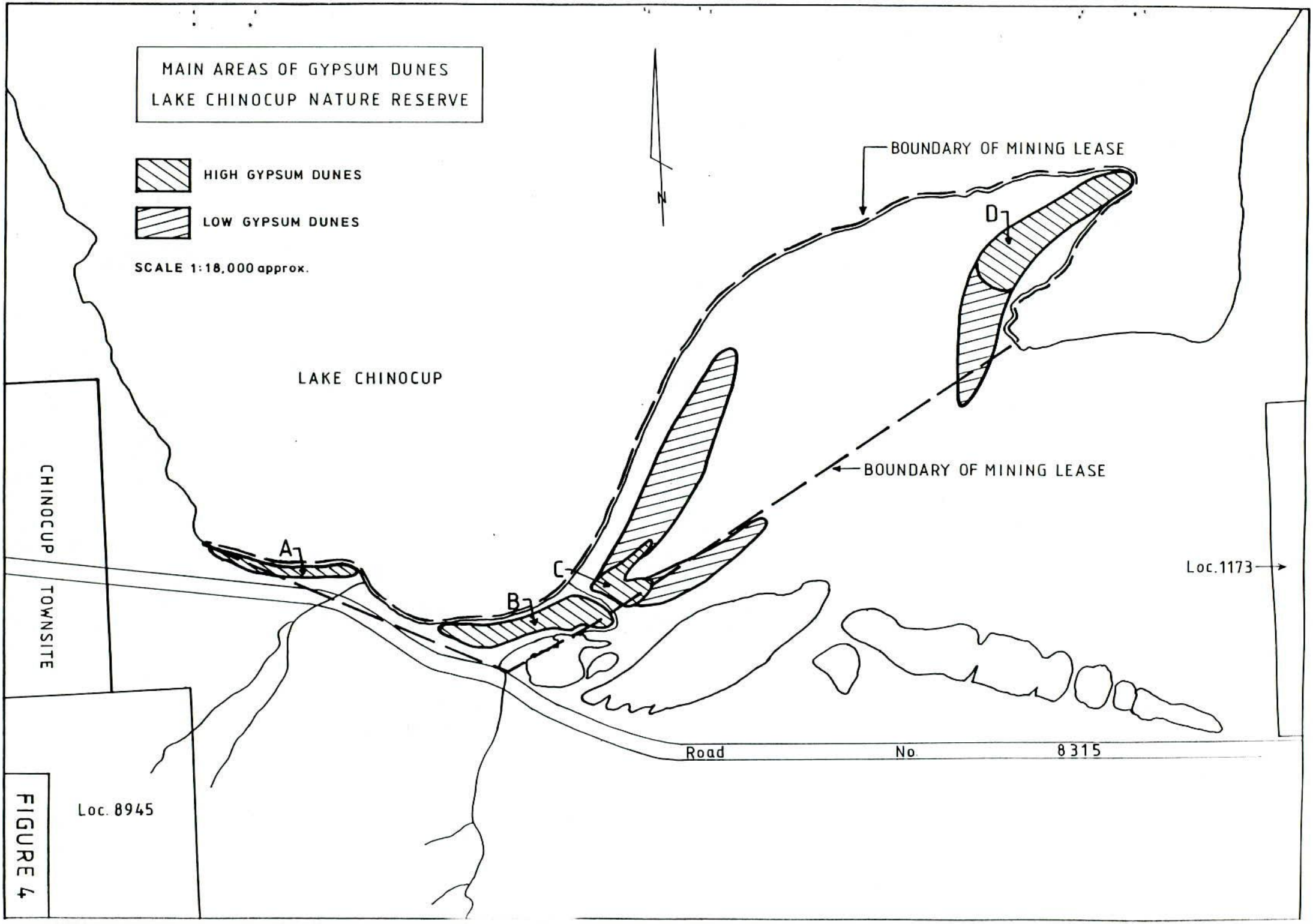

MAIN AREAS OF GYPSUM DUNES
LAKE CHINOCUP NATURE RESERVE
HIGH GYPSUM DUNES
LOW GYPSUM DUNES
SCALE 1:18,000 approx.
N
BOUNDARY OF MINING LEASE
BOUNDARY OF MINING LEASE
LAKE CHINOCUP
A
B
C
D
CHINOCUP TOWNSITE
Loc.1173
Road No 8315
Loc. 8945

FIGURE 4

Access will not be developed to allow traffic to travel through the Nature Reserve. The proponents will assist CALM in discouraging use of unmade road 8315 to the east of the mining area.

Once access has been provided, the operation will generally employ between one and three people to operate a front-end loader within the mining area, a truck taking gypsum to the stockpile area and a front-end loader at the stockpile area. Farmers and contractors will drive their own trucks to the stockpile area for loading.

Consultants will be employed on an as-needed basis to advise on rehabilitation methods, monitor revegetation and ensure compliance with conditions attached to the grant of the Mining Lease and others required by the EPA.

Contract employees may be hired to collect seed for use in rehabilitation. Should seedlings of dune plants be needed for planting out, these are likely to be grown by local nurseries. Strict attention shall be paid to the maintenance of dieback-free conditions within these nurseries.

Access between the mining area and the Chinocup townsite will be upgraded by improving the existing track that lies on the south side of the railway alignment. For most of its length, it is in a reasonably serviceable condition (see PHOTO 2) but two or three creek crossings will be upgraded to allow summer and autumn use.

It is expected that upgrading will comprise the use of gravel (possibly from the immediately adjacent railway reserve) and suitably sized concrete box or pipe culverts or similar. No substantial earthworks are proposed and the road will be capable of being readily removed upon completion of mining.

Since access by farmers to the mining area will not be allowed in the short-term, the existing access track will only be used by the proponents or their employees. The seasonal nature of mining will not require the track to be upgraded to an all weather road.

Should two-way access or passing bays be required, additional road surfaces will be developed on the existing railway formation. Prior to ground-disturbing activities, the small areas of native vegetation that may be needed to link the railway formation with the existing track will be surveyed by an experienced botanist so that Declared Rare and Priority species are not affected.

A maximum mining rate of 30,000 tonnes per annum is expected. With sales restricted to the late summer\autumn period, 10 weeks of sales over a 5 days per week operation will see some 600 tonnes of gypsum sold each day. Farmers' and contractors' trucks that cart grain and other bulk materials in the local area have an average capacity of about 15 tonnes. Hence, 80 truck movements per day (40 loaded and 40 empty) are likely to be generated by the mining proposal. The proponents and their employees may be responsible for a further 10 vehicle movements per day.

Based upon these relatively small numbers of vehicle movements, no new roads or upgrading of existing roads will be required. Even so, the Shire of Kent is a strong supporter of the proposed mining operation and their assistance is expected, should minor road improvements be sought.

4.0 EXISTING ENVIRONMENT

4.1 Regional Setting

Lake Chinocup is a large lake at the southern end of a north-flowing palaeo-drainage system that stretches 60 km north beyond Lake Grace townsite. Sediments within the lakes are the final products of erosion of the underlying acidic granitoid rocks, with secondary weathering products such as gypsum common to abundant within the uppermost levels of the sedimentary accumulations.

The lakes are generally saline, with hypersaline conditions preceding normally dry conditions over summer.

4.2 Climate

The general Pingrup area enjoys hot dry summers and cool winters. Pingrup receives about 350 mm of rain annually on about 100 wet days per year. Most rainfall occurs between May and October.

Lake Grace is the nearest town with a long recording history. Its average maximum and minimum temperatures vary from 14.8 and 5.5 degrees Celsius in July to 32.2 and 14.4 degrees in January.

Summer winds are hot and dry from the east and north east. Winter winds are cool and come from the west and north west. Evaporation exceeds three metres per year.

4.3 Geology

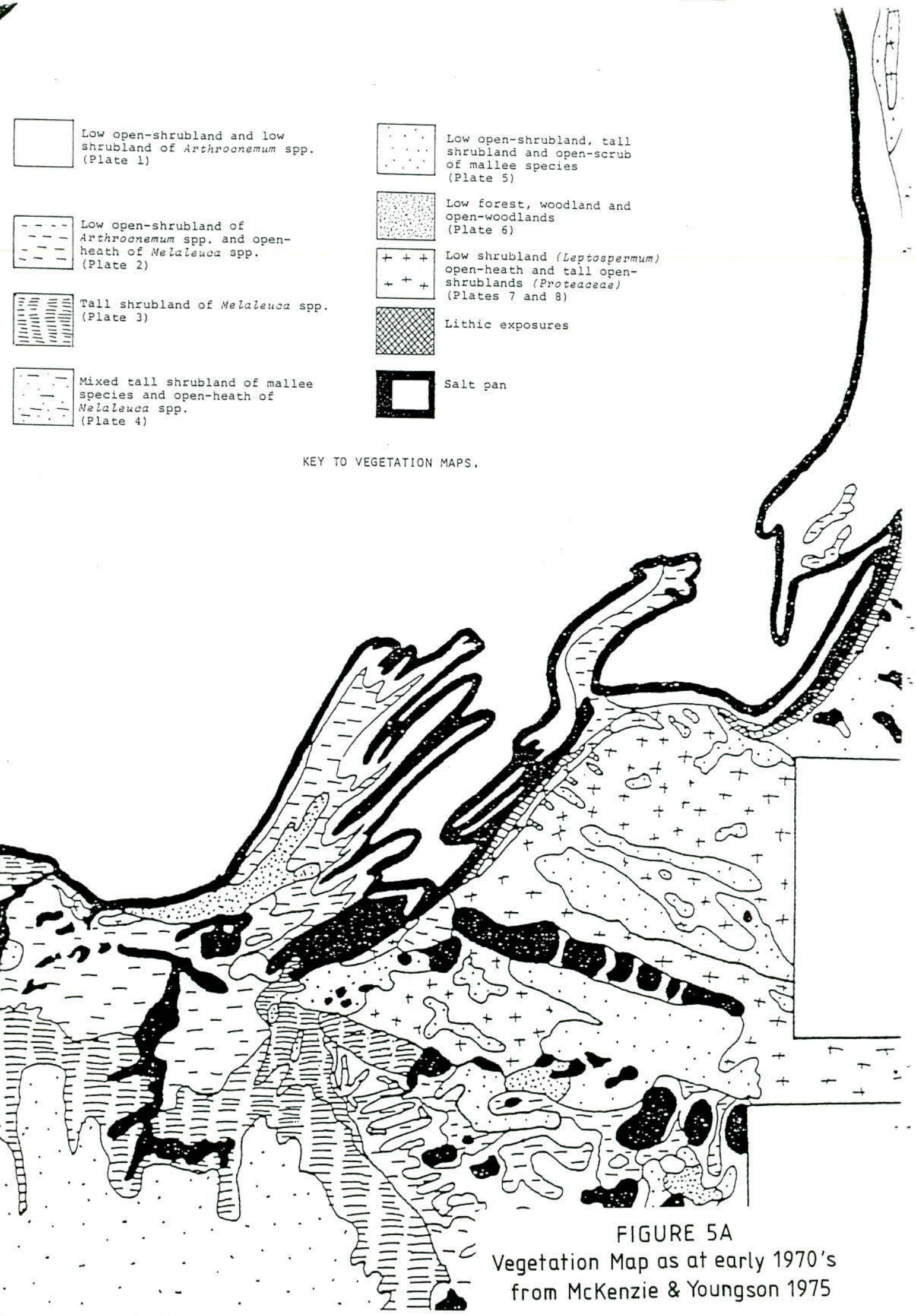
The general geology of the site is similar to most other salt lakes within the central and eastern wheatbelt. Up to several tens of metres of sandy sediments in the base of the palaeo-drainage underlie similar thicknesses of clays and silts in which secondary minerals such as gypsum and other evaporitic minerals are common (Chin and Brakel 1986; Thom et al 1984).

The proposed mining area contains a series of dunes to 6 metres in height that are contained within accumulations of sediment on the south east corner of the lake. West, north-west and north winds have blown sand-sized gypsum grains from the lake's bed and edge to create these dunes. (Strictly speaking, these accumulations are lunettes, but the word "dune" more readily conveys their aeolian origin and is used in this document).

Figures 5A and 5B compare the shapes of the dunal system within the proposed mining area as shown by vegetation mapping at an unknown date in the 1960s or 1970s (taken from McKenzie and Youngson 1975) and in 1993 (taken from Coates 1993). They show that the dunal systems are still active today.

In the 1960s, the dunes were a series of fingers pointing in a general north-easterly direction. Some 30 years later, continued sedimentation has allowed these dunes to extend further towards the north east and coalesce, thus forming a vegetated, oval-shaped accumulation.

Based upon this rate of growth, it appears that the entire dune system contained within the Mining Lease is geologically very young, having formed



KEY TO VEGETATION MAPS.

FIGURE 5A
Vegetation Map as at early 1970's
from McKenzie & Youngson 1975

The Southern Portion of Chinocup Nature Reserve No. A28395 and Surrounding Countryside Indicating Site Locations and Vegetation Boundaries.

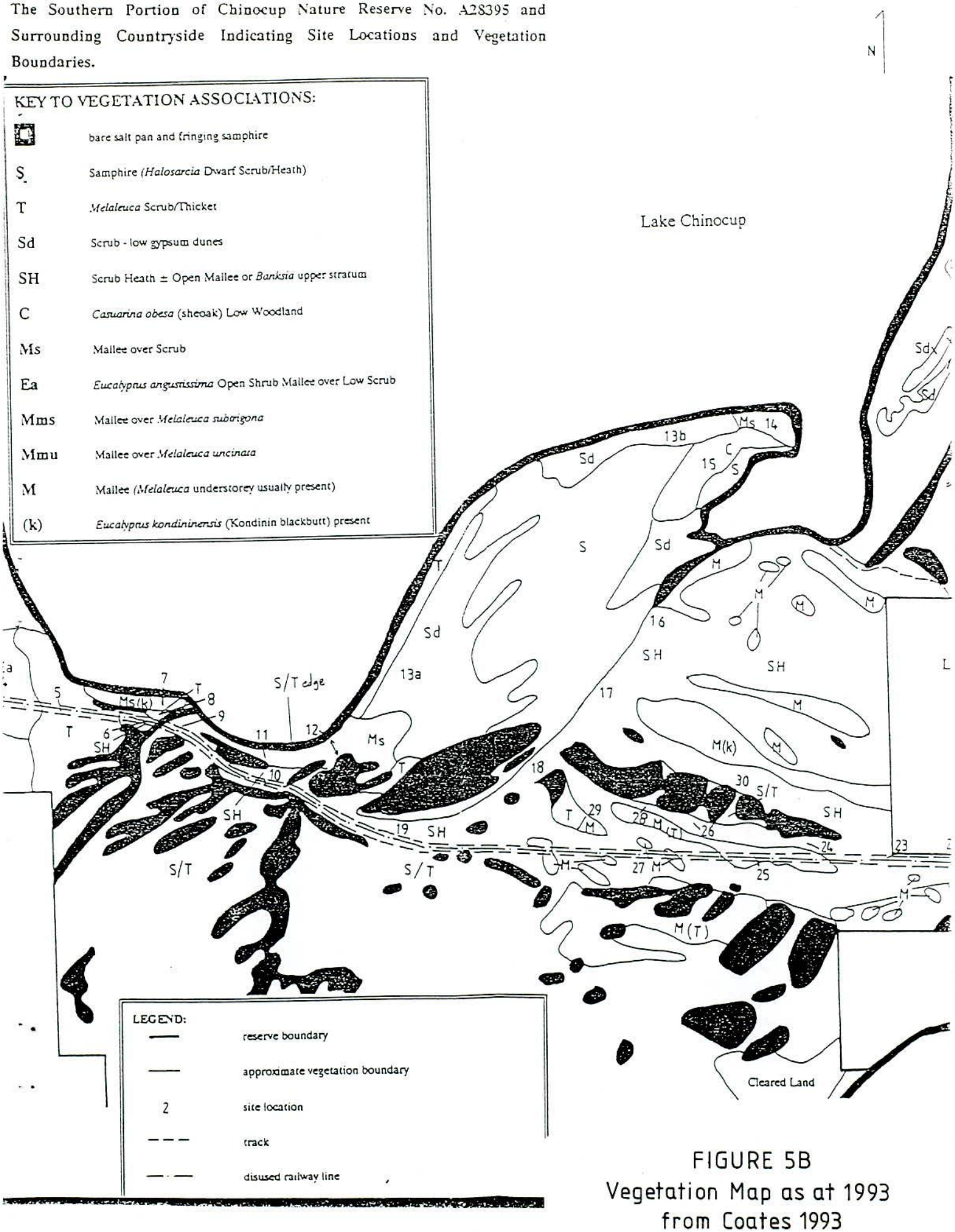


FIGURE 5B
Vegetation Map as at 1993
from Coates 1993

over a period of several hundred to a few thousand years. Once mining is completed, dune building processes are expected to continue, so that in time a landform similar to that which exists today will be returned.

Hand augering by the proponents has shown that most of the project area is underlain by granular gypsum, with 7 of 9 holes reporting 3 or 4 metres of high quality (>93% $CaCO_3.2H_2O$, <0.3% NaCl) gypsum. Even areas of samphire flats were found to be underlain by up to two metres of granular gypsum, (although mining will concentrate on the thicker sequences so that a smaller surface area is disturbed per tonne of recovered product).

4.4 Soils

The geological youthfulness of the landform within the Mining Lease combined with the harsh environmental conditions have not provided sufficient time for a well defined soil to develop.

Generally, vegetation covers less than 40% of the project area, with a thin (less than one centimetre) O horizon of organic matter accumulation (see McDonald et al, 1984) only in those areas where protective vegetation cover has allowed fallen vegetative material to be trapped.

A poorly developed A horizon (mineral horizons with some organic matter and clay/sesquioxide accumulations) was seen in at least one hand auger hole sunk into the dunes, but only a slight orange-brown discolouration over a few centimetres was present. In most parts of the gypsum dunes, the A horizon is less than 1 centimetre thick. Colouration of the dune surface is probably due to a combination of small amounts of organic matter and soil microflora such as algae.

No B horizon (mineral soil layers) exists within the project area and the C horizon (material little affected by pedogenic processes) is encountered immediately below the surface at depths of only a few centimetres.

In most areas, there appeared to be some post-depositional solution and re-deposition of gypsum within the surface sand grains, forming a light induration.

4.5 Hydrology

The highly porous nature of the sandy gypsum dunes allows rainfall to soak quickly in and make its way towards the ground water layer. Surface water is seen only within the lake itself.

Beneath the gypsum dunes, the clay-rich bed of the lake is believed to be flat-lying. Rainwater falling on the dunes sinks downwards (becoming groundwater), encounters the basal clays and then flows laterally into the lake. The basal clays have a very low permeability and little rainfall or groundwater would soak into them.

A layer of 0.3 metres of gypsum sand will be left at the base of all mined-out areas to assist in revegetation. This thickness appears to be the minimum amount required for growth of those species currently growing on the dunes. This layer will also allow existing hydrological processes to continue largely unchanged, with rainfall soaking into the sandy material and then moving laterally into the lake.

4.6 Wildlife

The Chinocup Nature Reserve is of undisputed high conservation value (McKenzie 1973, McKenzie and Youngson 1975, Environmental Protection Authority, 1975). It contains several rare and endangered plants and its vegetation is a valuable remnant from the days of pre-European settlement. Rare fauna have also been reported from the reserve.

4.6.1 FLORA

A comprehensive survey of the proposed mining area was conducted by a consultant botanist with extensive experience in the central wheatbelt area (see appendix 2).

The survey found that a "Mallee over Scrub" association was only found on the well-developed gypsum dunes within the proposed mining area (see figure 6). *Eucalyptus* aff. *incrassata* formed an open upper stratum , with *E. kondininensis* (Kondinin Blackbutt) at one site and the hybrid *E. phaenophylla* x aff. *incrassata* at another.

The scrub understorey generally consisted of three strata, with a Declared Rare species, *Adenanthos pungens* ssp. *pungens* occurring as a characteristic species in the lower two strata.

Low gypsum dunes in the centre of the proposed mining area are covered with a sparse vegetation of Scrub of *Melaleuca* and mixed plant species. A small area of sheoak (*Casuarina obesa*) Low Woodland occurs in the northern-most part of the proposed mining area.

A total of two gazetted rare plants and six priority species, along with two hydrids of scientific value, occurred within the general south-eastern section of the Nature Reserve. *Drakaea isolata* (ms), the Lonely Hammer Orchid, extends from the Nature Reserve into unmade road No. 8315 and the Chinocup townsite reserve. It is a Declared Rare species but is not found within the proposed mining area.

Adenanthos pungens ssp. *pungens* is found on both gypsum and quartz sand dunes throughout the south-eastern section of the Nature Reserve. A minimum of 1500 plants were found within the reserve, with at least 650 occurring on quartz sand dunes that will not be impacted by mining. Two populations of *Adenanthos pungens* ssp. *effusa* are known from the Tambellup area. A second population of *Adenanthos pungens* ssp. *pungens* has not been relocated in recent surveys of the Stirling Range National Park.

Adenanthos pungens ssp *effusa* does not appear to regenerate readily after disturbance, based upon observations south of Tambellup where a railway reserve passes through a population of this species (Mal Graham, Department of CALM, Katanning, pers. comm., 1993).

Of the Priority species located during the survey or described in CALM's files (none of which occur within the mining area), *Drosera salina* (ms) occurs in low lying areas, while *Eucalyptus angustissima* ssp. *quaerenda* was found to be more widespread south of Lake Chinocup that previously recorded by CALM.

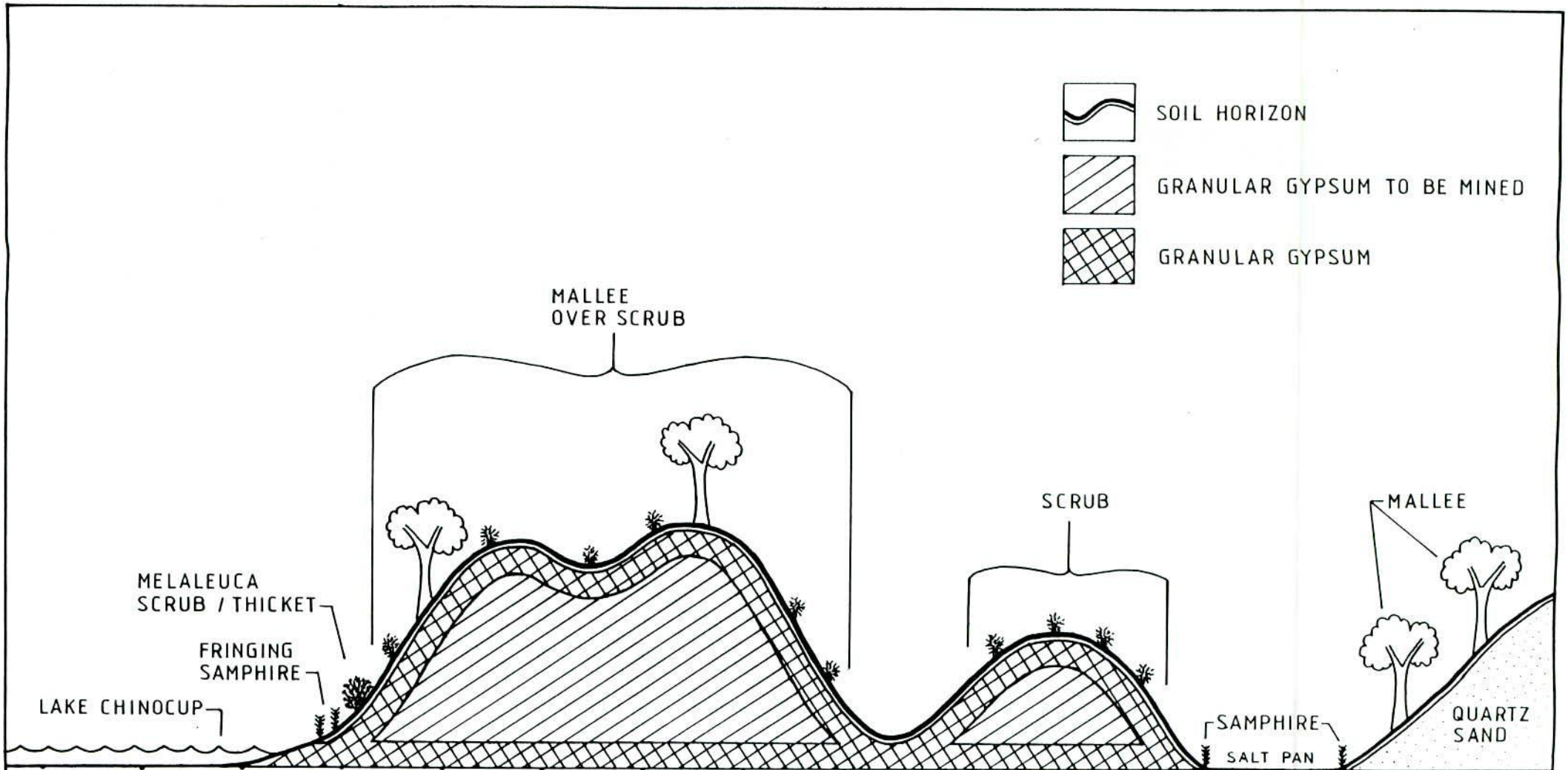


FIG. 6 GEOLOGICAL CROSS-SECTION SHOWING VEGETATION DISTRIBUTION
LAKE CHINOCUP NATURE RESERVE (DIAGRAMATIC - NOT TO SCALE)

Five other species of interest were found on unmade Road No. 8315. While none of these species will be directly affected by mining, a detailed survey of the road reserve will be carried out prior to any works that could impact on existing vegetation.

Two rare hybrids were also collected on the quartz sand dunes, with the *Adenanthos* hybrid also found on gypsum dunes within the proposed mining area. *Eucalyptus sparsicoma* is a newly described species found within both the road and Nature Reserve where it is locally abundant.

Throughout almost the entire proposed mining area, vegetation cover is sparse, with large areas of bare gypsum existing between clumps of scrub or mallee vegetation (see PHOTOs 3 and 4). Typical cover density is estimated at between 20 and 40%.

4.6.2 FAUNA

Past surveys have recorded the presence of four rare or endangered faunal species within the Chinocup Nature Reserve: Western Mouse, Tammar Wallaby, Western Bristlebird and Western Whipbird (western mallee subspecies). The vulnerable Mallee Fowl is also known to occur. Fortunately, the habitat requirements of all these species are markedly different to the sparse vegetation cover present within the gypsum dunes (see appendix 3).

The Western Mouse was trapped 1972 within the Nature Reserve south of Lake Chinocup. It was also collected from two other wheatbelt Nature Reserves shortly thereafter (McKenzie and Youngson, 1975).

The Tammar Wallaby no longer appears to be present within the Chinocup Nature Reserve (Kennedy, 1992), possibly due to predation by foxes or changed fire regimes.

McNee (1986) reported the presence of the Western Whipbird within the Nature Reserve:-

> "During 12 to 16 September, 1985, Bert and Babs Wells located Western Whipbirds on the Chinocup Reserve 28395. Western Whipbirds were also heard outside the Reserve near Chinocup Siding. It was thought that there were at least four different pairs in the area. The vegetation was predominantly mallee and teatree heath, and **Melaleuca sp** up to 4m high near the lake edge. There is some variation in the height, density and species composition of the vegetation of this area. (Babs Wells, pers. comm.)"

The Western Whipbird was recorded as recently as November, 1993, in mallee heath on the edge of more open country (Mal Graham, Department of CALM, Katanning, pers. comm., 1993)

Garnett (1992) fails to list the Chinocup Nature Reserve as a Conservation reserve affected by recovery plan for the Western Bristlebird, suggesting that the species had become locally extinct by the time of publication.

The proponents commissioned a report from John Dell and Norah Cooper, in their capacities as private wildlife consultants (both are

employed within the Terrestrial Vertebrate Section of the WA Museum). Their report is enclosed as appendix 4. They conclude:

> "From present knowledge of the habitat of the 2 rare and endangered mammals, the Western Mouse and the Tammar Wallaby, it would appear unlikely that they would be present on the gypsum lunette dunes at Lake Chinocup. Other mammals known from the region, though not recorded from the reserve itself, include Shortridge's Mouse *Pseudomys shortridgei*, the Red-Tailed Phascolgale *Phascogale calura* and the Chuditch *Dasyurus geoffroyii*. These mammals are also gazetted as rare and endangered but are currently not known from the Chinocup Nature Reserve."

When water is present in lakes around the Nyabing/Pingrup area, they are of major importance to waterfowl (McKenzie and Youngson, 1975). The larger lakes are used for breeding, while the smaller lakes, some of which are fresh, are used for feeding and drinking. Species include Black Swan, Australian Shelduck, Grey Teal, Chestnut Teal, Maned Duck, Pacific Black Duck, Pink-eared Duck and Australasian Shoveller.

No formal survey of the project area's fauna was carried out due to the high estimated cost (>$10,000), excessive time requirements (3 to 6 months), the poor quality of the minesite's vegetation as faunal habitat and CALM's existing knowledge of the reserve's fauna.

Trapping within an area of gypsum dunes at the Kondinin Nature Reserve as part of a pre-mining survey resulted in the conclusion that "the vertebrate ground fauna of the site was not rich". Tree-dwelling mammals and reptiles may have been common but techniques were not available to allow effective surveys to be carried out (Porter and Dunlop, 1984).

4.7 Dieback Disease

No evidence for the presence of the jarrah dieback disease *Phytophthora cinnamomi* is known within the proposed mining area or adjoining bush areas (Mal Graham, Department of CALM, pers. comm., 1993). The high calcium soils within the dunes are likely to be antagonistic to the presence of dieback (Dr Ray Hart, Hart Simpson & Associates, pers. comm., 1993).

Generally, the proposed mining area is considered to have only a low risk of dieback infection and spread. However, until it can be proven that there is **no** risk, it must be assumed that there is some potential for dieback to be present or to be capable of being introduced. Components of the flora are susceptible to the disease, should it be introduced (*Adenanthos pungens* ssp. *pungens* is reported to be highly susceptible to dieback (Coates, 1993)).

CALM has stated that the southern half of the Shire of Kent falls within the known dieback risk area (Anon, undated). Climatic conditions provide only short periods during the late autumn and early spring when both soil moisture and temperature are favourable for growth of the fungus. Hence, the general area probably has a low overall risk of sustaining the fungus, should it be introduced.

The proposed mining operation generally conforms to CALM's definition of a lowest risk operation (Anon. 1992) which has the following features:-

* operation over a small area
* simple operation
* little machinery
* little movement of soils
* well trained personnel
* experienced personnel.

While a large number of farmers' trucks will be picking up gypsum from the Chinocup townsite, no vehicles other than those used by employees will be allowed or encouraged to travel from the townsite to the mining area.

The proponents accept that the conservation value of the Nature Reserve is so high as to justify the adoption of strict dieback control procedures as part of the day-to-day mining activities (see sections 8.2).

4.8 Significance of Local Ecosystems, Habitats, Flora and Fauna and their Representation within the Conservation Estate

In the heavily cleared central wheatbelt, virtually all remnants of the original vegetation are of high conservation value. This is the case for the Chinocup Nature Reserve and Chinocup townsite reserve, where remnant vegetation contains a rare or uncommon plant and animal species.

Hence, the ecosystems within which mining is proposed must be considered to have high local and regional significance.

The representation of those ecosystems and their valuable components within other parts of CALM's conservation estate is variable. For some plant species such as *Adenanthos pungens* ssp. *pungens*, the Chinocup area is its stronghold. For all rare species of fauna known from the Nature Reserve, their existence within the mining area is extremely unlikely, since the habitats are unsuitable for their use.

All vertebrates of special conservation interest are represented in other parts of CALM's conservation estate. Although endangered, their continued existence seems secure in those reserves. More importantly, the proposed mining operation poses no threat to these populations.

The question of mining in an area of such high natural value thus depends upon determining whether mining activity is likely to have unacceptable impacts on wildlife or whether mining can be managed so as to pose only a low and acceptable risk to those important components of the ecosystem. Section 6 describes the expected environmental impacts of the proposed mining activity, while section 8 describes the management that will be undertaken to minimise impacts and to ensure high quality rehabilitation occurs after mining

4.9 Lake Function

The proposed mining operation will have no hydrological impacts on Lake Chinocup. The lake's value to waterbirds is largely restricted to feeding and loafing, neither of which will be significantly impacted upon by a mining operation covering no more than one hectare at any one time in a

lake area of several thousand hectares. Waterbirds readily accommodate human disturbances such as noise and visual impact, with birds simply swimming or flying away from the human activity.

4.10 Cultural Values

4.10.1 ABORIGINAL SITES

Informal inquiries by the Lake Chinocup Gypsum Community Committee (see section 7) have failed to find Aboriginal people with an expressed interest in the proposed mining area.

The proposed mining area is not known to carry sites of ethnographic or archaeological significance (Steve Corsini, Department of Aboriginal Sites, WA Museum, pers. comm., 1993). Casual surveys by the proponents and consultants have not located cultural or other relicts. The absence of fresh water, rock faces, caves or other landforms that may have been utilised by Aboriginal people in obvious ways suggests a generally low usage of the proposed mining area by Aborigines.

A total of 11 sites have been recorded by the WA Museum from the general area around Lake Dorothy, between the railway line and the Nyabing-Pingrup road and between Lakes Altham and Pingrup. All are artefact scatters.

The sparse vegetation cover and relative lack of fauna within the proposed mining area suggests that food resources would have been very small, again suggesting that Aboriginal usage was low.

Even so, the WA Museum have pointed out that Lake Chinocup may have contained fresh water in the past (prior to 6000 years before present), with food in the form of waterbirds attracting aboriginal people to the area. Vegetation may also have been different, possibly providing shelter and further food resources.

The proponents are aware of the potential for Aboriginal materials to be present within the gypsum dunes. Accordingly, should mining be approved, artefacts, food remains or skeletal material found within the gypsum dunes will not be mined. The WA Museum (and the WA Police in the case of skeletal remains) will be asked to investigate and report upon them.

Because of the large volume of gypsum present within the Mining Lease, altering the mining path so as to avoid sites of archaeological or ethnographic importance can be readily achieved.

4.10.2 HERITAGE

No sites of European heritage are known from within the proposed mining area. The access road to be developed along the track on the south side of the former railway line does not impact on buildings or other features of significance.

4.10.3 LAND USE

Mining as proposed in this report will not have adverse impacts on other land users or land owners in the general vicinity, except for an increase of truck movements over the late summer and autumn months. Since Nyabing and Pingrup are wheat and sheep producing areas, local roads commonly receive high levels of truck usage at infrequent periods, for example, when wheat is being harvested and transported to grain silos or when stock sales are being held at regional saleyards

4.10.4 SOCIAL ENVIRONMENT

The only social impact of note will be the improved profitability of farmers whose clay-rich soils will be treated with high quality gypsum sand mined from the Lake Chinocup deposit. At present, with many farmers facing financial hardship due to generally low produce prices, increased returns are to be welcomed.

For those farmers already using gypsum, a cost saving of between $5.00 and $10.00 per tonne is expected, once this local supply is operating. At present, gypsum must be carted from the east side of Lake Magenta.

5.0 EVALUATION OF ALTERNATIVES

5.1 Alternative Sources of Gypsum

Prior to applying for the Mining Lease over the Chinocup deposits, one of the proponents (Paul Shiner) examined 45 sites that the Geological Survey of W.A. had suggested may contain mineable gypsum of suitable quality. All sites were inspected and, in all cases, gypsum was either absent or too low in quality or quantity to allow mining to be favourably considered.

A copy of Paul Shiner's exploration report has been provided to the Geological Survey of WA. Also supplied were copies of letters from 8 private landowners whose properties were evaluated as part of the survey. In discussions with an officer of the Geological Survey of W.A., it was agreed that the Chinocup resource is probably the only sizeable sand-sized gypsum deposit in the vicinity of the Lake Chinocup and Lake Grace salt lake system within a reasonable distance of the Pingrup/Nyabing area (Mike Freeman, Geological Survey of W.A., pers. comm., 1993).

In many salt lakes within the central and eastern wheatbelt, gypsum crystals can grow in-situ within the lacustrine muds. They are capable of reaching large sizes (>0.5 metres long) and high purity. However, mining and processing of such crystals is far more complex and expensive than for dune sand deposits.

Access into the bed of the lake would require specialised equipment and/or the construction of appropriately engineered roads on the lake's surface. Once mined, the raw material must be washed to remove salt and clay, crushed to create suitably sized particles, screened to remove coarse material and stockpiled.

A processing plant capable of crushing and screening coarse lake bed crystals has an estimated capital cost of about $450,000 (Chris Tate, RCR Engineering, Bunbury, pers. comm., 1993), although a plant built from second-hand equipment would cost substantially less.

Processing of lake bed gypsum would generate liquid effluent high in salt and clay. Disposal would be back into the lake. Mining may not be possible after wet winters, since Lake Chinocup occasionally retains water from one winter to the next. This would require the stockpiling of a large volume of processed gypsum, causing a large stockpile area to be created at a suitable location.

With gypsum selling for between $7.50 and $11.00 per tonne ex-mine, the additional costs associated with mining and processing lake bed gypsum crystals would increase this sale price by an estimated 50%.

At Lake Campion near Merredin, a commercial plaster board manufacturer is exploiting a sand- to granule-sized gypsum layer within the lake bed. In spite of using specially modified machinery with wide tracks, the company is reported to be having continuing access problems due to the liquefied nature of the gypsum layer.

At Jurien Bay and Dongara, enclosed marine embayments have allowed granular gypsum to form beds up to four metres thick in what are now salt lakes. The gypsum is used as a source of sulphur in sandy, highly leaching soils of the Swan Coastal Plain, not as an amendment to clay-rick soils.

Mining of these marine deposits will occur in summer when the lake bed is dry. It will involve removal of a surface salt and clay layer, excavation of gypsum, stockpiling on the lake's edge to allow the following winter rains to wash salt back into the lake, and transport of clean gypsum to farmers' properties or stockpile areas (Dr Peter Woods, pers. comm., 1993).

These deposits are low in clay and the porous nature of the gypsum granules allows rainfall to effectively remove salt over just one winter. The high clay contents of wheatbelt salt lakes do not allow salt to be removed in the same manner and processing is required at an additional cost.

The geological history of these marine deposits is completely different to deposits formed in the wheatbelt. No lake deposits of equivalent thickness to those found at Jurien Bay or Dongara are known from inland salt lakes, and the nearest potential source of marine gypsum is from Eocene deposits near Norseman or Recent deposits near Esperance.

The 500 kilometre haulage distance precludes the use of this marine-derived gypsum in the Pingrup/Nyabing area.

5.2 Opportunity for Selective Mining

The proponents will be selectively mining within the Mining Lease area. They agree that the following procedures will be implemented:-

1) no mining within 10 metres of the edge of Lake Chinocup (the edge being defined as the vegetation boundary)

2) retention of denser clumps of vegetation to act as seed sources

3) retention of areas where *Adenanthos pungens* ssp. *pungens* is present in higher than normal densities

4) retention of the undisturbed edges of dunes next to water courses, mud flats and temporary saline wetlands on the inland side of the dunal system, and

5) restricting mining to dunes containing an average of more than 1.0 metres of recoverable gypsum.

These measures are estimated to reduce the mining area by up to 10% over the life of the proposed mining operation.

5.3 Alternatives to the Preferred Access Road

Examination of figure 2 shows that the proposed mining area is centrally located within the southern part of the Chinocup Nature Reserve. An alternative to the proposed access road would need to be shorter or have a lower impact on the Nature Reserve to be justified.

However, no practical alternatives to an access route along the existing track south of the former railway line exist.

For example, the north-eastern corner of the Chinocup townsite reserve lies less than 50 metres from the actual edge of Lake Chinocup. However, no road exists to this point and a new road extending some 1000 metres through high quality vegetation would need to be constructed. A road would then need to be built along the lake edge for some 1000 metres.

An access road could be developed from Chinocup Road through to the western side of the lake, traversing some 300 metres of land already degraded by saline groundwaters that has killed areas of native vegetation. However, some three kilometres of road would then need to be constructed along the edge of the lake. As well, the cost of road construction would be high, due to the clay-rich, water-saturated nature of the lake sediments.

Access from the north-east corner of Location 8945 would cause some 300 metres of high quality native vegetation to be cleared within the Nature Reserve or Chinocup townsite before encountering the existing track on the south side of the railway line.

Access from the east would have much greater environmental impacts within the Nature Reserve, due to steep sand dunes needing to be crossed and a longer distance of road needing to be made trafficable.

Overall, the use of an existing track, with minimal upgrading of creek cross-overs and sandy stretches, is considered to be the most appropriate and least environmentally damaging way of gaining access to the proposed mining area.

6.0 ENVIRONMENTAL IMPACTS

6.1 Volume and Nature of Drainage Waters Entering the Lake

With a layer of 0.3 metres of gypsum sand retained at the base of the dune system after mining, no changes to surface or ground water hydrology are expected. Rain falling on exposed mine workings and soaking into the gypsum sand will find its way to Lake Chinocup. Its passage through the gypsum will filter out any suspended solids that it may pick up within the mine site.

6.2 Changes in Lake Hydrology

Mining will have no impact on the hydrology of Lake Chinocup, as there will be no mining within the lake itself. The mining operation will allow existing hydrological conditions to continue, both during and after mining.

6.3 Likelihood, Nature and Impact of Chemical Spillage Entering the Lake

No wastes will be produced during the mining operation. Gypsum-bearing material not sold will be fully used in site rehabilitation.

Apart from diesel fuel used to operate the front-end loader and truck, no other toxic or potentially harmful chemicals will be present on site.

6.4 Disturbance and Loss of Lake Habitat

There will be no disturbance to the lake or its fringing wetland vegetation.

6.5 Visual Impacts

The remoteness of the mining area and the lack of visitors to the site will result in minimal visual impacts. The existing low vegetation cover on the gypsum dunes already causes large areas of white ground to be visible, with mining temporarily causing these bare areas to be larger in size.

Distant viewing points such as Chinocup Road on the west side of the Nature Reserve are sufficiently remote (three kilometres) for the relatively small annual mining area (about one hectare) to have little visual impact.

6.6 Noise and Dust Impacts on Residents, Flora and Fauna

Dust should not be generated on site since the content of fine-grained material within the gypsum sand is low.

The remoteness of the site from habitation and low noise levels arising from the use of one or two front-end loaders, a truck to deliver gypsum to the stockpile area and farm trucks that are licensed for road use will ensure that noise levels are low and of no consequence.

6.7 Wildlife Disturbance

6.7.1 FLORA

There will be unavoidable temporary impacts on the site's floral values, with successful rehabilitation expected to return most values within five years.

Mining will require that some rare *Adenanthos pungens* ssp. *pungens* plants be cleared from the mining area (although all vegetation will be respread over mined-out land as part of the rehabilitation process).

While this species ranges from Tambellup to Pingrup (Hopper et al, 1990), the subspecies population within the Stirling Range National Park has not been located in recent surveys and may have been destroyed by dieback. The botanical survey has shown that over 1500 of these plants exist within and near the proposed mining area at Lake Chinocup.

Examination of the botanical survey report's table 4 and figure 6 (see appendix 2) shows that, of the 1500 plants, over 600 (or 40% of the population) occur away from the gypsum dunes. These will remain untouched and unaffected by mining.

However, over 800 plants occur within the Mining Lease area of 213 hectares. On biological conservation grounds, the removal of 60% of the individuals within an isolated population is unwise. Accordingly, the proponents agree to conduct a pre-mining survey of the gypsum dune areas so as to identify those sections of the dunes that carry higher numbers than average of *Adenanthos* plants. Where this species occurs in clumps, or above gypsum of less than one metre thickness, mining will not take place.

The proponent makes the further commitment that mining beyond an initial 20 hectare area will be dependent upon the demonstrated success of revegetating mined out areas. In particular, re-establishment of *Adenanthos pungens* ssp. *pungens* will have the highest priority within the rehabilitation program. If this species cannot be returned to the minesite, then mining outside the original 20 hectare area will be restricted to sites where very low numbers of the species grow.

With only 20 hectares of the ML area to be mined initially, it is estimated that less than 100 *Adenanthos* plants will be removed by mining. This represents a reduction in population size of less than 10% and is unlikely to be of conservation consequence.

Transplanting of *Adenanthos* bushes during mining is an option to be discussed with CALM. If considered worthwhile, transplanting of all *Adenanthos* plants (including their root-stock) will occur in the first mining period of 1994> Assessment of their survival prior to the commencement of mining in 1995 will determine if this technique should become part of normal rehabilitation practice.

Figure 6 in appendix 2 should be compared with this report's figure 4 to compare the proposed mining area with the distribution of the area's high conservation value flora.

6.7.2 FAUNA

Rare or endangered fauna is extremely unlikely to be present within the proposed mining area, due to the complete absence of suitable habitat (see appendix 3).

The fauna of interest (Western Mouse, Tammar Wallaby, Western Bristlebird and Western Whipbird) require dense vegetation (heath or scrub) in which to forage for food and find nesting sites (Brouwer and Garnett 1990, Garnett 1992a & 1992b, Kennedy 1992, Poole et al 1991, Strahan 1991). The sparse vegetation of the gypsum dunes provides none of these species' essential food or nesting requirements and its temporary removal during mining cannot have an impact on these species.

In the Nyabing area, the Western Whipbird has been found in open scrub habitat, but requires dense *Banksia* shrubs for nesting (Mal Graham, Department of CALM, Narrogin, pers. comm., 1993). Within the proposed mining area, there is no vegetation capable of providing similar dense cover.

The Western Mouse requires a lateritic or gravelly sub-soil horizon, beneath which it constructs its burrows. Such soil features are completely absent from the proposed minesite.

Other species of conservation interest may occur close to the proposed mining area.

The Red-tailed Phascogale prefers "wandoo and rock oak communities" (Kennedy, 1992), both of which are absent from the proposed mining area. Shortridge's Mouse "now occurs almost exclusively in recently burnt, species-rich, dry heathlands" (Strahan, 1991). The Chuditch "feeds on a wide variety of small mammals, birds, insects and carrion" (Strahan, 1991), but these food sources are present in very low numbers within the sparsely vegetated gypsum dunes.

6.8 Loss of Ecological Functions

There will be no loss of ecological function, either temporary or permanent, from the lake.

Within the vegetated section of the Nature Reserve where mining is proposed, there will be a short-term (estimated at about 5 years) loss of ecological function associated with the removal of existing native vegetation. As the mining area is sparsely vegetated and offers low quality habitat to fauna, loss of faunal ecological functions will be minor.

In spite of the low vegetation cover, mining will cause the loss of a moderate number of shrubs and trees. Since one of the affected species is rare and endangered (*Adenanthos*), a permanent reduction in population size would reduce genetic variability and possibly reduce pollination success for remaining plants.

With some 1500 specimens of *Adenanthos pungens* ssp. *pungens* now known to exist within the Nature Reserve and with the proponents having made commitments to restrict the maximum number of plants removed by mining to

less than 100, the loss of ecological function will be minor, even if regrowth of this species is not possible.

Furthermore, with rehabilitation believed to be readily achievable (see sections 8.3 and 8.7 and PHOTOs 5 and 6), no permanent loss of ecological function is expected.

The geological youthfulness of the dunes within the proposed mining area suggest that they will reform over the next few hundred years or less, recreating the conditions under which *Adenanthos pungens* ssp. *pungens* naturally colonised them.

6.9 Susceptibility of Habitats to Dieback Disease and Potential for Spread

The calcium-rich soils of the proposed mining area are likely to be antagonistic towards the dieback fungus. Climatic conditions are such that times during the year when soils are both warm and moist are infrequent. Overall, the site can be classified as being relatively low risk.

Even so, it must be assumed that the risk of introducing dieback to the mining area is real (regardless of how slight that risk is), justifying the implementation of standard dieback control methods (see section 8.2).

Provided that close attention is paid to correct procedures, the risk of introducing dieback to the mining area and access road will be acceptably low.

6.10 Workforce Management

The principal employee will be Paul Shiner, one of the owners of the Mining Lease and hence one of the proponents. He will be the operator of the front-end loader within the mine site and will be the normal truck driver taking gypsum to the stockpile area.

As a Pingrup resident and part-owner of the project, he will ensure that site management will be strictly enforced, both by himself and by temporary employees hired on a seasonal basis.

All rubbish will be removed from the site; fires will be banned, especially since vegetation cleared as part of the mining operation is to be used for rehabilitation; firearms will be banned (unless foxes or feral cats are seen on site during the day-to-day mining operation, in which case a suitable firearm will be used for feral animal control, subject to CALM approval); no soil or similar seed-bearing material will be brought on site; and no domestic pets will be allowed on the mine site.

These restrictions and management actions will be enforced by the proponents so that, once mining is finished, the site can be returned to the Nature Reserve without further loss of environmental and other values.

6.11 Land Exchange as Compensation for Environmental Impacts

The Shire of Kent has agreed to provide up to half of the Chinocup townsite reserve to CALM free of charge, once all approvals to mine have been given (see appendix 5). Selection of the actual portions of the townsite to be given to CALM's control has yet to be made, with negotiations between CALM and the Shire to take place prior to the grant of the Mining Lease.

The townsite reserve covers some 243 hectares. Mining is proposed to initially affect 20 hectares of the Mining Lease, with a further 50 to 60 hectares mined in the following years. On this basis, compensation for land mined will be made at a ratio better than 1:1.

Vegetation of the townsite has been partially mapped (see appendix 2). In spite of part of the reserve having been used for railway and associated purposes for several decades in the early part of this century, it remains in good environmental condition.

It mainly consists of two vegetation associations, namely, Mallee over *Melaleuca uncinatum* and Mallee over *Melaleuca subtrigona*. *Eucalyptus angustissima* Open Shrub Mallee over Low Shrub occurs along the central eastern boundary, while mixed Samphire and Melaleuca Scrub/Thicket is found along the northern boundary.

Floral species of conservation significance occurring within the road reserve where it passes through the townsite include:-

Astartea clavifolia	Proposed Priority species
Dicrastylis glauca	Priority 3 species
Drakaea isolata (ms)	Rare and endangered
Eucalyptus angustissima ssp. *quaerenda*	Priority 2 species
Melaleuca polycephala	Priority 3 species
Verticordia brevifolia ssp. *brevifolia*	Priority 1 species

Of equal conservation significance is the potential for the townsite reserve to provide useable habitat to one or more of the four rare vertebrate species previously recorded from the Chinocup area.

The Tammar Wallaby, Western Mouse, Western Bristlebird and Western Whipbird all require dense heath vegetation within which to find food and shelter and to nest. Parts of the townsite are sufficiently dense to provide suitable habitat, with the Western Whipbird recently reported from near the eastern boundary of the townsite (Mal Graham, Department of CALM, Katanning, pers. comm., 1993).

As recommended by Kitchener et al (1980), reserves for mammal conservation within the wheatbelt area should be about 40,000 hectares in area. At present, the total Chinocup Nature Reserve is about half this size. Hence, its enlargement by adding valuable conservation land is desirable, even if the parcel of land is as small as 120 hectares.

The proponents will seek to have further land adjoining the western side of the Nature Reserve donated to CALM. Two areas of private land were assessed as a possible alternative to the Chinocup townsite. Both have been seriously degraded by salt intrusion and were found to be unsuitable for further consideration. However, the proponents are prepared to encourage the owners to provide the land to CALM at minimal cost, should CALM see

merit in such land act acting as a buffer between the Nature Reserve and actively farmed private land.

The proponents agree to pay survey, transfer and other costs associated with the land swap.

6.12 Conclusions

The geological youthfulness of the proposed mining area, combined with evidence of successful rehabilitation at other gypsum mining areas in the wheatbelt (see section 8.7), indicates that successful revegetation of mined areas will occur.

The loss of less than 10% of the population of *Adenanthos pungens* ssp. *pungens* will be adequately compensated by the inclusion of up to 120 hectares of high conservation land with other Declared Rare Flora from the Chinocup townsite reserve.

Overall, the environmental impacts of dune mining are considered to be low and temporary, with rehabilitation and land compensation providing valuable environmental benefits in both the short and long term.

7.0 PUBLIC PARTICIPATION AND CONSULTATION

Although no formal public consultation was undertaken prior to the public release of this document, the project is known to various interested parties.

Several of newspaper articles dealing with the proposed mining operation appeared in local newspapers, commencing in October 1992. The Lake Chinocup Gypsum Community Committee came into existence about the same time, having a membership comprising farming and other interests from throughout the Shire of Kent.

Copies of the Notice of Intent summary as given to DOMEWA in August 1993 were sent to the following organisations:-

Conservation Council of W.A.
W.A. National Parks and Reserves Association

The Department of CALM has been kept informed of this project from its inception in 1992, with communication between the consultant, Lake Chinocup Gypsum Community Committee members, and staff of CALM's Narrogin and Perth offices.

There is strong support for this project in the Pingrup and Nyabing areas from the farming community, many of whom are purchasing gypsum from remote minesites and having to transport it over 90 kilometres to their farms.

The project has been frequently discussed at meetings of the Shire of Kent who have given their support for the project.

7.1 Public Concerns

Two concerns have been raised by the above groups: mining within the conservation estate, and the need to provide land as compensation.

The conservation movement has expressed opposition to the proposal on the grounds that there should be no mining within any nature reserve anywhere in the state. This is especially so in the wheatbelt, where clearing of native vegetation for agriculture has left only 5 or 10% of the original vegetation.

While acknowledging the high conservation value of virtually all areas of remnant vegetation in the wheatbelt, the proponents believe that the principle of "no mining in any nature reserve" is not supportable if it can be shown that mining is both temporary and of low environmental impact. These two conditions apply in the case of this proposal.

Some sections of the farming community have questioned the need to provide alternative high conservation value land (the Chinocup townsite reserve) to CALM as partial compensation for mining within CALM's conservation estate.

The proponents believe that, since the farming community will be gaining significant benefits by development of a local source of sand-sized gypsum, it is reasonable to accept the concept of compensation via a land swap, as a way of guaranteeing that the overall conservation value of the broader region is not diminished.

8.0 ENVIRONMENTAL MANAGEMENT

8.1 Environmental Management Objectives

The aims of environmental management are to:-

1) minimise environmental impacts to the Nature Reserve during mining, and

2) conduct mining in a way that will assist post-mining rehabilitation in the achievement of the site's final land use.

These aims will be best achieved if:-

1) rare and otherwise important plant species are disturbed or removed during mining to the least possible degree

2) pollution and other impacts that could affect the site after mining has ceased are minimised or eliminated

3) the site is left in a condition which favours recolonisation by plants and animals that were present on the site prior to the commencement of mining.

Achievement of these environmental objectives requires that the following actions are taken:-

1) understand the pre-mining environmental conditions and effects of the proposed mining methods sufficiently well so that

   * the impacts from mining can be accurately predicted

   * actions to mitigate those impacts can be planned and implemented, and

   * a comprehensive rehabilitation plan can be formulated and carried out.

2) conduct mining in the most efficient and responsible manner possible, consistent with economic constraints

3) implement a comprehensive rehabilitation plan

4) monitor the success or otherwise of rehabilitation, and

5) based upon rehabilitation results, modify rehabilitation techniques as required.

The preparation of this Consultative Environmental Review is the first stage in achieving these environmental objectives. Advice has been received on the conservation values of the proposed mining area and this information has been used to judge the overall impacts of mining.

Having concluded that the impacts are likely to be relatively minor, the proponents are herein making appropriate commitments to manage the mining operation in a manner that will impact as little as possible on the site's natural values.

Once mining approvals have been gained, the proponents will prepare a detailed Environmental Management Program (EMP). To be formally approved by DOMEWA and CALM, the EMP will include the following:-

* operational procedures

* completion criteria

* timing and content of progress reports on the mining project as a whole (including rehabilitation, etc).

The EMP will provide detail on the stockpile area, access road, sections of dunes to be mined, vegetation clumps to be retained and all other important matters of relevance to the project.

To facilitate post-mining rehabilitation, the EMP will also detail the post-mining contours to be created on site and all other physical requirements needed to undertake successful rehabilitation, as outlined in section 8.3 following.

In consultation with CALM, an acceptable set of completion criteria will be formulated and incorporated into the EMP. Section 8.5 is the proponent's suggested completion criteria.

The EMP will also detail the monitoring program that will assess rehabilitation results on a regular basis.

8.2 Management of the Dieback Fungus

If CALM believe that the risk of dieback being introduced to the mining area is sufficiently high, the proponents commit themselves to mining being conducted in accordance with procedures laid down in CALM's Dieback Disease Hygiene Manual (1992) and with DOMEWA's Guidelines for Management of Dieback Disease in Mineral Exploration (1991).

Specifically, control and management measures will include:-

1) wash down of all vehicles wishing to enter the mining area at a site to be provided within the Chinocup townsite, with wash-down water to contain a CALM-approved fungicide. The wash-down facility will be designed to allow evaporation of wash water.

2) use of the gravel apron section of the Chinocup townsite as the stockpiling and loading area for farmers wishing to purchase gypsum, thus preventing farm trucks from entering the Nature Reserve

3) use of dieback-free materials in road construction, if required in road upgrading, with testing of suspect materials prior to use

4) on-going monitoring of the mining area and its access road for the presence of dieback, with a commitment to the use of phosphonate as a foliar spray on any vegetation suspected of being infected with dieback

5) immediate notification to CALM of any suspected dieback infection

6) extraction of gypsum from the mining area only under dry soil conditions in summer and autumn

7) education of mining employees of the risks and dangers of dieback disease

8) erect and maintain appropriately worded signs

9) use of equipment such as front-end loaders which pick up less soil than tracked vehicles

8.3 Rehabilitation Procedures

The proponents agree to full and progressive rehabilitation of the site, with the post-mining land use objective to be nature conservation. The area of land open to mining at any one time will be kept to an absolute minimum, with rehabilitation to commence in autumn as soon as mining has ceased for the year.

Pre-mining activity will include:-

* collection of seed from vegetation to be cleared

* surveying the mining area for clumps of *Adenanthos pungens* ssp. *pungens* and denser clumps of other vegetation

During mining, the proponents will:-

* retain all vegetation matter for stockpiling or for application directly onto mined out areas about to be rehabilitated

* retain the surficial soil layer of gypsum (5 to 10 centimetres) and stockpile it in layers no more than one metre thick for later use, or apply it directly to mined-out areas that are about to be rehabilitated (stockpile sites will be carefully chosen to ensure protection from strong winds)

* transplant *Adenanthos pungens* ssp. *pungens* shrubs to unmined or rehabilitated areas, to determine if they will regenerate from rootstock after disturbance (this technique will be made standard practice if it is shown to be effective)

* not mine those areas shown to have floral conservation values that are higher than average for the mining site (i.e. clumps of shrubs or trees)

* ensure that the unmined islands of vegetation retained within the mining area have stable slopes that are less than 1 in 3

* retain 0.3 metres of gypsum sand at the base of the dunes to ensure hydrological conditions that are similar to those prevailing prior to mining and to encourage regeneration of vegetation into a substrate equivalent to that existing on the site at present. Mining will proceed no deeper than 0.3 metres above the base height of the salt lake.

* implement appropriate weed and feral animal (especially rabbit) controls, if necessary

Once mining has finished in an area, the proponents will:-

* contour the mined out area so that features compatible with the existing landforms are created

* rip or scarify the surface of the mined-out area, depending upon the degree of compaction, if any, ensuring that basal clays are not brought to the surface

* apply the stored or freshly mined upper surface layer (topsoil) of dunal material

* leave a rough surface on the mined-out area to assist in trapping seeds and vegetation matter

* apply the stored or freshly cleared vegetative material

* disperse seed collected from the area prior to mining

* plant seedlings of selected species previously occurring on the mine site

* cut seed-bearing branches from vegetation in unmined areas for placing onto rehabilitated land, if recommended by CALM

When mining has finally ceased within the Mining Lease, the proponents will:-

* remove all equipment, facilities and refuse from the entire mine site, stockpile area and access road

* where appropriate, scarify or rip and revegetate those sections of the access road not required for Nature Reserve management.

The use of nitrogen and phosphorus fertilizer will be subject to approval by CALM but will be at very low application rates, if used at all. Topsoil spreading over mined-out areas will be completed by the onset of the first winter rains so that germination of contained seeds is encouraged.

Although salt levels are generally 0.1% or less within gypsum sand at the base of the dunes, the salt content will be monitored to ensure that the 0.3 metres of gypsum left behind as sub-soil is not unsuitable for plant growth. If salt levels are found to be too high, a greater thickness of gypsum will be retained. Alternatively, the site will be monitored to determine if salt levels fall to acceptable levels after one winter's rainfall.

Once mining has been completed, clay used as base and bunds to the fuel storage area will be buried on site and the disturbed ground covered with dunal gypsum. The same rehabilitation procedures as described above will be applied. Should this clay material be contaminated with spilt diesel oil, it will be removed off site and disposed of in an approved manner.

The same species of plants currently growing on the proposed mining area will be used exclusively during post-mining rehabilitation. These plants are adapted to growing in the normally harsh environment of a poorly developed soil, with higher salt levels than normal and sand blasting caused by wind-blown gypsum dune. Because of their adaptation to these difficult conditions, revegetation is expected to be reasonably straightforward.

8.4 Environmental Safeguards

The proponents agree to restricting initial mining activities to 20 hectares of taller gypsum dunes. Mining beyond this area will be dependent upon demonstrating that rehabilitation is being successfully conducted. In particular, the return of *Adenanthos pungens* ssp. *pungens* is considered a key goal in the rehabilitation program. If this species cannot be shown to be re-establishing within mined-out areas, then permission to remove more than the original 100 specimens will not be sought.

The position of the initial 20 hectares has not yet been selected, except that it will lie within the four tall dune areas as shown in figure 4. This issue will be resolved during preparation of the EMP, in consultation with CALM and DOMEWA, with the least sensitive areas to be selected for mining first.

Further safeguards are provided by the proponents' commitments to on-going monitoring of rehabilitation (see section 8.6) and a willingness to modify the rehabilitation plan, should monitoring show that better methods of establishing the required species diversity and density exist.

8.5 Completion Criteria

It is suggested that suitable completion criteria should include:-

* at least 75% of the pre-existing natural species diversity should be established and growing on site for at least three years after rehabilitation has been initiated

* vegetative cover should exceed 20% of the dune surface within five years of mining having ceased on a particular area

* bare patches of more than 200 square metres which develop within five years of the cessation of mining should be subject to further rehabilitation.

The final land use of the mining area is as a nature reserve for the conservation of flora and fauna. Hence, only locally indigenous species are to be used.

When the completion criteria have been met, DOMEWA will be requested to accept surrender of the Mining Lease. Both DOMEWA and CALM will need to be satisfied that rehabilitation has been successful and that the established vegetation will persist in the long term. Only then will the tenement be formally accepted for surrender, with subsequent return of the Mining Lease area into the Nature Reserve.

8.6 Monitoring Program

The proponents will employ consultants to devise and implement a monitoring program to assess the success or otherwise of post-mining rehabilitation. The chosen consultants will undertake a pre-mining survey to determine the existing density and frequency of plant species. The results from this survey will form the basis for measuring success of rehabilitation.

While the detail of the monitoring program is yet to be worked out, it will include a period of post-mining monitoring so that the long-term success of revegetation can be assessed.

Several suitable consultants who could undertake the monitoring program operate in WA. The Mulga Research Centre attached to Curtin University has conducted similar studies in the Kondinin Nature Reserve (for example, see Fox and van Etten, 1987).

Monitoring results will be provided to DOMEWA and CALM on a yearly basis and their comments sought. Copies of results will also be provided to the Shire of Kent for display in their public libraries, so that the local community is informed of the progress of rehabilitation.

8.7 Examples of Successful Rehabilitation In Similar Environments

Two previously mined sites near Pingrup have enjoyed rehabilitation success. A site adjoining the former rubbish dump (see PHOTO 5) has been planted with a wide variety of local species and has responded well. An illegal gypsum mining site (see PHOTO 6) has received no deliberate rehabilitation but a good cover of samphire and other species has self-seeded and become established within six months of mining having ceased.

Successful rehabilitation has been reported after gypsum mining at a deposit near Yelbeni (Phil Patterson, pers. comm. 1993) and in the Kondinin Nature Reserve (Professor John Fox, Curtin University, Perth, pers. comm., 1993).

At Kondinin, some 1.5 hectares of gypsum dunes were mined in 1984 and 1985. The vegetation of these dunes was different to the dunes within the Chinocup Nature Reserve, with a woodland of *Eucalyptus kondininensis* and *E. longicornis* and an understorey consisting of *Atriplex*, *Melaleuca*, *Hakea* and other shrubs and grasses. Although no pre-mining vegetation cover densities were determined, at least part of the Kondinin dunes were "open" with understorey consisting of just two species (Porter and Dunlop, 1984).

Mining in this Nature Reserve removed all gypsum down to a clay base which, after deep ripping, was covered with stockpiled topsoil.

Eighteen months after mining and rehabilitation, vegetation cover was 15% with 16 species present on mining area 1 and 20% cover with 14 species present on mining area 2 (Fox and van Etten, 1987).

The ecological consultants for this Kondinin project conclude that vegetation recovery is proceeding well, with changes in ant species representation also testifying to successional change occurring.

9.0 SUMMARY OF COMMITMENTS BY PROPONENTS

9.1 Commitments - Before Mining Commences

Prior to the commencement of mining, the proponents commit themselves to undertaking the following actions:-

1) carry out a vegetation survey of the most prospective gypsum dunes, using appropriately qualified and experienced consultants

2) in consultation with CALM, select the initial 20 hectare mining area, outside of which mining will not be allowed until successful rehabilitation has been demonstrated to the reasonable satisfaction of CALM and DOMEWA

3) prepare a detailed Environmental Management Plan (EMP) for submission to DOMEWA and CALM, detailing the proposed mining activities, including construction and use of the access road, use of the stockpile area within the Chinocup townsite, and definition of mining methods, mine path, etc

4) initiate negotiations between the Shire of Kent and CALM so that up to half of the Chinocup townsite reserve can be given over to CALM's control for inclusion within the Chinocup Nature Reserve, and

9.2 Commitments - During Mining

While mining is in progress, the proponents will:-

1) conduct mining in accordance with conditions attached to the grant of the Mining Lease and with the Environmental Management Program

2) rehabilitate mined-out areas on an on-going basis in accordance with this CER document and with procedures specified in the Environmental Management Program

3) initiate monitoring of rehabilitation and implement changes to the rehabilitation methods if monitoring results show that such changes are desirable or necessary, and

4) report annually to DOMEWA, CALM and the Shire of Kent on the progress of mining and rehabilitation

Once mining has been completed or is nearing completion within the initial 20 hectare mining area, seek approval from DOMEWA (who will liaise with CALM and EPA) for the extension of mining to other parts of the Mining Lease, subject to the demonstration of successful rehabilitation.

9.3 Commitments - After Mining has Ceased

Once mining has been completed within the Mining Lease, the proponent agrees to:-

1) rehabilitate all mined out areas, the access road, stockpile area and other sites disturbed by mining or associated activities, in accordance with the Environmental Management Program

2) continue post-mining monitoring of rehabilitated areas to ensure successful revegetation and, where deficiencies become apparent, continue to rehabilitate those mined-out sections until revegetation is satisfactory, for a maximum period of three years after the final cessation of mining, and

3) when rehabilitation has been completed to the reasonable satisfaction of CALM and DOMEWA, seek the surrender of the Mining Lease.

10.0 CONCLUSIONS

The proponents believe that, subject to the commitments made in this document, the mining of gypsum dunes within the Chinocup Nature Reserve can be carried out in an environmentally acceptable manner.

Short-term impacts will be relatively minor, with no more than 10% of the population of *Adenanthos pungens* ssp. *pungens* being removed by mining. Long-term impacts will be minimal, with successful rehabilitation of mined-out areas demonstrated or in progress at three other gypsum mining areas (an illegal site near Pingrup, Yelbeni and Kondinin Nature Reserve).

The land swap to be offered to CALM in the form of up to half of the 243 hectare, high conservation value Chinocup townsite reserve will significantly raise the conservation status of the Chinocup Nature Reserve.

Although the risk of introducing dieback is low, its impact on the reserve could be significant. The proponents' commitments to implementation of a dieback management program should provide sufficient confidence that dieback will not be introduced by gypsum mining.

The economic and environmental benefits from a greater use of gypsum on responsive soils will be significant, if a local, low cost source of suitable gypsum as occurs within the Chinocup Nature Reserve is made available for mining.

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PHOTO 1 - Poor crop growth caused by waterlogging of clay-rich soils.

PHOTO 2 - Existing track on the south side of the former railway line.

PHOTO 3 - Typical vegetation cover on dunes within the southern part of the proposed mining area.

PHOTO 4 - Typical vegetation cover on dunes within the northern part of the proposed mining area.

PHOTO 5 - Rehabilitated site near the Pingrup rubbish dump.

PHOTO 6 - Natural revegetation establishment on an illegally mined gypsum deposit, six months after the cessation of mining.

Appendix 1

Department of Agriculture Farmnote on use of gypsum for agricultural soil improvements

Farmnote
No. 32/85

Western Australian Department of Agriculture

Agdex 514

Gypsum improves soil stability

By G. Fosberry, Adviser and M. Howell, Research Officer, Dryland Research Institute, Merredin

Crop growth is often limited by the poor structure of heavy textured soils. Gypsum can improve soil structure, increasing crop yields and making soil more manageable.

Once a soil has been improved it is essential to prevent degradation re-occurring. Minimum tillage techniques play an important role in conserving the improvement.

Gypsum (calcium sulphate) is a naturally occurring mineral found commonly as dunes at the south eastern edge of salt lakes. When applied to a soil, gypsum dissolves and interacts with the clay. This interaction improves soil structure by making the clay more stable when wet and reducing the tendency to set hard when dry. In practice gypsum may:

- reduce crusting or surface sealing,
- improve crop establishment,
- aid drainage of the soil surface,
- lengthen the time the soil is suitable for cultivation, and
- prevent crops haying-off prematurely.

Gypsum is not a treatment for traffic compaction pans, non-wetting sands and soil acidity. Saline soils can be treated with gypsum but only when the soil has been drained and leached of salt.

A beneficial response from gypsum will only occur where:

- soil structure is limiting crop growth, and
- the soil is responsive to gypsum.

Recognising a gypsum-responsive soil

The Department of Agriculture has experimented with gypsum since 1965. Wheat yield improvements have been highly variable, ranging from nothing to over 450 per cent (in one case in 1983). Usually, responses ranged between 30 and 50 per cent. Most responses occurred on hard-setting grey sandy loams overlying a sandy clay, and on some red clays.

The following procedure will help you recognize a gypsum-responsive soil:

1. Take a sample of soil from the surface and another 15 cm below the surface.
2. Place about 50 mL of distilled water or freshly collected rainwater (stored rainwater and tap water may not be pure enough) into each of two clean jars. These jars should be labelled "surface" and "sub-surface" for easy identification.
3. Wet the soil sample with the distilled water to a moisture level similar to that when seeding in good conditions that is, soil should be easily manipulated but not sticky.
4. Re-mould the soil sample into a sphere (about seven millimetres in diameter) and gently drop into the appropriate labelled jar of water.
5. Leave the jars completely undisturbed for 24 hours. If, after this time, a milky cloud or halo has formed around either of the aggregates then the tested soil is likely to be gypsum responsive.
6. As soil can vary greatly even a few metres away, repeat the test with samples from different parts of the suspect area.

The test, though simple is a rough guide to responsive sites. Research into more accurate tests for gypsum responsiveness is continuing.

Gypsum test strips

If the problem soil is gypsum responsive according to the soil test, and crop yield is being depressed by the unstable structure of the soil, then test strips are warranted to assess whether gypsum application will be beneficial.

When doing test strips:

- Apply the gypsum at several rates, for example, 2.5 and 5.0 t/ha.
- It is essential to leave an untreated strip which will confirm whether there was a response to the application of gypsum and in subsequent years will enable an assessment of when re-application is necessary.
- Where no response is measured, continue observation of the strips over at least two seasons to account for seasonal variation.

Methods of gypsum application

Conventional chain-delivery superphosphate spreaders are not suitable for applying gypsum because gypsum is not a free-flowing material. However, there are several commercial spreaders which are suitable. A spreader can be bought or hired or a contractor hired to apply the gypsum.

Often, areas where gypsum is to be applied are bare. On these bare areas the gypsum should be "scratched" into the soil surface to reduce chances of it blowing away.

To be effective gypsum should be applied before the break of the season.

Application rates

In the 1984 experiments conducted by the Department of Agriculture, 2.5 t/ha gypsum gave maximum grain yields. However, for the more unstable soils and where the treated soil surface has suffered from untimely or intensive cultivation, gypsum may need to be re-applied sooner if 2.5 t/ha rather than 5 t/ha is used.

A possible strategy, following the 1984 results, would be:

- apply gypsum at 2.5 t/ha over most of the unstable soil, and
- use 5.0 t/ha on the most unstable country.

Research on the long term consequence of gypsum application: persistence, maintenance of favourable soil structure and cost effectiveness; is continuing.

Continued overleaf

Maximising gypsum effectiveness

Consideration of the following points will ensure that maximum benefit of gypsum application is obtained.

- Gypsum must dissolve in rain water before it can act on the soil. It should therefore be applied before the break of the season.
- Preventing the newly applied gypsum from blowing away is important. However, the gypsum should be kept as close to the soil surface as possible. If cultivation is necessary, do the minimum required.
- Increasing the normal rate of nitrogenous fertiliser or the application of nitrogenous fertiliser where none is normally used, should be seriously considered. Yield increases on some soils treated with gypsum have only been fully realised with additional nitrogen. Other soil types have shown minimal response to nitrogen after gypsum treatment. Use test strips of nitrogen as indicators.
- Following gypsum treatment, minimum tillage or direct drilling practices should be adopted. Minimum tillage techniques encourage a build up of organic matter at the soil surface which further improves soil structure. The improved soil conditions achieved with the gypsum and organic matter will be conserved by minimal surface disturbance, and the residual or undissolved gypsum will remain close to the soil surface. Protection of the treated surface from further degradation may make gypsum application a once-only requirement.

Persistence of the gypsum effect

A major factor in the economics of gypsum use is the persistence of favourable soil effects. Persistence will depend on many factors including:

- the rate of gypsum application—more gypsum lasts longer,
- the intensity and frequency of rainfall,
- the soil type, and
- the management practices adopted after the gypsum application (minimum tillage techniques required).

Gypsum quality

Gypsum suppliers should be able to provide a comprehensive analysis of their gypsum. However, a 500 g sample can be sent for analysis to:

Government Chemical Laboratories
30 Plain Street
EAST PERTH WA 6000
Telephone: (09) 325 5544

Ideally, the proportion of gypsum should be greater than 70 per cent. Lower percentages increase the cost of cartage and application.

The chloride or salt content is also important. Supplies which have over 1 per cent chloride, are suspect and those over 2 per cent chloride should not be used (figures from the Department of Agriculture, South Australia).

The costs of gypsum

Gypsum costs between $4 and $10 per tonne at the mine (1985 prices). The cost of gypsum per hectare is extremely variable and depends on:

- freight—this is usually the greatest cost, hence the distance from the source is important,
- the rate applied,
- purity of the gypsum used, and
- price

The table outlines the approximate costs of gypsum per hectare. The influence of gypsum quality and distance from the gypsum source is easily seen.

Examples of the costs of gypsum application

Gypsum rate (t/ha)	Distance from gypsum source (km)	Gypsum content (% calcium sulphate)	Total cost of gypsum application* ($/ha)
5.0	100	100	68.00
5.0	100	70	93.20
5.0	20	100	40.00
2.5	100	100	38.00
2.5	20	100	27.50

*Prices used: Gypsum = $5/tonne
Contract cartage = 7c/tonne/km
Contract spreading = $8/ha

NOTE: These costs can vary, especially if you use your own truck and spreader.

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Appendix 2

Vegetation and Flora Survey of the Proposed Gypsum Mine Site and Access Route Adjacent to Chinocup Lake on Nature Reserve No. A28395 and Unmade Road 8315

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Newdegate

Note: To reduce the length of this CER document (and save trees), some figures and appendices from Anne Coats' original report have not been included in this appendix, as follows-

Figure 1 of this report is reproduced as figure 2 in the CER

Figures 2 and 3 of this report have been combined and reproduced as figure 4A in the CER

Figure 4 of this report is reproduced as figure 4B in the CER

Photographs 1 to 10 have been omitted from this appendix

Appendix 1 (Plant Species List) and Appendix 2 (Site Descriptions) and Appendix 3 (Proposal for Addition to CALM Priority List) have been omitted from this appendix

VEGETATION AND FLORA SURVEY OF THE PROPOSED GYPSUM MINE SITE AND ACCESS ROUTE ADJACENT TO CHINOCUP LAKE ON NATURE RESERVE NO. A28395 AND UNMADE ROAD 8315

Prepared for: Lake Chinocup Gypsum Committee

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1.0 ABSTRACT

The mining of gypsum has been proposed for dunes south of Lake Chinocup on Nature Reserve No. A28395. The proposal includes road reserve No. 8315 (unmade road) as the access route. During the present survey the proposed access route, gypsum dunes and selected areas of interest were surveyed for vegetation and flora.

Ten vegetation associations were encountered during field work including samphire *(Halosarcia* Dwarf Scrub/Heath) and *Melaleuca* Scrub/Thicket in low lying areas adjacent to salt lakes, Scrub *(Melaleuca* and mixed plant species) and *Casuarina obesa* (sheoak) Low Woodland on low gypsum dunes, Mallee over Scrub on well developed gypsum dunes and Scrub Heath associations on sand dunes further from the lake. *Eucalyptus angustissima* Open Shrub Mallee over Low Scrub on sandy soils and Mallee over *Melaleuca uncinata* and/or *Melaleuca subtrigona* in clay soils cover the western end of the proposed access route including adjacent Chinocup townsite reserve. The Mallee over Scrub association was only found on the well developed gypsum dunes on the southern shore of Lake Chinocup.

A total of 227 plant species were identified for the area surveyed. This includes two gazetted rare plants, *Adenanthos pungens* ssp. *pungens* (gypsum dunes and adjacent sand dunes) and *Drakaea isolata* (ms) (road reserve 8315), previously identified by the Department of Conservation and Land Management. The extent of *Adenanthos pungens* in the survey area was found to be greater than originally recorded. Two Department of Conservation and Land Management priority species, *Drosera salina* (ms) (priority 1) and *Eucalyptus angustissima* ssp. *quaerenda* (priority 2), have also been previously recorded for road reserve 8315 and four more priority species were found on the road reserve during the present survey. These newly identified species include *Dicrastylis glauca* (priority 3), *Fitzwillia axilliflora* (priority 2), *Melaleuca polycephala* (priority 3) and *Verticordia brevifolia* ssp. *brevifolia* (priority 1). A rare *Astartea (Astartea clavifolia)* was also identified and this species has been proposed for priority status. Other collections of interest include two hybrids, *Eucalyptus phaenophylla* x aff. *incrassata* (gypsum and sand dunes) and *Adenanthos cuneatus* x *pungens* (sand dunes). Unmade road 8315 is also the location of the type specimen of the newly described *Eucalyptus sparsicoma* which is believed to be geographically restricted.

2.0 INTRODUCTION

Permission is being sort to mine gypsum on Nature Reserve No. A28395. The gypsum occurs as dune deposits on the south and eastern shore of Lake Chinocup. Unmade road 8315 which includes a disused railway formation has been proposed as the access route to the mine site.

The requirements of this project are to:

a. survey the flora and vegetation on the gypsum dunes, access route and adjacent areas of interest;

b. ascertain the extent of declared and other rare flora in the area; and

c. examine the extent to which the vegetation associations covering the dunes occur elsewhere on the reserve.

Lake Grace North, Lake Grace South and Lake Chinocup are part of a salt lake system which is the remnant of an ancient river system. The lakes lie along the floor of a broad shallow valley with a north-south trend. The drainage system only functions as a river in exceptionally wet years. Normally the lakes act as sumps in which water and salts accumulate (McKenzie and Youngson 1975).

Nature Reserve No. A28395 is approximately 19 825 hectares in size. Over half the area is covered by bare salt lake, devoid of vegetation, where saline and gypsiferous clay and silt have accumulated. The reserve is surrounded by cleared farmland with only a narrow strip of natural vegetation between cleared land and bare salt lake in some areas.

Adjacent to the lakes are areas of silt and sand in sheets and dunes which are gypsiferous near playa lakes (Chin and Brakel 1986). The dunes and lunettes are not more than 10 metres in height. A block of Crown land known as Chinocup townsite adjoins the reserve south west of Lake Chinocup. The proposed access route starts at Chinocup Road and passes through the Chinocup townsite reserve and the southern section of Reserve No. A28395 to the Pingrup townsite. Figure 1 provides cadastral and topographical information for the area surveyed.

Originally reserve No. 28395 was set aside for the purpose of "Protection of flora" with an area of 1 728 hectares. The area was increased to 17 728 hectares on 21 August 1970. McKenzie (1973) recommended that the reserve be vested in the West Australian Wildlife Authority (now the National Parks and Nature Conservation Authority), declared "A Class" status and that the purpose be changed to "Conservation of Flora and Fauna". These recommendations were implemented on 21 December 1979 and the size of the reserve was increased to 19 825 hectares. The current area is about 19 820.7 hectares having been reduced by road 17728 (6 November 1987). The reserve was named Chinocup Nature Reserve on 16 November 1984.

3.0 METHOD

The ground survey of the vegetation and flora of the gypsum dunes, proposed access route and adjacent areas on Nature Reserve No. A28395 and unmade road 8315 were carried out during the first half of November 1992 covering a period of 5 days. A further 2 days field work was carried out in December 1992 and January 1993 to examine sites on the eastern shore of Lake Chinocup and Lake Grace for rare flora and vegetation associations.

Vegetation and soils at selected sites were described. Vegetation association descriptions were based on the classification system devised by Muir (1977) which was specifically designed for describing wheatbelt vegetation (Table 1).

Voucher specimens of most plant species encountered were collected and identified using keys and by comparison with specimens at the Western Australian Herbarium. Experts involved in revising particular genera were consulted wherever possible to ensure accuracy with identification.

TABLE 1 - MUIR SYSTEM OF VEGETATION CLASSIFICATION

LIFE FORM/HEIGHT CLASS	CANOPY COVER			
	DENSE 70 - 100%	MID DENSE 30 - 70%	SPARSE 10 - 30%	VERY SPARSE 2 - 10%
T Trees > 30 metres	Dense Tall Forest	Tall Forest	Tall Woodland	Open Tall Woodland
M Trees 15 - 30 metres	Dense Forest	Forest	Woodland	Open Woodland
LA Trees 5 - 15 metres	Dense Low Forest A	Low Forest A	Low Woodland A	Open Low Woodland A
LB Trees < 5 metres	Dense Low Forest B	Low Forest B	Low Woodland B	Open Low Woodland B
KT Mallee tree form	Dense Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
KS Mallee shrub form	Dense Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
S Shrubs > 2 metres	Dense Thicket	Thicket	Scrub	Open Scrub
SA Shrubs 1.5 - 2.0 metres	Dense Heath A	Heath A	Low Scrub A	Open Low Scrub A
SB Shrubs 1.0 - 1.5 metres	Dense Heath B	Heath B	Low Scrub B	Open Low Scrub B
SC Shrubs 0.5 - 1.0 metres	Dense Low Heath C	Low Heath C	Dwarf Scrub C	Open Dwarf Scrub C
SD Shrubs 0.0 - 0.5 metres	Dense Low Heath D	Low Heath D	Dwarf Scrub D	Open Dwarf Scrub D
P Mat plants	Dense Mat Plants	Mat Plants	Open Mat Plants	Very Open Mat Plants
H Hummock Grass	Dense Hummock Grass	Mid Dense Hummock Grass	Hummock Grass	Open Hummock Grass
GT Bunch grass > 0.5 metres	Dense Tall Grass	Tall Grass	Open Tall Grass	Very Open Tall Grass
GL Bunch grass < 0.5 metres	Dense Low Grass	Low Grass	Open Low Grass	Very Open Low Grass
J Herbaceous spp.	Dense Herbs	Herbs	Open Herbs	Very Open Herbs
VT Sedges > 0.5 metres	Dense Tall Sedges	Tall Sedges	Open Tall Sedges	Very Open Tall Sedges
VL Sedges < 0.5 metres	Dense Low Sedges	Low Sedges	Open Low Sedges	Very Open Low Sedges
X Ferns,	Dense Ferns	Ferns	Open Ferns	Very Open Ferns
Mosses, Liverwort	Dense Mosses	Mosses	Open Mosses	Very Open Mosses

4.0 VEGETATION SURVEY

4.1 Previous Surveys

The area surveyed is situated within the Hyden Vegetation System which is a subdivision of the Roe Botanical district. Beard (1980) describes the vegetation in saline areas as a mosaic of woodland, shrubland and samphire.

A vegetation transect through Nature Reserve No. A28395 was included in "Results of a Biological Survey of the Shire of Kent" by McKenzie (1973). This report was followed by a more detailed survey of the area by McKenzie and Youngson (1975). The vegetation descriptions by McKenzie and Youngson were based on the density, height and crown cover system described by Specht (1970). The vegetation map (Figure 3) was constructed from aerial photo interpretation of data collected by both field traverses on the ground and an aerial reconnaissance. Figure 2 details the key to the vegetation map.

Taxonomic changes since the production of the map include *Arthrocnemum* species which are now recognised as species of the genus *Halosarcia.*

Mallee formations mapped by McKenzie and Youngson include areas of Low Open Shrubland of mainly *Eucalyptus angustissima* south and south west of Lake Chinocup and to a limited extent east of Lake Grace South, Tall Shrubland further away from Lake Chinocup of *Eucalyptus* species over *Melaleuca uncinata* and *Isopogon buxifolius* and Open Scrub near Chinocup townsite reserve of *Eucalyptus* species over *Melaleuca uncinata.*

4.2 Current Survey

A description of the structure and species composition of vegetation recorded at selected sites are presented in Appendix 2 and a map indicating the site localities and general vegetation boundaries is presented in Figure 4.

4.3 Vegetation of Road Reserve 8315

The western end of road reserve 8315 passes through the Chinocup townsite reserve. The vegetation consists of Mallee with an understorey of *Melaleuca uncinata* growing in clayey soils. Species of *Eucalyptus* recorded include *Eucalyptus anceps, Eucalyptus eremophila, Eucalyptus phaenophylla, Eucalyptus scyphocalyx* and *Eucalyptus spathulata.* Department of Conservation and Land Management priority species occurring in this vegetation association include *Melaleuca polycephala* and *Verticordia brevifolia* ssp. *brevifolia.* Further east *Melaleuca subtrigona* becomes a prominent understorey species growing in duplex soils of sand over clay. *Eucalyptus hypochlamydea* was also recorded in the *Melaleuca subtrigona* association along with priority species *Dicrastylis glauca* and declared rare flora *Drakaea isolata* (ms). Both Mallee over *Melaleuca* associations appear to be extensive locally and are found on the western edge of Chinocup Nature Reserve No. A28395.

East into the reserve *Eucalyptus angustissima* Open Shrub Mallee over Low Scrub occurs on sandy soils. *Eucalyptus angustissima* ssp. *quaerenda* (priority species) forms a very open patchy upper stratum over a sparse understorey with *Melaleuca* species prominent. This vegetation type is not extensive but McKenzie and Youngson (1975) report the association also occurring to a limited extent east of Lake Grace South.

Closer to the southern shore of Lake Chinocup unmade road 8315 crosses channels and small salt lakes. Samphire growing in saline soils of silt and clay fringe the edges of the water ways and lakes. *Melaleuca* Scrub and Thicket occur on the elevated margins or on sandy rises further from lake edges. These associations appear to be wide spread and McKenzie and Youngson (1975) report extensive areas occurring in low lying country throughout the reserve. *Drosera salina* (ms) is found at the edge of the salt lakes with *Astartea clavifolia,* a proposed priority species, occurring in areas of *Melaleuca* Scrub. *Melaleuca* species recorded include *Melaleuca brevifolia, Melaleuca lateriflora, Melaleuca hamulosa, Melaleuca thyoides, Melaleuca uncinata* and *Melaleuca urceolaris.*

The road reserve passes through the sand dune system south of Lake Chinocup which is covered with Scrub Heath growing in deep sandy soils. *Leptospermum* species and *Regelia inops* are characteristic of these areas and an open upper stratum of Tree Mallee occurs occasionally. The declared rare flora *Adenanthos pungens* ssp. *pungens* is also found in this association.

At the eastern end of the road reserve, further from but still associated with the salt lakes, Scrub Heath covers undulating dune systems. These dunes form relatively extensive flat sand plains to the east. The Scrub Heath is rich in plant species and *Banksia prionotes* forms an upper stratum on rises. Mallee may also form an upper stratum in areas closer to the salt lakes with *Adenanthos pungens* also occurring in areas of close proximity to the lakes. Some of the commonly occurring species of this association include *Adenanthos cuneatus, Andersonia lehmanniana, Allocasuarina acuaria, Banksia baueri, Banksia violacea, Dryandra cuneata, Dryandra nivea, Eremaea pauciflora* (prominent in places), *Hakea corymbosa, Hakea nitida, Isopogon* ?buxifolius, *Lachnostachys albicans, Leptospermum* species, *Melaleuca subtrigona, Petrophile ericifolia, Petrophile brevifolia* and *Petrophile* aff. *teretifolia*. This vegetation type tends to merge with the Scrub Heath areas with *Leptospermum* and *Regelia inops* prominent and district vegetation boundaries between these associations do not occur.

4.4 Vegetation of the Gypsum Dunes

A transect taken at site 12 illustrates the changes in vegetation associations from the lake bed to the higher ground on the southern shore of Lake Chinocup. The salt lake is mainly bare saline silt and clay with the margins vegetated closest to the shore with strands of samphire *(Halosarcia* Dwarf Scrub/Heath) and other halophytic shrubs. Species recorded at site 12 include *Halosarcia indica, Halosarcia pergranulata, Sarcocornia quinqueflora* and *Frankenia* species. Slightly raised above the level of the lake bed on sandy soils over saline clay is a narrow belt of *Melaleuca brevifolia* Scrub which is patchily distributed.

The well developed gypsum dunes on higher ground are covered with Mallee over Scrub with *Eucalyptus* aff. *incrassata* forming an open upper stratum. *Eucalyptus kondininensis* (Kondinin blackbutt) was also recorded at site 7 and the hybrid *Eucalyptus phaenophylla* x aff. *incrassata* at site 12. McKenzie and Youngson (1975) report that only isolated patches of Open Woodland occur throughout the lake system. The scrub understorey at site 12 consists of three stratum. Characteristic species in the upper stratum include *Actinostrobus pyramidalis, Alyxia buxifolia, Leptospermum erubescens, Melaleuca brevifolia* and *Santalum acuminatum.* Characteristic species in the two lower stratum include *Adenanthos pungens* ssp. *pungens* (DRF), *Billardiera lehmanniana, Bossiaea leptacantha, Atriplex hymenotheca, Conostephium drummondii, Disphyma crassifolium, Darwinia drummondii, Exocarpos aphyllus, Maireana erioclada, Rhagodia drummondii, Styphelia intertexta* and *Threlkeldia diffusa.* Towards the top of the dunes the understorey changes to Thicket or Scrub of *Melaleuca* species including *Melaleuca brevifolia, Melaleuca lateriflora, Melaleuca hamulosa, Melaleuca uncinata, Melaleuca thyoides* and *Melaleuca urceolaris* with *Eucalyptus hypochlamydea* also recorded.

Low gypsum dunes adjacent to the southern shore of Lake Chinocup further east (sites 13a, 13b, 32) are covered with a sparse vegetation of Scrub consisting of *Melaleuca* and mixed plant species. These low dunes are interspersed with samphire *(Halosarcia* Dwarf Scrub/Heath) in depressions. Commonly occurring species include *Actinostrobus pyramidalis, Adenanthos pungens, Atriplex* species, *Darwinia drummondii, Disphyma crassifolium, Casuarina obesa* (scattered trees), *Exocarpos aphyllus, Frankenia* species, *Hakea obliqua, Isopogon ?buxifolius, Melaleuca brevifolia, Rhagodia drummondii* and *Scaevola spinescens.*

On the south eastern shore of Lake Chinocup a small area of *Casuarina obesa* (sheoak) Low Woodland covers the gypsum dunes at site 15. The understorey consists of Open Low Scrub and Dwarf Scrub with areas of samphire (Low Heath) in depressions. Further away from the lake sand dunes carry the Scrub Heath associations.

The Mallee over Scrub association was only seen on well developed gypsum dunes south of Lake Chinocup surrounding sites 7, 11 and 12. This area was mapped as "Low Forest, Woodland and Open Woodland" by McKenzie and Youngson (1975). However *Eucalyptus kondininensis* (tree form) was only recorded at site 7 and the rest of the area has an upper stratum of Tree Mallee. On the east shore of South Lake Grace (Figure 5) low gypsum dunes are covered by samphire (site 34) and the sand dunes further east (site 35) are covered with a Low Woodland of *Eucalyptus kondininensis* and *Eucalyptus loxophleba* (York gum). More extensive gypsum dunes south of site 34 are also reported to be covered by samphire but were not examined during the present survey.

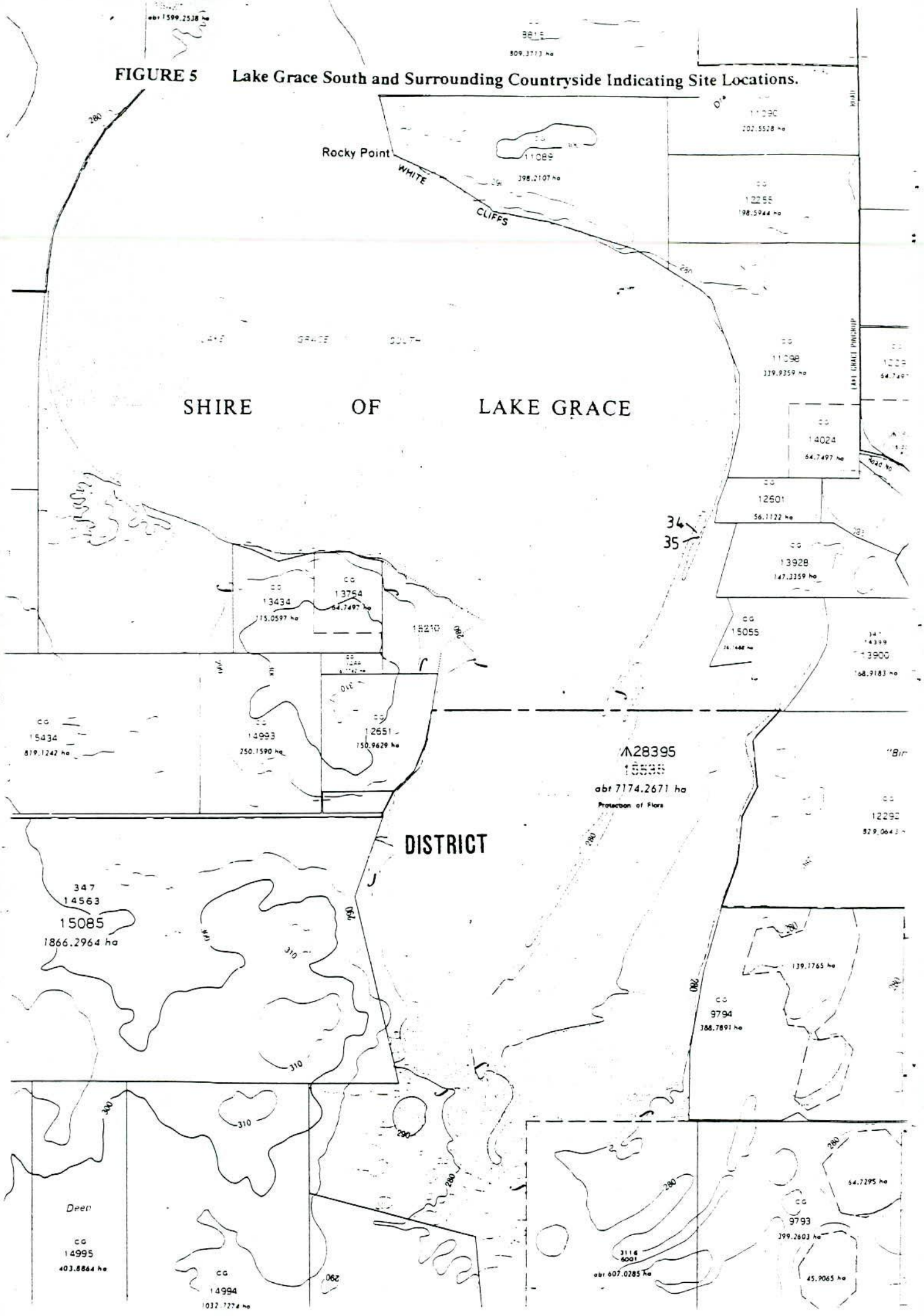
Species recorded only on gypsum dunes in the Mallee over Scrub, Scrub *(Melaleuca* and mixed plant species) and *Casuarina obesa* (sheoak) Low Woodland include *Alyxia buxifolia, Asteridea chaetopoda, Lawrencia squamata, Maireana erioclada, Schoenus submicrostachyus, Stipa ?hemipogon, Wilsonia backhousei, Zygophyllum glaucum* and *Zygophyllum ?aurantiacum.* These species are generally commonly occurring and may be found in adjacent areas after further, more intensive, survey work is carried out.

TABLE 2 - VEGETATION ASSOCIATIONS OF SELECTED AREAS ON NATURE RESERVE No. A28395 AND UNMADE ROAD 8315

SHRUBLAND AND HEATH FORMATIONS		
VEGETATION ASSOCIATIONS	**SITES**	**SOILS AND TOPOGRAPHY**
Samphire *(Halosarcia* Dwarf Scrub/Heath)	11, 12	low-lying country on saline soils of silt and clay, fringing salt lakes and drainage channels or covering smaller lakes and depressions
Melaleuca Scrub/Thicket	5, 8, 12	generally low lying undulating country near salt lakes, on the elevated margins of the lake beds or on sandy rises further from lake edges
Scrub - *Melaleuca* and mixed plant species	13a, 13b, 32	low gypsum dunes adjacent to Lake Chinocup interspersed with Samphire in depressions
Scrub Heath ± Open Mallee upper storey	6, 9, 10, 17, 18, 19, 28	deep sandy soils of the dune system found east and south east of Lake Chinocup, close to the lake margin with *Leptospermum* species and *Regelia inops* prominent. Small playa lakes interspersed.
Scrub Heath ± Open *Banksia* upper storey on rises. ± Open Mallee upper storey in places	16, 20 to 23, 24, 26, 27, 29, 30, 31	further from but still associated with the lakes on extensive dune system forming relatively flat sand plains in some areas.

MALLEE AND WOODLAND FORMATIONS		
VEGETATION ASSOCIATIONS	**SITES**	**SOILS AND TOPOGRAPHY**
Casuarina obesa (sheoak) Low Woodland	15	gypsum dunes on the south east shore of Lake Chinocup
Mallee over Scrub *(Eucalyptus kondininensis* at site 7)	7, 11, 12, 14	well developed gypsum dunes on the southern shore of Lake Chinocup
Eucalyptus angustissima Open Shrub Mallee over Low Scrub	4	well drained and very gently sloping sandy soils
Mallee over *Melaleuca subtrigona*	3, 25	sand over clay, very gently sloping terrain
Mallee over *Melaleuca uncinata*	1, 2	clay soils on Chinocup townsite Reserve

FIGURE 5 **Lake Grace South and Surrounding Countryside Indicating Site Locations.**



5.0 FLORA SURVEY

A total of 227 plant species are recorded in Appendix 1 as occurring in the area surveyed. Five of the species are exotic or introduced. Manuscript names (ms) have been included to help differentiate between undescribed species within a particular genus. Identifications with the generic name followed by "?" or "sp." are uncertain due to a lack of flowering or fruiting material or to confusion in the current taxonomy of the group concerned. Affinity or "aff." is used in relation to undescribed species which are very similar to named species yet different enough to be kept as separate taxa. The nomenclature follows that of Green (1985) and Supplement 7 (November 1988 unpublished) unless otherwise specified below.

Eucalyptus phaenophylla, Eucalyptus sparsicoma (Brooker and Hopper 1991)
Eucalyptus hypochlamydea (Brooker 1988)
Hakea newbeyana (Barker 1990)
Nemcia punctata (Crisp and Weston 1987)
Fitzwillia axilliflora (Short 1989)
Ozothamnus lepidophyllus (Wilson, Short and Orchard 1992)
Verticordia brevifolia, Verticordia eriocephala, Verticordia endlicheriana (George 1991)

The nomenclature further differs from Green (1985) and Supplement 7 in including the new combinations in *Burtonia* and *Gompholobium* (Crisp and Weston 1987). Information provided by Dr B Conn (pers. comm) has resulted in the retention of *Westringia rigida* which is recognised as occurring in the wheatbelt with *Westringia dampieri* typical of coastal areas.

The nomenclature for the Orchidacea follows Hoffman and Brown (1992). *Darwinia drummondii* has not been listed in Green, however this species name has been previously published and will be included in the revision of the genus *Darwinia* by Marchant and Keighery (pers. comm.).

Undescribed species identified in Appendix 1 by manuscript names or "aff." total 14 and two hybrids were also collected. Due to the seasonal and time constraints of the survey Appendix 1 only represents part of the flora of the area surveyed. Many ephemeral and herbaceous species had finished flowering by November and further survey work especially from August to October would provide a more comprehensive record of the flora present on the dunes and unmade road 8315.

5.1 Species of Interest

Plant species of interest recorded for the area surveyed are listed in Table 3. These species have been classified by the Department of Conservation and Land Management into categories which reflect their conservation status. These categories are listed below:

CONSERVATION CODES

R: Declared Rare Flora - Extant Taxa
Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

X: Declared Rare Flora - Presumed Extinct Flora
Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which known wild populations have been destroyed more recently, and have been gazetted as such.

1: Priority One - Poorly Known Taxa
Taxa which are known from one or a few (generally <5) populations, which are under threat either due to small population size, or being on lands under immediate threat, eg. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, eg. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

2: Priority Two - Poorly Known Taxa
Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (ie. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

3: Priority Three - Poorly Known Taxa
Taxa which are known from several populations, at least some of which are not believed to be under immediate threat (ie. not currently endangered). Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

4: Priority Four - Rare Taxa
Taxa which are considered to have been adequately surveyed and which whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Department of Conservation and Land Management personnel have previously recorded *Adenanthos pungens* ssp. *pungens* (declared rare flora) on the gypsum dunes and adjacent areas and *Drakaea isolata* (ms) (declared rare flora), *Drosera salina* (ms) (priority 1 species) and *Eucalyptus angustissima* ssp. *quaerenda* (priority 2 species) on unmade road 8315. The extent of some of these populations were examined during the present survey.

Drosera salina (ms) flowers in July and August. The extent of the population is therefore taken from Department of Conservation and Land Management records (see Figure 6). This species is found in low lying areas which may be subject to flooding, adjacent to watercourses, immediately south of Chinocup Lake including similar areas within road reserve No. 8315. Mr M Graham (Department of Conservation and Land Management) estimated the population at over 2 000 plants on 14 August 1990, scattered over approximately 1 hectare.

Eucalyptus angustissima ssp. *quaerenda* was found to be more extensive in the region south of Lake Chinocup than previously recorded by the Department of Conservation and Land Management (see Figure 6). Some specimens have been marked by M I H Brooker for *Eucalyptus* oil research.

Acacia leptalea (ms) (declared rare flora) has also been recorded by the Department of Conservation and Land Management on the verge of Chinocup Road, south west of Lake Chinocup. *Roycea pycnophylloides* (declared rare flora) and *Caladenia melanema* (ms) (priority 1 species) occur north of Lake Chinocup in the central portion of Reserve No. A28395. These species may occur in the area south and east of Lake Chinocup although they were not found during the present survey. *Caladenia melanema* (ms) flowers in August and early September.

Four priority species not previously recorded for the area were found on unmade road 8315 during the present survey. These species include *Dicrastylis glauca* (priority 3 species), *Fitzwillia axilliflora* (priority 2 species), *Melaleuca polycephala* (priority 3 species) and *Verticordia brevifolia* ssp. *brevifolia* (priority 1 species). For the exact location of these species see Table 3 and Figure 4. A rare *Astartea* has also been included in Table 3 as a proposed priority species (see Appendix 3 for covering letter).

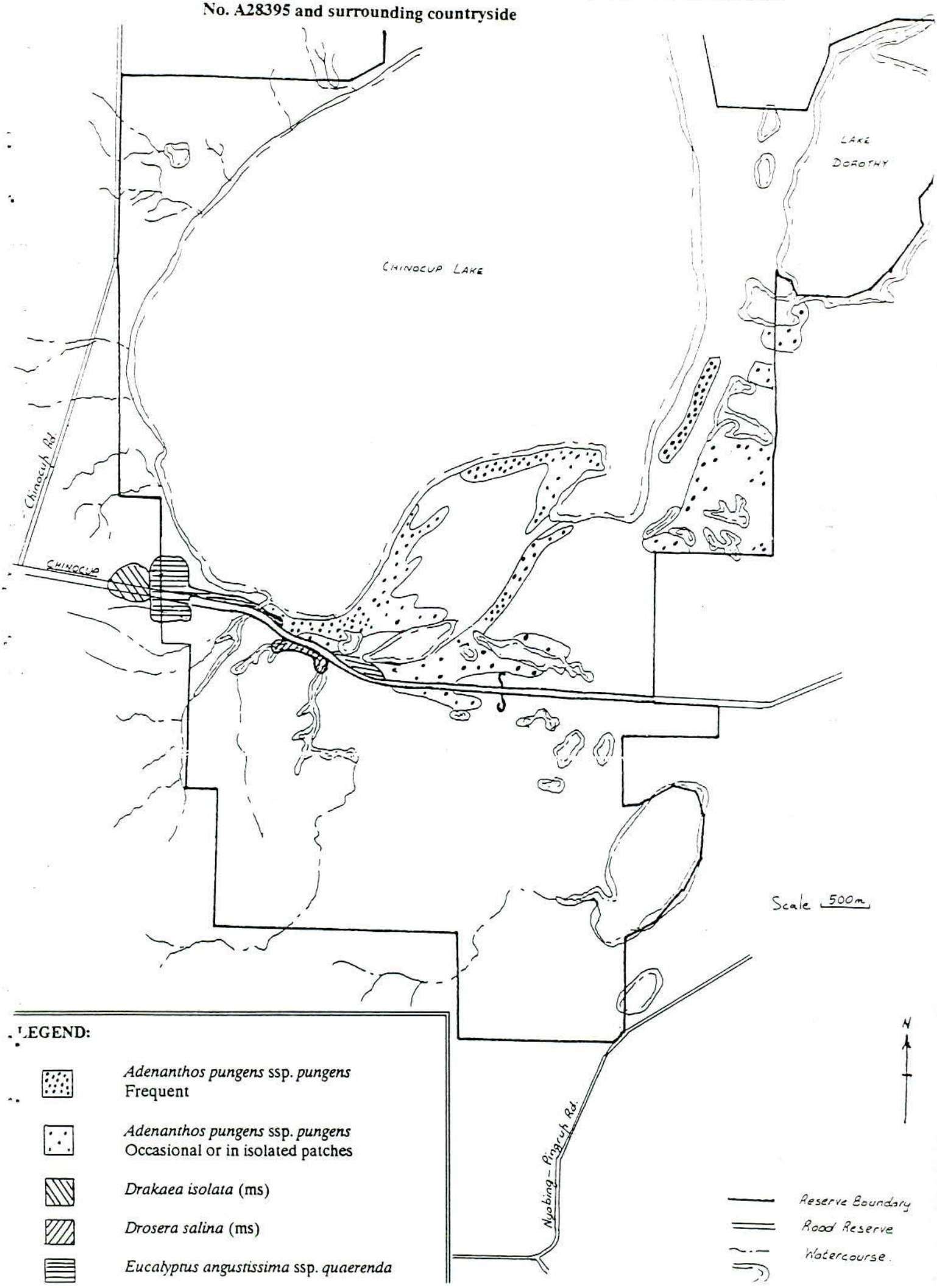
Two rare hybrids were also collected on the gypsum and sand dunes these include *Eucalyptus phaenophylla* x aff. *incrassata* (site 12, 16) and *Adenanthos cuneatus* x *pungens* (site 16). No other collections of the *Adenanthos* hybrid were found at the Western Australian Herbarium.

Unmade road 8315 is also the location of the type specimen of the newly described *Eucalyptus sparsicoma* given as 800 metres from the Chinocup Road turn-off. The conservation status of this species is described in Brooker and Hopper (1991) as "Requires further survey. Apparently geographically restricted but locally abundant and represented on a nature reserve."

TABLE 3: Species of Interest Occurring in the Area Surveyed

Species	Conservation Code	Location
Adenanthos pungens ssp. *pungens*	R	Dunes associated with salt lakes - gypsum and sand including sites 9 to 19, 26, 29, 30 to 33
Adenanthos cuneatus x *pungens*	-	Site 16
Astartea clavifolia	Proposed priority species	Sites 4, 5, 6
Dicrastylis glauca	3	Site 3
Drakaea isolata (ms)	R	Site 3
Drosera salina (ms)	1	South edge of unmade road 8315, ~250 metres south east of Site 9
Eucalyptus angustissima ssp. *quaerenda*	2	Sites 4, 5, 6, 9
Eucalyptus phaenophylla x aff. *incrassata*	-	Sites 12, 16
Fitzwillia axilliflora	2	Between Sites 9 and 19 on unmade road 8315
Melaleuca polycephala	3	Site 1 and 100 metres east of site 1
Verticordia brevifolia ssp. *brevifolia*	1	Site 2

FIGURE 6: **Distribution of Species of Interest in the southern portion of Nature Reserve No. A28395 and surrounding countryside**



5.2 Declared Rare Flora

Drakaea isolata (ms) - Lonely Hammer Orchid

Drakaea isolata (ms) occurs near the southern edge of Chinocup Lake. The population extends into road reserve No. 8315 and the Chinocup townsite reserve (Department of Conservation and Land Management records) see Figure 6. The flowering time of *Drakaea isolata* (ms) is from September to early October and therefore this species was not in flower at the time of the present survey. Mr M Graham (Department of Conservation and Land Management) surveyed the population on 11 October 1989 and estimated the number of plants at 500, covering an area of 1 000 square metres.

Adenanthos pungens ssp. *pungens* - Spiky *Adenanthos*

Adenanthos pungens ssp. *pungens* is present on the dunes proposed for gypsum mining and adjacent sand dunes including areas on Chinocup Nature Reserve No. A28395 and road reserve No. 8315. The only other population of this sub species is in the Stirling Range National Park. Two populations of *Adenanthos pungens* ssp. *effusa* are known from the Tambellup area. The distribution of *Adenanthos pungens* ssp. *pungens* within the area surveyed is illustrated in Figure 6. Over 1 500 plants were counted during field work. Due to time restrictions not all areas were covered in detail and exact plant numbers would be higher than those recorded. This species was common throughout the Mallee over Scrub, Scrub (*Melaleuca* and mixed plant species) and to a lesser extent the *Casuarina obesa* (sheoak) Low Woodland associations which occur on gypsum dunes south and east of Lake Chinocup and is less common in the Scrub Heath associations adjoining the salt lakes. The number of plants counted at different localities is presented in Table 4. Information from Department of Conservation and Land Management files indicate that a high level of plant deaths from *Phytophthora* sp. (dieback) has been reported by E Nelson (pers. comm. 1984) for *Adenanthos pungens* ssp. *pungens*. The response to soil disturbance of ssp. *pungens* is not known however ssp. *effusa* has regenerated poorly after site disturbance.

TABLE 4 - The Number of Plants of *Adenanthos pungens* ssp. *pungens* counted at different localities

Vegetation Association	Locality	Number Counted
Mallee over Scrub (gypsum)	area surrounding sites 11 and 12	268, 8 dead
Mallee over Scrub (gypsum)	area surrounding site 14	47
Scrub (low gypsum dunes)	area surrounding site 13a, 13b	292, 2 dead
Scrub (low gypsum dunes)	area surrounding site 32	211
Scrub (low gypsum dunes)	area south of sheoak woodland before site 16	20
Casuarina obesa (sheoak) Low Woodland	area surrounding site 15	13
Scrub Heath	isolated patches from site 16 to 19 prominent around site 17	202, 6 dead
Scrub Heath	area surrounding sites 9, 10	48
Scrub Heath	isolated patches, dunes interspersed with salt lakes area surrounding sites 26, 29, 30	96, 2 dead
Scrub Heath	area surrounding sites 31, 33	129, 6 dead
Scrub Heath	northern areas - east of Lake Chinocup	188, 4 dead

6.0 ACKNOWLEDGMENTS

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Appendix 3

Photocopies of articles on rare and endangered fauna of the Chinocup Nature Reserve

* Page 232 (Tammar Wallaby) from "The Complete Book of Australian Mammals", edited by Ronald Strahan, published by The Australian Museum

* Western Mouse. Mammals No. 22 pamphlet, Australian Endangered Species, published by the Australian National Parks and Wildlife Service, Canberra, 1978

* Western Bristlebird. Birds No. 5 pamphlet, Australian Endangered Species, published by the Australian National Parks and Wildlife Service, Canberra, 1977.

* Western Whipbird. Threatened Birds of Australia: An Annotated List. Brouwer, J. and Garnett, S. RAOU Report No. 68, pp 100-103.

Tammar Wallaby

Macropus eugenii

SIZE
(Kangaroo Island)
HEAD AND BODY LENGTH
590-680 (643) mm (males)
520-630 (586) mm (females)
TAIL LENGTH
380-450 (411) mm (males)
330-440 (379) mm (females)
WEIGHT
6-10 (7.5) kg (males)
4-6 (5.5) kg (females)
Animals from other populations are smaller, often considerably so.

IDENTIFICATION
Dark, grizzled grey-brown above, becoming rufous on the sides of the body and on the limbs, especially in males. Pale grey-buff below.

RECENT SYNONYMS
Thylogale eugenii, Thylogale flindersi, Protemnodon eugenii.

OTHER COMMON NAMES
Tammar, Kangaroo Island Wallaby, Dama Wallaby, Dama Pademelon.

STATUS
Common, limited.

SUBSPECIES
Trinomials have been proposed to distinguish several of the many distinct populations, and in some cases to link them to other populations. Insufficient is yet known about these to justify the designation of subspecies.

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With populations on 10 or more offshore islands and disjunct mainland populations in Western Australia and South Australia, the Tammar Wallaby was, at one time, distributed in at least a dozen areas, many of them isolated for more than 10,000 years. It is one of the smallest of the species of *Macropus*, reaching its largest size in the population on Kangaroo Island, SA. The population on Flinders Island, SA, now extinct, differed considerably from the Kangaroo Island form in having a finer, more graceful build and a short sleek coat.

The Tammar Wallaby requires dense low vegetation for daytime shelter and open grassy areas for feeding. It inhabits coastal scrub, heath, dry sclerophyll forest and thickets in mallee and woodland. During the day it rests in scrub and, although it begins to move at dusk, it does not leave the scrub until after dark, returning to it before dawn. A distance of more than 1 km may separate the feeding area from the daytime refuge.

On the semi-arid islands inhabited by some populations, fresh water may be unavailable for long periods. This is especially so on the islands of Houtman Abrolhos, WA, where rain falls only in June, July and August. Animals taken from the Abrolhos to a laboratory in Perth were found to be able not only to drink seawater but also to maintain body weight and even to suckle young on a diet of dry food while drinking only seawater. On Garden Island, WA, the Tammar has been seen drinking from the sea.

Each individual has a defined home range which overlaps the home ranges of others. While several wallabies may feed in the same area, no social grouping has been observed except between females and their young at foot.

The breeding cycle is well known only for the Kangaroo Island population. Most young are born in late January, very few being born outside January, February and March and (under natural conditions) none from July to December. Within a few hours of giving birth the female mates and the resulting embryo remains quiescent during lactation. Exceptionally, however, the quiescent embryo is not reactivated when the young is ready to leave the pouch in September or October. From late June to November the embryo remains quiescent even if the pouch young is lost and lactation ceases altogether. Moreover, the embryo formed in September or October in a young female which has mated for the first time also becomes quiescent. Typically the quiescent embryos of young and older females are reactivated within a few days after December 22 (the summer solstice) and the young are born about 25 days later, 12 months after the mating at which they were conceived. The single young is suckled in the pouch for 8–9 months so that most leave the pouch in September or October. Females become mature

The single young of the Tammar Wallaby is suckled in the pouch for eight to nine months.
Photo: G. Rogerson

ORDER DIPROTODONTA, SUPERFAMILY MACROPODOIDEA, Family Macropodidae

at about 9 months old while they are still suckling, but males do not become mature until nearly 2 years old.

The rate of reproduction is high, more than 90 per cent of all females carrying a pouch young by the end of the breeding season. However, in some years many pouch young are lost, especially by one-year-old females. In all years mortality is high amongst juveniles during their first summer, and may reach 40 per cent. When the summer has been long, hot and dry, food becomes limited and of poor quality, and many adults die at the onset of cold, wet weather. While natural predators of the Tammar Wallaby are few, feral cats are believed to have made a significant contribution to the extinction of the Flinders Island population. On Kangaroo Island, males may live to at least 11 years old, and females to 14 years old: a wild female known to be 13 or 14 years old carried a pouch young.

Clearing of scrub has reduced the shelter available for the Tammar Wallaby and the range of several populations has been reduced since European settlement. It was formerly widespread in mainland South Australia, occurring in most areas where there was dense scrub, but now it survives only in a small area near Cleve. Numbers have also been greatly reduced by clearing of the land for wheatgrowing in southwestern Western Australia. The Flinders Island population is almost certainly extinct, its numbers having been severely reduced by loss of habitat, bushfires and predation by feral cats. None now survive on St Francis, St Peter, or Thistle islands. The population on North Island, Houtman Abrolhos, had died out before European man arrived. Skulls found on Reevesby and North Gambier islands may represent unsuccessful introductions. Introduced populations are thriving on Greenly Island, SA, and in at least two localities in New Zealand. The species continues to be abundant on Kangaroo Island, despite ongoing persecution outside the Flinders Chase National Park.

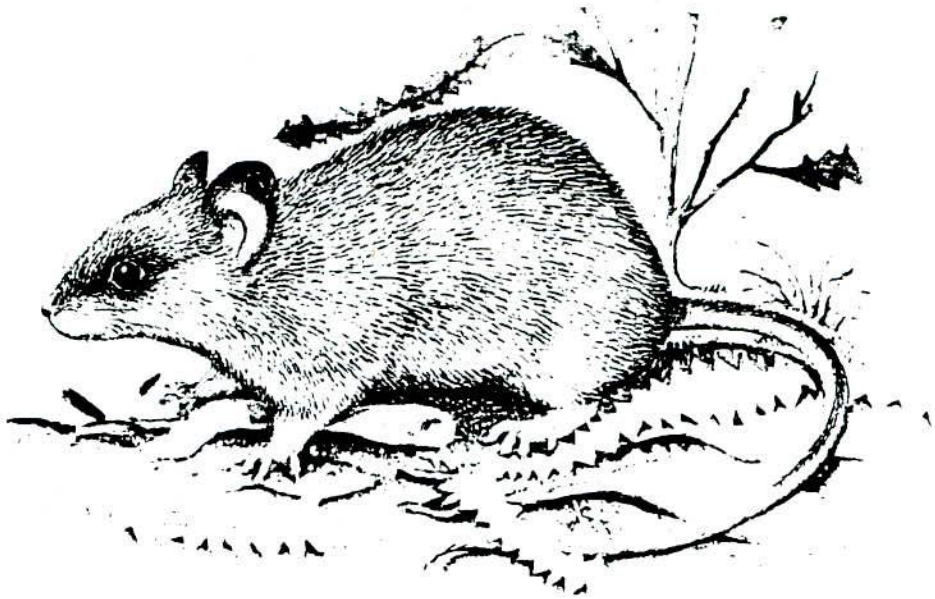
M. J. Smith

Only after dark does the Tammar Wallaby leave its daytime scrub refuge to travel to the grassy feeding areas which may be over one kilometre away. *Photo: L. F. Schick*

AUSTRALIAN ENDANGERED SPECIES

WESTERN MOUSE

Pseudomys occidentalis



ECOLOGY

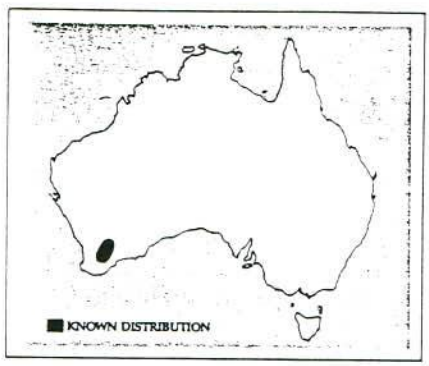
The Western Mouse has been found in habitats ranging from low heath to low woodland, mostly with a sparse to medium tree cover. It seems to prefer habitat in which there is a dense strata of low mallees and shrubs. The diet of the Western Mouse consists of vegetable material and insects such as beetles. The young are born during spring, probably four or five to a litter.

CONSERVATION

Though first discovered at Tambellup in the south-west of Western Australia in 1930, the Western Mouse was not recognised as a distinct species until 1951. Prior to 1968 it had been recorded only three times, but in the last few years the Western Mouse has been found in a number of fauna reserves and other areas in the wheat belt of south-west Australia.

The Western Mouse is protected under Western Australian legislation.

DISTRIBUTION



The Western Mouse has been recorded from near Tambellup, Nyabing, Lake Chinokup, Tarin Rock, Hatter's Hill, Dragon Rocks, Bendering and West Bendering. These are inland locations between 80 km and 240 km north-west of Albany, Western Australia.

READING

The Western Australian Museum has published a series of booklets entitled 'Biological Survey of the Western Australian Wheatbelt'. These examine the vegetation and vertebrate fauna of some of the many small reserves within this region. As a result of these surveys the Western Mouse is now known to be more common than once thought.

DESCRIPTION

The Western Mouse is one of the species in the *Pseudomys* genus of rodents. It has a dark greyish appearance, the back is a mixture of dark grey and yellowish-buff with a few long, dark hairs. The underparts are greyish-white, and the hands and feet are white. The tail is blackish above to about 2 cm from the tip which is white; the undersurface is buffy-white. The tail hairs are long.

The overall length of adults is approximately 20 cm of which 10 cm is the tail.

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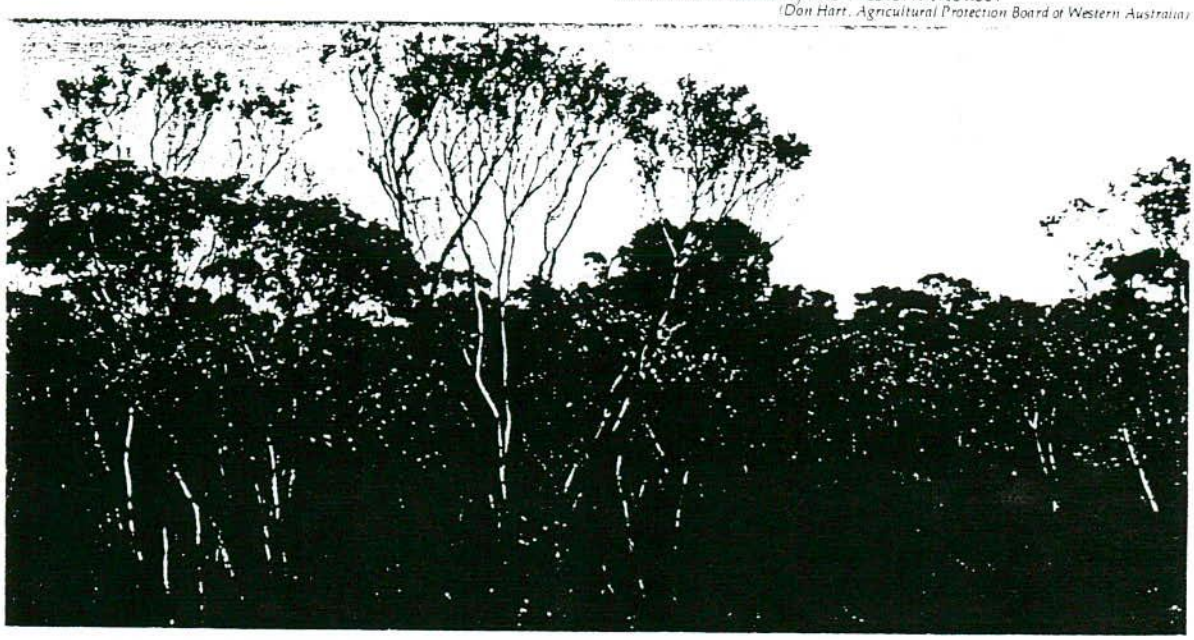
Woodland habitat of the Western Mouse.
(Don Hart, Agricultural Protection Board of Western Australia)



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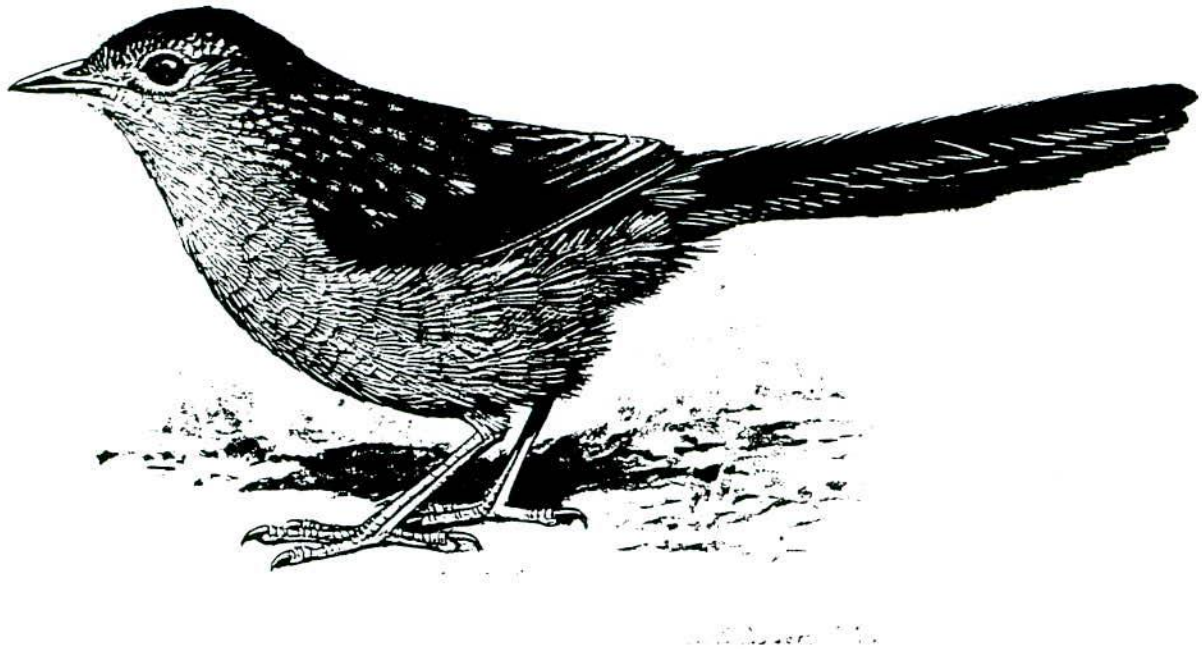
AUSTRALIAN ENDANGERED SPECIES

WESTERN BRISTLEBIRD

Dasyornis brachypterus longirostris



ECOLOGY

The Western Bristlebird is a shy, sedentary bird which inhabits dense, damp heathlands where it establishes territories of one to two hectares.

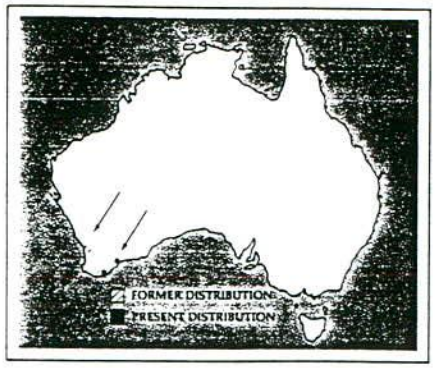
The Western Bristlebird is reluctant to fly and commonly the only sighting an observer may have is of a bird running quickly over the ground or scratching among the ground litter for insects and seeds. Its movements are extremely quick and jerky and when the bird runs, the tail is usually held erect. In the early morning or towards sunset the loud, clear and varied song of the male bird may be heard and is often accompanied by the female. The alarm call is a shrill whistle.

Usually concealed in a low, thick shrub or clump of coarse grass, the oval nest is composed of dry grass stalks and lined with finer grasses. It has a side entrance approximately 12 cm in diameter.
The breeding season is from October to January. Two eggs are usually laid and these are dull brownish-white blotched and freckled with purplish-brown.

CONSERVATION

The Western Bristlebird survives in moderate numbers in three small, restricted areas in the extreme south-western corner of Western Australia. Continued burning and clearing over much of its former range has deprived this species of its habitat. Its most protected habitat is within Two Peoples Bay Wildlife Sanctuary near Albany, Western Australia. This Sanctuary operates under a planned management program which provides for controlled public usage, fire management and research. The Western Bristlebird is protected in Western Australia and its survival within the Sanctuary should be assured. Classed as Rare by the International Union for the Conservation of Nature and Natural Resources (IUCN) the species is considered endangered because it is so localised. Trade in the species is restricted by the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

DISTRIBUTION



The Western Bristlebird was first collected by John Gilbert in 1839 in the vicinity of Perth but has never been observed there since. In 1868 further specimens were collected at King George Sound. A small colony was found near Wilson's Inlet in 1907 but was apparently wiped out by a bushfire in 1914.

Nothing more was heard of the bird until 1945 when a specimen was collected at Two Peoples Bay east of Albany. The species is still present there, in the nearby Mount Manypeaks area, and in the Fitzgerald River National Park.

DESCRIPTION

Dasyornis means 'hairy-bird' and refers to the strong bristles around the base of the pointed beak of bristlebirds which belong to the family of warblers (Acanthizidae). The Western Bristlebird is a small brown bird about 18 cm in total length. The head and upper parts are brown spotted with grey whilst the centre of the wings and the base of the tail are rufous brown. Grey underparts gradually blend into the brown of the upper surface. It has short rounded wings and a long tail with graduated feathers which are distinctly barred with a darker tint. The eye is orange-red, the beak dark brown and the legs grey-brown. The sexes are similar in colouring.

READING

Two Peoples Bay management plan is discussed in Volume 2(3) 1971 of S.W.A.N.S. (State Wildlife Advisory News Service) by the Western Australian Department of Fisheries and Fauna. The aims of the management plan are outlined and there is a map showing walking tracks and vehicular tracks as well as the areas zoned as limited or prohibited access.

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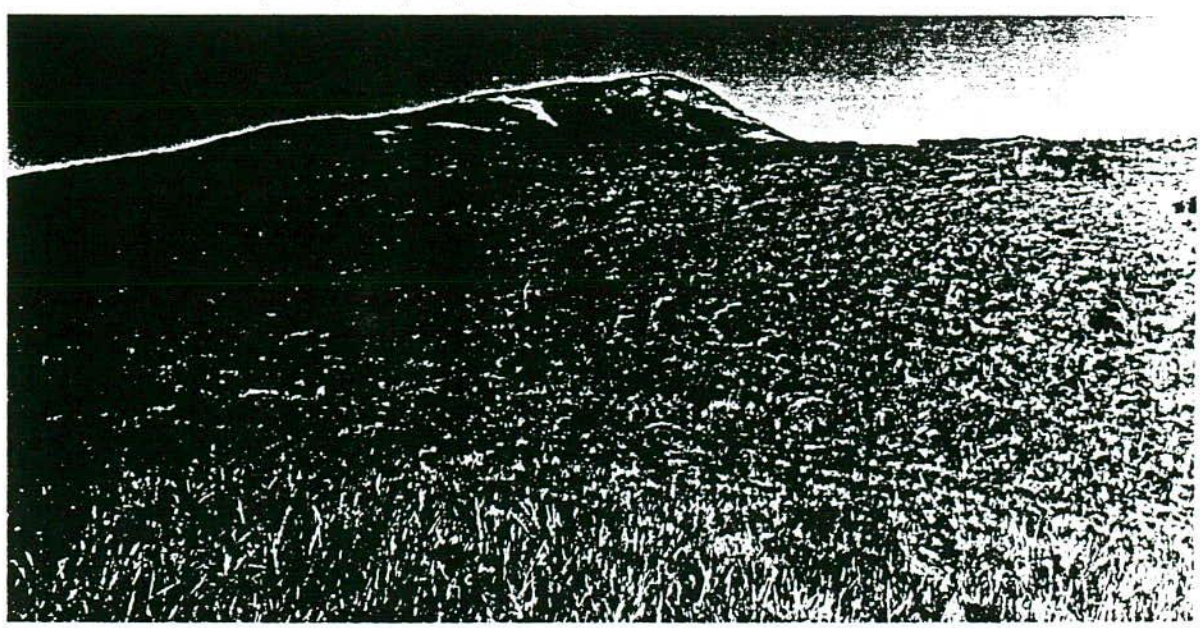
Dense heathlands at Two Peoples Bay, W.A.—habitat of the Western Bristlebird.

(G. T. Smith, Division of Wildlife Research, CSIRO)



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WESTERN WHIPBIRD

RARE

Psophodes nigrogularis Gould 1844

Order PASSERIFORMES

Family ORTHONYCHIDAE

Summary This whipbird occurs in mallee and thicket vegetation in coastal and inland areas along the south coasts of Western Australia and South Australia, and in north-west Victoria. Its distribution has decreased because of habitat clearance and altered fire regimes, which continue to be significant threats in certain parts of its range.

Distribution There are three subspecies of the Western Whipbird. In Western Australia *P.n.nigrogularis* had a wide distribution in the past. Along the west coast it extended from Perth to Augusta, while along the south coast it was found from Denmark east to Hopetoun and inland to Wongan Hills (Milligan 1904, Whittell 1941, Smith 1977). It is now restricted to locations east from Albany to east of Ravensthorpe including Two Peoples Bay Nature Reserve, Mount Manypeaks, Beaufort Inlet, Fitzgerald River National Park, Southern Ravensthorpe Range (McNee 1986) and Bandalup Hill (B.Newbey) and inland to the north as far as Pingrup. Knowledge of its distribution in the southern wheatbelt is incomplete (McNee 1986). In South Australia, this subspecies was first reported in 1937. It is now known to occur on the southern Eyre Peninsula from Coffin Bay eastwards to Lincoln Naional Park but has disappeared from the Cockaleechie district (Condon 1968).

P.n.pondalowiensis was found in 1965 on the southern Yorke Peninsula, South Australia, where it still occurs in Innes National Park (Condon 1968). On Kangaroo Island it is found at several localities along the north coast (L.Pedler), as well as on the south coast at Flinders Chase National Park, Vivionne Bay, Cape Gantheaume Conservation Park, and Dudley Peninsula (Condon 1968, Lashmar 1971, R.Kernot).

P.n.leucogaster was first recorded in Victoria in 1919, though not correctly identified until 1932 when a bird was collected (Howe and Ross 1933, Condon 1966). At present it is known from only a small number of widely scattered localities in the Murray Mallee of South Australia and Victoria, for instance Billiatt, Mount Rescue and Ngarkat Conservation Parks (Woinarski *et al.* 1988). It has disappeared from several other localities such as the Malinong area and Comet Bore (Woinarski *et al.* 1988, L.Pedler). At Billiatt Conservation Park, following the January 1988 fire, it has been found in unburnt remnants of mallee adjacent to the Park (L.Pedler).

Population The only reasonably accurate population estimates for the Western Whipbird are for *P.s.nigrogularis* at Two Peoples Bay Nature Reserve, Western Australia. When discovered there in 1962 (Webster

1966), it was restricted to the hilly headland round Mount Gardner from where it began expanding to the west in 1976. The population was estimated at 60 pairs in 1970, 87 pairs in 1976 (when it had spread onto the isthmus), about 100 pairs in 1983, and has continued to expand since (Smith 1985, S.McNee). The population increase has been attributed to the exclusion of fire from the area since 1970 (Smith 1985). The subspecies is relatively common in the Fitzgerald River National Park (Chapman and Newbey in press) and Southern Ravensthorpe Range (A.Chapman). However, it may only occur in low numbers further north in the southern wheatbelt of Western Australia, because of the habitat has been fragmented by clearance. The total population in Western Australia is thought to be less than 5,000 individuals (G.T.Smith), with a number of safe subpopulations.

There are no measures of the size of the South Australian population of *P.n.nigrogularis*, but it has disappeared from at least one district. *P.n.pondalowiensis* is considered moderately common (Condon 1968) and does not appear to be directly threatened. The distribution of *P.n.leucogaster* has shrunk with the clearance of vegetation and probably also because of wildfires and is rare within its remaining restricted distribution (Woinarski *et al.* 1988).

Habitat and threats In the drier parts of its distribution in Western Australia, the Western Whipbird's preferred habitat is open mallee vegetation including a tall shrub layer of up to 1.5 m (McNee 1986). In wetter areas such as at Two Peoples Bay it occurs in dense thickets. At Two Peoples Bay Nature Reserve the species has been observed to recolonise areas of burnt vegetation 7 to 10 years after fire (Smith 1985), while in Fitzgerald River National Park it has not been found in vegetation less than 14 to 15 years after fire. In the Stirling Range National Park the species was found only in vegetation that had not been burnt for at least 25 years (McNee 1986). In South Australia, the species occurs in dense vegetation of mallee, heath or acacia in coastal areas such as at the southern Eyre Peninsula and Pondalowie Bay. In the Murray Mallee the Western Whipbird occurs in thickets with a dense shrubby understorey (1.5-2 m) below an open mallee eucalypt layer (3-5 m). Its habitat is characterised more by vegetation structure than by vegetation age or floristics. However, most records are from vegetation last burnt 10 to 25 years previously (Woinarski *et al.* 1988).

In Western Australia fire is thought to have caused its disappearance from the Cape Mentelle - Margaret River area (Ashby 1921, Whitley 1971), and, after extensive fires in 1984, from areas in the Stirling Range National Park (McNee 1986). Fire is similarly the major threat to populations in Victoria and South Australia. Recolonisation after fire may occur only if there is another population nearby.

In Western Australia clearance has been a significant threat in the southern wheatbelt (McNee 1986), causing a population decline and local extinction. Because the species does not disperse readily in the fragmented habitat, recolonisation after local extinction is unlikely. There is no

information on a minimum viable population size, but given that territory size is about 10 ha, populations in vegetation remnants of less than 1,000 ha are unlikely to persist in the long term (G.T.Smith). On Kangaroo Island clearance for agriculture has largely restricted the species to the southern coastal areas of the island and further clearance of mallee is also considered to be the main threat to *P.n.leucogaster* (Woinarski *et al.* 1988).

Conservation measures taken At Two Peoples Bay Nature Reserve a fire exclusion management programme benefiting the Western Whipbird has been implemented since 1971 and a management plan for the Fitzgerald River National Park, including fire management, is nearly complete (A.H.Burbidge). In December 1988 about 25,000 ha of vacant crown land containing populations of the Whipbird was added to the Fitzgerald River National Park. To ascertain the species' status and present distribution in Western Australia a survey was conducted in 1985 by the RAOU (McNee 1986). In South Australia or Victoria most populations are within or adjacent to conservation reserves.

Conservation measures proposed In Western Australia a fire management programme is needed for the south coast, east of Two Peoples Bay Nature Reserve to Beaufort Inlet. This programme would aim to maintain existing populations and to ensure areas suitable for future colonisation are maintained. However, more information is required on habitat regeneration times (G.T.Smith).

A survey of distribution and population size is required in the wheatbelt region. The needs of small isolated populations should also be ascertained. Corridor reserves may be important to enable movement between remnants of uncleared vegetation.

All South Australian and Victorian populations require further study to refine knowledge of habitat requirements, remaining populations of *P.n.leucogaster* need to be found and a fire management programme designed to provide a mosaic of small area burns and long-unburnt areas is needed (Woinarski *et al.* 1988).

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Compiled by Shapelle McNee.

Refereed by Graeme Smith, Lynn Pedler and Peter Menkhorst.

Appendix 4

Report by John Dell and Norah Cooper, Environmental and Wildlife Consultants

JOHN DELL and NORAH K. COOPER
ENVIRONMENTAL AND WILDLIFE CONSULTANTS

236 Seventh Ave.
Inglewood
W.A. 6052
Tel: (09) 271 4613

Mr B Masters

PO Box 315

CAPEL WA 6271

3 April 1992

Dear Mr Masters

We provide the following comments on significant aspects of the fauna of Lake Chinocup Nature Reserve.

McKenzie (1973) recommended a comprehensive system of reserves for the conservation of flora and fauna in the shire of Kent. This proposed that Lake Chinokup, among other areas, should be vested as an "A Class" Reserve for the conservation of flora.

This recommendation was changed to include conservation of flora and fauna and to have it declared "A Class" by McKenzie and Youngson (1975). Part of the justification for this recommendation was the conclusion that the Lake Grace wetlands system (which includes Lake Chinokup) was of major importance to waterfowl. Other significant aspects of the fauna included the presence of the Western Mouse *Pseudomys occidentalis* a gazetted rare and endangered species on the Chinokup Nature Reserve (Number 28395), southwest of Lake Chinokup. McKenzie and Youngson

also recorded another rare and endangered species, the Tammar Wallaby *Macropus irma*, on Lake Chinokup Reserve.

In this statement we assess the likelihood of the above rare and endangered species occuring on the gypsum lunette dunes at the southeastern end of Lake Chinokup. We also comment on other significant fauna that is known to occur or is likely to occur.

MAMMALS

The Western Mouse although present on Reserve 28395, is unlikely to occur on the gypsum lunettes based on known information on its habitat preferences. The best data available is that in Kitchener and Chapman(1976 & 1977) and Muir (1976 & 1977) who compiled comprehensive vegetation and soils data for locations on Tarin Rock Reserve and Bendering Nature Reserve.The vegetation formations in which the Western Mouse was recorded ranged from tall woodlands to low heath and included the following plant associations: Low Forest A, Open Tree Mallee, Open Shrub Mallee, Very Open Shrub Mallee , Open Shrub Mallee, Dense Thicket, Scrub, Low Scrub B,Low Heath C and Open Low Woodland B on lithic (granite) complex.

Significantly the soil at all of the above locations where the Western Mouse was found had a high clay content and included pisolithic laterite pebbles or quartz components in some cases ranging up to 70% of soil

volume. The gypsum lunettes have vegetation and soil structures which are very different from all known habitats of the Western Mouse.

The Tammar Wallaby was previously widespread in many different habitats throughout the southwest of Western Australia. The introduced Fox *Vulpes vulpes* and other factors have led to a massive range reduction and fragmentation into small populations usually in areas of dense vegetation.

The vegetation on the lunette dunes is very open and unlikely to provide suitable Tammar habitat.

The other mammals mentioned by McKenzie and Youngson (1975) as being present on Lake Chinokup Nature Reserve are all relatively wide ranging and found on numerous conservation reserves.

BIRDS

The report by McKenzie and Yougson identified 56 birds on the Lake Chinokup/Lake Grace Reserves. None are gazetted rare and endangered and all are relatively wide-ranging in southwestern Australia. However, the list includes 2 species, the Scarlet Robin *Petroica multicolor* and Brown Flycatcher *Microeca leucophaea* which were considered by Kitchener et al.(1982) as having a "vulnerable" conservation status in the Wheatbelt. Another

3 species were deemed to have an uncertain conservation status in the Wheatbelt:Heath Wren *Sericornis cautus*; Blue-breasted Fairy-wren *Malurus pulcherimus* and Australian Sitella *Daphoenositta chrysoptera*. In addition, Kitchener et al.(1982) considered that the Purple-gaped Honeyeater *Meliphaga cratitia* and Yellow-plumed honeyeater M. *ornata* were recorded on few reserves in the Wheatbelt and must also be considered threatened.

REPTILES AND AMPHIBIANS

In the report by McKenzie and Youngson no species of reptiles or amphibians listed for the Lake Chinokup Nature Reserve are on the rare and endangered list or are listed as being vulnerable. Species from this reserve are also present on other reserves. There is no published information on reptiles occupying gypsum dunes.

SUMMARY

Lake Chinokup Nature Reserve was listed by the Department of Conservation and Land Management as an "A Class" Reserve because it is a large area of interesting and diverse vegetation not found on the Lake Magenta Nature Reserve. The diverse fauna includes species of mammals considered rare and likely to become extinct.

From present knowledge of the habitat of the 2 rarre and endangered mammals, the Western Mouse and the Tammar

Wallaby. it would appear unlikely that they would be present on the gypsum lunette dunes at Lake Chinokup. Other mammals known from the region, though not recorded for the reserve itself, include Shortridge's Mouse *Pseudomys shortridgei*, the Red-tailed Phascogale *Phascogale calura* and the Chuditch *Dasyurus geoffroii*. These mammals are also gazetted as rare and endangered but are currently not known from Lake Chinokup Nature Reserve.

RECOMMENDATION

Before any decision is made regarding possible gypsum extraction, the Department of Conservation and Land Management and the Environmental Protection Authority would require a detailed faunal assessment. Therefore it is recommended that a trapping programme using both Elliott and pit traps be carried out not only to assess the mammal fauna using the gypsum dunes but also to assess the reptile (and amphibian) fauna especially as previous collecting efforts in the area were extensive but not exhaustive and apparently did not sample the gypsum dunes.

As Lake Chinokup Nature Reserve is one of the most significant areas for waterfowl in the state, a study of the drainage system especially relating to the gypsum dunes would have to be undertaken to satisfy the Department of Coservation and Land Management that the

drainage system and the physical properties of the water would not be altered.

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Yours sincerely

JOHN DELL and NORAH COOPER

Appendix 5

Letter from the Shire of Kent regarding the Chinocup Townsite

SHIRE OF KENT
RICHMOND STREET, NYABING, W.A. 6341
Phone: Nyabing (098) 291051 or 291058

Your Ref:
Our Ref: BEJ/CJW
Enquiries: C.9.7

September 21, 1993

The Secretary
Chinocup Gypsum Committee
P.O Box 10
NYABING W.A 6341

Dear Sir,

The Kent Shire Council considered your request to vest part of or all of the Chinocup townsite reserve into the Chinocup Nature reserve if a land swap was required to obtain final approval for the proposed Gypsum mine, at its Ordinary meeting held on Wednesday, September 15, 1993. Council adopted the following resolution which is self explanatory.:-

> That Council advise the Chinocup Gypsum Committee that Council will agree to relinguish control of up to 50% of the Chinocup Townsite reserve to CALM, if this action is absolutely necessary to aquire permission to mine Gypsum from Lake Chinocup. Council to be advised in order to grant final approval prior to any negotiations being finalised.

Please contact the undersigned if further clarification is required.

Yours Faithfully

Brian Jones
Shire Clerk.

Appendix 6

Glossary

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

"A" Class	A category of reserved Crown land whose purpose or vesting can only be changed by approval of both houses of State Parliament
Acid granitoid rocks	A general term for rocks that are composed essentially of quartz, feldspar and lesser amounts of ferro-magnesium minerals, often granite or gneiss
Aeolian	Transported by wind
Antagonistic	In relation to dieback, a soil that will not prevent the establishment of the fungus but in which the fungus will not thrive
Archaeological	Relating to the study of humanity's past by scientific analysis of the material remains of a culture
Artefact	Normally pieces of rock used to create cutting or other tools
CALM	Department of Conservation and Land Management
Declared Rare Flora	A species which have been adequately searched for and are deemed to be in the wild either rare , in danger of extinction, or otherwise in need of special protection, and have been gazetted as such
Dieback	A fungal disease of plants which attacks the root system and, in the case of jarrah, causes the trees to die back from the outer branches inwards.
DOMEWA	Department of Minerals and Energy of Western Australia
Ecological function	The way in which all parts of the living and non-living environment interact with, and are dependent upon, each other
EMP	Environmental Management Program
Endangered	Species in danger of extinction and whose survival is unlikely if the causal factors continue to operate
EPA	Environmental Protection Authority
Ethnographic	Relating to the branch of anthropology that deals with the scientific description of individual human societies
Evaporitic minerals	Minerals precipitated from water that has been concentrated to a high salinity level by evaporation (halite, potash, gypsum, etc)
Geoscientific Survey	A non-ground disturbing survey approved by DOMEWA for nature reserves, national parks and other environmentally sensitive land
Heath	Shrubs to 2.0 metres having a moderate to high canopy cover or density
Hybrid	A plant this is the offspring of two separate species
Hydrology	The study of water in and on the Earth
Hypersaline	Having a salinity well in excess of seawater
Induration	Within a sediment, the degree to which individual grains are bound together by secondary minerals such as calcite, clay or iron oxides
Km	Kilometre
Lacustrine	Derived from or found within a lake

Mallee	Usually trees belonging to the genus Eucalyptus having a multi-stemmed habit, characteristic of low rainfall environments
Mining Lease	A tenement granted under the Mining Act by which productive mining is permitted subject to conditions
Miscellaneous License	A tenement granted under the Mining Act which allows an activity associated with a mining operation, such as a road, pipeline or power line, to be constructed and operated
Nature Reserve	A category of Crown land whose purpose is the conservation of wildlife (flora and fauna)
Palaeo-drainage	A former drainage feature of some antiquity which still collects water but which flows from one water body to another only under flood conditions
Pedogenic	Related to soil forming processes
Permeability	The degree to which water or other liquids are able to pass through a material
Phosphonate	A phosphorus-bearing chemical found to confer to a plant up to 5 years resistance to the dieback disease fungus
Priority Species	Species which are known from a small number of populations
Rare	Animal species with small populations that are nor at present "Endangered" or "Vulnerable" but are threatened
Remnant	Refers to an area of vegetation that remains after broad-scale land clearing has removed the majority of the pre-existing vegetation
Samphire	Plants growing in conditions of high salinity characterised by being low (<0.5 metres) and having a high salt content in its tissues
Scrub	A vegetation classification of sparsely distributed shrubs less than 2.0 metres high
Secondary weathering products	Clays, salts and other materials formed by the weathering of primary minerals found within igneous or metamorphic rocks
Sesquioxide	A natural material (usually iron oxide) containing two minerals having different iron:oxide ratios
Species diversity	The range of individual species which make up all or part of an ecosystem
Stratum	Within a vegetation complex, a distinctive layer of plants which share a roughly common height, e.g. a tall tree stratum
Vulnerable	Species believed likely to move into the "Endangered" category in the near future if the causal factors continue to operate

Appendix 7

CER Guidelines

GUIDELINES FOR CONSULTATIVE ENVIRONMENTAL REVIEW

Proposal to mine gypsum, Lake Chinocup

(Philip Garry Patterson)

Overview

In Western Australia all environmental reviews are about protecting the environment. The fundamental requirement is for the proponent to describe what they propose to do, to discuss the potential environmental impacts of the proposal, and then to describe how those environmental impacts are going to be managed so that the environment is protected.

If the proponent can demonstrate that the environment will be protected then the proposal will be found environmentally acceptable; if the proponent cannot show that the environment would be protected then the Environmental Protection Authority (EPA) would recommend against the proposal.

Throughout the process it is the aim of the EPA to advise and assist the proponent to improve or modify the proposal in such a way that the environment is protected. Nonetheless, the environmental review in Western Australia is proponent driven, and it is up to the proponent to identify the potential environmental impacts and design and implement proposals which protect the environment.

For this proposal, protecting the environment means that the natural and social values of Lake Chinocup, and the associated Nature Reserve, are protected. Where they cannot be protected, proposals to mitigate the impacts are required.

About these guidelines

These guidelines are prepared for the Consultative Environmental Review (CER) for the proposal by Mr Philip Garry Patterson to mine gypsum from Lake Chinocup and the associated Nature Reserve and are issued as a checklist of environmental issues which the EPA considers should be addressed in the CER. They are not exhaustive and other relevant wetland issues may arise during the preparatory and public consultation phases of document production, these should also be included in the CER.

The form of the document is a matter for the proponent and the consultant, however, a sample of subject headings is attached. Particular attention should be given to clearly defining the extent of excavation, the flora and fauna values and vesting of the areas to be affected and the associated environmental impacts and their management. In addition, direct impacts on Lake Chinocup should also be discussed, including hydrological considerations. The CER will need to provide sufficient information to allow the EPA to undertake an assessment of each of these aspects.

A copy of these guidelines should appear as an appendix in the CER.

1. SUMMARY

It is desirable to provide a brief summary of:

- environmental objectives of the CER;
- salient features of the proposal;
- an analysis of the likely impacts on both the lake and habitats and their significance;

- approaches used to reduce environmental impacts;
- environmental monitoring, management , safeguards and commitments thereto; and
- conclusions.

2. INTRODUCTION

The CER should include a brief explanation of the following:

- need for the mine;
- history of the project; including need for the project, studies conducted, leases acquired and previous approvals;
- identification of the proponent;
- timing of the proposal; and
- relevant statutory requirements and approvals (including reference to rare and endangered species);

and provide a context for the proposed mine.

3. DESCRIPTION OF PROPOSAL

The CER should include details of the following aspects, particularly where they are likely to impinge on the environmental values of the area:

- the overall location and method of mining;
- areas proposed for clearing, excavation and stockpiling;
- expected life of the mine;
- nature, volume, composition and fate of any aqueous discharges;
- auxiliary services (e.g. power, water supply, and sewerage); and
- construction workforce and vehicular movements, including road building and site access.

4. EXISTING ENVIRONMENT

The CER should provide a brief overall description of the environment, with emphasis on the area of immediate concern. The CER should then concentrate on the significant aspects of the area that are likely to be affected by the development. The habitats, ecological systems, communities and individuals which could be influenced should be defined.

The following matters should be addressed where it is likely that the development will have an effect:

Physical:

- existing lake water level regimes (where known);
- quantity and quality of surface and ground water entering the lake;
- lake geomorphology and rarity; and
- landscape value

Biological:

- identification and occurrence of aquatic and terrestrial flora;
- identification and occurrence of aquatic, terrestrial and avian fauna;
- the identification and distribution of rare, endangered or geographically restricted flora or fauna which occur, or are believed to occur, in the area;
- presence and distribution of dieback disease;
- significance of local ecosystems, habitats and flora and fauna and their representation in proclaimed conservation estates (that is, National Parks, Flora and Fauna Reserves); and

- lake function, with specific reference to waterbird breeding, loafing and feeding habitat.

Human:

- cultural impact on Aboriginal people with traditional affiliation to the land;
- Identification of lake management objectives - refer to "A guide to wetland management in Perth" (EPA, Bulletin 686) for guidance. Although this document is specific to the Swan Coastal Plain it remains applicable in this case; and
- human use functions of the area that will be affected.

5. EVALUATION OF ALTERNATIVES

A discussion of alternatives to the proposal including:

- alternative sources of gypsum in the region;
- opportunity for selective mining of the site;
- alternative to the preferred access road;

and a summary of their respective environmental merit should be given. The rationale for choosing certain alternatives should be clear.

6. ENVIRONMENTAL IMPACTS

This is the most important part of the CER and should show the overall effect of the proposal on the integrity of Lake Chinocup and the Nature Reserve, both during mining and after rehabilitation of the site.

The following should be determined and the environmental implications discussed:

- volume and nature of drainage waters entering the lake from the mine site (surface and groundwater);
- changes in lake hydrology (eg water level regime);
- likelihood, nature and impact of chemical spillage entering the lake;
- disturbance and loss of lake habitat (including fringing vegetation), both temporary and permanent;
- loss of ecological functions from both the lake and Nature Reserve (both temporary and permanent);
- visual impact;
- noise and dust impacts on residents, flora and fauna;
- wildlife disturbance;
- susceptibility of habitats to, and likely spread of, dieback disease; and
- workforce management, including rubbish disposal, fire management and firearm, weed and domestic pet control.

The final synthesis should include an assessment of the losses and resilience of flora and fauna to disturbance. Impacts should be quantified where possible (eg number of individuals of a population which will be lost). Criteria for making assessments of the significance of this should be outlined.

Desirable effects (such as the compensatory inclusion of lands into the Nature Reserve, etc) should also be identified.

7. PUBLIC PARTICIPATION AND CONSULTATION

A brief description should be provided of public participation and consultation activities undertaken by the proponent in preparing the CER. This should outline the activities undertaken, the timetable for activities, the groups or individuals involved and the objectives of the activities. A summary of concerns raised should be documented. This discussion should be

cross referenced with issues mentioned in Section 8 and should clearly indicate how each of these concerns has been addressed.

8. ENVIRONMENTAL MANAGEMENT

An Environmental Management Program should be described on the basis of, and cross-referenced to, the synthesis of potential environmental impacts.

The purpose of the overall management program is to demonstrate the manner in which the environmental impacts can be mitigated. Therefore, environmental objectives, performance standards and criteria should be defined, especially for those elements of the project that may alter over time. Emphasis should be placed on the manner in which monitoring results will lead, where appropriate, to amendments to the management programme. Rehabilitation methodologies and examples of previous rehabilitation efforts in comparable environments should be cited. Plans for the return of the mining lease to the Nature Reserve should also be addressed.

Environmental impacts should be minimized. Any unavoidable loss of rare and endangered flora or fauna should be identified and addressed in this section. Commitments to rehabilitate the site should be clearly stated as should ongoing and future management, administration, costs and funding.

Elements of monitoring and the environmental management programme should include the impacts identified in Section 7.

Environmental safeguards should be described.

Procedures for reporting the results of monitoring and management to appropriate authorities and the community should be given.

It is important that specific commitments are given to all components and procedures of the Environmental Management Program.

9 SUMMARY OF COMMITMENTS BY PROPONENT

The commitments being made by the proponent to protect the environment should be clearly defined and separately listed. Where an environmental problem has the potential to occur, there should be a commitment to rectify it. They should be numbered and take the form of:

a) who will do the work;

b) what the work is;

c) when the work will be carried out; and

d) on whose advice the work will be based.

- All actionable and auditable commitments made in the body of the document should be numbered and summarised in this list.

10. CONCLUSION

An assessment of the environmental acceptability of the project, in terms of its overall impact on the environment (in particular , rare and endangered species) and in the context of the proposed management program, should be given.

11. REFERENCES

All references used in the CER should be listed. These references need to be available to the public through normal sources.

12 APPENDICES

- Proponent commitments
- Glossary - definitions of technical terms, abbreviations should be included.
- CER Guidelines - a copy of these guidelines should be included in the document.
- Ancillary, technical or lengthy information related to discussion in the text (eg detailed fauna and flora listings).