# Mining of Yarloop Reserve 31900

# PUBLIC ENVIRONMENTAL REVIEW



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CABLE SANDS (W.A.) PTY. LTD.

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# YARLOOP NOTICE OF INTENT TO MINE

CABLE SANDS (WA) Pty Ltd

MAY 1996

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## EXECUTIVE SUMMARY

This Notice of Intent to Mine is submitted requesting permission for the mining of titanium minerals from a deposit identified at Yarloop. The deposit is located south east of Yarloop on the eastern side of the South West Highway to the south of Burney Road. The deposit is on post-1899 titles with mineral rights belonging to the state. Mining will occur under mining lease M70/49 with adjoining additional leases M70/937 and M70/938 pending. The mining proposal is to commence mining in early 1997 following mine development commencing late in 1996.

This document describes and appraises the environment in which the orebody is located, outlines the proposed method of mining, outlines the transportation of heavy mineral concentrate to the Bunbury plant, identifies environmental impacts and outlines an environmental management policy.

The orebody consists of two occurences of heavy minerals separated by the creek adjacent to Black Rock Road. The area to be affected will primarily consist of cleared agricultural land owned by Cable Sands. An area to the north contains a small reserve vested with the Shire of Harvey as the Yarloop refuse tip and an area of private property to the south is owned by Mr Andrew Jenkins. Agreements have been reached with the Shire of Harvey and are continuing with Mr. Jenkins.

The mining operation will be performed as a dry mining project with work occurring in the following sequence :

* Removal of vegetation
* Stripping and storage of topsoil
* Removal and stockpiling of overburden where necessary
* Mining of ore and separation of minerals
* Backfilling and recontouring of overburden and tailings
* Re-establishment of vegetation using natural regeneration from returned topsoil and supplementary seeding and planting of juvenile plants where applicable.

Water requirements will be met by a series of shallow bores located west of the minesite and pumped to a holding dam on site.

Heavy mineral concentrate will be transported south along the South West Highway then via Robertson Drive, the Eelup roundabout and Koombana Drive to Cable Sand's North Shore operations in Bunbury. This route is currently used for transporting heavy mineral concentrate from Waroona to Bunbury.

Rehabilitation of mined land will be incorporated into the mining process. Recontouring with overburden, final tails and slimes will return the landscape to a similiar topography. Stored topsoil will be replaced and the pre-existing vegetation will be re-established. The relatively high clay content of the mineral deposit means that a series of slimes dams will be required. These

will be mainly confined to the cleared areas.

The rubbish tip reserve contains an area of Ridge Hill Shelf vegetation complex which is comparatively rare along the coastal plain due to extensive clearing for agriculture. The area of this vegetation affected will be as restricted as practicable and rehabilitation will re-establish species currently found there. A detailed rehabilitation plan will be produced for the area affected by mining. The opportunity will be taken, in consultation with relevant authorities to improve the condition of the degraded area to the west of the orebody. The end result will be an area sympathetic with the adjacent proposed A-class reserve and available for consideration as part of a System Six Conservation Reserve.

A rubbish tip area will be available during the mining operations and following mining an area will be established for the continuation of the tip.

Environmental management of the mining operation will result in procedures that limit the impact of light, dust and noise in the vicinity.

Community consultation has occurred involving local residents and Shire of Harvey councillors and staff. Ongoing consultation is considered important to the success of the mining operation.

Cable Sands has a proven environmental record as evidenced by the rehabilitation of former minesites and recognised with the John Tonkin Award in 1988. The management commitments that resulted in these awards will be applied to the Yarloop project in a way that minimises the environmental impact of the operation.

## SUMMARY OF ENVIRONMENTAL ISSUES AND COMMITMENTS

| Category | Topic | Section of NOI | Objective | Management Commitments | Timing | Key Agency |
|---|---|---|---|---|---|---|
| Environmental Management | | 4.1 | * To achieve responsible environmental management | 1. Conduct regular environmental audits<br>2. Annual reporting of environmental performance to appropriate authorities<br>3. To progress development of an accredited Environmental Management System | Throughout mine life | DEP<br>DoME |
| Biophysical Environment | Flora | 2.6, 4.3 | * To minimise disturbance of Ridge Hill Shelf complex in reserve #31900 | 1. Minimise area of reserve #319000 impacted to the orebody as far as practical<br>2.Locate infrastructure and plant on cleared land | Throughout mine life | DoME |
| | Fauna | 2.7 | * To ensure that impact on fauna in the project area is minimised | 1. Restrict area of reserve #319000 impacted to the orebody as far as practical | Throughout mine life | DoME |
| | Rehabilitation | 4.4 | To rehabilitate affected areas to a standard compatible with current landuse | 1. To develop a rehabilitation plan for the mined area of reserve #31900 which reestablishes a woodland of similiar character to that existing<br>2. To improve condition of currently degraded area of reserve #31900 as far as practical<br>3. To consolidate the rubbish tip area with appropriate fencing and access<br>4. To re-establish productive pasture with shelter and shade belts on current agricultural land. | Prior to mining<br>During mining<br>After mining<br>During and after mining | Shire of Harvey<br>DoME<br>CALM |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Hydrology | 4.2 | * To ensure water usage is at levels below recharge rates<br>* To ensure that stream flows during winter are not adversely affected | 1. To monitor water usage from the Yarloop borefield<br>2. To incorporate consideration of stream flow into the mine plan | Throughout mine life<br>Prior to mining | WRC<br>DEP |
| Pollution Potential | Noise | 5.1 | * To minimise noise impacts on neighbouring properties<br>* To comply with statutory noise requirements | 1. Restrict earthmoving operations at night to within the pit as far as possible<br>2. Substitute flashing lights for beepers at night<br>3. Fit acoustic mufflers to earthmoving equipment<br>4. Construct noise reducing bunding where appropriate<br>5. Vegetation screens will be established or enhanced and maintained | Throughout mine life<br>Throughout mine life<br>Throughout mine life<br>Throughout mine life<br>Throughout mine life | DEP |
| | Dust | 5.2 | * To minimise dust impacts associated with haulage<br>* To minimise dust impacts associated with earthmoving, stockpiling and rehabilitation | 1. Haulage roads will be wetted down using a water cart when required<br>2. Stockpiles will be vegetated as far as practical to reduce dust<br>3. Mine planning will keep disturbed areas to a minimum and will retain maximum vegetation<br>4. Rehabilitation will follow as close to the passing of the mine front as possible<br>5. Vegetation screens will be established or enhanced and maintained | Throughout mine life<br>Throughout mine life<br>Prior to mining<br><br>During mining<br>Throughout mine life | DEP |
| | Water | 4.2 | * To have no discernible impact on water quality | 1. To regularly monitor water quality and respond appropriately to any measured anomolous results | Throughout mine life | DEP |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Visual | | * To reduce visual impact of the minesite | 1. Vegetation screens and bunding will be established or enhanced and maintained | Throughout mine life | DEP |
| | Radiation | 4.5 | * To keep surface radiation levels below pre-mining | 1. Use of approved procedures for handling process materials<br>2. Monitoring of rehabilitated areas to ensure favourable comparison with pre-mining levels | Throughout mine life<br>During and after mining | DoME |
| Social Impacts | Traffic | 3.3 | * To ensure trucking of heavy mineral concentrate has minimal impact on neighbours | 1. As far as is practicable restrict trucking to daylight hours on weekdays<br>2. Provide appropriate access to the South West highway causing minimum interruption to traffic flow | During mining<br>During development | DEP<br><br>Main Roads |
| | Aboriginal Heritage | 5.3 | * To avoid interfering with any sites of aboriginal significance | 1. If any aboriginal sites are unearthed production will cease until appropriate consultation with Dept. of Minerals and Energy and the Dept. of Aboriginal Affairs | Throughout mine life | Dept. Aboriginal Affairs |
| | Community Consultation | 5.7 | * To keep the community aware of all relevant aspects of the mining operation | 1. Develope a plan for consultation during development and operation of the mine | Throughout mine life | DEP |

## 1.0 INTRODUCTION

This Notice of Intent requests permission from the Department of Minerals and Energy for Cable Sands (W.A.) Pty. Ltd. to commence mining of the Yarloop deposit of titanium minerals.

The Yarloop deposit has been estimated to consist of 682,000 tonnes of titanium minerals composed primarily of ilmenite with minor amounts of leucoxene, garnet, zircon and monazite. Mining and preliminary concentration will occur on site with the heavy mineral concentrate (HMC) being transported to Bunbury for separation.

The life of the project is currently estimated at just over four years with development commencing in late 1996 and production in early 1997.

## 1.1 PROPONENT

Cable Sands (WA) Pty Ltd is the oldest titanium mineral mining company in Western Australia. Mining commenced in 1956 at Koombana Bay and has continued through a series of mineral deposits at Busselton, Capel, Waroona, Wonnerup and Minninup. Currently operating minesites are located at Busselton, Waroona and Jangardup and a new minesite at Capel will commence production in the middle of 1996.

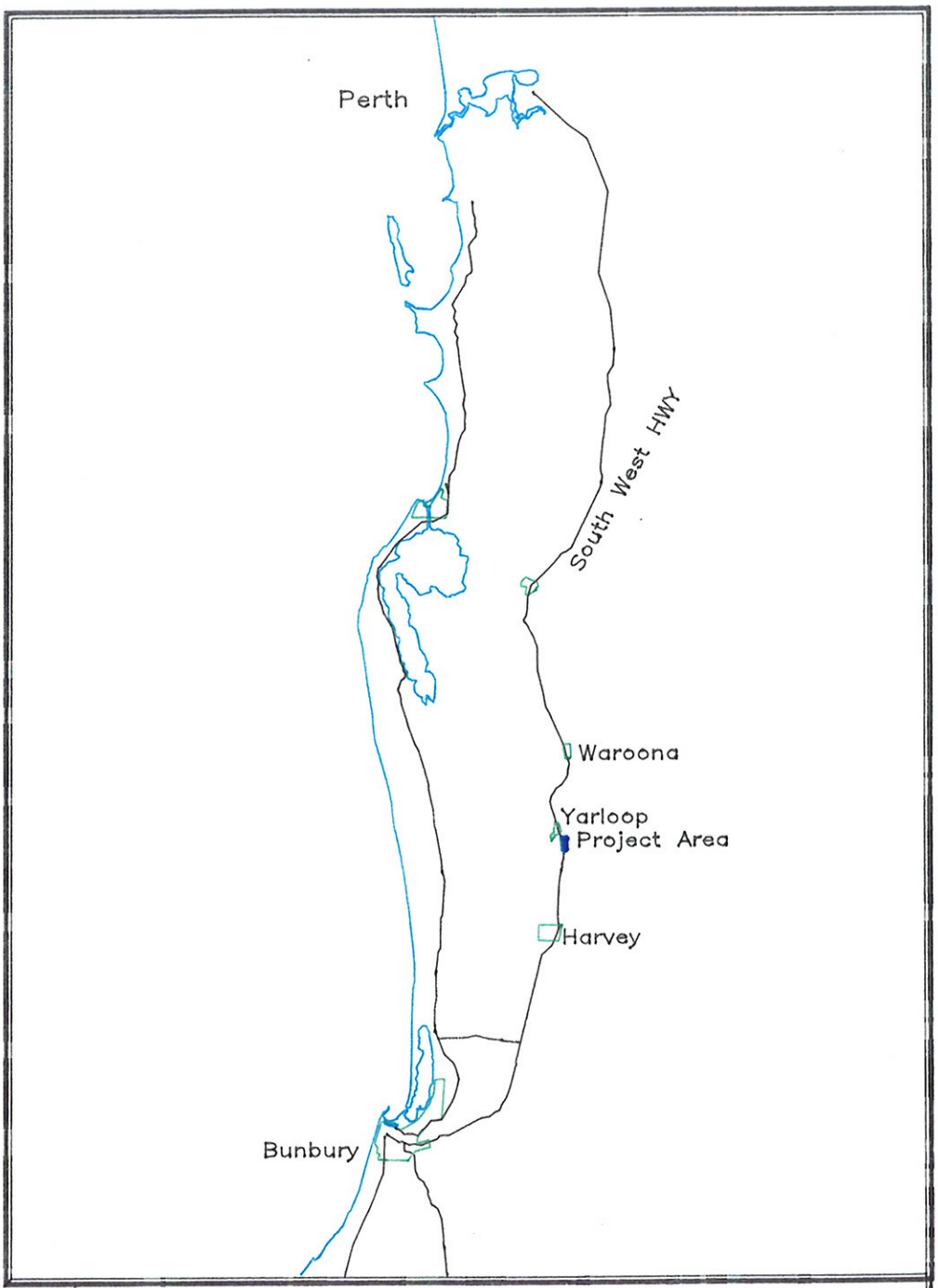
Cable Sands is one of two titanium mineral producing companies, along with RZM Pty Ltd, wholly owned by Sydney-based Kathleen Investments (Australia) Ltd which is part of the Nissho Iwai Corporation.

Development of the Yarloop minesite represents a continuation of the company's operations in the south-west. The Yarloop mine will replace the production from the current Waroona operations when that deposit is exhausted.

## 1.2 LOCATION

The proposed mine is located two kilometres south of the town of Yarloop in the Shire of Harvey. The mining leases are bounded by the South Western Highway to the west, Burney Road to the north and extend north and south of Black Rock Road. The location is shown as Figure 1. Figure 2 shows the mining leases which are discussed in detail in section 1.3 below. An aerial photograph of the site as Figure 3.

The town of Yarloop has a population of 587 (1991 census). The Bunnings timber mill is the main industry in Yarloop employing approximately 90 people. Alcoa's Wagerup alumina refinery is located approximately three kilometres north of Yarloop.




CABLE SANDS (WA) Pty. Ltd.

Location of Yarloop Project Area

| | | |
|---|---|---|
| DRAWN : ssc | SCALE 1 : 999999 | FIGURE 1 |
| DATE : 19 MAR 1996 | CHECKED : | |

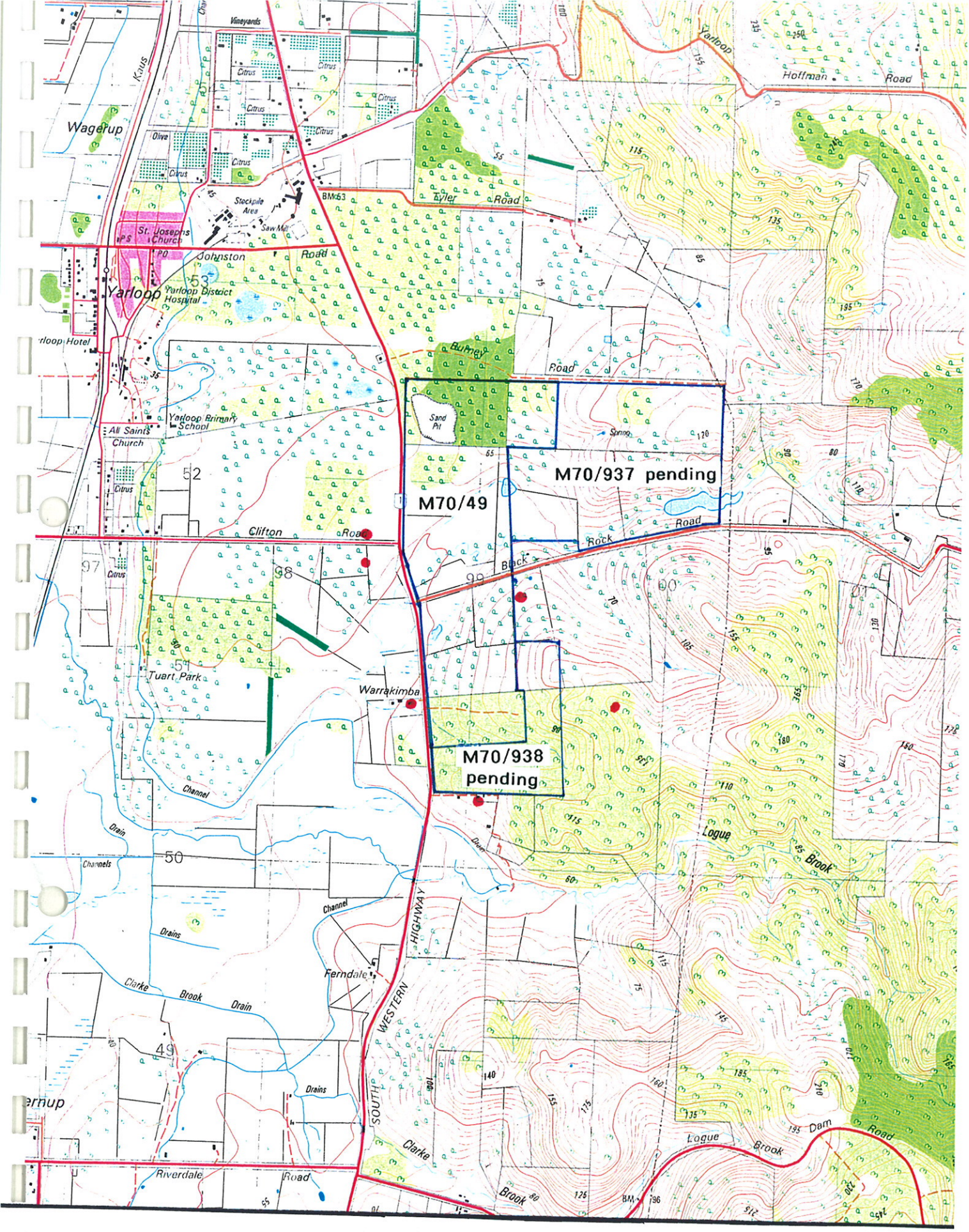



**Fig 2 Mining Lease Locations**

Scale 1:25 000

Mining Lease Boundaries
Location of Neighbours

**Cable Sands(WA) Pty Ltd**




Fig 3. AERIAL PHOTOGRAPH OF YARLOOP PROJECT AREA
APPROXIMATE BOUNDARY OF MINING IMPACT

## 1.3 OWNERSHIP

A mining lease, M70/49 (see Fig.2 for location) was granted to Cable Sands at Yarloop on the 18th of September 1986 extending over all or part of 5 titles. The title details are given below and are shown on Fig 3. These are all post-1899 titles and as such minerals belong to the crown.

| LOCATION | VOLUME | FOLIO | AREA(ha) | OWNER |
|---|---|---|---|---|
| Wellington Locn 816 | 1521 | 978 | 40.4686 | Cable Sands |
| Wellington Locn 3156 | 1405 | 195 | 90.9987 | Cable Sands |
| Wellington Locn 3156 | 1405 | 196 | 25.1093 | Cable Sands |
| Wellington Locn 3156 | 1212 | 744 | 329.5188 | Mr A Jenkins |
| Reserve 31900 5112 | | | 19.6995 | |

Cable Sands owns the first three of these listed titles. Wellington Location 3156 Vol 1212 Fol 744 is owned by Mr. A. Jenkins and Reserve 31900 5112 is vested with the Shire of Harvey as a sand pit and rubbish disposal reserve.

Two additional mining leases have been applied for adjacent to M70/49. These areas have been included to extend the area of orebody mined to the south and to increase areas for slime dam construction and other infrastructure if required. At present it is anticipated that only a relatively small area of the extended leases will be utilised.

M70/937 covers the remainder of Wellington location 3156 Vol. 1405 Folio 195 and Wellington location 816 Vol. 1521 Folio 978 to the east of the northern section of M70/49. These are two of the Cable Sands owned blocks.

M70/938 covers an additional section of Location 3156 Vol 1212 Fol 744 (owned by Mr A Jenkins) and part of Wellington location 3156 Vol. 1686 Folio 866. This land is owned by Mrs. V. Armstrong.

## 1.4 HISTORY

Development in the area was initially associated with timber production. A mill was established at Yarloop toward the end of last century shortly after the Perth to Bunbury railway was opened in 1893 (Staples, 1979).

Clearing of the area for agriculture in close proximity to the town quickly followed and the project area has been extensively cleared since the early part of the century. This area can currently be described as parkland cleared, scarp region broadacre farmland.

## 1.5 EXISTING FACILITIES

The existing facilities are limited and will be provided during mine establishment. South-west Highway adjoins the mine site and access to the minesite will be off this highway to the north of Black Rock Road and off Black Rock Road when the plant is moved to the southern section of the mine.

## 2.0 EXISTING ENVIRONMENT

### 2.1 REGIONAL SETTING

The South-west region of Western Australia is an important mining, processing, agricultural, manufacturing, timber and tourism region.

Mining and mineral processing is a $2.8 billion industry based largely around the alumina and titanium mineral industries. In the Yarloop area these industries are represented by Alcoa's Wagerup alumina refinery 3 kilometres north of Yarloop and titanium minerals mines currently operated by Cable Sands (Waroona South) and previously operated by Cable Sands (Waroona North) and ISK.

The South-west region also includes Western Australia's main centres for the dairy, horticulture and timber industries. Bunnings Yarloop sawmill is one of a reducing number of timber mills throughout the south-west.

Bunbury acts as a service city and port for the industries within the area. Bunbury has a population of approximately 28,000 with over 5,000 people residing in the Australind area.

The coastal area south of Perth is dominated by two main landforms - the Swan Coastal Plain and the Darling Plateau. The Swan Coastal Plain extends for approximately 25 kilometres from the Darling Scarp to the ocean. It is composed of a series of sedimentary materials of different ages deposited over millions of years. Mineral sands mining occurs where the sorting and deposition of heavy mineral sands occurs in sufficient concentrations to make mining economically viable.

### 2.2 GEOLOGY

The Yarloop heavy mineral deposit is part of the Waroona shoreline (Baxter, 1977). It lies at the foot of the Darling Scarp on the Swan Coastal Plain. The deposit was once continuous but now consists of two separated occurrences of heavy minerals having been dissected by the erosional incisement of a creek off the Darling Scarp. The stranded beach sequence rich in heavy minerals is juxtaposed against a line of sea-cliffs. The cliffs trend somewhat parallel to the line of the Darling Scarp - the cliffs do not occur in a perfectly straight line but oscillate mildly about their trend (approximately north). They are remarkably steep. Drilling information has shown that the cliffs rise as much as 12 metres over a horizontal distance of only 6 metres. Elsewhere the cliffs are much less steep, rising 6 metres over 6 horizontal metres. The cliffs are composed of a very coarse quartz rich sandy clay containing only traces of heavy minerals. Heavy minerals have accumulated thickest close to the cliff and gradually thin westward until only a metre of heavy mineral rich sand can be recognised.

A more or less continuous sheet of laterite occurs across the top of the entire deposit. It is commonly exposed at or very near to the surface above the line of sea cliffs, covered by a thin sand sheet. West of the cliffs the lateritic horizon deepens, occurring between 5 and 10 metres

below the surface. Here the laterite is covered by sand and sandy clay containing low to medium heavy mineral concentrations. In an idealised model the lateritic horizon is underlain by clayish sand often with abundant heavy mineral. The relative level of the bottom of the mineralised shore is about 43 metres occuring away from the sea cliff (off shore).No fossils were encountered during the drilling programme. Coffee rock (indurated sand cemented by iron) is developed throughout the deposit with varying degrees of thickness and hardness.

The heavy mineral strands are underlain by a few metres of grey-brown, fine-gravelly, sandy clay. This in turn overlies a dark-grey, fine sandy clay of floury texture. This horizon is many metres thick and it contains abundant fine biotite, becoming harder and more coherent with depth. It is most likely a deeply weathered schistose/granitic rock.

## Regional Geology

The Yarloop area straddles the eastern margin of the Perth Sedimentary Basin. This contains a thickness of about 6000m of Phanerozoic sedimenta downfaulted against the pre-Cambrian basement of the Yilgarn Block by the Darling Fault. The shallowest superficial formations are of Quarternary age and have a thickness of up to 90m. These rest on an unconformity which slopes gently to the west below which there are a series of sediments of Cretaceous and Jurassic age. The youngest of these is the Leederville formation, the sediments of which thicken in a westerly direction from the scarp reaching a maximum of 170m. This formation unconformably overlies the Cockleshell Gully Formation (early - mid Jurassic) throughout the Yarloop area.

The Quaternary is represented by a series of almost flat-lying formations each of which have sometimes complex relationships with its adjoining units both laterally and stratigraphically. The characteristics of the formations occurring in the Yarloop region are:-

**Quaternary** **Guildford Formation**. This unconformably overlies the Jandakot Beds, the Yoganup Formation and the pre-Cambrian basement east of the Darling Fault. The deposits lie in the eastern half of the Swan Coastal Plain tending to thin westwards from a maximum of 30m. The sediments include a brown clay or sandy clay member in the east grading westwards into a more sandy member.

**Yoganup Formation**. This is probably a lateral equivalent of the Jandakot Beds and rests unconformably on the Leederville Formation and the pre-Cambrian rocks east of the Darling Fault. It consists of poorly sorted sands and clayey sands reaching a maximum thickness of 20 metres at the foot of the scarp.

**Jandakot Beds**. These unconformably overlie the Leederville Formation and consist of medium to coarse sand ranging down in grain size to a clay. The beds are believed to reach a thickness of 13 metres.

**Cretaceous** **Warnboro Group**. This has the interbedded sands and shales of the

Leederville Formation as its main aquifer.

**Jurassic** **Cockleshell Gully Formation**. This occurs in the subsurface throughout the region and consists of interbedded sand and shale.

## 2.3 SOILS

The mining lease is situated on the eastern margin of the Swan Coastal Plain which is characterised by undulating foothill slopes dissected by seasonal creeks and minor valleys.The landform-soil unit within the lease area is typical of the Forrestfield Unit, with laterised foothills of the Darling Scarp becoming sandier and less gravelly downslope to the west. In the north-west sector of the lease area, within the shire reserve, the sandiest soils occur, and sand quarrying has taken place. The sandy upper profile in this sector appears to have been formed during a period of unconsolidation by sand drifting from the adjacent Guildford landform-soil units further westward, and currently these overlie laterised Forrestfield soils.

## 2.4 HYDROLOGY

The Yarloop minesite lies on the eastern margin of the Swan Coastal Plain. This extends in a westerly direction from the Darling Scarp to the coast. The physiography is broadly of two types: a slightly undulating plain to the west of the site and much higher relief to the east.

The plain extends between the foot of the escarpment and the eastern margins of a series of elongate low fixed dunes on the east side of Lake Preston. The main drainage which crosses the plain in a north-westerly direction is the Harvey River. This is confined to the Harvey main drain for much of its course across the coastal plain.

The other physiographic region lying to the east of the proposed minesite is characterised by a relatively deeply dissected juvenile topography. This is drained by a series of westerly discharging streams including Waterous Formation Creek, Clarke and Logue Brooks as well as the Harvey stream system which discharges into the southern end of the Harvey Estuary. The natural flows of the streams are highly seasonal. The low flows in summer are principally sustained by discharges of shallow groundwater. However flows are augmented by the tail water of irrigation schemes and discharges from land drainage ditches.

### Hydrogeology

The quaternary sediments constitute a continuous aquifer extending over the whole Swan Coastal Plain. The flow system, hydraulic characteristics and water resources have been investigated in some detail by the Geological Survey of Western Australia. The results have been recorded in a series of publications.

The Yarloop area lies within the Waroona flow system which, in common with the adjoining systems, is directly recharged by infiltrating rainfall. It also receives recharge as leakage from the many irrigation channels through the area. Groundwater movement is dominantly westerly

from the Darling escarpment down-gradient towards the Harvey River and main drain. The flow pattern is complicated by easterly groundwater movement from the Myalup flow system. This originates in the aeolian dunes to the west. Groundwater discharges in the form of spring flow to streams and transpirative draw by vegetation.

A series of interconnected groundwater bodies within the Leederville Formation and underlying Cockleshell Gully Formation are sustained by downward leakage from the Yoganup Formation.

Groundwater quality is directly controlled by the hydraulic characteristics and, to a lesser extent, by the chemical character of the sediments which provide the aquifer. Salinities tend to be particularly high where infiltration is hindered by a high clay content such as in the Guildford and Yoganup Formations. As a general trend, the total dissolved solid content of the waters tends to increase in a westerly direction towards the Harvey drains and river. The quality of the shallow groundwater is further adversely affected by the infiltration of brackish tail water from irrigation.

## 2.5 CLIMATE

The project area experiences a Mediterranean climate with hot, dry summers and mild, wet winters. Average rainfall at the nearest major meteorological station at Harvey, 14 km south of Yarloop, is 1013 mm and over 90% of this is experienced between April and October.

Average maximum temperatures, recorded at the Wokalup Research Station 20 km south of Yarloop, range from 30.9 degrees C in January to 16.7 degrees C in July and August. Average minimum temperatures range from 8.0 degrees C in August to 16.2 degrees C in February.

Strong winds are predominantly from the west. Winter storms bring squally winds from the north-west to south-west and summer afternoon sea-breezes are from the south-west. Hot dry easterly winds of moderate strength occur at night and early in the day during summer.

## 2.6 VEGETATION

An assessment of the vegetation at Yarloop has been undertaken to determine the significance of the project area. This assessment is attached as Appendix 1. This work and previous investigations in adjacent bushland (Keighery, 1995) and and Reserve 23307 (CALM,unpublished) have found no rare or priority listed flora in the Yarloop reserves.

The native vegetation at the Yarloop site has largely been cleared for agriculture. There is a small remnant located at the northern end of the mining lease and this is one of the few remaining areas of native vegetation on the Forrestfield landform-soil unit. This remnant is restricted to Reserve 31900 in the area to be affected by mining and is part of a larger remnant formed with four reserves north of Burney Road.

Two vegetation community types have been identified in these reserves (Keighery,1995). These are *Eucalyptus calophylla - Eucalyptus marginata* woodland on sandy clay soils and Eastern

*Banksia attenuata* and/or *Eucalyptus marginata* woodlands which are types 3b and 20b respectively in "A Floristic Survey of the southern Swan Coastal Plain" (Gibson et al, 1994).

Reserve 31900 is partly cleared for quarrying and landfill. Of a total reserve area of 20 ha approximately 8 ha is currently degraded, some severely, by sand excavation (see Figs 4 a,b and c) and the current rubbish tip. In the eastern section the Type 3b remnant vegetation is generally in good condition (Fig 4d), being relatively diverse and with dense foliage cover. This occupies approximately 9ha. Type 20b is restricted to the western section in Reserve 31900 and is remote from mining.

A section of the area of the reserve that will be mined is located to the east in the Type 3b vegetation. The overstorey here reflects the sandier soils of the site, with Jarrah co-dominant in the forest overstorey (20-28 metres in height) with *Allocauarina fraseriana* and *Banksia grandis* forming a lower stratum (2-3 metres in height). *Banksia attenuata* is also present but not common and *Xylomelum occidentalis* also occurs in the low tree stratum.

A tall shrub stratum (1-2 metres in height) which includes *Jacksonia sternbergiana*, juvenile *Persoonia longifolia* and *Xylomyelum sp.* is present although patchy. *Xanthorrea preissii* (Grass tree) are also common in this height stratum.

There is a particularly diverse low shrub/sedge stratum in the reserve which includes *Acacia aff. biflora, Astroloma sp., Bossiaea ornata, Burchardia umbellata, Calytrix Flavescens, Conospermum acerosum, Daviesia decurrens, Dianella revolta, Dryandra nivea, Hemiandra pungens, Hibbertia hypericoides, Hibbertia linearis, Hibbertia vaginata, Hypocalymma robustum, Lepidosperma angustata, Macrozamia reidlei, Mesomelaena stygia, Muehlenbeckia adpressa, Olearia paucidentata, Opercularia echinocephala, Oxylobium capitatum, Patersonia occidentalis, Persoonia saccata, Persoonia sp., Petrophile linearis, Phlebocarya ciliata, Phyllanthus calycinus, Schoenus sp., Stipa sp., Stirlingia latifolia, Thysanotus sp.* and *Trycoryne elatior.*

In the farmland areas, forest understorey species are now absent due to past clearing and grazing. Current tree cover on the farmland is scattered Jarrah, Marri and Sheoak which have been left as shade trees for livestock. *Eucalyptus rudis* occurs in drainage lines in the farmland.

**Regional Significance**

Most of the Forrestfield landform unit has been cleared for agriculture, therefore remnant vegetation generally occurring on the scarp and lower slopes has conservation importance. The conservation status of Reserve 31900 has been lessened by previous and current landuse activities. Landfill activities at the reserve are ongoing and the Shire of Harvey intend to continue using the reserve for this purpose.

Regionally, the clearing of the vegetation associated with the Ridge Hill Shelf landform for agriculture and grazing was because the heavier soils were highly sought after by early farmers. The sandier soils were in less demand and were included in reserves for community purposes.



Fig 4a: Yarloop Rubbish Tip Reserve - western section



Fig 4b: Yarloop Rubbish Tip Reserve- western section



Fig 4c: Yarloop Rubbish Tip Reserve - western section



Fig 4d: Yarloop Rubbish Tip Reserve - eastern section

Therefore, although the reserves north of Burney Road and reserve 31900 may represent only part of the range of vegetation types that previously existed on the Ridge Hill Shelf landform they do represent an example of a coencline with the Forrestfield Vegetation Complex to the west. Gibson et.al. (1994) concluded that community reservation and conservation status of vegetation types 3b and 20b were well reserved but vulnerable, and poorly reserved and vulnerable, respectively. This assessment is subject to review, however it is acknowledged that the group of reserves are of regional importance, and would complement the proposed consolidation of Reserves 17805 and 16030 at Harvey, particularly because much of the sandier lowland elements of the vegetation in those reserves have been degraded. The reserves north of Burney Road have been recommended for A class reservation. Reserve 31900 has not been included in this recommendation.

Type 3b vegetation has been identified from six sites on the southern Swan Coastal Plain ranging from Dunsborough to Byford. Mining at Yarloop will result in the loss of approximately 10% of this vegetation type in the Yarloop reserves. Type 20b has been identified at four sites and none of this vegetation will be impacted.

## 2.7 FAUNA

A fauna assessment of the project area was undertaken during March 1996. No evidence of any gazetted rare and/or endangered or priority listed species was found during site inspections. A full report on the fauna survey is attached as Appendix 2. The conclusion of the study was that fauna species which have been gazetted rare and/or endangered are unlikely to be dependent on the habitats of the area to be affected by mining.

The fauna values of Reserve 31900 are reduced because the reserve and its neighbours form an island of remnant vegetation with poor prospects of supporting diverse or rare fauna in the long term. The open nature of the reserve area, with only a sparse medium and tall shrub cover, would provide limited cover for species susceptible to predation by foxes.

Gazetted bird species which could visit the study area are wide ranging in daily and seasonal habits and consequently are unlikely to be affected by the mining operation.

Species observed or inferred during the fauna assessment included Western Grey Kangaroo (*Macropus fuliginosus*), Gould's Monitor (*Varanus gouldii*), Australian Raven (*Corvus coronoides*), Darter (*Anhinga melanogaster*) and Pacific Black Duck (*Anas superciliosa*).

## 2.8 RADIATION

A survey of surface gamma dose rates was undertaken in December 1994 and January 1995. Gamma radiation was measured at 280 points with an average of 0.16 ± 0.08 $\mu$Gy/hr. A frequency distribution of the gamma radiation levels is shown (Figure 5).

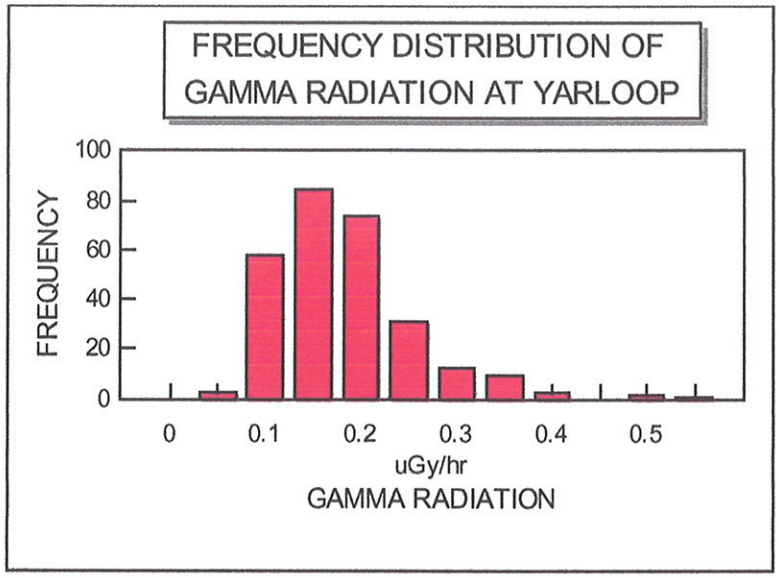



**Figure 5. Gamma Radiation at Yarloop.**

These rates are typical of background levels of the coastal plain. The graph shows a skewed distribution typical of low level readings. The majority of the results are in the range 0.1 to 0.25 $\mu$Gy/hr which is typical of this natural background radiation levels in this region.The maximum reading recorded was 0.52 $\mu$Gy/hr.

## 2.9 NOISE

Background noise measurement has been taken around the Yarloop area to enable assessment of noise impacts during the mining operation. The closest neighbouring property was chosen and measurements taken between 21st March 1996 and 25th March. These are shown in Table 1 below. These measurments reflect the proximity of the South West highway to the house. Additional measurements will be taken at other residences prior to commencement of mining.

| | Leq | Lmax | L10 | L50 | L90 | Lmin | Temp |
|---|---|---|---|---|---|---|---|
| **Weekdays** | | | | | | | |
| 7am - 7pm | 59.7 | 85.0 | 64.1 | 50.3 | 42.6 | 29.0 | 27.5 |
| 7pm - 10pm | 56.7 | 79.0 | 60.2 | 44.9 | 35.9 | 27.0 | 23.5 |
| 10pm - 7am | 49.8 | 81.0 | 49.9 | 36.2 | 30.5 | 26.0 | 17.2 |
| **Weekends** | | | | | | | |
| 7am - 7pm | 58.0 | 86.5 | 62.9 | 48.5 | 39.6 | 29.0 | 27.6 |
| 7pm - 10pm | 56.0 | 87.5 | 59.5 | 42.4 | 33.8 | 26.5 | 21.1 |
| 10pm - 7am | 49.1 | 79.0 | 48.9 | 37.8 | 34.0 | 26.5 | 16.0 |

**Table 1 Noise Measurements at Yarloop**

# 3.0 PROJECT DESCRIPTION

## 3.1 MINING

### Process

The Yarloop deposit will be dry mined using earthmoving equipment. This process is the same as is currently used at Waroona and at Busselton. The steps in this process are described briefly below.

The first step involves **clearing of vegetation** from areas to be mined. As far as possible the vegetated area cleared is minimised and appropriate use made of any timber involved. After examining the options available unusable vegetation that has been cleared will be burnt in accordance with fire restrictions and relevant smoke control guidelines.

Following land clearing **topsoil is stripped and stockpiled** using scrapers. Approximately 20cm of topsoil will be removed. Location of topsoil stockpiles are shown on Figure 5. As far as practical duration of topsoil storage will be kept to a minimum. This topsoil is later used to re-establish vegetation.

Earthmoving equipment is then used to **remove overburden** where this is of sufficient depth to be handled independently of the ore. This overburden is stockpiled for later replacement or is used to fill areas already mined.

The **ore is mined** using similiar earthmoving equipment. A rotary trommel with 50mm and 4.5mm screens is used to separate large rocks, roots and gravel. The fine fraction is then pumped as a slurry to the Primary Separation Plant where heavy mineral concentrate is separated by conventional wet gravity methods.

The water is recycled as much as possible. Clay is removed using a thickener tank. This clayey slurry is allowed to dry in one of a number of slimes dams constructed for this purpose. The **area is recontoured** to blend in with the existing landscape using the dried clay, overburden and tailing sand.

**Topsoil is then replaced** and **vegetation re-established** to a standard that is compatible with the intended landuse after mining.

### Mining Schedule

The proposal is to commence mine site construction in late 1996 and to commence mine production in early 1997. Mining should continue for approximately 4 years. A schematic outline of the proposed mining operations on the Yarloop project area is presented as Figure 5.

1200 E

2400 E

7000 N

7000 N

1500 E

2000 E

BURNEY ROAD

START MINING MAR 97

RUBBISH TIP

MINING DIRECTION

END 97

RELOCATE OB PRIOR TO MINING

RELOCATE ORE PRIOR TO MINING

SLIMES DAMS

TOPSOIL

INITIAL TAILS AREA

6500 N

ACCESS ROAD

SLIMES DAM

TOPSOIL

O/B STOCKPILE

Gully

SOUTH WEST HIGHWAY

HMC TOWERS

Cut Drain

June 1999

DAM

SLIMES DAM

SLIMES DAMS

PLANT SITE #1

W/S & OFFICE

THICKENER

YARD

SLIMES DAM

SLIMES DAM

WATER DAM

SLIMES DAM

6000 N

Causeway

SLIMES DAMS

BLACK ROCK ROAD

P/LINE

SLIMES DAMS

DAM

?

P/LINE

SLIMES DAMS

SURFACE ORE

DEEP ORE W/- OB

TOPSOIL

?

MINE W/- NORTHERN AREA FROM PLANT SITE #1

Start Nov 1998

HMC TOWERS

W/S & OFFICE

2nd

1st

RELOCATE OB

PLANT SITE #2

Topsoil Bund

Dam

SLIMES DAMS

End June 1999

5500 N

SOUTH WEST HIGHWAY

End Mining Sept 2001

August 1999

RELOCATE OB

MINE SURFACE ORE

MINE DEEP ORE AFTER OB REMOVAL

Topsoil Bund

O/B STOCKPILE

6500 N

ACCESS ROAD

SLIMES DAM

TOPSOIL

SOUTH WEST HIGHWAY

HMS TOWERS

PLANT SITE #1

W/S & OFFICE

THICKENER

YARD

END 97

RELOCATE OB PRIOR TO MINING

RELOCATE ORE PRIOR TO MINING

O/B STOCKPILE

Gully

Cut Drain

June 1999

DAM

SLIMES DAM

SLIMES DAMS

SLIMES DAM

SLIMES DAM

SLIMES DAM

WATER DAM

6000 N

Causeway

SLIMES DAMS

SLIMES DAMS

DAM

P/LINE

BLACK ROCK ROAD

SLIMES DAMS

P/LINE

DEEP ORE W/- OB

SURFACE ORE

TOPSOIL

?

Start Nov 1998

MINE W/- NORTHERN AREA FROM PLANT SITE #1

HMC TOWERS

W/S & OFFICE

2nd

1st

RELOCATE OB

PLANT SITE #2

Topsoil Bund

Dam

SLIMES DAMS

End June 1999

5500 N

SOUTH WEST HIGHWAY

End Mining Sept 2001

August 1999

RELOCATE OB

MINE SURFACE ORE

MINE DEEP ORE AFTER OB REMOVAL

Topsoil Bund

O/B STOCKPILE

RELOCATE OB

TOPSOIL

5000 N

DAM FENCE

RELOCATE OB

Topsoil Bund

MINE SURFACE ORE FIRST

Start Mining Aug 1999

4700 N

1200 E

4700 N

CABLE SANDS (WA) PTY LTD

YARLOOP – INITIAL LAYOUT PLAN

| | | |
|---|---|---|
| DRAWN : SAM | SCALE 1 : 5000 | FIG 6 |
| DATE : 9 MAY 1996 | CHECKED : | |

The mining operation involves two mining areas one north and one south of Black Rock Road. The plant will be moved once during the life of the mine when the operation crosses to the southern section.

Before mining commences topsoil and overburden from all areas north of Black Rock Road will be removed. Some of the overburden will be used in constructing part of the nothern infrastructure. The remainder will be stockpiled as will the topsoil.

The north-eastern strand will be relocated on to the southern end of the northern mining area. Mining will commence in the rubbish tip area and progress southwards. Initial tails will be pumped to the north-eastern strand area. Mining through the rubbish tip reserve will take approximately nine months. The remainder of the northern area, which includes the relocated north-eastern section, will be mined over a further eighteen months.

Mining in the southern ore area will commence approximately twenty months after the northern area begins. Initially the area closest to Black Rock Road will be mined and this material will be processed with the plant in its northern location. This will occur concurrently with finishing the mining of the northern area.

Thirty months after commencement the plant will be moved to a new site south of Black Rock Road. The bulk of the southern area will be mined from south to north. The exceptions are the area already mentioned and a small section on the eastern side which will be mined from north to south.

It is estimated that the mine will cease production 55 months after commencement. At current estimates this will mean that the mining will cease in September 2001.

Initially the mining and primary separation operations will be undertaken on a 24 hours per day and seven days per week basis, however this may vary depending on production requirements.

The heavy minerals concentrate will be dewatered and stockpiled at the mine site prior to being trucked to the Cable Sand's Secondary Separation Plant at North Shore, Bunbury.

## 3.1 INFRASTRUCTURE

The following plant will be required for the mining operation and will either be constructed on site or transferred from existing operations.

### 3.1.1 WATER

Make-up water will be pumped into a storage dam from a series of shallow bores in the surficial formation.

The bores will be located approximately four kilometres west of the minesite. An application to the Water and Rivers Commission will be submitted for the licencing of these bores. Potable

water for domestic purposes will be collected in rainwater tanks if bore water is not suitable, or purchased from the Yarloop town water supply.

The dam will be constructed below Plant Site #1 predominantly using on-site materials. It will have a capacity of 40,000 - 45,000 kL and will service all phases of the operation.

### 3.1.2 THICKENER TANK

A thickener will be constucted to remove fine clay from the water circuit. This will be located adjacent to the dam. Pipes will be installed below Black Rock Road to service the southern section of the orebody.

### 3.1.3 SLIMES DAMS

Slimes dams will be constructed to allow for drying of the fine clay separated by the thickener. These dams will cover approximately 50ha, a significant proportion of the area directly impacted by mining. Dams will be initially located on agricultural land and then will be located on the mined area after return of tails. The clay from the slimes dams is eventually incorporated with tails and overburden when the landscape is re-contoured.

### 3.1.4 INTERNAL ROADS

Internal roads are required to facilitate transportation within the minesite for mining and service operations. The approximate locations of these internal roads are shown in Fig. 5 although these are subject to change. The roads will be constructed from gravel or limestone obtained from local quarries or from oversize material obtained on site. During the summer months these roads will be wetted down as needed to control dust. A water cart will be on site for this purpose.

### 3.1.5 PLANT SITES

Two plant sites will be used in the course of the mining operation. Facilities will initially be transported from Cable Sand's Waroona South minesite where appropriate. These facilities will include workshops, store, shed, site office, toilets and a lunch room. Heavy mineral concentate towers will be located adjacent to the plant sites.

## 3.2 WORKFORCE

The operating minesite will employ approximately 28 people including those currently employed at the Waroona minesite. The sequential nature of Cable Sands mining operations provides the opportunity for continuity of employment for current personnel .

## 3.3 TRANSPORT OF HEAVY MINERAL CONCENTRATE

The transportation of the HMC will be by truck and trailer units similiar to those currently used to transport HMC from Cable Sand's existing operating minesites.

The route that the trucks will take from the minesite will be south along the South West highway to Bunbury then north along Robertson Drive and Koombana Drive to Cable Sands' North Shore Facility. This route is shown on Figure 1.

At estimated production rates and truck payloads between 42 and 58 tonnes there will be between 50 and 75 return truck journeys per week for the 4 year life of the mining operation.

The trucking regime is similiar to that currently operating for the transportation of HMC from Waroona. The net effect of the trucking will be negligible between Yarloop and Bunbury and a reduction in trucks between Waroona and Yarloop. The transportation of HMC for Cable Sands is insignificant in relation to the overall traffic on the South West highway.

## 4.0 ENVIRONMENTAL IMPACT AND MANAGEMENT

Cable Sands has considerable experience in the mining of titanium minerals in the south west of Western Australia. In particular, the two mines at Waroona have provided experience in dealing with similiar issues to those relevant to the Yarloop mine. Of particular relevance is the experience relating to dust, noise, radiation, groundwater, transport and light spill. These and other issues are discussed in detail below following an overview of Cable Sands' environmental management system which provides the framework for the company's environmental operations.

## 4.1 ENVIRONMENTAL MANAGEMENT

Cable Sand's environmental management has evolved over a number of years in response to relevant statutory requirements and commitments relating to individual projects. At present Cable Sands is working toward consolidating its environmental management under the ISO 14000 series of standards. This series addresses aspects of environmental management systems and the operation of such systems.

The company has developed a policy which broadly covers relevant areas of environmental management. The policy is based on 5 principles. These relate to operating in an environmentally responsible manner, continual improvement, community awareness, reducing environmental impacts and staff awareness. Consideration of these principles is central to the effective environmental management of the Yarloop mine.

## 4.2 WATER

The proposed dry mining operation will have minimal impact on the hydrology of the region. The location of the various dams will not affect the flow of Waterous Formation Creek which forms the central gully separating the two mining areas. The seasonal flow from the eroded gully to the north will be diverted to feed the storage dam or to join Waterous Formation Creek upstream of where it currently joins. This will not adversely affect the overall flow.

Experience with mining at Waroona indicates that the impact of the mining operation on water available for surrounding vegetation is confined to a small area immediately adjacent to the mine.

## 4.3 FLORA AND FAUNA

The significant impact on flora and fauna will largely be confined to the rubbish tip reserve. Environmental management will be focussed on minimising the vegetated area disturbed and rehabilitating the area to ensure that it complements the A class reserve proposed for the woodland north of Burney Road. Rehabilitation is discussed in detail in section 4.4.

The area to be disturbed in Reserve 31900 is estimated at 8 ha. There is some overlap with the area already degraded through previous and current landuse which is also approximately 9 ha. The total area of the 20ha reserve that will be impacted by the past, present and proposed

landuse will be approximately 16ha. The rehabilitation will improve the value of all but approximately 4ha of the currently degraded land which will continue to be used for rubbish disposal. There will be a loss of about 10% of vegetation type 3b within the group of reserves and 8% of the total vegetation within the reserves.

The proposed restoration plan will restore the overtorey stratum and many of the existing understorey species, however it is not practical to immediately recreate the existing understorey structure. Restoration will aim to restore and enhance conservation values where possible, although recognising the ongoing landuse as a landfill site.

## 4.4 REHABILITATION

Rehabilitation will be undertaken in accordance with a restoration plan that will be finalised prior to commencement of mining. The details of the plan will be finalised in consultation with the Shire of Harvey and CALM. Appendix 1 includes recommendations for restoration which followed subject to discussions with other relevant bodies. This restoration plan is outlined below.

The focus of the rehabilitation programme will be to rapidly stabilise restored landforms with vegetation selected to address the different landuse objectives within the mining lease area. Land restoration will be integrated with the mining process to ensure the earliest possible stabilisation and restoration.

The general objectives of the rehabilitation programme are to;

* Re-establish pasture on the private land in areas currently used for grazing.
* Enhance shade and stock shelter tree plantings on farmland areas, establishing groves of trees which would include local species.
* Conserve all topsoil and return topsoil to areas with a compatable landuse.
* Restore all mined areas to landforms which conform with the surrounding terrain, while controlling surface drainage with contoured gradients where necessary.
* Restore the degraded area of Reserve 31900, following appropriate discussions with the Shire of Harvey and CALM, with shrub and tree plantings complementary with surrounding vegetation.
* Areas of existing native vegetation within Reserve 31900 disturbed by mining will be revegetated with suitable species previously observed on site and in similiar adjacent vegetation.

### Woodland Restoration

The mining process will be preceded by collection of available seed and rootstock material for future nursery propagation of perennial shrubs and trees. Commercial timber will be removed and non-commercial timber will be heaped and burnt under permit. During clearing sedge and shrub material will be retained as much as possible for incorporation with topsoil.

Topsoil will be stripped in two stages, using scrapers where possible. The top 5cm will be removed first and stored separately. A further 10-15cm will then be removed. Following mining re-contouring will incorporate fine clays into the upper soil profile to aid moisture retention and rehabilitation success. Topsoil will then be returned in the layers previously separated. Care will be taken to spread topsoil evenly, particularly the upper layer, so that viable seeds and propagules are not buried too deeply for regeneration.

Some native species are expected to regenerate from the respread topsoil, however experience shows that regeneration response can be quite variable. Supplementary hand seeding and planting of nursery propagated seedlings will use seed collected on site as much as possible. Seedlings will be fertilised where appropriate to enhance rehabilitation success.

The establishing vegetation will be inspected following the first summer period to assess the need for supplementary planting and seeding. The need to eradicate weeds and control rabbit populations will also be assessed.

**Farmland Restoration**

Cable Sands has extensive experience in rehabilitating pasture at previous and current minesites including Waroona South and North, Capel, Busselton and Jangardup. In these cases, incorporation of slimes immediately below the topsoil layer provides high moisture and nutrient holding capacity leading to repid re-establishment of productive pasture

On the pastured land, clearing will utilise commercial timber, burn non-commercial timber under permit and strip and store topsoil in two stages. Following recontouring topsoil will be respread evenly and a clover-ryegrass mix sown after consultation with the landowner. Fertiliser applications will ensure a vigorous re-establishment of pasture.

Shelterbelt tree plantings will be located based on prevailing wind conditions and sympathetic to the surrounding landscape. Native species will be used for trees planted as part of the farmland restoration.

## 4.5 RADIATION

Present levels of surface radiation in the Yarloop area are typical of the Swan Coastal Plain. Experience with similiar mining operations indicates a reduction in gamma radiation levels in the post-mining landscape. It is likely that a reduction in the order of 0.05 $\mu$Gy/hr will be experienced at Yarloop.

## 4.6 STORAGE OF HYDROCARBONS

Hydrocarbons kept on site for fuelling the earthmoving equipment will be kept in appropriately constructed bunded areas capable of holding 110% of the largest vessel capacity.

## 5.0 SOCIAL IMPACTS

### 5.1 VISUAL

The mining operation is located adjacent to the South West highway and will be partially visible to passing traffic and also to neighbours. Extensive vegetation screening has been established parallel to the highway to reduce this impact. In addition a screen exists adjacent to the neighbouring property to the east using trees provided by Cable Sands. These screens are complemented by the vegetated topsoil bunding which will also be established along sections of the highway.

### 5.2 NOISE

The impact of noise will be limited due to the predominance of electrically driven machinery used in the separation of heavy mineral concentrate. The major potential for noise impact is through earth moving machinery. As is the normal practice with Cable Sands operations, the following procedures will contribute to reducing this noise impact:

* As far as possible night time earthmoving operations are restricted to within the pit
* Substitution of flashing lights for reversing beepers at night time.
* Fitting of acoustic exhaust mufflers to all earthmoving machinery working outside daylight hours.
* Construction of noise reducing bunding using topsoil stockpiles. This will apply particulary to the southern mining area alongside the South West highway.

### 5.3 DUST

Experience has shown that the major concern with dust generation involves the transportation of heavy mineral concentrate on internal gravel roads. The impact of dust from this source will be minimised through a wetting down dust control programme involving the use of an appropriate water cart during the summer months.

Dust generation from other sources is reduced by minimising the areas disturbed, restricting dust generating activities on excessively windy days and rehabilitating as soon as practical after mining has passed. Topsoil stockpiles are vegetated and slimes are used on tailings areas to reduce the amount of material available as dust. Vegetation screens established on site also assist in reducing dust problems.

These steps have proved effective in minimising dust at Waroona and it is not anticipated that there will be any major problems with dust at Yarloop.

### 5.4 ABORIGINAL SITES

The Department of Aboriginal Affairs were contacted in relation to the proposed mining operation. No recorded Aboriginal Heritage sites were listed for the project area.

Previous communication with the department has indicated that the likelihood of sites occurring is usually influenced by factors such as availability of water, access to raw materials (eg. quartz or chert), the presence of prominent features and level of prior disturbance or development of the land. Based on these considerations it is unlikely that there are unrecorded sites in the project area.

In the event of unearthing of skeletal remains or discovery of Aboriginal sites the Department of Aboriginal Affairs and the Department of Minerals and Energy will be informed immediately.

## 5.5 EUROPEAN HERITAGE

The project area does not contain any sites which are listed with the Heritage Commission or the National Trust.

## 5.6 LAND USE

The mining operation planned will not change the long term land use. Rehabilitation of the mined area will result in a return to similiar vegetation to that existing prior to mining on both the pasture and reserve land. The rubbish tip will continue to operate throughout the mining operation and will continue on an area set aside for this purpose after completion of the mine.

## 5.7 SOCIAL ENVIRONMENT

Cable Sands is an important contributor to the regional economy. The development of mining operations at Yarloop allows for continuity of employment for current personnel and helps to ensure the long term viability of Cable Sands with the intrinsic benefits to the country, state and local community.

## 6.0 COMMUNITY CONSULTATION

Cable Sands recognises the importance of keeping the community and relevant government bodies informed about the mining operation at Yarloop. To this end discussions have taken place with the following people or bodies;

Department of Environmental Protection - Bunbury and Perth
Department of Conservation an Land Management - Bunbury, Mornington and Woodvale
Department of Minerals and Energy - Collie and Perth
Department of Aboriginal Affairs - Albany
Shire of Harvey councillors and staff
Local residents
- Mr and Mrs A Jenkins
- Mr and Mrs M Jenkins
- Mr and Mrs A Angi
- Mr and Mrs C Angi
- Mr and Mrs F Venables
- Mr and Mrs N Armstrong
- Mr N Penny

Cable Sands personnel have discussed the proposed operation with neighouring residents in the course of preparation of this document. This has included discussion of information included in the information sheet prepared for the site (see Appendix 3) and discussion of issues raised by the residents. Where appropriate, concerns have been addressed in the mine plan. In addition Cable Sands has had numerous discussions with landowners adjacent to the proposed mining operation throughout the exploration phase and in establishing the water supply for the site.

Concerns raised by the residents related to dust, noise, transportation of concentrate, safety of schoolchildren, interference with television reception, preservation of the rubbish tip and light spill from the mine. There was a general acceptance by residents that the mining operation would proceed and a positive response to discussion of the issues raised.

Councillors and staff from the Shire of Harvey were briefed about the mining proposal and extensive discussions have taken place in establishing the agreement for the operation of the rubbish tip throughout and after the mine life. Concerns raised included those relating to dust and management of the tip.

## 7.0 REFERENCES

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# APPENDIX 1

# Yarloop Mineral Sands Lease:

## ASSESSMENT OF REMNANT VEGETATION

## AND RECOMMENDATIONS FOR RESTORATION

Prepared For:

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May, 1996

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## 1.0 SUMMARY

CABLE SANDS (W.A.) PTY LTD proposed mining operations at Yarloop will mostly occur on cleared farmland, however a small area of remnant bushland within reserve 31900 will also be affected. The vegetation is principally *Eucalyptus marginata-Allocasuarina fraseriana* woodland with a diverse perennial shrub and sedge understorey typical of the **Forrestfield Vegetation Complex** on **Ridge Hill Shelf** landform. As most of this vegetation type has been cleared regionally, the remnant vegetation of reserve 31900 and adjacent reserves have importance for conservation. No rare or priority listed flora were found to be present on the proposed mining area.

Recommendations for land restoration are outlined with the general objectives of restoring the farmland, old quarry sites, landfill areas and remnant bushland areas with appropriate soil management and replanting strategies. A revegetation programme is recommended that will achieve rapid stabilization of mined surfaces, and the restoration of a diverse woodland vegetation. This will provide a functional buffer surrounding the landfill site and this will complement the conservation aspects of the adjacent group of reserves north of Burney Road.

## 2.0 INTRODUCTION

CABLE SANDS (W.A.) PTY LTD proposed mining operations at Yarloop are predominantly located on cleared farmland currently used for grazing purposes, and also within a section of an adjacent public utility reserve 31900 used for sand quarrying and refuse landfill purposes. The proposed mining will encroach both on the quarry site and undisturbed remnant native woodland areas contained within this reserve. This report reviews the remnant vegetation on the private farmland and in the reserve which will be affected by mining, and also provides guidelines for post-mining land restoration and revegetation.

## 3.0 EXISTING ENVIRONMENT

### 3.1 LANDFORM AND SOILS

The mineral lease is situated on the eastern margin of the Swan Coastal Plain approximately two kilometres south of Yarloop. The Swan Coastal Plain is generally flat or of low relief, however the eastern margin is characterised by undulating foothill slopes dissected by seasonal creeks and minor valleys The landform-soil unit within the lease area is typical of the **Forrestfield** Unit, (D.C.E. 1980), with laterised foothills of the Darling Scarp becoming sandier and less gravelly downslope to the west. In the north-west sector of the lease area within the Shire reserve, the sandiest soils occur,

and sand quarrying has taken place. The sandy upper profile in this sector appears to have been formed during a period of unconsolidation by sand drifting from the adjacent **Guildford** landform-soil units further westward, on the Swan Coastal Plain, and currently these overlie laterised **Forrestfield** soils.

## 3.2 VEGETATION AND FLORA

The vegetation of the **Forrestfield** landform-soil unit west of the Darling Scarp has now been extensively cleared for farming, and most of the lease area comprising of gravel loam and sandy gravel soils has been cleared for this purpose. Typically, the vegetation was *Eucalyptus marginata* (Jarrah), *Eucalyptus calophylla* (Marri), and Sheoak-*Banksia* forest on the sandier soils, with *Eucalyptus wandoo* replacing the Sheoak and *Banksia* on the heavier soils. *Eucalyptus rudis* (flooded gum) and *Melaleuca rhaphiophylla* (paperbark) occur along drainage lines and in water-gaining depressions.

The forest understorey species are now generally absent in the farmland areas due to past clearing and grazing, and are now present only in the adjacent road reserves and nearby recreation and utility reserves. Current tree cover on the farmland is scattered Jarrah, Marri and Sheoak which have been left as shade trees for livestock. *Eucalyptus rudis* occurs in drainage lines on the farmland.

The public utility reserve (31900) included in the lease area is partly cleared for quarrying and landfill, however the remnant vegetation is generally in good condition, being relatively diverse and with dense understorey foliage cover. The flora of reserve 31900 was inspected during Janauary, 1995 and February, 1996 to tabulate vegetation and flora and search for rare plant species. The overstorey was found to reflect the sandy soils of the site, with Jarrah co-dominant in the upper stratum (20-28 metres in height) with *Banksia grandis* and *Allocasuarina fraseriana* forming a lower stratum (2-5 metres in height). *Banksia attenuata* is also present although not common on the eastern section of the reserve, however it is more common on the sandier western section. *Xylomelum occidentale* also occurs in the low tree stratum.

A tall shrub stratum (1-2 metres in height) which includes *Jacksonia sternbergiana,* juvenile *Persoonia longifolia* and *Xylomelum occidentale* is present, although of patchy distribution. *Xanthorrhoea preissii* (grass trees) are also common in this height stratum.

There is a particularly diverse low shrub/sedge stratum present in the reserve which includes *Acacia huegelii, Astroloma pallidum., Bossiaea ornata, Burchardia umbellata, Calytrix flavescens, Conospermum stoechadis, Davesia preissii, Dianella revoluta, Dryandra nivea, Hemiandra pungens, Hibbertia hypericoides, Hibbertia acerosa, Hibbertia vaginata, Hypocalymma robustum, Lepidosperma squamatum, Macrozamia reidlei, Mesomelaena tetragonia, Muehlenbeckia adpressa, Olearia paucidentata, Opercularia hispidula. Oxylobium capitatum, Patersonia occidentalis, Persoonia saccata, Persoonia elliptica., Petrophile linearis, Phlebocarya ciliata, Phyllanthus calycinus, Schoenus* sp., *Stipa* sp., *Stirlingia latifolia, Styphelia tenuiflora, Tetraria capillaris, Thysanotus* sp., and *Trycoryne elatior* as common species. A list of plant species observed to occur in reserve 31900 which includes

uncommon species is given in table 1.

The vegetation of the group of reserves in the vicinity of Burney Road has predominantly been classified as vegetation type 3b, *Eucalyptus calophylla - Eucalyptus marginata* on sandy clay soils. (Gibson et. al. 1994, Keighery, G., Unpublished). A small area of woodland on the western margin of reserve 31900 and 31901 was classified as vegetation type 20b, *Banksia attenuata* and or *Eucalyptus marginata* woodland. Vegetation type 3b was recorded during the survey from alluvial soils near the Peel-Harvey Estuarine System as well as on well drained sites on the eastern side of the Swan Coastal Plain. Community type 20b was found on sands at the base of the scarp between Byford and Yarloop.

## 4.0 CONSERVATION ASPECTS

Most of the **Forrestfield** landform unit has been cleared for agriculture, therefore remnant vegetation generally occurring on the scarp and lower slopes has conservation importance. The conservation status of public utility reserve 31900 has been lessened by landuse activities such as sand extraction and landfill. Landfill activities at the reserve are ongoing, and the local government at Yarloop plan to continue to utilize the reserve for this purpose.

Regionally, the clearing of the vegetation associated with the **Ridge Hill Shelf** landform for agriculture and grazing was because the heavier soils associated with this landform were highly sought after by early agriculturalists. The sandier soils were less in demand and therefore were included in reserves for community purposes - such as sand extraction and rubbish tips. Therefore, although the reserves north of Burney Road and reserve 31900 may represent only part of the range of vegetation types that previously existed on the **Ridge Hill Shelf** landform they do represent an example of a coenocline with the **Forrestfield Vegetation Complex** to the west. Gibson et. al. concluded that community reservation and conservation status of vegetation types 3b and 20b were well reserved but vulnerable, and poorly reserved and vulnerable, respectively. This assessment is subject to review, however it is acknowledged that the group of reserves are of regional importance and would complement the proposed consolidation of reserve 17805 and 16030 at Harvey, particularly because much of the sandier lowland elements of the vegetation in those reserves have been degraded. The reserves north of Burney Road have been recommneded for A class reservation. Reserve 31900 was not included in this recommendation..

The remnant vegetation of reserve 31900 was searched for the presence of rare or restricted flora. Priority listed flora known to occur in the vicinity of Yarloop and the nearby Harvey district include *Acacia flagelliformis, Rhodantha pyrethrun, Grevillea prominens* and *Caladenia uliginosa subsp. patulens m.s. Amperea simulens* is known to occur in the vicinity of Waroona. None of these or other priority listed flora observed in the reserve.

Extensive flora surveys undertaken in reserve 23307 (Department of C.A.L.M. Unpublished) and adjacent unreserved bushland (Keighery, 1995) also showed that rare and priority listed flora were

absent from the vegetation in those areas.

## 5.0 RECOMMENDATIONS FOR LAND RESTORATION

### 5.1 GENERAL OBJECTIVES

The programme of land restoration at Yarloop should focus on rapid stabilization of restored landforms with vegetation replanting based upon a rehabilitation strategy which addresses the different land-use objectives operating within the mining lease area. This will involve the restoration of pasture production, the creation of stock shelter belt vegetation, tipsite and quarry restoration and natural woodland revegetation. Land restoration works will need to be integrated with ongoing mining operations to ensure the earliest possible achievement of stabilization and restoration objectives.

The general objectives of the recommended rehabilitation programme are to;

* Re-establish pastures on the private land in areas currently used for grazing.
* Enhance shade and stock shelter tree plantings on farmland areas, establishing groves of trees which would include local species.
* Conserve all topsoil, and return soil to areas with a compatable future landuse.
* Restore all mined areas to landfoms which conform with the surrounding terrain, while controlling surface drainage with contoured gradients where necessary.
* Restore the quarry site with tree and shrub plantings complementary to the surrounding regional vegetation. The location of the quarry area is shown in **figure 1.**
* Areas of existing native vegetation within reserve 31900 disturbed by mining are to be revegetated with suitable species previously observed on the site and in similar to adjacent vegetation.

### 5.2 FARMLAND RESTORATION

Revegetation operations are best carried out during early winter months for both native perennial plantings and pasture establishment. Landforms restored to pasture should be seeded with a clover-ryegrass mix after consultation with the landowner as to species preferences.

To achieve a vigorous re-establishment of pasture, fertilize initially with an application of 400 Kg/ha of Superphosphate, potasium NPK and trace elements, and subsequent applications of 200 Kg/ha of a predominantly superphosphate mix.

Shelterbelt planting on the private land should be located according to prevailing winds and also to provide a buffer adjacent to the remnant vegetation on Reserve 31900 (rubbish and sand extraction) and Reserve 16681 (rifle range). Species selection should comprise native species compatable with

the surrounding landscape. A list of tree species recommended for shelterbelt planting on the farmland is provided in table 2.

## 5.3 WOODLAND RESTORATION

### 5.3.1 Preparation Works

Rehabilitation of mined remnant woodland on Reserve 31900 should be preceeded by collection of available seed from perennial shrubs and trees for future nursery propagation.
It is recommended that seed be collected from the site or from the general region. Propagation of rootstock material from species difficult to regenerate from seed should also be undertaken prior to mining.

Clearing of the remnant vegetation should commence with all the commercial timber being removed, and the residue of the non-commercial timber being heaped away from remaining vegetation and burnt under permit during Autumn or Spring. Some timber, particularly hollow logs, may be kept for respreading on to rehabilitated areas for microfauna habitat. During the clearing process, all shrub and sedge vegetation should be left behind as much as possible to be incorporated into the topsoil.

### 5.3.2 Topsoil Management

All topsoil on the vegetated areas should be stripped in two stages, using scrapers wherever possible. The top 5 cms of topsoil should be removed first, including understorey vegetation, and stored seperately. A further 10-15 cms would subsequently be removed for seperate storage. Topsoil from the reserve area should not be deposited on adjacent farmland topsoil so as to prevent contamination by weed seeds.

Overburden which does not require processing can be removed on a progressive basis in front of the minepath and where possible used immediately to reform post-mining surface levels. Some overburden will need to be transferred from within the lease area and used to restore surface topography in the quarried section of the reserve. Where possible, fine clays should be incorporated into the upper soil profile prior to topsoil replacement. The inclusion of the fine clays will further aid moisture retention and rehabilitation success.
The effect of heavy machinery on soil compaction needs to be carefully monitored during landform restoration and compacted areas ripped or cultivated as necessary.
After the landform surface has been shaped to the desired postmining contours, the topsoil should be respread as evenly as possible, with particular care taken to spread the first stripping evenly so that the viable seeds and propagules contained within are not buried too deeply for regeneration.

### 5.3.3 Seeding and Planting

Some native species are expected to regenerate from the respread topsoil on the restored woodland area in the reserve, however experience has shown that regeneration response can be quite variable. Volunteer regeneration from topsoil will need to be supplemented by nursery propagated seedlings and by hand seeding. Where possible seed should be collected prior to mining or from adjacent vegetation under permit. Seed can be collected mainly during November to February, and applied during May to July. It is anticipated that seed will also be required from commercial suppliers, collected from the same botanical provenance. Recommended species to be regenerated from seed or seedlings in the restored woodland areas are listed in **table 3.** Considerable regeneration can be expected from perennial understorey species that normally propagate by resprouting from roots, bulbs or corms provided that the period of topsoil storage is brief.

Regeneration of these species can be supplemented by harvesting root cuttings for propagation and storage prior to topsoil stripping. Plant species suitable for rootstock or stem propagation that are otherwise difficult to grow from seed are listed in **table 4.**

To achieve a comprehensive re-establishment of understorey species the nursery propagation programme will involve the production of potted seedlings from collected seed in addition to root and shoot cuttings. This can be undertaken on a contract basis. Tree species seedlings are best grown on to planting stage in 50x120 mm plastic airpots, while perennial shrub species can be grown in both 50x120 mm airpots and 50x50 mm peat pots. Some of the required propagation could be carried out at CABLE SANDS (W.A.) PTY LTD existing nursery at Bunbury, however, it is anticipated that a significent proportion of requirements will need to be contracted out to commercial suppliers and growers.
At the time of planting, tree seedlings other than *Banksia* species will require fertilizing with a 60 gram mixture of NPK with trace elements and Dynamic Lifter. Understorey species planted out on the restored quarry area should also receive this mixture, however understorey species planted on the restored woodland area should receive Dynamic Lifter only.

### 5.3.4 Maintenance Works

The establishing vegetation should be inspected after the first Summer period to assess the need for supplementary planting and seeding. Weeds may need to be eradicated regularly by spot spraying or mechanical methods, as weed invasion may be expected from the landfill area or the adjacent farmland. Regenerating seedlings should be protected by a vermin proof fence, and regular inspections for rabbit infestation should be undertaken. In the longer term, local landcare and conservation groups should be encouraged to take an interest in the restored quarry and landfill sites to ensure the success of the planting, as the heavy public usage of the reserve will require human impact and fire management strategies to be implemented and enforced.

## 6.0 DIEBACK MANAGEMENT

The past land usage of much of reserve 31900 and adjacent farmland indicates that dieback infection would have been introduced to these areas over a long period of time. Although the reserve contains a range of species susceptable to the disease, no symptoms were observed in the remnant woodland that would suggest that *Phytothphora* is presently active.

Hygiene proceedures are recommended when carrying out vegetation clearing, topsoil removal and replacement operations in the remnant woodland so as to minimize the risk of contaminating topsoil. All vegetated areas adjacent to the proposed mining zone should be quarantined from vehicular entry or disturbance. As the remnant woodland area is small and situated next to areas receiving uncontrolled vehicular access, it is recommended replanting should involve mostly dieback resistant species.

## 7.0 CONCLUSIONS

The principal impact of the proposed mining will involve the clearing of a small area of remnant vegetation in reserve 31900. This will result in the loss of approximately 10% of vegetation type 3b included within the group of reserves, and 8% of the total vegetation in the reserves. No vegetation type 20b will be affected by mining. A revegetation programme is proposed that would restore the overstorey stratum and many of the existing understorey species, however it is not practical to attempt to immediately recreate the existing understorey community structure.

The restoration programme will restore the landform of the disused quarry area and replant appropriate species compatable with the adjacent vegetation. The principal objective of the rehabilitation will be to restore and enhance where possible conservation values, although recognizing that ongoing landfill activities will continue to degrade the natural attributes of the reserve.

## 8.0 REFERENCES

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*A Floristic Survey of the Southern Swan Coastal Plain.*
Unpublished Report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc.)

Keighery, G., 1995

*Report on Floral Values of the Bushland in Yarloop Townsite opposite Johnson Road.*
Unpublished Report, C.A.L.M.




FIGURE 1

The northern section of the mining lease showing the position of the orebody in relation to reserve 31900

| | |
|---|---|
| — | Reserve 31900 boundary |
| 3b | Vegetation types |
| L | Landfill area |
| Q | Sand quarry area |

TABLE 1

## PLANT SPECIES OBSERVED TO OCCUR IN RESERVE 31900

*Acacia sessilis MIMOSACEAE*
*Acacia stenoptera MIMOSACEAE*
*Allocasuarina fraseriana CASUARINACEAE*
*Astroloma pallidum EPACRIDACEAE*
*Banksia attenuata PROTEACEAE*
*Banksia grandis PROTEACEAE*
*Bossiaea ornata PAPILIONACEAE*
*Burchardia umbellata COLCHICACEAE*
*Calytrix flavescens MYRTACEAE*
*Conospermum incurvum PROTEACEAE*
*Conospermum stoechardis PROTEACEAE*
*Cyathochaeta avenacea CYPERACEAE*
*Dampiera linearis GOODENIACEAE*
*Dasypogon bromeliifolius DASYPOGONACEAE*
*Davesia decurrens PAPILIONACEAE*
*Davesia divaricata PAPILIONACEAE*
*Davesia priessii PAPILIONACEAE*
*Dianella revoluta PHORMIACEAE*
*Dryandra nivea PROTEACEAE*
*Eucalyptus marginata MYRTACEAE*
*Grevillea quercifolia PROTEACEAE*
*Grevillea wilsonii PROTEACEAE*
*Haemodorum laxum HAEMODORACEAE*
*Hakea ruscifolia PROTEACEAE*
*Hemiandra pungens LAMIACEAE*
*Hibbertia acerosa DILLENIACEAE*
*Hibbertia commutata DILLENIACEAE*
*Hibbertia hypercoides DILLENICAEAE*

TABLE 1 cont.

*Hibbertia vaginata DILLENIACEAE*
*Hovea trisperma PAPILIONACEAE*
*Hybanthus floribundus VIOLACEAE*
*Hypocalymma robustum MYRTACEAE*
*Isopogon formosus PROTEACEAE*
*Lepidosperma angustatum CYPERACEAE*
*Lepidosperma squamatum CYPERACEAE*
*Leucopogon australis EPACRIDACEAE*
*Lomandra preissii DASYPONONACEAE*
*Lomandra purpurea DASYPOGONACEAE*
*Loxocarya fasciculata RESTIONACEAE*
*Lyginia barbata RESTIONACEAE*
*Macrozamia reidlei ZAMIACEAE*
*Mesomelaena tetragona CYPERACEAE*
*Muehlenbeckia adpressa POLYGONACEAE*
*Olearia paucidentata ASTERACEAE*
*Opercularia hispidula RUBIACEAE*
*Oxylobium capitatum PAPILIONACEAE*
*Patersonia occidentalis IRIDACEAE*
*Pentapeltis peltigera APIACEAE*
*Persoonia elliptica PROTEACEAE*
*Persoonia saccata PROTEACEAE*
*Petrophile linearis PROTEACEAE*
*Phlebocarya ciliata HAEMODORACEAE*
*Phyllanthus calycinus EUPHORBACEAE*
*Scaveola striata GOODENIACEAE*
*Schoenus sp. CYPERACEAE*
*Senecio quadridentatus ASTERACEAE*
*Stipa elegantissima POACEAE*
*Stirlingia latifolia PROTEACEAE*
*Styphelia tenuiflora EPACRIDACEAE*
*Tetraria capillaris CYPERACEAE*
*Thysanotus* sp. *ANTHERICACEAE*
*Trycoryne elatior ANTHERIACEAE*
*Xanthorrhoea gracilis XANTHORRHOEACEAE*
*Xanthorrhoea preissii XANTHORRHOEACEAE*
*Xanthosia candida APIACEAE*
*Xylomelum occidentale PROTEACEAE*

TABLE 2

TREE SPECIES RECOMMENDED FOR SHADE AND SHELTER BELT PLANTING ON FARMLAND.

| Species | Potential height (metres) |
|---|---|
| *Allocasuarina fraseriana* | 5 - 8 |
| *Eucalyptus accedens* | 10 - 20 |
| *Eucalyptus calophylla* | 30 - 40 |
| *Eucalyptus haemotoxylon* | 6 - 9 |
| *Eucalyptus laeliae* | 6 - 20 |
| *Eucalyptus lane-poolei* | 12 - 15 |
| *Eucalyptus marginata* | 15 - 46 |
| *Eucalyptus rudis* | 9 - 15 |
| *Xylomelum occidentale* | 5 - 8 |

## TABLE 3

### PLANT SPECIES OBSERVED IN OR ADJACENT TO RESERVE 31900 WHICH ARE SUITABLE FOR PROPAGATION FROM SEED.

*Acacia huegelii*
*Acacia preissiana*
*Acacia pulchella*
*Acacia saligna*
*Acacia sessilis*
*Acacia stenoptera*
*Allocasuarina fraseriana*
*Allocasuarina humilis*
*Bossiaea eriocarpa*
*Bosseaea ornata*
*Danthonia occidentalis*
*Davesia decurrens*
*Davesia divaricata*
*Davesia physodes*
*Davesia preissii*
*Eucalyptus calophylla*
*Eucalyptus marginata*
*Compholobium aristatum*
*Compholobium confertum*
*Compholobium knightianum*
*Compholobium ovatum*
*Compholobium polymortphum*
*Compholobium preissii*
*Compholobium shuttleworthii*
*Hakea cyclocarpa*
*Hakea prostrata*
*Hakea ruscifolia*
*Hakea varia*
*Hovea chorizemifolia*
*Hovea trisperma*
*Kennedia coccinea*
*Kennedia prostrata*
*Melaleuca scabra*
*Melaleuca thymoides*
*Scholtzia ciliata*

TABLE 4

PLANT SPECIES OBSERVED IN OR ADJACENT TO RESERVE 31900 WHICH ARE SUITABLE FOR ROOTSTOCK OR STEM PROPAGATION.

*Dasypogon bromeliifolius*
*Dianella revoluta*
*Haemodorum spicatum*
*Hibbertia acerosa*
*Hibbertia huegelii*
*Hibbertia hypericoides*
*Lechenaultia floribunda*
*Lepidosperma tenue*
*Lomandra* spp.
*Mesomelaema tetragona*
*Nuytsia floribunda*
*Patersonia occidentalis*
*Phlebocarya ciliata*
*Phyllanthus calycinus*
*Scaevola canescens*
*Tetraria capillaris*
*Tetraria octandra*
*Xanthorrhoea gracilis*
*Xanthorrhoea preissii*

# APPENDIX 2

# FAUNA ASSESSMENT
# ML70/47, SOUTH OF YARLOOP

for

**CABLE SANDS (WA) PTY LTD**

by

**W G MARTINICK AND ASSOCIATES**

**MARCH 1996**

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PLATE 1: Aerial photograph of the Study Area

PLATE 2: Reserve 31900: Where sandmining/rubbish dump adjoins the Jarrah forest. The soil profile is exposed showing shallow white sand over yellow loamy sands

PLATE 3: Reserve 31900: Jarrah forest over diverse groundcover species

PLATE 4: Reserve 31900: Sand mining areas

PLATE 5: Typical creek within the Study Area with riparian vegetation replaced by pasture species. Overstorey of Flooded Gum

PLATE 6: Dense stand of Jarrah in partially cleared areas where understorey has been replaced by pasture species

PLATE 7: Partially cleared areas with scattered Jarrah/Marri trees. The line of site is along a creek line

FIGURE 1: Locality map of the Study Area

## 1.0 SUMMARY AND CONCLUSION

The Study Area consists of farmland and reserve. The farmland has been parkland and totally cleared for cattle production. The habitats of the pasture areas include tree canopies and a fenced farm dam, both of which are common within the locality.

In the north of the Study Area is Reserve 31900 which is separate and fenced from the farmland. It is located entirely within Mining Lease M70/49 and is reserved for rubbish dumping and sand extraction. The total area of the reserve is approximately 20ha of which approximately 9ha supports vegetation which is in good condition with very little evidence of disturbance. The balance of the reserve consists of disturbed vegetation from which some trees have been removed and the understorey has been degraded. The value of the reserve is enhanced by its linkage to reserves to the north which vary in terms of disturbance and conservation value.

The conservation values of this reserve pertain mostly to botanical rather than fauna values. Botanical values of Reserve 31900 are high due to the limited presence elsewhere of its vegetation (report to Cable Sands by D. Backshall, Environmental Survey and Management Pty Ltd). The important habitats of the Study Area are located within the undisturbed area of Reserve 31900. The fauna values of the Study Area have been reduced because the reserve and neighbouring reserves are an island of remnant vegetation with poor prospects for supporting diverse or rare fauna in the long term.

Fauna species which have been recorded for the local region are listed and a discussion of rare fauna which might occur within the Study Area is included. It is concluded that fauna species which have been gazetted rare and/or endangered are unlikely to be dependant on the habitats of the Study Area.

## 2.0 OBJECTIVES

The objectives of this report are to assess the habitats of the Study Area and to determine the animal species which are most likely to be found within the Study Area.

## 3.0 LOCATION AND VEGETATION OVERVIEW

The Study Area consists of Mining Leases M70/49 and its outline is shown in Plate 1. Figure 1 shows the Study Area in a regional context. The northern boundary of the Study Area is located on the access road to the Yarloop rubbish tip which is approximately 2km to the south of the town of Yarloop. The Study Area is bounded to the west by South West Highway. To the east and south the Study Area is bounded by pasture.

The native vegetation of the freehold land within the Study Area has been parkland cleared and in places totally cleared. Reserve 31900 (Reserved for rubbish disposal and sand extraction) which consists of 19.7ha and is entirely located within the northern part of the Study Area consists of Jarrah dominated forest of which about 11ha has been partly degraded by vehicle tracks, rubbish dumping and sand extraction. The 9 hectares of undisturbed Jarrah forest are located in the east of Reserve 31900. Reserve 31900 is adjacent to Reserves 23307, 31901, 3672 and 16681 which lie further to the north, and which cover 76.5ha and support native vegetation which varies from disturbed to good condition. Apart from a corridor which has been cleared for a rifle range, these reserves form a continuous forest canopy and are entirely surrounded by cleared agricultural land.

The vegetation within the reserves represents remnant vegetation of the Forrestfield Complex on Ridge Hill Shelf Landform (D.C.E., 1980). Most of such vegetation has been cleared for agriculture.

The Study Area is dissected by four westward draining creeks which are fringed by Jarrah, Marri and Flooded Gum trees. There is a small dam within a fenced-off area in the south of the Study Area.

A fenced corridor of approximately 20m width and supporting near-mature *Acacia spp.* and *Eucalypt spp.* is adjacent to South West Highway.

## 4.0 METHODS

The entire Study Area was traversed during a one-day field inspection on 7 March 1996. Areas with important habitats, such as Reserve 31900 and the creeks were inspected in detail. The remnant vegetation was extensively searched and any signs which indicate the presence of fauna such as marks on bark, disturbed ground, burrows and scats were recorded.

Information which was utilised for the study includes aerial photography at a scale of 1:10,000, a botanical survey of the Study Area by Dr D Backshall, regional maps and a printout of the WA Museum fauna data for the locality.

## 5.0 RESULTS AND DISCUSSION

### 5.1 Jarrah forest habitats

These habitats are located in Reserve 31900 which is shown in Plate 1.

Plate 2 shows the extent of sand extraction on the western periphery of the forest. The undisturbed eastern portion of the reserve has a shallow horizon of white/grey coloured sands over deep yellow/orange sandy loams which are typical of the Ridge Hill Shelf soils. Undisturbed forest is shown in Plate 3. The white sand is considerably deeper on the western portion of the reserve where extensive sand extraction has taken place (see Plate 4).

The eastern side of Reserve 31900 consists of approximately 9ha of undisturbed Jarrah (*Eucalyptus marginata*) forest to 25m in height over a closed canopy of Jarrah to 15m in height. Between 2 and 4m in height is a lower stratum of *Allocasuarina fraseriana, Banksia grandis, Banksia attenuatum* an *Xylomelum occidentalis*.

Shrubs of 1 to 2m in height include *Jacksonia Sternbergiana* and juvenile *Persoonia longifolia* and *Xylomelum occidentalis*. *Xanthorrhoea preissii* (Blackboys) are common.

The low shrub/groundcover stratum is very diverse. There is no evidence of recent fires and the groundcover includes a dense layer of vegetation debris. This stratum has been extensively removed in sand mining and dumping areas in the west of the reserve.

The habitats of the Jarrah forest which are of importance to animal species which are native to the area include the following:

i. A large number of Jarrah trees which are located in the disturbed and undisturbed areas of the reserve. These trees contain hollows which are used by bats for roosting sites and by birds, especially *Psittacines* (parrot species), for nesting.

ii. Canopy of immature Jarrah and *Banksia, Jacksonia* and *Xylomelum* spp. which provide nesting, refuge and feeding habitats for a large number of bird species which are common on the Swan Coastal Plain. Food resources for bird and mammal species include blossom, leaf and invertebrate assemblage of the canopy.

iii. Ground stratum which consists of a diverse plant community with dense vegetation debris over sandy soils. The ground layer provides a complex foodchain from decomposing organic material through to insects and small reptiles which are in turn preyed upon by larger reptiles, birds and mammals. Refuge habitats are found in dense groundcover and sandy soils which are amenable for burrowing.

### 5.2 Revegetated habitats

These habitats are found within the 20m wide fenced area on the western boundary of the Study Area. Plants are mostly non-local species which form a dense stratum which is 1 to 4m in height. A line of Eucalypts sp. to 15m in height is within the road reserve and borders the rehabilitated area. The habitat is similar to that described in Section 6.1 (ii) except that the plant species are not representative of local species.

### 5.3 Creeks

The understorey vegetation of the four creeks within the Study Area has been replaced by pasture species (as per Plate 5). The exception being a fenced farm dam on the southern border of the Study Area (Plate 1). A degraded wetland with no remnant native vegetation is adjacent to South West Highway in the south of the Study Area.

The fenced dam is fringed by a remnant overstorey of trees to 15m in height and the groundcover is in good condition. This dam is approximately 0.5ha in extent and is a feeding and refuge habitat for water birds.

The creeks have an open overstorey of Jarrah, Marri and Flooded Gum trees and their habitats are similar to, but more degraded, than habitats described in Section 5.1 (ii).

### 5.4 Cleared pastures

The pasture areas vary from woodlands with a closed canopy (Plates 1 and 6) to pasture with scattered trees (Plate 7).

The habitats which these provide are similar to, but more degraded, than habitats described in Section 5.1 (ii).

### 5.5 Conservation value of the habitats

Habitats are usually of the highest value in areas which show the least disturbance and which provide the greatest vegetation cover and diversity. Thus the areas of the Study Area may be ranked as follows in terms of habitat values:

i. undisturbed forest
ii. disturbed forest and fenced farm dam
iii. revegetated areas and pasture with closed overstorey
iv. pasture with scattered trees

A more detailed discussion of these habitats follows:

i. The undisturbed forest in Reserve 31900 is a remnant of vegetation which is enhanced by its proximity to adjoining reserves to the north which in total form a large island of remnant vegetation. The conservation value of this area is related more to its representative flora than to animal habitats. This is because the remnant vegetation represents a vegetation community which is now poorly represented on the Swan Coastal Plain (D.Backshall).

ii.-iv. These habitats consist of tree canopy habitats and the wetland of the fenced farm dam. These habitats are of value to bird species but they have limited conservation value. This is because farm dams and pasture with scattered trees are common and widespread on the Swan Coastal Plain.

### 5.6 Fauna

A list of fauna which have been identified in the locality of the Study Area are given below.

| SPECIES | COMMON NAME | HABITAT |
|---|---|---|
| **REPTILES** | | |
| AGAMIDAE | | |
| *Lialis burtonis* | Burton's Snake Lizard | Forest |
| PYGOPODIDAE | | |
| *Pogona minor minor* | Western Bearded Dragon | Forest |
| *Pygopus lepidopodus lepidopodus* | Common Scaly-foot | Forest |

| SPECIES | COMMON NAME | HABITAT |
|---|---|---|
| **REPTILES** | | |
| GEKKONIDAE | | |
| *Phyllodactylus marmoratus marmoratus* | Marbled Gecko | Widespread |
| *Underwoodisaurus milii* | Barking Gecko | Forest |
| VARANIDAE | | |
| *Varanus gouldii** | Gould's monitor | Widespread |
| SCINCIDAE | | |
| *Egernia napoleonis* | Napoleon Skink | Widespread |
| *Glaphyromorphus* sp. | - | - |
| *Hemiergis initialis initialis* | - | Forest |
| *Hemiergis quadrilineata* | - | Coastal plain |
| *Lerista distinguenda* | - | Widespread |
| *Morethia lineoocellata* | - | Forest |
| BOIDAE | | |
| *Morelia spilota imbricata* r | Carpet Python | Widespread |
| ELAPIDAE | | |
| *Notechis coronatus* | - | - |
| *Notechis scutatus occidentalis* | Western Tiger Snake | Creek habitats |
| *Pseudonaja affinis affinis* | Dugite | Widespread |
| *Ramphotyphlops australis* | - | Widespread |
| *Ramphotyphlops pinguis* | Blind Snake | Widespread |
| *Rhinoplocephalus gouldii* | Gould's Whip Snake | Forest |
| *Rhinoplocephalus nigriceps* | Short-tailed Snake | Forest |
| CHELONIDAE | | |
| *Chelodina oblonga* | Oblong Turtle | Permanent water |
| **FROGS** | | |
| HYLIDAE | | |
| *Litoria moorei* | Bell Frog | Permanent water |
| *Crinia georgiana* | Quacking Frog | Coastal plain |
| *Geocrinia leai* | Lea's Frog | Streams and swamps |
| *Heleioporous eyrei* | Moaning Frog | Swamp areas |
| **MAMMALS** | | |
| BURRAMYIDAE | | |
| *Cercartetus concinnus* | Western Pigmy Possum | Forest and heath |
| *Antechinus flavipes* | Yellow-Footed Antechninus | Forest |
| *Dasyurus geoffroii* r | Western Quoll | Forest |
| *Hydromys chrysogaster* | Water Rat | Waterways |
| *Nyctophilus geoffroyi* | Lesser Long-eared Bat | Forest |
| *Trichosurus vulpecula* | Brush-tailed Possum | Forest |
| *Macropus fuliginosus** | Western Grey Kangaroo | Forest/pasture |

| SPECIES | COMMON NAME | HABITAT |
|---|---|---|
| **BIRDS** | | |
| *Corvus coronoides** | Australian Raven | Forest/pasture |
| *Anhinga melanogaster** | Darter | Farm dam |
| *Anas superciliosa** | Pacific Black Duck | Farm dam |

* species observed or signs observed during the field visit
r species gazetted rare and/or endangered

Although the Museum list does not contain any bird species, it is very likely that a large number of bird species which are common to the Swan Coastal Plain will be found from time to time within the habitats of the Study Area. Only a limited number of birds were observed within the Study Area at the time of the visit and these are listed in the table above.

Mammalian and reptilian species which were observed or signs of which were observed are also listed in the table above.

It is possible that some of the species listed above could be found within the Study Area, especially within the undisturbed area of Reserve 31900. Apart from common mammals such as the Grey Kangaroo, which was observed in Reserve 31900 during the visit, and the Brush-tailed Possum, many of the other mammals which are listed are more likely to be found in undisturbed or less disturbed forest habitats to the east of the coastal plain. Islands of remnant vegetation are unlikely to support any but common animal species. This is because animals in remnant vegetation communities are more exposed to predation pressures from species which are common, have greater mobility and which are not confined to the "island". These include birds of prey, common snakes such as the Dugite, and introduced species such as the fox, cat and dog. In extensive uncleared areas predation pressures are likely to be lower than in island refuges and these areas present a greater range and continuum of habitats which provide greater temporal and spatial variety. This variety is necessary for animals to find a continuum of resources throughout the year. In contrast island remnant habitats, such as Reserve 31900 and associated reserves, present a very restricted range of habitats and greater predation risks. Therefore it is very unlikely that rare species such as the Western Quoll and the Carpet Python, as listed above, would be found within the Reserve 31900.

A gazetted rare and/or endangered animal species which is found on the southern regions of the Swan Coastal Plain is the Western Ringtail Possum (*Pseudocheirus occidentalis*). This species is most commonly found in the Peppermint/Marri tree association which are usually closer to the coast than is the Study Area. The Ringtail Possum builds nests called dreys and these may often be found in Peppermint trees when the Ringtail Possum is present. No Peppermint trees are found within or near to the Study Area and the search of the Study Area did not reveal the presence of Ringtail Possum dreys. It is concluded that Ringtail Possums are not found within the locality of the Study Area.

Other gazetted species which do not appear in the WA Museum records for the locality but which could visit the Study Area include the Peregrine Falcon (*Falco peregrinus*), Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) and Carnaby's Black Cockatoo (*Calytorhynchus carnabii*). These species are all wide ranging in their daily and seasonal habits and consequently their ongoing survival will not depend on the fate of Reserve 31900.

RESERVE 31900

**PLATE 1**

CABLE SANDS (WA) PTY LTD

**SCALE 1:10,000**

# YARLOOP PROJECT

ML 70/49 Boundary

Ore Deposit

February 1995

## PLATES


| | |
|---|---|
| PLATE 1: | AERIAL PHOTOGRAPH OF THE STUDY AREA |
| PLATE 2: | RESERVE 31900: WHERE SANDMINING/RUBBISH DUMP ADJOINS THE JARRAH FOREST. THE SOIL PROFILE IS EXPOSED SHOWING SHALLOW WHITE SAND OVER YELLOW LOAMY SANDS |
| PLATE 3: | RESERVE 31900: JARRAH FOREST OVER DIVERSE GROUNDCOVER SPECIES |
| PLATE 4: | RESERVE 31900: SAND MINING AREAS |
| PLATE 5: | TYPICAL CREEK WITHIN THE STUDY AREA WITH RIPARIAN VEGETATION REPLACED BY PASTURE SPECIES. OVERSTOREY OF FLOODED GUM |
| PLATE 6: | DENSE STAND OF JARRAH IN PARTIALLY CLEARED AREAS WHERE UNDERSTOREY HAS BEEN REPLACED BY PASTURE SPECIES |
| PLATE 7: | PARTIALLY CLEARED AREAS WITH SCATTERED JARRAH/MARRI TREES. THE LINE OF SITE IS ALONG A CREEK LINE |

PLATE 2



PLATE 3




PLATE 4




PLATE 5

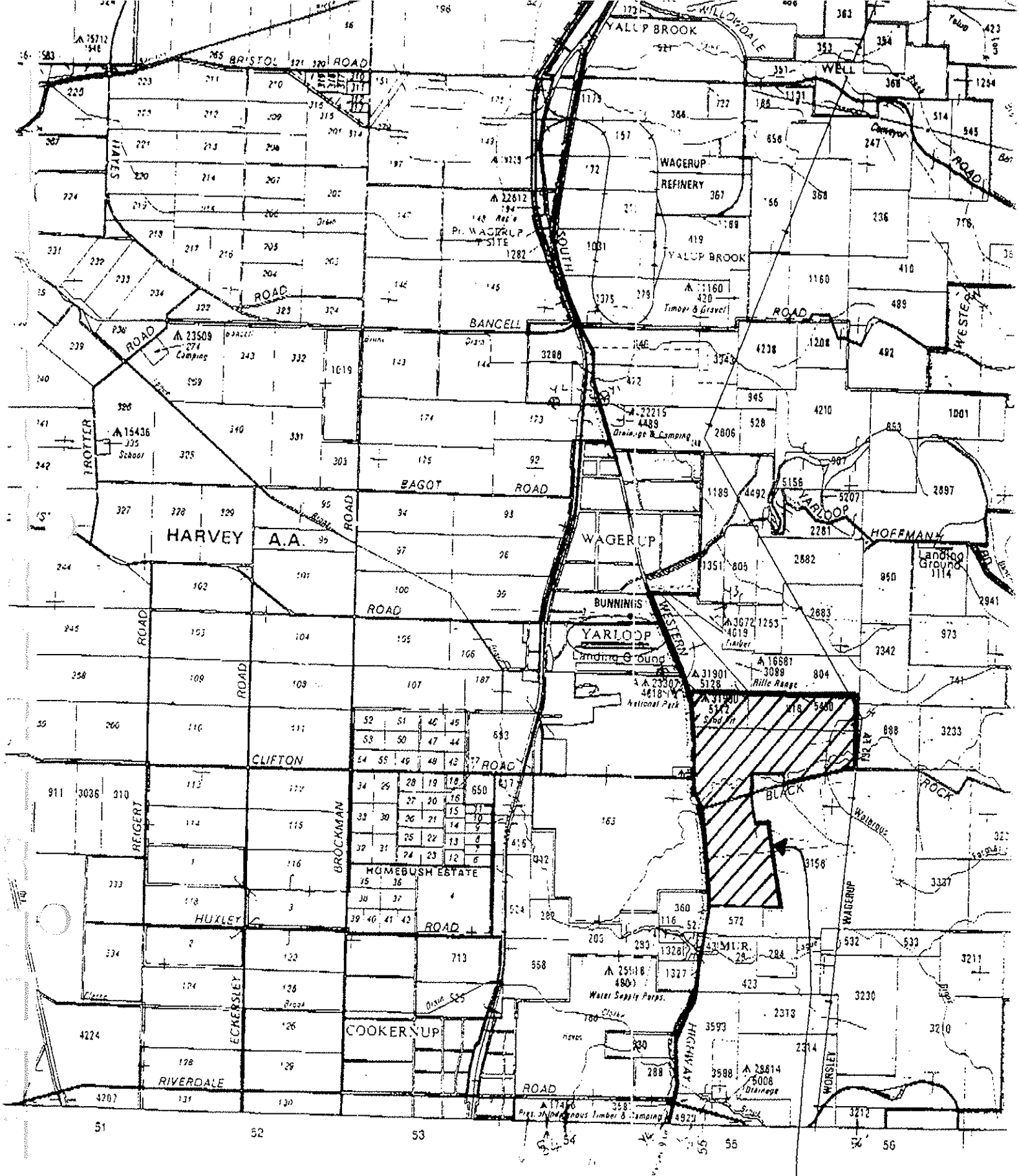


PLATE 6



PLATE 7






SCALE 1:50,000

AREA OF MINING LEASE AT YARLOOP

FIGURE 1

# APPENDIX 3

CABLE SANDS (W.A.) PTY. LTD.
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# YARLOOP HEAVY MINERAL MINE

This Information Sheet gives an introduction to the proposed Yarloop heavy mineral sand mine.

## Location

The mine will be located approximately two kilometres south of Yarloop on land to the east of the South-western Highway and north and south of Black Rock Road. The mine will extend north as far as Burney Road.

The mine will be on agricultural land primarily owned by Cable Sands. A section of the Yarloop rubbish dump will also be mined. The rubbish dump will remain open throughout the mine life. All land will be restored after mining has finished.

## Timing

The mine development is expected to commence in late 1996 and the mine operation will last for four years at current production and sales rates.

## Mining Company

The mine will be operated by Cable Sands (WA) Pty Ltd which is the oldest mineral sand mining company in Western Australia. Cable Sands has three minesites currently operating - at Waroona, Busselton and Jangardup, south of Nannup. Previous mines have operated at Capel, Busselton, Waroona, Wonnerup, Koombana Bay and Minninup.

## Mining Method

Mining is achieved using earthmoving equipment to strip topsoil and remove overburden. Ore is removed to be screened and concentrated to produce a heavy mineral concentrate and sand tailings. The mined area is then re-contoured using the overburden, tailings and clay that is separated from the water circuit. Finally, topsoil is returned and vegetation re-established.

## Environmental Management

Cable Sands is committed to operating all its minesites in a responsible manner with minimal impact on the surrounding environment. The mine will operate under a licence from the Department of Environmental Protection and the company is required to meet specified environmental standards in its mining operation.

Land clearance, particularly removal of trees, is as limited as possible and rehabilitation closely follows the mining front. Rehabilitation re-establishes agricultural land and establishes shade and shelter tree belts. In native bushland pre-mining species are re-established where applicable.

Dust is reduced by use of water carts along access roads during haulage, minimising cleared areas and revegetating each section of the mine as it is completed.

Noise is reduced as much as possible by using stockpiles to act as noise buffers, restricting earthmoving operations at night to within the pit, using acoustic exhaust mufflers and substituting reversing beepers for flashing lights after dark. Noise monitoring will be undertaken regularly.

## Further Information

Any further information required regarding this project can be obtained by contacting Cable Sand's Environmental Officer Graeme Kininmonth ph 21 4111.

# Yarloop Mineral Sands Lease:

## ASSESSMENT OF REMNANT VEGETATION

## AND RECOMMENDATIONS FOR RESTORATION

Prepared For:

Cable Sands (W.A.) Pty Ltd
North Shore
BUNBURY W.A.

Prepared by:

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May, 1996

updated January 1997

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## 1.0 SUMMARY

CABLE SANDS (W.A.) PTY LTD proposed mining operations at Yarloop will mostly occur on cleared farmland, however a small area of remnant bushland within reserve 31900 will also be affected. The vegetation is principally *Eucalyptus marginata-Allocasuarina fraseriana* woodland with a diverse perennial shrub and sedge understorey typical of the **Forrestfield Vegetation Complex** on **Ridge Hill Shelf** landform. As most of this vegetation type has been cleared regionally, the remnant vegetation of reserve 31900 and adjacent reserves have importance for conservation. No rare or priority listed flora were found to be present on the proposed mining area.

Recommendations for land restoration are outlined with the general objectives of restoring the farmland, old quarry sites, landfill areas and remnant bushland areas with appropriate soil management and replanting strategies. A revegetation programme is recommended that will achieve rapid stabilization of mined surfaces, and the restoration of a diverse woodland vegetation. This will provide a functional buffer surrounding the landfill site and this will complement the conservation aspects of the adjacent group of reserves north of Burney Road.

## 2.0 INTRODUCTION

CABLE SANDS (W.A.) PTY LTD proposed mining operations at Yarloop are predominantly located on cleared farmland currently used for grazing purposes, and also within a section of an adjacent public utility reserve 31900 used for sand quarrying and refuse landfill purposes. The proposed mining will encroach both on the quarry site and undisturbed remnant native woodland areas contained within this reserve. This report reviews the remnant vegetation on the private farmland and in the reserve which will be affected by mining, and also provides guidelines for post-mining land restoration and revegetation.

## 3.0 EXISTING ENVIRONMENT

### 3.1 LANDFORM AND SOILS

The mineral lease is situated on the eastern margin of the Swan Coastal Plain approximately two kilometres south of Yarloop. The Swan Coastal Plain is generally flat or of low relief, however the eastern margin is characterised by undulating foothill slopes dissected by seasonal creeks and minor valleys The landform-soil unit within the lease area is typical of the **Forrestfield** Unit, (D.C.E. 1980), with laterised foothills of the Darling Scarp becoming sandier and less gravelly downslope to the west. In the north-west sector of the lease area within the Shire reserve, the sandiest soils occur,

and sand quarrying has taken place. The sandy upper profile in this sector appears to have been formed during a period of unconsolidation by sand drifting from the adjacent **Guildford** landform-soil units further westward, on the Swan Coastal Plain, and currently these overlie laterised **Forrestfield** soils.

## 3.2 VEGETATION AND FLORA

The vegetation of the **Forrestfield** landform-soil unit west of the Darling Scarp has now been extensively cleared for farming, and most of the lease area comprising of gravel loam and sandy gravel soils has been cleared for this purpose. Typically, the vegetation was *Eucalyptus marginata* (Jarrah), *Eucalyptus calophylla* (Marri), and Sheoak-*Banksia* forest on the sandier soils, with *Eucalyptus wandoo* replacing the Sheoak and *Banksia* on the heavier soils. *Eucalyptus rudis* (flooded gum) and *Melaleuca rhaphiophylla* (paperbark) occur along drainage lines and in water-gaining depressions.

The forest understorey species are now generally absent in the farmland areas due to past clearing and grazing, and are now present only in the adjacent road reserves and nearby recreation and utility reserves. Current tree cover on the farmland is scattered Jarrah, Marri and Sheoak which have been left as shade trees for livestock. *Eucalyptus rudis* occurs in drainage lines on the farmland.

The public utility reserve (31900) included in the lease area is partly cleared for quarrying and landfill, however the remnant vegetation is generally in good condition, being relatively diverse and with dense understorey foliage cover. The flora of reserve 31900 was inspected during Janauary, 1995 and February, 1996 to tabulate vegetation and flora and search for rare plant species. The overstorey was found to reflect the sandy soils of the site, with Jarrah co-dominant in the upper stratum (20-28 metres in height) with *Banksia grandis* and *Allocasuarina fraseriana* forming a lower stratum (2-5 metres in height). *Banksia attenuata* is also present although not common on the eastern section of the reserve, however it is more common on the sandier western section. *Xylomelum occidentale* also occurs in the low tree stratum.

A tall shrub stratum (1-2 metres in height) which includes *Jacksonia sternbergiana,* juvenile *Persoonia longifolia* and *Xylomelum occidentale* is present, although of patchy distribution. *Xanthorrhoea preissii* (grass trees) are also common in this height stratum.

There is a particularly diverse low shrub/sedge stratum present in the reserve which includes *Acacia huegelii, Astroloma pallidum., Bossiaea ornata, Burchardia umbellata, Calytrix flavescens, Conospermum stoechadis, Davesia preissii, Dianella revoluta, Dryandra nivea, Hemiandra pungens, Hibbertia hypericoides, Hibbertia acerosa, Hibbertia vaginata, Hypocalymma robustum, Lepidosperma squamatum, Macrozamia reidlei, Mesomelaena tetragonia, Muehlenbeckia adpressa, Olearia paucidentata, Opercularia hispidula. Oxylobium capitatum, Patersonia occidentalis, Persoonia saccata, Persoonia elliptica., Petrophile linearis, Phlebocarya ciliata, Phyllanthus calycinus, Schoenus* sp., *Stipa* sp., *Stirlingia latifolia, Styphelia tenuiflora, Tetraria capillaris, Thysanotus* sp., and *Trycoryne elatior* as common species. A list of plant species observed to occur in reserve 31900 which includes

uncommon species is given in **table 1**.

The vegetation of the group of reserves in the vicinity of Burney Road has predominantly been classified as vegetation type 3b, *Eucalyptus calophylla - Eucalyptus marginata* on sandy clay soils. (Gibson et. al. 1994, Keighery, G., Unpublished). A small area of woodland on the western margin of reserve 31900 and 31901 was classified as vegetation type 20b, *Banksia attenuata* and or *Eucalyptus marginata* woodland. Vegetation type 3b was recorded during the survey from alluvial soils near the Peel-Harvey Estuarine System as well as on well drained sites on the eastern side of the Swan Coastal Plain. Community type 20b was found on sands at the base of the scarp between Byford and Yarloop.

## 4.0 CONSERVATION ASPECTS

Most of the **Forrestfield** landform unit has been cleared for agriculture, therefore remnant vegetation generally occurring on the scarp and lower slopes has conservation importance. The conservation status of public utility reserve 31900 has been lessened by landuse activities such as sand extraction and landfill. Landfill activities at the reserve are ongoing, and the local government at Yarloop plan to continue to utilize the reserve for this purpose.

Regionally, the clearing of the vegetation associated with the **Ridge Hill Shelf** landform for agriculture and grazing was because the heavier soils associated with this landform were highly sought after by early agriculturalists. The sandier soils were less in demand and therefore were included in reserves for community purposes - such as sand extraction and rubbish tips. Therefore, although the reserves north of Burney Road and reserve 31900 may represent only part of the range of vegetation types that previously existed on the **Ridge Hill Shelf** landform they do represent an example of a coenocline with the **Forrestfield Vegetation Complex** to the west. Gibson et. al. concluded that community reservation and conservation status of vegetation types 3b and 20b were well reserved but vulnerable. This assessment is subject to review, however it is acknowledged that the group of reserves are of regional importance and would complement the proposed consolidation of reserve 17805 and 16030 at Harvey, particularly because much of the sandier lowland elements of the vegetation in those reserves have been degraded. The reserves north of Burney Road have been recommended for A class reservation. Reserve 31900 was not included in this recommendation.

The remnant vegetation of reserve 31900 was searched for the presence of rare or restricted flora. Priority listed flora known to occur in the vicinity of Yarloop and the nearby Harvey district include *Acacia flagelliformis, Rhodantha pyrethrun, Grevillea prominens* and *Caladenia uliginosa subsp. patulens m.s. Amperea simulens* is known to occur in the vicinity of Waroona. *Tetraria australiensis* (gazetted rare and endangered) is also known to occur in similar vegetation regionally, however, herbarium collection notes for this species indicate a habitat preference for swamp margins, creeklines or granite watershed areas. These habitats do not occur within reserve 31900. The reserve was searched for rare or conservation proirity flora during February and November, 1996. None of these or other

priority listed flora were observed in the reserve during these surveys.

Flora surveys undertaken in reserve 23307 (Department of C.A.L.M. Unpublished) and adjacent unreserved bushland (Keighery, 1995) also showed that rare and priority listed flora were absent from the vegetation in those areas.

## 5.0 RECOMMENDATIONS FOR LAND RESTORATION

### 5.1 GENERAL OBJECTIVES

The programme of land restoration at Yarloop should focus on rapid stabilization of restored landforms with vegetation replanting based upon a rehabilitation strategy which addresses the different land-use objectives operating within the mining lease area. This will involve the restoration of pasture production, the creation of stock shelter belt vegetation, tipsite and quarry restoration and natural woodland revegetation. Land restoration works will need to be integrated with ongoing mining operations to ensure the earliest possible achievement of stabilization and restoration objectives.

The general objectives of the recommended rehabilitation programme are to;

* Re-establish pastures on the private land in areas currently used for grazing.
* Enhance shade and stock shelter tree plantings on farmland areas, establishing groves of trees which would include local species.
* Conserve all topsoil, and return soil to areas with a compatable future landuse.
* Restore all mined areas to landfoms which conform with the surrounding terrain, while controlling surface drainage with contoured gradients where necessary.
* Restore the quarry site with tree and shrub plantings complementary to the surrounding regional vegetation. The location of the quarry area is shown in **figure 1.**
* Areas of existing native vegetation within reserve 31900 disturbed by mining are to be revegetated with suitable species previously observed on the site and in similar to adjacent vegetation.

### 5.2 FARMLAND RESTORATION

Revegetation operations are best carried out during early winter months for both native perennial plantings and pasture establishment. Landforms restored to pasture should be seeded with a clover-ryegrass mix after consultation with the landowner as to species preferences.
To achieve a vigorous re-establishment of pasture, fertilize initially with an application of 400 Kg/ha of Superphosphate, potasium NPK and trace elements, and subsequent applications of 200 Kg/ha of a predominantly superphosphate mix.

Shelterbelt planting on the private land should be located according to prevailing winds and also to provide a buffer adjacent to the remnant vegetation on Reserve 31900 (rubbish and sand extraction) and Reserve 16681 (rifle range). Species selection should comprise native species compatable with the surrounding landscape. A list of tree species recommended for shelterbelt planting on the farmland is provided in table 2.

## 5.3 WOODLAND RESTORATION

### 5.3.1 Preparation Works

Rehabilitation of mined remnant woodland on Reserve 31900 should be preceeded by collection of available seed from perennial shrubs and trees for future nursery propagation.
It is recommended that seed be collected from the site or from the general region. Propagation of rootstock material from species difficult to regenerate from seed should also be undertaken prior to mining.

Clearing of the remnant vegetation should commence with all the commercial timber being removed, and the residue of the non-commercial timber being heaped away from remaining vegetation and burnt under permit during Autumn or Spring. Some timber, particularly hollow logs, may be kept for respreading on to rehabilitated areas for microfauna habitat. During the clearing process, all shrub and sedge vegetation should be left behind as much as possible to be incorporated into the topsoil.

### 5.3.2 Topsoil Management

All topsoil on the vegetated areas should be stripped in two stages, using scrapers wherever possible. The top 5 cms of topsoil should be removed first, including understorey vegetation, and stored seperately. A further 10-15 cms would subsequently be removed for seperate storage. Topsoil from the reserve area should not be deposited on adjacent farmland topsoil so as to prevent contamination by weed seeds.

Overburden which does not require processing can be removed on a progressive basis in front of the minepath and where possible used immediately to reform post-mining surface levels. Some overburden will need to be transferred from within the lease area and used to restore surface topography in the quarried section of the reserve. Where possible, fine clays should be incorporated into the upper soil profile prior to topsoil replacement. The inclusion of the fine clays will further aid moisture retention and rehabilitation success.
The effect of heavy machinery on soil compaction needs to be carefully monitored during landform restoration and compacted areas ripped or cultivated as necessary.
After the landform surface has been shaped to the desired postmining contours, the topsoil should be

respread as evenly as possible, with particular care taken to spread the first stripping evenly so that the viable seeds and propagules contained within are not buried too deeply for regeneration.

### 5.3.3 Seeding and Planting

Some native species are expected to regenerate from the respread topsoil on the restored woodland area in the reserve, however experience has shown that regeneration response can be quite variable. Volunteer regeneration from topsoil will need to be supplemented by nursery propagated seedlings and by hand seeding. Where possible seed should be collected prior to mining or from adjacent vegetation under permit. Seed can be collected mainly during November to February, and applied during May to July. It is anticipated that seed will also be required from commercial suppliers, collected from the same botanical provenance. Recommended species to be regenerated from seed or seedlings in the restored woodland areas are listed in table 3. Considerable regeneration can be expected from perennial understorey species that normally propagate by resprouting from roots, bulbs or corms provided that the period of topsoil storage is brief.

Regeneration of these species can be supplemented by harvesting root cuttings for propagation and storage prior to topsoil stripping. Plant species suitable for rootstock or stem propagation that are otherwise difficult to grow from seed are listed in table 4.

To achieve a comprehensive re-establishment of understorey species the nursery propagation programme will involve the production of potted seedlings from collected seed in addition to root and shoot cuttings. This can be undertaken on a contract basis. Tree species seedlings are best grown on to planting stage in 50x120 mm plastic airpots, while perennial shrub species can be grown in both 50x120 mm airpots and 50x50 mm peat pots. Some of the required propagation could be carried out at CABLE SANDS (W.A.) PTY LTD existing nursery at Bunbury, however, it is anticipated that a significant proportion of requirements will need to be contracted out to commercial suppliers and growers.
At the time of planting, tree seedlings other than *Banksia* species will require fertilizing with a 60 gram mixture of NPK with trace elements and Dynamic Lifter. Understorey species planted out on the restored quarry area should also receive this mixture, however understorey species planted on the restored woodland area should receive Dynamic Lifter only.

### 5.3.4 Maintenance Works

The establishing vegetation should be inspected after the first Summer period to assess the need for supplementary planting and seeding. Weeds may need to be eradicated regularly by spot spraying or mechanical methods, as weed invasion may be expected from the landfill area or the adjacent farmland. Regenerating seedlings should be protected by a vermin proof fence, and regular inspections for rabbit infestation should be undertaken. In the longer term, local landcare and conservation groups should be

encouraged to take an interest in the restored quarry and landfill sites to ensure the success of the planting, as the heavy public usage of the reserve will require human impact and fire management strategies to be implemented and enforced.

## 6.0 DIEBACK MANAGEMENT

The past land usage of much of reserve 31900 and adjacent farmland indicates that dieback infection would have been introduced to these areas over a long period of time. Although the reserve contains a range of species susceptable to the disease, no symptoms were observed in the remnant woodland that would suggest that *Phytothphora* is presently active.

Hygiene proceedures are recommended when carrying out vegetation clearing, topsoil removal and replacement operations in the remnant woodland so as to minimize the risk of contaminating topsoil. All vegetated areas adjacent to the proposed mining zone should be quarantined from vehicular entry or disturbance. As the remnant woodland area is small and situated next to areas receiving uncontrolled vehicular access, it is recommended replanting should involve mostly dieback resistant species.

## 7.0 CONCLUSIONS

The principal impact of the proposed mining will involve the clearing of a small area of remnant vegetation in reserve 31900. This will result in the loss of approximately 10% of vegetation type 3b included within the group of reserves, and 8% of the total vegetation in the reserves. No vegetation type 20b will be affected by mining. A revegetation programme is proposed that would restore the overstorey stratum and many of the existing understorey species, however it is not practical to attempt to immediately recreate the existing understorey community structure.

The restoration programme will restore the landform of the disused quarry area and replant appropriate species compatable with the adjacent vegetation. The principal objective of the rehabilitation will be to restore and enhance where possible conservation values, although recognizing that ongoing landfill activities will continue to degrade the natural attributes of the reserve.

## 8.0 REFERENCES

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FIGURE 4

The northern section of the mining lease showing the position of the orebody in relation to reserve 31900

— Reserve 31900 boundary

3b Vegetation types

L Landfill area

Q Sand quarry area

TABLE 1

PLANT SPECIES OBSERVED TO OCCUR IN RESERVE 31900

1 *Acacia sessilis MIMOSACEAE*
2 *Acacia stenoptera MIMOSACEAE*
3 *Adenanthos meisneri PROTEACEAE*
4 *Allocasuarina fraseriana CASUARINACEAE*
5 *Anigozanthus manglesi HAEMODORACEAE*
6 *Astroloma pallidum EPACRIDACEAE*
7 *Banksia attenuata PROTEACEAE*
8 *Banksia grandis PROTEACEAE*
9 *Bossiaea ornata PAPILIONACEAE*
10 *Burchardia umbellata COLCHICACEAE*
11 *Caladenia flavida ORCHIDACEAE*
12 *Calytrix flavescens MYRTACEAE*
13 *Conospermum incurvum PROTEACEAE* – If correct very significant
14 *Conospermum stoechardis PROTEACEAE*
15 *Cyathochaeta avenacea CYPERACEAE*
16 *Dampiera linearis GOODENIACEAE*
17 *Danthonia occidentalis POACEAE*
18 *Dasypogon bromeliifolius DASYPOGONACEAE*
19 *Davesia decurrens PAPILIONACEAE*
20 *Davesia divaricata PAPILIONACEAE*
1 *Davesia priessii PAPILIONACEAE*
2 *Dianella revoluta PHORMIACEAE*
3 *Dryandra nivea PROTEACEAE*
4 *Eriostemon spicatus RUTACEAE*
5 *Eucalyptus marginata MYRTACEAE*
6 *Gompholobium tomentosum PAPILIONACEAE*
7 *Gompholobium knightianum PAPILIONACEAE*
8 *Gompholobium marginatum PAPILONACEAE*

Flora list

Table 1 cont.

*Grevillea quercifolia PROTEACEAE*
*Grevillea wilsonii PROTEACEAE*
*Haemodorum laxum HAEMODORACEAE*
*Hakea ruscifolia PROTEACEAE*
*Hemiandra pungens LAMIACEAE*
*Hibbertia acerosa DILLENIACEAE*
*Hibbertia commutata DILLENIACEAE*
*Hibbertia hypercoides DILLENICAEAE*
*Hibbertia pachyrhiza DILLENIACEAE*
*Hibbertia vaginata DILLENIACEAE*
*Hovea chorizemifolia PAPILIONACEAE*
*Hovea trisperma PAPILIONACEAE*
*Hybanthus floribundus VIOLACEAE*
*Hypocalymma robustum MYRTACEAE*
*Isopogon formosus PROTEACEAE*
*Kennedya coccinea PAPILIONACEAE*
*Labichea punctata PAPILIONACEAE*
*Lagenifera huegelii ASTERACEAE*
*Lepidosperma angustatum CYPERACEAE*
*Lepidosperma squamatum CYPERACEAE*
*Leucopogon australis EPACRIDACEAE*
*Lomandra preissii DASYPONONACEAE*
*Lomandra purpurea DASYPOGONACEAE*
*Loxocarya fasciculata RESTIONACEAE*
*Loxocarya flexuosa RESTIONACEAE*
*Lyginia barbata RESTIONACEAE*
*Macrozamia reidlei ZAMIACEAE*
*Mesomelaena tetragona CYPERACEAE*
*Melaleuca thyoides MYRTACEAE*
*Muehlenbeckia adpressa POLYGONACEAE*
*Olearia paucidentata ASTERACEAE*
*Opercularia apicifolia RUBIACEAE*
*Opercularia hispidula RUBIACEAE*
*Oxylobium capitatum PAPILIONACEAE*
*Patersonia occidentalis IRIDACEAE*
*Pentapeltis peltigera APIACEAE*

Table 1 cont.

*Persoonia elliptica PROTEACEAE*

*Persoonia saccata PROTEACEAE*
*Petrophile linearis PROTEACEAE*
*Phlebocarya ciliata HAEMODORACEAE*
*Phyllanthus calycinus EUPHORBACEAE*
*Pimelia rosea THYMELIACEAE*
*Scaveola paludosa GOODENIACEAE*
*Scaveola striata GOODENIACEAE*
*Schoenus sp. CYPERACEAE*
*Senecio quadridentatus ASTERACEAE*
*Sowerbaea laxiflora ANTHERICACEAE*
*Stipa elegantissima POACEAE*
*Stirlingia latifolia PROTEACEAE*
*Stylidium* sp. *STYLIDIACEAE*
*Styphelia tenuiflora EPACRIDACEAE*
*Tetraria capillaris CYPERACEAE*
*Tetraria octandra CYPERACEAE*
*Thelmitrya crinita ORCHIDACEAE*
*Thysanotus* sp. *ANTHERICACEAE*
*Trycoryne elatior ANTHERIACEAE*
*Xanthorrhoea gracilis XANTHORRHOEACEAE*
*Xanthorrhoea preissii XANTHORRHOEACEAE*
*Xanthosia candida APIACEAE*
*Xylomelum occidentale PROTEACEAE*

TABLE 2

TREE SPECIES RECOMMENDED FOR SHADE AND SHELTER BELT PLANTING ON FARMLAND.

| Species | Potential height (metres) | |
|---|---|---|
| *Allocasuarina fraseriana* | 5 - 8 | |
| *Eucalyptus accedens* | 10 - 20 | Not in area |
| *Eucalyptus calophylla* | 30 - 40 | |
| *Eucalyptus haemotoxylon* | 6 - 9 | Not in area |
| *Eucalyptus laeliae* | 6 - 20 | Not in area |
| *Eucalyptus lane-poolei* | 12 - 15 | Not in area |
| *Eucalyptus marginata* | 15 - 46 | |
| *Eucalyptus rudis* | 9 - 15 | |
| *Xylomelum occidentale* | 5 - 8 | |

# ENTERED ON GIS

**Name:** Vegetation Survey of Selected Reserves at Yarloop
**Date:** 24/04/2006
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**Comments:**
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# VEGETATION SURVEY OF SELECTED RESERVES

# AT YARLOOP

**Prepared for:** Cable Sands Pty Ltd

**Prepared by:** Mattiske Consulting Pty Ltd

**CSC002/018/97**

**August 1997**

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2. Summary of Jaccard % similarity for presence/absence of species in all sites sampled

## SUMMARY

Mattiske Consulting Pty Ltd was commissioned by Cable Sands Pty Ltd to undertake a vegetation survey of selected reserves at Yarloop. These were Yarloop Reserve 31900, the adjacent proposed A Class reserves to the north of Reserve 31900, and Bunnings Land on the western side of South West Highway. Yarloop Reserve 31900 includes the active Yarloop rubbish tip.

Although the vegetation at Reserve 31900 had been classified as consisting of vegetation types 3b and 20b the current study was unable to readily separate the sample sites into these types, instead a continuum was apparent. This continuum was also present on the adjacent proposed reserves, so was not unique to Reserve 31900. Only 23% of all species recorded from Reserve 31900 were specific to vegetation site 3b or 20b, with most occurring throughout the whole reserve. The vegetation of the eastern section of the reserve was of a higher quality as there was very little weed infestation.

However in a previous study (Mattiske (1996)) where several 3b and 20b vegetation types had been surveyed the distinction between the two was apparent. All of the 3b vegetation type had *Eucalyptus marginata* and *Corymbia calophylla* as the dominant trees. Most of the 20b vegetation type had *Eucalyptus marginata* and *Banksia attenuata* as the dominant trees but some had only *Eucalyptus marginata*. However the understorey between the two vegetation types was markedly different.

Rehabilitation is an important aspect if permission to mine is granted. Seed collection methods, propagation techniques and rehabilitation methods were outlined. Possibly the method having the most success at present is the smoke treatment, preferably on site, which has been developed by Kings Park and Botanic Garden.

## LIST OF PARTICIPANTS

| | |
|---|---|
| Principal Ecologist: | Dr. E. Mattiske |
| Principal Botanist: | Dr. E. Bennett |
| Biologist: | Mr W. Evans |
| Data Processing: | Mr D. Bright |
| Word Processing: | Mrs J. Barrett |

## ACKNOWLEDGEMENTS

Mr. G. Kinninmonth is thanked for his assistance with providing the placement of the proposed mine and the provision of previous reports on the vegetation of Yarloop Reserve 31900.

# 1. INTRODUCTION

Mattiske Consulting Pty Ltd was commissioned by Cable Sands Pty Ltd in July 1997 to undertake an assessment of the vegetation at Yarloop Reserve 31900, the adjacent proposed A Class reserves (to the north of Reserve 31900) and Bunnings Land (on the western side of South West Highway). Cable Sands Pty Ltd proposes to mine a section of Yarloop Reserve 31900 if permission is granted.

Yarloop Reserve 31900 is just south of the Yarloop townsite and is bounded on the western side by the South West Highway, to the north by Burney Road and to the east and south by privately owned land. Yarloop is included in the Drummond Subdistrict of the Darling Botanical District of the South-West Botanical Province (Beard, 1980). This vegetation of this subdistrict is described as mainly banksia low woodland on leached sands with *Melaleuca* swamps where ill-drained; woodland of tuart (*Eucalyptus gomphocephala*), jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) on less leached soils.

A floristic survey of the Swan Coastal Plain undertaken by Gibson *et al.* (1994) identified four "supergroups". Yarloop Reserve 31900 is included in Group 1 which comprises sites almost entirely restricted to the Pinjarra Plain and Ridge Hill Shelf. These areas are concentrated on the eastern side of the plain and the alluvial soils bordering the Peel-Harvey estuary. A significantly higher species richness was recorded for this group than all other groups with a significantly higher rainfall, reflecting its position at the base of the Darling Scarp. There has been widespread clearance of this land system for agricultural use.

In the Vegetation Complexes mapped by Heddle *et al.* (1980) Yarloop Reserve 31900 is included in the Forrestfield Complex. This is dominated by an open forest of marri-jarrah-wandoo woodland on the heavier gravelly soils and of jarrah-marri-sheoak on the sandier soils. The open forest of marri-wandoo-jarrah, due to previous logging, now approximates a woodland which includes the remnant species *Banksia grandis, Xylomelum occidentale, Dryandra sessilis, Macrozamia riedlei, Xanthorrhoea preissii* and *Hibbertia* species. On the sandier soils remnant pockets of the jarrah-marri-sheoak open forest remain and these include *Banksia attenuata, Banksia grandis, Stirlingia latifolia, Mesomelaena tetragona* and *Nuytsia floribunda*.

Previous botanical assessments have identified the presence of two Vegetation Community Types 3b and 20b (Gibson *et al.*(1994)) both of which are considered vulnerable. Community Type 3b occurs on sandy clay soils and is dominated by *Eucalyptus marginata - Corymbia calophylla* woodlands with understorey species such as *Bossiaea eriocarpa* and *Conostylis juncea* differentiating this subgroup. It is recorded from the better drained sites on the eastern side of the plain as well as from the alluvial soils near the Peel-Harvey estuary. Community type 20b was found on sands at the base of the Scarp between Byford and Yarloop. This community was again very species rich. Most sites were *Eucalyptus marginata-Banksia attenuata* woodlands but can also be *Banksia* woodlands and heaths. *Mesomelaena pseudostygia* was common and other species which differentiated this subgroup were *Hakea*

*stenocarpa, Conostylis setosa* and *Johnsonia* aff. *pubescens*. However there is a considerable species overlap between the two community types and it is not the individual species which are representative of the particular associations but the combination of species.

In a previous survey undertaken by Mattiske Consulting Pty Ltd for Cable Sands Pty Ltd (Mattiske Consulting Pty Ltd, 1996) several areas of Community Types 3b and 20b were located on reserves and private land between Cannington and Yarloop.

## 2. OBJECTIVES

The objectives of this survey were:

- to undertake a detailed recording of the flora and vegetation on Reserve 31900 on a 100 metre grid basis.
- establish selected sites on the adjacent reserves and Bunnings land on the west side of the South West Highway to enable a detailed comparison of species richness, similarity indices and plant community composition on the adjacent reserves as compared with the Reserve 31900 and in particular the 6 hectare area of mineral potential.
- compare the conservation values of the respective areas, including particular reference to the proposed mining area and the adjacent reserve areas.
- review the Community Type 3b location and Forrestfield Complex areas within the survey areas.
- review the species suitable for rehabilitating in the disturbed areas, which includes the rubbish tip and the proposed mining areas.

## 3. METHODS

The field work was undertaken by two botanists from Mattiske Consulting Pty Ltd on 23rd July 1997. The whole of Reserve 31900 was sampled on a 100 metre grid from north to south. Mr G. Kinninmonth from Cable Sands Pty Ltd flagged the area of the proposed mine area prior to the commencement of the survey.

The first transect was 50m west of the Reserve boundary and the second was 150m west. For each transect, sites were recorded at 50m, 150m and 250m south of Burney Road. When returning to Burney Road a transect was walked at 50m west of the transect to ensure the vegetation associations were the same and to record any additional plant species. The transect at 150m nearly bordered the current tip area so due to the disturbance recorded the third transect was placed 50m west of the tip and the fourth transect 100m west of the tip. A site was recorded at 50m on the third transect, but at 75m the edge of the degraded sand quarry would have been sampled so this transect was aborted and a site to the south, behind the tip was sampled. The fourth transect had sites recorded at 50m and 150m. An additional site was sampled about 50m in from the South West Highway as it was the only area observed with *Melaleuca thymoides*, *Acacia alata* and *Jacksonia sternbergiana*.

In the adjacent reserves three sites were sampled, one opposite the first, second and fourth transects undertaken in Reserve 31900. An additional three sites were also recorded along the fire break beside the adjacent reserves and the rifle range. These were at 400m, 300m and 100m east along the firebreak from the South West Highway. Three sites were sampled in the Bunnings land parallel to the South West Highway.

Appendix D illustrates the positions of all these transects.

At each site a GPS reading was taken, the approximate age since fire, litter type and cover (%), bare ground (%) and soil colour and structure ratio was recorded. Each species was listed and the height recorded, together with the percentage of each species alive and dead. Samples were collected of those plants whose identity needed to be confirmed and these were checked with the collections at the Western Australian Herbarium.

All the sites were compared for similarity using Bray-Curtis similarity coefficient to compare the percentage cover of each species present and Jaccard binary similarity coefficient to compare the presence absence of the different species between each sampled site.

Analysis of Shan

# 4. RESULTS

## 4.A RESERVE 31900

### 4.A.1 Flora

Transects 1,2,3 and 4 making a total of 11 sites were sampled from this reserve.

A total of 113 vascular plant species from 72 genera were recorded from Reserve 31900. As the field work was undertaken in July some of the annual species (e.g. species of the family - Orchidaceae) are not included in this list of species. Further studies could be undertaken in spring months to cover these additional species. Environmental Survey and Management Pty Ltd (1996) in a survey undertaken in May 1996, recorded a total of 87 vascular plant species from 67 genera and 28 families. The vegetation of the eastern section of the reserve was of a higher quality as there was very little weed infestation. However surrounding the tip and the old sand pit the weed invasion was extensive.

### 4.A.2 Declared Rare and Priority Flora

No declared rare or priority flora as defined by the Department of Conservation and Land Management were located during the current survey work.

### 4.A.3 Vegetation

Two vegetation types, 3b and 20b (Gibson *et al.*, 1994) have been recorded from Reserve 31900, with a 20b site having been sampled in Reserve 31900 and a 3b site in the adjacent reserve north of the rifle range (Gibson, pers. com). A separation of the two associations in Reserve 31900 was made by G. Keighery (1995) from aerial photographs and from comparison with adjacent areas (Keighery, pers. com.). Below are listed the dominant species as given by Gibson *et al.* (1994) and also located during the current field work. Sites 1A, 1B, 1C, 2A, 2B, 2C have previously been mapped as 3b and sites 3A, 3B, 3C, 4A and 4B as 20b.

Vegetation Type 3b

| | |
|---|---|
| Trees: | *Eucalyptus marginata, Corymbia calophylla* (occasional sites), *Allocasuarina fraseriana, Xylomelum occidentale* |
| Shrubs: | *Xanthorrhoea preissii, Xanthorrhoea gracilis, Stirlingia latifolia* |
| Herbs: | *Phlebocarya ciliata, Mesomelaena tetragona, Drosera erythrorhiza* |

Vegetation Type 20b

| | |
|---|---|
| Trees: | *Banksia attenuata, Eucalyptus marginata, Allocasuarina fraseriana* |
| Shrubs: | *Grevillea wilsonii, Xanthorrhoea gracilis, Hibbertia hypericoides* |
| Herbs: | *Tetraria octandra, Mesomelaena tetragona, Lomandra sericea* |

Vegetation type 20b can be a *Eucalyptus marginata* woodland or a *Eucalyptus marginata - Banksia attenuata* woodland whereas vegetation type 3b is defined as a

*Eucalyptus marginata* - *Corymbia calophylla* woodland (Gibson *et al.* (1994)). *Corymbia calophylla* was not a dominant species present for vegetation type 3b and was only located to the southern and western extremity of the vegetation type. *Xylomelum occidentale* is recorded by Gibson *et al.*(1994), as a common tree in the 20b vegetation type and as only occasionally being present in the 3b vegetation type but was common throughout the eastern section and therefore in the 3b vegetation type. Heddle *et al.* (1980) stated that *Xylomelum occidentale* is one of the remnant species occurring in the marri-wandoo-jarrah forest, an association equivalent to vegetation type 3b.

Species only recorded for vegetation type 3b are: *Acacia pulchella* var. *pulchella* (1 site); *Astroloma pallidum* (1 site); *Conostylis setosa* (1 site); *Cyathochaeta avenacea* (1 site); *Daviesia incrassata* (1 site); *Gompholobium preissii* (1 site); *Hibbertia commutata* (1 site); *Hibbertia racemosa* (2 sites); *Hovea chorizemifolia* (1 site); *Lepidosperma tenue* (3 sites); *Lomandra brittanii* ( 1 site); *Lomandra hermaphrodita* (2 sites); *Lomandra preissii* (1 site); *Olearia paucidentata* (2 sites); *Patersonia occidentalis* (1 site); *Pimelea lehmanniana* (1 site); *Sowerbaea laxiflora* (2 sites); *Tetratheca hirsuta* (1 site); *Trichocline spathulata* (3 sites).

Species only recorded for vegetation 20b are: *Comesperma virgatum* (2 sites); *Daviesia preissii* (1 site); *Hibbertia pachyrrhiza* (1 site); *Jacksonia sternbergiana* (1 site); *Macarthuria apetala* (1 site); *Melaleuca thymoides* (1 site); *Pterostylis sanguinea* (1 site); *Trachymene pilosa* (1 site); *Xanthosia huegelii* (1 site).

Although some species were recorded as being vegetation type specific the number of sites from which they were recorded was minimal. *Trichocline spathulata* and *Lepidosperma tenue* were recorded from 50% of the 3b sites and *Comesperma virgatum* from 40% of the 20b sites. *Mesomelaena tetragona*, which is listed as an indicator species for vegetation type 3b (Gibson *et al.* (1994)) occurred throughout all the sites.

It would appear from the above information that it is impossible to distinguish between vegetation types 3b and 20b in this reserve due to the large overlap of species common between the two vegetation types. Only 28 species out of a total of 113 (23%) recorded for the reserve were specific to either 3b or 20b vegetation type.

## 4.B ADJOINING RESERVES TO NORTH OF RESERVE 31900

### 4.B.1 Flora

A total of 86 vascular plant species from 62 genera were recorded from the reserves adjoining Reserve 31900. This reserve had been burnt in the summer of 1995, whereas Reserve 31900 had not been burnt for many years.

### 4.B.2 Declared Rare and Priority Flora

No declared rare or priority flora were located during the current survey work.

### 4.B.3 Vegetation

The vegetation consists of the two types as in Reserve 31900. Vegetation type 3b is restricted to the eastern section and 20b to the western side. Sites 5A, 5B, 5D, 5E, were assessed as being vegetation type 3b and sites 5C, 5F and 7A as vegetation type 20b. There appears to be even less distinction between these two vegetation types than was observed in Reserve 31900 with most species occurring throughout both vegetation types.

## 4.C BUNNINGS LAND

### 4.C.1 Flora

A total of 68 vascular plant species from 52 genera were recorded from the Bunnings land opposite Reserve 31900.

### 4.C.2 Declared Rare and Priority Flora

No declared rare or priority flora were located during the current survey work.

### 4.C.3 Vegetation

The vegetation type recorded from this area is 20b. Sites 6A, 6B and 6C were located here.

## 4.D SIMILARITY BETWEEN THE SAMPLED SITES

Using Bray-Curtis similarity coefficients, sites which have the same percentage cover of each species would record a similarity coefficient of 1. FromTable 1 it can be seen that the sites 6A, 6B and 6C recorded the highest similarity. Transect 6 which included sites 6A, 6B and 6C were all on the Bunnings land and an example of Vegetation Type 20b. Only 8 sites classified by Gibson *et al.*(1994) as being 3b had a similarity of $>0.5$.

The sites showing the greatest dissimilarity using Bray-Curtis are 1A&4B; 1A&5E;

1C&4B; 2B&4B; 2B&5E; 2C&5E; 3C&5A; 3C&5B (mix of 3b and 20b) and 3B&4B; 3C&4A; 3C&5D; 3C&5E; 3C&7A; 4B&2C; 4B&6A; 4B&6B; 4B&6C (all 20b).

**Table 1: Summary of Bray-Curtis % similarity using the vegetation cover of all sites sampled**

| Bray-Curtis % similarity | Comparable Sites | Gibson *et al.* Vegetation Types |
|---|---|---|
| 0.7 + | 6B&6C; | 20b |
| 0.6-0.7 | 6A&6B; 6A&6C | 20b |
| 0.5-0.6 | 1A&1C; 1B&1C; 2B&2C; 2A&2C; 5A&5B; | 3b |
| | 2A&4A; 2A&5A; 2A&5C; 2A&5D; 2B&2C; 2A&5F; 2A&7A; 5A&3A; 5A&3B; 5A&4A; 5B&4B; 5A&5C; 2C&3A; | 3b & 20b |
| | 1C&3A; 3A&4A; 4A&5C; 4A&5D; 4A&6A; 4A&6B; 4A&6C; 5C&5F; 5C&6A; 5C&7A; 5D&7A; | 20b |

Using only the presence/absence of species for each site Table 2 illustrates the similarity between the sites. Using only the presence/absence data the Bunnings land sites only 6A&6C, 6B&6C had an equivalent similarity, and that was at the 0.45-0.5% level. Site 6C was more similar to 4A, another 20b vegetation type, and 2A a 3b vegetation type, rather than to 6A and 6B. Sites 1B&1C and 1A&1B recorded reasonable similarity using both the above methods.

Using the Jaccard, presence/absence data Site 4B showed the greatest dissimilarity with all the sites. This site was the most disturbed of all those recorded, having the greatest number of weed species and recording the most disturbance. It was also the site recording the least number of species.

**Table 2: Summary of Jaccard % similarity for presence/absence of species in all sites sampled**

| Jaccard % similarity | Sites | Gibson et al. Vegetation Types |
|---|---|---|
| 0.5-0.6 | 1B&1C; | 3b |
| | 2A&6C; | 3b & 20b |
| | 4A&6C; | 20b |
| 0.45-0.5 | 1A&1B; 1A&1C; | 3b |
| | 1A&6C; 2A&5C; 5B&6C; | 3b &20b |
| | 2C&3B; 3A&4A; 4A&6B; 6A&6C; 6B&6C | 20b |
| 0.4-0.45 | 1A&2A; 1C&2A; 1C&5A; 2A&2C; | 3b |
| | 2A&5A; 2A&5B; 5A&5B; 2C&4A; 2C&5F; 2C&5F; 2C&6C; | 3b & 20b |
| | 1A&3B; 1A&4A; 1B&3B; 1C&3B; 1C&6B; 2A&3A; 2A&3B; 2A&5F; 2A&6B; 2B&4A; 3B&4A; 4A&5C; 4A&5F; 5B&6B; 5C&6C; 5F&6C; 6A&6B; | 20b |

It is apparent from all the above information that it is very difficult to separate the vegetation types 3b and 20b on the presence/absence of species or the density of the species at each site. From the above it would appear that Reserve 31900 and the adjacent reserves consist of a continuum and a mixture of species representative of both vegetation types 3b and 20b. From the remaining species fringing the rubbish tip it is possible this could have been an example of vegetation type 3b. The southern and south eastern edge is fringed by *Corymbia calophylla* (vegetation type 3b), whereas *Banksia attenuata* (vegetation type 20b) is located on the western edge.

## 4.E INTRODUCED SPECIES

Typically the bushland had very little weed invasion, except where the bushland surrounds the current tip and disused sand quarry. More of a problem is the blowing of rubbish and the occasional dumping of rubbish throughout the bushland.

Most of the weed species located at Reserve 31900 can be readily killed with a total herbicide. However some of the cormous, bulbous and rhizomatous species eg Watsonia, Arum Lily require direct application of the herbicide, making it a very labour intensive process. Care must be taken when using a total herbicide to ensure

that none of the poison is wiped on the native species. The removal of the perennial grass species can be undertaken with a selective grass spray eg fusilade as this is very specific and has been proven to cause limited damage to a few native grasses but not to affect other monocotyledons.

Some of the common introduced species located were:

| **SCIENTIFIC NAME** | **COMMON NAME** |
|---|---|
| *Acacia longifolia* | Sydney Wattle |
| *Briza maxima* | Blow Fly Grass |
| *Cytisus proliferus* | Tagasaste |
| *Ehrharta calycina* | Perennial Veldt Grass |
| *Ehrharta longiflora* | Annual Veldt Grass |
| *Hypochaeris glabra* | Flat Weed |
| *Narcissus tazetta* | Jonquil |
| *Oxalis pes-caprae* | Soursob |
| *Oxalis purpurea* | Large Flower Wood Sorrel |
| *Pennisetum clandestinum* | Kikuyu Grass |
| *Ricinus communis* | Castor Oil Tree |
| *Solanum nigrum* | Blackberry Night Shade |
| *Sonchus oleraceus* | Milk Weed |
| *Watsonia bulbillifera* | Bulbil Watsonia |
| *Watsonia meriana* | Watsonia |
| *Zantedeschia aethiopica* | Arum Lily |

# 5. REHABILITATION

## 5.1 Preparation of Tip Area

Large items of rubbish (eg. concrete house slabs) are currently lying on the periphery of both the tip and sand quarry sites. The whole degraded area would need to be bulldozed and the larger items pushed into the base of the pits. The surrounding sand, dug out during the establishment of the pits, should then be pushed in to fill the hole. As mentioned above, the pit and quarry areas are full of weed species, so after preparation the whole of the pit area should be sprayed with a total herbicide to remove the perennial species. If the soil dug out in the original establishment of the pit is to be the surface soil, it should be spread over the prepared area and allowed to remain until after weeds have germinated with the onset of winter. It should then be sprayed with a total herbicide to kill all germinating plants. Only after this process has occurred should the seed be sown or the seedlings planted. Preferably the pit should be filled in during April and May to ensure there is no blowing of the sand and subsequent erosion.

During the mining process top soil from the area to be mined should be removed and stockpiled for later use or preferably should be utilised immediately over degraded sites. If top soil from the mining process is to be added to the tip area this should only be done after the area has been sprayed for weeds. As mining progresses the areas where mining has been completed should have the top soil from new areas applied. This will ensure that any seeds or rhizomes in the soil could possibly become established, thus improving the rehabilitation of the area.

## 5.2 Seed Collection

A seed collecting programme must be in place prior to mining. This should ensure that seed be collected from as many plants as possible from the area to be mined. Each collection must be labelled and stored in paper bags not plastic containers.

Some fruits retain the seed for several months eg eucalypts and banksias, and the fruit can be collected at any time of the year. Eucalypts shed their seed once the fruit is picked and left, but banksias require heat treatment. Banksia fruits should be burnt in a fire, removed once the valves are seen to open and then plunged in cold water. This should open the valves fully, if not the process should be repeated.

Peas and wattles shed their seeds with force, spreading the seeds for some distance. Timing to collect these seeds can be a problem as the fruits rapidly open in hot weather or take a lot longer to open when the weather is cool. A method used by several seed collectors is to place a sheet under each plant to collect the seed as it is shed. However a regular check must be kept on these plants and the seed collected as soon after shedding as possible as ants carry away quite a lot of pea and wattle seeds.

Another technique which can be used for many different plants, including peas and wattle is to place a cloth or paper bag over the developing fruit. This will ensure that

when the seed is shed it will be collected in the bag.

If insufficient seed is collected from the proposed mine area, permission should be sought to collect seed from the adjacent reserves. The same method should be applied.

## 5.3 Propagation Methods

By referring to Appendix C the usual method of propagation of the species recorded from Reserve 31900 is given. Most are readily propagated from seed or cuttings. A few plants eg *Macrozamia riedlei* and *Xanthorrhoea* spp. should be transplanted into the area to be rehabilitated.

Propagation by cuttings, requires the taking of cutting material, its treatment with hormone before planting in soil. Regular watering, preferably misting, should then occur and once the cuttings have developed roots they should be transferred into a large pot and grown on. Once well established they should be planted in the area for rehabilitation, preferably at the break of season.

Where it has been suggested that the parent plant can be divided it is suggested that this is most successful after fire (B. Dixon, pers. com.). Thought could be given to burning the proposed mine site area prior to the commencement of work and then divisions undertaken of several of the plants, especially the sedges (Cyperaceae) and twine rushes (Restionaceae).

However with the smoke technique recently developed by Kings Park and Botanic Garden, some species which previously proved difficult to propagate can now be propagated successfully. Research undertaken has shown that 77 species out of a total of 200 tested have shown a positive germination response (Ecoplan News 22 (1997)).

The methods of treatment:

- Smoke water. Smoke water is made by bubbling smoke from fresh plant material through water. In the field smoke water can be applied to the soil surface at about 1 litre per square metre to large areas to stimulate the soil seed bank. Another method using smoke water is to soak the seeds in smoke water for 3-4 hours. The soaked seed is dried and then sow immediately as it does not store after treatment.

- Apply smoke directly to the seeds for about 1 hour. This is achieved by having a fire in an enclosed container and placing the exposed seed away from the fire so they do not get burnt.

- Smoke can be applied to punnets with sown seed for one hour in a smoke filled tent. An old camping tent can be used.

- In the field a tent can be used to stimulate germination in small areas by lighting a fire on a raised container and allowing the smoke to fill the area. Again an old tent can be used for the purpose.

All smoke treatment in the field should be done before the onset of winter rains. It has been shown that smoke treatment can reduce predation by insects as well as improving seed germination and seedling growth.

Conventional methods would require the preparation of a seed mix of species found in the respective areas to be rehabilitated and scattering these over the surface. Pea and wattle seed should be scarified prior to sowing to increase their water uptake and subsequent germination percentage.

## 5.4 Rehabilitation of the Area Between the Tip and South West Highway

The area between the sand quarry and the South West Highway has patches of excellent bushland still remaining with some weed invasion, especially of *Watsonia* spp. and *Cytisus proliferus* and areas of dense mixed weed species. It was in this area that *Melaleuca thymoides, Jacksonia sternbergiana*, *Adenanthos meisneri* and *Acacia alata* were recorded. As this was unique bush for Reserve 31900 it is important that is area be preserved and rehabilitated in the areas where it is necessary in addition to rehabilitating the rubbish tip and mined area.

*Watsonia* spp. can reproduce by several methods including seed, cormlets in the flower axils as well as cormlets in the corm axils, but this species can be controlled by a total herbicide applied just before flowering. However it is an extremely time and personnel intensive process. *Cytisus proliferus* is a member of the pea family and will reproduce from seeds which are viable in the soil for many years. The mature trees can be cut at ground level and a total herbicide applied to kill them, but with the longevity of the seed the area will need to be weeded to remove seedlings for several years.

## 6. DISCUSSION

From the field work undertaken and the statistical analyses run on the data Reserve 31900 has a continuum of vegetation types, a combination of 3b and 20b (Gibson *et al.* (1994)). The proposed reserve on the north side of Burney Road also mirrored the associations present in Reserve 31900, but a direct comparison was very difficult due to the different times that the areas had been burnt. The adjoining reserves had been burnt within the last 2 years, whereas Reserve 31900 had not been burnt for many years.

In Reserve 31900 only 23% of the species recorded were specific to either the 3b or 20b vegetation types. In most instances those species were only recorded from one site. *Trichocline spathulata* and *Lepidosperma tenue* were recorded from 50% of the 3b sites and *Comesperma virgatum* from 40% of the 20b sites. (Gibson *et al.* (1994)) listed *Mesomelaena tetragona* as an indicator species for vegetation type 3b but this was recorded from most sites. Sites 4B, 5A, 5D and 7A were the only sites which did not record this species.

In the previous survey of vegetation sites 3b and 20b (Mattiske Consulting Pty Ltd (1996)) undertaken in several reserves and privately owned land, the variation between the two vegetation types was distinct. The 3b vegetation types sampled all had *Corymbia calophylla* and *Eucalyptus marginata* present, the 20b vegetation type was either *Eucalyptus marginata* woodland or *Eucalyptus marginata* and *Banksia attenuata* woodland. Typically the understorey of vegetation type 3b is more representative of scarp species and that of 20b of the sandplain species. However with Reserve 31900, the adjacent reserves and the Bunnings land the variation between the two vegetation types was not distinct.

Using the Bray-Curtis similarity coefficients for density of the species and Jaccard similarity coefficients for the presence/absence of the different species no correlation could be reached between those sites previously identified as 3b and those as 20b. A few 3b sites separated together as did some of the 20b sites but there were more sites of identified 3b which separated with 20b sites. The three sites along transect 6, all in Bunnings land, did separate as a group, indicating these are the most similar of all the sites.

Using Jaccard similarity coefficients for the presence/absence of species in the sites there was no clear grouping. Again as found with the Bray-Curtis method, some 3b and 20b sites separated together, but on the whole 3b sites would separate with 20b sites.

This leads to the conclusion that Reserve 31900 and the adjoining reserves do not have distinct representation of vegetation types 3b and 20b but are a continuum between the two types. The original vegetation type of the current rubbish tip is unclear but due to the *Corymbia calophylla* trees on the southern edge it is possible it could have been a better example of 3b but this is unclear.

As the field work was undertaken in July some of the annual species (e.g. species of the families Orchidaceae) are not included in this list of species. Further studies could be undertaken in spring months to cover these additional species.

The methods for preparation of the area before and during rehabilitation were discussed. The smoke treatment developed by Kings Park and Botanic Garden would seem a method worthy of trial. However seed must be collected from the proposed mine area before mining occurs and must be stored safely for use. Any top soil removed in the mining process should be placed immediately on areas for rehabilitation allowing any storage roots and rhizomes to grow and seed to germinate. In addition seed will need to be sown and possibly seedlings planted.

If insufficient seed is collected, permission should be obtained to collect seed from the adjacent reserves and Bunnings land and then sown the next winter.

## 7. REFERENCES

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## APPENDIX A: VASCULAR PLANT SPECIES YARLOOP RESERVE 31900, ADJACENT RESERVES AND BUNNINGS LAND

| Family | Genus | Species |
|---|---|---|
| ZAMIACEAE | *Macrozamia* | *riedlei* |
| POACEAE | *Amphipogon* | *turbinatus* |
| | * *Briza* | *maxima* |
| | * *Ehrharta* | *calycina* |
| | * *Ehrharta* | *longifolia* |
| | * *Pennisetum* | *clandestinum* |
| | *Stipa* | sp. |
| | *Tetrarrhena* | *laevis* |
| | * *Poaceae* | sp. |
| CYPERACEAE | *Cyathochaeta* | *avenacea* |
| | *Lepidosperma* | *squamatum* |
| | *Lepidosperma* | *squamatum (narrow stem)* |
| | *Lepidosperma* | *tenue* |
| | *Mesomelaena* | *gracilipes* |
| | *Mesomelaena* | *tetragona* |
| | *Schoenus* | *cruentus* |
| | *Tetraria* | *capillaris* |
| | *Tetraria* | *octandra* |
| ARACEAE | * *Zantedeschia* | *aethiopica* |
| RESTIONACEAE | *Desmocladus* | *flexuosus* |
| | *Hypolaena* | *exsulca* |
| | *Loxocarya* | *cinerea* |
| | *Loxocarya* | *fasciculata* |
| | *Lyginia* | *barbata* |
| DASYPOGONACEAE | *Dasypogon* | *bromeliifolius* |
| | *Lomandra* | *brittanii* |
| | *Lomandra* | *hermaphrodita* |
| | *Lomandra* | *nigricans* |
| | *Lomandra* | *preissii* |
| | *Lomandra* | *sericea* |
| | *Lomandra* | *sp.* |
| XANTHORRHOEACEAE | *Xanthorrhoea* | *gracilis* |
| | *Xanthorrhoea* | *preissii* |
| PHORMIACEAE | *Dianella* | *revoluta* |
| | *Stypandra* | *glauca* |

## APPENDIX A: VASCULAR PLANT SPECIES YARLOOP RESERVE 31900, ADJACENT RESERVES AND BUNNINGS LAND

| Family | | Genus | Species |
|---|---|---|---|
| ANTHERICACEAE | | *Chamaescilla* | *corymbosa* |
| | | *Sowerbaea* | *laxiflora* |
| | | *Tricoryne* | *elatior* |
| COLCHICACEAE | | *Burchardia* | *congesta* |
| HAEMODORACEAE | | *Anigozanthos* | *manglesii* |
| | | *Conostylis* | *juncea* |
| | | ~~*Conostylis*~~ | ~~*?juncea*~~ |
| | | *Conostylis* | *serrulata* |
| | | *Conostylis* | *setosa* |
| | | *Haemodorum* | *laxum* |
| | | *Haemodorum* | *spicatum* |
| | | *Phlebocarya* | *ciliata* |
| | | ~~*Haemodorum*~~ | ~~sp.~~ |
| AMARYLLIDACEAE | * | *Narcissus* | *tazetta* |
| IRIDACEAE | | *Patersonia* | *aff. juncea* |
| | | *Patersonia* | *occidentalis* |
| | | *Patersonia* | *pygmaea* |
| | | *Patersonia* | *umbrosa* |
| | * | *Watsonia* | *bulbillifera* |
| | * | *Watsonia* | *?bulbillifera* |
| | * | *Watsonia* | *meriana* |
| | * | *Watsonia* | sp. |
| ORCHIDACEAE | | *Caladenia* | sp. |
| | | *Prasophyllum* | *parvifolium* |
| | | *Pterostylis* | *recurva* |
| | | *Pterostylis* | *sanguinea* |
| | | *Pyrorchis* | *nigricans* |
| | | Orchidaceae | sp. |
| CASUARINACEAE | | *Allocasuarina* | *fraseriana* |
| PROTEACEAE | | *Adenanthos* | *meisneri* |
| | | *Banksia* | *attenuata* |
| | | *Banksia* | *grandis* |
| | | *Conospermum* | *affin. canaliculatum* |
| | | *Dryandra* | *bipinnatifida* |
| | | *Dryandra* | *lindleyana* |
| | | *Grevillea* | *bipinnatifida* |

## APPENDIX A: VASCULAR PLANT SPECIES YARLOOP RESERVE 31900, ADJACENT RESERVES AND BUNNINGS LAND

| Family | Genus | Species |
|---|---|---|
| PROTEACEAE (cont.) | *Grevillea* | *quercifolia* |
| | *Grevillea* | *wilsonii* |
| | *Hakea* | *ruscifolia* |
| | *Hakea* | *stenocarpa* |
| | *Persoonia* | *elliptica* |
| | *Persoonia* | *saccata* |
| | *Petrophile* | *linearis* |
| | *Stirlingia* | *latifolia* |
| | *Xylomelum* | *occidentale* |
| MOLLUGINACEAE | *Macarthuria* | *apetala* |
| DROSERACEAE | *Drosera* | *erythrorhiza* |
| | *Drosera* | *huegelii* |
| | *Drosera* | sp. |
| | *Drosera* | sp. climbing |
| PITTOSPORACEAE | *Pronaya* | *fraseri* |
| MIMOSACEAE | *Acacia* | *alata* |
| | *Acacia* | *applinata* |
| | *Acacia* | *lateriticola* |
| | * *Acacia* | *longifolia* |
| | *Acacia* | *pulchella* |
| | *Acacia* | *pulchella var. pulchella* |
| | *Acacia* | *sessilis* |
| | *Acacia* | *stenoptera* |
| | *Acacia* | *willdenowiana* |
| CAESALPINIACEAE | *Labichea* | *punctata* |
| PAPILIONACEAE | *Bossiaea* | *eriocarpa* |
| | *Bossiaea* | *ornata* |
| | * *Cytisus* | *proliferus* |
| | *Daviesia* | *costata* |
| | *Daviesia* | *divaricata* |
| | *Daviesia* | *incrassata* |
| | *Daviesia* | *physodes* |
| | *Daviesia* | *preissii* |
| | *Gompholobium* | *aristatum* |
| | *Gompholobium* | *marginatum* |
| | *Gompholobium* | *polymorphum* |
| | *Gompholobium* | *preissii* |

**APPENDIX A: VASCULAR PLANT SPECIES YARLOOP RESERVE 31900, ADJACENT RESERVES AND BUNNINGS LAND**

| Family | | Genus | Species |
|---|---|---|---|
| PAPILIONACEAE (cont.) | | *Hovea* | *chorizemifolia* |
| | | *Hovea* | *trisperma* |
| | | *Jacksonia* | *sternbergiana* |
| | | *Kennedia* | *coccinea* |
| | | *Kennedia* | *prostrata* |
| | | *Templetonia* | *biloba* |
| OXALIDACEAE | * | *Oxalis* | *pes-caprae* |
| | * | *Oxalis* | *purpurea* |
| RUTACEAE | | *Eriostemon* | *spicatus* |
| TREMANDRACEAE | | *Platytheca* | *verticillata* |
| | | *Tetratheca* | *hirsuta* |
| POLYGALACEAE | | *Comesperma* | *virgatum* |
| EUPHORBIACEAE | | *Phyllanthus* | *calycinus* |
| | * | *Ricinus* | *communis* |
| | | *Stachystemon* | *vermicularis* |
| DILLENIACEAE | | *Hibbertia* | *acerosa* |
| | | *Hibbertia* | *amplexicaulis* |
| | | *Hibbertia* | *commutata* |
| | | *Hibbertia* | *cunninghamii* |
| | | *Hibbertia* | *huegelii* |
| | | *Hibbertia* | *hypericoides* |
| | | *Hibbertia* | *pachyrrhiza* |
| | | *Hibbertia* | *racemosa* |
| | | *Hibbertia* | sp. |
| VIOLACEAE | | *Hybanthus* | *floribundus* |
| THYMELAEACEAE | | *Pimelea* | *lehmanniana* |
| | | *Pimelea* | *suaveolens* |
| MYRTACEAE | | *Corymbia* | *calophylla* |
| | | *Eucalyptus* | *marginata* |
| | | *Melaleuca* | *thymoides* |
| APIACEAE | | *Pentapeltis* | *peltigera* |
| | | *Trachymene* | *pilosa* |
| | | *Xanthosia* | *huegelii* |

## APPENDIX A: VASCULAR PLANT SPECIES YARLOOP RESERVE 31900, ADJACENT RESERVES AND BUNNINGS LAND

| Family | | Genus | Species |
|---|---|---|---|
| EPACRIDACEAE | | *Astroloma* | *pallidum* |
| | | *Conostephium* | *pendulum* |
| | | *Leucopogon* | *australis* |
| | | *Styphelia* | *tenuiflora* |
| PRIMULACEAE | * | *Anagallis* | *arvensis* |
| LAMIACEAE | | *Hemiandra* | *pungens* |
| SOLANACEAE | * | *Solanum* | *nigrum* |
| RUBIACEAE | | *Opercularia* | *apiciflora* |
| | | *Opercularia* | *hispidula* |
| GOODENIACEAE | | *Dampiera* | *linearis* |
| | | *Scaevola* | *calliptera* |
| STYLIDIACEAE | | *Stylidium* | *piliferum* |
| ASTERACEAE | | *Craspedia* | *variabilis* |
| | * | *Hypochaeris* | *glabra* |
| | | *Lagenifera* | *huegelii* |
| | | *Olearia* | *paucidentata* |
| | * | *Sonchus* | *oleraceus* |
| | | *Trichocline* | *spathulata* |

# APPENDIX B: DISTRIBUTION OF PLANT SPECIES IN THE SAMPLED SITES

| Species | Site | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 1c | 2a | 2b | 2c | 3a | 3b | 3c | 4a | 4b | 5a | 5b | 5c | 5d | 5e | 5f | 6a | 6b | 6c | 7a |
| *Acacia alata* | | | | | | | | | + | | | | | | | | | | | | |
| *Acacia applinata* | | | | | | | | | | | | | | | | | | + | + | + | |
| *Acacia lateriticola* | | | | | | | | | | | | | | | + | | | | | | |
| *Acacia pulchella* } one | | | | | | | | | + | | | | | | | | | | | | |
| *Acacia pulchella var. pulchella* } tree | | | | | | + | | | | | | | | | | | | | | | |
| *Acacia sessilis* | + | | + | | | | | + | | | | | | | | | | | + | | |
| *Acacia stenoptera* | + | | | | | | + | | | | | | | | | | | + | | | |
| *Acacia willdenowiana* | | | | | | | | | | | | | | | | | | | | | + |
| *Adenanthos meisneri* | | | | | | | | | | + | + | | | | | | | + | | | |
| *Allocasuarina fraseriana* | | + | + | + | + | + | + | | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Amphipogon turbinatus* | | | | | | | | | | | | | | | | | | + | | | |
| *Anigozanthos manglesii* | | | + | | | + | | + | | | | + | | | | | | | + | | + |
| *Astroloma pallidum* | + | | | | | | | | | | | | | | | | | + | + | + | |
| *Banksia attenuata* | | | | | | + | | + | | | + | | | | | | | | | | |
| *Banksia grandis* | + | + | + | | + | + | | + | | | + | + | + | + | + | + | + | + | + | + | + |
| *Bossiaea eriocarpa* | | + | + | | + | | + | | + | | | | | | | + | | | | | |
| *Bossiaea ornata* | | | | + | | + | + | + | | + | | | | + | + | | + | | | + | |
| **Briza maxima* | | + | + | | | | | | | | | | | | | | | | | + | |
| *Burchardia congesta* | + | + | + | | + | | + | | | + | | + | | + | | + | | + | | + | |
| *Caladenia sp.* | + | | + | | | | | | | | | + | + | | | + | | | | | + |
| *Chamaescilla corymbosa* | | + | + | + | | + | + | | + | | | + | + | + | + | + | + | + | + | + | |
| *Comesperma virgatum* | | | | | | | + | | | + | | | | | | | | | | + | |
| *Conospermum affin. canaliculatum* | + | + | | + | | | | | | | | + | + | + | | | | | | + | |
| *Conostephium pendulum* | | | | | | | + | + | + | + | | | | + | + | | + | | + | | |
| *Conostylis juncea* | | + | + | | | | | | + | | + | + | | | + | | | | | | |
| *Conostylis ?juncea* entered as aff. | | | | | | | | | | | | | | + | | | | | + | | |
| *Conostylis serrulata* | | | | | | + | | | | + | | | | | | | | | | | |
| *Conostylis setosa* | | | | | + | | | | | | | | | | | | | | | | |
| *Corymbia calophylla* entered as eucalyptus | | | | | + | + | | | | | | | | | | | | | + | | |
| *Craspedia variabilis* | + | + | | | | | | | | | | | | | | | | | | | |
| *Cyathochaeta avenacea* | + | | too | | few | | | | | | | | | | | | | | | | |
| *Dampiera linearis* | + | | | | | + | + | | + | + | | | + | + | | | + | + | + | + | + |
| *Dasypogon bromeliifolius* | + | + | | + | + | + | + | + | + | + | | + | + | + | + | | + | + | + | + | + |
| *Daviesia costata* | | | | | | | | | | | | | | | | | + | | | | + |
| *Daviesia divaricata* | + | + | + | + | + | + | + | + | + | + | | + | + | + | | + | + | + | + | + | |
| *Daviesia incrassata* | + | | | | | | | | | | | | | | | | | | | | |
| *Daviesia physodes* | | | | | + | | + | | + | + | | + | | | + | | | | + | + | |
| *Daviesia preissii* | | | | | | | + | | | | | | | | | + | | | | | |
| *Desmocladus flexuosus* | | + | | | + | | | | + | | | | | | | | | | | | |
| *Dianella revoluta* | | | + | + | | | | | + | | | | | | | | | | | | |
| *Drosera erythrorhiza* | + | + | + | + | + | + | + | + | | + | | + | + | + | + | + | + | + | + | + | |
| *Drosera huegelii* INCORRECT ID | | | | | | | | | | | | | | | | | + | | | | |
| *Drosera sp.* | | | | | | | | | | | | | | | + | | | | | | |
| *Drosera sp. climbing* | + | | | | | + | | | | + | | | | | | | | | | + | |
| *Dryandra bipinnatifida* | | | | | | | | | | | | | | | | | | | | | + |
| *Dryandra lindleyana* | + | + | + | + | + | | + | + | | + | | + | | + | + | | + | + | + | + | + |
| *Eriostemon spicatus* | + | | | | + | | + | | + | + | | | + | | + | + | | + | + | + | + |
| *Eucalyptus marginata* | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + |
| *Gompholobium aristatum* | | | | | | | | | | | | | | | | | | + | | | |
| *Gompholobium marginatum* | | | | | | | | | | | | + | | | + | | | | | | |

# APPENDIX B: DISTRIBUTION OF PLANT SPECIES IN THE SAMPLED SITES

| Species | Site | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 1c | 2a | 2b | 2c | 3a | 3b | 3c | 4a | 4b | 5a | 5b | 5c | 5d | 5e | 5f | 6a | 6b | 6c | 7a |
| *Gompholobium polymorphum* | + | | | + | | + | + | | | + | | | | | + | | | | | | |
| *Gompholobium preissii* | | + | | | | | | | | | | | | | | | | | | | |
| *Grevillea bipinnatifida* | | | | | | | | | | | | | + | | | | | | | | |
| *Grevillea quercifolia* | | | | | | + | | | | | | | + | | | + | | | + | + | + |
| *Grevillea wilsonii* | + | + | + | + | + | + | + | + | + | + | | + | + | + | + | + | + | + | + | + | + |
| *Haemodorum laxum* | | | | | | | + | | | | | | | + | | | | + | | + | |
| *Haemodorum spicatum* | | | | | | | | | | | | | | + | | | | | | | |
| *Haemodorum sp.* | | | + | + | | | + | | | | | + | | | | | | | + | | |
| *Hakea ruscifolia* | + | + | + | | + | | | | | | | | | | | | | | | | |
| *Hakea stenocarpa* | | | | | | | | | | | | | | | | | | | | | + |
| *Hemiandra pungens* | | | | | | + | + | | | | | | | | | | + | | | | |
| *Hibbertia acerosa* | + | | + | | | + | + | | | | | + | | | | | | | | | |
| *Hibbertia amplexicaulis* | + | | | | | + | | | | | | | + | | | | | | | | |
| *Hibbertia commutata* | | | | | | + | | | | | | | | | | | + | | | + | |
| *Hibbertia cunninghamii* | | | | | | | + | | | | | | | | + | | | | | | |
| *Hibbertia huegelii* | + | + | + | | | + | | + | | | + | + | + | | + | | | | + | | |
| *Hibbertia hypericoides* | + | + | + | + | + | + | + | + | | + | | | + | | + | | + | + | + | + | |
| *Hibbertia pachyrrhiza* | | | | | | | | | + | | | | | | | | | | | | |
| *Hibbertia racemosa* | | | | | + | + | | | | | | | | | | | | | | | |
| *Hibbertia sp.* | | | | | | | | | | | | | | | | | | + | | | |
| *Hovea chorizemifolia* | | | + | | | | | | | | | | | | | | + | | | | |
| *Hovea trisperma* | | | | | | | | | | | | | | | | | | | | | + |
| *Hybanthus floribundus* | + | | | | | | | | | + | | + | + | | | + | + | | + | + | |
| *Hypochaeris glabra | | | | | + | | + | | | | + | | | + | | | | | | | |
| *Hypolaena exsulca* | + | + | + | + | + | + | + | + | | + | | | | | | | + | | | | |
| *Jacksonia sternbergiana* | | | | | | | | | + | | | | | | | | | | | | |
| *Kennedia coccinea* | + | + | | | | | | | | + | | | + | | | | | | + | | |
| *Kennedia prostrata* | | | + | + | | | + | + | + | + | | + | + | + | + | | | | + | | |
| *Labichea punctata* | + | + | + | + | + | + | + | + | + | + | | | + | + | + | | + | + | + | + | + |
| *Lagenifera huegelii* | + | + | + | | | + | + | + | | | | + | | | | | | | | | |
| *Lepidosperma squamatum* | + | + | + | + | | + | + | + | + | + | | | | + | | + | + | + | + | + | + |
| *Lepidosperma squamatum narrow* | | | + | | | | | | | | | | + | | | | | | | | |
| *Lepidosperma tenue* | | | | + | + | + | | | | | | | | | | + | + | + | + | | |
| *Leucopogon australis* | | | | | | | | | | | | | | | + | | | | | | |
| *Lomandra brittanii* | | | | + | | | | | | | | | + | | | | | | + | + | |
| *Lomandra hermaphrodita* | | + | + | | | | | | | | | | + | | | + | | | + | + | |
| *Lomandra nigricans* | | + | | | | + | | + | + | | | | + | | + | + | | + | | | |
| *Lomandra preissii* | | | + | | | | | | | | | | | | | | | | | | |
| *Lomandra sericea* | + | + | + | + | + | + | + | + | | + | | + | + | + | + | + | + | | | + | + |
| *Lomandra sp.* | | | | | + | | | | | | | | | | | | | | | | |
| *Loxocarya cinerea* | | | | | | | | | | | + | | | | | | | | | | |
| *Loxocarya fasciculata* | + | | + | + | | + | + | | | + | | | + | + | | | + | + | + | + | |
| *Lyginia barbata* | | | | | | | | | | | | | | + | + | | | | | | |
| *Macarthuria apetala* | | | | | | | | | + | | | | | | | | | | | | |
| *Macrozamia riedlei* | | + | + | | + | + | | + | | | | | | | | | | | | | |
| *Melaleuca thymoides* | | | | | | | | | + | | | | | | | | | | | | |
| *Mesomelaena gracilipes* | | | | | | | + | | | | | | | | | | | | | | |
| *Mesomelaena tetragona* | + | + | + | + | + | + | | + | + | + | | | + | + | | + | + | + | + | + | |
| *Olearia paucidentata* | | | | + | | + | | | | | | | + | | | | + | | | + | |
| *Opercularia apiciflora* | + | | | + | | + | + | | | | | | | | + | | | | | + | |

# APPENDIX B: DISTRIBUTION OF PLANT SPECIES IN THE SAMPLED SITES

| Species | Site | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1a | 1b | 1c | 2a | 2b | 2c | 3a | 3b | 3c | 4a | 4b | 5a | 5b | 5c | 5d | 5e | 5f | 6a | 6b | 6c | 7a |
| *Opercularia hispidula* | | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | | | | | | | | | |
| Orchidaceae sp. | | | | | | | | | | | | + | | | | | | | | | |
| *Patersonia aff. juncea* | | | | | | | | | | | | | ✓ | | | | | | | | |
| *Patersonia occidentalis* | | | | | ✓ | | | | | | | | | | | | | | | | |
| *Patersonia pygmaea* | | | | | | | | | | | | | | | | | | | | | ✓ |
| *Patersonia umbrosa* | | | | | | | | | | | | | | | ✓ | | ✓ | | | | |
| *Pentapeltis peltigera* | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| *Persoonia elliptica* | | | ✓ | | | | | | | | | | | | | | | | | | |
| *Persoonia saccata* | ✓ | | | | ✓ | ✓ | | ✓ | | | | | | | ✓ | | | | | | |
| *Petrophile linearis* | | ✓ | ✓ | | ✓ | | ✓ | | | ✓ | | | | | ✓ | | | | ✓ | | ✓ |
| *Phlebocarya ciliata* | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | | | ✓ | |
| *Phyllanthus calycinus* | ✓ | | ✓ | | | ✓ | | ✓ | | | | ✓ | ✓ | | | | | | | | |
| *Pimelea lehmanniana* ?? ?10 | | | | | | | ✓ | | | | | | | | | ✓ | | | | | |
| *Pimelea suaveolens* | | | | | | | | | | | | | | | | | | | ✓ | | |
| *Platytheca verticillata* goniodes | | | | | | | | | | | | | | | | | ✓ | | | | |
| Poaceae sp. | | + | | | | + | | | | | | | | | | | | | | | |
| *Prasophyllum parvifolium* | | | | | | | | | | | | | | | | | | ✓ | | | |
| *Pronaya fraseri* | | | | | ✓ | ✓ | | | | ✓ | | | ✓ | | | | | | ✓ | | |
| *Pterostylis recurva* | | | | | | | | | | | | ✓ | ✓ | | | ✓ | | | | | |
| *Pterostylis sanguinea* | | | | | | | | | | ✓ | | | | ✓ | ✓ | | | ✓ | | | ✓ |
| *Pyrorchis nigricans* | ✓ | | | ✓ | ✓ | | | ✓ | | | | | | ✓ | ✓ | | | | ✓ | | ✓ |
| *Scaevola calliptera* | | | | ✓ | ✓ | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Schoenus ~~cruentus~~* NO = WETTER | | | | | | | | | | | | ✓ | ✓ | | ✓ | | | | | | |
| *Sonchus oleraceus | | | | | | | | | | | | ✓ | | | | | | | | | |
| *Sowerbaea laxiflora* | | | | ✓ | ✓ | | | | | | | ✓ | ✓ | | | | | | | ✓ | |
| *Stachystemon vermicularis* | | | | | | | ✓ | | | ✓ | | | | | ✓ | | | | | | ✓ |
| *Stipa sp.* | | | | | | | | | | | | | | | | | | | | ✓ | |
| *Stirlingia latifolia* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | | | ✓ | ✓ | ✓ | ✓ | |
| *Stylidium piliferum* | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | | | | | ✓ | | | | ✓ | | ✓ | ✓ |
| *Stypandra glauca* | | | | | | | | ✓ | | | | | | | | | | | | | |
| *Styphelia tenuiflora* | | | | | | | | | | | | | | | | | | | | | ✓ |
| *Templetonia biloba* | | | | | | | | | | | | | | | | | | ✓ | | | |
| *Tetraria capillaris* | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | | ✓ | | | | | | | ✓ | ✓ | ✓ |
| *Tetraria octandra* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Tetrarrhena laevis* | | | | ✓ | | | ✓ | | | | | ✓ | ✓ | ✓ | | | | | | | |
| *Tetratheca hirsuta* | | | | | ✓ | | | | | | | | | | ✓ | | ✓ | | ✓ | | |
| *Trachymene pilosa* | | | | | | | ✓ | | | | | | | | | | | | | | |
| *Trichocline spathulata* | | ✓ | ✓ | ✓ | | | | | | | | | | | | | | | | | ✓ |
| *Tricoryne elatior* | | | | | | | | | | | | | | | | | | ✓ | | | |
| *Watsonia bulbillifera* | | | | | | | | ✓ | | | | | | | | | | | | | |
| *Watsonia ?bulbillifera* | | | | | | | | | | | ✓ | | | | | | | | | | |
| *Watsonia sp.* | | ✓ | | | | | | | ✓ | | | | | ✓ | | | | | | | |
| *Xanthorrhoea gracilis* | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ |
| *Xanthorrhoea preissii* | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ | ✓ |
| *Xanthosia huegelii* | | | | | | | ✓ | | | | | | | | ✓ | | ✓ | | | | |
| *Xylomelum occidentale* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ | |

# APPENDIX C: SPECIES RECORDED FROM ALL SITES AND THEIR METHOD OF PROPAGATION

| Species | Method of Propagation |
|---|---|
| *Acacia alata* | Scarified seed |
| *Acacia applinata* | Scarified seed |
| *Acacia lateriticola* | Scarified seed |
| *Acacia pulchella* | Scarified seed |
| *Acacia pulchella var. pulchella* | Scarified seed |
| *Acacia sessilis* | Scarified seed |
| *Acacia stenoptera* | Scarified seed |
| *Acacia willdenowiana* | Scarified seed |
| *Adenanthos meisneri* | Seed |
| *Allocasuarina fraseriana* | Seed |
| *Amphipogon turbinatus* | Seed and division of parent plant |
| *Anigozanthos manglesii* | Treated seed and division of parent plant |
| *Astroloma pallidum* | Seed - often difficult to propagate |
| *Banksia attenuata* | Seed |
| *Banksia grandis* | Seed |
| *Bossiaea eriocarpa* | Scarified seed |
| *Bossiaea ornata* | Scarified seed |
| *Burchardia congesta* | Seed and underground bulbs |
| *Caladenia sp.* | Seed and underground bulbs |
| *Chamaescilla corymbosa* | Seed and underground bulbs |
| *Comesperma virgatum* | Seed |
| *Conospermum affin. canaliculatum* | Seed |
| *Conostephium pendulum* | Seed - often difficult to propagate |
| *Conostylis juncea* | Seed and division of parent plant |
| *Conostylis serrulata* | Seed and division of parent plant |
| *Conostylis setosa* | Seed and division of parent plant |
| *Corymbia calophylla* | Seed |
| *Craspedia variabilis* | Seed |
| *Cyathochaeta avenacea* | Seed and division of parent plant |
| *Dampiera linearis* | Seed and division of parent plant |
| *Dasypogon bromeliifolius* | Seed and division of parent plant |
| *Daviesia costata* | Scarified seed |
| *Daviesia divaricata* | Scarified seed |
| *Daviesia incrassata* | Scarified seed |
| *Daviesia physodes* | Scarified seed |
| *Daviesia preissii* | Scarified seed |
| *Desmocladus flexuosus* | Seed and division of parent plant |
| *Dianella revoluta* | Seed and division of parent plant |
| *Drosera erythrorhiza* | Seed and underground bulb |
| *Drosera huegelii* | Seed and underground bulb |
| *Drosera sp.* | Seed and underground bulb |
| *Drosera sp. climbing* | Seed and underground bulb |
| *Dryandra bipinnatifida* | Seed |
| *Dryandra lindleyana* | Seed |

## APPENDIX C: SPECIES RECORDED FROM ALL SITES AND THEIR METHOD OF PROPAGATION

| Species | Method of Propagation |
|---|---|
| *Eriostemon spicatus* | Seed |
| *Eucalyptus marginata* | Seed |
| *Gompholobium aristatum* | Scarified seed |
| *Gompholobium marginatum* | Scarified seed |
| *Gompholobium polymorphum* | Scarified seed |
| *Gompholobium preissii* | Scarified seed |
| *Grevillea bipinnatifida* | Seed. Cuttings |
| *Grevillea quercifolia* | Seed. Cuttings |
| *Grevillea wilsonii* | Seed |
| *Haemodorum laxum* | Seed and underground bulb |
| *Haemodorum spicatum* | Seed and underground bulb |
| *Haemodorum sp.* | Seed and underground bulb |
| *Hakea ruscifolia* | Seed |
| *Hakea stenocarpa* | Seed |
| *Hemiandra pungens* | Seed |
| *Hibbertia acerosa* | Seed - very difficult to propagate. Cuttings |
| *Hibbertia amplexicaulis* | Seed - very difficult to propagate. Cuttings |
| *Hibbertia commutata* | Seed - very difficult to propagate. Cuttings |
| *Hibbertia cunninghamii* | Seed - very difficult to propagate. Cuttings |
| *Hibbertia huegelii* | Seed - very difficult to propagate. Cuttings |
| *Hibbertia hypericoides* | Seed - very difficutl to propagate. Cuttings |
| *Hibbertia pachyrrhiza* | Seed - very difficult to propagate. Cuttings |
| *Hibbertia racemosa* | Seed - very difficult to propagate. Cuttings |
| *Hibbertia sp.* | Seed - very difficult to propagate. Cuttings |
| *Hovea chorizemifolia* | Seed |
| *Hovea trisperma* | Seed |
| *Hybanthus floribundus* | Seed. Cuttings |
| *Hypolaena exsulca* | Seed - very difficult to propagate. Division of parent plant |
| *Jacksonia sternbergiana* | Scarified seed |
| *Kennedia coccinea* | Scarified seed |
| *Kennedia prostrata* | Scarified seed |
| *Labichea punctata* | Scarified seed |
| *Lagenifera huegelii* | Seed. Underground swoollen root. |
| *Lepidosperma squamatum* | Seed - very difficult to propagate. Division of parent plant. |
| *Lepidosperma squamatum narrow* | Seed - very difficult to propagate. Division of parent plant. |
| *Lepidosperma tenue* | Seed - very difficult to propagate. Division of parent plant. |
| *Leucopogon australis* | Seed - can be difficult to propagate. |
| *Lomandra brittanii* | Seed. Division of parent plant |
| *Lomandra hermaphrodita* | Seed. Division of parent plant |
| *Lomandra nigricans* | Seed. Division of parent plant |
| *Lomandra preissii* | Seed. Division of parent plant |
| *Lomandra sericea* | Seed. Division of parent plant |
| *Lomandra sp.* | Seed. Division of parent plant |
| *Loxocarya cinerea* | Seed. Division of parent plant |

## APPENDIX C: SPECIES RECORDED FROM ALL SITES AND THEIR METHOD OF PROPAGATION

| Species | Method of Propagation |
|---|---|
| *Loxocarya fasciculata* | Seed. Division of parent plant |
| *Lyginia barbata* | Seed. Division of parent plant |
| *Macarthuria apetala* | Seed |
| *Macrozamia riedlei* | Seed. Very slow grower. Can be transplanted. |
| *Melaleuca thymoides* | Seed |
| *Mesomelaena gracilipes* | Seed. Division of parent plant |
| *Mesomelaena tetragona* | Seed. Division of parent plant |
| *Olearia paucidentata* | Seed. Cuttings |
| *Opercularia apiciflora* | Seed. Cuttings |
| *Opercularia hispidula* | Seed. Cuttings |
| Orchidaceae sp. | Bulb |
| *Patersonia aff. juncea* | Seed. Division of parent plant |
| *Patersonia occidentalis* | Seed. Division of parent plant |
| *Patersonia pygmaea* | Seed. Division of parent plant. |
| *Patersonia umbrosa* | Seed. Division of parent plant. |
| *Pentapeltis peltigera* | Seed |
| *Persoonia elliptica* | Seed - can be difficult to propagate |
| *Persoonia saccata* | Seed - can be difficult to propagate |
| *Petrophile linearis* | Seed |
| *Phlebocarya ciliata* | Seed. Division of parent plant |
| *Phyllanthus calycinus* | Seed |
| *Pimelea lehmanniana* | Seed - can be difficult to propagate. Cuttings |
| *Pimelea suaveolens* | Seed - can be difficult to propagate. Cuttings |
| *Platytheca verticillata* | Seed |
| *Prasophyllum parvifolium* | Seed. Underground bulb |
| *Pronaya fraseri* | Seed |
| *Pterostylis recurva* | Seed. Underground bulb |
| *Pterostylis sanguinea* | Seed. Underground bulb |
| *Pyrorchis nigricans* | Seed. Underground bulb |
| *Scaevola calliptera* | Seed. Cuttings |
| *Schoenus cruentus* | Seed. Division of parent plant |
| *Sowerbaea laxiflora* | Seed. Underground swoolen roots |
| *Stachystemon vermicularis* | Seed. Cuttings |
| *Stipa sp.* | Seed. Division of parent plant |
| *Stirlingia latifolia* | Seed. |
| *Stylidium piliferum* | Seed. Division and/or removal of parent plant |
| *Stypandra glauca* | Seed. Division of parent plant |
| *Styphelia tenuiflora* | Seed. Cuttings |
| *Templetonia biloba* | Scarified seed |
| *Tetraria capillaris* | Seed. Division of parent plant |
| *Tetraria octandra* | Seed. Division of parent plant |
| *Tetrarrhena laevis* | Seed. Division of parent plant |
| *Tetratheca hirsuta* | Seed. Cuttings |
| *Trachymene pilosa* | Seed |

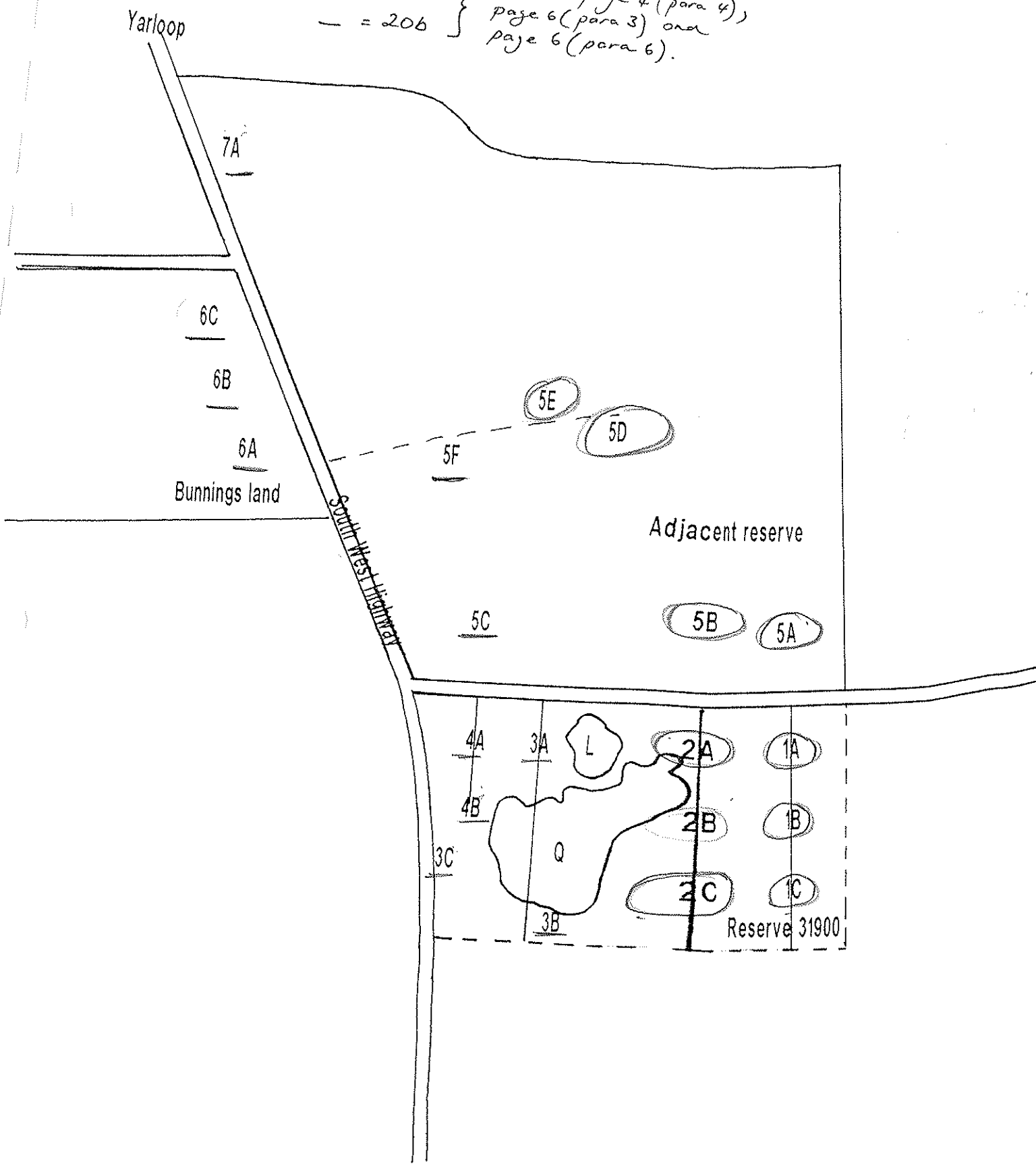
## APPENDIX D

**Position of transects (1-7) and sites (1A-7A) sampled in Reserve 31900, adjacent reserves and Bunnings land.**

L = tip site

Q = old sand quarry

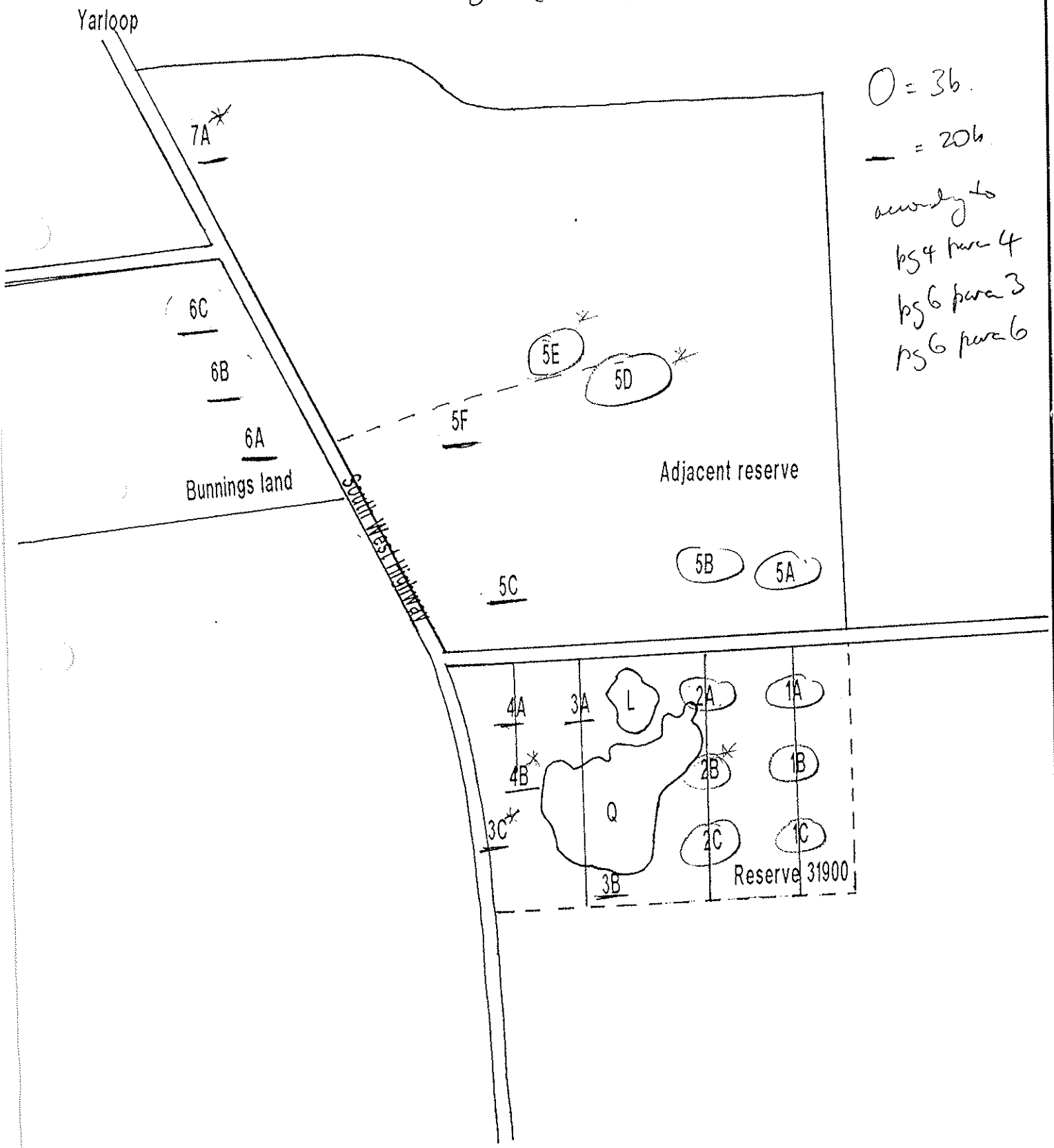
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— = 206



**APPENDIX D** **Position of transects (1-7) and sites (1A-7A) sampled in Reserve 31900, adjacent reserves and Bunnings land.**

L = tip site Q = old sand quarry

O = 36 } after page 4 (para 4), page 6 (para 3) and page 6 (para 6).
— = 206 }




O = 36.
— = 206
according to
pg 4 para 4
pg 6 para 3
pg 6 para 6

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# Mining of titanium minerals, 2km south of Yarloop

## Cable Sands (WA) Pty Ltd

Report and recommendations of the Environmental Protection Authority

Full document available on request

Environmental Protection Authority
Perth, Western Australia
Bulletin 838
December 1996

Ass # 1032
Bull # 838
State # 442

MINISTER FOR THE ENVIRONMENT;
EMPLOYMENT AND TRAINING

# STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE ENVIRONMENTAL PROTECTION ACT 1986)

MINING OF TITANIUM MINERALS, 2 KM SOUTH OF YARLOOP (1032)

CABLE SANDS (W.A.) PTY. LTD.

That part of the proposal relating to mining of titanium minerals within "C" Class Reserve No. 31900 may not be implemented.

That part of the proposal located on private land and within Mining Leases Nos 70/49, 70/937 and 70/938 (pending) may be implemented subject to the following conditions:

1 **Proponent Commitments**
The proponent has made a number of environmental management commitments in order to protect the environment.

1-1 In implementing the proposal, the proponent shall fulfil the commitments made in the Consultative Environmental Review and subsequently during the environmental assessment process by the Environmental Protection Authority; provided that the commitments and environmental management measures are not inconsistent with the conditions or procedures contained in this statement. In the event of any inconsistency, the conditions and procedures shall prevail to the extent of the inconsistency.

The consolidated and revised environmental management commitments of 2 January 1997 are attached.

2 **Implementation**
Changes to the proposal which are not substantial may be carried out with the approval of the Minister for the Environment.

2-1 Subject to these conditions, the manner of detailed implementation of the proposal shall conform in substance with that set out in any designs, specifications, plans or other technical material submitted by the proponent to the Environmental Protection Authority with the proposal.

Published on
17 APR 1997



18th FLOOR, ALLENDALE SQUARE, 77 ST. GEORGE'S TERRACE, PERTH 6000 TELEPHONE: (09) 421 7777 FACSIMILE: (09) 221 4665/8

2-2 Where, in the course of the detailed implementation referred to in condition 2-1, the proponent seeks to change the designs, specifications, plans or other technical material submitted to the Environmental Protection Authority in any way that the Minister for the Environment determines, on the advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

## 3 Proponent

These conditions legally apply to the nominated proponent.

3-1 No transfer of ownership, control or management of the project which would give rise to a need for the replacement of the proponent shall take place until the Minister for the Environment has advised the proponent that approval has been given for the nomination of a replacement proponent. Any request for the exercise of that power of the Minister shall be accompanied by a copy of this statement endorsed with an undertaking by the proposed replacement proponent to carry out the project in accordance with the conditions and procedures set out in the statement.

## 4 Mine Dewatering

4-1 Prior to dewatering the mine, the proponent shall develop a dewatering management plan to the requirements of the Environmental Protection Authority on advice of the Water and Rivers Commission and the Department of Environmental Protection. This plan shall include specific reference to maintaining an adequate water supply to the remnant vegetation of the area.

4-2 The proponent shall implement the dewatering management plan required by condition 4-1.

## 5 Environmental Management

5-1 The proponent shall exercise all care and diligence in managing the proposal to ensure the protection of the environment.

5-2 The proponent shall prepare and implement an environmental management plan and environmental management procedures in order to implement the proposal, and shall manage the relevant environmental factors to ensure that the environmental objectives (Section 3, Environmental Protection Authority Bulletin 838) are met.

5-3 In preparation of the plan referred to in condition 5-2, the proponent shall adopt quality assurance principles (such as those adopted in Australian Standards ISO 9000 series) and environmental management principles (such as those adopted in the voluntary Australian Standards ISO 14000 (Int):1995 series), with appropriate monitoring, auditing and reporting to ensure compliance with these conditions and the on-going protection of the environment.

5-4 If, through the implementation of the environmental management procedures referred to in condition 5-2, the proponent identifies a relevant environmental factor not reported on in Environmental Protection Authority Bulletin 838, the proponent shall immediately report to the Minister for the Environment on that factor, providing a proposed objective and the suggested means for managing the factor to achieve the objective.

## 6 Time Limit on Approval

The environmental approval for the proposal is limited.

6-1 If the proponent has not substantially commenced the project within five years of the date of this statement, then the approval to implement the proposal as granted in this statement shall lapse and be void. The Minister for the Environment shall determine any question as to whether the project has been substantially commenced.

Any application to extend the period of five years referred to in this condition shall be made before the expiration of that period to the Minister for the Environment.

Where the proponent demonstrates to the requirements of the Minister for the Environment on advice of the Department of Environmental Protection that the environmental parameters of the proposal have not changed significantly, then the Minister may grant an extension not exceeding five years.

7 **Compliance Auditing**
To help determine environmental performance and compliance with the conditions, periodic reports on the implementation of the proposal are required.

7-1 The proponent shall submit periodic Performance and Compliance Reports, in accordance with an audit programme prepared by the Department of Environmental Protection in consultation with the proponent.

**Procedure**

1 Unless otherwise specified, the Department of Environmental Protection is responsible for assessing compliance with the conditions contained in this statement and for issuing formal clearance of conditions.

2 Where compliance with any condition is in dispute, the matter will be determined by the Minister for the Environment.

**Note**

1 The proponent is required to apply for a Works Approval and Licence for this project under the provisions of Part V of the Environmental Protection Act 1986.

2 The Environmental Protection Authority reported on the proposal in Environmental Protection Authority Bulletin 838 (December 1996).

3 To achieve the principles of maintaining abundance, diversity, geographic distribution, productivity, protection and secure management of Reserves Nos 31900, 31901 and A22307, the Department of Conservation and Land Management will be responsible for ensuring that the status of Reserve No. 31900 is upgraded to "A" class, and that the three reserves Nos 31900, 31901 and A22307 are all vested in the National Parks and Nature Conservation Authority for conservation purposes.

CHERYL EDWARDES (Mrs) MLA
MINISTER FOR THE ENVIRONMENT

17 APR 1997

# Proponent's Environmental Management Commitments

**2 January 1997**

# MINING OF TITANIUM MINERALS
# 2 KM SOUTH OF YARLOOP (1032)

CABLE SANDS (WA) PTY LTD

## SUMMARY OF ENVIRONMENTAL ISSUES AND COMMITMENTS (1032)

| Category | Topic | Section of CER | Objective | Management Commitments | Timing | Key Agency |
|---|---|---|---|---|---|---|
| Environmental Management | | 4.1 | * To achieve responsible environmental management | 1. Conduct regular environmental audits<br>2. Annual reporting of environmental performance to appropriate authorities<br>3. To progress development of an accredited Environmental Management System<br>4. To prepare Environmental Management and Monitoring Programme (EMMP) relating to all environmental aspects | Throughout mine life | DEP<br>DoME |
| Biophysical Environment | Flora | 2.6, 4.3 | * To minimize disturbance of Ridge Hill Shelf complex in reserve #31900<br>* To prevent disturbance of remaining vegetation in Reserve #31900<br>* To prevent introduction and spread of dieback | 5. Minimize area of reserve #31900 impacted to the orebody as far as practical<br>6. Locate infrastructure and plant on cleared land<br>7. To use appropriate vehicle cleandown to prevent dieback introduction into Reserve 31900<br>8. To restrict access from mining areas to other areas of Reserve 31900 | Throughout mine life | DoME<br>Shire of Harvey<br>CALM<br>EPA |
| | Fauna | 2.7 | * To ensure that impact on fauna in the project area is minimized | 9. Restrict area of reserve #31900 impacted to the orebody as far as practical | Throughout mine life | DoME |

| | | | | | | |
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| | Rehabilitation | 4.4 | * To rehabilitate affected areas to a standard compatible with current landuse | 10. To develop a rehabilitation plan for the mined area of reserve #31900 which reestablishes a woodland of similiar character to that existing<br>11. To improve condition of currently degraded area of reserve #31900 following a developed rehabilitation plan<br>12. To re-establish productive pasture with shelter and shade belts on current agricultural land. | Prior to mining<br>During mining<br>During and after mining | Shire of Harvey<br>DoME<br>CALM |
| | Hydrology | 4.2 | * To have insignificant impact from water abstraction<br>* To ensure that stream flows during winter are not adversely affected | 13. To monitor water usage from the Yarloop borefield<br>14. To prevent restriction of stream flow in the mine plan | Throughout mine life<br>Prior to mining | WRC<br>DEP |
| Pollution Potential | Noise | 5.1 | * To minimize noise impacts on neighbouring properties<br>* To comply with statutory noise requirements | 15. Restrict earthmoving operations at night to within the pit as far as possible<br>16. Include noise aspects in EMMP<br>17. Fit acoustic mufflers to earth-moving equipment<br>18. Construct noise reducing bunding where appropriate<br>19. Vegetation screens will be established or enhanced and maintained | Throughout mine life | DEP |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Dust | 5.2 | * To minimize dust impacts associated with haulage<br>* To minimize dust impacts associated with earthmoving, stockpiling and rehabilitation | 20. Haulage roads will be wetted down using a water cart when required<br>21. Stockpiles will be vegetated as far as practical to reduce dust<br>22. Mine planning will keep disturbed areas to a minimum and will retain maximum vegetation<br>23. Rehabilitation will follow as close to the passing of the mine front as possible<br>24. Vegetation screens will be established or enhanced and maintained<br>25. Include dust aspects in EMMP | Throughout mine life<br><br>Prior to mining<br><br>During mining<br><br>Throughout mine life | DEP |
| | Water | 4.2 | * To have no discernible impact on water quality | 26. To regularly monitor water quality and respond appropriately to any measured anomolous results<br>27. To gain appropriate approval for septic system<br>28. To prevent overflow of slimes from slimes dams<br>29. Construction of detention areas around workshop areas to settle suspended solids<br>30. Construct oil and grease traps where appropriate<br>31. Store chemicals in accordance with relevant guidelines | Throughout mine life | DEP<br>DoME |

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| | Visual | | * To reduce visual impact of the minesite | 32. Vegetation screens and bunding will be established or enhanced and maintained | Throughout mine life | DEP |
| | Radiation | 4.5 | * To keep surface radiation levels below pre-mining | 33. Use of approved procedures for handling process materials<br>34. Monitoring of rehabilitated areas to ensure favourable comparison with pre-mining levels | Throughout mine life<br>During and after mining | DoME |
| Social Impacts | Traffic | 3.3 | * To ensure trucking of heavy mineral concentrate has minimal impact on neighbours | 35. As far as is practicable restrict trucking to daylight hours on weekdays<br>36. Provide appropriate access to the South West highway causing minimum interruption to traffic flow | During mining<br>During develop-ment | DEP<br>Main Roads |
| | Aboriginal Heritage | 5.3 | * To avoid interfering with any sites of aboriginal significance | 37. If any aboriginal sites are unearthed production will cease until appropriate consultation with Dept. of Minerals and Energy and the Dept. of Aboriginal Affairs | Throughout mine life | Dept. Aboriginal Affairs |
| | Community Consultation | 5.7 | * To keep the community aware of all relevant aspects of the mining operation | 38. Develope a plan for consultation during development and operation of the mine | Prior to mining | DEP |

Files in use

550

**Schedule 2**

# Proponent's Consolidated Environmental Management Commitments

MINERAL SANDS MINING & RUBBISH TIP RELOCATION,
RESERVE 31900, YARLOOP, SHIRE OF HARVEY
(Assessment Number 1326)

CABLE SANDS (WA) PTY LTD

*Proponent's Environmental Management Commitments – Mineral Sands Mining & Rubbish Tip Relocation, Reserve 31900, Yarloop (1326)*

Where relevant, these commitments include those made for the existing operations.

| | Commitment (Who/What) | Objective (Why) | Action (How/where) | Timing (When) | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|---|
| 1 | Incorporate environmental aspects of Reserve 31900 into the Yarloop Environmental Management and Monitoring Plan (EMMP) | To ensure environmental management is in accordance with EPA objectives and continually improves | Incorporate into existing EMMP | Prior to construction and throughout mine life | DME | Submission of modified EMMP |
| 2 | Report environmental performance on a 6-monthly basis. | To inform Government on environmental performance of the proposal | 1. Preparation of 6-monthly environmental performance reports.<br>2. Make report publicly available. | Operation and decommissioning | | Receipt of 6-monthly report |
| 3 | Locate infrastructure for mining and primary processing on cleared land outside Res 31900. | To minimise impact on vegetation in Reserve 31900. | Incorporate in Mine Planning | Prior to and during mining | | Infrastructure not present on reserve |
| 4 | Acquire the 9.1ha part of Location 826 indicated in Figure 3 for incorporation in the conservation estate. | To Increase security of Forrestfield Complex | By acquiring part of Location 826 | Prior to clearing native vegation within Reserve 31900 | | Letter from proponent |
| 5 | Fence Reserves A23307, 31900, 31901 and the land purchase area to restrict access to these areas. | To reduce threatening processes in these reserves | The three reserves and the land purchase area | During mining (reserves A23307, 31901 and the land purchase area) ; and<br>At completion of mining (reserve 31900) . | CALM | Advice with environmental performance reports |
| 6 | Retain and fence the area of overstorey on the Loc 816 immediately east of the reserve and facilitate growth of native understorey species. | To provide a buffer to conservation values of Reserves 31900 and 31901 | Within fenced area of Loc 816 | During mining | | Advice with environmental performance reports |
| 7 | Maintain vegetation clearing to a practical minimum. | To minimise impact on vegetation in Reserve 31900. | Within the reserve | During mining | CALM | Rehabilitation Plan meets CALM requirements |
| 8 | Preserve as much seed and plant material as practical for rehabilitation | To facilitate rehabilitation success | Within the reserve | Prior to mining | CALM | Rehabilitation Plan meets CALM requirements |
| 9 | Rehabilitate unmined degraded areas in Reserve 31900 west of the mining areas. | To consolidate values of Reserve 31900 | Incorporate with Rehabilitation Plan | During mining | CALM | Rehabilitation Plan meets CALM requirements |
| 10 | Retain a strip of native vegetation along the northern boundary of Reserve 31900. | To provide a buffer and fauna corridor between Res 31900 and 31901 | Incorporate in Mine Planning | Prior to mining | CALM | Rehabilitation Plan meets CALM requirements |
| 11 | Implement the noise management plan | To ensure appropriate management of noise issues | For all Yarloop Mining including Reserve 31900 | Prior to Mining | | Advice with environmental performance reports |
| 12 | Wet haulage roads with a water cart as required | To minimise dust emissions | Within and in the vicinity of the reserve | Throughout mine life | | Advice with environmental performance reports |

| | Commitment (Who/What) | Objective (Why) | Action (How/where) | Timing (When) | Whose Advice | Measurement Compliance Criteria |
|---|---|---|---|---|---|---|
| 13 | Stockpiles will be vegetated as far as practicable to prevent dust emissions. | To minimise dust emissions | Within and in the vicinity of the reserve | Throughout mine life | | Advice with environmental performance reports |
| 14 | Keep disturbed areas to a minimum. | To minimise dust emissions | Within and in the vicinity of the reserve | Throughout mine life | | Advice with environmental performance reports |
| 15 | Develop a groundwater management plan | To ensure appropriate management of water issues including abstraction | 1. Around minesite and borefield area.<br>2. Make the plan publicly available. | Prior to Mining. | WRC | WRC approval of Plan<br>Meets EPA requirements. |
| 16 | Implement a groundwater management plan | To ensure appropriate management of water issues including abstraction | Around minesite and borefield area | Throughout minelife | WRC | Advice with environmental performance reports |
| 17 | Enhance or maintain vegetation screens | To minimise impacts on visual amenity | Around mining area | Throughout mine life | | Advice with environmental performance reports |
| 18 | Cease production in any area where Aboriginal sites are discovered and consult with the Dept of Aboriginal Affairs. | To comply with the Aboriginal Heritage Act 1972 | Within the mining area | Throughout mine life | AAD | Letter from AAD |
| 19 | Prepare a Management Plan for Decommissioning of the Yarloop Rubbish Tip | To ensure appropriate management of rubbish tip | Within mining area | Prior to Mining | Shire of Harvey | Letter form Shire and from DEP |
| 20 | Implement the Management Plan for Decommissioning of the Yarloop Rubbish Tip | To ensure appropriate management of rubbish tip | Within mining area | Throughout minelife | Shire of Harvey | Advice with environmental performance reports |
| 21 | Prepare a programme for mining and rehabilitation of Reserve 31900 in consultation with CALM and DEP. The programme will include the requirement to re-instate the final landform, consistent with the surrounding terrain, within 12 months of completion of mining of the orebody | To ensure appropriate rehabilitation of mined areas and degraded areas | Throughout Reserve 31900 | Prior to Mining | CALM | Letter from CALM |
| 22 | Implement the mining and rehabilitation programme | To ensure appropriate rehabilitation of mined areas and degraded areas | Throughout Reserve 31900 | Throughout minelife | CALM | Advice with environmental performance reports |

Note: Figure numbers in this table refer to figures in the Proponent's environmental review document of May, 2000.

### 1.1.1 Abbreviations

AAD = Aboriginal Affairs Department
CALM = Department of Conservation and Land Management
DEP = Department of Environmental Protection
DME = Department of Minerals and Energy
EPA = Environmental Protection Authority
WRC = Water and Rivers Commission

944

# Titanium Minerals Mining and Rehabilitation, Reserve 31900 Yarloop

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**Cable Sands (WA) Pty Ltd**

**Report and recommendations of the Environmental Protection Authority**

Full document available on request

**Environmental Protection Authority**
**Perth, Western Australia**
**Bulletin 944**
**July 1999**

**DATE: 19/20 October 1998**

**BRIEFING NOTE**

**Subject:** Titanium Minerals Mining and Rehabilitation, Reserve 31900 Yarloop

**Stage of Assessment:** Out-of-session discussions on assessment strategy.

**10.00 am, 19 October 1998 (internal only)**
**Attending Officer(s):** Michelle Mifka (Resources Development), Tim Gentle (A/Manager, Resources Development), Kim Taylor (Director, Evaluation Division), Rob Sippe (Director, Policy Coordination Division), Bronwen Keighery (Conservation Branch),

EPA - Bernard Bowen, ~~Libby Mattiske~~ and Sally Robinson

**2.00pm, 20 October 1998 (internal/external)**
**Attending Officer (s):** Michelle Mifka (Resources Development), Tim Gentle (A/Manager, Resources Development), Rob Sippe (Director, Policy Coordination Division), Bronwen Keighery (Conservation Branch)

EPA - Bernard Bowen and Sally Robinson

Graeme Kininmonth (Cable Sands (WA) Pty Ltd)
Gary Cockford (General Manager, Cable Sands (WA) Pty Ltd)
Charlie Welker (Environmental Consultant)
Gary Fee (Cable Sands (WA) Pty Ltd)

**Purpose:** To seek advice on vegetation and biodiversity issues.

## 1. Background

Previous proposal

A mining proposal at Yarloop, which included mining within the Reserve 31900, was previously assessed by the EPA (Bulletin 838, 1996). The project area is located within the Shire of Harvey, approximately 2 kilometres south east from the township of Yarloop (see Attachment 1).

Reserve 31900 is vested in the Shire of Harvey for sand extraction and rubbish disposal. Based on information available at the time of the original assessment, this Reserve contains remnant vegetation community type 3b and 20b. It is therefore considered to be regionally significant and has been recognised by the EPA as an Interim Protection Area under the System 6 review.

Recommendation 5 of (Assessment 1032, 1996) stated "that the Shire of Harvey establish an alternative site outside Reserve 31900 for rubbish disposal and sand excavation purposes to ensure protection of the significant conservation values of Reserve 31900". Discussions are currently being held with the Appeals Convenor to resolve this issue.

The PER includes results from further botanical studies of the vegetation in Reserve 31900. Based on these further studies, the proponent has concluded that:

- the threatened community (3b) is not present in the area to be mined; and that,
- the area to be mined is part of a continuum between vegetation types 3b and 20b and is therefore of less conservation significance.

The Conservation Branch (see attachment 3) notes that:

- the additional studies were carried in July and December (outside the spring flowering season) and it is therefore likely that species identification was incomplete; and
- if the area is in a fact a continuum, this actually increases its conservation significance.
- information indicate variability in plant communities in area

Proposed land swap - Bunnings Location 826

Bunnings Location 826 (located within the Yarloop Townsite Reserve) is privately owned by Millars (WA) Pty Ltd (a subsidiary of Bunnings). It covers an area of approximately 205 hectares of which 10 hectares is proposed to be set aside for conservation purposes as part of this proposal.

So far as DEP is aware, there is no written undertaking from Bunnings that they will sell the land to the proponent.

The Conservation Branch has noted (see attachment 3) that:

- the Bunnings land could be protected in any case as it ~~may~~ is be regionally significant under System 6 update;
- variability in plant communities, as needed.
- the Bunnings land is separated from the other areas of bushland in the overall Yarloop remnant by South West Highway. This has significant implications for the continuity of biological processes between this area and the rest of the Yarloop remnant;
- the Bunnings land has been degraded, and the severity is unknown - sawdust/ash, grazing effect; and
- it is therefore questionable whether the proposed swap would actually be a net gain; and

## 3. Rehabilitation

The relevant area for this factor is the 20 hectares of land that falls within Reserve 31900.

The PER states that rehabilitation of Reserve 31900 will be a crucial part of the proposed operation to improve vegetation values of the Reserve. Mining will provide the opportunity and resources to rehabilitate the degraded areas in the Reserve in addition to any areas impacted by mining.

A detailed rehabilitation plan will be prepared, in consultation with CALM, prior to commencement of mining.

The Conservation Branch has noted (see attachment 3) that:

- the rehabilitation proposed by Cable Sands of the area that would be mined and existing degraded areas (rubbish tip and other areas) would be desirable if the mining went ahead, as it would reduce the difficulty of management of the remaining areas and replace some biodiversity values;

- the critical point is whether or not the loss of a further 6.1h ha of native vegetation of high conservation value would be compensated for in this way;

- It is very unlikely that rehabilitation would replace the vegetation values of the Reserve. What would result would be a vegetation of similar but probably more uniform appearance, with lower cover and diversity; and

- given that no spring survey has been carried out it is still possible that the area may also have flora values that would not be replaced.

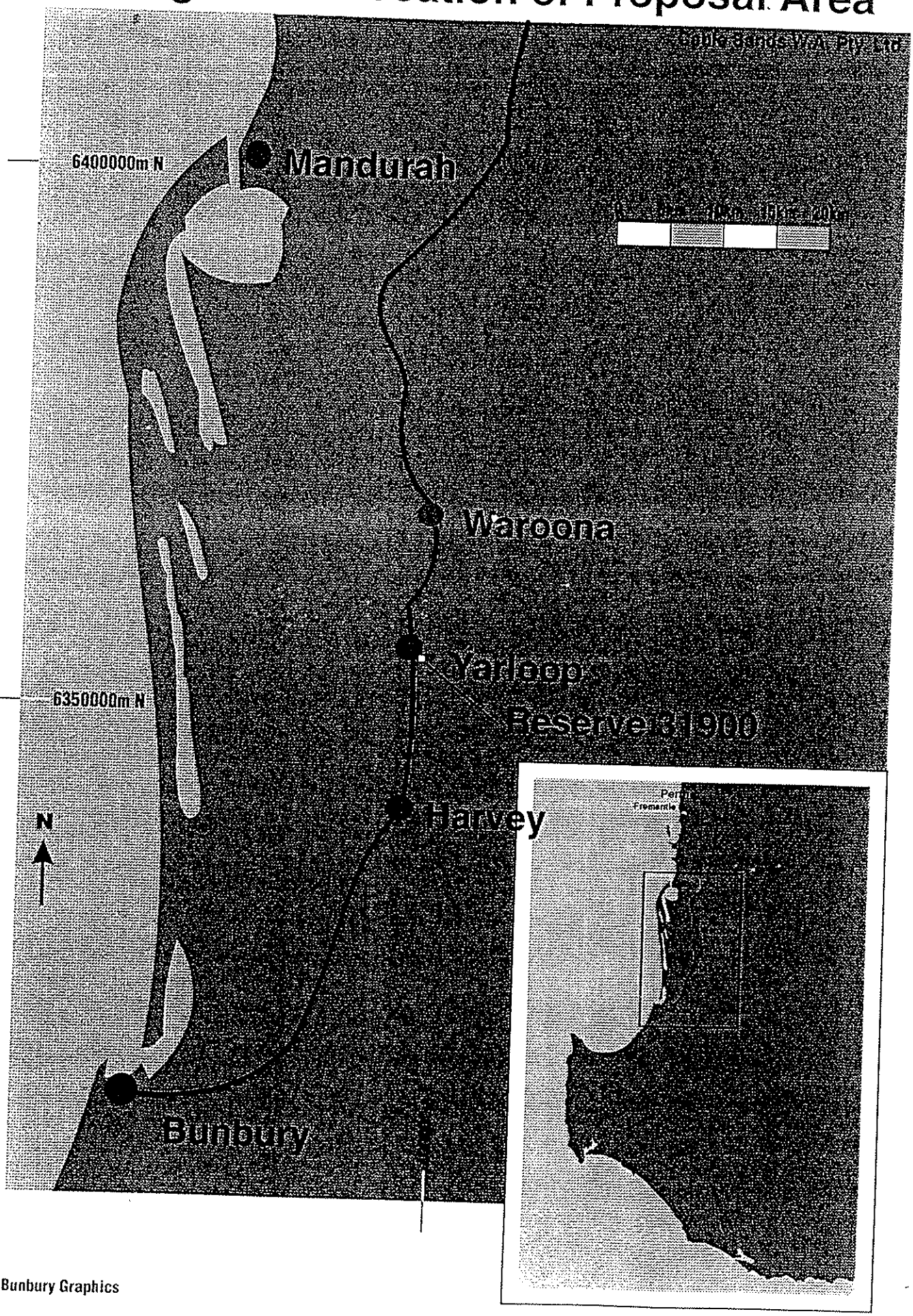
## 4. Aboriginal Heritage and Culture

The relevant area for this factor is the 6.1 hectares of land that would potentially be cleared.

As part of the EPA guidelines, the proponent was requested to identify any Aboriginal cultural and heritage sites of significance through archaeological and ethnographical surveys of the project area and through consultation with local Aboriginal groups and the Department of Aboriginal Affairs. However, the proponent has not undertaken this survey. It is not possible to complete assessment of this factor in the absence of these survey results.

Attachment 1

# Figure 1 - Location of Proposal Area




Bunbury Graphics

Attachment 2.
Ass # 1032
Bull # 838
State # 442

MINISTER FOR THE ENVIRONMENT;
EMPLOYMENT AND TRAINING

# STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE ENVIRONMENTAL PROTECTION ACT 1986)

MINING OF TITANIUM MINERALS, 2 KM SOUTH OF YARLOOP (1032)

CABLE SANDS (W.A.) PTY. LTD.

That part of the proposal relating to mining of titanium minerals within "C" Class Reserve No. 31900 may not be implemented.

That part of the proposal located on private land and within Mining Leases Nos 70/49, 70/937 and 70/938 (pending) may be implemented subject to the following conditions:

**1 Proponent Commitments**
The proponent has made a number of environmental management commitments in order to protect the environment.

1-1 In implementing the proposal, the proponent shall fulfil the commitments made in the Consultative Environmental Review and subsequently during the environmental assessment process by the Environmental Protection Authority; provided that the commitments and environmental management measures are not inconsistent with the conditions or procedures contained in this statement. In the event of any inconsistency, the conditions and procedures shall prevail to the extent of the inconsistency.

The consolidated and revised environmental management commitments of 2 January 1997 are attached.

**2 Implementation**
Changes to the proposal which are not substantial may be carried out with the approval of the Minister for the Environment.

2-1 Subject to these conditions, the manner of detailed implementation of the proposal shall conform in substance with that set out in any designs, specifications, plans or other technical material submitted by the proponent to the Environmental Protection Authority with the proposal.

Published on
17 APR 1997



18th FLOOR, ALLENDALE SQUARE, 77 ST. GEORGE'S TERRACE, PERTH 6000 TELEPHONE: (09) 421 7777 FACSIMILE: (09) 221 4665/8

2-2 Where, in the course of the detailed implementation referred to in condition 2-1, the proponent seeks to change the designs, specifications, plans or other technical material submitted to the Environmental Protection Authority in any way that the Minister for the Environment determines, on the advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

## 3 Proponent

These conditions legally apply to the nominated proponent.

3-1 No transfer of ownership, control or management of the project which would give rise to a need for the replacement of the proponent shall take place until the Minister for the Environment has advised the proponent that approval has been given for the nomination of a replacement proponent. Any request for the exercise of that power of the Minister shall be accompanied by a copy of this statement endorsed with an undertaking by the proposed replacement proponent to carry out the project in accordance with the conditions and procedures set out in the statement.

## 4 Mine Dewatering

4-1 Prior to dewatering the mine, the proponent shall develop a dewatering management plan to the requirements of the Environmental Protection Authority on advice of the Water and Rivers Commission and the Department of Environmental Protection. This plan shall include specific reference to maintaining an adequate water supply to the remnant vegetation of the area.

4-2 The proponent shall implement the dewatering management plan required by condition 4-1.

## 5 Environmental Management

5-1 The proponent shall exercise all care and diligence in managing the proposal to ensure the protection of the environment.

5-2 The proponent shall prepare and implement an environmental management plan and environmental management procedures in order to implement the proposal, and shall manage the relevant environmental factors to ensure that the environmental objectives (Section 3, Environmental Protection Authority Bulletin 838) are met.

5-3 In preparation of the plan referred to in condition 5-2, the proponent shall adopt quality assurance principles (such as those adopted in Australian Standards ISO 9000 series) and environmental management principles (such as those adopted in the voluntary Australian Standards ISO 14000 (Int):1995 series), with appropriate monitoring, auditing and reporting to ensure compliance with these conditions and the on-going protection of the environment.

5-4 If, through the implementation of the environmental management procedures referred to in condition 5-2, the proponent identifies a relevant environmental factor not reported on in Environmental Protection Authority Bulletin 838, the proponent shall immediately report to the Minister for the Environment on that factor, providing a proposed objective and the suggested means for managing the factor to achieve the objective.

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Any application to extend the period of five years referred to in this condition shall be made before the expiration of that period to the Minister for the Environment.

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To help determine environmental performance and compliance with the conditions, periodic reports on the implementation of the proposal are required.

7-1 The proponent shall submit periodic Performance and Compliance Reports, in accordance with an audit programme prepared by the Department of Environmental Protection in consultation with the proponent.

**Procedure**

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2 Where compliance with any condition is in dispute, the matter will be determined by the Minister for the Environment.

**Note**

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3 To achieve the principles of maintaining abundance, diversity, geographic distribution, productivity, protection and secure management of Reserves Nos 31900, 31901 and A22307, the Department of Conservation and Land Management will be responsible for ensuring that the status of Reserve No. 31900 is upgraded to "A" class, and that the three reserves Nos 31900, 31901 and A22307 are all vested in the National Parks and Nature Conservation Authority for conservation purposes.

CHERYL EDWARDES (Mrs) MLA
MINISTER FOR THE ENVIRONMENT

17 APR 1997

# Proponent's Environmental Management Commitments

2 January 1997

# MINING OF TITANIUM MINERALS
# 2 KM SOUTH OF YARLOOP (1032)

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| | Fauna | 2.7 | * To ensure that impact on fauna in the project area is minimized | 9. Restrict area of reserve #31900 impacted to the orebody as far as practical | Throughout mine life | DoME |

| | | | | | | |
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| | Hydrology | 4.2 | * To have insignificant impact from water abstraction<br>* To ensure that stream flows during winter are not adversely affected | 13. To monitor water usage from the Yarloop borefield<br>14. To prevent restriction of stream flow in the mine plan | Throughout mine life<br>Prior to mining | WRC<br>DEP |
| Pollution Potential | Noise | 5.1 | * To minimize noise impacts on neighbouring properties<br>* To comply with statutory noise requirements | 15. Restrict earthmoving operations at night to within the pit as far as possible<br>16. Include noise aspects in EMMP<br>17. Fit acoustic mufflers to earth-moving equipment<br>18. Construct noise reducing bunding where appropriate<br>19. Vegetation screens will be established or enhanced and maintained | Throughout mine life | DEP |

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| | Water | 4.2 | * To have no discernible impact on water quality | 26. To regularly monitor water quality and respond appropriately to any measured anomolous results<br>27. To gain appropriate approval for septic system<br>28. To prevent overflow of slimes from slimes dams<br>29. Construction of detention areas around workshop areas to settle suspended solids<br>30. Construct oil and grease traps where appropriate<br>31. Store chemicals in accordance with relevant guidelines | Throughout mine life | DEP<br>DoME |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Visual | | * To reduce visual impact of the minesite | 32. Vegetation screens and bunding will be established or enhanced and maintained | Throughout mine life | DEP |
| | Radiation | 4.5 | * To keep surface radiation levels below pre-mining | 33. Use of approved procedures for handling process materials<br>34. Monitoring of rehabilitated areas to ensure favourable comparison with pre-mining levels | Throughout mine life<br>During and after mining | DoME |
| Social Impacts | Traffic | 3.3 | * To ensure trucking of heavy mineral concentrate has minimal impact on neighbours | 35. As far as is practicable restrict trucking to daylight hours on weekdays<br>36. Provide appropriate access to the South West highway causing minimum interruption to traffic flow | During mining<br>During develop-ment | DEP<br>Main Roads |
| | Aboriginal Heritage | 5.3 | * To avoid interfering with any sites of aboriginal significance | 37. If any aboriginal sites are unearthed production will cease until appropriate consultation with Dept. of Minerals and Energy and the Dept. of Aboriginal Affairs | Throughout mine life | Dept. Aboriginal Affairs |
| | Community Consultation | 5.7 | * To keep the community aware of all relevant aspects of the mining operation | 38. Develope a plan for consultation during development and operation of the mine | Prior to mining | DEP |

Attachment 3.

# CONSERVATION BRANCH
## INTRA DEPARTMENTAL ADVICE
NB: For Internal Use Only

**TO:** Gary Whisson, Michelle Mifka, Tim Gentle
**SUBJECT:** Mining in Reserve 31900 Yarloop
**FROM:** Malcolm Trudgen
**DATE:** 8/10/1998

Acting Manager Conservation Branch 8/10/98

Please could I be provided with a copy of your final advice. Thank you.

**A. Comment on the report *Vegetation survey of selected reserves at Yarloop* (Mattiske Consulting December 1997)**

This report describes the recording of a number of sites in reserve 31900 and adjoining areas and the conclusions made from the analysis of the data. The main conclusion was that Reserve 31900 has vegetation that is intermediate (a continuum, or transition) between Floristic Community Types 3b and 20b. The methodology section of the report does not describe what type of plot was used (or if a releve, or undefined site, was used). The sampling of most of the plots was carried out on the 23rd of July 1997 and those in Location 5322 on the 3rd of December 1997. The timing of the sampling has reduced the quality of the data obtained through the reduced sampling of cryptophyte (bulbous, cormous) and (particularly) annual species, the sites were only visited once each. This may partly explain the conclusion reached with regard to a continuum; which is at variance with earlier work carried out by CALM, which identified the presence of Floristic Community 20b in the north-west corner of Reserve 31900 and structural mapping of the vegetation which would suggest the likely distribution of floristic community types 3b and 20b in the reserve.

"Although the vegetation at Reserve 31900 had been classified as consisting of vegetation types 3b and 20b the current study was unable to readily separate the sample sites into these types, instead a continuum was apparent. This continuum was also present on the adjacent proposed reserves, so was not unique to Reserve 31900." (Mattiske Consulting December 1997, p. i, para 2)

"However in a previous study (Mattiske Consulting Pty Ltd 1996) where several 3b and 20b vegetation types had been surveyed the distinction between the two was clearly apparent." (Mattiske Consulting December 1997, p i, para 3)

"Both vegetation types 3b and 20b were represented in Location 5322, although vegetation type 20 b did not have *Banksia attenuata* which was present in the same vegetation type in Reserve 31900." (Mattiske Consulting December 1997, p. i, para 4)

"Two vegetation types, 3b and 20b (Gibson *et al.*, 1994) have been recorded from Reserve 31900, with a 20b site having been sampled in Reserve 31900 and a 3b site in

the adjacent reserve north of the rifle range (Gibson, pers. comm.). A separation of the two associations in Reserve 31900 was made by G. Keighery (1995) from aerial photographs and from comparison with adjacent areas (Keighery, pers. comm.)." (Mattiske Consulting December 1997, p. 4).

If the vegetation on Reserve 31900 and parts of the adjoining areas is a continuum or transition between Floristic Community Types 3b and 20b, then this would increase the conservation value of the area, as it would represent an aspect of biodiversity that had not previously been recognised as existing. In this regard it should be realised that in general, sites chosen to be recorded for the survey of the Southern Swan Coastal Plain (Gibson *et al* 1994) were chosen to avoid ecotonal areas and so continua are deliberately under represented in the sampling. However, it seems that the area of continuum identified by Mattiske Consulting (December 1997) is of a larger scale than would be avoided by assessment of possible sites, as it would not be obviously apparent as an ecotone. It therefore not only represents (if correctly identified) a previously unrecognised aspect of biodiversity (thus having value in its own right) but also is of significant scientific research interest as an area where the controlling factors of species distribution related to Floristic Community Types 3b and 20b might be studied.

It should be noted, that the authors of Mattiske Consulting (December 1997) are not suggesting that Floristic Community Types 3b and 20b do not exist, in fact they confirm their presence in nearby areas.

The report (Mattiske Consulting December 1997) also comments on the condition of the vegetation on Reserve 13900. "The vegetation of the Reserve varied in quality as a result of the rubbish tip and the degree of weed invasion. The eastern section of the Reserve was less disturbed and had less weed species than other sections of the Reserve. Despite the disturbance and presence of weeds, the vegetation outside the immediate rubbish tip area was in relatively good condition ...." (Mattiske Consulting December 1997, p.5 para 6).

There is a significant issue relating to whether or not the techniques applied by Mattiske Consulting in their report (Mattiske Consulting December 1997) are appropriate to discern the presence or absence of particular floristic community types. In effect what they have done is sample areas that have been assigned to either FCT 3b or 20b previously (some on the basis of computer analysis of plot data using the programmes used to define the FCTs and others on the basis of subjective interpretation) and compare them to nearby areas using two different statistical analysis approaches, both of which differ from the analysis used by Gibson *et al* (1994) to define the floristic community types for the Swan Coastal Plain. This obviously raises questions of what is being compared and at what scale or level of detail (especially what level of data collection). In this context it is important to understand that vegetation analysis is a complex issue that can be approached from different viewpoints that define units on the basis of different factors.

The approaches Mattiske Consulting (December 1997) have used is to look at the vegetation firstly on the basis of the percentage cover (a measure of abundance) of each species present and secondly on the basis of the presence and absence of the species at the sites recorded.

The first approach is a substantially different analysis to that used by Gibson *et al* (1994), which was based on presence and absence of species rather than structure (abundance). The floristic community types defined by Gibson *et al* (1994) are broad regional presence/absence floristic units that often include a range of stuctural units. Therefore, it would not be surprising if an abundance based analysis reached a different conclusion to that reached by Gibson *et al*.

The second approach is obviously more similar to that used by Gibson *et al*, being also based on presence/absence data. There is a significant problem here in the absence of spring recording of the sites recorded by Mattiske Consulting and the consequent near absence of annual species and under representation of cryptophyte species (bulbous, cormous species). It is possible that this may have affected the data to the point that instead of distinguishing floristic community types 3b and 20b at some (or all) of the sites recorded the data seems to indicate a continuum.

In the end, such issues are of secondary importance, as whatever the analysis of vegetation or floristic community types shows, the final assessment of conservation value for the Reserve 31900 and the adjoining reserves will show high values based on the high level of regional clearing and the poor representation of areas on the eastern side of the Swan Coastal Plain in conservation reserves. The presence of a substantial area of a continuum between floristic community types 3b and 20b on Reserve 31900- and adjoining areas would only add to this value, rather than detract from it.

**B. Vegetation complex level assessment**

The Yarloop reserves and the Bunnings land (which is on the opposite side of the South West Highway) fall within the Forrestfield Vegetation Complex of Heddle *et al* (1980). The distribution of this vegetation complex is the same as that of the Ridge Hill Shelf landform, which has an area of 20,126 ha (DEP 1996a) and which lies at the eastern side of the Swan Coastal Plain. The Forestfield Vegetation Complex has been largely cleared, with DEP figures (N. Thorning pers com) indicating that at the most 7% of the complex remains. This figure is likely to include some areas that have been significantly degraded. For the Perth Metropolitan Area, this figure is similar to estimates made by the Ministry for Planning "Within the Perth Metropolitan Area, the Forrestfield Vegetation Complex is considered to be 92% cleared (Ministry for Planning). Accurate figures are not available beyond the Perth Metropolitan Area but it is estimated that the complex has been subject to more clearing in country areas than in the Metro area. The eastern side of the of the coastal plain, of which the Forrestfield Vegetation Complex is a party (sic, part), has been estimated by CALM to be 97% cleared (DEP 1996a, Attachment 2).

At the vegetation complex level of assessment, the overall bushland remnant at Yarloop (which includes Reserve 31900) would have to be considered to have very high conservation value because of:

- the relatively small amount of the complex remaining uncleared;
- the high level of clearing of the eastern side of the coastal plain where it lies; and
- the large size of the overall remnant at Yarloop, which is the largest remnant of the Forrestfield Vegetation Complex.

**C. Floristic community type level assessment**

"there is approximately 185 ha of the Ridge Hill Shelf vegetation community Type 3b and 97 ha of Type 20b remaining on the Swan Coastal Plain, of which 100ha and 38 ha respectively are located within existing conservation reserves" (DEP 1996a, Attachment 2, quoting Mr G. Kinnimonth of Cable Sands).

The areas of floristic community types 3b and 20b that remain uncleared are obviously very small and consequently have very high conservation value. It is therefore a matter of fine judgment as to whether or not any further clearing of these floristic community types is environmentally acceptable.

Survey work and analysis carried out for the proponent (Mattiske Consulting, December 1997) suggests (and accepting this unless shown otherwise) that the vegetation on Reserve 31900 and on parts of the adjoining remnant bushland is an area of a continuum between floristic community types 3b and 20b. Given this, then Reserve 31900 and the adjoining areas have particularly high value as they currently have areas of floristic community types 3b, 20b and a continuum between them. This adds significantly to the value of the Yarloop Reserve group, which was already of significance as the largest area of floristic community types 3b and 20b remaining.

This new information (the existence of the continuum) and its implications for the Conservation value of reserve 31900 is of critical significance in making an informed decision as to the acceptability of mining in Reserve 31900. Although the continuum extends into adjoining areas, it is still a very restricted "unit" and as such (particularly as there may be no other surviving example) has very significant conservation value. The small overall areas involved, the low level of reservation and the high degree of clearing of the region would suggest that further loss was unacceptable at the floristic community type level of assessment of the conservation value of the native vegetation at Yarloop.

It should be noted that both Floristic Community Type 3b and Floristic Community Type 20b are considered to be threatened ecological communities by English and Blyth (1997), who rated it Community 3b as "vulnerable" and Community 20b as Endangered.

C. More detailed assessment

The information (or the presentation of it) regarding the vegetation at Yarloop is not highly detailed. The vegetation has been mapped only at the floristic community type level, ie. into broad, regional units which would be expected to have significant variation.

Mattiske Consulting (December 1997) did not map the vegetation but, when carrying out their survey checked (page 3, para 2) that they had sampled the vegetation associations present. That is, they did not consider the vegetation at the plant community level. However, the data presented by Mattiske Consulting (December 1997) was collected at fairly close intervals and therefore has significantly more information in it.

Examination of Table 1 of Mattiske Consulting (December 1997, p. 7) which examines the relationship between pairs of sites using the Bray-Curtis similarity co-efficient indicates significant variation both between sites on Reserve 31900 and between sites on that reserve and adjoining reserves or lots (as well as between sites in those areas). For their report Mattiske Consulting recorded 26 sites, this gives 325 possible pairs of sites that can be contrasted using the Bray-Curtis similarity co-efficient. Table 1 of Mattiske Consulting shows one pair of sites (6B&6C - from the Bunnings land) with a co-efficient of 0.7+, that is very similar to each other (a co-efficient of 1 would indicate they were the same). Four pairs of sites had a co-efficient of 0.6-0.7 (still very similar), two of these pairs were on the Bunnings land and two on Location 5322. Thirty-six pairs had co-efficients between 0.5 and 0.6 (still quite similar) seven of these pairs are between sites on Reserve 31900 (out of a possible 66 pairs on the Reserve). The remaining possible 284 comparisons between sites had co-efficients of less than 0.5. Overall, this supports the suggestion made at the beginning of this paragraph that in fact the data presented by Mattiske Consulting shows significant variation is present on Reserve 31900 and between it and adjoining bushland areas.

Data is also presented in Mattiske Consulting (December 1997, page 7 second last paragraph) on the sites with the greatest dissimilarity using the Bray-Curtis similarity co-efficient. This shows six pairs of sites from Reserve 31900 as having high dissimilarity to each other, again suggesting significant variation on the Reserve. Three pairs of sites with one site from Reserve 31900 and the other from the Bunnings land also had high dissimilarity using the Bray-Curtis similarity co-efficient, suggesting very significant difference between each of the sites on the Bunnings land and sites on Reserve 31900. Similarly, pairs of sites with one member from Reserve 31900 and the other from the other areas of the overall remnant (Reserves 31901 and 23307 and Lot 5322) had high dissimilarity, showing significant variation between Reserve 31900 and parts of the other sections of the overall remnant.

Similar arguments to those made in the two paragraphs above could be made from the data presented in Mattiske Consulting (December 1997, Table 2, page 8) regarding Jaccard similarity co-efficients for their presence and absence data.

Overall, the available data strongly suggest that below the floristic community type and vegetation association level that there is significant variation in both structure and species distribution both on Reserve 31900 and between it and the other components of the overall remnant. The amount of variation that appears to be present would suggest that effective conservation of the variation remaining within the overall remnant would require no significant loss of vegetation in reasonable condition. The loss of the area that Cable Sands proposes to mine would constitute a significant loss in this regard.

**D. Impact of the mining proposal**

Reserve 31900 has an area of 19.7 ha. The mining proposal would "result in the clearing of approximately 6.1 ha of native vegetation with significant conservation value." (Cable Sands 1998, p34, section 6.1.3, para. 2).

In assessing the impact of the proposal on the Reserve 31900, it is very significant that parts of the reserve are already cleared and that these areas are in the centre of the reserve. The mining would almost double the amount of land cleared, meaning that only about 6.6 ha of the reserve would remain uncleared. Importantly, these areas would be around the edges of the Reserve. Thus it is clear that the mining process would have a substantial impact on the reserve both in terms of the loss of vegetation and the spatial distribution of the loss.

Although the continuum identified by Mattiske Consulting (December 1997) between floristic community types 3b and 20b extends beyond Reserve 31900, the loss of 6.1 ha of this intermediate "unit" would also constitute a high impact.

**E. Proposed rehabilitation and land swap**

The rehabilitation proposed by Cable Sands of the area that would be mined and the existing degraded areas (the rubbish tip in the reserve and other degraded areas) would be desirable if the mining went ahead, as it would reduce the difficulty of management of the remaining areas and replace some biodiversity values. The critical point however, is whether or not the loss of a further 6.1 ha of native vegetation of high conservation value would compensated for in this way. Given the significant variation in the area shown by the work of Mattiske Consulting (December 1997, see discussion above) it is very unlikely that rehabilitation would replace the vegetation values of the reserve. What would result would be a vegetation of similar but probably more uniform appearance, with lower cover and diversity, the latter especially as measured in smaller areas. Given that no spring survey has been carried out it is still possible that the area may also have flora values that would not be replaced.

The proposed land swap also has significant problems. Firstly the area proposed (the Bunnings land) is separated from the other areas of bushland in the overall Yarloop remnant by Southwest Highway. This has significant implications for the continuity of biological processes between this area and the rest of the Yarloop remnant. Movement of animals, particularly in their role as vectors for seed and pollen is substantially constrained by the highway.

Other issues relate to whether or not the proposed swap is actually a net gain, as it is unlikely that permission to clear the area would be given and it is likely to be recommended for protection under the System Six review. A further issue is the condition of the area, as there has apparently recently been dumping of ash and sawdust in the area which may also be being grazed by stock.

**E. References**


Cable Sands (1998). Mining of Yarloop Reserve 31900. Public Environmental Review. Cable Sands (W.A.) Pty. Ltd.

DEP (1996a). Conservation Branch file material, subject: Mining of titanium minerals, Yarloop (Assessment No. 1032).

English, V.J. and J. Blyth (1997). Identifying and conserving Threatened Ecological Communities in the South West Botanical Province. Final report for Project No. N702 to Environment Australia by the Department of Conservation and Land Management, Western Australia.

Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H., and Lyons, M.N. (1994). *A Floristic Survey of the southern Swan Coastal Plain*. Unpublished report for the Australian Heritage Commission, prepared by the Department of Conservation and Land Management and the Conservation Council of WA (Inc.)

Heddle, E.M, O.W. Loneragan and J.J. Havel (1980). *Vegetation complexes of the Darling System, Western Australia*. In *Atlas of natural resources Darling System, Western Australia*. Department of Conservation and Environment Western Australia, Perth, 1980.

Mattiske Consulting (December 1997). *Vegetation survey of selected reserves at Yarloop*. Unpublished report by Mattiske Consulting Pty. Ltd., dated December 1997, report CSC003/052/97. Prepared for Cable Sands Pty Ltd.

# ENTERED ON GIS

**Name:** Mining of Yarloop Reserve 31900 – Public Environmental Review
**Date:** 24/04/2006
**Capture Author:** Thomas Leong

**Comments:**
*Polygon*
Created to match documented study area with high level of accuracy

Accuracy Levels:

- High = Document contained visual references easily copied, resulting in little or no polygon boundary errors
- Acceptable = Document contained visual references with complex boundaries, resulting in possible polygon boundary errors
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Content – Captured without problems

## Briefing Notes

## Meeting 20th October 1998

# Mining of Yarloop Reserve 31900

## Cable Sands (WA) Pty Ltd

**Cable Sands representatives**

| | |
|---|---|
| **Gary Crockford** | **General Manager** |
| **Garry Fee** | **Environmental superintendent** |
| **Graeme Kininmonth** | **Senior Environmental Officer** |
| **Charlie Welker** | **Welker Environmental Consultancy** |

# Background to the Proposal

1964 - Application for Mining Claim (long period of negotiation)

1973 - Reserve 31900 vested with Shire of Harvey

1977 - Mineral Claim granted

1983 - System 6 report released – Reserve 31900 not included

1994 - Advice to Cable Sands from DEP that formal assessment was unlikely (informal (verbal not in writing))

1995 - Reserve included on maps issued as part of System 6 upgrade ('interim' areas)
- Third agreement with Shire of Harvey signed

1996 - CER for Yarloop Titanium Minerals Mine submitted

1997 - Approval for Mining given (not including Reserve 31900) - All approvals not pursued (ultimate mine shut)
- Mining commenced Important ore body, do not wish to let go

1998 – Proposal for Reserve 31900 modified and PER submitted

# Key Aspects of the Proposal

## Mining

- Mining of 178,000 tonnes of Heavy Mineral Concentrate (HMC)
- Mine life approximately 16 months
- Rehabilitation continuing for a number of years following mining
- Clearing of 6.1 ha of native vegetation
- Mining in a further 3 ha of degraded land and active rubbish tip
- Use of other degraded land for mining stockpiles etc

## Rehabilitation and Management of Reserve 31900

detailed plan prepared with CALM

- 13 ha (9.1 ha mined + degraded areas) to be rehabilitated to native vegetation (assuming no tip required)
- Range of techniques used to maximise the number of species in rehabilitated ground (eg translocation, seeding, maximising topsoil return for natural regeneration, planting of seedlings from a range of propagation techniques including use of smoke)
- Weed management throughout the reserve (shelter area of reserve)
- Fencing of the reserve to minimise unauthorised access and dumping
- Development of detailed rehabilitation plan involving input from CALM ?? DEP
- Negotiations between DEP and Shire to determine long term rubbish disposal options for Yarloop

## Provision of Land to the Conservation Estate

- Identification of suitable vegetated land on adjoining Bunnings land 9.91 ha
- Conditional Contract of Sale currently being finalised
- Land to be transferred to the state for management as a conservation reserve
- Upgrade of fencing to appropriate standard to prevent stock access (restrict access

draft contract req'd

will have before Monday

# Other Relevant Information

## Reserve 31900

- Current use as rubbish disposal site and for sand extraction
- Although DEP has indicated that the tip will not be relicenced, Shire of Harvey have not ruled out continued use of the Reserve for rubbish disposal or for a transfer station
- Closure of Yarloop tip has not been planned or resourced
- Rehabilitation of the reserve has not been planned or resourced
- Even with removal of the active tip operations the reserve will continue to be threatened by continued weed invasion, unauthorised dumping and windblown rubbish

## Other Yarloop Reserves

- Reserve 23307 is unvested. Reserve 31901 is vested with MRWA. CALM has initiated the process to obtain vesting of these reserves.
- MRWA wish to widen the South West Highway through Yarloop by taking part of the reserves to the east of the highway
- Reserve 23307 has had vegetation cleared to establish a truck parking bay

## Summary of Environmental Issues, Potential Impacts and Management

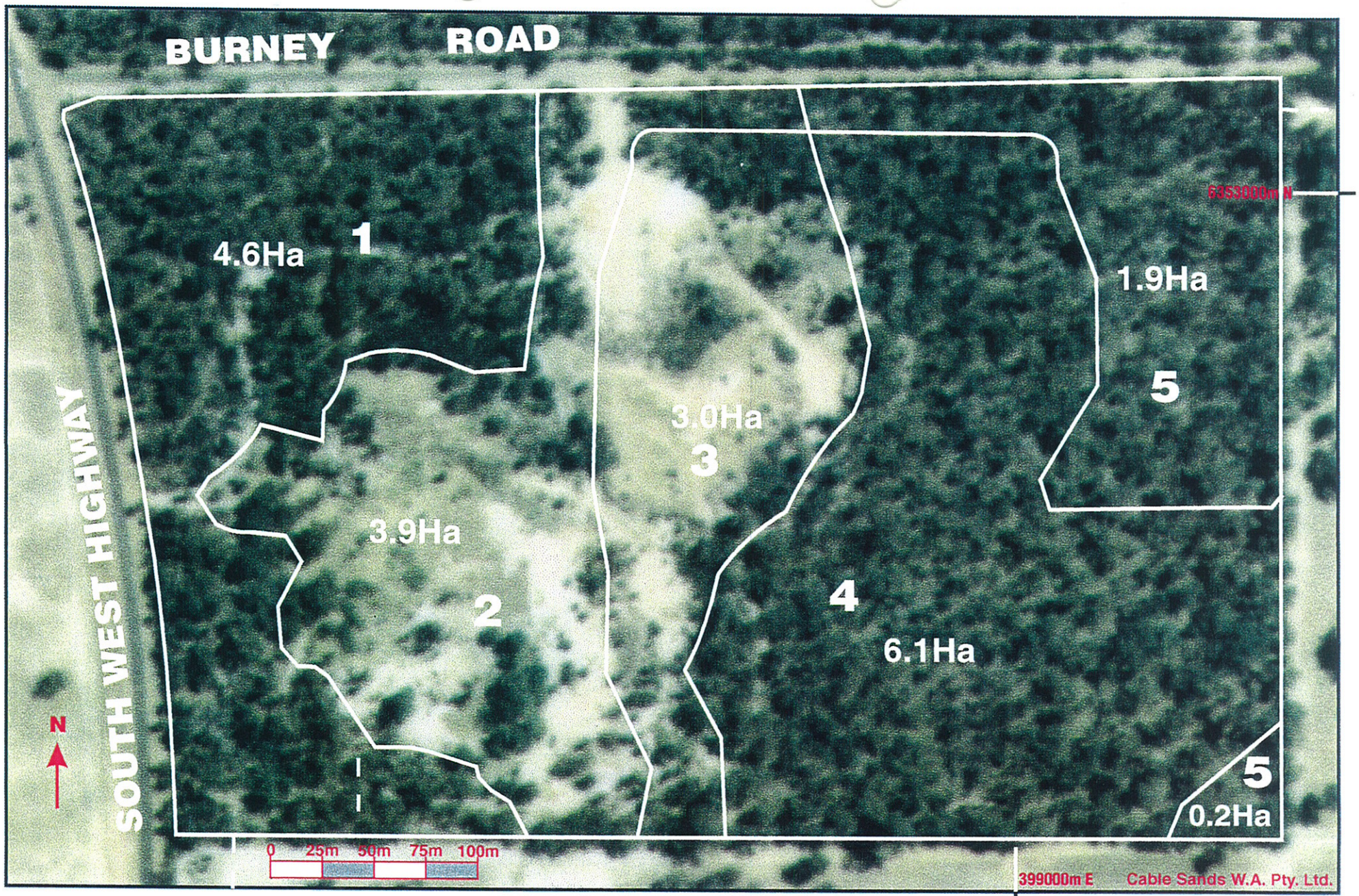
| FACTOR | EPA OBJECTIVE | EXISTING ENVIRONMENT | POTENTIAL IMPACT | MANAGEMENT | PREDICTED OUTCOMES |
|---|---|---|---|---|---|
| **BIOPHYSICAL** | | | | | |
| Vegetation Communities | To maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities. | The values and condition of vegetation vary across the reserve. The eastern side of the reserve has significant conservation value.<br>The reserve is subject to substantial threatening processes as result of the operation, within the reserve, of a tip and sand pit. | About 6.1 hectares of vegetation with significant conservation value will be cleared. | Rehabilitation of mined and unmined areas of the reserve to improve vegetation values.<br>About 10 ha of land with vegetation of comparable conservation value will be acquired for incorporation into the conservation estate. | Overall the reserve will have increased conservation value in the long term. Increased protection, security and management of vegetated areas with conservation value |
| Declared Rare and Priority Flora | To protect Declared Rare and Priority Flora, consistent with the provisions of the *Wildlife Conservation Act 1950.* | Declared Rare or Priority Flora have not been located in the reserve. | No impact | Refer to vegetation communities above. | No impact. |
| Fauna | To maintain the abundance, species diversity and geographical distribution of fauna | Faunal values of the reserve are low. | A small amount of Jarrah Forest habitat will be cleared. | Refer to vegetation communities above. | Improved habitat in the reserve for fauna in the long term. |
| Specially Protected (Threatened) and Priority Fauna | To protect Specially Protected (Threatened) and Priority Fauna and their habitats, consistent with the provisions of the *Wildlife Conservation Act 1950* | Unlikely to be present or dependent on habitats in the reserve. | Negligible. | Refer to vegetation communities above. | Negligible |
| Landform and Rehabilitation | To establish stable sustainable landform consistent with surroundings<br>To ensure proposal area and any other area affected by the proposal, is rehabilitated to a standard consistent with the intended post mining long term land use. | Substantial areas of the reserve are degraded and subject to threatening processes. Refer also the vegetation communities above. | NA | Application of rehabilitation procedures in mined and unmined areas consistent with long term land uses and conservation values.<br>Rehabilitation plan to be prepared and submitted for approval. | Refer vegetation communities above. |

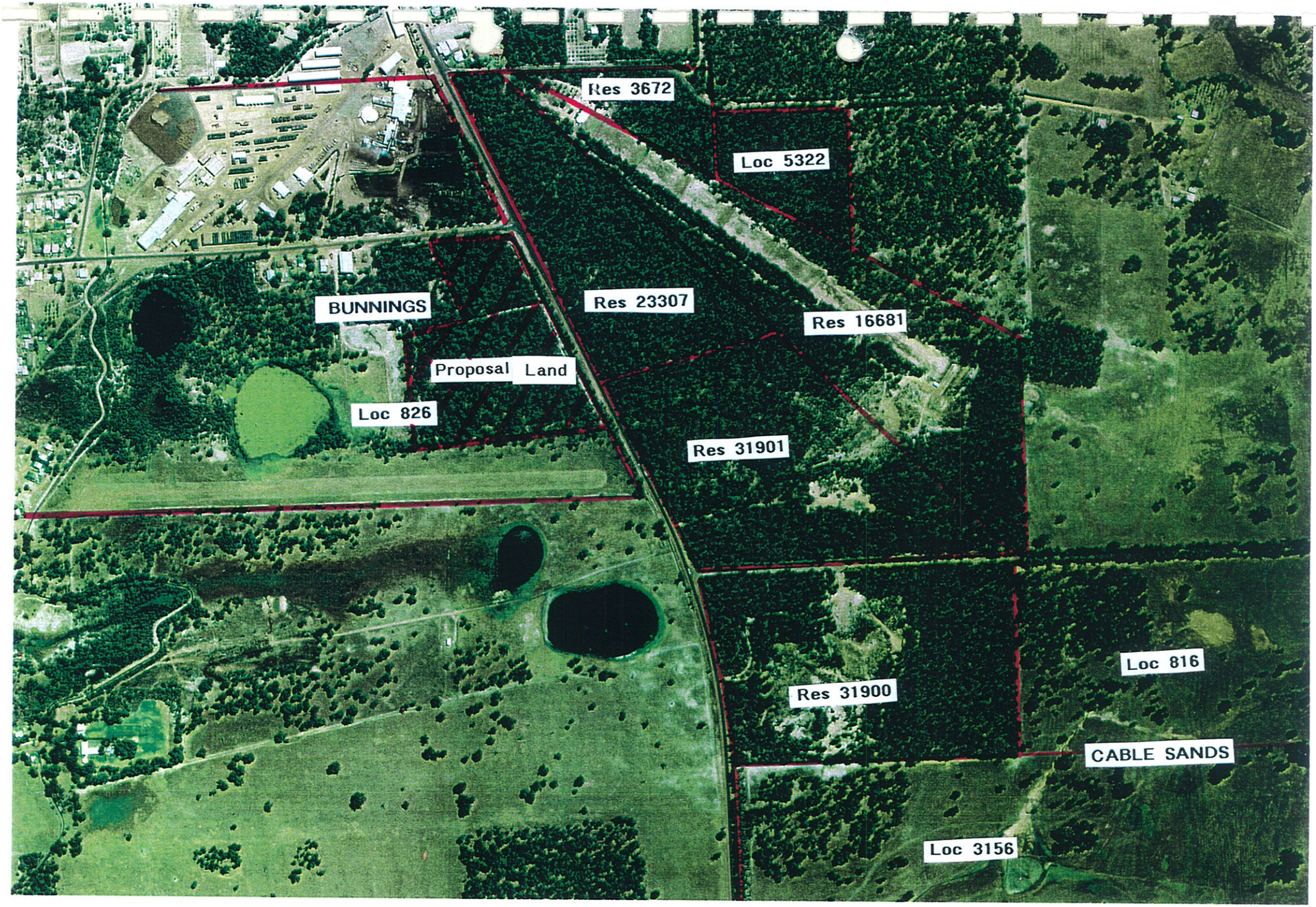
| FACTOR | EPA OBJECTIVE | EXISTING ENVIRONMENT | POTENTIAL IMPACT | MANAGEMENT | PREDICTED OUTCOMES |
|---|---|---|---|---|---|
| **POLLUTION MANAGEMENT** | | | | | |
| Particulates/Dust | To ensure that particulate emissions, both individually and cumulatively, do not cause an environmental or health problem.<br>To use all reasonable and practicable measures to minimise the discharge of particulate wastes. | Adjoins an existing sand mining operation. The nearest residence is 1 km away. | Potential visible emissions and nuisance. | Dust suppression procedures applied in accordance with good industry practice. | Negligible |
| Greenhouse gases | To ensure that greenhouse gas emissions, both individually and cumulatively, do not cause an environmental or health problem.<br>To use all reasonable and practicable measures to minimise the discharge of greenhouse gases. | NA | Minor release of greenhouse gases. | All reasonable and practicable measures will be taken to reduce energy consumption. | Minor release of greenhouse gases. |
| Surface water quality | To maintain or improve the quality of surface water to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters | The reserve does not contain any significant watercourses.<br>No significant amount of acid generating materials in the ore body. | Potential offsite release of turbid water and hydrocarbon spillages. | Water will be use in a closed circuit and offsite discharge of waste water will not occur.<br>Fuel storage areas to be bunded | No significant impact |
| Noise | To ensure noise impacts emanating from the proposal comply with statutory<br>requirements and acceptable standards. | The surrounding environment is rural but the proposal adjoins the South West Highway. | Noise emissions have the potential to breach noise regulatory levels at sensitive premises. | Restrictions on mine operations at night. Noise suppression equipment on equipment and construction of noise bunds. | Compliance with noise statutory standards. |

| FACTOR | EPA OBJECTIVE | EXISTING ENVIRONMENT | POTENTIAL IMPACT | MANAGEMENT | PREDICTED OUTCOMES |
|---|---|---|---|---|---|
| **SOCIAL SURROUNDINGS** | | | | | |
| Visual amenity | Visual amenity of the area adjacent to the project should not unduly be affected by the proposal. | Surrounding landscape is rural; with wooded areas. The mine adjoins the South West Highway. Nearest residence is 1 km away. | The visual amenity road users and neighbours may be potentially affected. | Vegetation buffers and vegetated bunds would be established between the mine and the South West Highway and neighbours. | Visual amenity would not be unduly affected |
| Aboriginal culture and heritage | To ensure that the proposal complies with requirements of the *Aboriginal Heritage act 1972.*<br>To ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations with the area. | Aboriginal sites unlikely to be present | No impact | Production will cease if sites are discovered. | Compliance with the Aboriginal Heritage Act 1972. |

## Possible Outcomes for Reserve 31900

| | Current Situation | Mining Not Allowed | Mining Allowed |
|---|---|---|---|
| **Conservation Estate in Yarloop** | No conservation reserves | Likely 32ha of conservation reserves (Res 23307 and Res 31901) | Likely 42ha of conservation reserves (Res 23307, Res 31901and Bunnings land) |
| **Reserve31900** | Rubbish tip operating<br><br>12.8 ha native vegetation under threat<br><br>6.9 ha degraded area enlarging<br><br>Threatening processes :<br>Aggressive Weeds<br>Rubbish disposal<br>Windblown rubbish<br>Firewood collection | Rubbish tip may close leaving degraded reserve areas<br><br>12.8 ha native vegetation under threat<br><br>6.9 ha degraded area enlarging<br><br>Threatening processes continue:<br>Aggressive Weeds<br>Rubbish disposal(authorised or not)<br>Windblown rubbish<br>Firewood collection | Largely intact reserve more likely to be managed for conservation<br><br>6.7 ha native vegetation<br><br>11-13 ha rehabilitated native veg<br><br>Threatening processes reduced:<br>Weed control programme<br>Fencing to reduce access<br>Rubbish buried<br>Access reduced |
| **Bunnings land** | Freehold land not managed for conservation values<br><br>Inappropriate fencing | Freehold land not managed for conservation values<br><br>Inappropriate fencing | Land managed for identified conservation values<br><br>Fencing upgraded |
| | | | |


BURNEY ROAD
SOUTH WEST HIGHWAY
4.6Ha
1
3.9Ha
2
3.0Ha
3
4
6.1Ha
1.9Ha
5
5
0.2Ha
N
0 25m 50m 75m 100m
6353000m N
399000m E
Cable Sands W.A. Pty. Ltd.


Res 3672
Loc 5322
BUNNINGS
Res 23307
Res 16681
Proposal Land
Loc 826
Res 31901
Loc 816
Res 31900
CABLE SANDS
Loc 3156

# ENTERED ON GIS

**Name:** Yarloop Titanium Minerals Mine – Consultative Environmental Review
**Date:** 24/04/2006
**Capture Author:** Thomas Leong

**Comments:**
*Polygon*
Creating to match documented study area with high level of accuracy

Accuracy Levels:

- High = Document contained visual references easily copied, resulting in little or no polygon boundary errors
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Report Info – Captured without problems
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Content – Captured without problems

**MEMO TO:** Directors,
Policy Division & Pollution Prevention Division

**FROM:** Director, Evaluation

**DATE:** 10 July 1996

**SUBJECT:** **CER - Yarloop Titanium Minerals Mine**

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Cable Sands' CER is now in the public review period (8 July 1996 to 5 August 1996). A copy is attached for your consideration and comment.

As you are aware from previous consultations, the key issue of this proposal is the inclusion within the mine area of a System 6 Interim Protection Area containing threatened or poorly reserved plant communities (p12)

With regard to Part V, the mining process will involve the use of a mobile screening plant (2 locations to be used during life of project). A wet gravity separation method is being used for the heavy mineral concentrate (p18). Shallow ground water abstraction bores are also proposed.

Please forward your comments/advice to me by 5 August 1996. (Deanna Juxford ext 7047).

GRAEME KININMONTH
SENIOR ENVIRONMENTAL OFFICER

**CABLE SANDS (W.A.) PTY. LTD.**
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Clear about cavn type.
Status re:
Need consideration of no of these sites that are liable to be mined. check info sent by Tony Smurthwaite.

Proponents need to take into consideration the affect the mining will have on ground water levels & likely affect this will have on adjacent reg^.

?

# YARLOOP TITANIUM MINERALS MINE

## CONSULTATIVE ENVIRONMENTAL REVIEW

CABLE SANDS (WA) Pty Ltd

July 1996

# INVITATION

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

The Consultative Environmental Review (CER) proposes the mining of titanium minerals at Yarloop. The proponent for the proposal is Cable Sands (WA) Pty Ltd. In accordance with the Environmental Protection Act has been prepared which describes this proposal and its likely effects on the environment. The CER is available for a public review period of 4 weeks from 8 July 1996, closing 5 August 1996.

Comments from government agencies and from the public will assist the EPA to prepare an assessment report in which it will make recommendations to government.

**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 will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in each report.

**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 help to 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 discussed in the CER or the specific proposals. 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 the CER:

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

**Points to keep in mind**

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

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;

- refer each point to the appropriate section, chapter or recommendation in the CER;

- if you discuss different sections of the CER 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,
- address,
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is 5 August 1996.

Submissions should be addressed to:

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

Attention: Colin Murray

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## EXECUTIVE SUMMARY

This Consultative Environmental Review relates to a Cable Sands (WA) Pty Ltd proposal for the mining of titanium minerals from a deposit identified at Yarloop. The deposit is located two kilometres south east of Yarloop on the eastern side of the South West Highway. The deposit is on post-1899 titles with mineral rights belonging to the state. Mining will occur under mining lease M70/49 with adjoining additional leases M70/937 and M70/938 pending. The mining proposal is to commence mining in early 1997 following mine development commencing late in 1996.

This document describes and appraises the environment in which the orebody is located, outlines the proposed method of mining, outlines the transportation of heavy mineral concentrate to the Bunbury plant, identifies environmental impacts and outlines an environmental management policy.

The orebody consists of two occurrences of heavy minerals separated by the creek adjacent to Black Rock Road. The area to be affected will primarily consist of cleared agricultural land owned by Cable Sands. An area to the north contains a small reserve vested with the Shire of Harvey as the Yarloop refuse tip and an area of private property to the south is owned by Mr Andrew Jenkins. Agreements have been reached with the Shire of Harvey and are continuing with Mr. Jenkins.

The mining operation will be performed as a dry mining project with work occurring in the following sequence :

* Removal of vegetation
* Stripping and storage of topsoil
* Removal and stockpiling of overburden where necessary
* Mining of ore and separation of minerals
* Backfilling and recontouring of overburden and tailings
* Re-establishment of vegetation using natural regeneration from returned topsoil and supplementary seeding and planting of juvenile plants where applicable.

Water requirements will be met by a series of shallow bores located west of the minesite and pumped to a holding dam on site.

Heavy mineral concentrate will be transported south along the South West Highway then via Robertson Drive, the Eelup roundabout and Koombana Drive to Cable Sand's North Shore operations in Bunbury. This route is currently used for transporting heavy mineral concentrate from Waroona to Bunbury.

Rehabilitation of mined land will be incorporated into the mining process. Recontouring with overburden, final tails and slimes will return the landscape to a similar topography. Stored topsoil will be replaced and vegetation similiar to pre-mining will be established.

The relatively high clay content of the mineral deposit means that a series of slimes dams will be required. These will be mainly confined to the cleared areas.

The rubbish tip reserve contains an area of Ridge Hill Shelf vegetation complex which is comparatively rare along the coastal plain due to extensive clearing for agriculture. The area of this vegetation affected will be as restricted as practicable and rehabilitation will re-establish species currently found there. A detailed rehabilitation plan will be produced for the area affected by mining. The opportunity will be taken, in consultation with relevant authorities to improve the condition of the degraded area to the west of the orebody. The end result will be an area sympathetic with the adjacent proposed A-class reserve and available for consideration as part of a System Six Conservation Reserve.

A rubbish tip area will be available during the mining operations and following mining an area will be established for the continuation of the tip.

Environmental management of the mining operation will result in procedures that limit the impact of light, dust and noise in the vicinity.

Community consultation has occurred involving local residents and Shire of Harvey councillors and staff. Ongoing consultation is considered important to the success of the mining operation.

Cable Sands has a proven environmental record as evidenced by the rehabilitation of former minesites and recognised with the John Tonkin Award in 1988. The management commitments that resulted in these awards will be applied to the Yarloop project in a way that minimises the environmental impact of the operation.

## SUMMARY OF COMMITMENTS

| Category | Topic | Section of CER | Objective | Management Commitments | Timing * | To the Satisfaction of : |
|---|---|---|---|---|---|---|
| Environmental Management | | 4.1 | * To achieve responsible environmental management | 1. Conduct regular environmental audits<br>2. Annual reporting of environmental performance to appropriate authorities<br>3. To progress development of an accredited Environmental Management System | Throughout mine life | DEP<br>DoME |
| Biophysical Environment | Flora | 2.6, 4.3 | * To minimise disturbance of Ridge Hill Shelf complex in reserve #31900 | 1. Minimise area of reserve #319000 impacted to the area required for extraction of ore.<br>2.Locate infrastructure and plant on cleared land | Throughout mine life | DoME |
| | Fauna | 2.7 | * To ensure that impact on fauna in the project area is minimised | 1. Restrict area of reserve #319000 impacted to the area required for extraction of the ore. | Throughout mine life | DoME |
| | Rehabilitation | 4.4 | * To rehabilitate affected areas to a standard compatible with current landuse | 1. To develop a rehabilitation plan for the mined area of reserve #31900 which reestablishes a woodland of similiar character to that existing<br>2. To consult with relevant authorities regarding improving condition of degraded section of Reserve#31900<br>3. To consolidate the rubbish tip area with appropriate fencing and access<br>4. To re-establish productive pasture with shelter and shade belts on current agricultural land. | Prior to mining<br>During mining<br>After mining<br>During and after mining | Shire of Harvey<br>DoME |
| | Hydrology | 4.2 | * To ensure that stream flows during winter are not adversely affected | 1. To monitor water usage from the Yarloop borefield<br>2. To prevent restriction of stream flow in the mine plan. | Throughout mine life<br>Prior to mining | DEP |
| Pollution Potential | Noise | 5.1 | * To minimise noise impacts on neighbouring properties<br>* To comply with statutory noise requirements | 1. Restrict earthmoving operations at night to within the pit as far as possible<br>2. Replace reversing beepers with flashing lights at night<br>3. Fit acoustic mufflers to earthmoving equipment<br>4. Construct noise reducing bunding where appropriate<br>5. Vegetation screens will be established or enhanced and maintained | Throughout mine life<br>Throughout mine life<br>Throughout mine life<br>Throughout mine life<br>Throughout mine life | DEP |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Dust | 5.2 | * To minimise dust impacts associated with haulage<br>* To minimise dust impacts associated with earthmoving, stockpiling and rehabilitation | 1. Haulage roads will be wetted down using a water cart when required<br>2. Stockpiles will be vegetated as far as practical to reduce dust<br>3. Mine planning will keep disturbed areas to a minimum and will retain maximum vegetation<br>4. Vegetation screens will be established or enhanced and maintained | Throughout mine life<br>Throughout mine life<br>Prior to mining<br>Throughout mine life | DEP |
| | Water | 4.2 | * To have no discernible impact on water quality | 1. To regularly monitor water quality in local creeks and piezometres and respond appropriately to any measured anomolous results | Throughout mine life | DEP<br>WRC |
| | Visual | | * To reduce visual impact of the minesite | 1. Vegetation screens and bunding will be enhanced or maintained | Throughout mine life | DEP |
| | Radiation | 4.5 | * To keep surface radiation levels below pre-mining | 1. Use of approved procedures for handling process materials<br>2. Monitoring of rehabilitated areas to ensure acceptable radiation levels and modifying any high levels with low level material. | Throughout mine life<br>During and after mining | DoME |
| Social Impacts | Traffic | 3.3 | * To ensure trucking of heavy mineral concentrate has minimal impact on neighbours | 1. Maximise trucking during daylight hours on weekdays<br>2. Provide appropriate access to the South West highway causing minimum interruption to traffic flow | During mining<br>During development | DEP<br>Main Roads |
| | Aboriginal Heritage | 5.3 | * To avoid interfering with any sites of aboriginal significance | 1. If any aboriginal sites are unearthed production will cease until appropriate consultation with Dept. of Minerals and Energy and the Dept. of Aboriginal Affairs | Throughout mine life | Dept. Aboriginal Affairs |
| | Community Consultation | 5.7 | * To keep the community aware of all relevant aspects of the mining operation | 1. Develope a plan for consultation during development and operation of the mine | Prior to mining | DEP |

**** Throughout mine life is defined as all stages from pre-mine planning to decommissioning.***

## SUMMARY OF ISSUES AND MANAGEMENT OF YARLOOP TITANIUM MINERALS MINE

| Category | Topic | Aspect of Concern | Present Status | Managment Objectives | Management Proposed | Outcome |
|---|---|---|---|---|---|---|
| Biophysical Environment | Vegetation / Rehabilitiation | Loss of Native Vegetation | Reserve 31900 has 12ha native vegetation in good condition and 8 ha degraded | * Minimise area of the reserve cleared.<br>* Rehabilitate to diverse woodland. | 1. Only clear area of orebody plus that required for removal of ore.<br>2. Recontouring orebody after mining including layer of retained topsoil.<br>3. Rehabilitation as soon as possible after mining using locally collected seed and rootstock supplemented where necessary. | Temporary loss of woodland area.<br>Rehabilitated diverse woodland with compatible with adjoining reserves. |
| | | Loss of agricultural land | Remainder of area to be impacted is cleared. | * Return to productive pasture as soon as possible | 1. Recontour area compatible with other landforms.<br>2. Incorporate slimes into upper layers.<br>3. Seed and fertilise to establish pasture.<br>4. Plant trees where appropriate. | Temporary loss of agricultural land.<br>Rehabilitated agricultural land of similar character to premining. |
| | Fauna | Impact on rare or endangered fauna | No rare or endangered species identified in Reserve 31900 or adjoining farm land. | * No adverse impact on fauna | 1. None required | Temporary loss of potential habitat in reserve. |
| | Hydrology | Impact on surface water | Seasonal creek through site | * Not to interfere with creek flows | 1. Mine design to avoid impeding creek | No significant impact on hydrology. |
| | Radiation | Increase in radiation levels | Levels typical of Swan Coastal Plain | * No increase in radiation levels.<br>* Compliance with relevant statutory requirements | 1. Majority of radioactive material removed with HMC | Decrease in radiation levels on site. |
| Pollution Potential | Dust | Loss of amenity for neighbours | Levels typical of agricultural areas | * Minimise dust generation.<br>* Compliance with DEP guidelines | 1. Watering roadways.<br>2. Retricting dust generating activities on high wind days.<br>3. Vegetate topsoil stockpiles.<br>4. Maximise vegetation screens<br>5. Rehabilitate as soon as possible after mining. | Minimal impact from dust during mining.<br>No long term change following revegetation. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Water | Polluction of waterways or ground water | Water quality variable with seasonal conditions | * Prevent impacts of process on water.<br>* Compliance with statutory requirements and specified guidelines | 1. Bunding of hydrocarbon storage.<br>2. Recycling of process water | Minimal impact on water quality. |
| | Noise | Loss of amenity for neighbours | Levels typical of areas along South West Highway | * Minimise noise generation.<br>* Compliance with DEP guidelines | 1. Limit night time earthmoving operation.<br>2. Use flashing lights at night.<br>3. Use acoustic mufflers.<br>4. Construction of bunding. | Minimal impact of noise. |
| Social Surrounding | Visual | Loss of amenity | Vegetation sceening along highway | * Minimise visual impact.<br>* Prevent nuisance light spill. | 1. Maintain screening.<br>2. Use of bunding.<br>3. Maximise night time use of pit. | Minimal visual impact.<br>Minimal impact from light spill. |
| | Transport | Loss of amenity for neighbours | Site on major highway | * Minimise impact of trucking noise, dust and vibration. | 1. Locate truck entry away from houses.<br>2. Minimise transport at night and on weekends.<br>3. Water down roadways during summer. | Minimal impact of transporation. |

## 1.0 INTRODUCTION

This Consultative Environmental Review relates to a proposal for Cable Sands (WA) Pty Ltd to commence mining of the Yarloop deposit of titanium minerals.

The Yarloop deposit has been estimated to consist of 682,000 tonnes of titanium minerals composed primarily of ilmenite with minor amounts of leucoxene, garnet, zircon and monazite. Mining and preliminary concentration will occur on site with the heavy mineral concentrate (HMC) being transported to Bunbury for separation.

The life of the project is currently estimated as just over four years with development commencing in late 1996 and production in early 1997.

## 1.1 ENVIRONMENTAL APPROVAL PROCESS

This Consultative Environmental Review has been prepared as part of the requirements for environmental impact assessment as set out in the Environment Protection Act, 1986. It has been compiled under guidelines set out by the Department of Environmental Protection which are attached as Appendix 1.

The CER is subject to a four week public review period. Written submission are summarised and forwarded by the DEP to Cable Sands for response. The Environment Protection Authority then assesses the project and reports to the Minister of the Environment.

The Minister then publishes the report. Recommendations contained in the report are open to appeal for 14 days.

The Minister will then set conditions for the implementation of the project.

## 1.2 PROPONENT

Cable Sands (WA) Pty Ltd is a Western Australian company which is the oldest titanium mineral mining company in the state. Mining commenced in 1956 at Koombana Bay and has continued through a series of mineral deposits at Busselton, Capel, Waroona, Wonnerup and Minninup. Currently operating minesites are located at Busselton, Waroona and Jangardup and a new minesite at Capel will replace Busselton in the middle of 1996.

Development of the Yarloop minesite represents a continuation of the company's operations in the south-west. The Yarloop mine will replace the production from the current Waroona operations when that deposit is exhausted.

## 1.3 LOCATION

The proposed mine is located two kilometres south of the town of Yarloop in the Shire of Harvey. The mining leases are bounded by the South Western Highway to the west, Burney Road to the north and extend north and south of Black Rock Road. The location is shown as Figure 1. Figure 2 shows the mining leases which are discussed in detail in section 1.4 below. An aerial photograph of the site is shown as Figure 3.

The town of Yarloop has a population of 587 (1991 census). The Bunnings timber mill is the main industry in Yarloop employing approximately 90 people. Alcoa's Wagerup alumina refinery is located approximately three kilometres north of Yarloop.

## 1.4 OWNERSHIP

A mining lease, M70/49 (see Fig.2 for location) was granted to Cable Sands at Yarloop on the 18th of September 1986 extending over all or part of 5 titles. The title details are given below and are shown on Fig 3. These are all post-1899 titles and as such minerals belong to the crown.

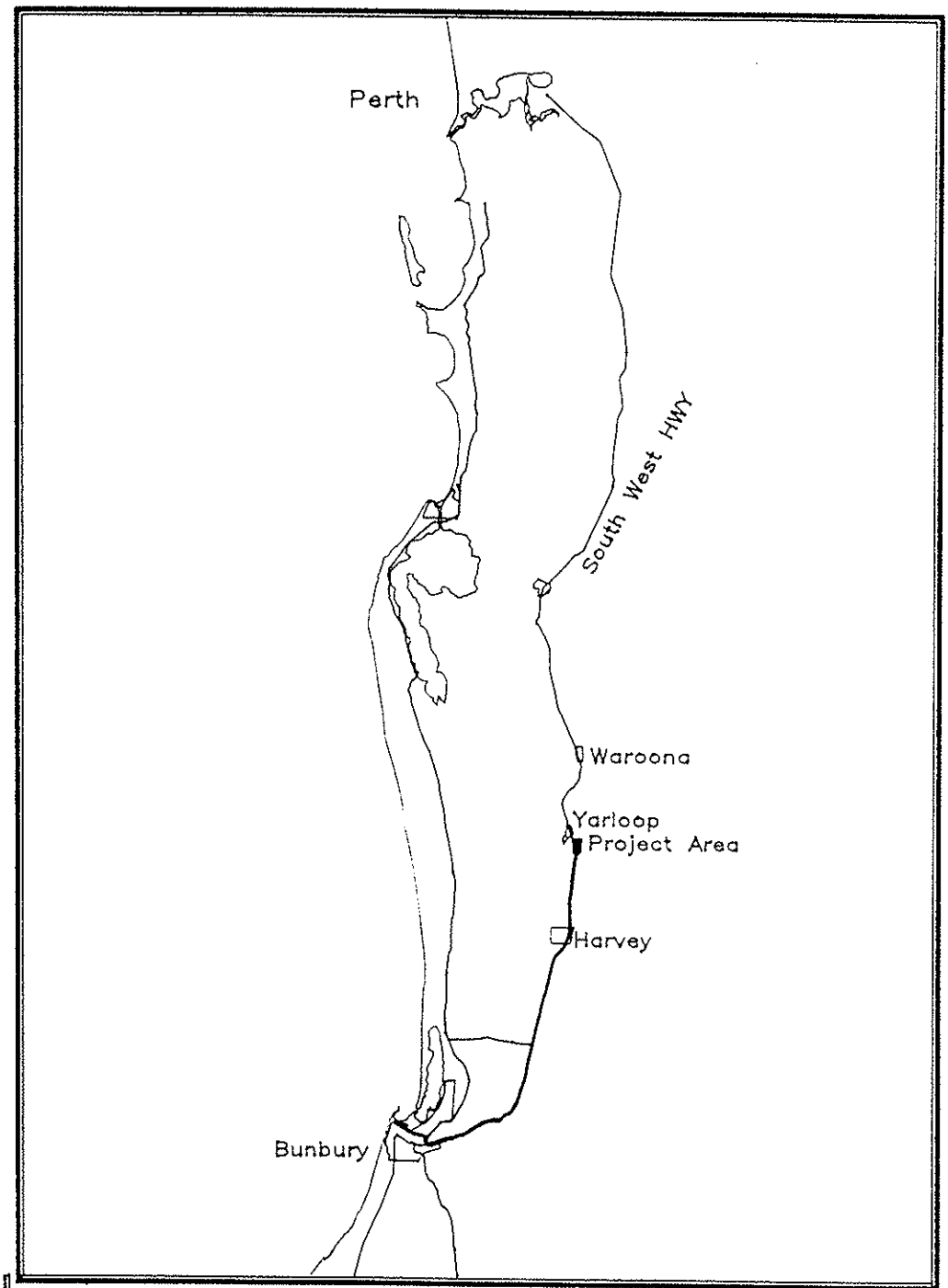
| LOCATION | VOLUME | FOLIO | AREA(ha) | OWNER |
|---|---|---|---|---|
| Wellington Locn 816 | 1521 | 978 | 40.4686 | Cable Sands |
| Wellington Locn 3156 | 1405 | 195 | 90.9987 | Cable Sands |
| Wellington Locn 3156 | 1405 | 196 | 25.1093 | Cable Sands |
| Wellington Locn 3156 | 1212 | 744 | 329.5188 | Mr A Jenkins |
| Reserve 31900 5112 | | | 19.6995 | |

Cable Sands owns the first three of these listed titles. Wellington Location 3156 Vol 1212 Fol 744 is owned by Mr. A. Jenkins and Reserve 31900 5112 is vested with the Shire of Harvey as a sand pit and rubbish disposal reserve.

Two additional mining leases have been applied for adjacent to M70/49. These areas have been included to extend the area of orebody mined to the south and to increase areas for slime dam construction and other infrastructure if required. At present it is anticipated that only a relatively small area of the extended leases will be utilised.

M70/937 covers the remainder of Wellington location 3156 Vol. 1405 Folio 195 and Wellington location 816 Vol. 1521 Folio 978 to the east of the northern section of M70/49. These are two of the Cable Sands owned blocks.

M70/938 covers an additional section of Location 3156 Vol 1212 Fol 744 (owned by Mr A Jenkins) and part of Wellington location 3156 Vol. 1686 Folio 866. This land is owned by Mrs V Armstrong.




CABLE SANDS (WA) Pty. Ltd.

Location of Yarloop Project Area

Trucking Route ——

| | | |
|---|---|---|
| DRAWN : ssc | SCALE 1 : 999999 | FIGURE 1 |
| DATE : 19 MAR 1996 | CHECKED : | |

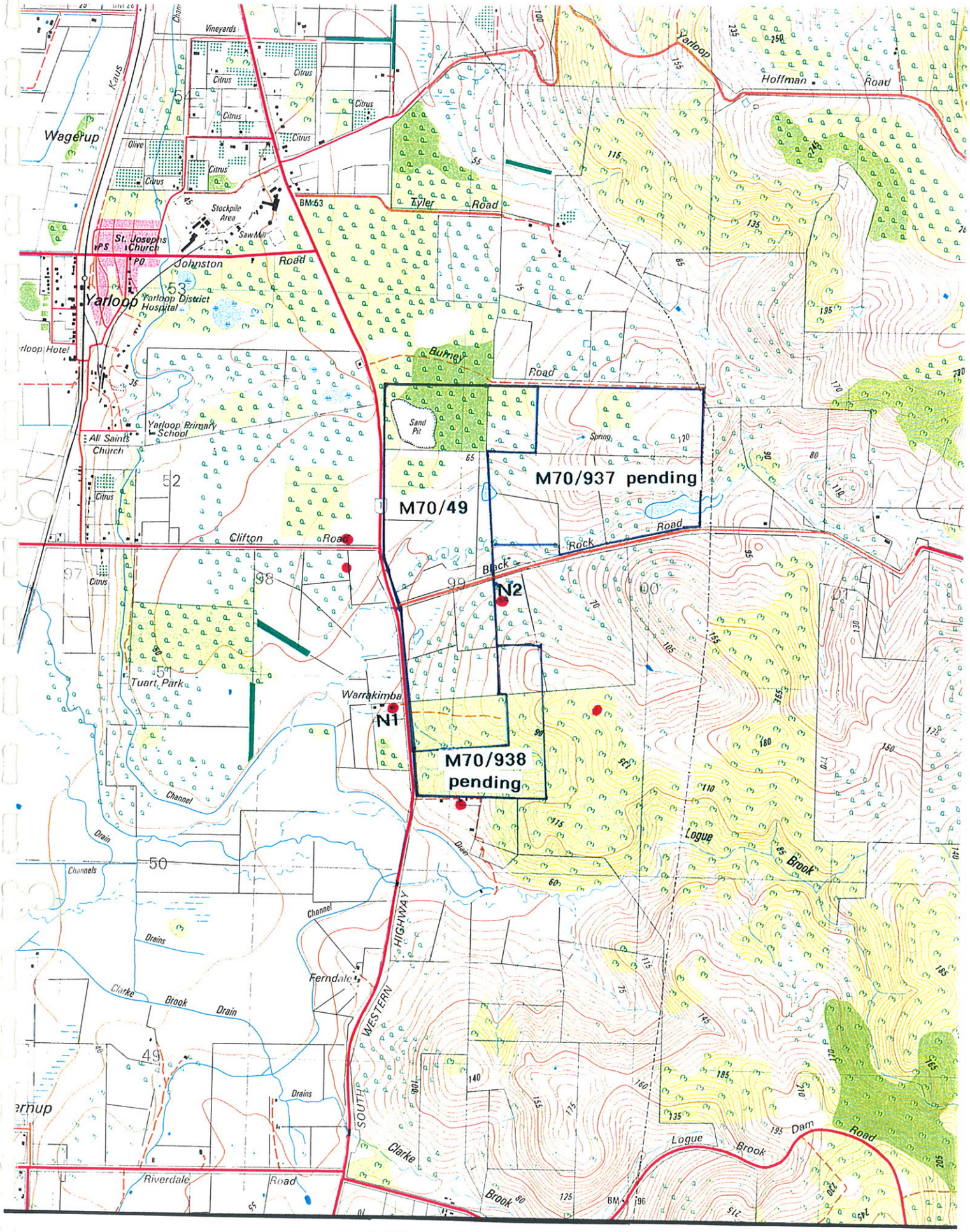



**Fig 2 Mining Lease Locations**

Mining Lease Boundaries
Location of Neighbours
Noise Monitoring Sites N1

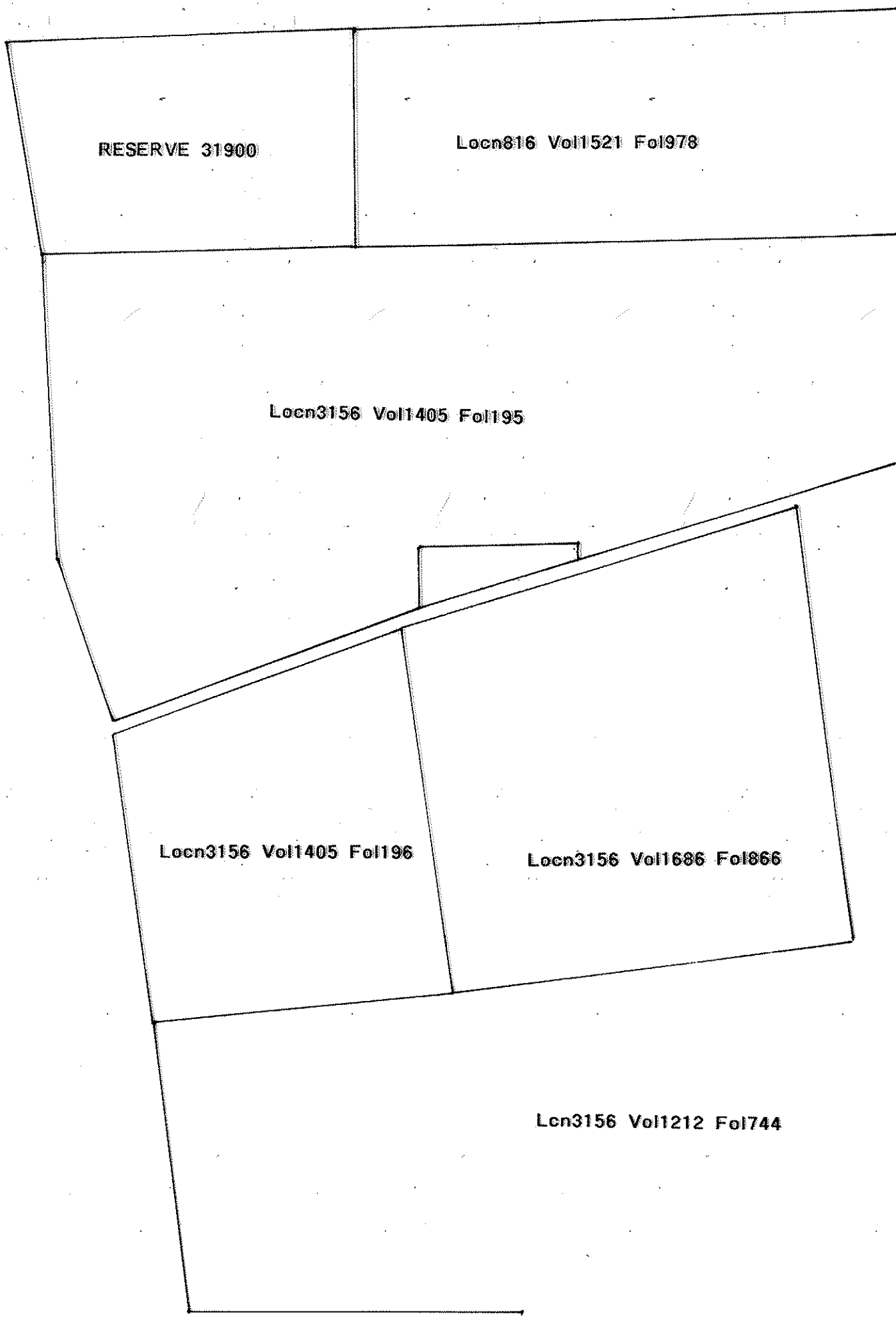

RESERVE 31900
Locn816 Vol1521 Fol978
Locn3156 Vol1405 Fol195
Locn3156 Vol1405 Fol196
Locn3156 Vol1686 Fol866
Lcn3156 Vol1212 Fol744




Fig 3. AERIAL PHOTOGRAPH OF YARLOOP PROJECT AREA
APPROXIMATE BOUNDARY OF MINING IMPACT

## 1.5 HISTORY

Development in the area was initially associated with timber production. A mill was established at Yarloop toward the end of last century shortly after the Perth to Bunbury railway was opened in 1893 (Staples, 1979).

Clearing of the area for agriculture in close proximity to the town quickly followed and the project area has been extensively cleared since the early part of the century. This area can currently be described as parkland cleared, scarp region broadacre farmland.

## 1.6 EXISTING FACILITIES

The existing facilities are limited and will be provided during mine establishment. South-west Highway adjoins the mine site and access to the minesite will be off this highway to the north of Black Rock Road and off Black Rock Road when the plant is moved to the southern section of the mine.

# 2.0 EXISTING ENVIRONMENT

## 2.1 REGIONAL SETTING

The South-west region of Western Australia is an important mining, processing, agricultural, manufacturing, timber and tourism region.

Mining and mineral processing is a $2.8 billion industry based largely around the alumina and titanium mineral industries. In the Yarloop area these industries are represented by Alcoa's Wagerup alumina refinery 3 kilometres north of Yarloop and titanium minerals mines currently operated by Cable Sands (Waroona South) and previously operated by Cable Sands (Waroona North) and ISK.

The South-west region also includes Western Australia's main centres for the dairy, horticulture and timber industries. Bunnings Yarloop sawmill is one of a reducing number of timber mills throughout the south-west.

Bunbury acts as a service city and port for the industries within the area. Bunbury has a population of approximately 28,000 with over 5,000 people residing in the Australind area.

The coastal area south of Perth is dominated by two main landforms - the Swan Coastal Plain and the Darling Plateau. The Swan Coastal Plain extends for approximately 25 kilometres from the Darling Scarp to the ocean. It is composed of a series of sedimentary materials of different ages deposited over millions of years. Mineral sands mining occurs where the sorting and deposition of heavy mineral sands occurs in sufficient concentrations to make mining economically viable.

## 2.2 GEOLOGY

The Yarloop heavy mineral deposit is part of the Waroona shoreline (Baxter, 1977). It lies at the foot of the Darling Scarp on the Swan Coastal Plain. The deposit was once continuous but now consists of two separated occurrences of heavy minerals having been dissected by the erosional incisement of a creek off the Darling Scarp. The stranded beach sequence rich in heavy minerals is juxtaposed against a line of sea-cliffs. The cliffs trend somewhat parallel to the line of the Darling Scarp - the cliffs do not occur in a perfectly straight line but oscillate mildly about their trend (approximately north). They are remarkably steep. Drilling information has shown that the cliffs rise as much as 12 metres over a horizontal distance of only 6 metres. Elsewhere the cliffs are much less steep, rising 6 metres over 6 horizontal metres. The cliffs are composed of a very coarse quartz rich sandy clay containing only traces of heavy minerals. Heavy minerals have accumulated thickest close to the cliff and gradually thin westward until only a metre of heavy mineral rich sand can be recognised. This is shown in Fig. 4.

CABLE SANDS (WA) Pty. Ltd.

Fig 4. Yarloop cross section

| | |
|---|---|
| DRAWN : ssc | SCALE 1 : 1700 |
| DATE : 28 JUN 1996 | CHECKED : |

A more or less continuous sheet of laterite occurs across the top of the entire deposit. It is commonly exposed at or very near to the surface above the line of sea cliffs, covered by a thin sand sheet. West of the cliffs the lateritic horizon deepens, occurring between 5 and 10 metres below the surface. Here the laterite is covered by sand and sandy clay containing low to medium heavy mineral concentrations. In an idealised model the lateritic horizon is underlain by clayish sand often with abundant heavy mineral. The relative level of the bottom of the mineralised shore is about 43 metres occurring away from the sea cliff (off shore). No fossils were encountered during the drilling program. Coffee rock (indurated sand cemented by iron) is developed throughout the deposit with varying degrees of thickness and hardness.

The heavy mineral strands are underlain by a few metres of grey-brown, fine-gravelly, sandy clay. This in turn overlies a dark-grey, fine sandy clay of floury texture. This horizon is many metres thick and it contains abundant fine biotite, becoming harder and more coherent with depth. It is most likely a deeply weathered schistose/granitic rock.

## Regional Geology

The Yarloop area straddles the eastern margin of the Perth Sedimentary Basin. This contains a thickness of about 6000m of Phanerozoic sediments downfaulted against the pre-Cambrian basement of the Yilgarn Block by the Darling Fault. The shallowest superficial formations are of Quaternary age and have a thickness of up to 90m. These rest on an unconformity which slopes gently to the west below which there are a series of sediments of Cretaceous and Jurassic age. The youngest of these is the Leederville formation, the sediments of which thicken in a westerly direction from the scarp reaching a maximum of 170m. This formation unconformably overlies the Cockleshell Gully Formation (early - mid Jurassic) throughout the Yarloop area.

The Quaternary is represented by a series of almost flat-lying formations each of which have sometimes complex relationships with its adjoining units both laterally and stratigraphically. The characteristics of the formations occurring in the Yarloop region are:-

**Quaternary** **Guildford Formation**. This unconformably overlies the Jandakot Beds, the Yoganup Formation and the pre-Cambrian basement east of the Darling Fault. The deposits lie in the eastern half of the Swan Coastal Plain tending to thin westwards from a maximum of 30m. The sediments include a brown clay or sandy clay member in the east grading westwards into a more sandy member.

**Yoganup Formation**. This is probably a lateral equivalent of the Jandakot Beds and rests unconformably on the Leederville Formation and the pre-Cambrian rocks east of the Darling Fault. It consists of poorly sorted sands and clayey sands reaching a maximum thickness of 20 metres at the foot of the scarp.

**Jandakot Beds**. These unconformably overlie the Leederville Formation and consist of medium to coarse sand ranging down in grain size to a clay. The beds are believed to reach a thickness of 13 metres.

**Cretaceous** **Warnboro Group**. This has the interbedded sands and shales of the Leederville Formation as its main aquifer.

**Jurassic** **Cockleshell Gully Formation**. This occurs in the subsurface throughout the region and consists of interbedded sand and shale.

## 2.3 SOILS

The mineral lease is situated on the eastern margin of the Swan Coastal Plain which is characterised by undulating foothill slopes dissected by seasonal creeks and minor valleys. The landform-soil unit within the lease area is typical of the Forrestfield Unit, with laterised foothills of the Darling Scarp becoming sandier and less gravelly downslope to the west. In the north-west sector of the lease area, within the shire reserve, the sandiest soils occur, and sand quarrying has taken place. The sandy upper profile in this sector appears to have been formed during a period of unconsolidation by sand drifting from the adjacent Guildford landform-soil units further westward, and currently these overlie laterised Forrestfield soils.

## 2.4 HYDROLOGY

The Yarloop minesite lies on the eastern margin of the Swan Coastal Plain. This extends in a westerly direction from the Darling Scarp to the coast. The physiography is broadly of two types: a slightly undulating plain to the west of the site and much higher relief to the east.

The plain extends between the foot of the escarpment and the eastern margins of a series of elongate low fixed dunes on the east side of Lake Preston. The main drainage which crosses the plain in a north-westerly direction is the Harvey River. This is confined to the Harvey main drain for much of its course across the coastal plain.

The other physiographic region lying to the east of the proposed minesite is characterised by a relatively deeply dissected juvenile topography. This is drained by a series of westerly discharging streams including Waterous Formation Creek, Clarke and Logue Brooks as well as the Harvey stream system which discharges into the southern end of the Harvey Estuary. The natural flows of the streams are highly seasonal. The low flows in summer are principally sustained by discharges of shallow groundwater. However flows are augmented by the tail water of irrigation schemes and discharges from land drainage ditches.

### Hydrogeology

The quaternary sediments constitute a continuous aquifer extending over the whole Swan Coastal Plain. The flow system, hydraulic characteristics and water resources have been investigated in some detail by the Geological Survey of Western Australia. The results have been recorded in a series of publications.

The Yarloop area lies within the Waroona flow system which, in common with the adjoining systems, is directly recharged by infiltrating rainfall. It also receives recharge as leakage from the many irrigation channels through the area. Groundwater movement is dominantly westerly from the Darling escarpment down-gradient towards the Harvey River and main drain. The flow pattern is complicated by easterly groundwater movement from the Myalup flow system. This originates in the aeolian dunes to the west. Groundwater discharges in the form of spring flow to streams and transpirative draw by vegetation.

A series of interconnected groundwater bodies within the Leederville Formation and underlying Cockleshell Gully Formation are sustained by downward leakage from the Yoganup Formation.

Groundwater quality is directly controlled by the hydraulic characteristics and, to a lesser extent, by the chemical character of the sediments which provide the aquifer. Salinities tend to be particularly high where infiltration is hindered by a high clay content such as in the Guildford and Yoganup Formations. As a general trend, the total dissolved solid content of the waters tends to increase in a westerly direction towards the Harvey drains and river. The quality of the shallow groundwater is further adversely affected by the infiltration of brackish tail water from irrigation.

## 2.5 CLIMATE

The project area experiences a Mediterranean climate with hot, dry summers and mild, wet winters. Average rainfall at the nearest major meteorological station at Harvey, 14 km south of Yarloop, is 1013 mm and over 90% of this is experienced between April and October.

Average maximum temperatures, recorded at the Wokalup Research Station 20 km south of Yarloop, range from 30.9 degrees C in January to 16.7 degrees C in July and August. Average minimum temperatures range from 8.0 degrees C in August to 16.2 degrees C in February.

Strong winds are predominantly from the west. Winter storms bring squally winds from the north-west to south-west and summer afternoon sea-breezes are from the south-west. Hot dry easterly winds of moderate strength occur at night and early in the day during summer.

## 2.6 VEGETATION

An assessment of the vegetation at Yarloop has been undertaken to determine the significance of the project area. This assessment is attached as Appendix 2. This work and previous investigations in adjacent bushland (Keighery, 1995) and Reserve 23307 (CALM, unpublished) have found no rare or priority listed flora in the Yarloop reserves.

The native vegetation at the Yarloop site has largely been cleared for agriculture. There is a small remnant located at the northern end of the mining lease and this is one of the few remaining areas of native vegetation on the Forrestfield landform-soil unit. This remnant is restricted to Reserve 31900 in the area to be affected by mining and is part of a larger remnant formed with four reserves north of Burney Road.

Two vegetation community types have been identified in these reserves (Keighery, 1995). These are *Eucalyptus calophylla - Eucalyptus marginata* woodland on sandy clay soils and Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands which are types 3b and 20b respectively in "A Floristic Survey of the southern Swan Coastal Plain" (Gibson et al, 1994).

Reserve 31900 is partly cleared for quarrying and landfill. Of a total reserve area of 20ha approximately 8ha is currently degraded, some severely, by sand excavation and the current rubbish tip. In the eastern section the Type 3b remnant vegetation is generally in good condition, being relatively diverse and with dense foliage cover. This occupies approximately 8ha. Type 20b is restricted to the western section in Reserve 31900 and is remote from mining.

A section of the area of the reserve that will be mined is located to the east in the Type 3b vegetation. The overstorey here reflects the sandier soils of the site, with Jarrah co-dominant in the forest overstorey (20-28 metres in height) with *Allocauarina fraseriana* and *Banksia grandis* forming a lower stratum (2 - 3 metres in height). *Banksia attenuata* is also present but not common and *Xylomelum occidentalis* also occurs in the low tree stratum.

A tall shrub stratum (1-2 metres in height) which includes *Jacksonia sternbergiana*, juvenile *Persoonia longifolia* and *Xylomyelum sp.* is present although patchy. *Xanthorrea preissii* (Grass tree) are also common in this height stratum.

There is a particularly diverse low shrub/sedge stratum in the reserve which includes *Acacia aff. biflora, Astroloma sp., Bossiaea ornata, Burchardia umbellata, Calytrix Flavescens, Conospermum acerosum, Daviesia decurrens, Dianella revolta, Dryandra nivea, Hemiandra pungens, Hibbertia hypericoides, Hibbertia linearis, Hibbertia vaginata, Hypocalymma robustum, Lepidosperma angustata, Macrozamia reidlei, Mesomelaena stygia, Muehlenbeckia adpressa, Olearia paucidentata,Opercularia echinocephala, Oxylobium capitatum, Patersonia occidentalis, Persoonia saccata,*

*Persoonia sp., Petrophile linearis, Phlebocarya ciliata, Phyllanthus calycinus, Schoenus sp., Stipa sp., Stirlingia latifolia, Thysanotus sp.* and *Trycoryne elatior.*

In the farmland areas, forest understorey species are now absent due to past clearing and grazing. Current tree cover on the farmland is scattered Jarrah, Marri and Sheoak which have been left as shade trees for livestock. *Eucalyptus rudis* occurs in drainage lines in the farmland.

### Regional Significance

Most of the Forrestfield landform unit has been cleared for agriculture, therefore remnant vegetation generally occuring on the scarp and lower slopes has conservation importance. The conservation status of Reserve 31900 has been lessened by previous and current landuse. Landfill activities at the reserve are ongoing and the Shire of Harvey intend to continue using the reserve for this purpose.

Regionally, the clearing of the vegetation associated with the Ridge Hill Shelf landform for agriculture and grazing was because the heavier soils were highly sought after by early farmers. The sandier soils were in less demand and were included in reserves for community purposes.

Therefore, although the reserves north of Burney Road and reserve 31900 may represent only part of the range of vegetation types that previously existed on the Ridge Hill Shelf landform, they do represent an example of a coencline with the Forrestfield Vegetation Complex to the west. Gibson et al, (1994) concluded that community reservation and conservation status of vegetation types 3b and 20b were well reserved by vulnerable, and poorly reserved and vulnerable, respectively. This assessment is subject to review, however it is acknowledged that the group of reserves are of regional importance, and would complement the proposed consolidation of Reserves 17805 and 16030 at Harvey, particularly because much of the sandier lowland elements of the vegetation in those reserves have been degraded. The reserves north of Burney Road have been recommended for A class reservation. Reserve 31900 has not been included in this recommendation.

Type 3b vegetation has been identified from six sites on the southern Swan Coastal Plain ranging from Dunsborough to Byford. These sites are listed in Table 1 below. Mining at Yarloop will result in the loss of approximately 10% of this vegetation type in the Yarloop reserves (see Appendix 1, Figure 1). Type 20b has been identified as four sites and none of this vegetation will be impacted.

| Reserve No. | Locality | Current Vesting | Area ha. |
|---|---|---|---|
| 2457 | Cardup | NPNCA | 70.70 |
| 23756 | Kooljerrenup | NPNCA | 1019.00 |
| 6268 | Coolup | unvested | 15.67 |
| 20585 | Waroona | Main Roads | 8.18 |
| 23307 | Yarloop | unvested | 12.95 |
| 3672 | " | " | 3.40 |
| 16681 | " | " | 21.37 |
| 31901 | " | Main Roads | 19.11 |
| 31900 | " | Shire of Harvey | 19.40 |
| 21626 | Dunsborough | Shire of Busselton | 570.92 |

**Table 1 : Reserves where Type 3b Vegetation has been identified.**

Leeuwin NP.

## 2.7 FAUNA

A fauna assessment of the project area was undertaken during March 1996. No evidence of any gazetted rare and/or endangered or priority listed species was found during site inspections. A full report on the fauna survey is attached as Appendix 3. The conclusion of the study was that fauna species which have been gazetted rare and/or endangered are unlikely to be dependent on the habitats of the area to be affected by mining.

The fauna values of Reserve 31900 are reduced because the reserve and its neighbours form an island of remnant vegetation with poor prospects of supporting diverse or rare fauna in the long term. The open nature of the reserve area, with only a sparse medium and tall shrub cover, would provide limited cover for species susceptible to predation by foxes.

Gazetted bird species which could visit the study area are wide ranging in daily and seasonal habits and consequently are unlikely to be affected by the mining operation.

Species observed or inferred during the fauna assessment included Western Grey Kangaroo (*Macropus fuliginosus*), Gould's Monitor *(Varanus gouldii)*, Australian Raven (*Corvus coronoides*), Darter *(Anhinga melanogaster)* and Pacific Black Duck *(Anas superciliosa)*.

## 2.8 RADIATION

A survey of surface gamma dose rates was undertaken in December 1994 and January 1995. Gamma radiation was measured at 280 points with an average of 0.16 ± 0.08 $\mu$Gy/hr. A frequency distribution of the gamma radiation levels is shown (Figure 5).

These rates are typical of background levels of the coastal plain. The graph shows a skewed distribution typical of low level readings. The majority of the results are in the range 0.1 to 0.25 $\mu$Gy/hr which is typical of this natural background radiation levels in this region. The maximum reading recorded was 0.52 $\mu$Gy/hr.

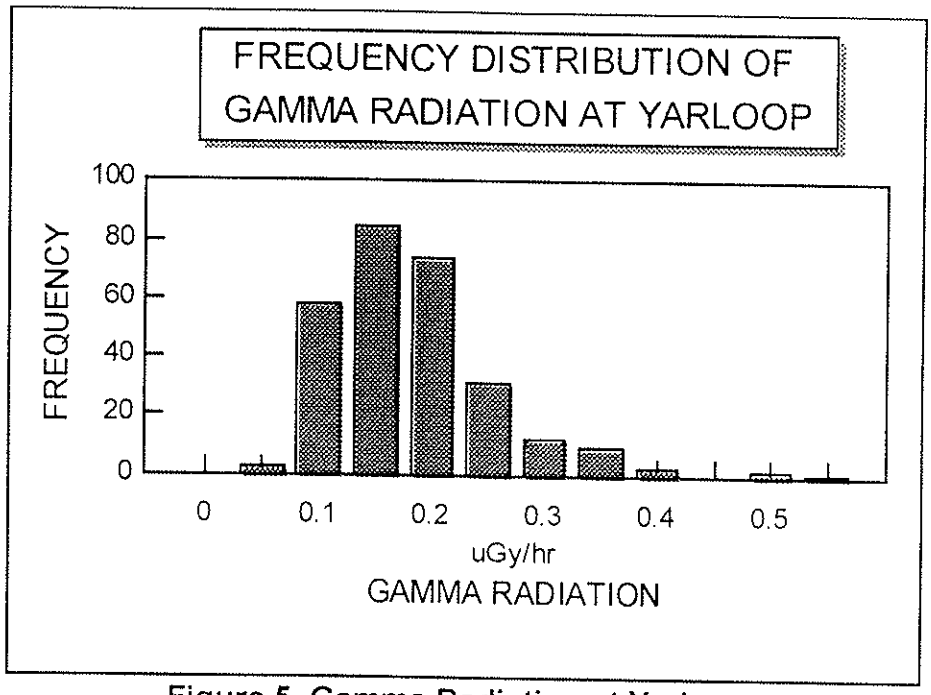



**Figure 5. Gamma Radiation at Yarloop.**

## 2.9 NOISE

Background noise measurement has been taken around the Yarloop area to enable assessment of noise impacts during the mining operation. Neighbouring properties which will potentially be affected by noise are shown on Figure 2. The closest neighbouring property (N1 on Figure 2) was chosen and measurements taken between 21st March and 25th March 1996. These are shown in Table 1 below. These measurements reflect the proximity of the South West highway to the house.

| | Leq | Lmax | L10 | L50 | L90 | Lmin | Temp |
|---|---|---|---|---|---|---|---|
| **Weekdays** | | | | | | | |
| 7am - 7pm | 59.7 | 85.0 | 64.1 | 50.3 | 42.6 | 29.0 | 27.5 |
| 7pm - 10pm | 56.7 | 79.0 | 60.2 | 44.9 | 35.9 | 27.0 | 23.5 |
| 10pm - 7am | 49.8 | 81.0 | 49.9 | 36.2 | 30.5 | 26.0 | 17.2 |
| **Weekends** | | | | | | | |
| 7am - 7pm | 58.0 | 86.5 | 62.9 | 48.5 | 39.6 | 29.0 | 27.6 |
| 7pm - 10pm | 56.0 | 7.5 | 59.5 | 42.4 | 33.8 | 26.5 | 21.1 |
| 10pm - 7am | 49.1 | 79.0 | 48.9 | 37.8 | 34.0 | 26.5 | 16.0 |

**Table 2: Noise Measurements at Yarloop**

Additional measurements were made on the eastern side of the proposed mining operation (N2 on Figure 2) between the 2nd and 3rd April 1996. Results are shown in Table 3 below.

| | Leq | Lmax | L10 | L50 | L90 | Lmin | Temp |
|---|---|---|---|---|---|---|---|
| Weekdays | | | | | | | |
| 7am - 7pm | 40.8 | 83.0 | 42.8 | 38.0 | 34.8 | 27.5 | 32.3 |
| 7pm - 10pm | 36.5 | 57.0 | 40.0 | 33.8 | 29.6 | 28.2 | 20.1 |
| 10pm - 7am | 40.1 | 47.9 | 42.6 | 38.9 | 36.6 | 26.5 | 19.0 |

Table 3 Noise Measurements at Yarloop

# 3.0 PROJECT DESCRIPTION

## 3.1 MINING

### Process

The Yarloop deposit will be dry mined using earthmoving equipment. This process is the same as is currently used at Waroona and at Busselton. The steps in this process are described briefly below.

The first step involves **clearing of vegetation** from areas to be mined. As far as possible the vegetated area cleared is minimised and appropriate use made of any timber involved. After examining the options available unusable vegetation that has been cleared will be burnt in accordance with fire restrictions and relevant smoke control guidelines.

Following land clearing **topsoil is stripped and stockpiled** using scrapers. Approximately 20cm of topsoil will be removed. As far as practical duration of topsoil storage will be kept to a minimum. This topsoil is later used to re-establish vegetation.

Earthmoving equipment is then used to **remove overburden** where this is of sufficient depth to be handled independently of the ore. This overburden is stockpiled for later replacement or is used to fill areas already mined.

The **ore is mined** using heavy earthmoving equipment. A rotary trommel with a 50mm screen and a secondary trommel with a 4.5mm screen are used to separate large rocks, roots and gravel. The fine fraction is then pumped as a slurry to the Primary Separation Plant where heavy mineral concentrate is separated by conventional wet gravity methods.

The water is recycled as much as possible. Clay is removed using a thickener tank. This clayey slurry is allowed to dry in one of a number of slimes dams constructed for this purpose. The **area is recontoured** to blend in with the existing landscape using the dried clay, overburden and tailing sand.

**Topsoil is then replaced** and **vegetation re-established** to a standard that is compatible with the intended landuse after mining.

### Mining Schedule

The Yarloop deposit is estimated to contain 682,000 tonnes of heavy mineral concentrate (HMC). The intention is to mine at a rate up to 200,000 tonnes of HMC per annum although production rates should normally be 160,000 tonnes of HMC per annum. The key characteristics of the schedule are summarised in Table 4. These are estimates only and may vary substantially.

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|
| Area cleared (ha) | 17.6 | 40.2 | 17.7 | 14.9 | 8 | 2.2 | |
| HMC produced (tonnes) | | 116000 | 160000 | 160000 | 160000 | 104000 | |
| Trucking rate (tonnes) | | 96000 | 160000 | 160000 | 160000 | 124000 | |
| Area rehabilitated (ha) | | | 5 | 10 | 20 | 25 | 40.6 |

Table 4 Key Characteristics of Mining Proposal

The proposal is to commence mine site construction in late 1996 and to commence mine production in early 1997. Mining should continue for approximately 4 years. A schematic outline of the proposed mining operations on the Yarloop project area is presented as Figure 6.

The mining operation involves two mining areas one north and one south of Black Rock Road. The plant will be moved once during the life of the mine when the operation crosses to the southern section.

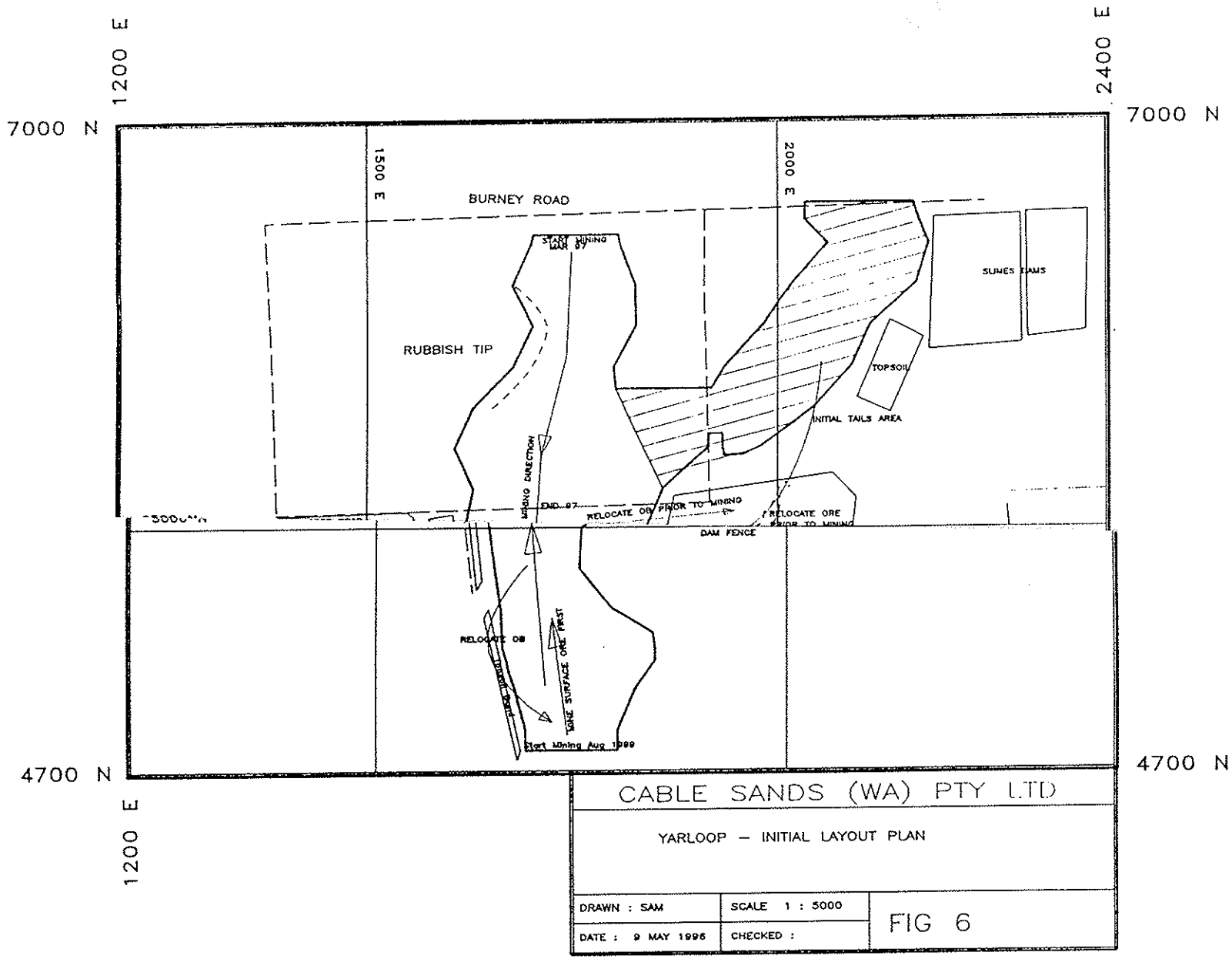
Before mining commences topsoil and overburden from all the northern areas will be removed. Some of the overburden will be used in constructing part of the northern infrastructure. The remainder will be stockpiled as will the topsoil.

The north-eastern strand will be relocated on to the southern end of the northern mining area. Mining will commence in the rubbish tip area and progress southwards. Initial tails will be pumped to the north-eastern strand area. Mining through the rubbish tip reserve will take approximately nine months. The remainder of the northern area, which includes the relocated north-eastern section, will be mined over a further eighteen months.

Mining in the southern ore area will commence approximately twenty months after the northern area begins. Initially the area closest to Black Rock Road will be mined and this material will be processed with the plant in its northern location. This will occur concurrently with finishing the mining of the northern area.

An agreement has been reached for relocation of a short section of Black Rock Road so that the reserve can be mined. If this occurs a short detour to the north of the current road will be constructed and the road will be replaced along its current alignment following mining.

Thirty months after commencement the plant will be moved to a new site south of Black Rock Road. The bulk of the southern area will be mined from south to north. The exceptions are the area already mentioned and a small section on the eastern side which will be mined from north to south.


1200 E
2400 E
7000 N
7000 N
1500 E
2000 E
BURNEY ROAD
START MINING MAR 97
RUBBISH TIP
SLIMES DAMS
TOPSOIL
INITIAL TAILS AREA
MINING DIRECTION
END 97
RELOCATE OB PRIOR TO MINING
RELOCATE ORE PRIOR TO MINING
DAM FENCE
RELOCATE OB
MINE SURFACE ORE FIRST
Start Mining Aug 1999
4700 N
4700 N
1200 E
CABLE SANDS (WA) PTY LTD
YARLOOP – INITIAL LAYOUT PLAN
DRAWN : SAM
SCALE 1 : 5000
DATE : 9 MAY 1996
CHECKED :
FIG 6

It is estimated that the mine will cease production 55 months after commencement. At current estimates this will mean that the mining will cease in September 2001.

Initially the mining and primary separation operations will be undertaken on a 24 hours per day and seven days per week basis, however this may vary depending on production requirements.

The heavy minerals concentrate will be dewatered and stockpiled at the mine site prior to being trucked to the Cable Sand's Secondary Separation Plant at North Shore, Bunbury.

## 3.1 INFRASTRUCTURE

The following plant will be required for the mining operation and will either be constructed on site or transferred from existing operations.

### 3.1.1 WATER

Make-up water will be pumped into a storage dam from a series of shallow bores in the surficial formation. The bores will be located approximately four kilometres west of the minesite. Potable water for domestic purposes will be collected in rainwater tanks if bore water is not suitable, or purchased from the Yarloop town water supply.

Water usage ranges form none in winter to a maximum of 180$m^3$/hr during summer. Yearly abstraction is estimated at 1,000,000$m^3$/year. All process water is recycled with stormwater being responsible for the only site discharge.

The dam will be constructed below Plant Site #1 predominantly using on-site materials. It will have a capacity of 40,000 - 45,000 kL and will service all phases of the operation.

### 3.1.2 THICKENER TANK

A thickener will be constructed to remove fine clay from the water circuit. This will be located adjacent to the dam. Pipes will be installed below Black Rock Road to service the southern section of the orebody.

### 3.1.3 SLIMES DAMS

Slimes dams will be constructed to allow for drying of the fine clay separated by the thickener. These dams will cover approximately 50ha, a significant proportion of the area directly impacted by mining. Dams will be initially located on agricultural land and then will be located on the mined area after return of tails. The clay from the slimes dams is eventually incorporated with tails and overburden when the landscape is re-contoured.

### 3.1.4 INTERNAL ROADS

Internal roads are required to facilitate transportation within the minesite for mining and service operations. The approximate locations of these internal roads are shown in Fig. 6 although these are subject to change. The roads will be constructed from gravel or limestone obtained from local quarries or from oversize material obtained on site. During the summer months these roads will be wetted down as needed to control dust. A water cart will be on site for this purpose.

### 3.1.5 PLANT SITES

Two plant sites will be used in the course of the mining operation. Facilities will initially be transported from Cable Sand's Waroona South minesite where appropriate. These facilities will include workshops, store, shed, site office, toilets and a lunch room. Heavy mineral concentrate towers will be located adjacent to the plant sites.

## 3.2 WORKFORCE

The operating minesite will employ approximately 28 people including those currently employed at the Waroona minesite who wish to continue employment at Yarloop. The sequential nature of Cable Sands mining operations provides the opportunity for continuity of employment for current personnel.

## 3.3 TRANSPORT OF HEAVY MINERAL CONCENTRATE

The transportation of the HMC will be by truck and trailer units similar to those currently used to transport HMC from Cable Sand's existing operating minesites.

The route that the trucks will take from the minesite will be south along the South West highway to Bunbury then north along Robertson Drive and Koombana Drive to Cable Sands' North Shore Facility. This route is shown on Figure 1.

At estimated production rates and truck payloads between 42 and 58 tonnes there will be between 50 and 75 return truck journeys per week for the 4 year life of the mining operation. Trucking, as per the existing Waroona operation, will be as batch runs to meet the demands of the Bunbury processing plant.

Trucking will usually occur during daylight hours on weekdays although some weekend trucking may be required.

The trucking regime is similar to that currently operating for the transportation of HMC from Waroona. The net effect of the trucking will be negligible between Yarloop and Bunbury and a reduction in trucks between Waroona and Yarloop. The transportation of HMC for Cable Sands is insignificant in relation to the overall traffic on the South West highway.

## 4.0 ENVIRONMENTAL IMPACT AND MANAGEMENT

Cable Sands has considerable experience in the mining of titanium minerals in the south west of Western Australia. In particular, the two mines at Waroona have provided experience in dealing with similar issues to those relevant to the Yarloop mine. Of particular relevance is the experience relating to dust, noise, radiation, groundwater, transport and light spill. These and other issues are discussed in detail below following an overview of Cable Sands' environmental management system which provides the framework for the company's environmental operations.

## 4.1 ENVIRONMENTAL MANAGEMENT

Cable Sand's environmental management has evolved over a number of years in response to relevant statutory requirements and commitments relating to individual projects. At present Cable Sands is working toward consolidating its environmental management under the ISO 14000 series of standards. This series addresses aspects of environmental management systems and the operation of such systems.

The company has developed a policy which broadly covers relevant areas of environmental management. The policy is based on 5 principles. These relate to operating in an environmentally responsible manner, continual improvement, community awareness, reducing environmental impacts and staff awareness. Consideration of these principles is central to the effective environmental management of the Yarloop mine.

## 4.2 WATER

The proposed dry mining operation will have minimal impact on the hydrology of the region. The location of the various dams will not affect the flow of Waterous Formation Creek which forms the central gully separating the two mining areas. The seasonal flow from the eroded gully to the north will be diverted to feed the storage dam or to join Waterous Formation Creek upstream of where it currently joins. This will not adversely affect the overall flow.

Experience with mining at Waroona indicates that there is no discernible impact of the mining operation on water availability for surrounding vegetation. It is anticipated that there will be no adverse impacts on uncleared vegetation in Reserve 31900 or in the adjoining reserves.

## 4.3 FLORA AND FAUNA

The significant impact on flora and fauna will largely be confined to the rubbish tip reserve. Environmental management will be focussed on minimising the vegetated area disturbed and rehabilitating the area to ensure that it complements the A class reserve proposed for the woodland north of Burney Road. Rehabilitation is discussed in detail

in section 4.4 below.

The area to be disturbed in Reserve 31900 is estimated at 8 ha. There is some overlap with the area already degraded through previous and current landuse which is also approximately 9 ha. The total area of the 20ha reserve that will be impacted by the past, present and proposed landuse will be approximately 16ha. The rehabilitation will improve the value of all but approximately 4ha of the currently degraded land which will continue to be used for rubbish disposal. There will be a loss of about 10% of vegetation type 3b within the group of reserves and 8% of the total vegetation within the reserves.

The proposed restoration plan will restore the overstorey stratum and many of the existing understorey species, however it is not practical to recreate the existing understorey structure. Restoration will aim to restore and enhance conservation values where possible, although recognising the ongoing landuse as a landfill site.

## 4.4 REHABILITATION

Rehabilitation will be undertaken in accordance with a restoration plan that will be finalised prior to commencement of mining. The details of the plan will be finalised in consultation with the Shire of Harvey and CALM. Appendix 1 includes recommendations for restoration which followed subject to discussions with other relevant bodies. This restoration plan is outlined below.

The focus of the rehabilitation program will be to rapidly stabilise restored landforms with vegetation selected to address the different landuse objectives within the mining lease area. Land restoration will be integrated with the mining process to ensure the earliest possible stabilisation and restoration. Management of the reserve area will also include fencing as agreed with the Shire of Harvey.

The general objectives of the rehabilitation program are to :

- Re-establish pasture on the private land in areas currently used for grazing.
- Enhance shade and stock shelter tree plantings on farmland areas, establishing groves of trees which would include local species.
- Conserve all topsoil and return topsoil to areas with a compatible landuse.
- Restore all mined areas to landforms which conform with the surrounding terrain, while controlling surface drainage with contoured gradients where necessary.
- Restore the degraded area of Reserve 31900, following appropriate discussions with the Shire of Harvey and CALM, with shrub and tree plantings complementary with surrounding vegetation.
- Areas of existing native vegetation within Reserve 31900 disturbed by mining will be revegetated with suitable species previously observed on site and in similar adjacent vegetation.

## Woodland Restoration

The mining process will be preceded by collection of available seed and rootstock material for future nursery propagation of perennial shrubs and trees. Commercial timber will be removed and non-commercial timber will be heaped and burnt under permit. During clearing sedge and shrub material will be retained as much as possible for incorporation with topsoil.

Topsoil will be stripped in two stages, using scrapers where possible. The top 5cm will be removed first and stored separately. A further 10-15cm will then be removed. Following mining re-contouring will incorporate fine clays into the upper soil profile to aid moisture retention and rehabilitation success. Topsoil will then be returned in the layers previously separated. Care will be taken to spread topsoil evenly, particularly the upper layer, so that viable seeds and propagules are not buried too deeply for regeneration.

Some native species are expected to regenerate from the respread topsoil, however experience shows that regeneration response can be quite variable. Supplementary hand seeding and planting of nursery propagated seedlings will use seed collected on site as much as possible. Seedlings will be fertilised where appropriate to enhance rehabilitation success.

The establishing vegetation will be inspected following the first summer period to assess the need for supplementary planting and seeding. The need to eradicate weeds and control rabbit populations will also be assessed.

## Farmland Restoration

Cable Sands has extensive experience in rehabilitating pasture at previous and current minesites including Waroona South and North, Capel, Busselton and Jangardup. In these cases, incorporation of slimes immediately below the topsoil layer provides high moisture and nutrient holding capacity leading to rapid re-establishment of productive pasture.

On the pastured land, clearing will utilise commercial timber, burn non-commercial timber under permit and strip and store topsoil in two stages. Following recontouring topsoil will be respread evenly and a clover-ryegrass mix sown after consultation with the landowner. Fertiliser applications will help ensure re-establishment of pasture.

Shelterbelt trees plantings will be located based on prevailing wind conditions and sympathetic to the surrounding landscape. Native species will be used for trees planted as part of the farmland restoration.

## 4.5 RADIATION

Present levels of surface radiation in the Yarloop area are typical of the Swan Coastal Plain. Experience with similar mining operations indicates a reduction in gamma radiation levels in the post-mining landscape. It is likely that a reduction in the order of 0.05 $\mu$Gy/hr will be experienced at Yarloop.

## 4.6 STORAGE OF HYDROCARBONS

Hydrocarbons kept on site for fuelling the earthmoving equipment will be kept in appropriately constructed bunded areas capable of holding 110% of the largest vessel capacity.

# 5.0 SOCIAL IMPACTS

## 5.1 VISUAL

The mining operation is located adjacent to the South West highway and will be partially visible to passing traffic and also to neighbours. Extensive vegetation screening has been established parallel to the highway to reduce this impact. In addition a screen exists adjacent to the neighbouring property to the east using trees provided by Cable Sands. These screens are complemented by the vegetated topsoil bunding which will also be established along sections of the highway.

## 5.2 NOISE

The impact of noise will be limited due to the predominance of electrically driven machinery used in the separation of heavy mineral concentrate. The major potential for noise impact is through earth moving machinery. As is the normal practice with Cable Sands operations, the following procedures will contribute to reducing this noise impact:

* As far as possible night time earthmoving operations are restricted to within the pit
* Substitution of flashing lights for reversing beepers at night time.
* Fitting of acoustic exhaust mufflers to all earthmoving machinery working outside daylight hours.
* Construction of noise reducing bunding using topsoil stockpiles. This will apply particularly to the southern mining area alongside the South West highway.

## 5.3 DUST

Experience has shown that the major concern with dust generation involves the transportation of heavy mineral concentrate on internal gravel roads. The impact of dust from this source will be minimised through a wetting down dust control program involving the use of an appropriate water cart during the summer months.

Dust generation from other sources is reduced by minimising the areas disturbed, restricting dust generating activities on excessively windy days and rehabilitating as soon as practical after mining has passed. Topsoil stockpiles are vegetated and slimes are used on tailings areas to reduce the amount of material available as dust. Vegetation screens established on site also assist in reducing dust problems.

These steps have proved effective in minimising dust at Waroona and it is not anticipated that there will be any major problems with dust at Yarloop.

## 5.4 ABORIGINAL SITES

The Department of Aboriginal Affairs was contacted in relation to the proposed mining operation. No recorded Aboriginal Heritage sites were listed for the project area.

Previous communication with the department has indicated that the likelihood of sites occurring is usually influenced by factors such as availability of water, access to raw materials (eg. quartz or chert), the presence of prominent features and level of prior disturbance or development of the land. Based on these considerations it is unlikely that there are unrecorded sites in the project area.

In the event of unearthing of skeletal remains or discovery of Aboriginal sites the Department of Aboriginal Affairs and the Department of Minerals and Energy will be informed immediately.

## 5.5 EUROPEAN HERITAGE

The project area does not contain any sites which are listed with the Heritage Commission or the National Trust.

## 5.6 LAND USE

The mining operation planned will not change the long term land use. Rehabilitation of the mined area will result in a return to similar vegetation to that existing prior to mining on both the pasture and reserve land. The rubbish tip will continue to operate throughout the mining operation and will continue on an area set aside for this purpose after completion of the mine.

## 5.7 SOCIAL ENVIRONMENT

Cable Sands is an important contributor to the regional economy. The development of mining operations at Yarloop allows for continuity of employment for current personnel and helps to ensure the long term viability of Cable Sands with the intrinsic benefits to the country, state and local community.

## 6.0 COMMUNITY CONSULTATION

Cable Sands recognises the importance of keeping the community and relevant government bodies informed about the mining operation at Yarloop. To this end discussions have taken place with the following people or bodies;

Department of Environmental Protection - Bunbury and Perth
Department of Conservation an Land Management - Bunbury, Mornington and Woodvale
Department of Minerals and Energy - Collie and Perth
Department of Aboriginal Affairs - Albany
Shire of Harvey councillors and staff
Local residents
- Mr and Mrs A Jenkins
- Mr and Mrs M Jenkins
- Mr and Mrs A Angi
- Mr and Mrs C Angi
- Mr and Mrs F Venables
- Mr and Mrs N Armstrong
- Mr N Penny
- Mr R Parrick

Cable Sands personnel have discussed the proposed operation with neighbouring residents in the course of preparation of this document. This has included discussion of information included in an information sheet prepared for the site and discussion of issues raised by the residents. Where appropriate, concerns have been addressed in the mine plan. In addition Cable Sands has had numerous discussions with landowners adjacent to the proposed mining operation throughout the exploration phase and in establishing the water supply for the site.

Concerns raised by the residents related to dust, noise, transportation of concentrate, safety of schoolchildren, interference with television reception, preservation of the rubbish tip and light spill from the mine. There was a general acceptance by residents that the mining operation would proceed and a positive response to discussion of the issues raised.

Councillors and staff from the Shire of Harvey were briefed about the mining proposal and extensive discussions have taken place in establishing the agreement for the operation of the rubbish tip throughout and after the mine life. Concerns raised related to dust and management of the tip.

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# APPENDIX 1

1200 E

2400 E

7000 N

7000 N

1500 E

2000 E

BURNEY ROAD

START MINING MAR 97

RUBBISH TIP

SLIMES DAMS

TOPSOIL

INITIAL TAILS AREA

MINING DIRECTION

END 97

RELOCATE OB PRIOR TO MINING

RELOCATE ORE PRIOR TO MINING

6500 N

ACCESS ROAD

SLIMES DAM

TOPSOIL

O/B STOCKPILE

GULLY

SOUTH WEST HIGHWAY

Cut Drain

HMC TOWERS

June 1999

DAM

SLIMES DAM

SLIMES DAMS

PLANT SITE #1

W/S & OFFICE

THICKENER

YARD

SLIMES DAM

SLIMES DAM

WATER DAM

6000 N

Causeway

SLIMES DAMS

BLACK ROCK ROAD

SLIMES DAMS

DAM

P/LINE

P/LINE

SLIMES DAMS

SURFACE ORE

DEEP ORE W/- OB

TOPSOIL

MINE W/- NORTHERN AREA FROM PLANT SITE #1

Start Nov 1999

HMC TOWERS

2nd

1st

W/S & OFFICE

RELOCATE OB

PLANT SITE #2

ROAD BERM

DAM

End June 1999

5500 N

SLIMES DAMS

August 1999

End Mining Sept 2001

SOUTH WEST HIGHWAY

RELOCATE OB

MINE SURFACE ORE

ROAD BERM

MINE DEEP ORE AFTER OB REMOVAL

O/B STOCKPILE

TOPSOIL

RELOCATE OB

5000 N

DAM FENCE

RELOCATE OB

MINE SURFACE ORE FIRST

ROAD DIVERSION

Start Mining Aug 1999

4700 N

4700 N

1200 E

CABLE SANDS (WA) PTY LTD

YARLOOP – INITIAL LAYOUT PLAN

| | | |
|---|---|---|
| DRAWN : SAM | SCALE 1 : 5000 | FIG 6 |
| DATE : 9 MAY 1995 | CHECKED : | |

# MINING OF TITANIUM MINERALS
# YARLOOP

# CONSULTATIVE ENVIRONMENTAL REVIEW (CER) GUIDELINES

## Overview

All environmental reviews have the objective of protecting the environment, and environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe the proposal, receiving environment, potential environmental impacts and the management of the issues arising from the environmental impacts, so that the environment is protected to an acceptable level.

Throughout the assessment, the Department of Environmental Protection (DEP) aims to assist the proponent to improve the proposal so that environmental impacts are minimised. The DEP also co-ordinates advice from relevant government agencies and the public about environmental matters during the assessment of the Consultative Environmental Review (CER).

## Objectives of the CER

- To communicate clearly with the public and government agencies, so that the EPA can obtain informed comment to assist in providing advice to government.
- To describe all aspects of the proposal adequately, so that the Minister for the Environment can consider approval of a well-defined project.
- To provide the basis for the environmental management programme, which should demonstrate that the environmental issues resulting from the proposal can be acceptably managed.

The contents of the CER should reflect these objectives.

## Contents of the CER

The text of the CER should be simple, concise, and referenced. This document would form the legal basis of the Minister for the Environment's approval of the proposal and should include a description of all the components of the proposal.

The environmental management programme for the proposal should be developed in conjunction with the engineering and economic programs of the proposal. That is, the CER should be designed to be immediately useful at the start of the proposal, and the DEP recommends that an environmental management and audit programme be incorporated as a concluding part of the CER.

The textual content of the CER should include:

- introduction to the proponent, the project and location;
- the legal framework, decision making authorities and involved agencies;
- description of the components of the proposal and identification of the potential environmental impacts;
- description of the receiving environment which may be affected;
- discussion of the key environmental topics (shown in the next section), including an assessment of their significance in comparison to relevant objectives, policies or standards;

- discussion of the objectives for management of the issues, including commitments to appropriate action; and
- a summary of the environmental management programme, including the key commitments, monitoring work and the auditing of the programme.

The EPA considers that environmental management is best approached in terms of best practice, which can include:

- development of an environmental policy;
- agreed environmental objectives;
- management practices to achieve the objectives;
- involve the public as appropriate;
- audit environmental performance against agreed indicators;
- regular reporting to the EPA (or nominated agency);
- commitment to a quality assured management system and continuous improvement; and
- periodic review in conjunction with the EPA (or nominated agency).

Additional content requirements for the CER are included in the next section.

## Key environmental topics

The key topics can be determined from a consideration, called scoping, of the potential impacts of the proposal on the environment. The receiving environment includes social surroundings.

The CER should focus on the key topics for the proposal as agreed in consultation with the DEP and relevant government agencies. A description of the project component and the receiving environment should be directly included with, or referenced to, the discussion of the topic. The technical basis for measuring the impact and any objectives or standards for assessing and managing the topic should be provided.

The key topics (and their corresponding objectives) identified at this stage include:

| Environmental Topic | Assessment Objectives |
|---|---|
| ***Biophysical environment*** | |
| Water (ground and surface) quantity | • Ensure that the impact of groundwater extraction on indigenous vegetation is minimised |
| Flora and fauna | • Protect Declared Rare and Priority flora and ensure no significant loss of locally and regionally significant vegetation associations and habitats<br>• Protect Threatened and Priority fauna species and significant habitats |
| Rehabilitation | • To ensure the sustainable rehabilitation of the site to the requirements of the land owner and the Commissioner for Soil Conservation<br>• That the rehabilitation prescriptions developed reflect the environment existing prior to mining |
| ***Pollution Potential*** | |
| Water (ground and surface) quality | • To ensure that the quality of ground and surface water supplies is not adversely affected |

| | |
|---|---|
| ***Pollution Potential (cont.)*** | |
| Noise and dust emissions | • Comply with statutory requirements and DEP guidelines |
| ***Social Surroundings*** | |
| Noise and dust emissions | • Protect the amenity of neighbouring residents from unacceptable noise and dust impacts |
| Light Spill | • Protect the amenity of neighbouring residents from nuisance light spill impacts |
| Radiation | • Comply with the Mines Safety and Inspection Regulations 1995 - Part 16 |
| Transport - noise, dust and vibration | • Protect the amenity of neighbouring residents from unacceptable noise, dust and vibration impacts associated with materials transport |

Further key topics may be raised during the preparation of the CER, and on-going consultation with the DEP and relevant agencies is recommended. Minor issues which can be readily managed as part of normal operations may be briefly described. Information used to reach conclusions should be properly referenced, including personal communications. Assessments of the significance of an impact should be soundly based rather than unsubstantiated opinions, and the assessment should lead to a discussion of the management of the issue.

In discussing the key topics identified in the table above, the CER should contain:

- the results of recent fauna and flora surveys;
- an assessment of the regional significance of the vegetation associations likely to be affected by this proposal, including discussion of the representation of these associations in secure conservation areas;
- evidence of an adequate EMS and demonstrated proponent commitment to environmental performance;
- a table summarising the key characteristics of the proposal. For example, clearing rates, mining rate, separation & processing rates, and trucking rate. This will facilitate the assessment of any future changes to the operation;
- base maps and an overlay of the proposed project layout. The base maps should show the existing physical and social environment, which when displayed with the overlay illustrate the physical disturbance likely, and the impacts on residents and residential centres;
- a table summarising the environmental impacts of the proposal and describing:
  - the present state of the environment;
  - potential impacts of the proposal on the environment;
  - environmental management objectives for those aspects which require management;
  - environmental management proposed to manage impacts to meet those objectives; &
  - envisaged resultant state of the environment.

  These topics should be presented under the major headings used in the table above ie. biophysical environment, pollution potential, and social surroundings.

## Public consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the CER. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference

should be made with the description of environmental management of the issues which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

## Environmental management commitments

The method of implementation of the proposal and all commitments made by the proponent in the CER become legally enforceable under the conditions of environmental approval issued by the Minister for the Environment. Commitments which address key environmental topics form a schedule to the Minister's environmental conditions and will be audited by the DEP. The commitments have the form of: the proponent (who) will prepare a plan or take action (what) to meet an objective, to the timing for its achievement (when), and to which agencies will be consulted or to whose requirements, if not the DEP, the action/plan will be prepared.

Other commitments show that the proponent is dedicated to good environmental management of the project, and the DEP expects that the proponent will audit these commitments by internal processes under an Environmental Management System. Though not subject to routine audit, the DEP may request that compliance with, or the in-house audit of, these commitments be demonstrated, so as to verify satisfactory environmental performance. The commitments define the goals/objectives for the environmental management programme and procedures (the details of how the commitment will be met), which should be described in as much detail as possible. The DEP acknowledges that, with the implementation of best practice and continuous improvement for the project, the procedures may need to be modified, or added to, in regular updates to the environmental management programme. A typical commitment is:

| Issue bio-physical | Objective | Commitment | Timing (Phase) | Whose requirements | Specification (Performance Indicator) |
|---|---|---|---|---|---|
| Protect-ion of conserv-ation values of reserve | Manage surrounding land in concert with reserve | Develop a plan of recommended conservation strategies | Within 1 year of start of pipeline | CALM, NPNCA | Agreements signed with adjacent landowners; fences built; optimum cattle stocking rates determined; etc |

# APPENDIX 2

# Yarloop Mineral Sands Lease:

## ASSESSMENT OF REMNANT VEGETATION

## AND RECOMMENDATIONS FOR RESTORATION

Prepared For:

Cable Sands (W.A.) Pty Ltd
North Shore
BUNBURY W.A.

Prepared by:

Environmental Survey & Management Pty Ltd
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May, 1996

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## 1.0 SUMMARY

CABLE SANDS (W.A.) PTY LTD proposed mining operations at Yarloop will mostly occur on cleared farmland, however a small area of remnant bushland within reserve 31900 will also be affected. The vegetation is principally *Eucalyptus marginata-Allocasuarina fraseriana* woodland with a diverse perennial shrub and sedge understorey typical of the **Forrestfield Vegetation Complex** on **Ridge Hill Shelf** landform. As most of this vegetation type has been cleared regionally, the remnant vegetation of reserve 31900 and adjacent reserves have importance for conservation. No rare or priority listed flora were found to be present on the proposed mining area.

Recommendations for land restoration are outlined with the general objectives of restoring the farmland, old quarry sites, landfill areas and remnant bushland areas with appropriate soil management and replanting strategies. A revegetation programme is recommended that will achieve rapid stabilization of mined surfaces, and the restoration of a diverse woodland vegetation. This will provide a functional buffer surrounding the landfill site and this will complement the conservation aspects of the adjacent group of reserves north of Burney Road.

## 2.0 INTRODUCTION

CABLE SANDS (W.A.) PTY LTD proposed mining operations at Yarloop are predominantly located on cleared farmland currently used for grazing purposes, and also within a section of an adjacent public utility reserve 31900 used for sand quarrying and refuse landfill purposes. The proposed mining will encroach both on the quarry site and undisturbed remnant native woodland areas contained within this reserve. This report reviews the remnant vegetation on the private farmland and in the reserve which will be affected by mining, and also provides guidelines for post-mining land restoration and revegetation.

## 3.0 EXISTING ENVIRONMENT

### 3.1 LANDFORM AND SOILS

The mineral lease is situated on the eastern margin of the Swan Coastal Plain approximately two kilometres south of Yarloop. The Swan Coastal Plain is generally flat or of low relief, however the eastern margin is characterised by undulating foothill slopes dissected by seasonal creeks and minor valleys The landform-soil unit within the lease area is typical of the **Forrestfield** Unit, (D.C.E. 1980), with laterised foothills of the Darling Scarp becoming sandier and less gravelly downslope to the west. In the north-west sector of the lease area within the Shire reserve, the sandiest soils occur,

and sand quarrying has taken place. The sandy upper profile in this sector appears to have been formed during a period of unconsolidation by sand drifting from the adjacent **Guildford** landform-soil units further westward, on the Swan Coastal Plain, and currently these overlie laterised **Forrestfield** soils.

## 3.2 VEGETATION AND FLORA

The vegetation of the **Forrestfield** landform-soil unit west of the Darling Scarp has now been extensively cleared for farming, and most of the lease area comprising of gravel loam and sandy gravel soils has been cleared for this purpose. Typically, the vegetation was *Eucalyptus marginata* (Jarrah), *Eucalyptus calophylla* (Marri), and Sheoak-*Banksia* forest on the sandier soils, with *Eucalyptus wandoo* replacing the Sheoak and *Banksia* on the heavier soils. *Eucalyptus rudis* (flooded gum) and *Melaleuca rhaphiophylla* (paperbark) occur along drainage lines and in water-gaining depressions.

The forest understorey species are now generally absent in the farmland areas due to past clearing and grazing, and are now present only in the adjacent road reserves and nearby recreation and utility reserves. Current tree cover on the farmland is scattered Jarrah, Marri and Sheoak which have been left as shade trees for livestock. *Eucalyptus rudis* occurs in drainage lines on the farmland.

The public utility reserve (31900) included in the lease area is partly cleared for quarrying and landfill, however the remnant vegetation is generally in good condition, being relatively diverse and with dense understorey foliage cover. The flora of reserve 31900 was inspected during Janauary, 1995 and February, 1996 to tabulate vegetation and flora and search for rare plant species. The overstorey was found to reflect the sandy soils of the site, with Jarrah co-dominant in the upper stratum (20-28 metres in height) with *Banksia grandis* and *Allocasuarina fraseriana* forming a lower stratum (2-5 metres in height). *Banksia attenuata* is also present although not common on the eastern section of the reserve, however it is more common on the sandier western section. *Xylomelum occidentale* also occurs in the low tree stratum.

A tall shrub stratum (1-2 metres in height) which includes *Jacksonia sternbergiana,* juvenile *Persoonia longifolia* and *Xylomelum occidentale* is present, although of patchy distribution. *Xanthorrhoea preissii* (grass trees) are also common in this height stratum.

There is a particularly diverse low shrub/sedge stratum present in the reserve which includes *Acacia huegelii, Astroloma pallidum., Bossiaea ornata, Burchardia umbellata, Calytrix flavescens, Conospermum stoechadis, Davesia preissii, Dianella revoluta, Dryandra nivea, Hemiandra pungens, Hibbertia hypericoides, Hibbertia acerosa, Hibbertia vaginata, Hypocalymma robustum, Lepidosperma squamatum, Macrozamia reidlei, Mesomelaena tetragonia, Muehlenbeckia adpressa, Olearia paucidentata, Opercularia hispidula. Oxylobium capitatum, Patersonia occidentalis, Persoonia saccata, Persoonia elliptica., Petrophile linearis, Phlebocarya ciliata, Phyllanthus calycinus, Schoenus* sp., *Stipa* sp., *Stirlingia latifolia, Styphelia tenuiflora, Tetraria capillaris, Thysanotus* sp., and *Trycoryne elatior* as common species. A list of plant species observed to occur in reserve 31900 which includes

uncommon species is given in table 1.

The vegetation of the group of reserves in the vicinity of Burney Road has predominantly been classified as vegetation type 3b, *Eucalyptus calophylla - Eucalyptus marginata* on sandy clay soils. (Gibson et. al. 1994, Keighery, C., Unpublished). A small area of woodland on the western margin of reserve 31900 and 31901 was classified as vegetation type 20b, *Banksia attenuata* and or *Eucalyptus marginata* woodland. Vegetation type 3b was recorded during the survey from alluvial soils near the Peel-Harvey Estuarine System as well as on well drained sites on the eastern side of the Swan Coastal Plain. Community type 20b was found on sands at the base of the scarp between Byford and Yarloop.

## 4.0 CONSERVATION ASPECTS

Most of the **Forrestfield** landform unit has been cleared for agriculture, therefore remnant vegetation generally occurring on the scarp and lower slopes has conservation importance. The conservation status of public utility reserve 31900 has been lessened by landuse activities such as sand extraction and landfill. Landfill activities at the reserve are ongoing, and the local government at Yarloop plan to continue to utilize the reserve for this purpose.

Regionally, the clearing of the vegetation associated with the **Ridge Hill Shelf** landform for agriculture and grazing was because the heavier soils associated with this landform were highly sought after by early agriculturalists. The sandier soils were less in demand and therefore were included in reserves for community purposes - such as sand extraction and rubbish tips. Therefore, although the reserves north of Burney Road and reserve 31900 may represent only part of the range of vegetation types that previously existed on the **Ridge Hill Shelf** landform they do represent an example of a coenocline with the **Forrestfield Vegetation Complex** to the west. Gibson et. al. concluded that community reservation and conservation status of vegetation types 3b and 20b were well reserved but vulnerable, and poorly reserved and vulnerable, respectively. This assessment is subject to review, however it is acknowledged that the group of reserves are of regional importance and would complement the proposed consolidation of reserve 17805 and 16030 at Harvey, particularly because much of the sandier lowland elements of the vegetation in those reserves have been degraded. The reserves north of Burney Road have been recommneded for A class reservation. Reserve 31900 was not included in this recommendation..

The remnant vegetation of reserve 31900 was searched for the presence of rare or restricted flora. Priority listed flora known to occur in the vicinity of Yarloop and the nearby Harvey district include *Acacia flagelliformis, Rhodantha pyrethrun, Grevillea prominens* and *Caladenia uliginosa subsp. patulens m.s. Amperea simulens* is known to occur in the vicinity of Waroona. None of these or other priority listed flora observed in the reserve.

Extensive flora surveys undertaken in reserve 23307 (Department of C.A.L.M. Unpublished) and adjacent unreserved bushland (Keighery, 1995) also showed that rare and priority listed flora were

absent from the vegetation in those areas.

## 5.0 RECOMMENDATIONS FOR LAND RESTORATION

### 5.1 GENERAL OBJECTIVES

The programme of land restoration at Yarloop should focus on rapid stabilization of restored landforms with vegetation replanting based upon a rehabilitation strategy which addresses the different land-use objectives operating within the mining lease area. This will involve the restoration of pasture production, the creation of stock shelter belt vegetation, tipsite and quarry restoration and natural woodland revegetation. Land restoration works will need to be integrated with ongoing mining operations to ensure the earliest possible achievement of stabilization and restoration objectives.

The general objectives of the recommended rehabilitation programme are to;

* Re-establish pastures on the private land in areas currently used for grazing.
* Enhance shade and stock shelter tree plantings on farmland areas, establishing groves of trees which would include local species.
* Conserve all topsoil, and return soil to areas with a compatable future landuse.
* Restore all mined areas to landfoms which conform with the surrounding terrain, while controlling surface drainage with contoured gradients where necessary.
* Restore the quarry site with tree and shrub plantings complementary to the surrounding regional vegetation. The location of the quarry area is shown in **figure 1.**
* Areas of existing native vegetation within reserve 31900 disturbed by mining are to be revegetated with suitable species previously observed on the site and in similar to adjacent vegetation.

### 5.2 FARMLAND RESTORATION

Revegetation operations are best carried out during early winter months for both native perennial plantings and pasture establishment. Landforms restored to pasture should be seeded with a clover-ryegrass mix after consultation with the landowner as to species preferences.

To achieve a vigorous re-establishment of pasture, fertilize initially with an application of 400 Kg/ha of Superphosphate, potasium NPK and trace elements, and subsequent applications of 200 Kg/ha of a predominantly superphosphate mix.

Shelterbelt planting on the private land should be located according to prevailing winds and also to provide a buffer adjacent to the remnant vegetation on Reserve 31900 (rubbish and sand extraction) and Reserve 16681 (rifle range). Species selection should comprise native species compatable with

the surrounding landscape. A list of tree species recommended for shelterbelt planting on the farmland is provided in table 2.

## 5.3 WOODLAND RESTORATION

### 5.3.1 Preparation Works

Rehabilitation of mined remnant woodland on Reserve 31900 should be preceeded by collection of available seed from perennial shrubs and trees for future nursery propagation.
It is recommended that seed be collected from the site or from the general region. Propagation of rootstock material from species difficult to regenerate from seed should also be undertaken prior to mining.

Clearing of the remnant vegetation should commence with all the commercial timber being removed, and the residue of the non-commercial timber being heaped away from remaining vegetation and burnt under permit during Autumn or Spring. Some timber, particularly hollow logs, may be kept for respreading on to rehabilitated areas for microfauna habitat. During the clearing process, all shrub and sedge vegetation should be left behind as much as possible to be incorporated into the topsoil.

### 5.3.2 Topsoil Management

All topsoil on the vegetated areas should be stripped in two stages, using scrapers wherever possible. The top 5 cms of topsoil should be removed first, including understorey vegetation, and stored seperately. A further 10-15 cms would subsequently be removed for seperate storage. Topsoil from the reserve area should not be deposited on adjacent farmland topsoil so as to prevent contamination by weed seeds.

Overburden which does not require processing can be removed on a progressive basis in front of the minepath and where possible used immediately to reform post-mining surface levels. Some overburden will need to be transferred from within the lease area and used to restore surface topography in the quarried section of the reserve. Where possible, fine clays should be incorporated into the upper soil profile prior to topsoil replacement. The inclusion of the fine clays will further aid moisture retention and rehabilitation success.
The effect of heavy machinery on soil compaction needs to be carefully monitored during landform restoration and compacted areas ripped or cultivated as necessary.
After the landform surface has been shaped to the desired postmining contours, the topsoil should be respread as evenly as possible, with particular care taken to spread the first stripping evenly so that the viable seeds and propagules contained within are not buried too deeply for regeneration.

### 5.3.3 Seeding and Planting

Some native species are expected to regenerate from the respread topsoil on the restored woodland area in the reserve, however experience has shown that regeneration response can be quite variable. Volunteer regeneration from topsoil will need to be supplemented by nursery propagated seedlings and by hand seeding. Where possible seed should be collected prior to mining or from adjacent vegetation under permit. Seed can be collected mainly during November to February, and applied during May to July. It is anticipated that seed will also be required from commercial suppliers, collected from the same botanical provenance. Recommended species to be regenerated from seed or seedlings in the restored woodland areas are listed in **table 3**. Considerable regeneration can be expected from perennial understorey species that normally propagate by resprouting from roots, bulbs or corms provided that the period of topsoil storage is brief.

Regeneration of these species can be supplemented by harvesting root cuttings for propagation and storage prior to topsoil stripping. Plant species suitable for rootstock or stem propagation that are otherwise difficult to grow from seed are listed in **table 4.**

To achieve a comprehensive re-establishment of understorey species the nursery propagation programme will involve the production of potted seedlings from collected seed in addition to root and shoot cuttings. This can be undertaken on a contract basis. Tree species seedlings are best grown on to planting stage in 50x120 mm plastic airpots, while perennial shrub species can be grown in both 50x120 mm airpots and 50x50 mm peat pots. Some of the required propagation could be carried out at CABLE SANDS (W.A.) PTY LTD existing nursery at Bunbury, however, it is anticipated that a significent proportion of requirements will need to be contracted out to commercial suppliers and growers.
At the time of planting, tree seedlings other than *Banksia* species will require fertilizing with a 60 gram mixture of NPK with trace elements and Dynamic Lifter. Understorey species planted out on the restored quarry area should also receive this mixture, however understorey species planted on the restored woodland area should receive Dynamic Lifter only.

### 5.3.4 Maintenance Works

The establishing vegetation should be inspected after the first Summer period to assess the need for supplementary planting and seeding. Weeds may need to be eradicated regularly by spot spraying or mechanical methods, as weed invasion may be expected from the landfill area or the adjacent farmland. Regenerating seedlings should be protected by a vermin proof fence, and regular inspections for rabbit infestation should be undertaken. In the longer term, local landcare and conservation groups should be encouraged to take an interest in the restored quarry and landfill sites to ensure the success of the planting, as the heavy public usage of the reserve will require human impact and fire management strategies to be implemented and enforced.

## 6.0 DIEBACK MANAGEMENT

The past land usage of much of reserve 31900 and adjacent farmland indicates that dieback infection would have been introduced to these areas over a long period of time. Although the reserve contains a range of species susceptable to the disease, no symptoms were observed in the remnant woodland that would suggest that *Phytothphora* is presently active.

Hygiene proceedures are recommended when carrying out vegetation clearing, topsoil removal and replacement operations in the remnant woodland so as to minimize the risk of contaminating topsoil. All vegetated areas adjacent to the proposed mining zone should be quarantined from vehicular entry or disturbance. As the remnant woodland area is small and situated next to areas receiving uncontrolled vehicular access, it is recommended replanting should involve mostly dieback resistant species.

## 7.0 CONCLUSIONS

The principal impact of the proposed mining will involve the clearing of a small area of remnant vegetation in reserve 31900. This will result in the loss of approximately 10% of vegetation type 3b included within the group of reserves, and 8% of the total vegetation in the reserves. No vegetation type 20b will be affected by mining. A revegetation programme is proposed that would restore the overstorey stratum and many of the existing understorey species, however it is not practical to attempt to immediately recreate the existing understorey community structure.

The restoration programme will restore the landform of the disused quarry area and replant appropriate species compatable with the adjacent vegetation. The principal objective of the rehabilitation will be to restore and enhance where possible conservation values, although recognizing that ongoing landfill activities will continue to degrade the natural attributes of the reserve.

## 8.0 REFERENCES

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*Report on Floral Values of the Bushland in Yarloop Townsite opposite Johnson Road.*
Unpublished Report, C.A.L.M.

TABLE 1

PLANT SPECIES OBSERVED TO OCCUR IN RESERVE 31900

Table 12- Fronotic. Species that typify.

20b Acacia sessilis MIMOSACEAE
3b 20b Acacia stenoptera MIMOSACEAE
Allocasuarina fraseriana CASUARINACEAE end range D.
3b 20b Astroloma pallidum EPACRIDACEAE S 20b
20b Banksia attenuata PROTEACEAE T 20b
Banksia grandis PROTEACEAE
Bossiaea ornata PAPILIONACEAE
3b 20b Burchardia umbellata COLCHICACEAE H 20b
20b ✓ Calytrix flavescens MYRTACEAE
Conospermum incurvum PROTEACEAE
Conospermum stoechardis PROTEACEAE
3b 20b Cyathochaeta avenacea CYPERACEAE H 3b
3b 20b Dampiera linearis GOODENIACEAE
3b 20b Dasypogon bromeliifolius DASYPOGONACEAE H 20b
Davesia decurrens PAPILIONACEAE
Davesia divaricata PAPILIONACEAE
3b Davesia priessii PAPILIONACEAE
3b ✓ Dianella revoluta PHORMIACEAE
3b 20b Dryandra nivea PROTEACEAE S 20b
3b 20b Eucalyptus marginata MYRTACEAE T 3b 20b
Grevillea quercifolia PROTEACEAE
Grevillea wilsonii PROTEACEAE
3b 20b Haemodorum laxum HAEMODORACEAE H 3b 20b
3b 20b Hakea ruscifolia PROTEACEAE H 20b
20b Hemiandra pungens LAMIACEAE
Hibbertia acerosa DILLENIACEAE
Hibbertia commutata DILLENIACEAE
3b 20b Hibbertia hypercoides DILLENICAEAE S 3b 20b

Flora list

TABLE 1 cont.

*Hibbertia vaginata* DILLENIACEAE
*Hovea trisperma* PAPILIONACEAE
*Hybanthus floribundus* VIOLACEAE
*Hypocalymma robustum* MYRTACEAE
*Isopogon formosus* PROTEACEAE
*Lepidosperma angustatum* CYPERACEAE
*Lepidosperma squamatum* CYPERACEAE
*Leucopogon australis* EPACRIDACEAE
*Lomandra preissii* DASYPONONACEAE
*Lomandra purpurea* DASYPOGONACEAE
*Loxocarya fasciculata* RESTIONACEAE
*Lyginia barbata* RESTIONACEAE
*Macrozamia reidlei* ZAMIACEAE
*Mesomelaena tetragona* CYPERACEAE
*Muehlenbeckia adpressa* POLYGONACEAE
*Olearia paucidentata* ASTERACEAE
*Opercularia hispidula* RUBIACEAE
*Oxylobium capitatum* PAPILIONACEAE
*Patersonia occidentalis* IRIDACEAE
*Pentapeltis peltigera* APIACEAE
*Persoonia elliptica* PROTEACEAE
*Persoonia saccata* PROTEACEAE
*Petrophile linearis* PROTEACEAE
*Phlebocarya ciliata* HAEMODORACEAE
*Phyllanthus calycinus* EUPHORBACEAE
*Scaveola striata* GOODENIACEAE
*Schoenus sp.* CYPERACEAE
*Senecio quadridentatus* ASTERACEAE
*Stipa elegantissima* POACEAE
*Stirlingia latifolia* PROTEACEAE
*Styphelia tenuiflora* EPACRIDACEAE
*Tetraria capillaris* CYPERACEAE
*Thysanotus* sp. ANTHERICACEAE
*Trycoryne elatior* ANTHERIACEAE
*Xanthorrhoea gracilis* XANTHORRHOEACEAE
*Xanthorrhoea preissii* XANTHORRHOEACEAE
*Xanthosia candida* APIACEAE
*Xylomelum occidentale* PROTEACEAE

TABLE 2

TREE SPECIES RECOMMENDED FOR SHADE AND SHELTER BELT PLANTING ON FARMLAND.

| Species | Potential height (metres) |
|---|---|
| *Allocasuarina fraseriana* | 5 - 8 |
| *Eucalyptus accedens* | 10 - 20 |
| *Eucalyptus calophylla* | 30 - 40 |
| *Eucalyptus haemotoxylon* | 6 - 9 |
| *Eucalyptus laeliae* | 6 - 20 |
| *Eucalyptus lane-poolei* | 12 - 15 |
| *Eucalyptus marginata* | 15 - 46 |
| *Eucalyptus rudis* | 9 - 15 |
| *Xylomelum occidentale* | 5 - 8 |

TABLE 3

PLANT SPECIES OBSERVED IN OR ADJACENT TO RESERVE 31900 WHICH ARE SUITABLE FOR PROPAGATION FROM SEED.

*Acacia huegelii*
*Acacia preissiana*
*Acacia pulchella*
*Acacia saligna*
*Acacia sessilis*
*Acacia stenoptera*
*Allocasuarina fraseriana*
*Allocasuarina humilis*
*Bossiaea eriocarpa*
*Bosseaea ornata*
*Danthonia occidentalis*
*Davesia decurrens*
*Davesia divaricata*
*Davesia physodes*
*Davesia preissii*
*Eucalyptus calophylla*
*Eucalyptus marginata*
*Compholobium aristatum*
*Compholobium confertum*
*Compholobium knightianum*
*Compholobium ovatum*
*Compholobium polymortphum*
*Compholobium preissii*
*Compholobium shuttleworthii*
*Hakea cyclocarpa*
*Hakea prostrata*
*Hakea ruscifolia*
*Hakea varia*
*Hovea chorizemifolia*
*Hovea trisperma*
*Kennedia coccinea*
*Kennedia prostrata*
*Melaleuca scabra*
*Melaleuca thymoides*
*Scholtzia ciliata*

TABLE 4

PLANT SPECIES OBSERVED IN OR ADJACENT TO RESERVE 31900 WHICH ARE SUITABLE FOR ROOTSTOCK OR STEM PROPAGATION.

*Dasypogon bromeliifolius*
*Dianella revoluta*
*Haemodorum spicatum*
*Hibbertia acerosa*
*Hibbertia huegelii*
*Hibbertia hypericoides*
*Lechenaultia floribunda*
*Lepidosperma tenue*
*Lomandra* spp.
*Mesomelaema tetragona*
*Nuytsia floribunda*
*Patersonia occidentalis*
*Phlebocarya ciliata*
*Phyllanthus calycinus*
*Scaevola canescens*
*Tetraria capillaris*
*Tetraria octandra*
*Xanthorrhoea gracilis*
*Xanthorrhoea preissii*

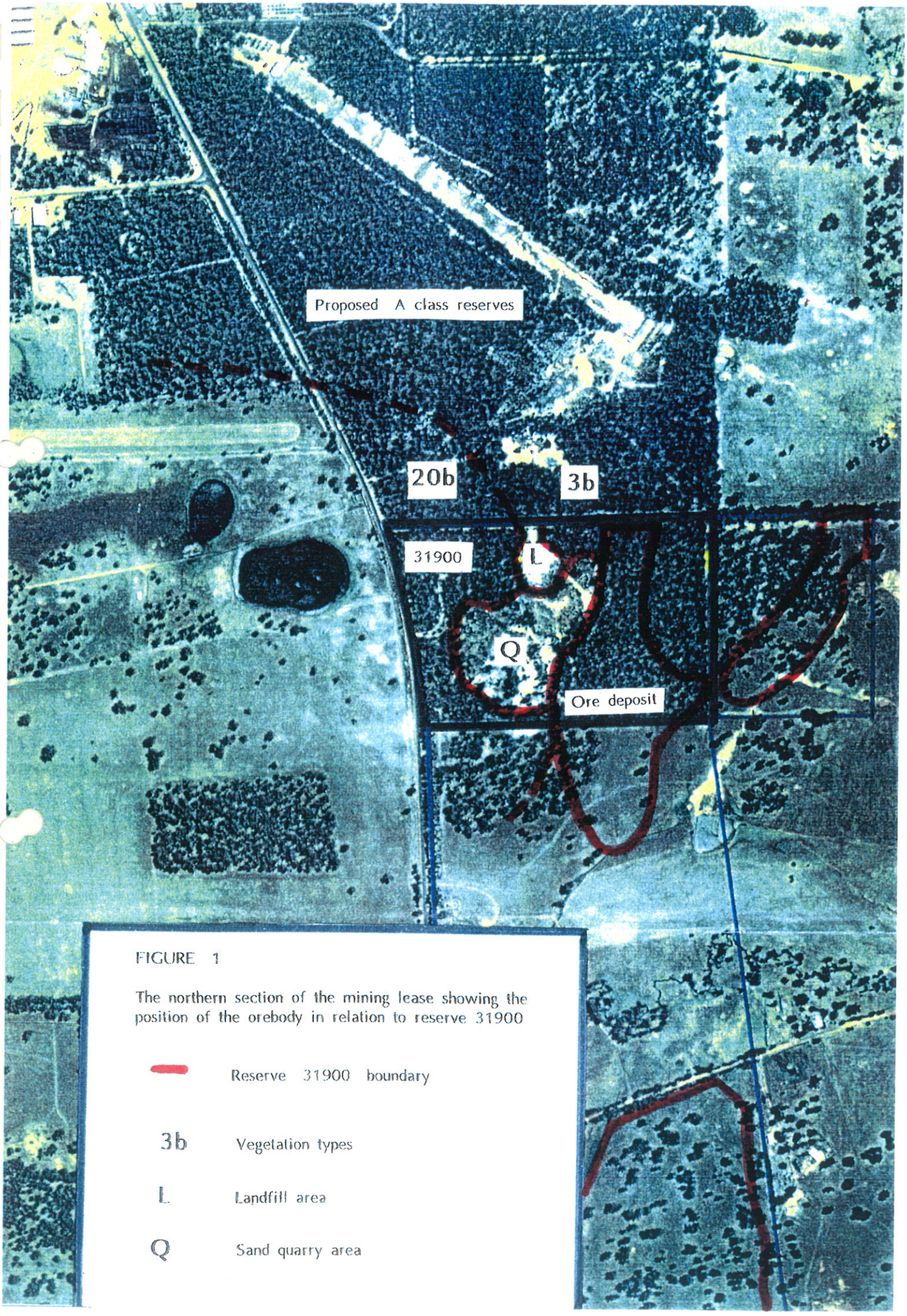



FIGURE 1

The northern section of the mining lease showing the position of the orebody in relation to reserve 31900

Reserve 31900 boundary

3b Vegetation types

L Landfill area

Q Sand quarry area

# APPENDIX 3

# FAUNA ASSESSMENT
# ML70/47, SOUTH OF YARLOOP

for

**CABLE SANDS (WA) PTY LTD**

by

**W G MARTINICK AND ASSOCIATES**

**MARCH 1996**

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PLATE 1: Aerial photograph of the Study Area

PLATE 2: Reserve 31900: Where sandmining/rubbish dump adjoins the Jarrah forest. The soil profile is exposed showing shallow white sand over yellow loamy sands

PLATE 3: Reserve 31900: Jarrah forest over diverse groundcover species

PLATE 4: Reserve 31900: Sand mining areas

PLATE 5: Typical creek within the Study Area with riparian vegetation replaced by pasture species. Overstorey of Flooded Gum

PLATE 6: Dense stand of Jarrah in partially cleared areas where understorey has been replaced by pasture species

PLATE 7: Partially cleared areas with scattered Jarrah/Marri trees. The line of site is along a creek line

FIGURE 1: Locality map of the Study Area

## 1.0 SUMMARY AND CONCLUSION

The Study Area consists of farmland and reserve. The farmland has been parkland and totally cleared for cattle production. The habitats of the pasture areas include tree canopies and a fenced farm dam, both of which are common within the locality.

In the north of the Study Area is Reserve 31900 which is separate and fenced from the farmland. It is located entirely within Mining Lease M70/49 and is reserved for rubbish dumping and sand extraction. The total area of the reserve is approximately 20ha of which approximately 9ha supports vegetation which is in good condition with very little evidence of disturbance. The balance of the reserve consists of disturbed vegetation from which some trees have been removed and the understorey has been degraded. The value of the reserve is enhanced by its linkage to reserves to the north which vary in terms of disturbance and conservation value.

The conservation values of this reserve pertain mostly to botanical rather than fauna values. Botanical values of Reserve 31900 are high due to the limited presence elsewhere of its vegetation (report to Cable Sands by D. Backshall, Environmental Survey and Management Pty Ltd). The important habitats of the Study Area are located within the undisturbed area of Reserve 31900. The fauna values of the Study Area have been reduced because the reserve and neighbouring reserves are an island of remnant vegetation with poor prospects for supporting diverse or rare fauna in the long term.

Fauna species which have been recorded for the local region are listed and a discussion of rare fauna which might occur within the Study Area is included. It is concluded that fauna species which have been gazetted rare and/or endangered are unlikely to be dependant on the habitats of the Study Area.

## 2.0 OBJECTIVES

The objectives of this report are to assess the habitats of the Study Area and to determine the animal species which are most likely to be found within the Study Area.

## 3.0 LOCATION AND VEGETATION OVERVIEW

The Study Area consists of Mining Leases M70/49 and its outline is shown in Plate 1. Figure 1 shows the Study Area in a regional context. The northern boundary of the Study Area is located on the access road to the Yarloop rubbish tip which is approximately 2km to the south of the town of Yarloop. The Study Area is bounded to the west by South West Highway. To the east and south the Study Area is bounded by pasture.

The native vegetation of the freehold land within the Study Area has been parkland cleared and in places totally cleared. Reserve 31900 (Reserved for rubbish disposal and sand extraction) which consists of 19.7ha and is entirely located within the northern part of the Study Area consists of Jarrah dominated forest of which about 11ha has been partly degraded by vehicle tracks, rubbish dumping and sand extraction. The 9 hectares of undisturbed Jarrah forest are located in the east of Reserve 31900. Reserve 31900 is adjacent to Reserves 23307, 31901, 3672 and 16681 which lie further to the north, and which cover 76.5ha and support native vegetation which varies from disturbed to good condition. Apart from a corridor which has been cleared for a rifle range, these reserves form a continuous forest canopy and are entirely surrounded by cleared agricultural land.

The vegetation within the reserves represents remnant vegetation of the Forrestfield Complex on Ridge Hill Shelf Landform (D.C.E., 1980). Most of such vegetation has been cleared for agriculture.

The Study Area is dissected by four westward draining creeks which are fringed by Jarrah, Marri and Flooded Gum trees. There is a small dam within a fenced-off area in the south of the Study Area.

A fenced corridor of approximately 20m width and supporting near-mature *Acacia spp.* and *Eucalypt spp.* is adjacent to South West Highway.

## 4.0 METHODS

The entire Study Area was traversed during a one-day field inspection on 7 March 1996. Areas with important habitats, such as Reserve 31900 and the creeks were inspected in detail. The remnant vegetation was extensively searched and any signs which indicate the presence of fauna such as marks on bark, disturbed ground, burrows and scats were recorded.

Information which was utilised for the study includes aerial photography at a scale of 1:10,000, a botanical survey of the Study Area by Dr D Backshall, regional maps and a printout of the WA Museum fauna data for the locality.

## 5.0 RESULTS AND DISCUSSION

### 5.1 Jarrah forest habitats

These habitats are located in Reserve 31900 which is shown in Plate 1.

Plate 2 shows the extent of sand extraction on the western periphery of the forest. The undisturbed eastern portion of the reserve has a shallow horizon of white/grey coloured sands over deep yellow/orange sandy loams which are typical of the Ridge Hill Shelf soils. Undisturbed forest is shown in Plate 3. The white sand is considerably deeper on the western portion of the reserve where extensive sand extraction has taken place (see Plate 4).

The eastern side of Reserve 31900 consists of approximately 9ha of undisturbed Jarrah (*Eucalyptus marginata*) forest to 25m in height over a closed canopy of Jarrah to 15m in height. Between 2 and 4m in height is a lower stratum of *Allocasuarina fraseriana, Banksia grandis, Banksia attenuatum* an *Xylomelum occidentalis.*

Shrubs of 1 to 2m in height include *Jacksonia Sternbergiana* and juvenile *Persoonia longifolia* and *Xylomelum occidentalis. Xanthorrhoea preissii* (Blackboys) are common.

The low shrub/groundcover stratum is very diverse. There is no evidence of recent fires and the groundcover includes a dense layer of vegetation debris. This stratum has been extensively removed in sand mining and dumping areas in the west of the reserve.

The habitats of the Jarrah forest which are of importance to animal species which are native to the area include the following:

i. A large number of Jarrah trees which are located in the disturbed and undisturbed areas of the reserve. These trees contain hollows which are used by bats for roosting sites and by birds, especially *Psittacines* (parrot species), for nesting.

ii. Canopy of immature Jarrah and *Banksia, Jacksonia* and *Xylomelum* spp. which provide nesting, refuge and feeding habitats for a large number of bird species which are common on the Swan Coastal Plain. Food resources for bird and mammal species include blossom, leaf and invertebrate assemblage of the canopy.

iii. Ground stratum which consists of a diverse plant community with dense vegetation debris over sandy soils. The ground layer provides a complex foodchain from decomposing organic material through to insects and small reptiles which are in turn preyed upon by larger reptiles, birds and mammals. Refuge habitats are found in dense groundcover and sandy soils which are amenable for burrowing.

### 5.2 Revegetated habitats

These habitats are found within the 20m wide fenced area on the western boundary of the Study Area. Plants are mostly non-local species which form a dense stratum which is 1 to 4m in height. A line of Eucalypts sp. to 15m in height is within the road reserve and borders the rehabilitated area. The habitat is similar to that described in Section 6.1 (ii) except that the plant species are not representative of local species.

### 5.3 Creeks

The understorey vegetation of the four creeks within the Study Area has been replaced by pasture species (as per Plate 5). The exception being a fenced farm dam on the southern border of the Study Area (Plate 1). A degraded wetland with no remnant native vegetation is adjacent to South West Highway in the south of the Study Area.

The fenced dam is fringed by a remnant overstorey of trees to 15m in height and the groundcover is in good condition. This dam is approximately 0.5ha in extent and is a feeding and refuge habitat for water birds.

The creeks have an open overstorey of Jarrah, Marri and Flooded Gum trees and their habitats are similar to, but more degraded, than habitats described in Section 5.1 (ii).

### 5.4 Cleared pastures

The pasture areas vary from woodlands with a closed canopy (Plates 1 and 6) to pasture with scattered trees (Plate 7).

The habitats which these provide are similar to, but more degraded, than habitats described in Section 5.1 (ii).

### 5.5 Conservation value of the habitats

Habitats are usually of the highest value in areas which show the least disturbance and which provide the greatest vegetation cover and diversity. Thus the areas of the Study Area may be ranked as follows in terms of habitat values:

i. undisturbed forest
ii. disturbed forest and fenced farm dam
iii. revegetated areas and pasture with closed overstorey
iv. pasture with scattered trees

A more detailed discussion of these habitats follows:

i. The undisturbed forest in Reserve 31900 is a remnant of vegetation which is enhanced by its proximity to adjoining reserves to the north which in total form a large island of remnant vegetation. The conservation value of this area is related more to its representative flora than to animal habitats. This is because the remnant vegetation represents a vegetation community which is now poorly represented on the Swan Coastal Plain (D.Backshall).

ii.-iv. These habitats consist of tree canopy habitats and the wetland of the fenced farm dam. These habitats are of value to bird species but they have limited conservation value. This is because farm dams and pasture with scattered trees are common and widespread on the Swan Coastal Plain.

### 5.6 Fauna

A list of fauna which have been identified in the locality of the Study Area are given below.

| SPECIES | COMMON NAME | HABITAT |
|---|---|---|
| **REPTILES** | | |
| AGAMIDAE | | |
| *Lialis burtonis* | Burton's Snake Lizard | Forest |
| PYGOPODIDAE | | |
| *Pogona minor minor* | Western Bearded Dragon | Forest |
| *Pygopus lepidopodus lepidopodus* | Common Scaly-foot | Forest |

| SPECIES | COMMON NAME | HABITAT |
|---|---|---|
| **REPTILES** | | |
| GEKKONIDAE | | |
| *Phyllodactylus marmoratus marmoratus* | Marbled Gecko | Widespread |
| *Underwoodisaurus milii* | Barking Gecko | Forest |
| VARANIDAE | | |
| *Varanus gouldii** | Gould's monitor | Widespread |
| SCINCIDAE | | |
| *Egernia napoleonis* | Napoleon Skink | Widespread |
| *Glaphyromorphus* sp. | - | - |
| *Hemiergis initialis initialis* | - | Forest |
| *Hemiergis quadrilineata* | - | Coastal plain |
| *Lerista distinguenda* | - | Widespread |
| *Morethia lineoocellata* | - | Forest |
| BOIDAE | | |
| *Morelia spilota imbricata* r | Carpet Python | Widespread |
| ELAPIDAE | | |
| *Notechis coronatus* | - | - |
| *Notechis scutatus occidentalis* | Western Tiger Snake | Creek habitats |
| *Pseudonaja affinis affinis* | Dugite | Widespread |
| *Ramphotyphlops australis* | - | Widespread |
| *Ramphotyphlops pinguis* | Blind Snake | Widespread |
| *Rhinoplocephalus gouldii* | Gould's Whip Snake | Forest |
| *Rhinoplocephalus nigriceps* | Short-tailed Snake | Forest |
| CHELONIDAE | | |
| *Chelodina oblonga* | Oblong Turtle | Permanent water |
| **FROGS** | | |
| HYLIDAE | | |
| *Litoria moorei* | Bell Frog | Permanent water |
| *Crinia georgiana* | Quacking Frog | Coastal plain |
| *Geocrinia leai* | Lea's Frog | Streams and swamps |
| *Heleioporous eyrei* | Moaning Frog | Swamp areas |
| **MAMMALS** | | |
| BURRAMYIDAE | | |
| *Cercartetus concinnus* | Western Pigmy Possum | Forest and heath |
| *Antechinus flavipes* | Yellow-Footed Antechninus | Forest |
| *Dasyurus geoffroii* r | Western Quoll | Forest |
| *Hydromys chrysogaster* | Water Rat | Waterways |
| *Nyctophilus geoffroyi* | Lesser Long-eared Bat | Forest |
| *Trichosurus vulpecula* | Brush-tailed Possum | Forest |
| *Macropus fuliginosus** | Western Grey Kangaroo | Forest/pasture |

| SPECIES | COMMON NAME | HABITAT |
|---|---|---|
| **BIRDS** | | |
| *Corvus coronoides** | Australian Raven | Forest/pasture |
| *Anhinga melanogaster** | Darter | Farm dam |
| *Anas superciliosa** | Pacific Black Duck | Farm dam |

* species observed or signs observed during the field visit
r species gazetted rare and/or endangered

Although the Museum list does not contain any bird species, it is very likely that a large number of bird species which are common to the Swan Coastal Plain will be found from time to time within the habitats of the Study Area. Only a limited number of birds were observed within the Study Area at the time of the visit and these are listed in the table above.

Mammalian and reptilian species which were observed or signs of which were observed are also listed in the table above.

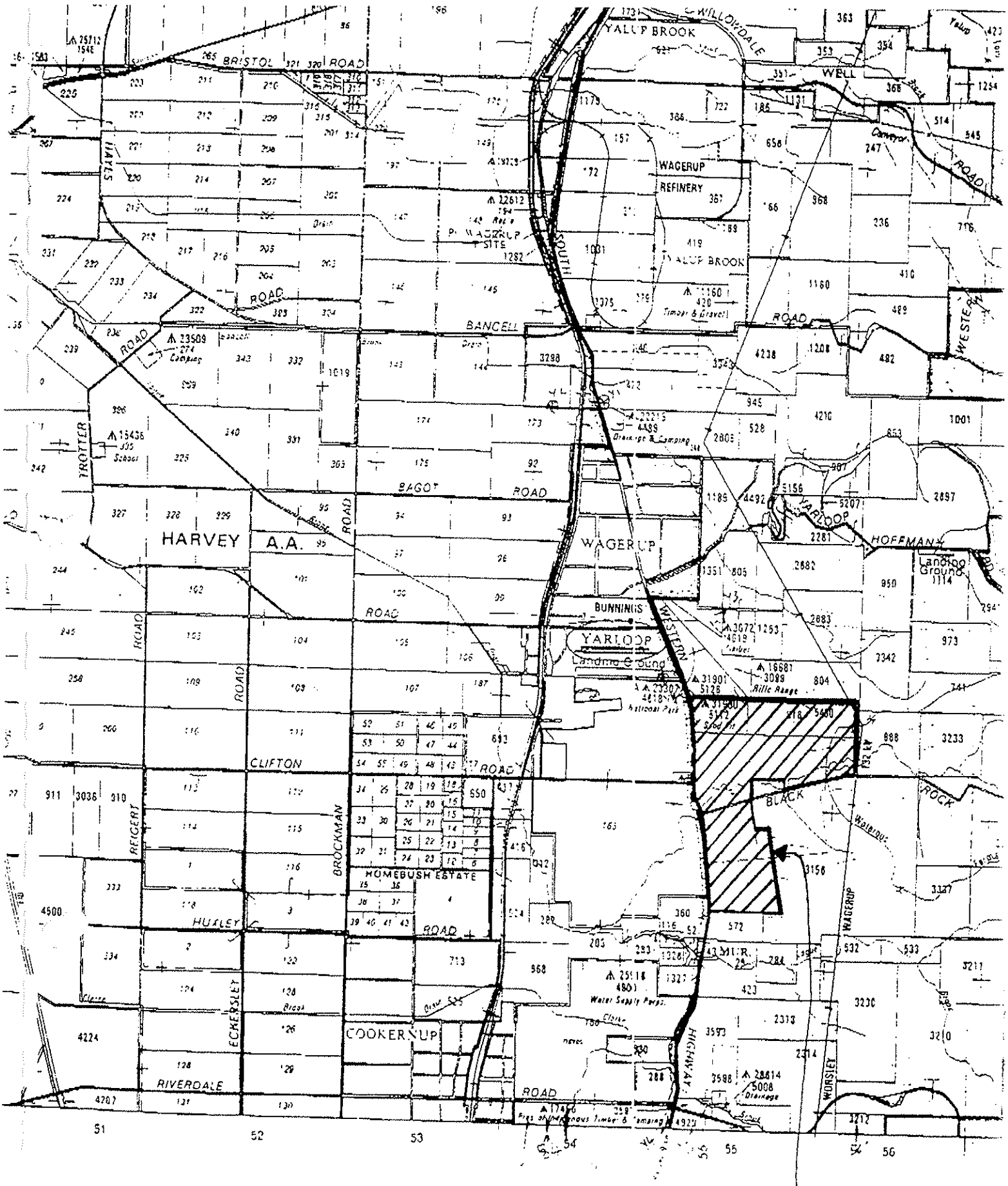
It is possible that some of the species listed above could be found within the Study Area, especially within the undisturbed area of Reserve 31900. Apart from common mammals such as the Grey Kangaroo, which was observed in Reserve 31900 during the visit, and the Brush-tailed Possum, many of the other mammals which are listed are more likely to be found in undisturbed or less disturbed forest habitats to the east of the coastal plain. Islands of remnant vegetation are unlikely to support any but common animal species. This is because animals in remnant vegetation communities are more exposed to predation pressures from species which are common, have greater mobility and which are not confined to the "island". These include birds of prey, common snakes such as the Dugite, and introduced species such as the fox, cat and dog. In extensive uncleared areas predation pressures are likely to be lower than in island refuges and these areas present a greater range and continuum of habitats which provide greater temporal and spatial variety. This variety is necessary for animals to find a continuum of resources throughout the year. In contrast island remnant habitats, such as Reserve 31900 and associated reserves, present a very restricted range of habitats and greater predation risks. Therefore it is very unlikely that rare species such as the Western Quoll and the Carpet Python, as listed above, would be found within the Reserve 31900.

A gazetted rare and/or endangered animal species which is found on the southern regions of the Swan Coastal Plain is the Western Ringtail Possum (*Pseudocheirus occidentalis*). This species is most commonly found in the Peppermint/Marri tree association which are usually closer to the coast than is the Study Area. The Ringtail Possum builds nests called dreys and these may often be found in Peppermint trees when the Ringtail Possum is present. No Peppermint trees are found within or near to the Study Area and the search of the Study Area did not reveal the presence of Ringtail Possum dreys. It is concluded that Ringtail Possums are not found within the locality of the Study Area.

Other gazetted species which do not appear in the WA Museum records for the locality but which could visit the Study Area include the Peregrine Falcon (*Falco peregrinus*), Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) and Carnaby's Black Cockatoo (*Calyptorhynchus carnabii*). These species are all wide ranging in their daily and seasonal habits and consequently their ongoing survival will not depend on the fate of Reserve 31900.

## PLATES


| | |
|---|---|
| PLATE 1: | AERIAL PHOTOGRAPH OF THE STUDY AREA |
| PLATE 2: | RESERVE 31900: WHERE SANDMINING/RUBBISH DUMP ADJOINS THE JARRAH FOREST. THE SOIL PROFILE IS EXPOSED SHOWING SHALLOW WHITE SAND OVER YELLOW LOAMY SANDS |
| PLATE 3: | RESERVE 31900: JARRAH FOREST OVER DIVERSE GROUNDCOVER SPECIES |
| PLATE 4: | RESERVE 31900: SAND MINING AREAS |
| PLATE 5: | TYPICAL CREEK WITHIN THE STUDY AREA WITH RIPARIAN VEGETATION REPLACED BY PASTURE SPECIES. OVERSTOREY OF FLOODED GUM |
| PLATE 6: | DENSE STAND OF JARRAH IN PARTIALLY CLEARED AREAS WHERE UNDERSTOREY HAS BEEN REPLACED BY PASTURE SPECIES |
| PLATE 7: | PARTIALLY CLEARED AREAS WITH SCATTERED JARRAH/MARRI TREES. THE LINE OF SITE IS ALONG A CREEK LINE |




SCALE 1:50,000

AREA OF MINING LEASE AT YARLOOP

FIGURE

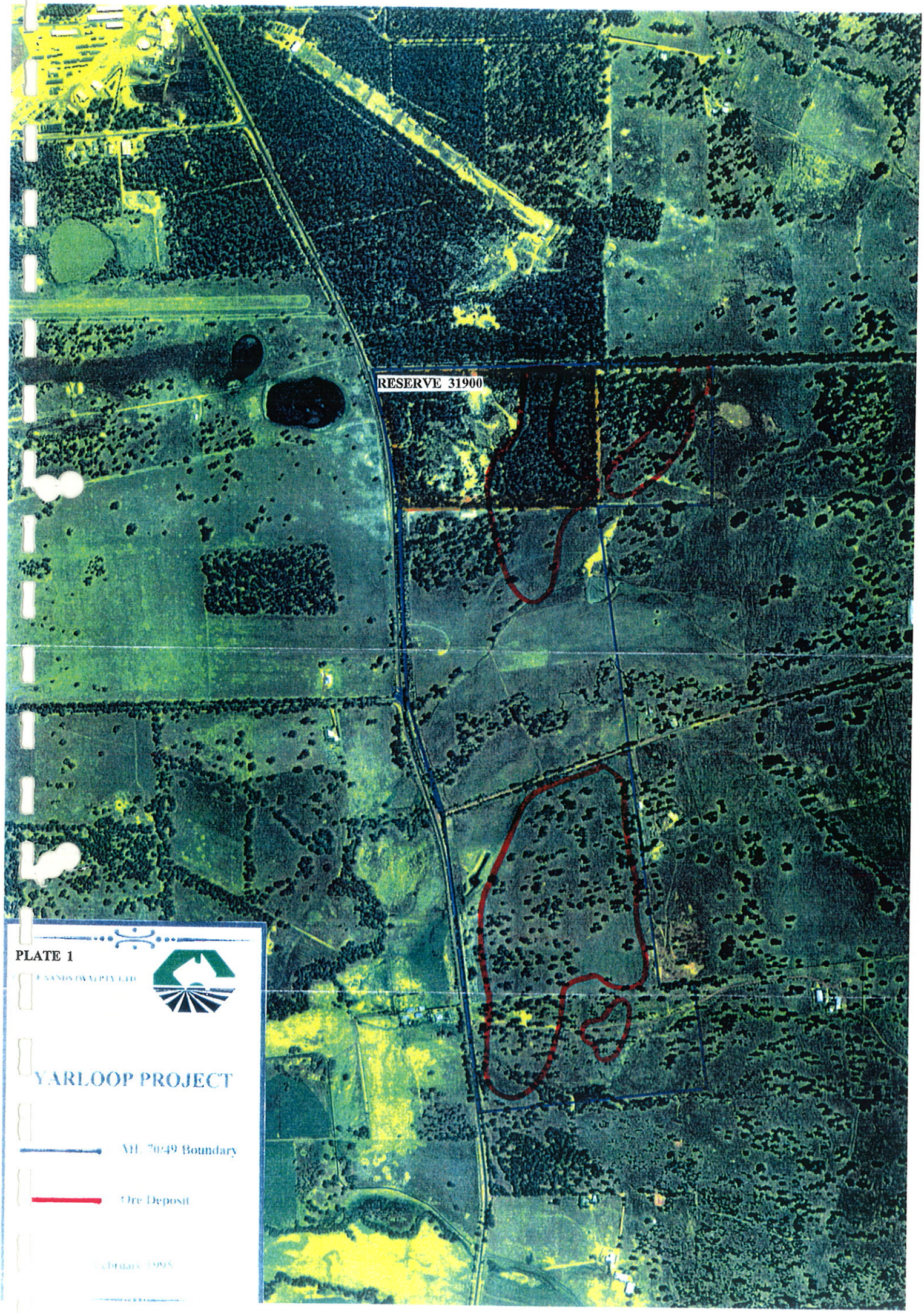

RESERVE 31900
PLATE 1
YARLOOP PROJECT
ML 70/49 Boundary
Ore Deposit

PLATE 2



PLATE 3




PLATE 4




PLATE 5



PLATE 6



PLATE 7

