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Preliminary environmental survey : Drake prospect N.S.W. :

vegetation, fuana, water quality, archaeology

Aberfoyle Limited

Preliminary Environmental Survey
Drake, N.S.W.

APRIL 1981

Environmental Consultants

PRELIMINARY ENVIRONMENTAL SURVEY

DRAKE PROSPECT

N.S.W.

Vegetation
Fauna
Water Quality
Archaeology

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APRIL, 1981

Cover: Mining at Drake during the late 19th century. Probably the now abandoned copper workings, Wann's Mine, just south of Mt. Carrington

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1.0 INTRODUCTION

1.1 Context

Aberfoyle Exploration Pty. Ltd. are the operators of a joint venture with Mt. Carrington Mines Ltd. to explore and develop several prospects around Drake, a small town in northern New South Wales, about 70 km west of Casino. Drilling continues to determine more fully the extent and grade of mineralisation, but results to date indicate sub-economic deposits of silver, gold, copper, lead and zinc. Further reserves of silver will need to be delineated to consider the feasibility of mining. The location of the project is shown in Figure 1.

The present study initiates systematic environmental work associated with the project, which must ultimately meet two objectives:

(a) permit the assessment of environmental effects and safeguards by government agencies;

(b) define the status of the project area and surrounds prior to any development, as a basis for monitoring its effects in operation.

The present study is neither a full impact assessment nor pre-operation baseline; however it addresses specifically what are believed to be the major issues raised by the proposal at this time.

1.2 Physical Setting

Drake lies on the eastern slopes of the New England Range in northeastern New South Wales, midway between Tenterfield and Lismore. The climate is cool subtropical, with rainfall of 1430 mm and a distinct wetter season from December to April. The average summer maximum temperature is 30°C and winter 20°C. Terrain varies from steep and mountainous in the south, with a maximum height of 1100 m A.S.L. at Mt. Richmond, to undulating hills in the central and northern sectors of the study area (Figure 2). Dry sclerophyll forest covers most of the study area, although large tracts have been cleared for agriculture, logging, power line easements and past mining activities. Small pockets of rainforest are found in the south of the Girard State Forest, a flora and fauna reserve which occupies about 50% of the study area. A dendritic pattern of small streams drain toward the northeast where they meet the northerly flowing Clarence River.

The area's history, since European settlement, is dominated by mining. Silver, gold and copper mines at White Rock and Lady Adeline were opened in 1886 and numerous shafts were sunk producing metals to the value of £250,000 prior to 1908. In all, nineteen major mineral deposits have been recorded at Drake (Appendix D). Mining waned from the early 1900's to the end of World War II, when North Broken Hill Limited revived exploration activities. Today hundreds of abandoned shafts, open cuts and mullock heaps can be found around Drake in various stages of revegetation.

Pastoral and timber industries were also important and today they support the much reduced Drake township. Forest is being cleared for cattle grazing and Ford Timber Pty. Ltd. operate a sawmill on the outskirts of Drake (Plate 5).

1.3 Project Outline

The joint venturers have delineated silver and gold mineralisation in two pockets but further exploration and feasibility studies will be needed before the viability of a mine(s) is established. However, for the purpose of this study it is assumed that any future development would comprise the following on-site elements:

(a) A mining rate of 500 t.p.d. eventually increasing to 2000 t.p.d.
(b) One or more open cut pits.
(c) A crushing mill with associated flotation and cyanidation plant.
(d) Coarse and slimes tailings dams.
(e) Waste rock dumps.
(f) Maintenance facilities and an administration block.
(g) Ore stockpile areas.

Ancillary components would necessarily include the following:

(a) Water supply scheme.
(b) Road construction.
(c) Re-routing and upgrading of existing power supply.
(d) Provision of housing for construction and operation workforce at Drake.

Those effects, or potential effects, which are a predictable function of this type of project in this type of environment are addressed in this report. On the other hand, there are effects or potential effects that are a function of final mine planning, detailed engineering design and selected management policies, for example noise, vibration, dust and rehabilitation. These effects can only be described and assessed when the project is substantially further advanced.

1.4 Issues and Objectives

Experience with similar mining operations and environments indicates the following to be the principal issues:

(a) The effect of mining, milling and ore processing at Drake, on the sediment load, water quality and aquatic life (ecology) of the downstream drainage (in the context of past land disturbance in this area).

(b) The loss of a natural area (albeit disturbed land) and rare or endangered species of plants or animals (if any).

(c) The loss of, or increased threat to, archaeological sites (if any).

The present study is concerned specifically with these issues and its objectives are defined accordingly:

(a) To survey the environment, archaeology and land use of the project area.

(b) To confirm and/or revise the environmental, archaeological and land use issues raised by the project.

(c) To assess the significance of each issue in the light of the survey results, and classify the issues as either,
(i) resolved and not requiring further investigation;
or (ii) likely to be the subject of a request for information from the government.

1.5 Future Work

The principal legislation to which this study ultimately relates is the Environmental Planning and Assessment Act 1979. This stipulates that applications for "Designated Developments" require an Environmental Impact Statement (s.77,3[d]), and a future mine at Drake would fall into this category, being "mining authorised by a lease under the Mining Act 1906". When an E.I.S. is required, then the results of this initial study of aspects of principal concern can be augmented by such additional information, collection and analysis as is appropriate. In addition to further environmental data (probably a full water quality baseline for subsequent monitoring) the granting of a mining lease is dependent on the Department of Mineral Resources acceptance that matters such as mine safety, noise, vibration and dust have been adequately handled, either by design measures, or the project's management programme. These items are typically contained in an E.I.S., and would also be addressed in a future statement for this project.

1.6 Study Team

The following individuals contributed to this study.

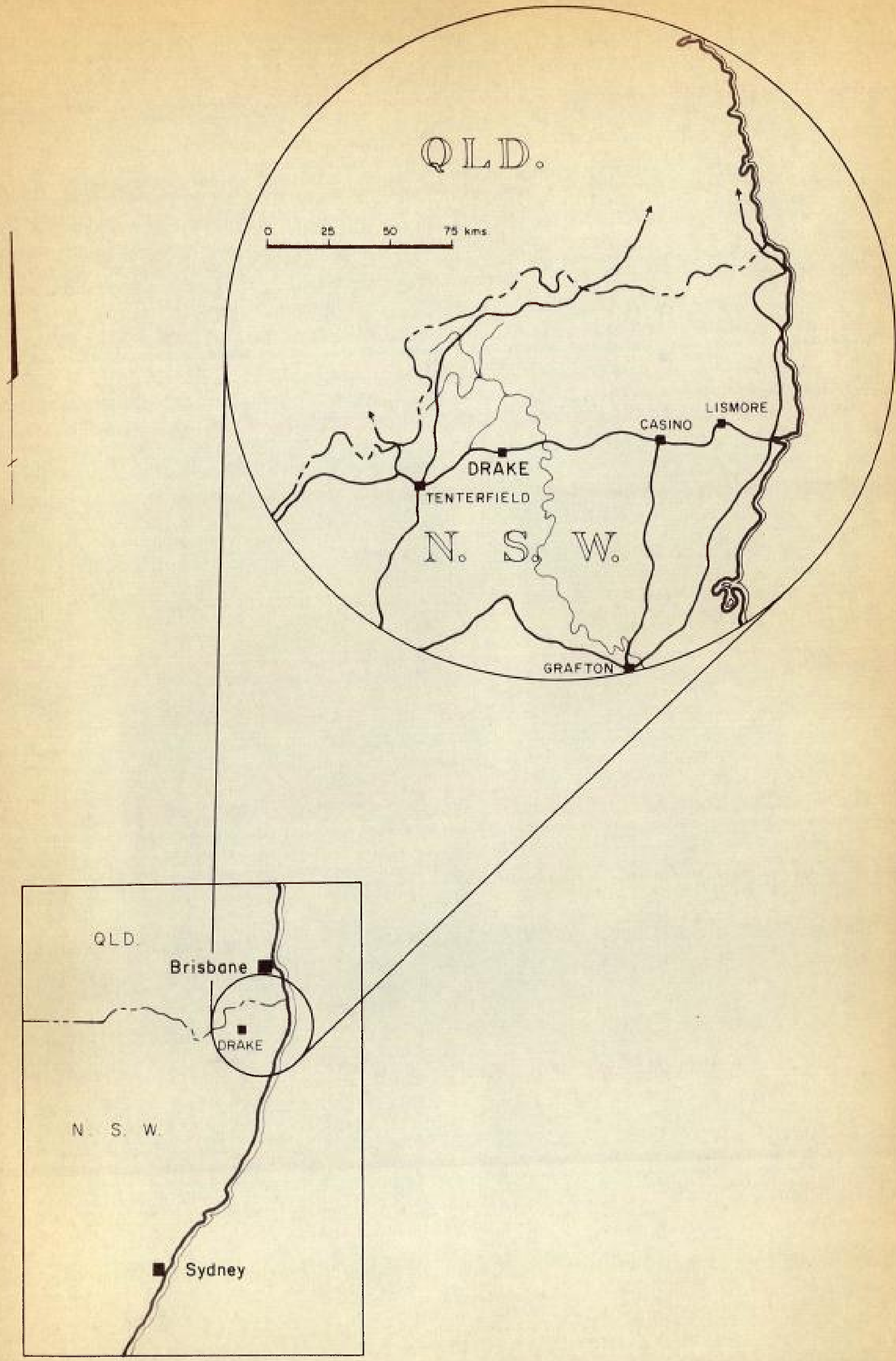
Mr. A.V. Sharp-Paul	Project director; editing
Mr. D.J. Strachan	Project manager; hydrogeology

Dr. R.D.B. Whalley	Terrestrial vegetation
Ms. S. Humphries	Terrestrial fauna; aquatic biology
Mr. P.F. Manning	Hydrology; water quality
Dr. P.H. Hughes)	
Ms. A. Blackwell)	Archaeology

Editorial responsibility for the substance, conclusions and implications in this report lies wholly with the main consultant, Natural Systems Research Pty. Ltd. and its principals.

1.7 Acknowledgements

The willing co-operation of Aberfoyle Limited personnel at the exploration office and site, particularly Messrs. John Fry and Frank Hankinson, are acknowledged with thanks. Helpful advice was obtained from: Messrs. G. McIlveen and K. Brooks (Department of Mineral Resources, Sydney), Mr. M. Slater (Department of Mineral Resources, Lismore), Mr. L. Drury (Water Resources Commission, Sydney), Mr. L. Martin (Water Resources Commission, Lismore), Mr. G. Mugridge (Council of the Shire of Tenterfield), Messrs. A. Butler and P. Ovenden (Forestry Commission, Tenterfield) Mr. J. Williams and Mrs. P. Wheeler (University of New England, School of Botany), Dr. I. McBryde (Australian Institute of Aboriginal Studies, Canberra), Ms. M. Sullivan (National Parks and Wildlife Service, Sydney), Messrs. R. Collins, T. Collins, A. Ford, E. Ford, Laurie, J. Sommerlad, Mrs. Ramsay, Mrs. Oakes and Mrs. Kelly (residents of Drake, Tabulam and Tenterfield). Many people contributed to the faunal studies and they are listed and acknowledged in Section 5.0



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FOR
ABERFOYLE LIMITED

DRAKE PROSPECT

LOCALITY MAP

FIGURE 1

2.0 SUMMARY

2.1 Overview

The gold, silver and copper mineralization around Drake has been intermittently worked over the past 90 years, and the area is pitted with old diggings, mullock heaps and tailings impoundments. The fortunes of the town of Drake have risen and fallen with its cyclical mining industry in the familiar sequence of growth and recession (Plates 1, 2, 3 and 4).

The environmental legacy of the past is noticeable as the bare acid earth of old diggings and the barren creeks draining them; on these have been superimposed more modern and more consistent activities, such as pastoral use and logging, and the effects of land clearing for tracks and transmission lines.

Present proposals are to redevelop two of the nineteen major mineral deposits that have been found and worked within a few kilometres of Drake. From a historical perspective, this represents yet another period of activity; but no fundamentally new elements are involved.

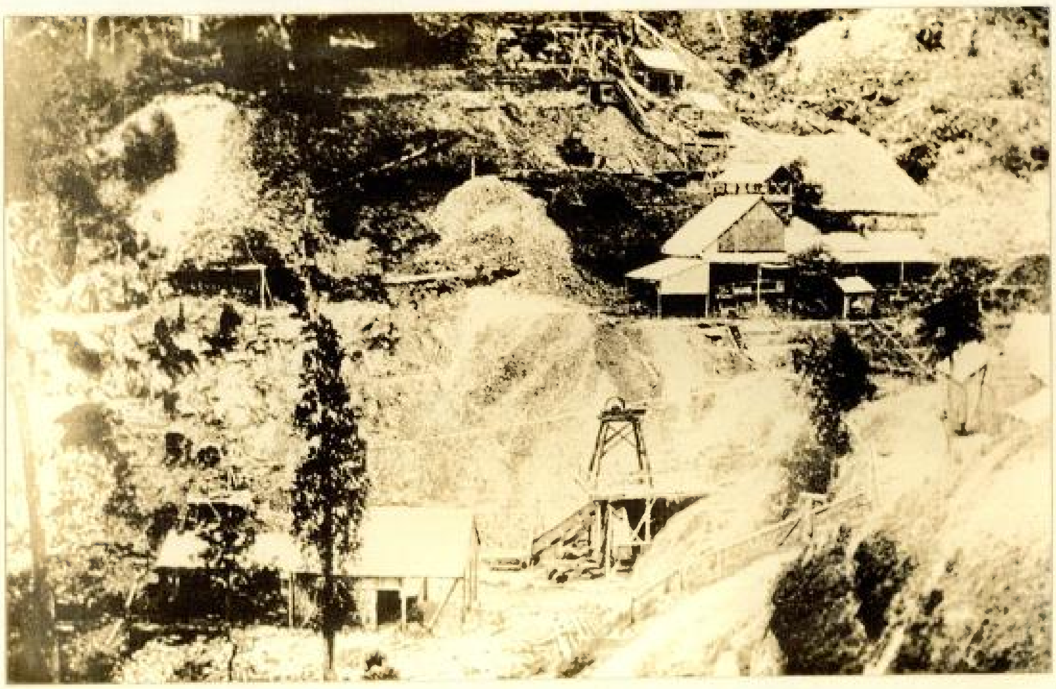


PLATE 1
Mining near Drake ca. 1900; location unknown, possibly White Rock.

From an environmental point of view, these proposals raise the question of renewed impact. Of the characteristic issues raised by such a project in this sort of environment, this survey can conclude that significant adverse effects on sites of aboriginal archaeological or contemporary mythological significance, on the fauna and flora of the area, and on its beneficial economic uses will not occur. However the project has the potential to perpetuate and exacerbate the current metal pollution of local creeks. Geographically speaking, the extent of this existing contamination appears limited, by dilution and perhaps the precipitation of toxic metals downstream, but in close proximity to the source the effects are substantial.

The environmental acceptability of renewed mining at Drake appears feasible in principal. From the point of view of the existing natural environment, containment of water pollution is the one issue requiring substantive further work, in the form of an appropriate mine and processing design and operating procedures. When the feasibility of the project has been established, including water pollution controls, then a full pre-operation water quality baseline can be established, by which actual effects on water quality can be monitored during operation. In a future mining and processing operation at Lady Hampden or White Rock, existing sources of pollution would be contained by normal modern industry practices in drainage control, water treatment and re-use. The net effect, therefore, would be a long term improvement in water quality.

PLATE 2
Mining near Drake ca. 1900, probably the Lady Hampden mine, crusher and plant.

Insofar as the human environment is concerned, the economic and social effects of renewed mining are likely to be beneficial (particularly in a region with a tradition of mining, but many closed mines). A number shut down in the 1970's, including Lady Hampden itself, and one of Tenterfield's two meatworks closed at the end of 1980. Unemployment is reputedly high, particularly in the Shire of Tenterfield.

Locally, the effect of mining on the amenity of Drake itself is largely a matter of appropriate design and operation. Despite their proximity, neither orebody nor associated workings will be visible from the Bruxner Highway and dust, noise and vibration can be controlled to acceptable limits.

In the event that the project proceeds, and an E.I.S. is prepared in accordance with N.S.W and Federal legislation, then it is expected that emphasis will be on the substantiation of the project's environmental feasibility with reference to appropriate design and operating criteria. As a condition of government approval, the construction of a water quality baseline for future monitoring is appropriate, but the need for other substantive environmental field investigations is not apparent.

PLATE 3
Sunday procession through Drake township, ca. 1900.

(X)

PLATE 4
Drake township today, a small settlement dependant on farming and timber milling.

PLATE 5
Sawmill in Drake owned by Ford Timber Pty. Ltd.

PLATE 6
Land clearing for power-line easement close to Drake.

2.2 Technical Summaries

This survey initiates systematic environmental work associated with the Drake project. It has been concerned specifically with the preparation of an initial account of the vegetation, terrestrial, bird and aquatic fauna, water quality and archaeology of the project area and surrounds. The potential effects of the project in these areas were identified prior to the study as the principal issues requiring investigation; the likely effects and practicable safeguards are described in this report.

The findings of the present study are summarized under the individual investigation headings below.

2.2.1 Vegetation

The vegetation in the study area is typical of the eastern escarpment of the Divide, with wet sclerophyll forest on the higher slopes and valleys and pockets of rainforest in protected locations on suitable soils. Lower relief areas and dry slopes make up most of the land and these carry dry sclerophyll forest.

Five major types of vegetation have been delineated, and are mapped and classified into eight associations as follows:

(a) Closed Forest (Rainforest)

1. *Toona australis*-*Ficus coronata*-*Archontophoenix cunninghamiana* association

2. *Sloanea woolsii*-*Syzygium crebrinerve*-*Dysoxylum fraseranum* association

3. *Schizomeria ovata*-*Orites excelsa* association

(b) Open Forest

4. Eucalyptus acmenioides-E. propinqua-E. microcorys association (wet sclerophyll forest)
5. E. maculata-E. paniculata association (dry sclerophyll forest)

(c) Cleared Forest-Grasslands

6. Paspalum dilatatum-Axonopus affinis association

(d) Fringing Woodland

7. Casuarina cunninghamiana association

(e) Disturbed Communities

8. Clearings for forestry and mining purposes.

The vegetation has been considerably modified by logging, pastoral and mining activities over the last century, although many areas have now regenerated. More recent mining operations at White Rock, Red Rock and Lady Hampden have not yet regrown.

Of the main communities, the rainforest has the most restricted distribution regionally, is floristically the most complicated and environmentally the most sensitive.

The effects of mining and treatment operations will be localised. The open cuts, mill site, waste dumps and tailings dams would necessitate the clearing of vegetation, with additional clearance for roads and other works. The vegetation types likely to be disturbed are of fairly widespread occurrence in the region and any small decrease in their area would be of minor significance. The evidence of this survey is that rare and endangered species would not be affected; similarly, none of the areas of disturbed rainforest are threatened.

2.2.2 Fauna

(a) Terrestrial Surveys

The vertebrate fauna were surveyed by observation, literature review, and discussion with employees at the Aberfoyle camp, local naturalists and research biologists familiar with the area. An unusually high diversity of species of birds, mammals and reptiles exists in the area because it is a transition zone between the coast and tablelands and includes components of both ecosystem types, as well as being central in the north-south ecological gradient.

Systematic studies of the area's herpetofauna have not been carried out but discussions with herpetologists suggest that the occurrence of any rare, endangered or locally restricted species is unlikely. The possibility of endemic species occuring in the poorly studied rainforest pockets cannot be excluded.

Bird records for the area can be considered reasonably complete. Present and past land uses have had little effect on the naturally high species diversity and any future mining and forestry operations would also have little effect, particularly compared to land clearing for pastoral use and settlement.

There are no mammal species occurring in the study area which have particularly restricted ranges. However, pademelons (Thylogale sp.) are restricted to rainforest and wet sclerophyll forest and on a regional scale this habitat is not common. The only endangered species which possibly occurs in the area is the eastern native cat (Dasyurus viverrinus).

Habitat would be lost with the construction of mining and related facilities but in a regional context, the area loss would be minor and would have little affect on the species present. Pollutants to escape from a mining operation could include turbid runoff and leaching of toxins from waste dumps. If not contained, this would affect locally the aquatic invertebrates, which are a food for some birds, reptiles, amphibians and mammals. Loss of animals by feral cats and dogs, indiscriminant shooting, cross-country driving and bushfires, can also be minimised with controls and the education of the larger human population.

(b) Stream Surveys

A qualitative sampling of the study area streams was carried out, by net and subsequent identification, at sixteen selected sites. While the survey was carried out in low-flow streams after a prolonged drought, aquatic biota indicated a clear pattern of water quality.

The most prominent problems within the study area were identified downstream of the old mines at White Rock and Lady Hampden, where there is a low species diversity of aquatic biota. There is a strong correlation with water runoff from the old waste rock dumps, which is turbid, acidic and carrying heavy metal concentrations. Forestry and pastoral activities, and runoff from Drake township, are not correlated with reduced diversity of aquatic invertebrates in the study area.

Downstream, of the old mining areas, the diversity of invertebrates is restored, indicating a return to satisfactory water quality.

2.2.3 Water Quality

The Clarence River Catchment, of which the study area forms a small part, yields considerable quantities of good quality surface water, which is presently only partially utilized. Several sites have been examined by the Water Resources Commission as potential storages, but as yet there are no firm proposals.

Groundwater resources are little utilised, and principal supplies occur downstream of Grafton, some 100 km from the project area. There are no bores in the vicinity of Drake, which relies solely on surface water for town supply and domestic and stock purposes.

The water quality investigation concentrated on the characteristic pollution by uncontrolled leachate and runoff from sulphide orebodies, that is, with emphasis on pH, sulphate, TSS and selected heavy metals. The results substantiate the findings of a June 1980 Department of Mineral Resources study and show the following:

(a) High concentrations of metals immediately downstream of Lady Hampden (Cu, Zn, As, Pb, Cd) and White Rock (Zn). Minor contamination only is apparent below Red Rock.

(b) The evidence suggests rapid improvement with increasing distance downstream, either by dilution or the complexing and precipitation of heavy metals, or both.

(c) Low diversity of aquatic invertebrates is qualitatively correlated with high heavy metals in water, and these are both, in turn, correlated qualitatively with proximity to areas of past mining.

(d) Both current and DMR studies sampled at one point in time. To establish actual loads of metals entering the natural drainage, and hence the baseline conditions, requires time series data over a representative range of hydrological conditions.

The predicted effects of the project are a function of the degree of waste water containment embodied in the final design. The following measures are common in contemporary developments of the sort envisaged for Drake. If adopted, there would be a short term increase during construction, but a net, long term reduction, in current levels of heavy metal pollution in the vicinity of Lady Hampden and White Rock, since existing sources would be embraced by controls for the new operation. The Drake water supply, on Fairfield Creek, would not be affected either way.

Typical controls are:

(a) Containment of acid waste waters: site runoff, waste dump leachate and mine water;

(b) Waste water to process make up or neutralized to precipitate heavy metals for containment;

(c) Diversion of stormwater around the minesite;

(d) Containment of mill tailings;

(e) Recycling or retention and natural breakdown by oxidation of cyanide wastes.

If the project is feasible, further water quality work, in the form of a full chemical baseline, supported by aquatic invertebrate indicators, is necessary, by which the effects of the project can be monitored.

2.2.4 Archaeology

Surveys, discussions with local residents, and published archaeological and ethnohistorical data indicate that sites are likely to occur infrequently in the study area and that any sites would have been disturbed by past logging and mining activities and/or be obscured by forest litter.

Aboriginal use of the tract of country encompassing the study area was probably transitory.

This, combined with the lack of suitable rock outcrops which could have acted as foci for prehistoric activity, poor surface exposure and landscape disturbance, can account for the lack of archaeological evidence and paucity of sites.

Little information of archaeological importance would be recovered by further surveys in the study area and it is recommended that the development be allowed to proceed without additional archaeological investigations.

3.0 VEGETATION

3.1 Introduction

This section presents a review of the available literature relevant to the area, the results of a brief field survey and a checklist of the plants collected in the area.

3.1.1 Objectives

The objectives of the study were to examine the present status of the vegetation of the area with respect to the vegetation of the region and to identify any vegetation types or name any endangered species which may be sensitive to the proposed mining operations.

3.1.2 Study Components

The study components were:

(a) To evaluate available literature on the vegetation relevant to the area.

(b) To undertake a brief field survey, identify major vegetation communities and make a species checklist.

(c) To map the distribution and determine the present condition of the vegetation communities.

(d) To assess the impact of past European land use and to assess the effect of future mining on the natural vegetation of the study area.

(e) To assess the regional significance of the major vegetation types.

3.2 Methods

A preliminary literature study was made of the published material available. The major vegetation types were determined by ground survey and examination of aerial photographs and a vegetation map prepared from the aerial photographs in conjunction with information provided by the Forestry Commission of N.S.W. Plant specimens were identified in the field or collected when field identification was not possible. The survey was undertaken in early February 1981, and therefore some winter growing annual species would not have been apparent. Some specimens could not be identified as floral or fruiting material was not available.

3.3 Results

3.3.1 Regional Vegetation

The exploration licenses and various leasehold titles comprising the study area at Drake are on the eastern fall of the Divide. The highest point of the study area is Richmond Trig. Station at 1100 m while the lowest point is on the Cataract River (330 m) in the northwestern corner of the study area. The topography in the southwestern portion is steep and precipitous (Plate 7), while the eastern and northeastern part is more undulating.

The vegetation is typical of the eastern escarpment of the Divide, with wet sclerophyll forest on the higher slopes and valleys with pockets of rainforest in protected locations on parent materials rich in calcium felspars (Plate 8). The lower areas and dry slopes carry dry sclerophyll forest. Pockets of the forest have been cleared for cattle grazing.

Girard State Forest covers about half of the study area and contains all of the rainforest patches. The State Forest is covered by a network of fire and logging trails and is managed on a sustained yield basis by selective logging. Logging also occurs outside the State Forest and ironbark (Eucalyptus paniculata and E. siderophloia) has been selectively logged by sleeper cutters for many years.

PLATE 7
View south from Mt.Richmond Trig Station (1,100m A.S.L.) showing the more rugged terrain in the south of the project area.

PLATE 8
Ecotone between the rain-forest and wet sclerophyll forest near Richmond Trig.

The most environmentally sensitive vegetation types are in the pockets of rainforest which are part of the chain extending along the eastern escarpment of the Divide. The limited extent of these pockets can be seen from Figure 3. Many of these rainforests have been disturbed by logging and mining operations last century and some of the patches are not well developed. It is present Forestry Commission policy not to log them and part of the Girard State Forest rainforest containing a large white beech (see 3.4.4) (Gmelina leichhardtii) is being set aside as a reserve.

Patches of the dry sclerophyll forest have been cleared for cattle grazing and are now grasslands dominated by Paspalum dilatatum, Eremochloa bimaculata and Axonopus affinis. Timber encroachment continually occurs onto these cleared areas and local graziers periodically have to re-clear the regrowth.

The disturbances created by the mining operations last century are largely overgrown. The exception is the site of the Silver King treatment plant 0.5 km north of Drake on the Cheviot Hills road which is still completely devoid of vegetation (Plates 12, 13, 14). Only minor regrowth has occurred on the bare areas produced by the more recent mining operations at White Rock, Red Rock and Lady Hampden (Plates 15, 16, 17).

Little research work has been done on the local vegetation. The Forestry Commission of N.S.W. has produced a map of the forest types of the Girard State Forest and has also produced an internal report on the rainforests of the region (Floyd 1980).

3.3.2 Classification of Vegetation Types

Structurally, the vegetation grades from a closed forest (rainforest) in the southwestern part of the area, through wet sclerophyll open forest to dry sclerophyll open forest which covers the greater part of the study area (terminology according to Specht *et al*., 1974). Part of the dry sclerophyll forest has been cleared for grazing and has been mapped as grassland. The tree height and the size of the stems of the open forest associations varies throughout the area and is dependent on past disturbances such as logging and subsequent regrowth as well as site factors. It was not possible to distinguish between the effects of site factors and past disturbances in this study.

The closed forest associations are floristically the most complicated formations occurring in the study area. Species lists of these rainforests have recently been prepared by Floyd (1980) and are reproduced in this report. The rainforests are confined to protected areas on fertile soils in the southwestern portion of the area with the exception of the Long Gully Scrub which occurs in a deep gorge. The wet sclerophyll forest occurs in more exposed situations or on somewhat less fertile soils and is often confined to southeast facing slopes. The species composition of the dry sclerophyll forest grades from southwest to northeast with a greater proportion of species such as *E. andrewsii* and *E. laevopinea* at the higher elevations and *E. maculata* and *E. punctata* in the northeast.

The Forestry Commission has produced a detailed map of the forest types in the Girard State Forest. The extension of this detailed mapping to the rest of the area has not been made and accordingly, the various dry and wet sclerophyll forest subdivisions were mapped as one unit. The distinction between the dry and wet sclerophyll forests was clear on the aerial photographs provided. A simplified version of the Forestry Commission map was used for the western side of the study area which was not covered by the aerial photographs (Figure 3).

3.3.3 Description of Vegetation

A. Closed Forest Formation (Rainforest)

Three rainforest associations were recognised by Floyd (1980) as occurring within the study area. The first two of these are classed as sub-tropical rainforest and the third as warm temperate rainforest. The boundaries between the rainforests and the surrounding sclerophyll forests are usually quite sharp and appear to be fire and disturbance controlled (Plate 8). The seedlings of the rainforest species are able to establish in sclerophyll forest but are killed by fire which is common in the sclerophyll forests. Where an appreciable area of rainforest is disturbed, it is replaced by a tangled mass of vines which seem to be an early stage in the succession back to rainforest. The Forestry Commission maps these viney scrubs as separate entities, but in this report, they have been included with the wet sclerophyll forest.

(1) Toona australis - Ficus coronata - Archontophoenix cunninghamiana association

The only occurrence of this association is in the Long Gully Scrub in the southeast of the study area. This area has been extensively disturbed in the past, first by the red cedar cutters and next by the gold miners last century. There are several huge specimens of Ficus obliqua in the gully and red cedar (Toona australis) regrowth is common. Smaller trees continue to be felled for their epiphytes and the forest is at present fragmented with low viney scrub in the openings. It is understood that this area has recently been declared as a State Forest.

(2) Sloanea woolsii - Syzygium crebrinerve - Dysoxylum fraseranum association

Examples of this association occur south and east of Richmond Trig. at about 700-900 m. The diversity of species in these rainforests is poor with only 22 species of trees recorded, of which seven were rated as rare. The more accessible parts of these rainforests have previously been logged.

(3) Schizomeria ovata - Orites excelsa association

Examples of this association occur above the previous association between 900 and 1000 m and to the west of Richmond Trig. They have been logged in the past and are floristically very poor with only 11 tree species recorded, of which four are rare for these localities.

B. Open Forest Formation

(1) Wet Sclerophyll forest
Eucalyptus acmenioides - E. propinqua - E. microcorys association

The species composition of the wet sclerophyll forest has undoubtedly been altered by selective logging over the years. The majority of the area is within the Girard State Forest, although limited patches occur in the north of the study area. At the higher elevations, the wet sclerophyll forest occurs on most aspects, although often the dry northwestern facing slopes carry dry sclerophyll forest. Such patches of wet sclerophyll forest as occur in the northern part of the study area are confined to the valley floors and southeastern facing slopes.

A feature of these forests is the occurrence of Xanthorrhoea australis in the understorey. This species is not common in wet sclerophyll forests in general but occurs quite frequently in the Girard State Forest. Its occurrence may be associated with specific parent material types (Plate 9). Other understorey species commonly consist of rainforest species such as Cyathea leichhardtiana, Dicksonia antarctica, Schizomeria ovata and Orites excelsa. Often grasses such as Poa sieberana and Themeda australis occur in more open patches.

Associated tree species include Eucalpytus saligna, E. laevopinea, E. globoidea, E. amplifolia (isolated patches in the north), E. eugenoides, E. tereticornis and Tristania conferta.

PLATE 9
Wet sclerophyll forest: Eucalyptus acmenioides-E. propinqua - E. microcorys association. The understorey is frequently Xanthorrhoea australis.

(2) Dry Sclerophyll Forest
E. maculata - E. paniculata

The species composition of the dry sclerophyll forest has also been markedly changed by selective logging, particularly by the sleeper cutters who only take the ironbarks E. paniculata and E. siderophloia. The forest is taller, with a more open structure and a grassy understorey in the southwest of the study area compared with the shorter, denser forest with smaller trees in the northeast. Again, the size of the trees and the density of the stems is a reflection of past disturbances and site factors (Plate 10).

Understorey species include Xanthorrhoea sp., grasses such as Themeda australis, Cymbopogon refractus, Panicum simile and Sorghum leiocladum. Zornia dyctiocarpa, Glycine clandestina, Desmodium brachypodium and Helichrysum apiculatum are also common.

Associated tree species include Eucalyptus eugenoides, E. gummifera, E. punctata, E. paniculata, Angophora floribunda and Casuarina torulosa.

PLATE 10
Dry sclerophyll forest: Eucalyptus maculata-E. paniculata association on the road to "Cheviot Hills".

C. Cleared Forest-Grasslands
Paspalum dilatatum - Axonopus affinis association

The grasslands are dominated by warm season perennial grasses (Plate 11). The graziers of the area have tried a number of improved pasture species in the past but the only one which persists with suitable topdressing is white clover. This species was not apparent because of the drought conditions which prevailed in the winter, spring and early summer of 1980. Timber regrowth in these cleared areas is continuous and must be repeatedly cleared.

The pastures, in February 1981, consisted of Paspalum dilatatum, Axonopus affinis, Eremochloa bimaculata, Eragrostis elongata, Eragrostis brownii, Bothriochloa macra and Aristida ramosa with herbs and small native legumes such as Hypochoeris radicata, Helichrysum apiculatum, Gnaphalium japonicum, Glycine clandestina and Desmodium varians.

D. Fringing Woodland
Casuarina cunninghamiana association

The Casuarina cunninghamiana occurs as a narrow band along the banks and in the creek beds, often with an understorey of Callistemon viminalis, Tristania laurina, Syzigium paniculatum, Melaleuca alternifolia and Leptospermum flavescens (Plate 11). These fringing woodlands have often been cleared in the grazing land. Various sedges and other water plants such as Carex longibrachiata also occur in the creek beds.

PLATE 11
Cleared forest grasslands: Paspalum dilatatum-Axonopus affinis association. Dry schlerophyll forest has not been cleared from the hill top or along the creek line but remains as refuge habitat for many animal species.

E. Clearings for Forestry and Mining Purposes.

A number of clearings, such as fire trails, loading platforms and open cut mines are scattered throughout the area. Some of these clearings, particularly at the old treatment plant and tailings dam at Silver King, just north of Drake, will take a very long time to become revegetated. The other clearings are all distinguished by the typical plant species which seem to follow the activities of man such as Cirsium vulgare, Rubus rubiginosa, Conyza bonariensis, Senecio minimus and Paspalum dilatatum. The amount of vegetation on these disturbed areas depends on the nature of the disturbance and the time that has elapsed since disturbance.

3.3.4 Soil-Water-Vegetation Relationships

There is an increase in rainfall with increasing elevation in the southwestern part of the study area. The rainfall at the Girard State Forest office is considerably higher than that at the Drake Post Office and this difference in rainfall affects the distribution of the vegetation. In addition, the different soil parent materials affect the availability of critical plant nutrients and the distribution of the vegetation types. Rainforests are confined to the wetter sites on the more fertile soils. The critical nutrients appear to be calcium and phosphorus availability (Floyd 1980). The wet sclerophyll forests occur on slightly less favoured sites and the dry sclerophyll forest on the least favourable. Aspect is also important in that the wet sclerophyll forests tend to occur on southeast facing slopes.

The ecotone between the rainforest and the sclerophyll forests is fire controlled (Plate 8). Wet sclerophyll forest is often considered to be dependent on periodic fires for its existence, because rainforest species readily germinate and establish in the wet sclerophyll forest, while the converse is not the case: unless periodic fires occur, the wet sclerophyll forest will be converted to rainforest. Dry sclerophyll forest usually occurs in drier situations or on less fertile soils and so where it is adjacent to rainforest, the boundary tends to be sharper.

3.3.5 Past Modification of the Vegetation

Very little of the vegetation of the study area has not been modified in the past. Possibly little modification has occurred in the most inaccessible gullies but these would be relatively small in area. The most significant modifications have been the clearing for grazing purposes and the selective logging both within and without the Girard State Forest. Past mining has caused little disturbance when the area involved is taken into account although specific sites such as the old treatment plant at Silver King and the open cuts are permanently altered (Plates 12, 13).

3.4 Effects of the Proposal

3.4.1 Clearing and Disturbance

Construction of the mine(s) and treatment plant will necessitate the destruction of the vegetation in the areas concerned. Some of these areas are already extensively disturbed (Plates 12 to 17). The release of toxic substances into streams and/or tailings dams from any future treatment plant should be avoided. Insufficient information is available at present about the future mining plans to make any more detailed comments at this stage.

3.4.2 Regional Significance

The wet and dry sclerophyll communities described above are typical of the region and contain no special features which are not available elsewhere. The rainforests are of limited area and are part of the chain of small patches of rainforest along the eastern side of the Divide.

3.4.3 Potential for Natural Regeneration

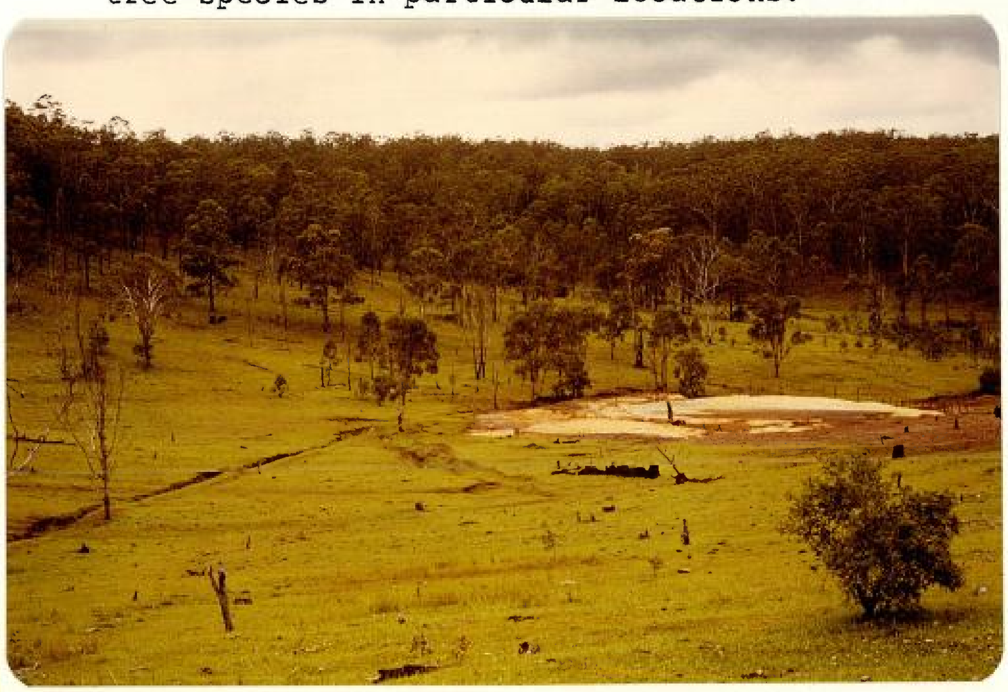
Because of the relatively high rainfall and the low susceptibility of most of the soils to erosion, the regeneration of mined areas should present no problems provided suitable procedures are followed.

(a) Reconstruction of a suitable landscape with a layer of topsoil on the surface.

(b) Seeding of pasture species for a quick cover using for example <u>Paspalum dilatatum</u> and white clover. Adequate topdressing with superphosphate would be necessary to initially stimulate clover growth.

(c) Control of noxious weeds which may appear after seeding.

(d) Following the establishment of a vegetative cover, natural regeneration of trees would follow. It may be desirable to plant selected tree species in particular locations.



We call this Ramsey's

PLATE 12
Tailings dam at Silver King mine near Drake.

PLATE 13
Sterilised ground near the old Silver King mine workings.

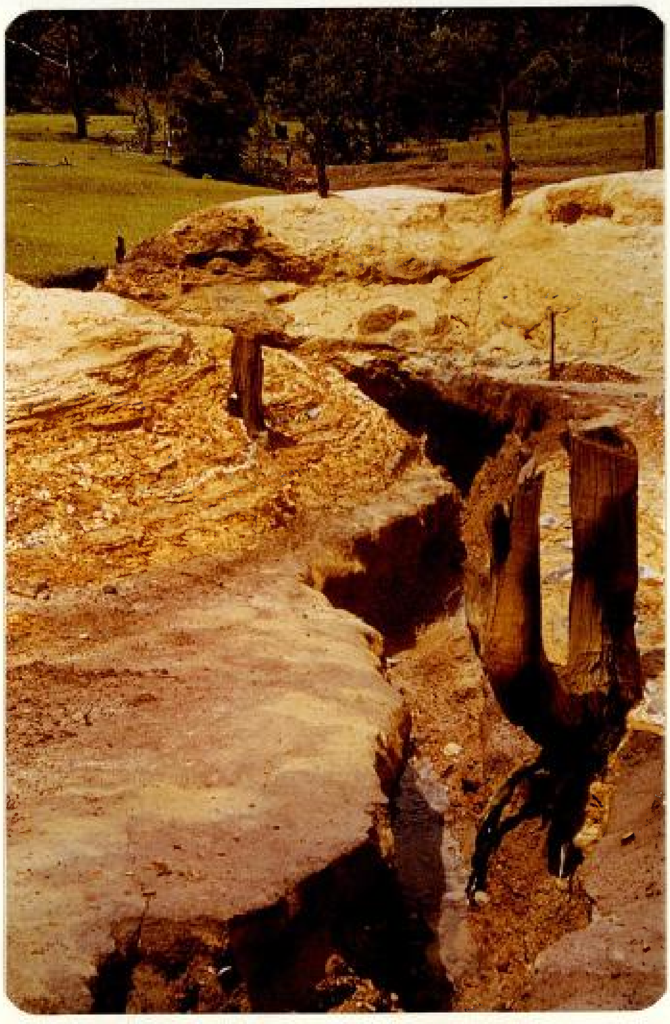


PLATE 14
Erosion of tailings at Silver King (stump in foreground 1 m high).

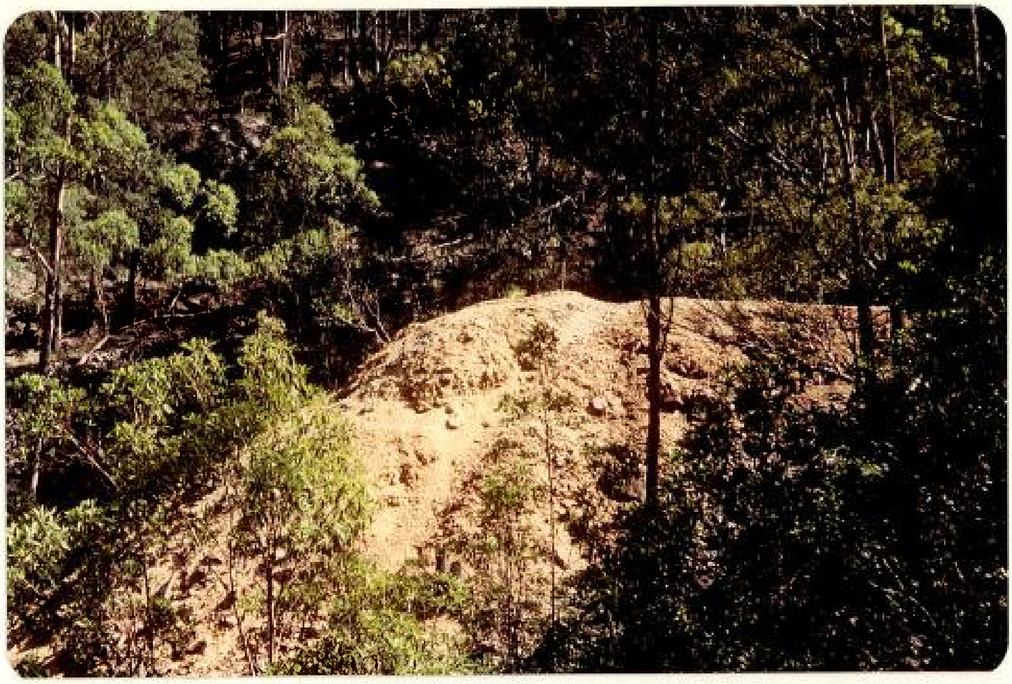


PLATE 15
Mullock heaps near White Rock mine with some *Eucalyptus* spp. revegetation.

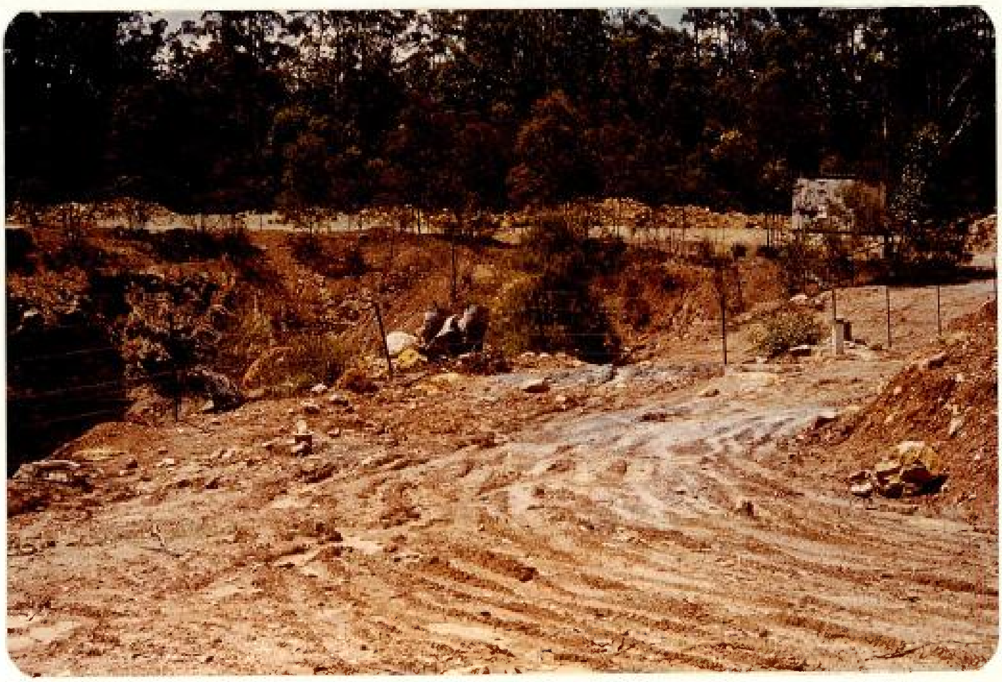


PLATE 16
Lady Hampden open cut mine which ceased operating during the 1970's.

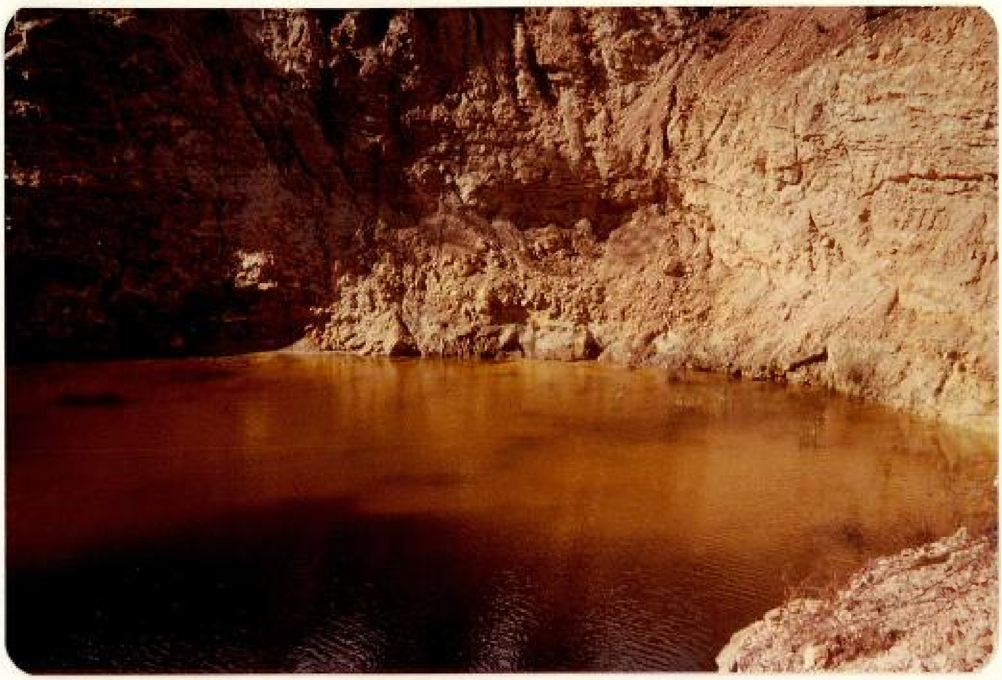


PLATE 17
Lady Hampden open cut mine. Juncus sp. are the only plants to pioneer the acidic waters which have high concentrations of base metals and pH2.9.

3.4.4 Special Features

The small stinging tree, Dendrocnide moroides has been recorded in the past for the Drake area (Floyd 1977). This occurrence would be at the southern extension of its range but Floyd (1980) did not find it in the Girard State Forest rainforests. The suspected occurrence of this species in the study area represents a further reason in addition to the intrinsic variety and vulnerability of this association, why the rainforests should not be further disturbed.

No rare or endangered plant species as listed by Specht et al. (1974) were recorded for the area, but Hartley & Leigh (1979) include white beech (Gmelina leichhardtii) in category 5c of plants at risk and as only occurring in Queensland. This category includes species which are considered at risk because, though widely distributed and known to occur in national parks and other declared reserves, they have suffered marked depletions in population size. Although Hartley & Leigh (1979) only list this species for Queensland, Floyd (1980) records it for the Girard State Forest and Beadle et al. (1972) record it as far south as Sydney.

3.5 References

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4.0 TERRESTRIAL FAUNA

4.1 Introduction

This section presents the results and interpretation of an investigation carried out on the vertebrate fauna in the study area. The data and conclusions are based on a literature review, a visit to the site in February 1981 and liaison with employees at the mine site, local naturalists and a number of research biologists familiar with the area.

4.1.1 Objectives

The objectives of the study are to determine the effect of the proposed mining operations on the vertebrate fauna. The effects are to be assessed in a historical and regional context, with emphasis on sensitive and restricted habitats and rare or endangered species.

4.1.2 Study Components

(a) To survey and describe the terrestrial habitats with reference to special features.

(b) To provide a species list of birds, mammals and reptiles for the area, annotated with available information on present status.

(c) To assess the habitats and species present in a regional context and with reference to past habitat modification and competition from introduced species.

(d) To assess the effect of the proposed mining operation on the species present and their habitat in a local and regional context and in the light of past and present land use.

4.2 Methods

The major habitat types were determined by ground inspection and by color aerial photograph interpretation.

4.2.1 Fauna Assessment

A fauna inventory by direct observation and trapping requires an extensive elapsed time and was not made. Most of the information was gathered by discussion with researchers or naturalists and from the literature.

The persons and institutions contacted are listed below:

(a) Felix Schlager,
Department of Ecosystem Management,
University of New England, Armidale, N.S.W.

Provided an annotated mammal list of species sighted or trapped on the property "Cheviot Hills" during the previous 18 months.

(b) Robert Harden,
National Parks and Wildlife Service, Armidale, N.S.W.
Provided a mammal list based on work done in the New England area and discussion on the status of the species.

(c) Mervin Goddard,
180 Manners Street,
Tenterfield, N.S.W.
Local amateur birdwatcher with 28 years experience in the area; provided a bird list.

(d) Richard Noske,
Zoology Department,
University of New England,
Armidale, N.S.W.
Ornithologist; provided an annotated bird list.

(e) Glenn Holmes,
P.O. Box 258, Kyogle, N.S.W.
Local professional ornithologist; has conducted extensive surveys in many parts of the Clarence-Maclean area, including Girard State Forest; provided an annotated bird list.

(f) Margaret Blakers,
Royal Australasian Ornithologists Union,
21 Gladstone Steet,
Moonee Ponds, Vic.
Provided partial bird list from records of the Atlas of Australian Birds.

(g) The Richmond Valley Naturalist Club,
P.O. Box 630, Lismore, N.S.W.
Provided partial bird list.

(h) National Parks and Wildlife Service,
G.P.O. Box 2626,
Sydney. N.S.W.

(i) D. Binns
Forestry Commission of N.S.W.
P.O. Box 40,
Urbenville, N.S.W.

(j) Janet Taylor and Eric van Burden
Zoology Department
University of New England,
Armidale, N.S.W.
Herpetologists; provided information on work done on reptiles and amphibians of the area.

(k) Alan Greer
Australian Museum
Sydney, N.S.W.
Herpetologist; provided discussion on likely status of species in the area.

(l) B.L. Bolton, Bird Surveys,
Northern Rivers College of Advanced Education,
P.O. Box 157,
Lismore, N.S.W.

4.3 Results

4.3.1 Habitat

(a) Habitat types

Major vegetation structural formations are described in Section 3.0 and are summarized below:

(i) Closed Forest Rainforest (Plate 8)
Rainforest pockets cover approximately 5% of the study area and all of them fall within Girard State Forest. At present there is no logging of rainforest species and one part has recently been set aside as a nature reserve. All the rainforest patches are small so that during dry years the leaf litter is likely to be a dried food source for the vertebrate fauna. However, invertebrates and moisture loving species would be adversely affected as their habitat and food source diminishes during prolonged droughts. The largest area of rainforest, at Long Gully, may be large enough to sustain moisture, even during prolonged dry periods.

(ii) Open Forest formation - Wet Sclerophyll Forest (Plate 9)
(Eucalyptus acmenioides - E. propinqua - E. microcorys association), and

(iii) Open Forest - Dry Sclerophyll (E. maculata and E. paniculata association) (Plate 10)
Wet sclerophyll forest covers approximately 10% of the area while dry sclerophyll forest covers the majority at about 70%.

The species composition of both forest types has undoubtedly been changed by selective logging which has continued since the last century. There is also some cattle grazing. Features of the forest habitat are the hilly terrain, shallow soils and rocky outcrops.

(iv) Cleared Forest - Grasslands (Plate 11)
(Paspalum dilatatum, Axonopus affinis dominated pasture)
About 15% of the area has been cleared for

pasture. These areas are dotted with dams, providing some waterfowl habitat and permanent drinking water.

(v) Fringing Woodland and Stream (Casuarina cunninghamiana) association

Occurs as a narrow band along the banks and in the creek beds. This habitat is cleared on grazing land. The area is dissected by many small streams, a few of which are large enough to be flowing even in drought years. The water quality of some of the streams, for example Sawpit Creek, has been affected by previous mining operations (Sections 5.0 and 6.0).

(b) Habitat Quality

All habitat types have been disturbed since European settlement in the area. The major types of disturbance are:

(i) Clearing of forest for pasture, and the introduction of exotic animals and pasture plants.

(ii) Selective logging in the forests which has changed the species composition of the forest community. The construction of roads has disturbed the area by clearing of the land, increasing soil erosion and introducing vehicular traffic.

(iii) Mining operations have resulted in some clearing of land, road building and tailings dam construction. Runoff from mine sites into the streams has seriously affected the water quality immediately downstream (Section 5.0 and 6.0). An area of land below Lady Hampden mine is completely devoid of vegetation, presumably as a result of mining activities, and possibly by a lowering of soil pH.

4.3.2 Fauna Records

The noteworthy feature of this area is the unusually high diversity of birds, mammals and reptiles. It is geographically located in the transition zone between the coast and the tablelands and includes components of both ecosystem types as well as being central in the north-south ecological gradient.

(a) Herpetofauna

No systematic collecting of herpetofauna has been done around Drake: the New England Herpetological survey did not cover the area. Data from spot collections is lodged in the Australian Museum, but specimens had not been grid referenced at the time of this study so this information was not available. The species list in Appendix B-1 is extracted from distribution data given in Cogger (1979), Barker and Grigg (1977) and Cann (1978). Listed as likely to occur are species of lizards, frogs, snakes, and tortoises.

The area is overtly rich in reptiles; numerous skinks, dragon lizards and one tiger snake were sighted during the survey; there was insufficient time for trapping and positive identification of species. Mine personnel had frequently sighted goannas.

The rocky outcrops, fallen logs and abandoned railway sleepers through the open forest provide ideal habitat for many of the reptiles.

There are ample habitats for frogs in the small pools, streams and in farm dams. Tadpoles were caught during the water quality survey but no frogs were heard calling despite the rains.

Land clearing for grazing has almost certainly improved habitat availability for pond breeding frogs and brown snakes, by the provision of dams and surrounding littoral vegetation.

Forestry practices increase the availability of habitat for skinks and small lizards which shelter under fallen logs and wood. Climbing lizards may have been marginally affected by loss of trees due to logging, clearing and road construction.

Regional Context for Herpetofauna

The known ranges of the amphibian and reptile species listed in Appendix B-1 are given in Cogger (1979) (frogs and reptiles) and Barker and Grigg (1977) (frogs). None of the species have restricted geographic ranges.

The herpetofauna of the area has not been studied systematically, but from discussions with herpetologists from the University of New England and the Australian Museum, it can be concluded that the occurrence of any rare, endangered or locally restricted species is unlikely. The only habitat which is a possible exception is the rainforest. Rainforest pockets are not well studied regionally and the possibility of endemic species occurring cannot be excluded.

A tortoise caught during the water quality survey has been identified as an undescribed *Emydura* species, probably *Emydura* sp. No.1 of Cann (1978). Although still undescribed, it is unlikely to be uncommon (Plate 18).

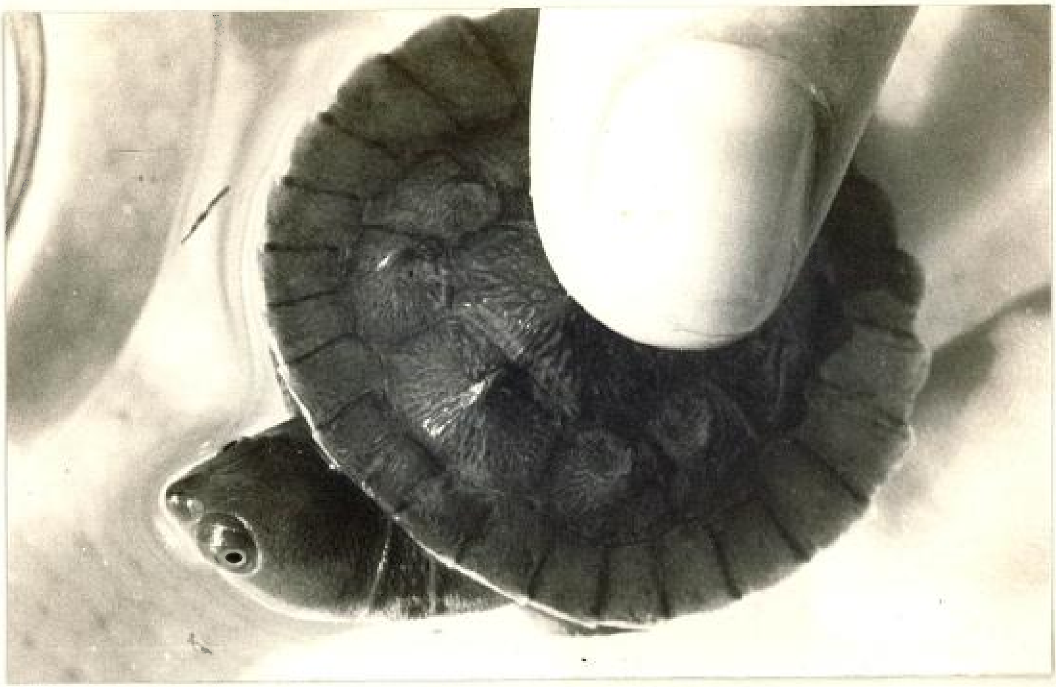

PLATE 18
An undescribed tortoise found during the terrestrial fauna survey, probably Emydura sp. No.1 of Cann (1978).

(b) Avifauna

The bird record can be considered reasonably complete because several professional and amateur ornithologists are familiar with the area and have done extensive surveys. Section 4.2.1 lists the ornithologists consulted for this study.

The species are listed in Appendix B-2. Nomenclature follows the Royal Australasian Ornithologists Union 1978 publication "Recommended English Names for Australian Birds" (Emu 77, Supplement).

210 species are listed as occurring by Holmes. Of these 177 are listed as breeding in the area, 65 are nomadic, 27 migratory and 108 are resident. Further information on habitat preferences of each species and their status is given in Appendix B-2.

Holmes gives the following comment on the avifauna:

(i) All species in the area have a relatively wide distribution in N.S.W.

(ii) Powerful and sooty owls are generally uncommon to scarce in N.S.W. but they are not as rare as may be inferred from the popular literature.

(iii) The species diversity is very high for an area of limited diversity of habitat (especially lacking in aquatic diversity). The total number of species in N.S.W. is 520-530, of which about 70 are strictly marine. The 210 species of the study area comprise a large proportion of the total occurring in N.S.W. The main reason for the diversity is that coastal species (e.g. white-throated honeyeater, fruit pigeons, bowerbirds) overlap with tableland species (e.g. white-eared and brown-headed honeyeaters, chestnut-rumped hylacola, flame robin).

(iv) Occurrences of interest are the southern emu-wren (typically occurring in near-coastal heath) and the chestnut-rumped hylacola (generally absent from north-coastal N.S.W.).

(v) The area coincides with the transition from the nominate race of the superb lyrebird to the race Menura novaehollandiae edwardi (of granitic terrain).

The effect of present and past land use on avifauna has probably not been very great on a local or regional scale. Land clearing and settlement would have had the most serious consequences on species composition and population size, while mining and forestry would have had very little effect. The reasons are as follows:

(i) Clearing land reduces the area of forest habitat. Many species are tolerant of some modification of habitat (for example selective logging or roads), provided it is not too extensive.

(ii) Pasture increases the habitat availability for aquatic birds, raptors, swifts and swallows and grassland species such as quail.

(iii) Exotic bird species such as sparrows and starlings thrive in areas of human settlement.

(iv) Domestic and feral cats would have some effect on population size but it is unlikely to be significant. Only two feral cats were sighted in the area (Section 4.3.2(c)) so the population of cats is unlikely to be large.

Regional Context for Avifauna

None of the birds listed for the study area have extreme range restrictions. The area is in the transition zone between the coastal and tablelands ecosystems and consequently is noteworthy as an area of very high species diversity.

The rainforest pockets are not a common or extensive habitat regionally and any species restricted in the rainforest are correspondingly uncommon. None are believed to be so restricted, however.

(c) Mammal Fauna

The mammal fauna is also rich; twenty native mammals excluding bats are reliably recorded for the area, mainly by Schlager of the University of New England during a current 18 month study. No work has been done on the bats of the area. A further six species are likely to occur on the basis of range distribution and habitat preferences, but have not yet been recorded. Six species are listed as possibly occurring; one of these, the eastern native cat, is on the endangered species list. The rock wallaby is unlikely to occur because there are no areas of sufficiently rugged topography.

Five feral mammals are recorded, but only the dingo is common. Rabbits and hares are ecologically marginal because the area of cleared land is too small to support large viable populations.

Whiptail wallabies and red-necked wallabies were commonly observed during the site visit; bats were heard at dusk and during the night.

Mammal habitat alteration by human activities has not been extensive. Land clearing is the most drastic modification and will destroy the habitat of all of the listed small carnivorous marsupials (dasyurids), bandicoots and the arboreal marsupials (koalas and possums). The brush-tail possum is an exception because it becomes commensal with humans. The wallabies, both large and small, and the rat-kangaroo are also critically dependent on dense vegetation or thicket for shelter and are therefore particularly vulnerable to clearing and stock introduction (Ride, 1970). Bats are dependent on some forest for shelter and as a food source, but will tolerate some cleared patches.

The kangaroos and wallaroos will tolerate cleared land provided there is sufficient adjacent woodland for shelter.

Regional Context for the Mammal Fauna

There are no mammal species occurring in the study area which have particularly restricted ranges. Pademelons are restricted to rainforest and adjacent wet sclerophyll forest however, and on a regional scale this habitat is not common. The parma wallaby, according to Ride (1970), possibly occurs in the area, and the eastern native cat is on the endangered species list.

4.4 Effects of the Proposal

The construction of roadwork, open cut pits, tailings dams, erosion control structures, mine buildings and facilities will cause partial or total loss of habitat. The perpetuation of these effects at White Rock and Lady Hampden, with localised extensions, represents a very small proportion of land already cleared for the Drake township, pasture at "Bunijah" and "Cheviot Hills" and forestry, which amounts to some 15% of the study area. In regional terms such disturbance around Drake amounts to little.

In this context, the direct habitat effect of the project is negligible.

Any pollution of the water will affect the invertebrates of the area which are a food source for some birds, reptiles, amphibians and mammals. Toxins in sufficiently high concentrations could affect the vertebrate fauna directly.

Noise and dust from construction and operation will displace animals from an area larger than that covered by the mining site itself.

Small marsupials and birds are vulnerable to predation by cats. Domestic and feral cats, and probably dogs, are likely to increase with the human population unless controls are implemented on their introduction by mine personnel. Domestic refuse should be properly disposed of to minimize food supplies for feral animals.

The killing of animals by vehicular traffic is a problem wherever roads are built, and some losses are inevitable but generally insignificant.

Increased human population size increases problems associated with shooting, cross-country driving and bushfires but with appropriate controls and education, these need have little effect on the fauna.

4.4.1 Implications

The development of further mining operations in the study area will be only of minor regional significance to the vertebrate fauna provided that:

(a) The area of habitat destruction remains a small percentage of the total area so that intact, large refuges are available.

(b) No mining is done in the rainforest which is a regionally uncommon and little studied habitat, possibly containing some endemic species. A large area of eucalypt forest needs to be left intact to preserve the rainforest habitat, and burning of rain forest pockets should be avoided at all costs.

(c) Precautions outlined above and in Section 6.0, Water Quality, are adhered to.

(d) Revegetation is carried out.

4.4.2 Special Features

Allowing for limitations of the data gathering methods and the lack of study of reptiles, no unique species of vertebrate fauna are threatened as a result of the mining proposals which, as outlined, would cover only a small proportion of the study area. The only environmentally sensitive habitat which is regionally uncommon is the rainforest.

It is noteworthy that the area is unusually diverse in species because it falls in a transition zone between the coastal and tablelands ecosystems and contains elements of both. It also lies centrally in the north-south ecological gradient.

4.5 References

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(X)

5.0 AQUATIC BIOTA

5.1 Introduction

This report describes the biological characteristics of representative aquatic habitats within and in the region of the joint venture mineral exploration tenements near Drake, N.S.W.

Results are from a four day field survey conducted in February 1981. The data are interpreted to provide an initial assessment of water quality based on biological indicators and to identify any key problem(s) for further investigation.

5.1.1 Objectives

The objectives of this study are to make an initial geographic account of surface water quality in the project area, using biological indicators, with emphasis on the effects of past and present land use.

5.1.2 Study Components

(a) Survey and describe important aquatic habitats; particular reference to be given to drainage paths through and downstream of existing and proposed mine sites.

(b) Identify taxa of aquatic fauna and flora collected at each sampling site during the field survey.

(c) Identify variations in water quality based on the composition and diversity of the biota.

(d) Comment on the severity and possible causes of water quality variability.

(e) Comment on the effect of future mining activities on water quality of the study area and of the region.

5.2 Methods

5.2.1 Site Assessment

Sampling sites were chosen using maps and aerial photographs and by consultation with Aberfoyle employees and other members of the study team. Sites were chosen with reference to existing and possible mining sites, land use and topographical features of the area. The following rationale was used:

(a) The effects of past mining operations were identified by using upstream and downstream comparisons of similar habitats.

(X)

(b) Downstream effects were followed for appropriate distances to infer regional effects.

(c) Effects of mining activities were distinguished from other land use effects by choosing appropriate comparisons.

(d) Different drainage areas were compared by sampling similar habitats as far as was possible, e.g. same size of stream, intensity of running water, nature of stream bed, etc.

5.2.2 Sampling Methods

All sampling was qualitative. A coarse net was used to sample larger organisms, a phytoplankton (fine mesh) net was used for microscopic organisms (Plate 21). Macro-organisms were inspected immediately in the field and samples were taken for closer examination. Plankton tows were done where water depth permitted. Rocks and other suitable substrates were inspected for attached larvae and algae. Rapidly flowing water was sampled by the 'stop net' technique - dislodging rocks and sediments to capture sheltering organisms. Quiet water was sampled by scooping the net along stream edges, particularly in the vicinity of overhanging banks and littoral vegetation.

All available habitats were sampled at each site (e.g. running water, quiet water) and the samples were pooled.

One plankton tow and one net sample was taken from each site. Collections were preserved with 5% formalin or 70% alcohol.

5.2.3 Taxonomic Classification

Organisms were identified to the lowest taxonomic level possible in the time available. Importance was given to recognizing functional groups and organisms indicative of 'healthy' or 'polluted' conditions, rather than to the detailed taxonomy of the aquatic biota.

5.3 Results

5.3.1 Timing

The sampling survey was carried out between February 2-5. It coincided with heavy rainfall which broke a severe and prolonged drought. The January 1981 rainfall total was 51 mm (1897-1977 median for January is 134 mm). During the first three days of sampling a total of 85.4 mm of rainfall was recorded.

The above rainfall pattern and consequent flow responses must be taken into account when interpreting the present results and planning future sampling programs. Several specific effects of the particular flow patterns experienced during the study are made below:

(a) Many of the invertebrates are larval stages of terrestrial insects. Dry conditions reduce the number of adult insects able to breed and larval numbers and diversity drops during prolonged drought.

(b) Small streams stop flowing in drought; small pools may remain, but these are not representative of conditions during flow.

(c) Water levels rose during the study so stream and pool edges were not fully colonized.

(d) The sudden high flows would have caused washout and dilution of organisms.

5.3.2 Sampling Results and Water Quality Assessment

Sixteen sampling sites are listed and described in Table 5.1 and Figure 6. Tables 5.2 to 5.4 list the aquatic organisms collected at each site. Despite the preliminary nature of the sampling, a clear pattern of water quality was apparent from the results. A summary is given at the end of Table 5.4.

Site 1, a small creek crossing, in a forested steep catchment was sampled before the heavy rains. Small, shallow pools survived the drought but there was no flow. The pools did not have a high diversity of organisms but there were sufficient numbers of larvae and attached filamentous algae to conclude that the low diversity was a function of the restricted habitat caused by the drought. Forestry and light grazing were the only land uses in the catchment.

Site 2, Crooked Creek upstream of Red Rock mine was sampled twice; first, in a large pool before the rains and again when flow in the river was rapid. Both results showed that the stream is healthy with a high diversity of algae and breeding insects, as well as fish and shrimps, which are good indicators of healthy conditions.

Sites 3, 4, 5 and 6 follow Crooked Creek below Red Rock mine to its confluence with the Cataract River. The weir and shallow pools below the weir were sampled before and after the rains. The low diversity and low abundance of algae and invertebrates was in marked contrast to the similar habitats sampled upstream of the mine. Turbidity was also higher and heavy silting of the streambed was evident. The weir samples were dominated by fungi and high numbers of bacteria in the sediments indicating abnormal conditions.

At Site 6, the river had widened, the terrain was flatter and the streambed gravel and small rocks had replaced large boulders and rocky outcrops (Plate 19). Flow was rapid. The stream was sampled thoroughly and no evidence of aquatic invertebrates was found. Similar flows and rocky streambeds in the Cataract River (Site 14) were highly diverse. Abandoned mine shafts were found along the shoreline and a copper precipitate (probably $Cu(OH)_2$) covered the walls. Copper is toxic to aquatic organisms, and leachate from the mine probably caused sterility of the stream at this site.

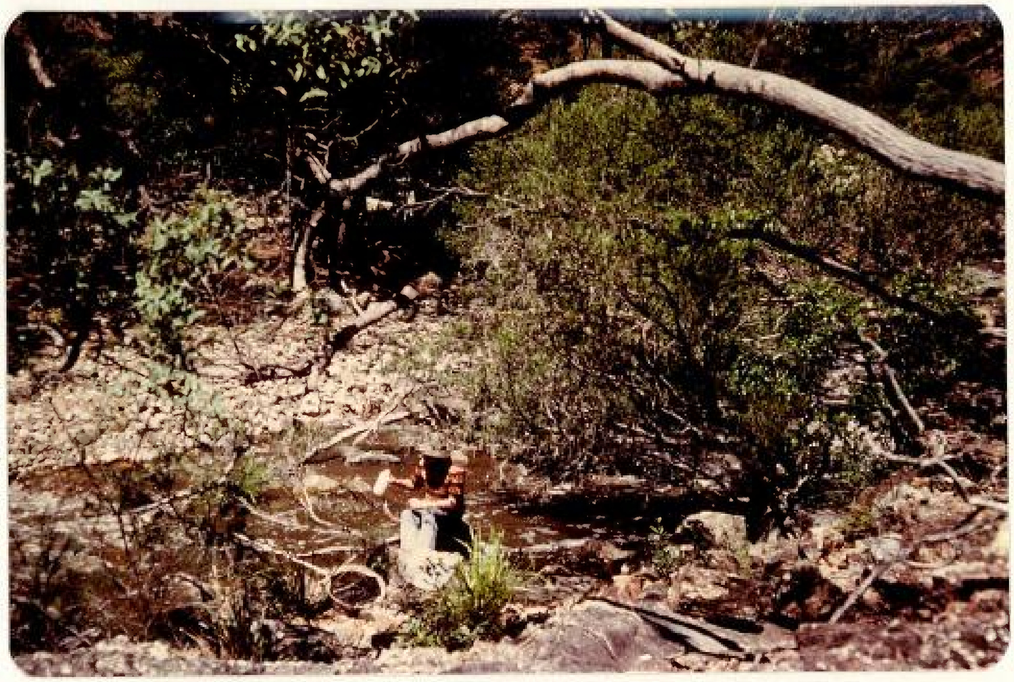

PLATE 19
Crooked Creek at Cataract River confluence (Aquatic Biota Station A6 and Water Quality Station W15).

Site 7 is on the Cataract River, 100 m upstream of the confluence with Crooked Creek. A high diversity of organisms was found in abundance, indicating healthy conditions.

Sites 8 upstream of Drake, was sampled as a control for a downstream sample (Site 9) to investigate the effect of the settlement, which includes a sawmill and a 'DURAPOST' creosoting business. The upstream site, a large permanent pool, receives drainage from a forested catchment and cleared grazing land. The samples showed a very high diversity of organisms and hence healthy conditions. The downstream sample was from Plumbago Creek. There was a reduction in diversity between the upstream and downstream sample, but the habitats are not strictly comparable. Higher diversity can be expected in a large, permanent pool when compared with a small stream, recently subjected to a sudden increase in flow. The nature of the organisms (fish, shrimps, odonate larvae) indicate good quality water.

Site 10 was on a very small stream resembling a ditch at the point of sampling. Species diversity, as at Site 9, was not high but the nature of the organisms present suggests that the stream was healthy (i.e. fish and shrimps). The catchment is forested with only limited clearing for grazing so water quality problems are not expected. Good quality conditions in Plumbago Creek persist to the crossing at Paddy's Flat Road (Site 11, Plate 20).

PLATE 20
Plumbago Creek at Paddy's River crossing
(Aquatic Biota Station A11 and Water
Quality Station W19).

Sites 12, 13 on Emu Creek, indicate highly abnormal conditions. The paucity of organisms was immediately obvious with the first net haul and the river was then thoroughly sampled at two sites. No living organisms were found at Site 13 and one caddisfly larva only at Site 12. Land use in the catchment is restricted to grazing and the cause of sterility is unknown. Agricultural toxicants, such as herbicides, may have been applied in the catchment.

Site 14 The Cataract River was sampled at its confluence with the Clarence (Plate 21). This sample had a high diversity of invertebrates. The algae consisted mainly of large, clean water species of diatoms, indicating low nutrient levels and very clean water.

Site 15, White Rock Creek downstream from the White Rock mine, did not increase in flow throughout the duration of the study period (Plate 22). Only small pools were available for sampling. Diversity of species was low, consisting of adult beetles, backswimmers and waterboatmen all of which could have flown in from elsewhere. A few tadpoles and snails were recorded. Only one filamentous species of algae was present.

Although the stream did not look obviously unhealthy compared with similar habitats e.g. downstream of Red Rock mine (Site 4), there is insufficient evidence to draw any conclusions.

Sawpit Creek upstream of Lady Hampden mine was not sampled; high flows had started and it was not possible to tell how much water had been in the creek prior to the rains. The water was turbid, no attached algae were visible on the rocks and no macro invertebrates were obvious.

Site 16, below Lady Hampden mine, Sawpit Creek had enlarged and permanent pools occurred. Adult insects only were found, which could have flown in from elsewhere. No algae were present. The low diversity of aquatic life may be due to the low pH of the water. The area around the creek has been highly disturbed; silting of the water was heavy, and revegetation of large areas along the streambed had not begun.

5.3.3 Regional Significance

Overall, areas of reduced invertebrate diversities appear to be geographically restricted to the apparent pollution source, with improved diversities downstream.

Water quality problems at Sawpit Creek (Site 16) were not evident at Site 11, further downstream. Similarly, the influence of Crooked Creek (Sites 2-6) is not perceptible in the Cataract River at Site 14.

The water quality problem identified at Emu Creek is difficult to explain. The sample was taken below the confluence with Girard Creek which drains a central portion of the study area, and land use within the Girard Creek and Emu Creek catchments does not include past mining activities. It is possible that herbicides or insecticides used on properties within either of these catchments was the cause of stream sterility, and in such a case it is probable that the condition is transient.

5.4 Effects of Past and Present Land Use

5.4.1 Mining

On the basis of biological criteria, the most prominent problems with water quality within the exploration lease have been identified downstream of Red Rock mine and Lady

Raining of course

PLATE 21

Cataract River (foreground) near the Clarence River confluence at Paddy's Flat (Aquatic Biota Station A14 and Water Quality Station W17). A biological sample is being collected by towing a phytoplankton (fine mesh) net.

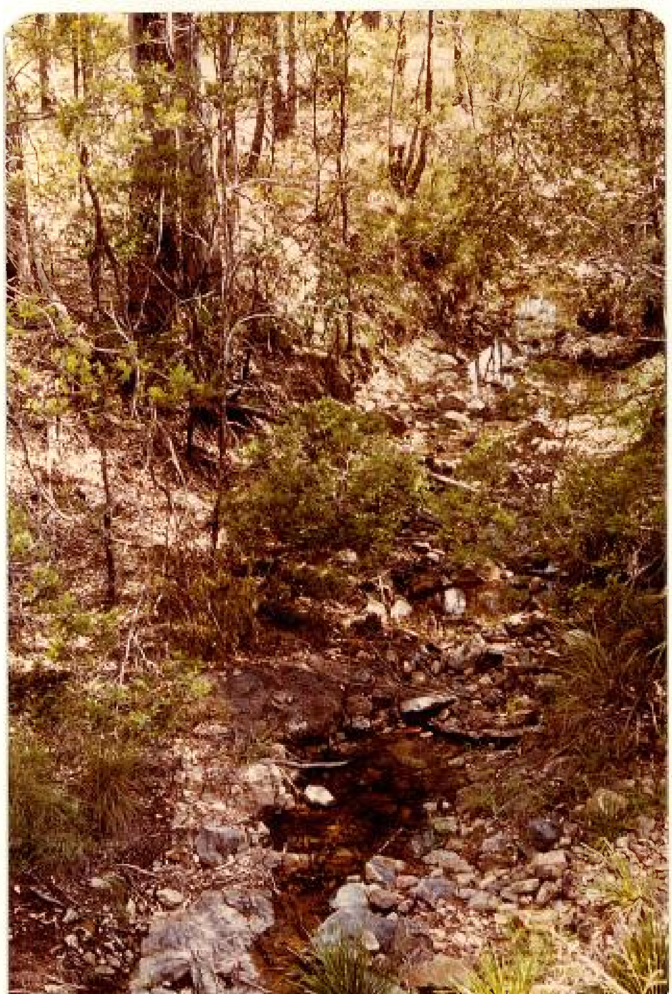

PLATE 22

White Rock Gully Creek a Bruxner Highway (Aquatic Biota Station A15 and Water Quality Station W1).

Hampden mine. Although the specific cause of the low biological diversity has not been isolated by the biological survey, the condition is correlated with areas receiving drainage from the mines.

The mines have not been active for at least a decade, indicating that the effects, probably associated with pH shifts and leaching of heavy metals, are reasonably long term. There was also evidence that erosion from mineral areas had also increased turbidity.

Geographically speaking the effects are localized, with a recovery in water quality downstream as mine area drainage is increasingly diluted. Water quality below White Rock mine could not be adequately assessed because the stream was not flowing and only very small pools were available for sampling. However, chemical indicators (Section 6.0) show similar effects to Lady Hampden.

5.4.2 Settlement

There was no evidence from the sites, which receive drainage from the town, to indicate water quality problems at the time of sampling.

5.4.3 Forestry

Lumbering in Girard Forest is restricted to selective cutting; no clearfelling occurs. The main effect of lumbering operations, therefore, is increased water turbidity from road runoff. Erosion however is not a serious problem in the area because soils are very shallow and rocky. Exposure of the soil along roads may have increased leaching of heavy metals into the streams or caused pH shifts but the effect is insufficient to have affected the invertebrate indicators.

5.4.4 Pastoral Activity

Clearing of land for pasture may have increased soil erosion although this effect was not evident. The major effect of grazing is to increase the nutrient load into the streams. The present survey has not revealed particularly high levels of eutrophication probably due to low stocking and hence low nutrient runoff.

5.5 Implications for Future Mining

The likelihood of a net improvement in water quality if renewed mining occurs at Lady Hampden and White Rock is discussed at the conclusion of Section 6.0.

If development is feasible, further investigations could include the following:

(a) What component(s) of the soil are responsible for the adverse effects on water quality identified by this survey.

(b) Control of erosion and toxic-runoff and leachate from a renewed mining operation.

(c) More detailed biological sampling under different conditions of flow to establish a baseline, in association with a water chemistry baseline, by which the effects of the project can be monitored.

Growth of the population at Drake during mining development could result in increasing eutrophication of Plumbago Creek from septic tank seepage. Plumbago Creek is small with an apparently slow flow through the town and seems likely to be susceptible to eutrophication.

5.6 References

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TABLE 5.1 AQUATIC BIOTA SAMPLING SITES

No.	Location	Description	Habitat Sampled
1	Girard Ck. on Pinch Fire Trail Ford	Small feeder stream; not flowing; forested	Shallow, rocky pool
2	Crooked Ck. upstream of Red Rock Mine	Large scenic stream in steep rocky terrain; flowing; forested	Running water and deep pool
3	Weir on Crooked Ck. at Red Rock Mine	Deep water permanent pool; heavily silted	Edge and bottom
4	Crooked Ck. downstream of weir at Red Rock Mine	See Site 2	Shallow, rocky pool; silted
5	Crooked Ck. downstream of tailings pond at Red Rock Mine	See Site 2	Flowing and quiet water
6	Crooked Ck. at confluence of Cataract River	Wider than at Sites 2-5; shallow (<0.5m); flowing; rocky	Flowing shallow water and stream bed
7	Cataract R. upstream of confluence with Crooked Ck.	Large river;deeper water than Site 6 (>0.5m)	Flowing and quiet water
8	Plumbago Ck. upstream of Drake	Large, permanent pool on flat, grazing land	Edge and center
9	Plumbago Ck. downstream of Drake, upstream of Violet Ck.	Small stream on grazing land; slow flowing	Edge and flowing water
10	Violet Ck. at Buxner Highway crossing	Similar to Site 9	Edge and flowing water
11	Plumbago Ck. on Paddy's Flat road crossing	Slow flowing river (>0.5m) deep; flat, grazing land	Edge and flowing water
12	Emu Ck. on Paddy's Flat road crossing	Large fast flowing river (<0.5m) deep; rocky; in flat, grazing land	Flowing water and riverbed
13	Emu Ck. 200m upstream of Site 12	Deeper (>0.5m) and more quiet than Site 12	Edge and flowing water
14	Cataract R. at confluence with Clarence R. at Paddy's Flat	Large river, shallow (<0.5m); rocky bed; fast flow	Flowing water and riverbed
15	White Rock Gully at Bruxner Highway	Small feeder stream; not flowing	Small shallow rocky pool
16	Sawpit Ck. downstream from Lady Hampden Mine	Fast flowing stream; area highly disturbed	Flowing and quiet water; rocky pool

Note: locations are shown on Figure 6

TABLE 5.2 BIOTA COLLECTED AT SAMPLING SITES
ALGAE, DIATOMS AND FUNGI

KEY TO TABLES
1 = 1 individual or colony
2 = 2-10 individuals
3 = >10

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CHLOROPHYCEAE (Green algae)																
Volvocaceae																
Volvox sp.		3						3								
Chlamydomonadaceae																
Chlamydomonas sp.							2									
Ulotrichaceae																
Ulothrix sp.		3?														
Endosphaeraceae																
Ankistrodesmus sp.		3		3												
Oocystaceae																
Characium sp.		3					3							3		
Oocystis sp.		1														
Zygnemataceae																
Spirogyra		3					3	3	3	3	1					
Zygnema		3						3							3	
Characeae																
Nitella		1														
Euglenaceae																
Trachelomonas		1	1								1					
Desmidiaceae (desmids)																
Closterium		1									1			2		
Cosmarium								2			1			2		
Filamentous Chlorophyceae (unidentified)	2	3					2		2	2				3		
MYXOPHYCEAE																
Blue-green algae																
Oscillatoriaceae																
Oscillatoria			2				3									
Lyngbya																
Nostocaceae																
Anabaena							3									

TABLE 5.2 (cont'd)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BACILLARIOPHYCEAE (diatoms)																
Amphora																
Navicula	2	3	3	3			3	3	3	3				3		
Gomphonema		1		1												
Gyrosigma							1							3		
Tabellaria	1		2				3	3			2			3		
Nitzschia		3				2	3	3								
Synedra		2														
Unidentified		2					3		2	2				3		
FUNGI			3													

TABLE 5.3 BIOTA COLLECTED AT SAMPLING SITES
INVERTEBRATES

KEY TO TABLES
1 = 1 individual or colony
2 = 2-10 individuals
3 = >10

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PROTOZOA (Excluding Mastigophora)																
Rhizopoda																
Difflugia																
Ciliata											1					
Paramecium																
Unidentified		1					1	3								
Aschelminthes																
Nematoda							1									
Rotifera; Monogononta																
Collothecidae																
MOLLUSCA																
Gastropoda (snails)																
Planorbidae											1			2		
Limnaeidae		1									1			1		
Unidentified		1					1									
Eggs		2												2		
ARTHROPODA																
Arachnida																
Hydracarina (water mite)											3					
Crustaceae																
Ostracoda								3			3					
Copepoda											1					
Malacostraca (decapoda) (shrimp)																
Atydae							3		3	3	3			3		
Palaemonidae		3					3		3	3	3			3		
Unidentified		3									1					
Insecta																
Megaloptera (alderflies)														2		
Plecoptera (stoneflies)														2		
Odonata																
Zygoptera (damselflies)	2	2					2				2			2		
Anisoptera (dragonflies)		2												2		

TABLE 5.3 (cont'd)

KEY TO TABLES
1 = 1 individual or colony
2 = 2-10 individuals
3 = >10
A = Adult

	1	2	2	4	5	6	7	8	9	10	11	12	13	14	15	16
Hemiptera (bugs)					+		+									
Notonectidae (backswimmers)	3A	3A			2A		3A	3A	3A	3A	3A			3A	3A	3A
Corixidae (waterboatmen)		3A					3A	3A			3A			3A	3A	3A
Gelastocoridae		1A												1A		
Gerridae		3A												1A		
Diptera (true flies)																
Tabanidae														2		
Chironomidae		1					2							2		
Trichoptera (caddisflies)	1								2			1		2		
Coleoptera (beetles)																
Sphaeridae														2		
Hygrobiidae														2		
Gyrinidae (whirligig)														2		
Noteridae									1A							
Unidentified		2								2A	2A				2A	
OTHER GROUPS																
AMPHIBIA																
Tadpoles	3				1									2	2	
Egg masses	1										1					
OSTEICHTHYES																
Fish							3	2	2	2	2					
Eels								?								
REPTILIA																
Emydura sp. (tortoise)							1				2					
No. of recognized taxa	8	30	5	3	2	1	22	13	10	9	21	1	0	28	5	2

TABLE 5.4 CLASSIFICATION AND QUALITY OF AQUATIC HABITATS

Site Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SIZE CLASSIFICATION AT SAMPLING POINT																
River >20m wide (Plate 21)														x		
10-20m wide (Plate 20)							x				x	x	x			
Stream 5-10m wide (Plate 19)			x	x	x	x										
Stream <5m wide (Plate 22)	x							x	x	x					x	x
HABITAT SAMPLED																
Flowing deep (>0.5m) water							x				x		x			
Shallow fast flowing water; rocky bottom		x			x	x						x		x		x
Quiet water near bank					x		x		x	x	x					x
Pool >0.5m deep, large (>3m wide)		x	x		x			x								
Pool <0.5m deep, small (<3m wide)	x			x	x										x	
VEGETATION AT SAMPLING POINT																
Forested	x	x	x	x	x	x	x							x		x
Cleared for grazing								x	x	x	x	x	x		x	
Emergent littoral vegetation							x	x	x	x	x					
WATER QUALITY ASSESSMENT BASED ON BIOLOGICAL CRITERIA																
Good	x	x					x	x	x	x	x			x		
Evidence of reduced quality			x	x	x	x						x	x			x
Insufficient data															x	

6.0 WATER QUALITY

6.1 Introduction

This chapter presents the objectives, methods and results of a water sampling programme undertaken in early February 1981.

6.1.1 Objectives

The objectives of the water quality investigation were as follows:

(a) To establish the geographic variability of water quality in the project area and downstream, and likely causes, with particular reference to past mining activity.

(b) To provide the geographic basis for an intensive, time-series water quality baseline, to be established if the project proceeds to development.

6.1.2 Study Components

The study components may be summarised as follows:

(a) To describe the drainage characteristics of the region.

(b) To identify and locate suitable sampling stations.

(c) To collect water samples using standardised sampling, preservation and transportation techniques.

(d) To describe the status of water quality of water courses draining the mine areas, in the light of past mining activity.

(e) To investigate the need for additional sampling to complete the water quality baseline.

6.1.3 Methods

A total of sixteen stream sample stations were established (Table 6.3 and Figure 6). A further two samples were collected, from the pit at Lady Hampden and the shaft at White Rock mine.

At each location temperature and pH were recorded and water collected for analysis from filtered and unfiltered samples. Each sample was analysed for copper, lead, zinc, cadmium, arsenic, silver, gold and sulphate. The unfiltered sample was also analysed for suspended solids.

Field temperature was measured using a standard 0-50^{o}C thermometer and a Selby pH 800 meter was used for measuring field pH.

Sample bottle preparation: one litre polyethylene bottles were used for sample collection and preservation. After removing and discarding the cap insert, bottles were:

(i) Rinsed with tap water
(ii) Washed with an alkaline detergent (Extram 100)
(iii) Rinsed with tap water
(iv) Washed with concentrated nitric acid
(v) Rinsed with tap water
(vi) Rinsed with distilled water
(vii) Allowed to soak in 20% nitric acid for one week.

Sample Handling and Preservation: on collecting two samples at each location, one sample (unfiltered) was adjusted to pH 1-2 by the addition of 5ml of Analar grade 40% nitric acid. The second sample was filtered through a 0.45 micron cellulose acetate membrane filter previously washed in nitric acid to remove contaminants. After filtration, the sample was again preserved. Following preservation, samples were kept cool by storing in polystyrene containers and air-freighted to SGS Laboratories in Sydney for analysis.

6.2 Hydrological Setting and Water Use

6.2.1 Hydrology

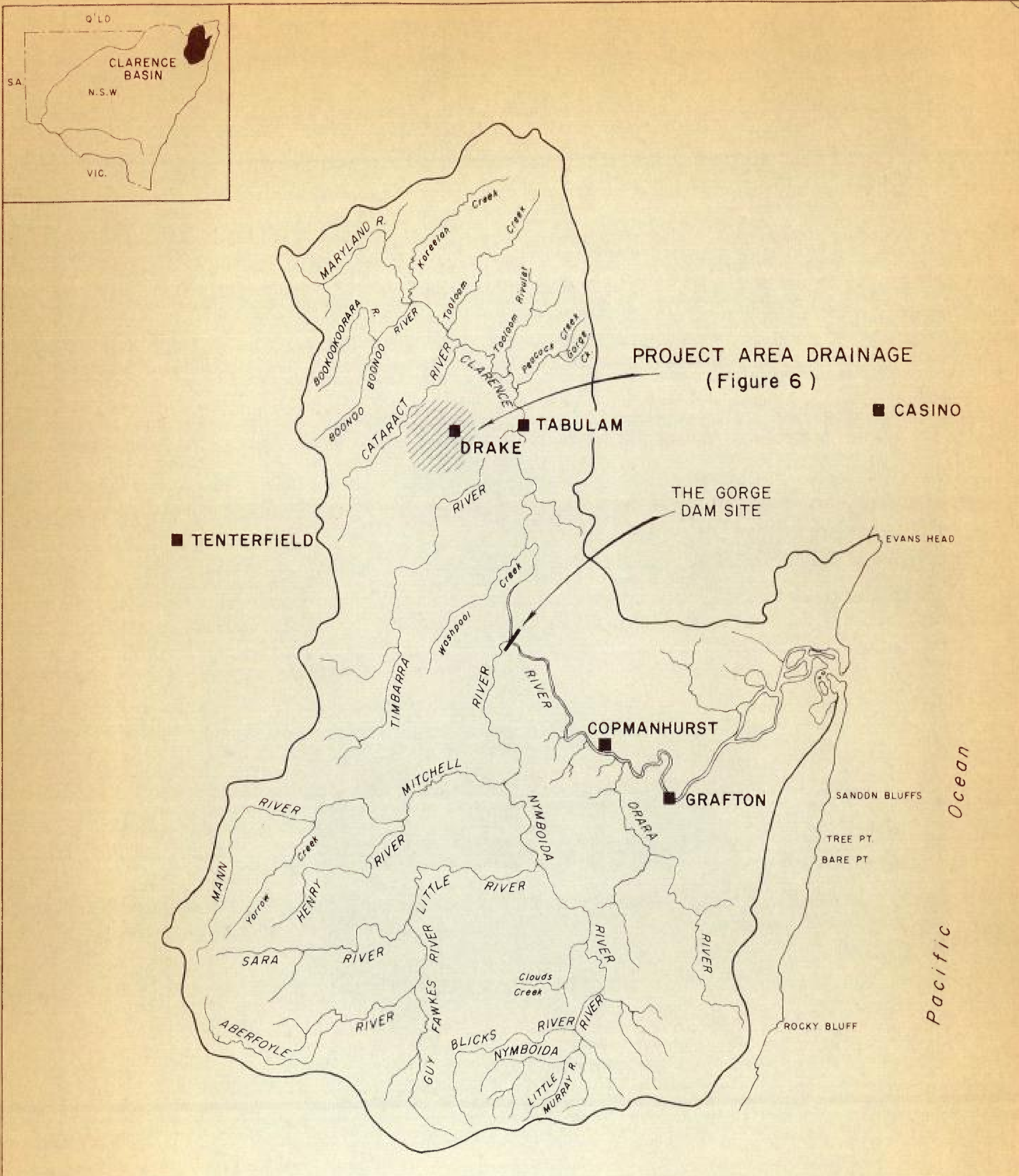
The project area is drained by headwaters of tributaries of the Clarence River, whose 22,700 km^2 catchment forms the largest drainage basin in the north coast area of N.S.W. (Figure 4).

Rainfall is high, with average annual totals reaching 1920 mm on the high plateau areas in the northwest. Except for the coastal fringe, the valley experiences a distinct wetter period from December to April, when some 55% of annual precipitation occurs.

The average annual discharge of all streams is estimated to be 4.9 million megalitres (Ml). Records available indicate that the quality of surface water is suitable for most purposes with little or no treatment, and is therefore also suitable for the maintenance of aquatic ecosystems.

The closest river gauging station to the project area is on the Clarence River at Tabulam, some 3 km upstream of the confluence of the Timbarra River, into which Plumbago Creek flows, and 22 km from Drake itself. Average annual yield over the period of record (57 years) is 0.9 million megalitres.

Surface flows in this subcatchment display considerable variability in annual, monthly and instantaneous flows (Table 6.1).



Source: Water Resources Commission of N.S.W.

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DRAKE PROSPECT

CLARENCE RIVER BASIN
AND
REGIONAL DRAINAGE

FIGURE 4

TABLE 6.1 CLARENCE RIVER AT TABULAM, FLOW FREQUENCY AVERAGES

% time	Flow (Ml/day)
10	3675
30	833
50	318
70	122
90	37
95	12
98	0

Source: Water Resources Commission of N.S.W., Tabulam Gauge.

On average, there is no flow for 2% of the time; the longest period of sustained no flow has been a period of 80 consecutive days (Sept.-Nov., 1915) and the lowest average daily flow over a 12 month period has been 47,220 Ml/day in 1923. Flow variability of this degree on the Clarence at Tabulam will reflect even greater fluctuations in the tributaries and in particular, their headwaters, such as those that drain the project area.

6.2.2 Water Development and Use

Despite the size and yield of the Clarence Basin, no major storages have been constructed and natural river flows provide most of the water consumed.

Over one third of the Basin is almost entirely undeveloped, and with limited agricultural demand and easy availability of surface waters, little groundwater exploitation has occurred. The majority of groundwater potential is in the lower part of the Basin, below Grafton. Upstream, the capacity of potential aquifers is small and yields are likely to be adequate only for domestic and stock watering on individual holdings. Official records show only 50 bores in the entire Basin; although there are known to be many additional bores on the Clarence flood plain alluvium, usage is not substantial, and, like the surface waters, is only a small proportion of the estimated potential yield (Table 6.2).

TABLE 6.2 CLARENCE BASIN WATER RESOURCE AND USE ($Ml x 10^3$ p.a.)

	Annual Use	Exploitable Yield
Surface Water	47	2500
Groundwater:		
0-1000mg/l	0.5	68
1000-3000mg/l	0.1	113
3000-7000mg/l	0	0
7000-14000mg/l	0	33

Source: Water Resources Commission of N.S.W.

Six possible dam sites have been identified by the W.R.C. The largest yield (1.6×10^6 Ml) would be captured at the Gorge, whose catchment includes the Tabulam Gauge subcatchment and the study area (Figure 4). A project to develop this site, and divert impounded flow by tunnel through the Divide to the Darling catchment has been, from time to time, the subject of public discussion.

6.3 Influence of Geology on Water Quality

The geology of the Drake area is dominated by a history of volcanic activity. During the Permian (289-247 million years ago), acid and intermediate lavas flowed from volcanoes very close to where Drake is now situated. As the volcanic activity subsided, igneous processes continued below the land surface, resulting in a complex of dykes, sills and domes which intruded into the surrounding country rock. Volcanic and intrusive igneous activity were probably the main contributors and controls of the Drake prospect mineralisation, which is dominated by sulphides of iron, copper, zinc and lead.

The chemistry of surface and groundwater is largely influenced by the terrain over and through which they flow. Waters that flow over rocks and sediments rich in base metals will consequently show higher levels of the metals than waters that have flowed over unmineralised ground if other conditions are kept constant (e.g. Eh, pH and temperature). This relationship is the basis for hydrogeochemical prospecting.

Before mining occurred around Drake, the waters from mineralised catchments (e.g. White Rock Gully, Sawpit Creek and Cataract River) would almost certainly have had higher natural background levels of zinc, copper, lead, cadmium and arsenic than those waters from unmineralised catchments (e.g. Violet Creek, Upper Plumbago Creek and Cedar Log Creek). As mining occurred, the mineralised catchments were cleared of forest and stockpiled with mineralised rock, which allowed faster chemical weathering of the minerals, causing more metals to be freed into the drainage. Warm temperatures and high rainfall accentuate the oxidation of the metal sulphides to acid sulphates, which increase the solubility, and hence mobility, of the metals. With acid oxidising conditions, zinc and copper have the highest mobility while arsenic and cadmium have a relatively medium mobility. Lead, on the other hand, has a relatively low mobility under these conditions and tends to precipitate in stable complexes a short distance from the source of solution. Figure 5 shows a schematic representation of metal contamination from two catchments: one mineralised catchment with mine workings and the other unmineralised. The model shows notional orders of magnitude of metal contribution from the two catchments. Based on the author's geochemical experience, the model only approximates the metal contributions from volcanogenic terrain, similar to that found around Drake.

At the confluence of mineralised and unmineralised catchment waters, mixing causes dilution of the metal concentrations.

As mining occurs, the metal concentrations increase according to the relative contributions and chemistries of the two catchment waters. Further downstream, the chemistry of the mixed waters change; pH increases to neutral or basic and the larger volumes of the stream may cause a decrease in Eh to less oxidising conditions. Conditions of high total dissolved salts, higher pH and lower Eh are conducive to the precipitation of metals as salts and organic complexes. The precipitates remain as sediments as long as the water chemistry is suitable. If there is no other interference, the stream purges itself of metal contamination and becomes cleaner downstream. If the stream should become acidic and oxidising, for example by flowing through areas high in humic acids and over oxidising riffle zones, such as rapids, the metals can again become mobilised. Also, deep water storages may have several stratifications of different Eh, pH, temperature and mixing conditions which may overturn and mix during the different seasons, also causing changes to the solubility, and hence mobility, of the metals.

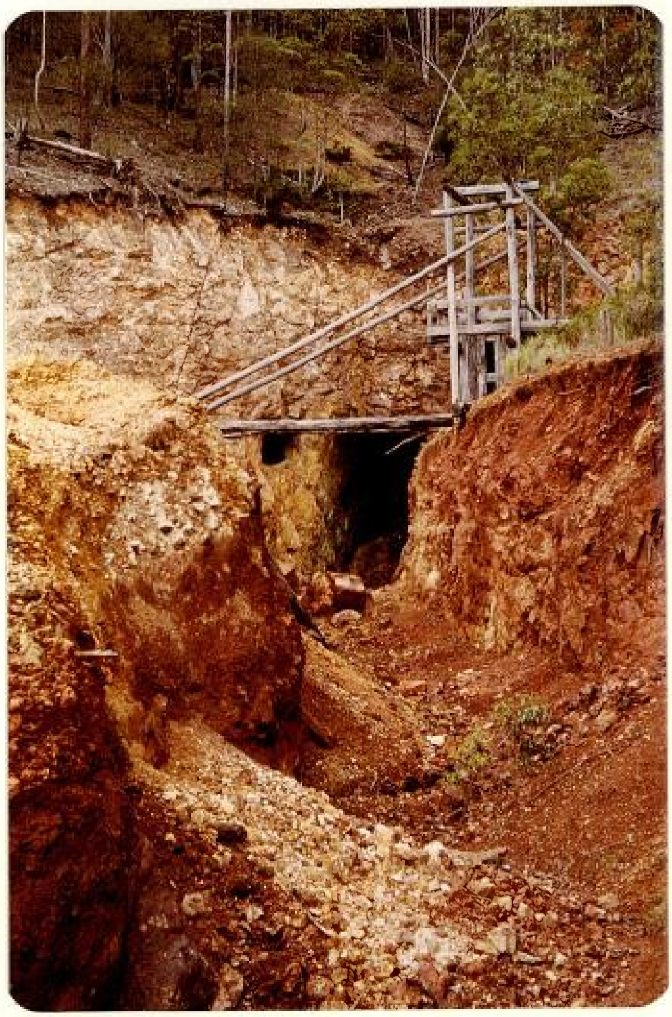
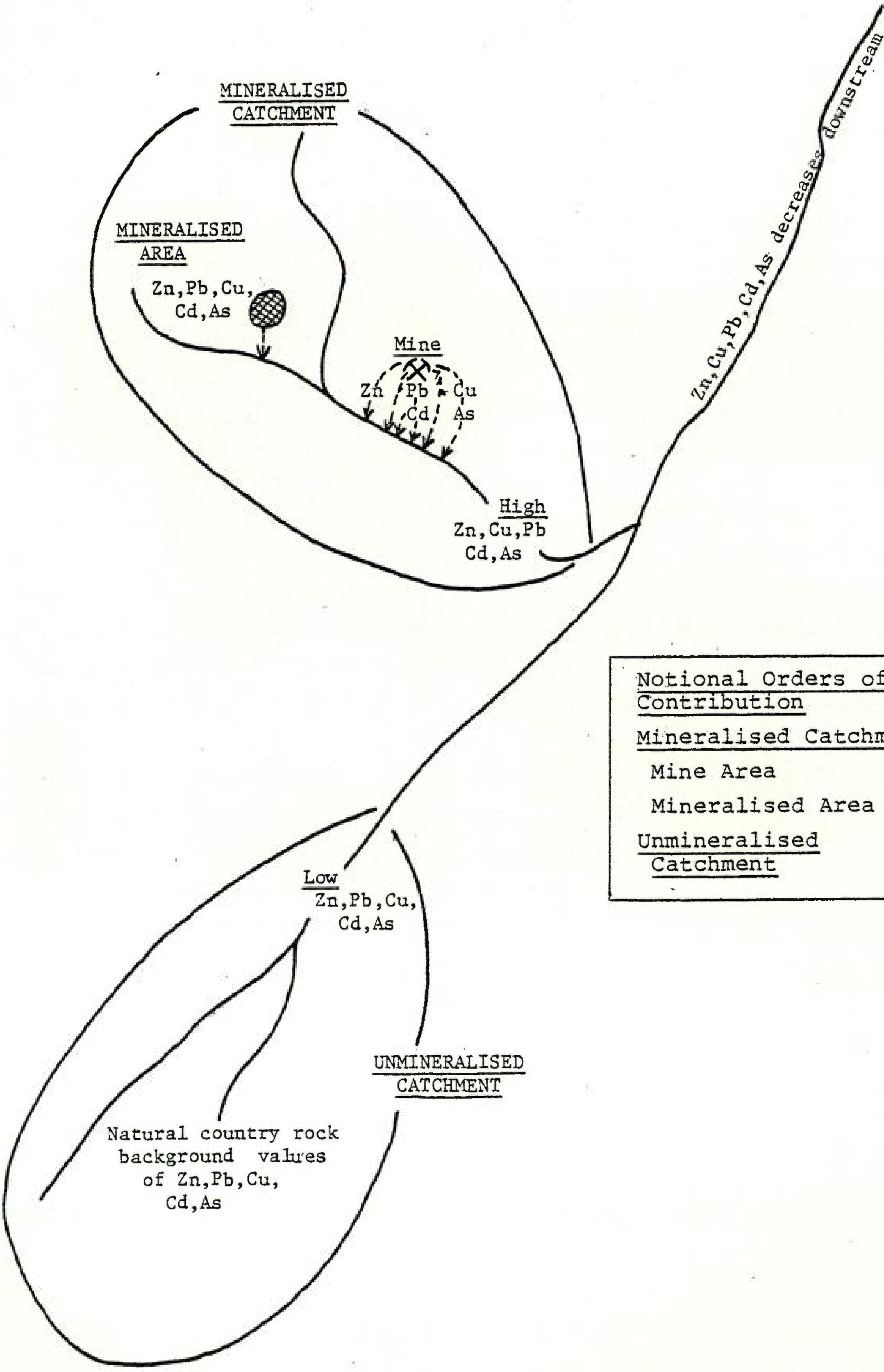


PLATE 23
An abandoned copper mine 1 km north of the Ford Sawmill. Large mullock heaps remain unvegetated and the portal opening is stained green/blue from copper precipitates.

FIGURE 5 SCHEMATIC REPRESENTATION OF METAL CONTAMINATION FROM MINERALISED AND UNMINERALISED CATCHMENTS



Notional Orders of Metal Contribution	
Mineralised Catchment	
Mine Area	x 100
Mineralised Area	x 10
Unmineralised Catchment	x 1

6.4 Metal Toxicity and Aquatic Ecosystems

Copper, lead, zinc, cadmium and arsenic in solution in aquatic ecosystems are cumulative toxins lethal to most species at low concentrations.

In extremely polluted water, all life is killed. With decreasing metal pollution, some algae and bacteria can survive and may thrive from lack of predation by higher animals. As the water quality improves, the ecosystem returns to normal with primary producers feeding the higher trophic level herbivores and carnivores. Detritivores feed on the detritus of the plants and animals of all the trophic levels. The effects vary with intermediate concentrations: while occasional species are tolerant of higher metal contamination in the water, most species find it acutely toxic (lethal) or chronically toxic (perhaps affecting reproduction or mobility).

Metals held in complexes and sediment may be eaten by detritivores and cause lethal accumulation of metals in dependant species higher up the food chain.

Heavy metal toxicity in aquatic ecosystem is poorly understood in Australia. However, it is known that base metals are toxic while in solution, but substantially less so when ions are bound in complexes with particles of sediment or organic matter.

6.5 Results

6.5.1 Sampling Locations

The location of sampling stations is shown in Figure 6, and Table 6.3 and the results of water analyses are given in Table 6.4.

The two subcatchments of prime interest are Sawpit Creek, containing the old Mt. Carrington and Lady Hampden workings, and White Rock Gully, containing the old White Rock workings. Cedar Log Creek was sampled as a control, being adjacent and environmentally similar to White Rock Gully. Plumbago Creek receives the drainage of all three, and has been sampled below the last confluence, to give an indication of dilution and complexing effects.

In the northwest of the study area, old diggings at Red Rock are drained by Crooked Creek, which joins the Cataract River some 4 km downstream. Samples were taken above and below Red Rock, and below the confluence.

6.5.2 Analysis Results

Findings conform to expectations, with localised pollution associated with acid mine drainage and elevated heavy metals, particularly copper and zinc, downstream of areas of past mining activity, but with a substantial improvement in water quality in terms of pH and metals downstream (Table 6.4).

TABLE 6.3 WATER QUALITY SAMPLE STATION LOCATIONS

Sample No.	Location
1.	White Rock Gully at Bruxner Highway (Plate 22).
2.	Cedar Log Creek, upstream of confluence with Plumbago Creek (Plate 25).
3.	Sawpit Creek, downstream of old Mt.Carrington mines.
4.	Lady Hampden mine pit.
5.	Sawpit Creek, downstream of Lady Hampden mine.
6.	Plumbago Creek (not sampled).
7.	Violet Creek, at Bruxner Highway.
8.	White Rock Gully, downstream of White Rock mine (200m).
9.	Plumbago Creek, upstream of confluence with Cedar Log Creek.
10.	Plumbago Creek, at Bruxner Highway.
11.	Fairfield Creek (not sampled).
12.	Plumbago Creek, upstream of confluence with Violet Creek.
13.	Crooked Creek, upstream of Red Rock mine.
14.	Crooked Creek, downstream of Red Rock mine.
15.	Crooked Creek, upstream of confluence with Cataract River (Plate 19).
16.	Cataract River, downstream of confluence with Crooked Creek.
17.	Cataract River, upstream of confluence with Clarence River (Plate 21).
18.	Emu Creek at Tabulam.
19.	Plumbago Creek, upstream of confluence with Stony River (Plate 20).
20.	White Rock mine shaft.

(see Figure 6 for locations)

TABLE 6.4 RESULTS OF WATER QUALITY ANALYSES

			DETERMINANDS														
			Unfiltered Samples Results µg/l						mg/l		Filtered Samples Results µg/l					mg/l
Location	T C	pH	Cu	Pb	Zn	Cd	As	Ag	Au	SS	SO4	Cu	Pb	Zn	Cd	As	SO4
1	21.7	6.2	17	0.8	240	1.1	2.0	1.5	*1.0	36	23	19	1.1	210	1.0	1.5	20
2	20.3	7.0	3.8	0.5	7.8	0.22	1.0	0.4	*1.0	18	10	4.4	0.5	8.0	0.26	1.0	22
3	20.4	6.3	260	0.9	1560	39	2.0	1.5	*1.0	27	93	250	0.9	1530	39	2.0	95
4	20.9	2.9	4050	2.2	23200	150	60	7.8	*1.0	14	1430	4370	2.3	25900	150	62	1592
5	20.3	3.9	960	1.8	3050	37	10	2.9	*1.0	12	285	900	2.0	2950	38	1.0	265
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	20.5	6.8	9	0.5	16	0.25	*1.0	2.1	*1.0	93	14	14	0.6	18	0.26	*1.0	14
8	20.2	6.6	29	1.9	15400	35	5.0	1.2	*1.0	10	135	32	2.1	13800	35	1.0	139
9	20.5	6.9	15	1.2	20	0.54	*1.0	1.8	*1.0	20	45	9	0.3	20	0.56	*1.0	15
10	20.6	6.3	7.8	0.3	20	0.22	*1.0	0.7	*1.0	16	26	10.5	0.8	18	0.26	1.0	24
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	21.9	7.2	70	0.8	126	2.4	*1.0	0.6	*1.0	13	40	72	0.8	125	2.2	1.0	30
13	23.0	6.5	11.5	0.5	20	0.35	*1.0	0.6	*1.0	20	15	4.8	0.2	12	0.21	*1.0	14
14	22.7	6.9	39	0.4	30	0.32	1.0	1.1	*1.0	15	30	46	0.9	32	0.31	1.0	16
15	22.9	7.6	11	0.4	3.4	1.1	1.0	0.1	*1.0	64	24	11	0.3	16	0.29	*1.0	25
16	23.0	7.0	58	1.7	51	1.65	*1.0	1.6	*1.0	21	31	41	0.6	50	0.45	*1.0	13
17	20.5	7.3	31	1.3	18	1.4	*1.0	0.9	*1.0	5	3	6.3	0.3	12	0.22	*1.0	4
18	20.4	7.2	5.5	0.2	19	0.19	*1.0	1.1	*1.0	2	48	6.0	0.5	18	0.24	*1.0	27
19	20.5	7.3	9.2	0.5	21	0.35	*1.0	0.6	*1.0	8	53	7.1	0.6	25	0.26	*1.0	39
20	-	6.92	46	35	21000	46	2.0	10.5	*1.0	50	163	41	30	21000	46	2.0	150

* = below the level of detection (µg/l)

In Sawpit Creek, contaminated water from Location 3 below the old Mt. Carrington workings (copper 260 µg/l; zinc 1560 µg/l) picks up drainage from the Lady Hampden area (Loc. 5), where copper (960 µg/l), zinc (3050 µg/l) and pH 3.9 reflect values in the standing waters in Lady Hampden open pit (copper 4050 µg/l; zinc 23,200 µg/l; pH 2.9).

At White Rock, a similar picture emerges: in the old shaft (Loc. 20) 21,000 µg/l zinc is followed by 15,400 µg/l downstream in White Rock Gully (Loc. 8).

With increasing distance downstream elevated metal concentrations dropped rapidly. In White Rock Gully, 4 km below Location 8 at the Bruxner Highway (Loc. 1), zinc was down to 240 µg/l; by a further 8 km downstream on Plumbago Creek this had decreased to 126 µg/l (Loc. 12). Location 19 on Plumbago Creek is some 20 km below Lady Hampden and 40 km below White Rock but by this point, concentrations had fallen to 9.2 µg/l copper and 21 µg/l zinc.

At Red Rock, a comparison between samples above and below the old mine workings showed elevated levels of copper, zinc and sulphate downstream, but increases were small.

PLATE 24
White Rock mine headframe, at the headwaters of the White Rock Gully creek (foreground).

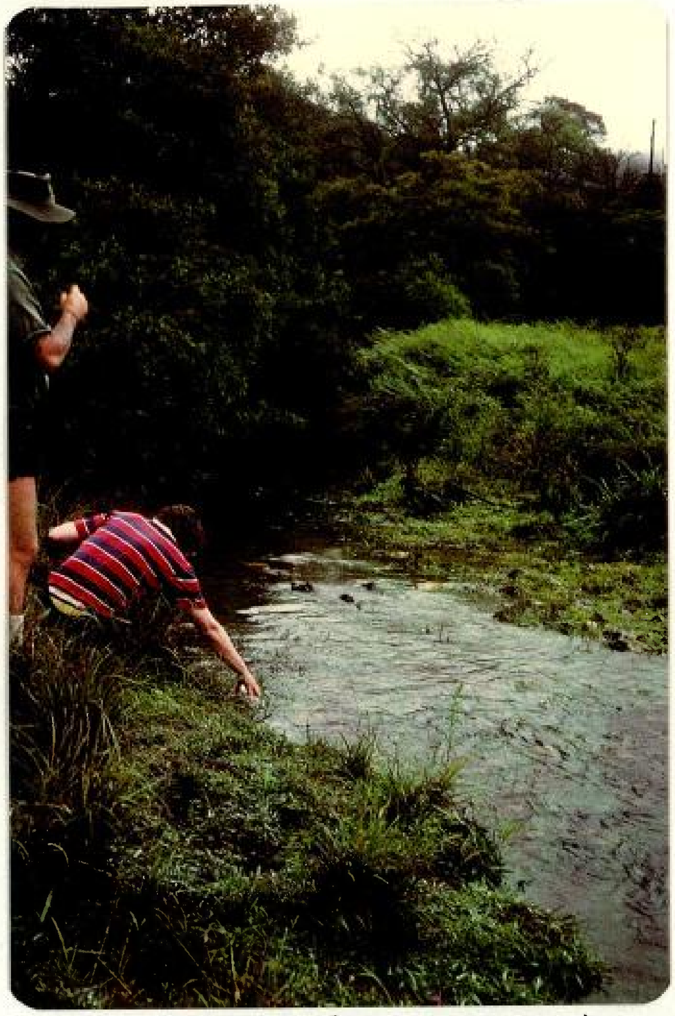


PLATE 25
Cedar Log Creek (Water Quality Station W2).

Conversely, metal concentrations in the subcatchments undisturbed by past mining, such as Cedar Log Creek (Loc. 2), Violet Creek (Loc. 7) and Upper Plumbago Creek (Loc. 10), showed low metal values and pH around neutral, as did the larger river stations some distance downstream of the project area, such as Cataract River below Crooked Creek (Loc. 16), and above Clarence (Loc. 17).

It is not possible to compare relative loadings contributed by the locations sampled, as concentrations must be systematically related to the hydrogaph for a given location, which requires samples to be taken for different stage heights and modes. However, an approximate indication can be inferred from Table 6.5, which compares the catchment areas of the various points sampled.

TABLE 6.5 SAMPLING LOCATION SUBCATCHMENT AREAS

Location	Area (sq.km)	Location	Area (sq.km)
1	1.6	12	27
2	3.8	13	44.4
3	1.5	14	46.6
5	2.8	15	50.4
6	4.5	16	452
7	5.8	17	606
9	7.4	18	210
10	16.3	19	177

(Stations 4, 8, 11 and 20 do not represent catchments)

It can be seen how dilution of the contribution of small contaminated catchments, such as Locs. 1 and 5, will be substantial, particularly in the context of, say, the Clarence River at the Gorge.

Other points worthy of note are as follows:

(a) In addition to copper and zinc, levels of cadmium, arsenic and sulphate are high in the Lady Hampden pit and cadmium is high in Sawpit Creek.

(b) There were no substantial differences between filtered and unfiltered determinations, indicating either that most metals were in solution, or were in complexes small enough to pass through the 0.45 micron filter. Around the mining areas, the acidic water suggests the former, while in the larger river stations further down the catchment, neutral to slightly basic conditions encourage the complexing of metals, and suggest that here, the latter could be the case.

6.6 Comparison with Other Studies

6.6.1 Department of Mineral Resources

The results of the present surveys substantiate the findings of an earlier investigation by the Department of Mineral Resources, N.S.W. in the Plumbago Creek catchment upstream of Plumbago above Sawpit (June 1980). Sampling was carried out by Aberfoyle and the locations are detailed in Table 6.6 and Figure 6.

Water analyses are given in Table 6.7. Values conform to the findings of the present study. Copper and zinc, and to a lesser extent cadmium and arsenic emerge as relatively high concentrations in the Lady Hampden pit and immediately downstream in Sawpit Creek. High levels of zinc show downstream of the White Rock mine. The larger rivers outside the project area were not sampled.

Sediment determinations are given in Table 6.8. These demonstrate a similar pattern to the water results from both surveys, with the same correlation of high metal values immediately downstream of areas of past mining activity at Lady Hampden and White Rock. As might be expected, however, the decline in concentrations with increasing distance downstream is less pronounced, compared to the rapid drop for water. This may be a reflection of the low flow conditions prevailing at the time of sampling, with the sediments representing longer term and average conditions, compared to a highly variable flow sampled at one point in time.

6.6.2 Aquatic Biota Study

Invertebrate fauna diversity is a simple but reliable indicator of water pollution. Table 6.9 summarizes the results of the aquatic biota sampling from Section 5.0 and compares its qualitative water quality rating with a similar interpretation of chemical indicators. While this classification cannot be made on a strictly statistical basis, for which a great deal more data is required, the results are mutually supporting, with a pattern of localised impact, and an apparent recovery of water quality and the invertebrate fauna downstream.

6.7 Implications

The redevelopment of the old mines at Lady Hampden and White Rock has the potential to add substantially to the present release of heavy metals to the natural drainage. Sources would include waste rock leachate, mine water, runoff and leachate from disturbed mineralized areas and tailings (Plate 26).

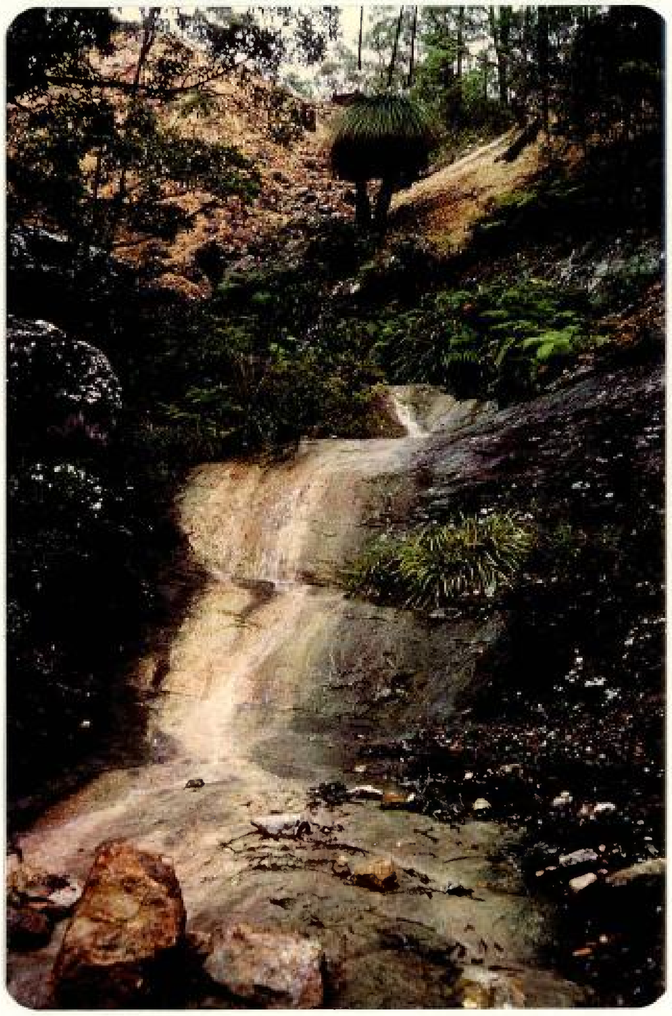


PLATE 26
Water runoff from old mullock heap near Lady Hampden mine.

However, modern mining and processing practice is able to pre-empt such discharges by a closed hydrological circuit for process waters, leachate and runoff, or treatment and precipitation of metals, and controled discharge of water and it is expected that such a management policy will be feasible in this case. If this can be demonstrated, then it will be an inevitable consequence that many existing sources of heavy metals will be contained, and the most likely outcome will be a net improvement in water quality in the catchment of Plumbago Creek. Some short term but substantial turbidity will be caused during construction, however, possibly associated with some discharge of heavy metals, depending on the nature of the ground disturbed.

On the assumption that containment of contaminated wastes from new mining operations at Lady Hampden and White Rock will form part of the mine design and operations plan, and that the impact of the project can be predicted in terms of a net improvement in water quality, the emphasis of future work lies, not in further investigations for impact assessment, but in the establishment of a water quality baseline for existing conditions, by which changes resulting from the new development can be monitored.

A preliminary definition of this work is as follows:

Objective: to establish a water quality baseline prior to the start of renewed mining and ore processing at Lady Hampden and White Rock.

Rationale: for a given water analysis taken during a future operation to be set in context, the pre-operation range in a given determinand must be known. Since this range is a function of hydrology, and in particular antecedent conditions, flow rate and flow mode, a pre-operation baseline will be based on time series samples taken for a representative range of hydrological conditions.

Locations and Determinands: the current survey permits these to be reduced to the following:

Determinands	Locations
Cu	1
Zn	5
Pb	DMR 1
As	DMR10
Cd	19
TSS	10
Sulphate	
pH	
Invertebrate diversity	

Timing: sufficient elapsed time will remain after the feasibility of development is established to initiate this work at that time, and complete it before substantive site works and disturbance begin.

TABLE 6.6 DEPARTMENT OF MINERAL RESOURCES, SAMPLE STATION LOCATIONS (JUNE 1980)

Sample No.	Location
D1	Plumbago Creek, downstream of Sawpit Creek confluence.
D2	Sawpit Creek, upstream of Plumbago Creek confluence.
D3	Lady Hampden mine pit.
D4	White Rock mine shaft.
D6	Plumbago Creek, downstream of Violet Creek confluence.
D7	Plumbago Creek, downstream of Oak Hollow Creek confluence.
D8	Plumbago Creek, downstream of Cedar Log Creek confluence.
D9	Fairfield Creek, downstream of White Rock Gully confluence.
D10	Fairfield Creek, upstream of White Rock Gully confluence.
D11	White Rock Gully at Bruxner Highway.
D13	White Rock Gully, downstream of White Rock mine.
D15	Sawpit Creek, upstream of Lady Hampden mine.

(see Figure 6 for locations)

TABLE 6.7 DEPARTMENT OF MINERAL RESOURCES, WATER QUALITY RESULTS JUNE 1980

Location	Cd	Cu	Fe	Pb	Zn	Mn	As	S04 (mg/l)	pH
	Determinands µg/l				Water Analysis (unfiltered)				
D1	20	240	150	* 10	1000	2000	10	150	4.4
D3	180	8000	155000	* 10	37000	11500	170	2500	2.8
D4	30	30	27000	* 10	1000	1000	60	125	6.4
D6	* 10	30	250	* 10	130	* 10	* 10	40	6.1
D7	* 10	10	150	30	160	* 10	* 10	45	6.4
D8	* 10	* 10	* 50	80	* 20	* 10	* 10	25	6.4
D9	40	* 10	* 50	* 10	* 20	* 10	* 10	10	6.7
D10	* 10	10	* 50	* 10	* 20	* 10	* 10	5	6.8
D11	* 10	* 10	* 50	* 10	30	* 10	* 10	10	6.4
D13	* 10	20	* 50	10	7200	* 10	* 10	40	6.5
D15	50	180	* 50	* 10	3100	* 10	* 10	160	6.5

* = below the level of detection (µg/l)

TABLE 6.8 DEPARTMENT OF MINERAL RESOURCES STREAM SEDIMENT ANALYSES

Field Number	Sieve Analysis Fraction	%	As	Cd	Cu	Pb	Mn	Zn
			Trace Metal Content in Micrograms per Gram					
D1	+25	84	50	2.0	200	135	200	355
	-25+80	9.5	60	5.0	360	210	300	520
	-80+150	2.3	is	9.5	645	270	550	950
	-150	4.3	100	13	740	275	800	1350
D2	+25	45	70	0.5	310	165	300	295
	-25+80	42	60	* 0.5	340	210	200	290
	-80+150	6.5	90	1.0	575	380	250	355
	-150	7.2	90	1.5	620	330	250	430
D6	+25	72	20	2.5	110	40	240	290
	-25+80	25	10	2.5	115	45	216	260
	-80+150	1.7	20	4.5	205	95	365	455
	-150	0.7	20	9.0	355	130	655	685
D7	+25	93	20	2.5	130	45	280	325
	-25+80	6.3	10	3.0	140	55	235	305
	-80+150	0.2	is	6.0	415	110	565	505
	-150	0.2	is	8.5	485	130	680	655
D8	+25	53	30	0.5	50	40	685	105
	-25+80	40	* 10	1.0	80	30	1200	105
	-80+150	2.5	* 10	0.5	50	20	1900	95
	-150	4.5	* 10	0.5	40	20	2000	25
D9	+25	71	10	* 0.5	20	35	560	250
	-25+80	28	10	* 0.5	30	55	390	290
	-80+150	0.6	* 10	* 0.5	35	60	475	285
	-150	0.4	is	0.5	70	105	735	400
D10	+25	77	10	* 0.5	10	15	600	55
	-25+80	19	* 10	* 0.5	15	10	505	45
	-80+150	2.0	* 10	* 0.5	25	20	600	55
	-150	2.2	* 10	* 0.5	40	35	875	90
D11	+25	93	30	1.0	20	125	650	660
	-25+80	5.7	20	1.0	30	140	565	705
	-80+150	0.3	is	1.5	40	120	735	645
	-150	0.6	is	2.0	70	130	665	750
D13	+25	65	70	0.5	85	960	460	4500
	-25+80	25	80	7.0	70	780	400	2850
	-80+150	5.4	90	9.5	95	670	260	3000
	-150	5.3	80	12.5	105	935	365	3500
D15	+25	71	100	7.0	565	275	985	670
	-25+80	25	70	6.0	535	300	625	655
	-80+150	2.1	80	10.0	790	385	685	940
	-150	2.0	50	18.5	1450	320	1200	1250

* = below the level of detection (μg/g)
is = inadequate sample

TABLE 6.9 QUALITATIVE COMPARISON OF WATER QUALITY INDICATORS

	Heavy Metals		Invertebrate Diversities
	Water	Sediments	
Sawpit Creek Catchment (Lady Hampden, Mt.Carrington mines)	High (high Zn,Cu Pb)	High (high Cu,Pb low Zn)	Reduced
White Rock Gully Catchment (White Rock mine)	High (high Zn medium Cu,Pb)	High (high Zn low Cu,Pb)	Reduced
Crooked Creek Catchment (Red Rock mine)	High (high Cu low Zn,Pb)	-(n.a.)-	Reduced
Upper Plumbago Creek Catchment	Low (low Zn,Cu,Pb)	Low (low Zn,Cu,Pb)	Good
Violet Creek Catchment	Low (low Zn,Cu,Pb)	-(n.a.)-	Good
Cedar Log Creek Catchment	Low (low Zn,Cu,Pb)	-(n.a.)-	-(n.a.)-
Lower Plumbago Creek Catchment	Low (low Zn,Cu,Pb)	-(n.a.)-	Good

7.0 ARCHAEOLOGY

7.1 Introduction

This chapter presents the conclusions of a 10 day archaeological study within, and in the region of, the Aberfoyle Ltd. exploration licences near Drake, N.S.W. Four days were spent surveying the area and six days of literature search and discussion with archaeologists completed the study.

7.1.1 Objectives

The overall objective of this investigation has been to assess the impact of the proposed development on archaeological sites in the area covered by the exploration licences generally and in particular the areas of the proposed Lady Hampden and White Rock mines.

7.1.2 Study Components

The consultants were specifically required to:

(a) Undertake a ground survey of the areas to be directly impacted by mining of the Lady Hampden and White Rock deposits, and an archaeological reconnaissance of the rest of the exploration tenements.

(b) Record and describe any archaeological sites located in the course of these surveys and advise on measures that could be taken to mitigate the impact of the development on such sites.

(c) Collate available information on the archaeology, ethnography and environment of the study area and to relate this information to the regional prehistory.

(d) On the basis of (a), (b) and (c), advise on the need for further archaeological investigations.

7.2 The Environment of the Study Area

The study area is located in the far northeastern corner of the New England region as defined by the Atlas of New England (Lea _et al_. 1977). In this part of the region the New England plateau or tableland falls eastward into the upper Clarence River valley and the height above sea level of the landscape is between 400 and 750 m.

The bedrock geology of the eastern two thirds of the lease area consists predominately of acid to intermediate volcanic rocks of Permian age, whereas the western third consists predominately of Permian siltstone, sandstone and quartzite (Drake Geological Series Sheet 9340 (ed.1) 1974, 1:100,000). The terrain is rugged to very rugged and the local relief (stream bed to ridge crest) varies between 50 and 250 m. Despite the rugged relief there are very few massive outcrops of rock that might have acted as foci for Aboriginal activity. In this respect the study area contrasts strongly with the sandstone country in the Clarence-Moreton Basin to the east and the granite country elsewhere in the New England region, where there are numerous rock outcrops with shelters and overhangs in which Aboriginal people camped and containing suitable rock surfaces for painting (McBryde 1974).

Virtually the entire area is covered with eucalypt-dominated open forest, which has been extensively logged for many decades. The only major cleared areas are around the Drake township and at Cheviot Hills property in the northeast corner of the exploration lease.

7.3 Previous Archaeological Investigations

No previous systematic archaeological investigations are known to have been carried out in the study area. The site records held by National Parks and Wildlife Service in Sydney and those held by the Australian Institute of Aboriginal Studies in Canberra (both of which include sites recorded by Dr. Isabel McBryde in the course of her extensive field work in northeast N.S.W.) contain details of a number of archaeological sites and sites which are significant to Aboriginal people within a 30 km radius of Drake. No sites are reported from the area covered by the licences and leases.

7.4 Types of Sites

The types of Aboriginal archaeological sites which might occur within the study area are described in detail in McBryde (1974) and Connah et al. (1977).

7.4.1 Stone Quarries

Areas where stone has been quarried for the manufacture of stone artefacts: the New England region is particularly noted for its large number of stone axe quarries. The closest known quarry sites to Drake in the New England region are at Graman 170 km to the west and at Aberfoyle 130 km to the south (McBryde 1974:158). Grinding grooves resulting from the manufacture of stone axes occur more frequently than quarries, but the closest known grooves are at Graman and at Grafton 65 km to the southeast, where quartz sandstones occur.

7.4.2 Surface Scatters of Stone Artefacts

In these locations, worked stone and other evidence for Aboriginal occupation remains in the landscape.

(a) Knapping floors, which are discrete scatters of stone artefacts, anywhere in the landscape (including at quarries resulting from stone having been worked on that spot). The use of this term, as distinct from campsite, implies that the scattered pieces of knapped stone can be reconstructed to the original block.

(b) Campsites are general artefact scatters which may contain flaked or ground stone artefacts, hearth stones (or other transported stones, called manuports), charcoal from fires and food remains such as bone and shell. Campsites may occur as surface scatters of material, generally in the open, or as stratified deposits where there have been repeated occupation, either in the open or in rockshelters. These scatters do not necessarily imply that people actually camped on the site; rather they indicate only that some type of activity was performed there.

7.4.3 Burial Sites

A range of burial methods have been recorded for the New England region (McBryde 1974:ch.4). Cremations were uncommon and inhumation varied from tree burials, contracted burials wrapped in strips of bark in shallow graves, earth mounds and stone cairns. Some of these burials were marked by carved trees. Cave burials have also been recorded for the region. In 1933 three skeletons, presumed to be Aboriginal, were recovered from a sandstone cave at Tabulam, about 20 km east of Drake (McBryde 1974:146-7).

7.4.4 Ceremonial Sites

(a) Some natural landscape features, such as rocky promontories and mountain tops may have a 'dreaming' or mythological significance. Two such sites in the vicinity of Tabulam are recorded in the National Parks and Wildlife Service site file.

(b) Stone arrangements and cairns: in northeast N.S.W., these artificial features are usually considered to have ceremonial functions. Groups of low stone cairns are the most usual stone arrangement for the region (McBryde 1974:29). Groups of standing stones, small circles and stone alignments have also been recorded for the region but these are rare (ibid).

(c) Bora grounds are the most common type of ceremonial site and they were most often associated with initiation ceremonies. In northeast N.S.W., bora grounds in the form of earth circles and, less commonly, stone arrangements, have been recorded. The most common type of earthen bora ring is a circular cleared area (9-14 m in diameter) edged with a low bank of earth up to 0.5 m high and about 2 m wide (Connah _et al_. 1977:133).

Within a radius of 30 km of Drake at least three bora grounds have been reported, although none are known from the exploration licences. The Wheatley Creek ceremonial site, which is in terrain similar to that of the study area and lies less than 10 km north of the northern limit of the lease, is considered by John Sommerlad (National Parks and Wildlife Service) to be of particular local importance (pers. comm.).

(d) Carved trees: these are often associated with bora grounds, other ceremonial sites and burial sites; they may also mark tribal boundaries. They are usually carved either in a geometric design or with mythological or totemic symbols (McBryde 1974:126).

7.4.5 Scarred Trees

Slabs of bark were cut from trees by Aborigines and used for a variety of purposes, including roofing shelters and constructing canoes, shields and containers. Scars also resulted from the cutting of toe holds for climbing trees to obtain honey or capture animals such as possums. The classification of scarred trees as natural, European or Aboriginal is as yet a largely subjective process, but if the scar is prehistoric, the tree must now be more than 100 years old. Two scarred trees, taken to be Aboriginal, were recorded in the course of an archaeological survey in the Washpool State Forest about 50 km south of Drake (Bell 1980).

7.4.6 Rock Art Sites

Rock art sites in this region consist of painted sites, mainly in rock shelters or on the surfaces of boulders (McBryde 1974:ch.3). The only rock art site in the local area is the Old Mission Cave at Tabulam. Carved trees can also be considered as art sites.

7.5 Fieldwork - Procedures and Results

The fieldwork phase of the project was carried out by Anne Blackwell over a four day period between the 6th and 10th February. No archaeological sites were found in the course of the field surveys described below, nor were any such sites or sites likely to be of significance to local Aboriginal communities reported in the course of discussions with local residents.

7.5.1 The Lady Hampden and White Rock Areas

The Lady Hampden area was surveyed as follows:

(a) On the summits of two hills to the east of the Cheviot Hills road, large impressive boulders of igneous rock crop out. These were examined carefully for rock art and other evidence of Aboriginal association, such as stone arrangements, carved trees and surface scatters of stone artefacts. The forested flanks of these hills have been severely disturbed by logging and as there was virtually no surface exposure because of the complete ground cover of grasses, shrubs and forest litter, they were examined only cursorily.

(b) The area to the west of the Cheviot Hills road, which is covered with secondary forest dominated by closely spaced eucalypt saplings and with a complete ground cover, was traversed at roughly 100 m intervals. The ground surface was dotted with abandoned mine shafts and has clearly been extensively disturbed by mining as well as logging.

(c) Vertical creek sections through the unconsolidated sediment fills of Sawpit Creek and other unnamed creeks were examined, as were the few road cuttings in the area. Areas of surface exposure, in particular vehicle tracks, were also examined.

The White Rock area is located at the bottom of a very steep-sided, rugged, V-shaped gully. The gully bottom has been extensively disturbed by mining activities over the last 100 years. The valley sides support a dense forest cover with very little ground surface exposure.

The main gully was surveyed on foot, as were a number of tributary gullies to the south. The slopes to the north of the mine site are criss-crossed by vehicle tracks, many of which were examined on foot. Part of the ridge crest to the north was also traversed. A number of large boulders cropped out here and these and their immediate surroundings were examined closely.

7.5.2 The Exploration Licences

A full day was than spent driving along roads and forest tracks. Frequent stops were made at localities where there was good surface exposure, at creek crossings, gullies and outcrops of large boulders. In this way much of the exploration area was able to be examined.

It was clear from this reconnaissance, firstly that the region is broadly environmentally homogenous and secondly that archaeological sites are uncommon and/or difficult to locate given the nature of the vegetation cover and the degree of landscape disturbance.

7.5.3 Discussions with Local Informants

As no archaeological sites were found in the above surveys, it was decided that the most profitable method to obtain maximum information about Aboriginal knowledge and use of the area was to consult with local residents (Aboriginal and European) and with local National Parks and Wildlife personnel. The following account of discussions with informants is summarised from Blackwell's field notes.

"Two trips were made to the Aboriginal settlement at Tabulam. Residents there informed me that Mr. Robert Collins and Mrs. Walker would be the most knowledgeable people about the Drake Area. I spoke to Mr. Collins, who knew of no sites in the vicinity of Drake. However he produced a copy of a land grant at Drake, made to the Aboriginal community at Tabulam in 1969. This area totals approximately 120 ha and is located adjacent to the Laurie family property and Plumbago Creek, approximately half a kilometre to the north of the Mt. Carrington Ltd. camp in the Drake township. The land issued under the grant was the location of a post-contact Aboriginal camp, housing up to 60 people (Albert Ford pers. comm.) before the people moved to the now Tabulam settlement. I visited the site of this camp but few traces remained of the Aboriginal occupation. I was unable to locate Mrs. Walker on either trip to the settlement.

"Mr. Albert Ford (a European, aged 87) has lived in Drake since 1898. He provided me with details of the history of the township, a history of mining in the area - including information about Chinese mining activities - as well as some information about the Aboriginal camp on Plumbago Creek. Mr. Ernie Ford (aged 80) confirmed his brother's statements and added information about the history and the effects of logging in the area. Mr. Ernie Ford has been the proprietor of the Drake sawmill since 1928 when commercial logging began and his comments regarding the Drake timber industry confirmed my impression that logging activities on the area covered by the exploration lease area have been very extensive.

"Mrs. Ramsay, a local historian and descendant of the Smith family, owners of the Cheviot Hills property since 1842, confirmed the Ford brothers' statements about the Plumbago Aboriginal settlement. She added that she thought that the Aboriginal community moved from Drake about 1910. Mrs. Ramsay also told me of a scattering of small fragments in the Drake cemetery, which she believes was associated with the Aborigines. I visited the cemetery and asked Mr. Laurie, the owner of the adjacent property, if he had ever seen any such shell fragments. He knew of none, and I was unable to locate any. As Mrs. Ramsay remembered seeing these some years ago, it is possible that they have been destroyed. Mrs. Ramsay also reported that the two 'bloodwood' trees at the gates of the cemetery were known to the local Aborigines as the 'Place of the Flying Squirrels'. This information was related to Mrs. Ramsay by John Snowden who was the local police constable who investigated the discovery of the Aboriginal skeletons at Tabulam in 1933. According to Mrs. Ramsay, John Snowden has collected an extensive scrapbook on the history of Drake. Mrs. Ramsay told me of a Mrs. Marjory Oakes who lives in Lismore. I wrote to Mrs. Oakes and she provided me with an extract from a family booklet produced by Mrs. Kelly of Tara Hills, Tenterfield, describing the Millera (Malara) bora ground, 15 km south of Drake (this manuscript will be transcribed and a copy will be sent to the National Parks and Wildlife Service).

"Mr. Tom Collins, an Aborigine who lives in Drake, and Mrs. Daly, an Aborigine formerly from Tabulam, knew of no sites in the Drake area. Similarly neither John Sommerlad nor Mrs. Jessie Geyer, a long time member of the Tenterfield Historical Society whom I went to visit, knew of any sites in the area."

In summary therefore, none of the above people, all of who have a considerable knowledge of the district and its history, were able to provide any information about prehistoric Aboriginal use and knowledge of the area covered by the exploration lease.

7.6 Discussion

A number of writers have commented on the comparative harshness and lack of resources of the Tablelands as compared with the rich adjacent coastal regions, and have proposed explanations for the marked contrasts in the nature and distribution of archaeological sites in these two areas in terms of availability of resources (McBryde 1974; various papers in McBryde 1978) and the round of ceremonial activities (Bowdler and Coleman in press). A discussion of the prehistory of this wider region is beyond the scope of this report except where it provides an indication of the pattern of occupation of the tract of dissected country between the Tablelands and the upper Clarence River valley, in which the study area lies.

The ethnohistorical evidence, sparse as it is, suggests that there may have been seasonal movements of people from the Tablelands to the coastal plains and vice versa across this tract of country. Bowdler and Coleman (in press) have argued that as well as coastal groups, there were others who were confined to the foothills (which included the upper reaches of rivers such as the Clarence). It was these foothill groups who visited the Tablelands (particularly in the summer) and who were in turn visited by groups from the Tablelands, especially during the harsher winter months.

This evidence suggests that Aboriginal use of the tract of country encompassing the study area may always have been transitory. This, combined with the lack of suitable rock outcrops (which could have acted as foci for prehistoric activity), poor surface exposure and landscape disturbance, can account for the lack of archaeological evidence reported in this study and the paucity of sites shown on the various maps in McBryde (1974) and Connah et al. (1977) and recorded in the National Parks and Wildlife Service's site file.

7.7 Recommendations

The results of the archaeological surveys and discussions with local residents described above, combined with the published archaeological and ethnohistorical evidence, indicate that sites are likely to occur infrequently in the study area and that they will have been disturbed by logging and mining activities and/or obscured by forest litter. This is particularly true of ceremonial sites which were considered to be the most important type of site that might occur in the study area, given what is known about the archaeology and prehistory of the New England region in general. There is no evidence from any sources of information that any such sites are likely to exist in the study area. Therefore it is considered that little information of archaeological importance would be recovered by further survey in the study area and it is recommended that the development be allowed to proceed without additional archaeological investigations. However archaeological sites are protected by legislation and any sites discovered in the course of development must be reported to the National Parks and Wildlife Service.

7.8 References

Bell, D. (1980). A Report on an Archaeological Survey of the Washpool area, Northern N.S.W. The Forestry Commission of New South Wales.

Bowdler, S. and Coleman, J. (in press). The Aboriginal People of the New England Tablelands: Ethnohistory and Archaeology. Armidale and District Historical Society Journal, 24.

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McBryde, I. (1974). Aboriginal Prehistory in New England. Sydney University Press.

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APPENDIX A

Botanical Species Checklist

This checklist is divided into two parts. The first contains the species found in the rainforests of the study area and is taken from Floyd (1980). The second contains the species found in the other plant communities of the study area and was compiled during the field survey. All the field survey identifications are unverified and voucher specimens have not been retained. An asterisk (*) denotes a naturalised species and the abundance in the study area is indicated (VC=very common, C=common, O=occasional and R=rare).

APPENDIX A-1 RAINFOREST SPECIES (after Floyd 1980)

PTERIDOPHYTA		
Adiantaceae		
Adiantum formosum	Giant maidenhair fern	C
Aspidiaceae		
Arachnoides aristata	Shield fern	O
Aspleniaceae		
Asplenium australasicum	Birds nest fern	O
Athyriaceae		
Athyrium australe	Austral lady-fern	O
Blechnaceae		
Blechnum cartilagineum	Gristle fern	VC
Doodia aspera	Rasp fern	O
Cyathaceae		
Cyathea leichhardtiana	Prickly tree fern	VC
C. australis	Rough tree fern	C
Davalliaceae		
Davallia pyxidata	Hare's foot fern	O
Dennstaedtiaceae		
Hypolepis muelleri	Harsh ground fern	VC
Dicksoniaceae		
Culoita dubia	False bracken	O
Dicksonia antarctica	Soft tree fern	O
Hymenophyllaceae		
Macroglena caudata	Jungle bristle fern	O
Polypodiaceae		
Dictymia brownii	Strap fern	C
Platycerium bifurcatum	Elk horn fern	C
P. superbum	Stag horn fern	O
Pyrrosia confluens	Horshoe felt fern	C
P. rupestris	Rock felt fern	VC

APPENDIX A-1 (cond'd)

Pteridaceae		
Pteris tremula	Tender bracken	R
P. umbrosa	Jungle brake	C
ANGIOSPERMAE-DICOTYLEDONS		
Alangiaceae		
Alangium villosum	Black muskheart	O
Anacardiaceae		
Euroshinus falcata	Chinaman's cedar	R
Apocyanaceae		
Ervatamia angustisepala	Banana bush	O
Araliaceae		
Polyscias elegans	Celery wood	O
Boraginaceae		
Ehretia acuminata	Koda	C
Celastraceae		
Denhamia pittosporoides	Orange boxwood	R
Cunoniaceae		
Ackama paniculata	Corkwood	C
Ceratopetalum apetalum	Coachwood	R
Schizomeria ovata	Crabapple	VC
Ebenaceae		
Diosporos australis	Yellow persimmon	R
Elaeocarpaceae		
Elaeocarpus obovatus	Blueberry ash	R
Sloanea woollsii	Yellow carabeen	VC
Escalloniaceae		
Quintinia sieberi	Brown possumwood	R
Euphorbiaceae		
Baloghia lucida	Brush bloodwood	R
Claoxylon australe	Brittlewood	O
Croton verreauxii	Green native cascavilla	R
Glochidion ferdinandi	Cheese tree	R
Omalanthus populifolius	Bleeding heart	O
Eupomatiaceae		
Eupomatia laurina	Bolwarra	C
Icacinaceae		
Citronella moorei	Soapy box	R
Pennautia cunninghamii	Brown beech	O

APPENDIX A-1 (cont'd)

Lauraceae		
Beilschmiedia elliptica	Grey walnut	R
Cryptocarya erythroxylon	Pidgeonberry	O
C. glaucescens	Jackwood	O
C. obovata	Pepperberry	R
Endiandra muelleri	Mueller's walnut	R
E. sieberi	Hard corkwood	R
Neolitsea dealbata	White bolly gum	C
N. cassia	Smooth bolly gum	R
Lobeliaceae		
Lobelia trigonocaulis	Brush lobelia	R
Malvaceae		
Hibiscus splendens	Pink cottonwood	R
Meliaceae		
Didymocheton rufum	Hairy rosewood	O
Dysoxylum fraseranum	Rosewood	C
Synonum glandulosum	Scentless rosewood	C
Toona australis	Red cedar	VC
Mimosaceae		
Abarema sapindoides	Snow wood	O
Monimiaceae		
Daphandra micrantha	Socketwood	O
Doryphora sassafras	Sassafras	O
Moraceae		
Ficus coronata	Creek sandpaper fig	VC
F. obliqua	Small leaved fig	O
F. watkinsonia	Strangler fig	O
Maclura cochinchinensis	Cockspur thorn	R
Malaisia scandens	Burny vine	R
Myrsinaceae		
Embelia australasica	Embelia	R
Rapanea howittiana	Howitt's muttonwood	O
Myrtaceae		
Acmena brachyandra	Red apple	R
Decaspermum paniculatum	Currant myrtle	R
Rhodamnia trinervia	Brush turpentine	O
Syzygium crebrinerve	Purple cherry	C
S. paniculatum	Brush cherry	C
Tristania conferta	Brush box	VC
Pittosporaceae		
Citriobatus pauciflorus	Orange thorn	R
Hymenosporum flavum	Native frangipani	O
Pittosporum undulatum	Sweet pittosporum	O
Piperaceae		
Piper novae-hollandiae	Peppervine	C

Appendix A-1 (cont'd)

Proteaceae		
Orites excelsa	Prickly ash	C
Stenocarpus salignus	Scrub beefwood	R
Rhamnaceae		
Alphitonia excelsa	Red ash	R
Emmenosperma alphitonioides	Yellow ash	O
Rubiaceae		
Hodgkinsonia ovatiflora	Golden ash	R
Morinda jasminoides	Jasmine morinda	O
Psychotria loniceroides	Hairy psychotria	R
Sapindaceae		
Alectryon subcinereus	Wild quince	O
Diploglottis australis	Tamarind	O
Guioa semiglauca	Guioa	O
Simaroubaceae		
Guilfoylia monostylis	Native plum	O
Sterculiaceae		
Brachychiton acerofolium	Flame tree	R
Ulmaceae		
Trema aspera	Poison peach	R
Urticaceae		
Dendrocnide excelsa	Giant stinging tree	C
Elatostemma reticulatum	Smooth nettle	O
Verbenaceae		
Gmelina leichhardtii	White beech	O
Callicarpa pedunculata		R
Vitaceae		
Cayratia clematidea	Slender grape	R
C. eurynema	Smooth tender grape	R
Cissus antarctica	Simple watervine	VC
C. hypoglauca	White leaved watervine	O
Tetrastigma nitens	Shiny leaved grape	C
Winteraceae		
Tasmannia insipida	Tasteless pepper bush	O
ANGIOSPERMAE - MONOCOTYLEDONS		
Araceae		
Alocasia macrorrhizos	Cunjevoi	C
Commelinaceae		
Aneclema acuminatum	Slug herb	R
Dioscoreaceae		
Dioscorea transversa	Yam	O

APPENDIX A-1 (cont'd)

Liliaceae		
Cordyline terminalis	Broad palm lily	O
Orchidaceae		
Dendrobium gracilicaule	Spotted orchid	O
D. linguiforme	Thumb-nail orchid	R
Palmae		
Archontophoenix cunninghamiana	Bangalow palm	VC
Linospadix monostachyus	Midginbil	VC
Philesiaceae		
Geitonoplesium cymosum	Scrambling lily	R
Smilacaceae		
Ripogonum discolor	Two-tone supple-jack	R
R. elseganum	Rusty supple-jack	C
Zingiberaceae		
Alpinia caerulea	Wild ginger	O

APPENDIX A-2 SCLEROPHYLL FOREST, FRINGING WOODLAND, CLEARED AND DISTURBED VEGETATION SPECIES.

PTERIDOPHYTA		
Dennstaedtiaceae		
Pteridium esculentum	Bracken	VC
Sinopteridaceae		
Cheilanthes tenuifolia	Rockfern	VC
ANGIOSPERMAE-DICOTYLEDONS		
Amaranthaceae		
Alternanthera denticulata		O
Asclepiadaceae		
*Gomphocarpus physocarpus	Cotton bush	O
Campanulaceae		
Wahlenbergia sp.	Bluebells	VC
Caryophyllaceae		
Paronychia brasiliana	Chilean whitlow wort	C
*Silene anglica		C
Casuarinaceae		
Casuarina cunninghamiana	River oak	VC
C. luehmanii	Bull oak	R
C. torulosa	Forest oak	VC
Chenopodiaceae		
Rhagodia hastata		C

APPENDIX A-2 (cont'd)

Compositae (Asteraceae)		
Bidens pilosa	Cobbler's peg	C
**Cirsium vulgare*	Spear thistle	C
**Conyza canadensis*	Canadian fleabane	VC
**Gnaphalium luteo-album*	Jersey cudweed	C
Helichrysum apiculatum	Yellow buttons	VC
**Hypochoeris radicata*	Flatweed	VC
Senecio minimus		VC
Vernonia cinerea		C
Vittadinia triloba	Fuzzweed	C
Convolvulaceae		
Dichondra repens	Kidney weed	C
Epacridaceae		
Leucopogon juniperinus		C
Goodeniaceae		
Goodenia gracilis		O
Haloragidaceae		
Haloragis glauca		O
Labiateae		
Ajuga australis	Bugle	O
Malvaceae		
Sida rhombifolia	Paddy's lucerne	VC
Mimosaceae		
Acacia concurrens		O
A. floribunda		O
A. irrorata	Green wattle	VC
Moraceae		
Ficus coronata	Creek sandpaper fig	R
Myrtaceae		
Angophora floribunda	Rough barked apple	C
Callistemon viminalis	Drooping bottlebrush	VC
Eucalyptus acmenioides	Narrowleaf mahogany	C
E. amplifolia	Cabbage gum	O
E. andrewsii	New England blackbutt	VC
E. blakelyi	Red gum	O
E. campanulata	New England blackbutt	C
E. eugenoides	Thin leaved stringybark	C
E. globoidea	White stringybark	C
E. gummifera	Bloodwood	O
E. laevopinea	Silvertop stringybark	VC
E. maculata	Spotted gum	VC
E. melliodora	Yellow box	O
E. microcorys	Tallow wood	C
E. notabilis	Red mahogany	C
E. paniculata	Grey ironbark	C
E. propinqua	Grey gum	VC
E. punctata	Grey gum	VC
E. resinifera	Red mahogany	C
E. saligna	Sydney bluegum	VC

APPENDIX A-2 (cont'd)

Myrtaceae (cont'd)		
E. siderophloia	Red ironbark	C
E. tereticornis	Forest redgum	C
Leptospermum flavescens		VC
Melaleuca alternifolia		VC
Syzigium paniculatum	Brush cherry	C
Tristania conferta	Brush box	VC
T. laurina	Water gum	O
Oxalidaceae		
Oxalis corniculata	Yellow wood sorrel	C
Papilionaceae		
Desmodium varians	Slender tick-trefoil	C
D. brachypodium		C
Glycine clandestina	Twining glycine	C
Zornia dyctiocarpa		O
Plantaginaceae		
Plantago varia		C
Polygonaceae		
Polygonum aviculare	Wire weed	O
Rumex brownii	Swamp dock	C
Portulacaceae		
*Portulacca oleracea	Pigweed	C
Rosaceae		
*Rubus vulgaris	Blackberry	C
Santalaceae		
Exocarpos cupressiformis	Native cherry	C
Sterculiaceae		
Brachychiton populneum	Currajong	O
Thymelaeaceae		
Pimelia linifolia	Rice flower	C
Urticaceae		
Urtica incisa	Stinging nettle	C
Verbenaceae		
Verbena bonariensis	Purple top	VC
V. rigidus	Veined verbena	VC
ANGIOSPERMAE-MONOCOTYLEDONS		
Cyperaceae		
Carex inversa		C
C. longibrachiata		VC
Fimbristylis dichotoma		VC
Cyperus sp.	Sedge	C
Gramineae (Poaceae)		
Alloteropsis semiatata	Cockatoo grass	O
Aristida ramosa	Wire grass	VC

APPENDIX A-2 (cont'd)

*Axonopus affinis	Narrow leaved carpet grass	VC
A. compressus	Broad leaved carpet grass	R
Bothriochloa macra	Red-leg grass	VC
*Bromus unioloides	Prairie grass	C
Capillipedium spicigerum	Scented top grass	C
Cymbopogon refractus	Barbed wire grass	VC
Cynodon dactylon	Couch grass	VC
Danthonia caespitosa	Ringed wallaby grass	C
D. racemosa	Wallaby grass	C
Dichelachne micrantha	Short hair plume grass	C
Digitaria parviflora	Small flower finger grass	O
*D. sanguinalis	Summer grass	C
Echinopogon ovatus	Forest hedgehog grass	C
*Eleusine indica	Crab grass	C
Entolasia marginata	Margined panic grass	O
Eremochloa bimaculata	Poverty grass	VC
Eragrostis brownii	Brown's love grass	O
*E. curvula	African love grass	O
E. elongata	Clustered love grass	O
E. leptostachya	Paddock love grass	C
*Holcus lanatus	Yorkshire fog	O
*Hyparrhenia hirta		O
Imperata cylindrica	Blady grass	VC
Microlaena stipoides	Weeping grass	C
Panicum effusum	Hairy panic grass	O
P. simile	Two colour panic grass	O
*Paspalum dilatatum	Paspalum	VC
P. orbiculare	Ditch millet	O
Paspalidium radiatum		O
*Pennisetum clandestinum	Kikuyu grass	VC
Poa labillardieri	Tussock grass	C
P. sieberana	Tussock grass	VC
Sorghum leiocladum	Wild sorghum	VC
Sporobolus creber	Slender rat's tail	VC
S. diander	Tussock sporobolus	O
S. elongatus	Slender rat's tail	VC
Themeda australis	Kangaroo grass	VC
Commelinaceae		
Commelina cyanea		C
Murdannia graminea		C
Juncaceae		
Juncus subsecundus		VC
Liliaceae		
Tricoryne elatior		C
Xanthorrhoeaceae		
Lomandra spp. (2 species)		VC
Xanthorrhoea australis	Blackboy	VC
Xanthorrhoea sp.	Blackboy	VC

APPENDIX B-1

HERPETOFAUNA SPECIES CHECKLIST

Checklist of the regional vertebrate fauna. Compiled from the literature sources listed.

FROGS (Barker and Grigg, 1977; Cogger, 1979)

LEPTODACTYLIDAE (southern frogs, ground frogs)

Adelotus brevis

Limnodynastes dumerili dumerili
(Eastern banjo frog)

L. fletcheri
(Long-thumbed frog)

L. ornatus
(Ornate burrowing frog)

L. peroni
(Brown-striped frog)

L. salmini
(Salmon-striped frog)

L. tasmaniensis
(Spotted grass frog-northern call race)

L. terrareginae
(Northern banjo frog)

Mixiphyes iteratus
(Giant barred frog)

Mixophyes fasciolatus

Pseudophryne bibroni
(Bibron's toadlet)

Pseudophryne coriacea

Ranidella parinsignifera
(Froglet)

R. signifera
(Froglet)

Hylidae (Tree frogs)
Litoria booroolongensis
L. brevipalmata

L. caerulea
(Green tree frog)

L. dentata

APPENDIX B-1 (cont'd)

L. fallax
(Eastern dwarf tree frog)

L. glandulosa

L. latopalmata

L. lesueuri
(Lesueur's frog)

L. peroni
(Peron's tree frog)

L. phyllocroa

L. rubella
(Desert tree frog)

L. verreauxi
(Whistling tree frog)

Bufonidae (Toads)
Bufo marinus

REPTILES (Cogger, 1979)

CHELIDAE (Tortoises)

Chelodina longicollis
(Long-necked tortoise)

Emydura signata
(Murray turtle)

Emydura sp. No.1
(Undescribed)

Elseya latisternum
(Saw-shelled turtle)

GEKKONIDAE (Geckoes)

Diplodactylus vittatus
(Wood gecko)

Gehyra punctata
(Spotted dtella)

G. variegata
(Tree dtella)

Oedura lesueuri
(Lesueur's velvet gecko)

O. robusta
(Robust velvet gecko)

O. tryoni
(Southern spotted velvet gecko)

APPENDIX B-1 (cont'd)

Underwoodisaurus milii
(Thick-tailed or barking gecko)

PYGOPODIDAE (Legless lizards)

Delma inornata

D. tincta

Lialis burtonis

Pygopus lepidopodus

Agamidae (Dragon lizards)

Amphibolurus barbatus
(Bearded dragon)

A. muricatus
(Jacky lizard)

A. nobbi
(Nobbi)

Gonocephalus spinipes

Physignathus lesueuri
(Eastern water dragon)

VARANIDAE (Goannas, monitor lizards)

V. varius
(Lace monitor)

Scincidae (Skink lizards)

Anomalopus sp.

A. reticulatus

A. verreauxii

Carlia burnetti

C. tetradactyla

C. vivax

Cryptoblepharus boutonii

Ctenotus robustus

C. taeniolatus
(Copper-tailed skink)

Egernia cunninghami
(Cunningham's skink)

APPENDIX B-1 (cont'd)

E. frerei
(Gunther)

E. major
(Land mullet)

E. modesta
E. saxatilis
(Black rock skink)

E. striolata
(Tree skink)

E. whitii
(White's skink)

Hemiergis decresiensis

Lampropholis challengeri

L. delicata

L. guichenoti

Saiphos equalis

Sphenomorphus quoyi

Sphenomorphus murrayi
(Eastern water skink)

S. scutirostrum

S. tenuis

Tiliqua gerrardi
(Pink tongued lizard)

T. scincoides
(Eastern blue tongued lizard)

SNAKES

TYPHLOPIDAE (Worm snakes)

Typhlina affinis

T. broomi

T. nigrescens

T. proxima

T. wiedii

BOIDAE (Pythons)

Python spilotes
(Carpet snake)

APPENDIX B-1 (cont'd)

COLUBRIDAE (Rear-fanged snakes and tree snakes)

Amphiesma mairii
(Fresh water snake)

Boiga irregularis

Dendrelaphis punctulatus
(Common tree snake)

Elapidae (Front-fanged snakes)

Acanthophis antarcticus
(Death adder)

Cryptophis nigrescens
(Small-eyed snake)

Demansia psammophis
(Whip snake)

Furina diadema
(Red-naped snake)

Hemiaspis signata
(Black-bellied swamp snake)

Hoplocephalus bitorquatus
(Pale-headed snake)

H. stephensi
(Stephen's banded snake)

Notechis scutatus
(Tiger snake)

P. guttatus
(Spotted black snake)

P. porphyriachus
(Red-bellied black snake)

Pseudonaja textilis
(Eastern brown snake)

Simoselaps australis
(Coral snake)

Tropidechis carinatus

Unechis gouldi
(Black-headed snake)

Vermicella annulata
(Bandy-bandy)

APPENDIX B-2 AVIFAUNA SPECIES CHECKLIST

HABITAT

R = Rainforest
W = Wet sclerophyll forest
D = Dry sclerophyll forest
M = Modified
A = Aquatic

Nomenclature follows RAOU 1978 - 'Recommended English Names for Australian Birds' (Emu 77, Supplement).

STATUS

* = Introduced species
B = Breeding
M = Migratory
N = Nomadic
4 - 1 = Common to scarce

Tachybaptus novaehollandiae (Australasian Grebe)	A	NB	2
Pelecanus conspicillatus (Australian Pelican)	A	N	1
Anhinga melanogaster (Darter)	A	N	1
Phalacrocorax carbo (Great Cormorant)	A	N	2
P. varius Pied Cormorant	A	N	1
P. sulcirostris (Little Black Cormorant	A	N	2
P. melanoleucos (Little Pied Cormorant)	A	N	2
Ardea pacifica (Pacific Heron)	AM	N	2
A. novaehollandiae (White-faced Heron)	AM	NB	3
Ardeola ibis (Cattle Egret)	M (grassland)	N	1
Egretta alba (Great Egret)	A	N	2
E. garzetta (Little Egret)	A	N	1
E. intermedia (Intermediate Egret)	A	N	1

APPENDIX B-2 (cont'd)

Nycticorax caledoincus (Rufous Night Heron)	A	N	2
Dupetor flavicollis (Black Bittern)	A	B	1
Plegadis falcinellus (Glossy Ibis)	A	N	1
Threskiornis aethiopica (Sacred Ibis)	A	N	2
T. spinicollis (Straw-necked Ibis)	AM (Grassland)	N	2
Platalea regia (Royal Spoonbill)	A	N	2
P. flavipes (Yellow-billed Spoonbill)	A	N	2
Cygnus atratus (Black Swan)	A	N	1
Anas superciliosa (Pacific Black Duck)	A	NB	3
A. gibberifrons (Grey Teal)	A	NB	3
A. rhynchotis (Australasian Shoveler)	A	N	1
Aythya australis (Hardhead)	A	N	2
Chenonetta jubata (Maned Duck)	M (grassland)	NB	2
Elanus notatus (Black-shouldered Kite)	M	NB	2
Aviceda subs (Pacific Baza)	RWDM	B	1
Haliastur sphenurus (Whistling Kite)	M	NB	2
Accipiter fasciatus (Brown Goshawk)	RWDM	B	2
A. girrhocephalus (Collared Sparrowhawk)	RWDM	B	2
A. novaehollandiae (Grey Goshawk)	RWD	B	1

APPENDIX B-2 (cont'd)

Aquila audax (Wedge-tailed Eagle)	RWDM	B	2
Hieracetus morphnoides (Little Eagle)	DM	B	1
Falco peregrinus (Peregrine Falcon)	RWDM		1
F. longipennis (Australian Hobby)	M	B	1
F. berigora (Brown Falcon)	DM	B	2
F. cenchroides (Australian Kestrel)	DM	B	2
Alectura lathami (Australian Brush-turkey)	RW	B	2
Coturnix novaezelandiae (Stubble Quail)	M	NB	1
C. australis (Brown Quail)	M	B	2
Turnix varia (Painted Button-quail)	DM	B	3
Rallus pectoralis (Lewin's Rail)	A	B	1
R. philippensis (Buff-banded Rail)	A	B	1
Porzana pusilla (Baillon's Crake)	A	NB	1
P. fluminea (Australian Crake)	A	NB	1
P. tabuensis (Spotless Crake)	A	NB	1
Gallinule tenebrosa (Dusky Moorhen)	A	B	3
Porphyrio porphyrio (Purple Swamphen)	A	B	1
Fulica atra (Eurasian Coot)	A	NB	2
Vanellus miles (Masked Lapwing)	M (grassland)	B	3
V. tricolor (Banded Lapwing)	M (grassland)	NB	1

APPENDIX B-2 (cont'd)

Charadrius melanops (Black-fronted Plover)	A	B	1
Himantopus himantopus (Black-winged Stilt)	A	N	1
Gallinago hardwickii (Latham's Snipe)	A	M	2
Calidris acuminata (Sharp-tailed Sandpiper)	A	M	1
Chlidonias hybrida (Whiskered Tern)	A	N	1
Ptilinopus magnificus (Wompoo Fruit-dove)	RW	B	1
Lopholaimus antarcticus (Topknot Pigeon)	RWD	NB	2
Columba leucomela (White-headed Pigeon)	RW	NB	2
Macropygia amboinensis (Brown Cuckoo-dove)	RW	B	2
Geopelia placide (Peaceful Dove)	DM	B	3
G. humeralis (Bar-shouldered Dove)	M	B	1
Chalcophaps indica (Emerald Dove)	RWD	B	1
Phaps chalcoptera (Common Bronzewing)	DM	B	3
Ocyphaps lophotes (Crested Pigeon)	M	B	2
Leucosarcia melanoleuca (Wonga Pigeon)	RWD	B	3
Calyptorphnchus lathami (Glossy Black-Cockatoo)	WD	NB	2
C. funerens (yellow-tailed Black-Cockatoo)	RWDM	NB	2
Cacatua roseicapilla (Galah)	DM	NB	2
C. galerita (Sulphur-crested Cockatoo)	RWDM	N	2
Trichoglossus haematodus (Rainbow Lorikeet)	RWDM	NB	3

APPENDIX B-2 (cont'd)

T. chlorolepidotus (Scaly-breasted Lorikeet)	WDM	NB	2
Glossopsitta concinna (Musk Lorikeet)	DM	NB	1
G. pusilla (Little Lorikeet)	WDM	NB	3
Alisterus scapularis (Australian King-Parrot)	RWDM	B	3
Platycercus elegans (Crimson Rosella)	RWD	B	3
P. eximius (Eastern Rosella)	DM	B	3
Cuculus saturatus (Oriental Cuckoo)	RWD	M	1
C. pallidus (Pallid Cuckoo)	DM	MB	2
C. variolosus (Brush Cuckoo)	RWDM	MB	3
C. pyrrhophanus (Fan-tailed Cuckoo)	RWD	NB	3
Chrysococcyx basalis (Horsfield's Bronze-Cuckoo)	DM	NB	2
C. lucidus (Shining Bronze-Cuckoo)	RWDM	NB	3
C. malayanus (Little Bronze-Cuckoo)	M	MB	1
Endynamys scolopacea (Common Koel)	RWDM	MB	2
Scythrops novaehollandiae (Channel-billed Cuckoo)	RWDM	MB	2
Centropus phasianinus (Pheasant Conceal)	M (Rank veg.near water)	B	1
Ninox strenua (Powerful Owl)	RWD	B	1
N. novaesedandiae (Southern Boobook)	RWDM	B	3
Tyto alba (Barn Owl)	DM	B	3

APPENDIX B-2 (cont'd)

T. novaehollandiae (Masked Owl)	RWDM	B	1
T. tenebricosa (Sooty Owl)	RW	B	1
Podargus strigoides (Tawny Frogmouth)	WDM	B	3
Aegotheles cristatus (Australian Owlet-nightjar)	RWDM	B	3
Caprimulgus mystacalis (White-throated Nightjar)	DM	B	2
Hirundepus candacutus (White-throated Needletail)	(strictly aerial)	M	3
Apus pacificus (Fork-tailed Swift)	(strictly aerial)	M	1
Ceyx azurens (Azure Kingfisher)	A	B	2
Dacelo novaeguineae (Laughing Kookaburra)	RWDM	B	3
Halcyon sancta (Sacred Kingfisher)	WDM	MB	3
Merops ornatus (Rainbow Bee-eater)	DM	MB	3
Eurystomus orientalis (Dollarbird)	DM	MB	2
Pitta versicolor (Noisy Pitta)	RW	NB	1
Menura novaehollandiae (Superb Lyrebird)	RWD	B	3
Hirundo neoxena (Welcome Swallow)	RWDM	B	4
Cecripis nigricans (Tree Martin)	WDM	B	3
C. ariel (Fairy Martin)	M	MB	2
Anthus novaeseclandiae (Richard's Pipit)	M (grassland)	B	3
Coracine novaehollandiae (Black-faced Cuckoo-shrike)	WDM	B	4
C. papuensis (White bellied Cuckoo-shrike)	DM	B	2

APPENDIX B-2 (cont'd)

C. tenuirostris (Cicada bird)	WD	MB	2
Lalage sueurii (White-winged Triller)	DM	MB	2
L. leucomele (Varied Triller)	RW	B	1
Zoothera dauma (White's Thrush)	RWD	B	3
Petroica rosea (Rose Robin)	RWDM	NB	4
P. phoenicea (Flame Robin)	DM	B	2
P. multicolor (Scarlet Robin)	DM	B	2
Melanodryes cucullata (Hooded Robin)	DM	B	1
Eopsaltrie australis (Eastern Yellow Robin)	RWD	B	4
Microeca lencophaee (Jacky Winter)	DM	B	3
Tregellasie capoito (Pale-yellow Robin)	RW	B	2
Falcunculus frontatus (Crested Shrike-tit)	RWD	B	3
Pachycephale pectoralis (Golden Whistler)	RWDM	NB	4
P. rufiventris (Rufous Whistler)	DM	MB	4
Colluricincla harmonica (Grey Shrike-thrush)	RWD	B	4
Monarche melanopsis (Black-faced Monarch)	RWD	MB	3
Monarche frivirgatus (Spectacled Monarch)	RW	MB	1
Myiagra ribecula (Leaden Flycatcher)	WD	MB	4
M. cyanoleuca (Satin Flycatcher)	D	MB	2
M. inquieta (Restless Flycatcher)	DM	B	3

APPENDIX B-2 (cont'd)

Rhipidura rufifrens (Rufous Fantail)	RWD	MB	3
R. fuliginosa (Grey Fantail)	RWDM	B	4
R. leucophrys (Willie Wagtail)	DM	B	4
Psophodes olivacens (Eastern Whipbird)	RWD	B	3
Cinclosome punctatum (Spotted Quail-thrush)	D	B	2
Pomatostomus temporalis (Grey-crowned Babbler)	DM	B	1
Acrocephalus stentoreus (Clamorous Reed-Warbler)	Reeds and adjacent shrubbery	MB	1
Megalurus graminens (Little Grassbird)	Reeds and tall sedges	NB	1
Cinclorhamphus mathewsi (Rufous Songlark)	DM	MB	2
Malurus cyaneus (Superb Fairy-wren)	DM	B	4
M. lamberti (Variegated Fairy-wren)	DM	B	3
M. melanocephalus (Red-backed Fairy-wren)	M	B	1
Stipiturus malachurus (Southern Emu-wren)	M Rank vegetation near water	B	1
Sericornis magnirostris (Large billed Scrub-wren)	RW	B	3
S. citreogularis (Yellow throated Scrub-wren)	RW	B	3
S. frontalis (White-browed Scrub-wren)	RWD	B	4
S. pyrohopygius (Chestnut-rumped Hylacola)	D	B	1
S. sagittatus (Speckled Warbler)	DM	B	2
Smicrormis brevirostris (Weebill)	DM	B	1

APPENDIX B-2 (cont'd)

Gerygone mouki (Brown Gerygone)	RWD	B	4
G. olivacea (White-throated Gerygone)	DM	MB	4
Acanthiza pusilla (Brown Thornbill)	RWD	B	4
A. reguloides (Buff-rumped Thornbill)	DM	B	4
A. chrysorrhoa (Yellow-rumped Thornbill)	M	B	4
A. nana (Yellow Thornbill)	RWDM	B	4
A. lineata (Striated Thornbill)	WDM	B	4
Daphoenositta chrysoptera (Varied Sittella)	WDM	B	4
Climacteris leucophaea (White-throated Treecreeper)	RWD	B	4
C. erythrops (Red-browed Treecreeper)	WD	B	3
C. picumnus (Brown Treecreeper)	DM	B	2
Anthochaera carunculata (Red Wattlebird)	WDM	NB	3
A. chrysoptera (Little Wattlebird)	WD	N	1
Phileman corriculatus (Noisy Friarbird)	WDM	NB	4
P. citreogularis (Little Friarbird)	DM	N	2
Xanthomyza phrygia (Regent Honeyeater)	DM	NB	1
Entomyzon cyanotis (Blue-faced Honeyeater)	DM	NB	2
Manorina melanophrys (Bell Miner)	WD	B	2
M. melanocephela (Noisy Miner)	DM	B	4
Meliphaga lewinii (Lewin's Honeyeater)	RWD	B	4

APPENDIX B-2 (cont'd)

Lichenostomus chrysops (Yellow-faced Honeyeater)	WDM	NB	4
L. leucotis (White-eared Honeyeater)	DM	B	2
L. melanops (Yellow-tufted Honeyeater)	WD	B	2
L. fuscus (Fuscons Honeyeater)	DM	B	2
L. penicillatus (White-plumed Honeyeater)	DM	B	1
Mellithreptus gularis (Black-chinned Honeyeater)	DM	B	1
M. brevirostris (Brown-headed Honeyeater)	DM	B	2
M. albogularis (White-throated Honeyeater)	DM	B	1
M. lunatus (White-naped Honeyeater)	WDM	NB	4
Lichmera indistincta (Brown Honeyeater)	DM	NB	2
Phylidomyris novaehollandiae (New Holland Honeyeater)	WD	NB	2
Acanthorhynchus tenuirostris (Eastern Spinebill)	RWDM	B	4
Myzomela sangninolenta (Scarlet Honeyeater)	RWDM	NB	3
Dicaeum hirundinaceum (Mistletoebird)	RWDM	NB	4
Pardalotus punctatus (Spotted Pardalote)	WD	B	4
P. striatus (Striated Pardalote)	WDM	B	2
Zosterops lateralis (Silvereye)	RWDM	NB	4
Carduelis carduelis (European Goldfinch)*	M	B	1
Passer domesticus (House Sparrow)*	M	B	4
Embleme temporalis (Red-browed Firetail)	RWDM	B	4

APPENDIX B-2 (cont'd)

Poephila bicherovii (Double-barred Finch)	DM	B	3
Lonchura castaneotherax (Chestnut-breasted Mannikan)	M	NB	1
Sturnus vulgaris (Common Starling)*	M	B	4
Oriolus sagittatus (Olive-backed Oride)	WDM	B	3
Sphecotheses viridis (Figbird)	RWDM	N	1
Dicrurus hottentottus (Spangled Drongo)	WDM	N	1
Ptilinorhynchus violaceus (Satin Bowerbird)	RWDM	B	3
Ailuroedus crassirostris (Green Catbird)	RW	B	2
Ptiloris paradisens (Paradise Riflebird)	RWD	B	1
Corcorax melanophomphos (Whitewinged Chough)	DM	B	2
Grallina cyanolenca (Australian Magpie-lark)	M	B	4
Artamus leucorpynchus (White-breasted Woodswallow)	M	MB	1
A. superciliosus (White-browed Woodswallow)	DM	NB	1
A. cyanopterus (Dusky Woodswallow)	DM	MB	3
Croeticus torquatus (Grey Butcherbird)	DM	B	3
C. nigrogularis (Pied Butcherbird)	DM	B	3
Gymnorhine tibicen (Australian Magpie)	M	B	4
Strepere graculine (Pied Currawong)	RWDM	B	4
Corvus coronoides (Australian Raven)	DM	B	3
C. orru (Torresian Crow)	DM	B	3

APPENDIC B-3 MAMMAL SPECIES CHECKLIST

Mammals occurring in study area
* Recorded by Felix Schlager during 18 month 1978-1981 Study
** On endangered species list
+ 'Pademelons' recorded by locals in rainforest

	Comments
TACHYGLOSSIDAE	
Tachyglossus aculeatus (Shaw) (Echidna)	common
ORNITHORHYNCHIDAE	
Ornithorhynchus anatinus (Shaw) (Platypus)	probably occurs
DASYURIDAE	
Antechinus swainsonii (Waterhouse) (Swainson's marsupial mouse)	possibly occurs
Antechinus flavipes (Waterhouse) (Yellow-footed marsupial mouse)	probably occurs
Antechinus stuartii (Macleay)* (Brown marsupial mouse)	couple of cat kills; seen in Girard State forest.
Antechinus maculatus (Gould) (Pigmy marsupial mouse)	possibly occurs
Phascogale tapoatafa (Meyer)* (Brush-tailed phascogale)	two cat kills and two others found dead
Sminthopsis murina (Waterhouse)* (Common marsupial mouse)	one cat kill and one trapped.
Dasyurus maculatus (Kerr)* (Tiger cat)	couple seen, road kills in Girard State Forest
Dasyurus viverrinus (Shaw)** (Eastern native cat)	possibly occurs
PERAMELIDAE	
Perameles nasuta (Geoffroy)* (Long-nosed bandicoot)	one cat kill
Isoodon macrourus (Gould)* (Brindled bandicoot)	two seen
PHASCOLARCTIDAE	
Phascolarctus cinereus (Goldfuss) (Koala)	recorded by locals
BURRAMYIDAE	
Acrobates pygamaeus (Shaw)* (Pigmy glider)	one cat kill
PETAURIDAE	
Petaurus breviceps (Waterhouse)* (Sugar glider)	occurs in Girard State Forest
Petaurus norfolcensis (Kerr) (Squirrel glider)	probably occurs
Petaurus australis (Shaw)* (Yellow-bellied glider)	one seen on Cheviot Hills
Schoinobates volans (Kerr)* (Greater glider)	

APPENDIX B-3 (cont'd)

Pseudocheirus peregrinus (Boddert) (Ringtail possum)	probably occurs
PHALANGERIDAE	
Trichosurus vulpecula (Kerr)* (Brush-tailed possum)	very common throughout
Trichosurus caninus (Ogilby) (Mountain possum)	probably occurs
MACROPODIDAE	
Aepyprymnus rufescens (Gray)* (Rufous rat kangaroo)	common particularly in dry sclerophyll forest
Macropus giganteus (Shaw)* (Grey kangaroo)	common
Macropus robustus (Gould)* (Wallaroo)	Common on Cheviot Hills
Macropus parma (Waterhouse) (Parma wallaby)	possibly occurs
Macropus parryi (Bennett)* (Whiptail wallaby)	common
Macropus dorsalis* (Black-striped wallaby)	common in Girard State Forest
Macropus rufogriseus (Desmarest)* (Red-necked wallaby)	common throughout
Wallabia bicolor (Desmarest) (Swamp wallaby)	becoming more common according to locals
Thylogale thetis (Lesson)+ (Red-necked pademelon)	probably occurs
Thylogale stigmatica (Gould)+ (Red-legged pademelon)	possibly occurs
Petrogale penicillata (Griffith) (Rock wallaby)	possible but unlikely
OTHER	
Bats (unknown)	common occasionally
Lepus europaeus (hare)*	seen on open pasture
Oryctolagus cuniculus (rabbit)*	uncommon
Canis familiaris dingo (dingo)*	common
Vulpes vulpes (fox)*	only one seen in 18 mths
Felis catus L. (feral cat)*	couple seen in 18 mths

APPENDIC C WATER ANALYSES

SGS Australia Pty. Ltd.

NEW SOUTH WALES
74 McEvoy St., Alexandria, Sydney, N.S.W. 2015
Telephone 699 7625 Telex: SGSSYD AA22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park
Telephone 458 1421 Telex: SGSPTH AA92624

NATURAL SYSTEMS RESEARCH PTY L
BRASCOM HOUSE
25 BURWOOD ROAD
HAWTHORN - MELBOURNE _ VIC. 312

Our ref LA 9189/Unfiltered Samples

Your ref

Date received 6/ 2/81

Date completed 27/ 2/81

Issued at SYDNEY

27TH FEBRUARY, 1981

RECEIVED 2 MAR 1981

ANALYTICAL REPORT

	Sample Ref.	µg/L Cu	µg/L Pb	µg/L Zn	µg/L Cd	µg/L As	µg/L Ag	µg/L Au	mg/L SS	mg/L SO_4	
1	1	17	0.8	240	1.1	2.0	1.5	< 1	36	23	
2	2	3.8	0.5	7.8	0.22	1.0	0.4	< 1	18	10	
3	3	0.26 *	0.9	1.56 *	39	2.0	1.5	< 1	27	93	
4	4	4.05 *	2.2	23.2 *	150	60	7.8	< 1	14	1430	
5	5	0.96 *	1.8	3.05 *	37	10	2.9	< 1	12	285	
6	7	9.0	0.5	16	0.25	< 1.0	2.1	< 1	93	14	
7	8	29	1.9	15.4 *	35	5.0	1.2	< 1	10	135	
8	9	15	1.2	20	0.54	< 1.0	1.8	< 1	20	45	
9	10	7.8	0.3	20	0.22	< 1.0	0.7	< 1	16	26	
10	12	70	0.8	126	2.4	< 1.0	0.6	< 1	13	40	
11	13	11.5	0.5	20	0.35	< 1.0	0.6	< 1	20	15	
12	14	39	0.4	30	0.32	1.0	1.1	< 1	15	30	
13	15	11	0.4	3.4	1.1	1.0	0.1	< 1	64	24	
14	16	58	1.7	51	1.65	< 1.0	2.6	< 1	21	31	
15	17	31	1.3	18	1.4	< 1.0	0.9	< 1	5	3	
16	18	5.5	0.2	19	0.19	< 1.0	1.1	< 1	2	48	
17	19	9.2	0.5	21	0.35	< 1.0	0.6	< 1	8	53	
18	21	46	35	21.0 *	46	2.0	10.5	< 1	50	163	
19	NB. Please note * mg/L										
20											

SGS Australia Pty. Ltd.

NEW SOUTH WALES
74 McEvoy St., Alexandria, Sydney, N.S.W. 2015
Telephone 699 7625 Telex: SGSSYD AA22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park
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Page . 2 ..

NATURAL SYSTEMS RESEARCH PTY LIMITED

Our ref LA 9189/ Filtered Sample

Your ref

Date received 6/2/81

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Issued at SYDNEY

ANALYTICAL REPORT

	Sample Ref.	µg/L Cu	µg/L Pb	µg/L Zn	µg/L Cd	µg/L As	mg/L SO_4			
1	1 F	19	1.1	210	1.0	1.5	20			
2	2 F	4.4	0.5	8.0	0.26	1.0	22			
3	3 F	0.25*	0.9	1.53*	39	2.0	95			
4	4 F	4.37*	2.3	25.9*	150	62	1592			
5	5 F	0.90*	2.0	2.95*	38	1.0	265			
6	7 F	14	0.6	18	0.26	< 1.0	14			
7	8 F	32	2.1	13.8*	35	1.0	139			
8	9 F	9.0	0.3	20	0.56	< 1.0	15			
9	10 F	10.5	0.8	18	0.26	1.0	24			
10	12 F	72	0.8	125	2.2	1.0	30			
11	13 F	4.8	0.2	12	0.21	< 1.0	14			
12	14 F	46	0.9	32	0.31	1.0	16			
13	15 F	11.0	0.3	16	0.29	< 1.0	25			
14	16 F	41	0.6	50	0.45	< 1.0	13			
15	17 F	6.3	0.3	12	0.22	< 1.0	4			
16	18 F	6.0	0.5	18	0.24	< 1.0	27			
17	19 F	7.1	0.6	25	0.26	< 1.0	39			
18	21 F	41	30	21.0*	46	2.0	150			
19										
20	NB Please note * mg/L									

ABERFOYLE LTD

Preliminary environmental survey, Drake prospect, N.S.W. : vegetation, fauna, water quality, archaeology

APPENDIX D

PRINCIPAL MINERAL DEPOSITS AT DRAKE

Lady Hampden	Au, Ag, Pb, Zn
Strausses Open Cut	Ag, Au, Pb, Zn, Cu
Kylo	Au, Cu, Zn
Gladstone	Au, Cu, Zn
All Nations	Au, Cu, Zn
Lady Mary Extended	Au, Cu, Zn
Mount Carrington	Cu, Zn
Perserverence	Cu, Zn
Rainbow	Cu, Zn
Pioneer	Au, Cu, Zn
Silver King	Ag, Au, Cu, Zn
Border Chief	Au
White Rock	Ag, Pb, Zn, Au
Kelleys Silver Reef	Ag
Adeline	Au, Cu, Zn
Mascotte	Au, Ag
Golden Drake	Au, Ag
Lady Jersey	Au
White Rock West	Ag, Pb, Zn, Au

Source: Herbert, H.K. (1977) *in* Lea, D.A.M., Pigram, J.J. & Greenwood, L. (eds). *An Atlas of New England*. Dept. Geog., Univ. New England.