DEWATERING AND DEPRESSURISATION STUDIES FOR DEVELOPMENT OF THE LOCHIEL OPEN PIT MINE, SOUTH AUSTRALIA

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ABSTRACT

The Lochiel Lignite Deposit in South Australia is being evaluated as a possible fuel source for a 1000 MW power station. The deposit lies in a semi-isolated Tertiary basinal sequence which is characterised by unconsolidated overburden containing a multi-aquifer system subject to excess artesian groundwater heads of 20 m. These conditions represent a particularly difficult environment for open cut mine development and studies have shown that gradual depressurisation of the fine grained overburden units, in addition to dewatering of the major aquifers, will be required to maintain dry and efficient working conditions as well as to promote pit stability.

Trial depressurisation bores have been installed, operated and monitored over periods of up to 3 months to provide field confirmation of the feasibility of depressurising fine grained overburden units within a realistic timescale. These trial bores, consisting of wells screened in the major basal aquifer and filter packed over their full length to promote depressurisation through minor aquifer zones, were pumped at rates up to 35 l/sec and achieved average dissipation of up to 35% within 30 days.

These results have been used to develop the preliminary design of a combined groundwater control system for the Lochiel Deposit which will dewater the major aquifer zones and sufficiently depressurise the overburden to permit dragline mining under efficient and economical conditions.

1.0 INTRODUCTION

The Electricity Trust of South Australia (ETSA) is currently involved in evaluating four coal deposits as potential fuel sources for a 1000 MW thermal station to supply the S.A. power grid over a projected life of 35 to 39 years. The Lochiel Deposit, located 130 km north north west of Adelaide (Figure 1) contains geological reserves of 570 M tonnes of Lignite B (ASTM) or Soft Brown Class 15 (ISO). Supply to the power station from Lochiel would require the winning of 235 Mt run of mine coal from the multiseam deposit by open cut mining. Following discovery of the Lochiel

Deposit by ETSA in 1982, feasibility level studies were completed in 1983 and detailed mine planning and cost estimating were carried out in 1984.

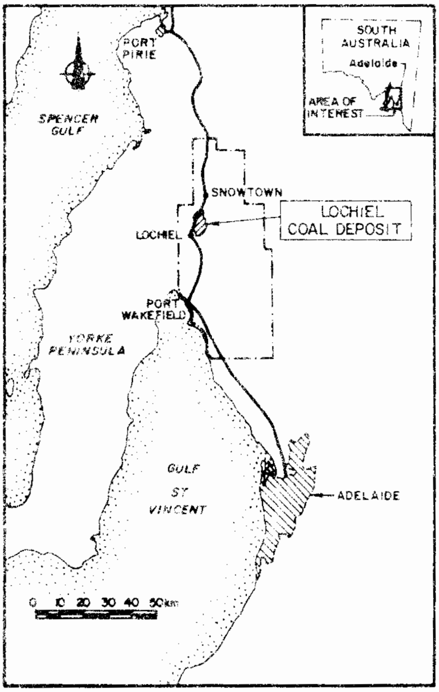

FIGURE 1 - LOCATION PLAN

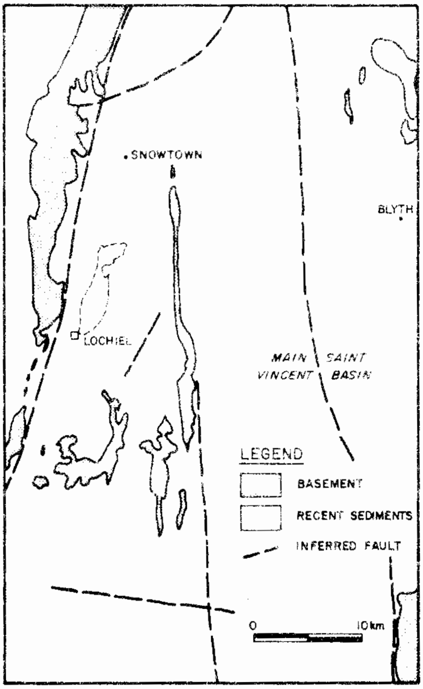

FIGURE 2 - REGIONAL GEOLOGY

The deposit lies within a semi-isolated Tertiary basinal sequence which fills a north-south elongated valley extending northwards from the Lochiel township. The sediments are part of a much larger structure called the Northern St. Vincent Basin which contains other deposits south and east of Lochiel and was formed by tectonic movement of the Proterozoic and Palaeozoic basement with deposition of marine and non-marine sediments.

The Lochiel Deposit has many of the characteristics of isolated basinal deposits [1] which pose particular problems for the mine development of an open cut mine including unconsolidated sediments containing a multi-aquifer sequence subject to highly artesian groundwater conditions. This paper describes the hydrogeological conditions encountered at Lochiel and their impact, with geotechnical factors, on the development of a safe and economic mining strategy for the Lochiel Lignite Deposit. In this regard the Lochiel Deposit represents a particularly difficult mining environment in which it has been necessary to carry out hydrological and geotechnical studies to a degree of sophistication that is rarely, if ever, contemplated in the development of open pit mines. However, in the authors' experience, Lochiel is likely to be the forerunner to an emerging trend for development of open pit mines in difficult ground and water conditions.

Other instances of mines for which similar levels of investigation might also be required are the Ohinewai Prospect and the South Island Lignite

Deposits of New Zealand, some of the isolated basinal deposits in northern and southern Thailand and the oil shale deposits of eastern Australia.

2.0 DESCRIPTION OF LOCHIEL DEPOSIT

2.1 Location and Topography

The Lochiel Deposit occurs within a narrow elongate valley bounded on the east and west and partly along the south by outcropping rocks (Figure 2). The outcropping rocks comprise a series of ranges which rise to heights of 200 m to 350 m above the valley. The valley opens to the north and north east and joins the northern extension of the Adelaide Plains.

The valley floor is gently undulating and dominated by Lake Bumbunga, a large salt lake elongated along the valley axis with an elevation of approximately 76 m. Numerous small salt pans also occur throughout the valley. The valley floor is a recent alluvial or aeolian plain with gypsum dunes up to 20 m high along the eastern margin of Lake Bumbunga.

2.2 Climate and Surface Hydrology

Lochiel lies within a semi arid area with average annual rainfall of 380 mm and monthly maximum of 46 mm in August and 15 mm in February. Maximum and minimum temperatures are 31 to 14^{o} in summer and 15 to 4^{o} in winter.

The deposit occurs within a closed drainage basin within which Lake Bumbunga is the major terminal lake. Surface drainage is internal towards the various salt pans and Lake Bumbunga. There are few well defined drainage lines and there are no perennial streams in the catchment, although a few small springs and seepages occur, both along the shore of Lake Bumbunga and in the ranges to the west. Any ephemeral surface flows which reach the terminal lakes are infrequent and irregular.

2.3 Regional Geology

The deposit is approximately 12 km long by 5 km wide and consists of a sequence of Tertiary to Quaternary soils and lignites which have been laid down in a small sub-basin formed by block faulting within the Pre-Cambrian and Palaezoic basement rocks. The faults form part of the regional north-south trending system which defines the major St. Vincent's Coalfield.

The general stratigraphic profile consists of some 30 to 55 m of clay, silt and sand overlying three main lignite seams. The overburden is of soil strength and ranges from very stiff and fissured clays to stiff, massive silts and cohesionless silts and sands.

In the north of the valley (just to the north of Lake Bumbunga) the lignite seams die out and the overlying fine grained sequence is replaced by fluvial sands. These sands, together with the basal aquifer, comprise a major relict fluvial channel system which extends well to the north and which connects around the northern end of the eastern basement ridge with the main St. Vincent Basin.

2.4 Overburden Geology

A generalised stratigraphic column of the deposit sediments is presented in Figure 3. The overburden can be broadly classified into the upper Quaternary sequence and the silty, sandy and carbonaceous Tertiary sequence. Overall the sediments comprise a fining up series with a thick basal sand grading upwards through the lignite zone to the thick overlying clay layer. The Quaternary sequence is made up essentially of clay/sandy clay with the dominant units being the Hindmarsh Clay and Nyowee Beds which are both present throughout the proposed mining areas. The Tarama Beds and Maro Creek Sands are minor units and generally occur to the west of Lake Bumbunga and the Gypsum Hill Beds to the east. The Tertiary sequence is comprised of the Tarella and Warrindi Silts. The silts are typically dark brown to black, carbonaceous and clayey although a major facies change to silty carbonaceous sand occurs in the Warrindi Silt to the southern, eastern and western margins of the deposit. Interspersed through those silts are numerous thin laminations and beds of clean sand and silt.

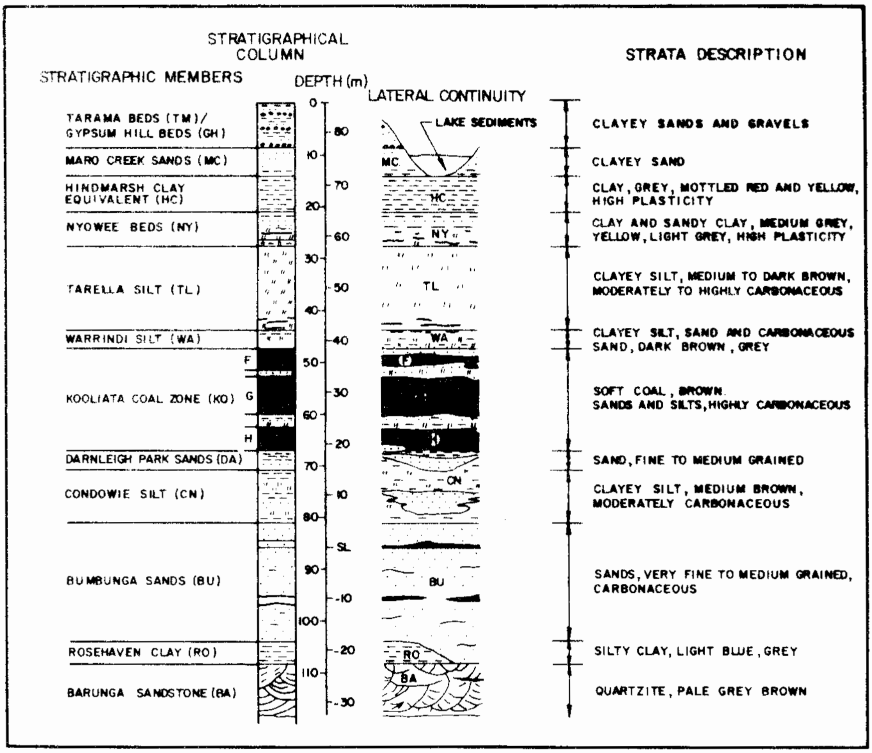

FIGURE 3 - TYPICAL STRATIGRAPHIC COLUMN

2.5 Coal, Interburden, Partings and Coal Quality

The margin of the depositional basin which contains the Lochiel Coal Deposit is confined to the south, east and west by outcrops of basement quartzite and to the north by a facies change from coal to sand. Coal accumulation was controlled by the subsidence of the basement with the centre of sediment deposition located approximately at the northern end of Lake Bumbunga.

Within the resource area the Kooliata Zone has an average thickness of 20 m and contains three correlatable coal bearing intervals separated by well defined interbeds of sand, silt and clay. These intervals have been informally named the F, G and H zones. The F-G interburden is generally sandy while the G-H interburden is composed primarily of sandy silt. For the chosen mining area the geological strip ratio varies between 4 and 6. Insitu geological reserves are 562 million tonnes in the measured and indicated categories as at November 1984. Average coal quality data (dry basis) for insitu geological reserves for the three seams are - Ash 15.1%, moisture 61.5%, sulphur 2.89%, sodium 0.95%, chlorine 0.48% and specific energy 23.4%.

2.6 Floor and Basement Geology

The immediate working floor is the basal section of the Kooliata Coal Zone. This material is generally a highly carbonaceous silty sand or sandy silt. Immediately below the coal zone, which is replaced to the north of Lake Bumbunga by the Darnleigh Park Sands, is the Condowie Silt. The Bumbunga Sands directly overlie basement and consist of fine to medium grained clean sands and carbonaceous silty sands.

Two types of basement have been intersected beneath the Lochiel Deposit. Firstly, the Rosehaven Clay which is typically a light blue grey silty clay and secondly the Proterozoic ABC Range.

2.7 Regional Hydrogeology

Groundwater in the Lochiel-Snowtown area occurs in a complex system of leaky, confined aquifers within the Tertiary sediments and as a largely unconfined system in the surrounding basement rocks.

The Bumbunga Sands, which underlie the coal seams, comprise up to 30 m of fine to medium grained sand and are the major aquifer. Some thinner sand aquifers occur within the sequence, however, they are generally of restricted areal extent. Minor thin, discontinuous, confined aquifers also occur within the near surface units. To the north of the deposit the basal aquifer system is extensive and continuous and the upper sand aquifers appear to be in hydraulic continuity with this system.

2.8 Groundwater Flow and Recharge

Groundwater flow through the deposit occurs from the north towards the south and south-east. A similar flow direction is evident in the main St. Vincent Basin to the east of the basement ridge. A groundwater divide has been identified near Snowtown to the north of which groundwater flow may be either to the north or may swing around to join the southerly flow of groundwater in the main part of the St. Vincent Basin.

Groundwater recharge takes place in the Hummock and Barunga Ranges by infiltration of both winter rain and gully runoff into the aquifers in the quartzite basement rocks. In the ranges these aquifers have higher potentiometric levels than the aquifers in the basin and can discharge into the basin aquifers along the faulted basin margin. The generally high salinities, even in the ranges where recharge probably occurs, is indicative of very low rates of recharge as would be expected from the climate and topography.

3.0 EXPLORATION AND EVALUATION OF THE LOCHIEL DEPOSIT

3.1 Exploration History

Initial exploration activity was in the Port Wakefield area and centred around the Bowmans Deposit where 1600 million tonnes of coal had been delineated. However, combustion testing of coal recovered from an open pit trial mine [2] proved the deposit was unsuitable. Hence, in 1981 a major regional programme was initiated and this led to the discovery of the Lochiel Coal Deposit in 1982.

3.2 Deposit Evaluation

As of July 1984 exploration and development work in the Lochiel area has comprised 499 holes at 297 different sites. These include 18 fully or partially cored 100 mm diameter holes for geotechnical and hydrological studies. Large diameter (1000 mm) coring programmes were undertaken in late 1982 and late 1984 to obtain bulk samples for combustion testing.

All holes were drilled by standard rotary techniques using a range of muds for hole stabilisation. Despite poor drilling conditions virtually all holes were geophysically logged for gamma gamma density, caliper, natural gamma, neutron, self potential and resistance. Stratigraphic correlation, coal thicknesses and general interpretation have largely been based on geophysical logs and core data but cuttings samples were used occasionally to cross check other data.

3.3 Mining Related Studies

Pre-feasibility level mining studies were carried out in late 1982 based on two fully cored geotechnical bores and 3 groundwater holes in which airlift, flow recession and pressure recovery tests were carried out. The initial mining strategy comprised excavation by draglines with overall highwall slopes of 30 to 35^{o}, inpit dumping at 20 to 25^{o} and with provision of an extensive deep well dewatering system in the major basal aquifer [3].

In 1983 an additional two fully cored holes were drilled and tested to review and further investigate geotechnical parameters required for mine design. In this study [4], highwall and spoil pile design parameters were reduced to such an extent that dragline rehandle quantities became prohibitive and required a revised and more costly mining strategy based on bucketwheel excavators.

In a separate, independent review of geotechnical and groundwater conditions, it was established that satisfactory dragline mining conditions could be achieved provided that a properly designed dewatering system was installed at least 12 months in advance of excavation. The rationale for this operation was that excess artesian pressures within the unconsolidated overburden would be sufficiently relieved by making use of the drainage effects associated with minor aquifer zones within the overburden and lignite units. On this basis, mine design parameters corresponding to overall highwall slopes up to 35^{o} and inpit spoil dumps up to 30^{o} were adopted for the dragline mining configuration [5].

In mid 1983 additional hydrogeological work was carried out to confirm this assessment and thus to establish the technical feasibility of the deposit as an open pit dragline mine. This work involved the installation of piezometers and a pumped drainage well to demonstrate the practicality of depressurising the overburden. However, it is important to note that the technical feasibility of dragline mining with depressurisation was established on the basis of laboratory geotechnical testing alone without the benefit of large scale field trials.

Extensive geotechnical and hydrogeological investigations were carried out during 1984 into the main areas which are listed below:

- regional hydrogeology including initially 49 observation bores into major aquifers at the deposit and surrounding areas with airlift, flow recession and pressure recovery;
- mine site hydrogeology including six multi-stage drawdown and 72 hour pumping tests;
- laboratory testing of core samples from 7 fully cored 100 mm diameter holes for geotechnical purposes;
- 2 fully cored angle holes to determine the orientation of jointing within the deposit and 3 fully cored bores (100 mm diameter) drilled close to an existing borehole to evaluate clay seams within the sediments;
- testing with a self boring pressuremeter at 3 sites to determine the insitu stress conditions, deformation parameters and insitu shear strength;
- installation of 2 additional trial depressurisation sites, including extensometers, pneumatic piezometers, conventional piezometers, water wells, surface settlement points.

These studies form an important part of the detailed mine planning studies being undertaken by ETSA.

4.0 MINE SITE HYDROGEOLOGY

4.1 Aquifer Characteristics

There are six aquifers in the Lochiel Deposit significant enough to require specific dewatering requirements. They are, in order of descending depth:

- Tarella
- Warrindi
- F-G Interburden
- G-H Interburden
- Darnleigh Park Sand
- Bumbunga Sand

Of these the first five will either be exposed in the mine highwall or just below the floor, while the Bumbunga Sand occurs at a depth below the floor of the proposed mine.

A summary of results from the pump testing is presented in Table 1. The aquifers are generally comprised of fine to medium grained sand except for Bumbunga Sand which becomes medium to coarse to the north of Lake Bumbunga and the southern section of the Warrindi which is generally fine grained (coarse silt to fine sand) and laterally variable. The distribution of the main aquifers is shown diagrammatically in Figures 4 and 5.

TABLE 1
SUMMARY OF PUMP TEST RESULTS

Aquifer	Transmissivity (m^2/day)		Hydraulic Conductivity (m/day)	
	Minimum	Maximum	Minimum	Maximum
Tarella	10	36	2.5	6.0
Warrindi	6	62	0.6	6.2
F-G Interburden	6.6	9.2	4.4	6.1
Bumbunga Sand	37	256	1.2	28.4

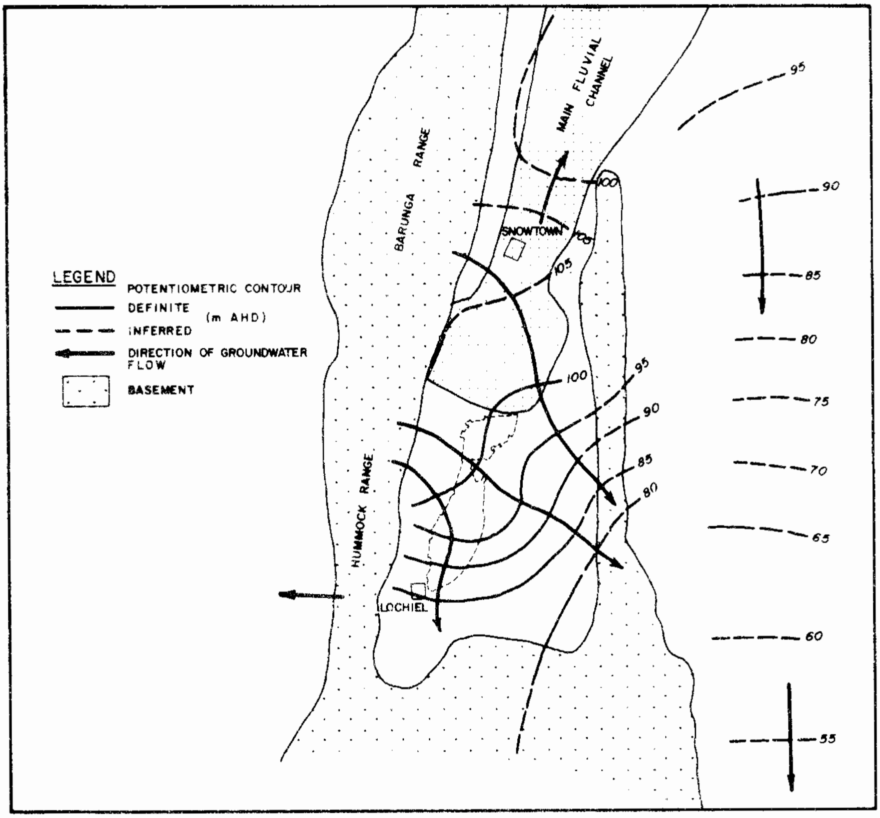

FIGURE 4 - GROUNDWATER FLOW AND RECHARGE SYSTEM

4.2 Groundwater Flow and Artesian Pressures

Potentiometric data for all aquifers within the deposit and vertical pressure profiles for some sites show that groundwater flow through the mine area occurs from the north-west towards the south-east. This is shown

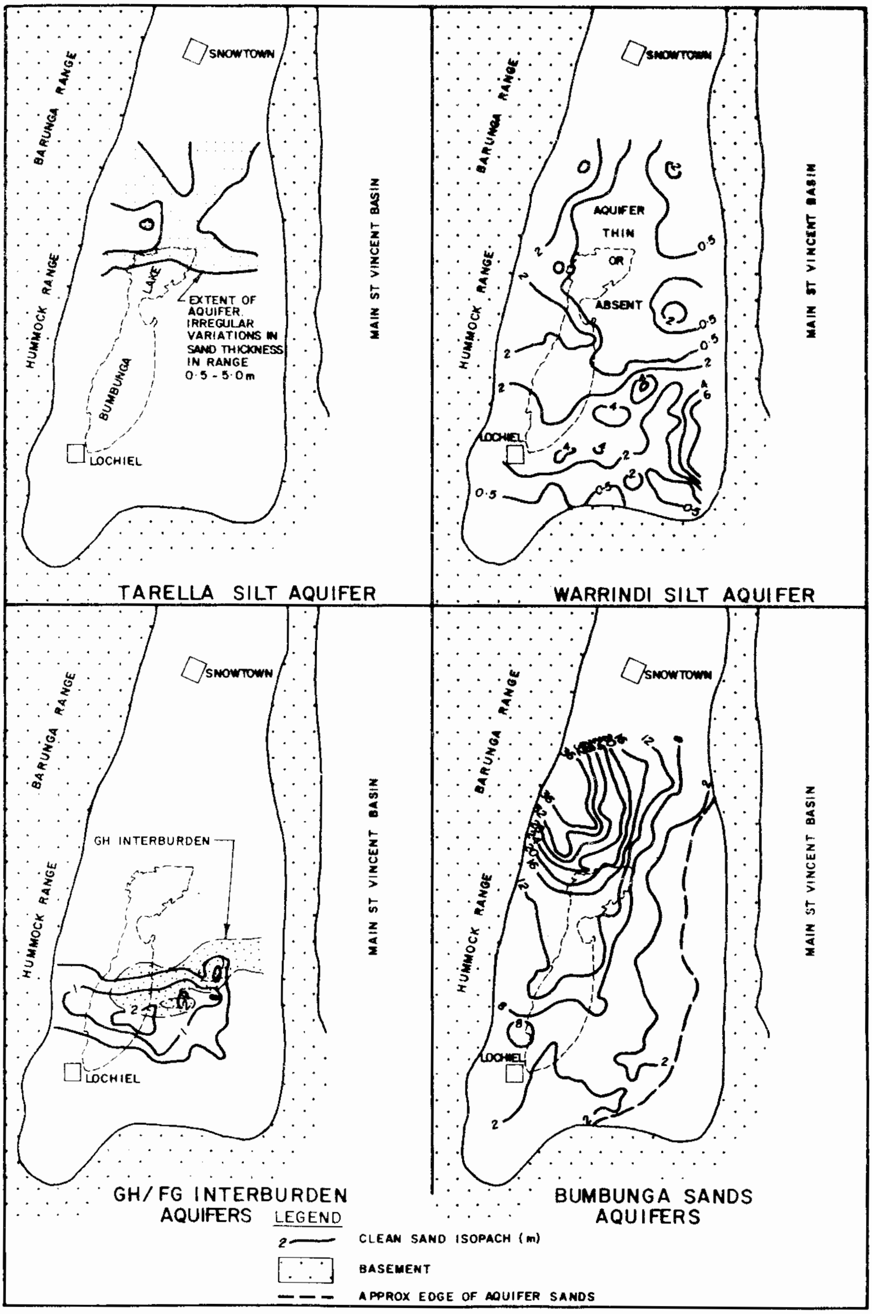

FIGURE 5 - DISTRIBUTION OF MAIN AQUIFER UNITS

best by potentiometric contours and groundwater flow lines for the Bumbunga Sand aquifer (Figure 4). Some groundwater discharge must occur vertically through the Hindmarsh Clay but considering both its low permeability and the groundwater gradient throughout the basin it seems likely that a large proportion of the groundwater flow discharges through the eastern and, maybe, southern basement ranges into the main part of the St. Vincent Basin. The main basin has groundwater levels 20 to 30 m lower than those near Lochiel.

Monitoring of groundwater pressures has shown that a net upward flow of groundwater occurs over the full depth of the deposit. The major basal aquifer is subjected to artesian groundwater pressures with an excess head of approximately 20 m at the ground surface adjacent to the lake. The Hindmarsh Clay forms a confining bed to the whole system and the average vertical gradient is 125%.

4.3 Groundwater Quality

Groundwater quality in the study area is poor everywhere. Salinities less than 2000 mg/l are rare and most samples were in the range 4000 to 9000 mg/l, even in the adjacent ranges. The highest salinity recorded was 104000 mg/l from the main St. Vincent Basin east of the coal deposit. Thus no groundwater of potable quality exists in the area. Most is barely suitable for irrigation, even for salt-tolerant crops such as lucerne, but would be suitable for livestock such as sheep. Most waters are of the sodium chloride type with much smaller concentrations of the other common ions (sulphate, bicarbonate, calcium and magnesium).

5.0 DEWATERING AND DEPRESSURISATION FOR MINE DEVELOPMENT

5.1 General Discussion

The overburden sequence at Lochiel consists of fine grained unconsolidated sediments which are subject to high artesian groundwater pressures. This situation will result in very poor stability conditions for high walls, pit floor and spoil pile bases, unless the sequence can be satisfactorily depressurised and drained. Mine planning studies had shown that substantial economy would be achieved by developing an adequate depressurisation/drainage scheme in this situation.

Conventional wisdom suggests that the drainage of silt strata cannot be achieved within practical timescales due to the inherent low permeability of such materials. However, at Lochiel the overburden sequence and the coal zone contain minor sandy aquifers which can be exploited as potential drainage paths. The presence of these minor aquifers leads to the prospect of depressurisation and drainage by large diameter bores drilled into and screened within the basal aquifer and, in addition, filter packed over their full depth so that the minor aquifers within the overburden/coal sequence can be depressurised and drained in conjunction with the depressurisation of the basal aquifer.

5.2 Depressurisation Field Trials

The efficiency of depressurisation cannot be properly judged by laboratory testing procedures and prototype scale field testing is required. This approach has been adopted at Lochiel and three depressurisation trials have been completed.

5.2.1 Construction of Depressurisation Bores

Trial sites were selected to test the depressurisation response of portions of the deposit considered to represent the finer grained overburden sequence at TD1 in the north of the deposit, the coarser grained sequences at TD3 to the south and an intermediate sequence at TD2 in the central west of the deposit. The design and completion details for each of the depressurisation bores were selected specifically for the conditions at each site and are described as follows:-

(1) Depressurisation Bore TD1

This bore was designed to dewater by drainage some thin aquifers within the overburden, to depressurise the silts and very fine sands and to conventionally depressurise the major basal aquifer by single well completion. All aquifers were naturally under artesian pressure heads and construction was considered as a prototype installation. Construction problems were experienced from contamination of the calcium chloride drilling fluid by fine lignitic fragments and resulted in abandonment of the first bore which was backfilled and sealed. A slightly modified design (Figure 6) was installed as a multiple screen filter packed bore within the overburden and completed with telescoped screens in the basal aquifer.

(2) Depressurisation Bore TD2

This bore was screened within sandy sections in the Tarella, Warrindi and Condowie Silt as well as the Bumbunga Sand and was filter packed over its full depth except for the upper 8 m (Figure 6). TD2 was drilled at a higher elevation than TD1 and artesian pressures were controlled by a degradable polymer mud with sodium chloride weighting in the basal unit.

(3) Depressurisation Bore TD3

This installation consisted of two production bores and a "sandwick" as shown in Figure 6. The deeper production bore was screened in the Bumbunga Sands while the shallower bore was completed in the sandy Warrindi Silt. The "sandwick" was constructed as a fully filter packed bore screened in the Bumbunga Sand. It was designed to provide for vertical drainage from the overburden sequence to the Bumbunga aquifer and, therefore, was not equipped for pumping.

5.2.2 Instrumentation

All three depressurisation sites were intensively instrumented to permit the monitoring of water pressures, surface settlements and the vertical settlement profile. Instrumentation consisted of:

- Pneumatic piezometers installed adjacent to each depressurisation site within the finer grained units. A total of 13, 16, 18 were installed at sites TD1, TD2, TD3 respectively.
- Standpipe piezometers in coarser grained units. A total of 6, 8, 11 were installed at sites TD1, TD2, TD3 respectively.
- Surface settlement points established on radial lines at distances up to 250 m from the production bore.
- Magnetic settlement gauges adjacent to the bore with up to 12 measuring points within the profile.

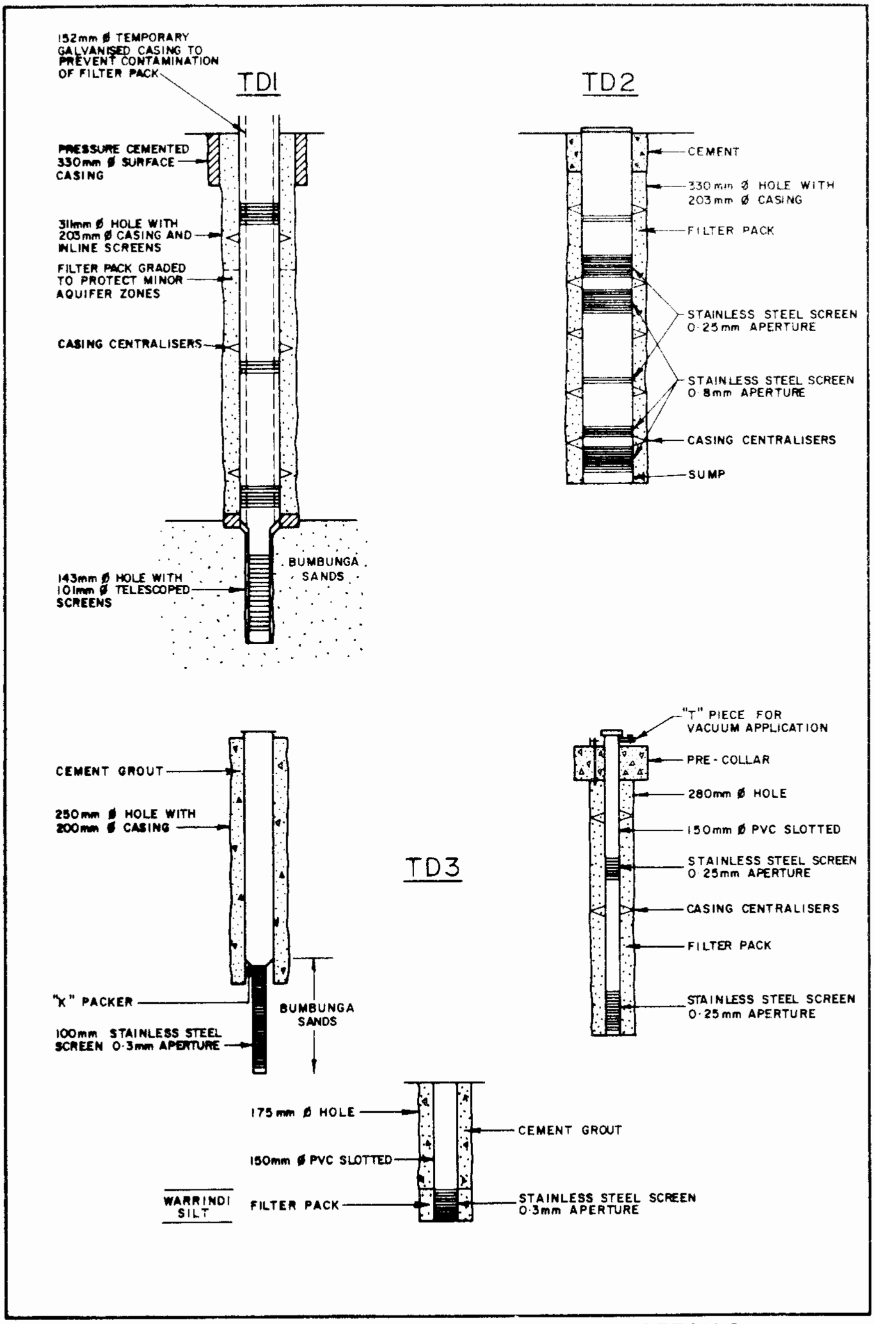

FIGURE 6- DEPRESSURISATION BORE CONSTRUCTION DETAILS

5.2.3 Results of Depressurisation Trials

The depressurisation trials represent a major investigation carried out over a six month period which has yielded extensive data upon the response of aquifer and confining units to medium term pumping. It would be inappropriate to attempt to present more than a brief synopsis of the results in this paper.

5.2.3.1 Mechanism for Depressurisation

When pumping occurs, the piezometric head is lowered in both the well and aquifers, and depressurisation and/or consolidation by both vertical and radial flow are initiated in the less permeable layers as shown diagrammatically in Figure 7.

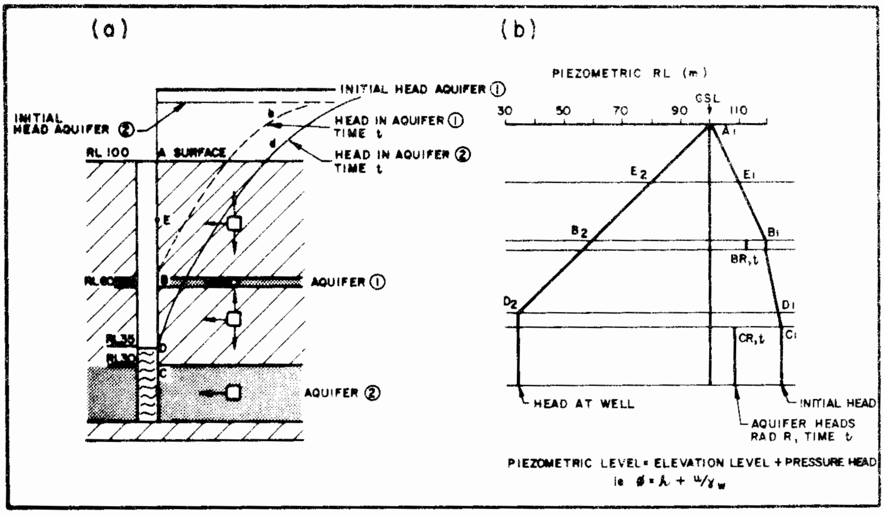

FIGURE 7 - MECHANISM FOR DEPRESSURISATION

Before pumping, the piezometric head varies through the profile as shown on Figure 7(b) by lines A1, B1 and C1. This variation is in response to the steady upward flow which occurs naturally at the site. The vertical axis represents the position of each point in the profile and the horizontal axis represents the piezometric level at each point.

(a) Radial Drainage Conditions

When the water level in the well is drawn down to point D (Figure 7(a)) then at a point above D, such as E in the well, the soil pore water is at atmospheric pressure and hence pressure head must be zero and the piezometric head is the elevation or reduced level (R.L.) of the point, plotted on Figure 7(b) as E2. Below D, the piezometric level in the bore is constant and equal to the level of D.

Thus the initial driving head for radial flow to the well is given in Figure 7(b) by the distance between the initial undisturbed head line through the deposit A1, E1, B1, D1 and C1 and the head line at the well boundary A1, E2 and D2. If the drawdown level is constant, then the well represents a constant boundary. Thus, in response to this difference in lateral pressure there will be generated a component of radial flow from the surrounding material towards the well. This flow will result in depressurisation of the overburden units around the well with the extent of depressurisation spreading radially with time at a rate dependent upon the radial drainage characteristics of the overburden units. This is the process of radial consolidation.

(b) Vertical Drainage Conditions

On the other hand the piezometric heads drop more quickly in the aquifers than in other layers due to preferential lateral drainage through these aquifers,. Hence vertical piezometric pressure gradients are also developed through the more impermeable layers and are relieved gradually by vertical flow from within these layers to the adjacent aquifers. At some time after drawdown of the well to level "D" the piezometric levels in the aquifers will vary with radial distance from the well as shown by curves such as Bb and Dd in Figure 7(a). The head in the aquifers, which act as drainage boundaries for vertical flow in the more impermeable layers, is therefore dependent on both radial distance from the well and the time for drawdown of the well. However, the piezometric levels in the aquifers will tend to stabilise quickly compared to the speed of response of other layers and can therefore be treated, for all practical purposes, as dependent only on radial distance from the well for any particular test. This is the process of vertical consolidation.

In general terms the process of radial and vertical consolidation will occur simultaneously and both will act to reduce the excess pore pressures within the more impermeable overburden units. The rate of depressurisation at any point within the overburden will therefore be determined by the boundary drainage conditions and the drainage or consolidation characteristics of the overburden units in radial and vertical directions. It is important, at this point, to appreciate that the overburden units are generally not uniform in their drainage characteristics and are comprised of a sequence of horizontally layered units of varying fineness and permeability. Thus, each overburden unit consists of an interlayered complex in which some form of composite radial/vertical drainage pattern will develop. It is not considered necessary to deal in detail with the interlayered character of the overburden units and the approach applied in this study is to interpret observed response in terms of mass behaviour of the overburden units on the basis of effective uniform mass behaviour. This is a well established engineering technique for treating complex geological conditions which is justified provided the range of test conditions is applicable to field operating conditions.

5.2.3.2 Results of Depressurisation Trials

For the analysis of radial and vertical consolidation effects, sets of standard curves were developed appropriate to the test conditions. The results for radial consolidation in selected fine grained overburden units are shown in Figure 8.

The depressurisation achieved throughout the profile at site TD1 is presented in Figure 9 for pumping period of 3 days and 30 days. This shows that significant reductions in pore pressure within the minor aquifer zones and the fine grained overburden units can be achieved for relatively short periods of pumping. Comparable results for TD2 and TD3 are presented in Figure 10.

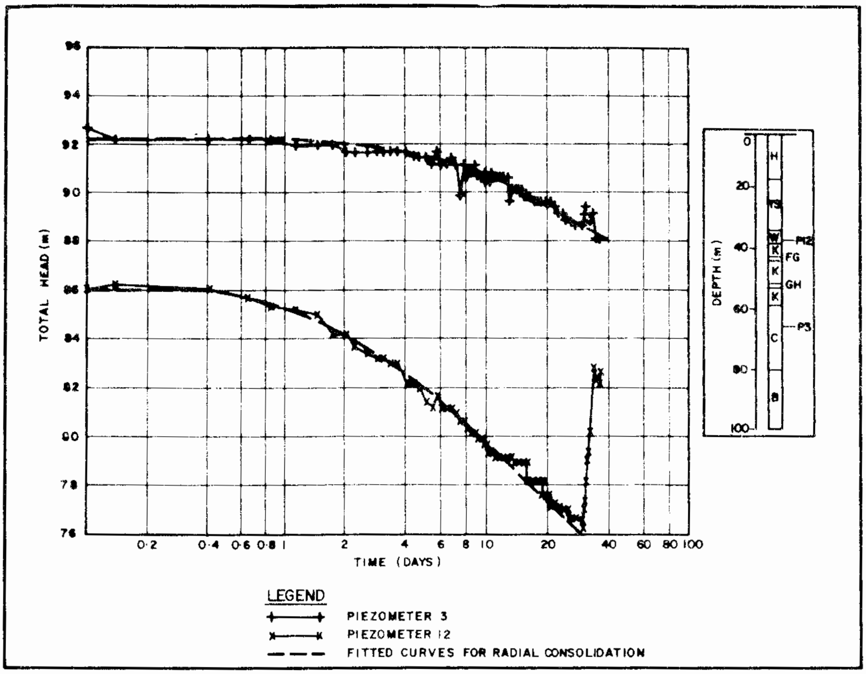

FIGURE 8 - RADIAL CONSOLIDATION OF SELECTED FINE GRAINED OVERBURDEN UNITS FROM SITE TD1

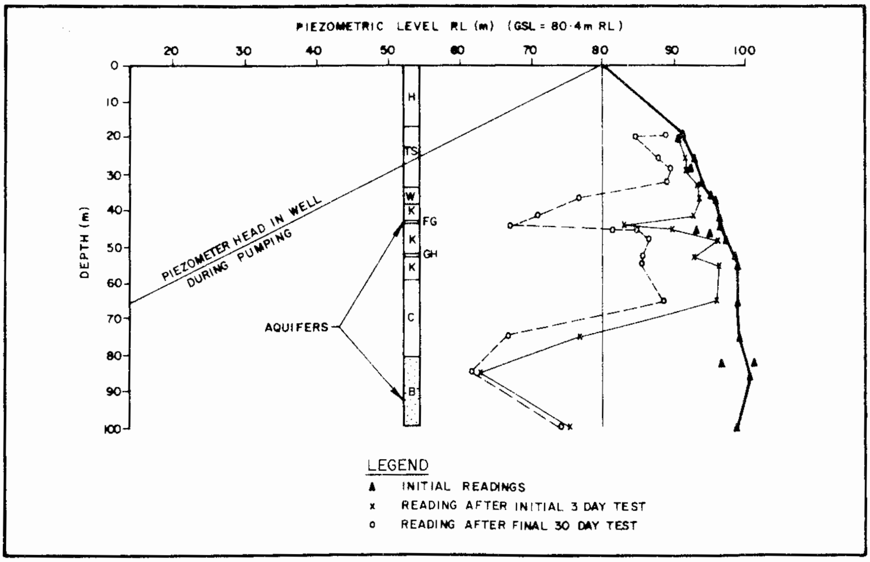

FIGURE 9 - RESULTS OF DEPRESSURISATION TRIAL TD1

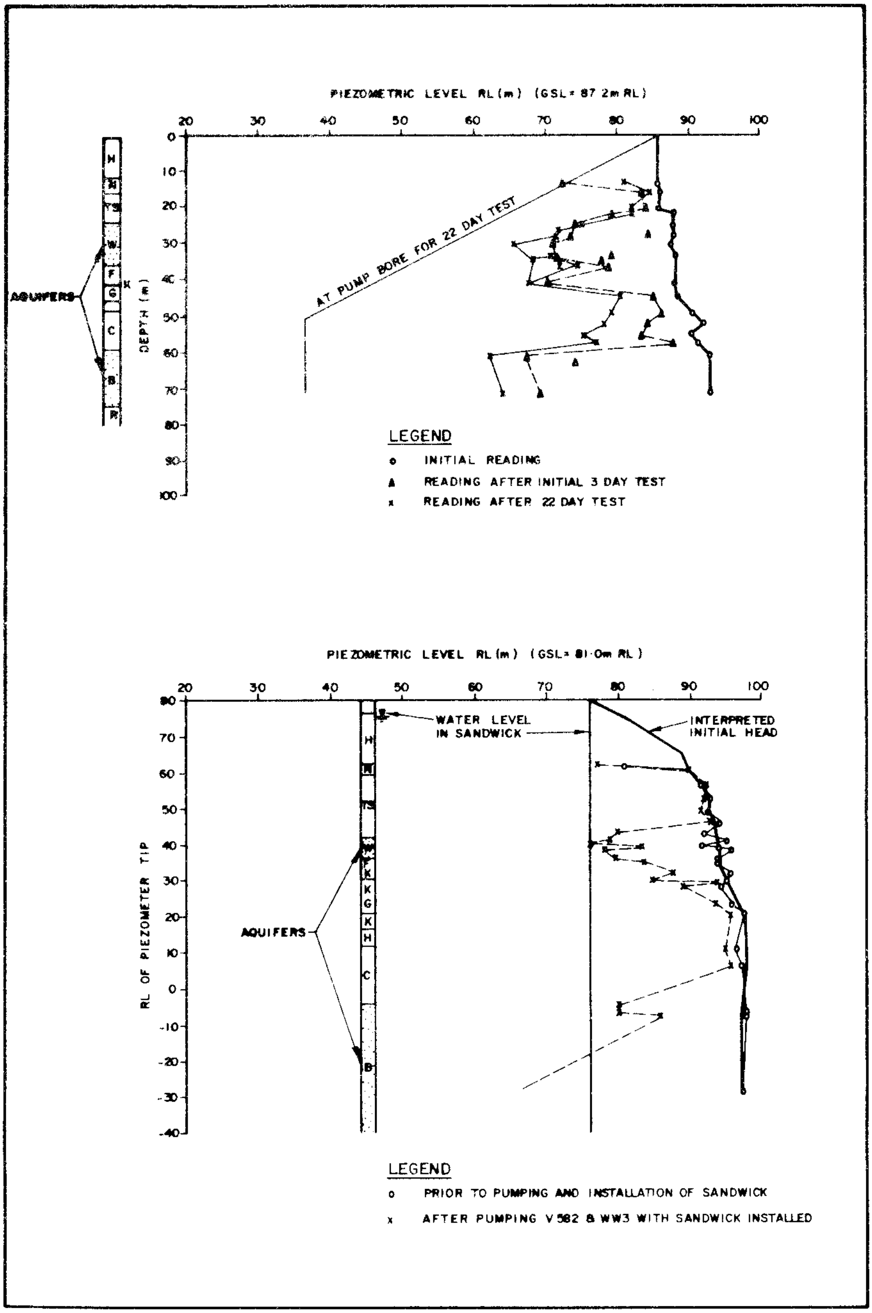

FIGURE 10 - RESULTS OF DEPRESSURISATION TRIALS TD2 AND TD3

Space limitations prevent other than a brief presentation of results. However, consolidation parameters estimated from the field trials are summarised in Table 2.

TABLE 2
CONSOLIDATION PARAMETERS FROM FIELD TRIALS

Geological Unit	Vertical Consolidation (m^2/year)	Horizontal Consolidation (m^2/year)
Hindmarsh Clay	40	40
Nyowee Beds	40	1000
Tarella Silt	60	1000
Kooliata Zone	140	1500 to 4000 +
Condowie Silt	60	4000

5.2.3.3 Secondary Effects

The conduct and analysis of field depressurisation trials is a complex and involved study, the results of which can be affected by numerous secondary influences including:-

- disturbance of groundwater pressure associated with well construction;
- well losses and non linear consolidation effects;
- possibility of radial arching in upper layers producing non-uniformity in total stress conditions and thereby affecting pore pressure response;
- presence of dissolved gases within unconsolidated sediments and the effect of released gases on formation permeability;
- changes in permeability due to consolidation adjacent to aquifer and well boundaries.

These and related effects can have an important influence on the results achieved and should be considered at each specific site.

5.3 Mine Design Factors

A dewatering system of deep bores pumping from the basal aquifer system has been designed for the proposed dragline mining scheme for Lochiel. This system will be installed progressively with mining to ensure that groundwater flows do not enter the pit and do not affect stability of spoil piles. In general, this requires bores at 225 to 300 m centres capable of handling flows in the range of 10 to 15 litres per second. The flows to be pumped vary throughout the life of the mine and will reach a maximum value of 22 Ml/day after 5 years of operation.

In addition to the control of groundwater, the dewatering system also serves a role in respect of depressurising the highwall overburden materials in advance of mining. Depressurisation will be achieved by installing and pumping the deep bore system for 12 months prior to commencement of mining in a particular area. Over the northern section of the deposit it will be necessary to install unpumped, filter packed, drainage wells on a 60 m grid at least 12 months in advance of mining.

These drainage wells, together with deep bore pumping to maintain the water level well below pit floor, will result in substantial consolidation of the highwall overburden. This depressurisation together with a partial pre-strip system, will permit overall highwall slopes on the range 25 to 40^o and bench slopes up to 50^o.

6.0 CONCLUSIONS

On the basis of relatively short term field trials, the use of depressurisation and drainage by deep bores has been established as a practical solution to the stability problems of the Lochiel deposit. Further trials are currently in progress to assess the most efficient and economical means of depressurisation, including the use of vacuum assistance to further enhance the drainage response of overburden and lignite zones.

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