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THE PROBLEMS OF AUSTRALIAN UNDERGROUND COAL MINING OPERATIONS IN WATER CATCHMENT AREAS

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ABSTRACT

This paper outlines the general water problems encountered in Australian underground coal mining activities which are exacerbated by the location of certain large coal producers either adjacent to or within water catchment areas. Mining leases do not always take into consideration seam sterilization and complexities caused by water controls on mine development. The pertinent state legislation on planning and environmental protection of water courses in N.S.W. together with details of the water authority's role in mining in water catchment areas are outlined. Specific case studies are given whereby the proposed mine centroid has been relocated in order to satisfy legislative requirements. The specific problems of coal mining under stored bodies of water and dams are examined with regard to restriction and potential hazards. The paper outlines the procedure adopted for mining in such situations and pertinent case studies are quoted.

INTRODUCTION

In Australia there is a distinct twofold split in terms of coal mining development for black coal, with 88% of the national production from deep mining operations located in New South Wales while the majority of open cast coal mining capacity (67.4% national output) is located in Queensland. In 1982 production of saleable black coal in Australia amounted to 91.08 Mt of which 47.15 Mt is exported overseas[1]. The rapid expansion of coal production particularly for the export market has been accompanied by the problem of deep mining operations beneath another scarce commodity; that of water.

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The climatic conditions of New South Wales and Queensland result in water shortages for domestic and industrial use. It is also inevitable that a conflict of interest should occur between authorities responsible for water supply and colliery operators who wish to mine under water catchment and stored water for economic return.

ENVIRONMENTAL PLANNING FOR MINING DEVELOPMENT IN NEW SOUTH WALES

Any major coal mining development in New South Wales comes under the jurisdiction of the Environmental Planning and Assessment Act, 1979 [2]. This particular Act allows for special procedures for a development which it is anticipated will result in a possible environmental impact. Such developments are called "designated" developments under the Act and require the production of an Environmental Impact Statement (EIS). This document sets out a series of data on the existing situation with regard to land use, hydrology, topography, geology, meteorology, natural habitats and visual intrusion amongst others.

The effect of mining on any of the above areas is considered in an EIS based on projected activity at the proposed mining operation.

ENVIRONMENTAL PROTECTION - MINE WATER

Environmental protection for water courses in New South Wales is controlled by a State Government body namely, the State Pollution Control Commission (SPCC). They are responsible for the implementation of the Clean Waters Act, 1970 [3] under Section 19 of the Act. The SPCC may issue or approve for a mining company to install, construct and modify equipment which results in the discharge of pollutants into waters. They are also concerned with the method of treatment of pollutants and the disposal of waste products emanating from any coal mine and its associated development. The SPCC may approve an application with or without any attached conditions or they may refuse it. Any applicant who feels aggrieved by an SPCC decision may appeal under Section 25 of the Clean Waters Act 1970. Having obtained an approval from the SPCC the construction work is completed and a licence is then required. The licence issued under Section 20 of the Clean Waters Act sets down the expected quantity and quality of the water emanating from the particular mining operation.

In order to allow the SPCC to assess the impact of the mining development as far as water is concerned the following details are required from the mining company or its consultants:-

(i) A location plan showing contours, waste disposal points, site boundaries, public roads and existing natural watercourses.

(ii) Details of processes resulting in waste water.

(iii) Details of treatment methods proposed (including any disposal of sludge produced).

(iv) A flowsheet of treatment processes proposed as well as average and maximum volumes of wastes to be discharged in kilolitres per day.

(v) A statement of estimated quality of wastes before and after treatment.

Usually the above material has been detailed to some degree in an Environmental Impact Statement (EIS). In considering a mining application it is not unusual for the SPCC to seek views of other relevant bodies (such as Metropolitan Water Sewerage and Drainage Board and Parks and Wildlife Service) before granting an approval.

THE WATER AUTHORITY AND ITS CATCHMENTS

The major water authority in New South Wales is the Metropolitan Water, Sewerage and Drainage Board (MWSDB). Under the Metropolitan Water Sewerage and Drainage Act [4] water catchment areas can be proclaimed (under Section 55 and Section 56a of the Act)and if necessary can later be subsequently revoked.

As far as underground coal mining operations are concerned the MWSDB is consulted before the Department of Mineral Resources designates a coal mining lease if that lease is beneath a water catchment area. The MWSDB can object to proposed lease arrangements on the basis that it would interfere with their role as a water authority. If a dispute exists between the Department of Mineral Resources and the MWSDB an independent arbitrator conducts an inquiry. The assessment of the arbitrator is final and the decision is then implemented.

The MWSDB may approve of the coal mining lease but may require the attachment of certain conditions to restrict impact on the catchment area. As a general rule the MWSDB would prefer that coal mining operations did not take place on water catchment areas. However, there are examples of ventilation shafts and men and materials shafts as well as collieries such as Cordeaux Colliery in which the total surface layout is sited on land proclaimed as water catchment area. Obviously in a part of the world where potable water is a scarce commodity the role of the water authority is an important one, however, some conflicts of interest do occur with mining operations taking place beneath the surface.

It can be seen in Figure 1 that there is potential future conflict as mine leases require servicing perhaps away from the original adits, particularly when underground transport and ventilation distances increase significantly, effecting production and productivity.

Case study - Cordeaux Colliery

Cordeaux colliery is one of the most modern underground coal mines in Australia, producing an average daily output 2900t. It is a Broken Hill Proprietary (BHP) mine located on the Metropolitan Water Sewerage and Drainage Board catchment area. That location in itself has produced a number of restrictions.

Initial proposals were produced to locate the surface facilities at the centroid of the lease area. That location would have been too close to the Cataract Dam which was unacceptable to MWSDB. The alternative and subsequently constructed surface facilities were moved 2km off the centroid. This distance has resulted in increased travel time to the underground production units and the number of permanent roadways in operation has increased.

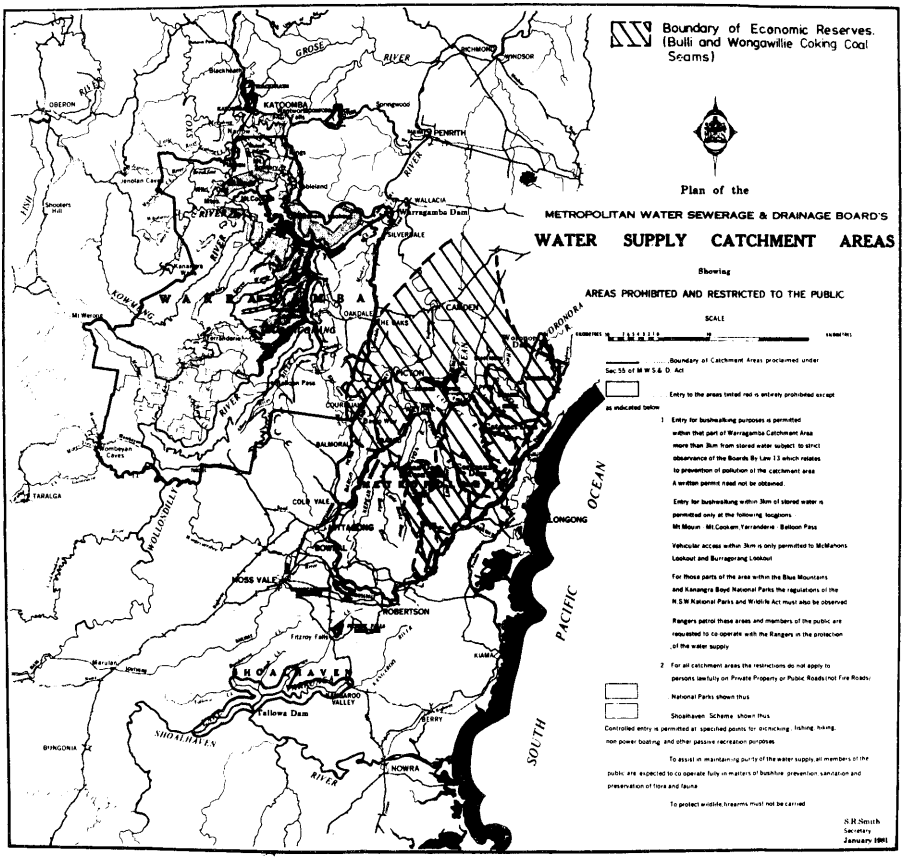


Figure 1 Indicates the boundary of economic reserves (Bulli and Wongawillie Seams) in the MWSDB water supply catchment areas.

The area of the surface facilities is 160 ha (400m x 400m) which encompasses two shafts (i) men and materials (ii) coal clearance. The mined coal is transported by enclosed conveyor to a surface storage bin and trucked away to the company's central southern washery. The other surface facilities included office, bathhouse, workshop, store and storage area as well as car park.

The MWSDB produced the most stringent requirements prior to development approval and Figure 2 illustrates the water collection and treatment system. Obviously the major area of interest was the water pollution measures which can be divided into four distinct areas and are outlined briefly as follows [5] :-

(i) Collection, treatment and disposal off the catchment area of dry weather contaminated water.

(ii) Collection of mine water, its use and discharge of excess off the catchment area.

(iii) The collection, treatment and disposal off the catchment area of treated sewerage effluent.

(iv) The diversion of external run off way from the site.

i) Contaminated Water

(a) Collection - Contaminated water is generated by the wash down facilities in the workshop, wash down bay, oil storage and diesel filling area. The contaminants are oil and coal. Clean down water from the coal conveyor as well as water from dust control equipment and run off from ancillary areas collects in a holding sump. Water from the sump is pumped to a Corrigated Plate Interceptor as indicated in Figure 2 adjacent to the Primary Separator Lagoon. Coal spillage at the loading bins is collected in another sump under the bin system.

Cap park run off is collected and drained through a flow limiting weir to the primary separator to remove any oil. Rainfall from the electricity substation, men and materials shaft areas as well as hard standing areas flow by gravity through a flow limiting weir to the primary separator. Rainfall from access roads and roofs are reticulated directly to the natural water courses.

(b) Treatment - Run off from the contaminated water areas is treated on the basis of a 1 in 3 year return period intensity storm. The treatment system has a capacity to deal with 28,000 ℓ/min. Any flows in excess of 28,000 ℓ/min are passed untreated to a natural water course via an underpass/overflow weir. This allows the heavier particles to be treated and the lighter uncontaminated material to flow to the water course.

Oil is initially removed by a Corrugated Plate Interceptor. The remaining water flows onto the primary separator where further oil is separated by a skimmer. The oils are collected in a central sump for subsequent removal. The primary separators other function is that of setting basin which allows partly clarified water to be drawn off to a filter lagoon.

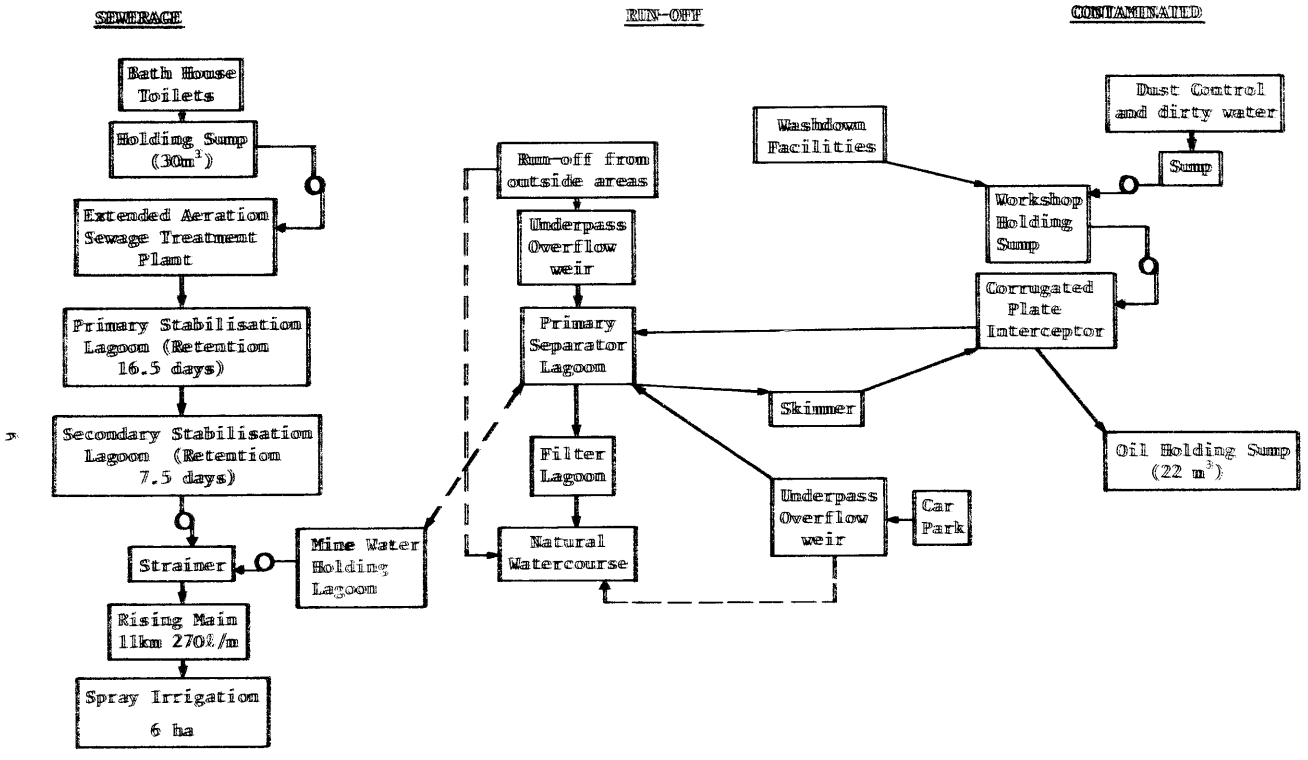


FIGURE 2. WATER COLLECTION AND TREATMENT - CORDEAUX COLLIERY

(ii) Mine Water

Excess mine water is pumped from underground sumps to a 2.5Mℓ holding lagoon with a nominal retention time of seven days. There is opportunity for re-use of lagoon water in the areas of fire fighting and underground dust suppression.

The excess lagoon water is piped and used off the catchment area as an irrigation source. During heavy rainfalls the overflow in the holding lagoon discharges into the primary separator for treatment.

(iii) Sewage Treatment

Sewage from the bath house, office, workshop and coal handling facilities produces approximately 50,000 ℓ/day. The sewage is collected in a holding tank and is then pumped into a Smith and Loveless extended aeration treatment plant. The sewage treatment plant effluent flows into a chlorinator and onto the primary stabilisation lagoon to be held for 16.5 days. A secondary stabilisation lagoon is used with a retention period of 6.5 days. A spray irrigation system is used to dispose of effluent onto a site of approximately 6 ha off the catchment area.

(iv) Diversion

A series of intercepts drains were used to reduce the amount of run-off from surrounding area from entering the surface operational site. A simple system of creeks and drains achieved this particular water control.

MINING UNDER STORED WATER

In New South Wales there are a number of examples whereby dams and reservoirs are underlain by coal seams of economic importance. Collieries have been granted leases for coal extraction which include areas below reservoirs and dam structures. The collieries wish to gain an economic recovery from their lease but the state authorities (Public Works Department) wish to maintain the structures and water supply intact.

There are a number of hazards that are possible in the extraction of minerals from beneath stored water or the retaining structures:-

- Dam Structures.

  (a) Minor distortion - cracking and increased seepage.

  (b) Major distortion - rupture, failure, loss of life and property.

- Stored Water.

  (a) Minor leakage - loss of safe yield.

  (b) Major leakages - total loss of supply.

TABLE 1.

IN-SITU COAL RESERVES UNDER STORAGE RESERVOIRS, SOUTHERN COALFIELD (Mt)

SEAM		RESERVOIR AVON	CATARACT	CORDEAUX	NEPEAN	WORONORA	TOTAL
BULLI	a	21.65	20.67	6.89	0.79	9.84	59.84
	b	51.18	50.19	14.76	2.46	46.25	164.85
BALGOWNIE	a	-	5.91	7.38	-	6.89	20.18
	b	-	19.68	16.73	-	30.51	66.92
WONGAWILLIE	a	19.68	23.62	30.51	3.44	-	77.25
	b	47.24	69.88	75.78	9.84	-	202.74
TONGARA	a	0.89	-	-	-	-	0.89
	b	2.95	-	-	-	-	2.95

a : Under stored water.
b : Under stored water plus 35^{o} angle of draw.

(Adapted from Reynold Inquiry) [6]

Mining Operations.

(a) Minor leakage - requires installation and operation of pumps.

(b) Major leakage - loss of life, equipment and possibly the mine.

There are a range of possibilities outlined above that range from catastrophy to annoyance.

The conflict of interest resulted in an enquiry [6] Chaired by Mr. Justice Reynolds in 1974 which attempted to clarify the subject and produce a series of recommendations that would attempt to reduce the conflict in the future. An estimate of the scale of the conflict is set down in Table 1.

THE LIMITATIONS OF MINING UNDER STORED WATER

As a result of the Reynolds Inquiry [6] the following mining limitations were set down.

(i) No mining whatsoever in areas of 60m or less cover.

(ii) Bord and pillar mining is allowed at depths of greater than 60m. The bords have a maximum width of 5.5m and pillars the minimum width of 15 times the extraction height (or 1/10 the depth of cover whichever is greater).

(iii) Panel and pillar mining is allowed at depths above 120m. The panel sizes not greater than the third the depth of cover. The pillar sizes of a length co-extensive with that of the panel extracted and a width not less than one fifth of the depth of cover or 15 times the height of extraction, whichever is the greater.

(iv) The marginal zone around stored waters should be determined by an angle of draw of $26\frac{1}{2}^{o}$ taken down from the boundary of the stored water at full storage level as indicated by Figure 3.

(v) There should be no mining or driving of access roads beneath a dam structure within a coal pillar at a point 200 metres away from the edge of the structure and an angle of draw of 35^{o}.

Certain changes have been made to the criteria since the Reynolds Inquiry. These changes include the following:

(a) Panel and pillar mining are allowed with widely spaced cross-cuts to allow underground development.

(b) The depth used in the panel width calculation is taken as the least solid cover. For the pillar width calculation the greatest solid cover is used. The result of this amendment is a reduction in recovery rates.

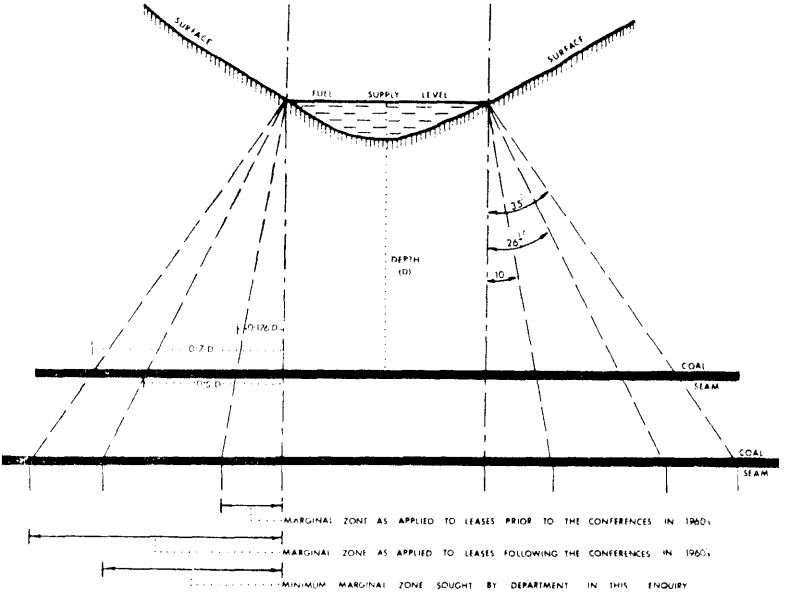
(c) The marginal zones were increased to 35^{o} from the top water level. At the intercept of that angle with the seam a further distance of half the depth from the bottom of the seam to the top water level is used as a restricted zone.

Inorder to regulate the potential hazards the New South Wales Government produced the Dam Safety Act, 1978 [7]. The Act set down a procedure for collieries to adopt when there is a possibility that mining operations, either for extraction or access roadway which would lie beneath stored water.

As the amount of water inflow to mine workings may depend upon surface subsidence caused by coal extraction, a subsidence of the New South Wales coalfield analysis is necessary.

NEW SOUTH WALES SUBSIDENCE ANALYSIS

Kapp [8] has observed surface subsidence in the Southern Coalfield and Newcastle Coalfield compared with the average subsidence of some 100 studies in the United Kingdom as illustrated by Figure 4.



	WIDTH OF MARGINAL ZONE (m)		
	ANGLE OF DRAW		
DEPTH (m)	10^{O}	$26\frac{1}{2}^{O}$	35^{O}
100	18	50	70
200	35	100	140
300	53	150	210
400	71	200	280
500	88	250	350

Figure 3 The Effect of Draw Angle on the Width of Marginal Zone (adapted from the Reynolds Inquiry [6])

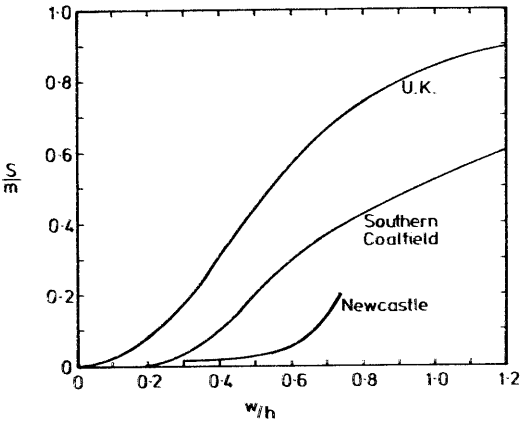


Figure 4 Maximum Subsidence related to Mine Geometry (after Kapp [8])

The results indicate that subsidence in New South Wales is not as great as some U.K. situations because of the following reasons:

- Properties of the superincumbent strata.

  In the U.K. the coal measures are generally argillaceous and contain significant thickening of mudstones and claystones. The strata of the Southern Coalfield consists largely of massive sandstone which contain occasional beds of shale and mudstone, while in the Newcastle Coalfield the strata contains the beds of sandstone and conglomerate.

- Caving Properties.

  During caving the strata of the N.S.W. coalfields occupy a larger bulk volume than the generally argillaceous strata of the U.K. coal fields.

THE PROCEDURES OF MINING UNDER STORED WATER

As a result of the Dam Safety Act a Dam Safety Committee (DSC) was appointed. The individual members of that Committee were drawn from the regulating authorities as well as mining groups. The Committee soon adopted a view that all embracing standards were not possible and each application had to be evaluated on its own individual merits. The first problem was to establish those areas covered by the Dam Safety Committee's jurisdiction. The areas under study were named "notification areas" which are shown for the Southern Coalfield in Figure 5.

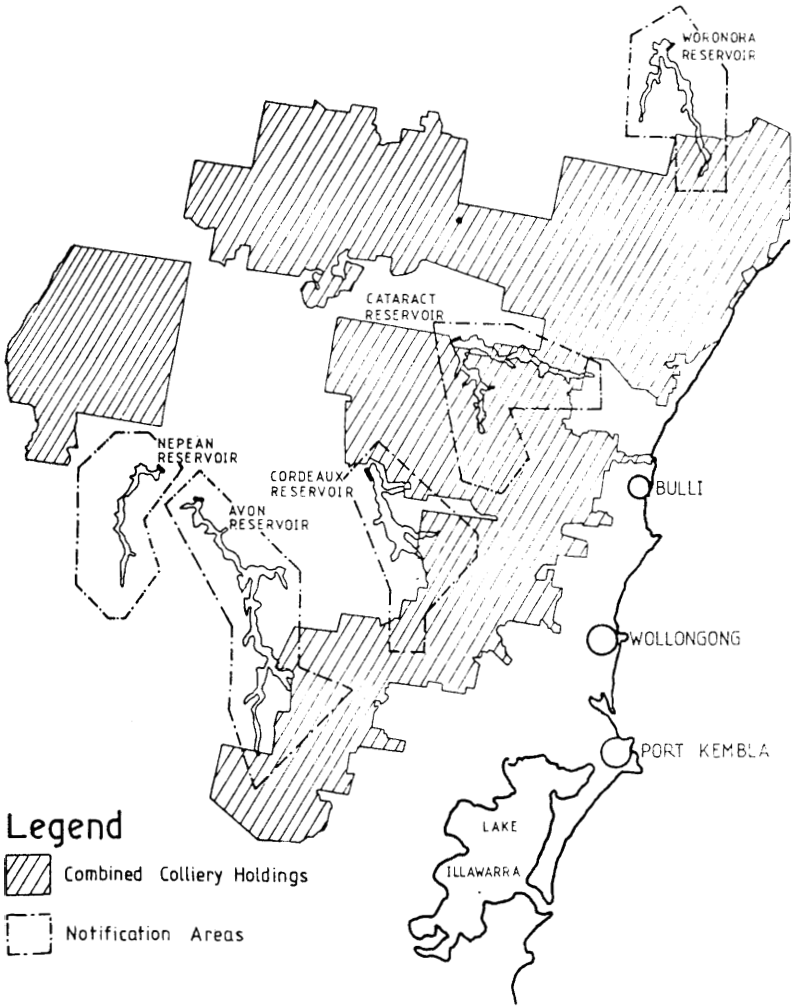


Figure 5. Notification Area of the Southern Coalfields

The notification area was the boundary on the surface whereas the mine operators were interested in the effect on mining in an underground seam or seams. In order to clarify this situation the restriction zones were established as determined by an angle of draw of 35^{o} together with an additional seam sterilization of 0.5 depth. Any proposed mining activity within the restricted zones needs to be submitted to the Dam Safety Committee for assessment. In order to make that assessment meaningful the Committee requires supportive material which should include the following:-

- The proposed mine plan.
- The proposed mining timetable.
- Details of local geology in the area of mining operations including details of strata, faults, dykes, surface features, joint orientation and spacing.
- Predictions of subsidence and surface strains at various key times during mining operations.

The DSC considers the application and the supportive material and makes its recommendations to the Minister of Mineral Resources for approval, conditional approval or rejection. The conditions are usually related to the establishment of a monitoring programme to match the predictions with the actual mining situation. Typical conditions which could be imposed are as follows:-

- Production of regular mine plans identifying progress and geological features encountered.
- Observations of water flows including seepages and their sediment content.
- Measurements of surface subsidence and strains.
- Measurements of water entering and leaving the mine covered by the restriction zone.
- The possible results of borehole logs showing the fluctuation of ground water levels.

The cost of an annual monitoring programme could be as much as A$100,000.

CASE STUDIES OF COAL MINING UNDER STORED WATER

Since the establishment of the DSC there have been two major examples of coal mining under stored water.

Bulli Colliery

The mine is located north of Wollongong in the South Coast Coalfield. In 1979 the DSC received an application from Bulli Colliery to carry out panel and pillar extraction within the restricted zone of the Cataract Reservoir. The application involved the mining of two panels in the restricted zoning providing a 50% extraction rate. The application was approved by the DSC and the aforementioned conditions were

imposed. Mining has proceeded since 1980 along with the monitoring tasks. There has been no biological evidence to suggest that the stored water has percolated through the strata. The presence of water would have been particularly noticeable in this example as it is recognised as a "dry" pit. The subsidence has been within the expected limits.

Wyee State Mine

The mine is located south of Newcastle in the Newcastle-South Maitland Coalfield. During 1980 the DSC received an application from the Wyee State Mine to extract coal by panel and pillar methods under an ash dam operated by the Vales Point Power Station. The application was subsequently approved and mining proceeded to a point where panels within the area of the reservoir and dam structure have been extracted. The monitoring programme identified no visible changes in the structure condition. Surface subsidence slopes were less than 20mm/m. Horizontal movements have been too small to be determined accurately. In general the predictions were over cautious.

In the period 1979 to 1982 approximately 35 applications have been made to the DSC related directly to coal mining operations. There have been no appeals which is probably a result of the constructive attitude taken by the DSC.

CONCLUSIONS

Mining under large bodies of water has three major implications,

- loss of water,
- safety of mine workings,
- financial implications through sterilization of coal reserves and possible increase in mining pumping due to increased seepage.

The paper indicates that the environmental pressure on mining is continuously increasing. In order to exploit valuable reserves of coal for the overall national economy, it is necessary that a compromise solution be reached to the satisfaction of the parties concerned. The paper describes the procedure of obtaining planning permission for working coal seams under water in the Sydney basin and illustrates the procedure by case examples.

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