PREVENTION OF POLLUTION FROM A COAL MINE AT THE PLANNING STAGE

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ABSTRACT Prior to the establishment of new mines or expansion of existing mines in South Africa, the Inspector of Mines through the Mines and Works Act and Regulations, requires a detailed and approved rehabilitation flow and programme regarding the potential impact of mining on the environment. The ground water resource aspect is dealt with in a phased approach, detailing existing premining conditions, evaluation of the potential impacts, design of a monitoring network and an on-going review and recommendations. A strong liaison should exist in this regard between consultants and the various State Departments.

A case study of an extension to a Natal coal mine using the phased approach, was found to be effective in evaluating the ground water scenario.

INTRODUCTION

Any new mine or proposed extension to a mine requires the permission of the Inspector of Mines. Permission will only be granted should all the regulations cited in the Mines and Works Act 27 of 1956 are adhered to.

In the past the main emphasis of the Inspectors' decision making has been placed on the safety of the workings with respect to life and property. Water was looked at only in the light of a potential threat to life in terms of the flooding of underground workings. Under clauses 5.3.1 and 5.3.2 of the Mines and Works Act, undermining of water courses requires special permission from the Inspector, and mines are normally prohibited from undermining the watercourses without the stringent use of safety barriers and pillars.

Recently, through the efforts of the Department of Water Affairs (DWA) and the media, the Inspector's attention has been drawn to the effect of mining on the water resources of South Africa. Specific examples of polluted water flowing from operating and abandoned mines have been noted from coal mining activities in Natal as well as in the Transvaal coal fields.

The pollution problem caused by coal mining activities has led to more strict legislation and specific environmental measures being instituted. Applications for the establishment of new mines or the expansion of existing mines are now examined in terms of their potential impact on the water resources as well as mine safety.

To assess the probable impact of the mine on the water resources the Inspector can call upon the relevant division of the DWA for advice. Permission for mining can be withheld until the mine complies with recommendations made by the DWA.

This recent shift in emphasis and cooperation between the two Departments gives the DWA a much greater effectiveness in the prevention and control of pollution and thus protection of the nations water resources.

To comment and advise on the impact of mining the DWA need to investigate the specific water resources in the immediate vicinity of the site.

This paper outlines a typical investigation and details a case study as an example of its application. For the purposes of this symposium the results of the ground water investigation are emphasised.

TYPICAL INVESTIGATION

Overall Investigation

A ground and surface water assessment would normally be conducted in four phases, each phase consisting of various activities:
(a) Establish base line/pre-mining/existing conditions.
(b) Determine potential impact.
(c) Design and install monitoring network.
(d) Ongoing review and recommendations.

Phase 1

To establish the base line conditions the following activities would be undertaken:
(a) Review of all readily available data.
(b) Surface water mapping.
(c) 1:50 year flood levels of water courses.
(d) Borehole census.
(d) Plot of premining water table.
(e) Plot of premining water quality.
(f) Catchment modelling.
(g) Structural mapping - aerial photography.
(h) Review of proposed mine plans.
(i) Review of mining method/s.

The above would normally be achieved during a desk and preliminary site survey. If insufficient data are available the first phase may then include drilling of additional boreholes and/or the yield testing of existing or new boreholes.

Phase 2

Phase 2 uses all the data collected in Phase 1 to assess the potential impact of mining on the water resources.

For this level of investigation we have assumed that no water is expected to leave the mine lease area. In cases where the mine plans to treat and dispose of mine effluent to the catchment a further study would be made in conjunction with water treatment specialists. This would probably involve the completion of a Receiving Water Quality Objective (RWQO) study and is beyond the scope of this paper.

The activities involved in such a detailed investigation would include producing a plot of the post mining drainage pattern, ground water levels and likely sources of pollution. Potential areas of ground water seepage into the mine would also be investigated.

The final result of Phase 2 is a report detailing the impact of the mine on the water resources; these impacts would then be discussed by mine management, DWA and the Inspector of Mines. Where necessary, the mining method would be adjusted to reduce impacts on certain areas considered critical in terms of the impact on the water resource.

Certain areas might be excluded from the Inspector's permission.

Phase 3

Phase 3 is the establishment of a monitoring network.

The objective of Phase 3 is to determine the effect of the mine during and after mining operations. The network would monitor both water quantity and quality and would consist of the following:

(a) Mine water balance.
(b) Borehole levels (and yields, if possible).
(c) Stream and spring flow.
(d) Water quality analysis.

The final setup of the monitoring network would be designed according to the results and recommendations made in Phase 2. The network is intended to be dynamic with emphasis on certain monitoring stations changing as the mine advances. For example, water levels in boreholes within 1 km of active development would be monitored more frequently than boreholes say 5 km away.

A data base capture programme would be written for the mine and made compatible with the DWA data base for the area. Normally the mine would capture its own data and produce plots of specific data on request.

The mine should appoint a rock mechanics engineer to assist in the final and ongoing mine planning.

Phase 4

Phase 4 is the ongoing review of data collected in the monitoring programme. It involves not only the review of any changes in water quantity or quality but also ongoing review of the effectiveness of the monitoring network itself.

Phase 4 is intended to continue throughout the life of the mine, through the de commissioning stage and into and beyond the rehabilitation stage. The continued review of the data on a six monthly to annual basis will enable the timeous identification of potential pollution problems.

CASE STUDY

Background

An investigation having the typical structure outlined above was recently undertaken to phase 3 level at a colliery in Northern Natal. The colliery requested an extension to its mining activities. The Inspector of Mines conferred with the DWA and requested a hydrological survey of the area before they would give permission to the mine.

As the DWA are no longer encouraged to do specific site investigations, consultants were approached by the mine and Steffen, Robertson and Kirsten (CE) Inc (SRK) was appointed to do the investigation.

Methodology

Activities were initially restricted to that of a desk- and field-study without expensive site investigation and drilling. The objective of the investigation was to identify, at a preliminary level, the hydrological and hydrogeological regime of the new extension and to assess the probable impact of mining on the ground and surface water systems. The approach used was to collect all readily available information on the area, and in the light of experience on coal mines in similar environments, determine how the development of the new extension would impact on the ground and surface water systems.

The investigation comprised the following activities:
(a) Site visit - inspection of inflows into underground workings.
(b) Borehole census.
(c) Review of information.
(d) Geological and aerial photograph mapping and review.
(e) Assessment of 1:50 year flood levels.
(e) Assessment of potential impact.
(f) Recommendations.

As this study was for an extension it was possible to determine from the existing workings without an expensive drilling exercise the probable impact of different mining methods on the water resources for the area.

Hydrogeology

The seam is horizontal and located in a dissected plateau, significantly elevated above the surrounding countryside.

A thick dolerite sill (80-90 m thick) caps the bulk of the plateau and overlies a sequence of well indurated sandstones and coal seams.

The exploitable seam is approximately 150 m below the sill (Fig 1).

In undisturbed areas where the dolerite is competent and unfractured, the sill acts as an impermeable boundary in the ground water system and results in a perched water table distinct from the regional water table. Aquifers within the plateau will be typically discrete, layered and of limited extent located on fault or dyke contacts. Ground water storage is limited to surface vleis and near surface weathered horizons. The source of recharge to the limited aquifers found on the plateau is restricted to infiltration collected in the plateau catchment.

Water Quality

Water quality sampling and analyses were undertaken to establish

(a) Premining ground and surface water quality at the proposed extension.
(b) The degree of contamination if any, of the ground water system in the vicinity of the existing mine workings.

The results provided a base data set which should be compared with regularly gathered data to determine any deterioration in ground water quality.

The overall results showed the sampled water not to be polluted by coal mining activity.

RESULTS

The results of the investigation are presented as a discussion with general comment made on the vulnerability of the ground and surface water systems to the impacts from mining.

Effect of geological discontinuities on the ground water regime

Ground water inflow into underground coal workings is often associated with geological discontinuities, such as faults and dykes, which connect near surface aquifers with the workings. The discontinuities can be natural or induced by mining, and can frequently act as conduits for ground water flow.

Structural mapping from aerial photograph interpretation and on-site mapping located discontinuities/lineaments associated with the surface drainage and near surface ground water storage (Fig 2).

Two ages of dykes intersect the workings

(a) dykes intruded after sill emplacement
(b) dykes intruded during sill emplacement

Dykes intruded after sill emplacement crosscut the sill and can act as conduits for water flow from surface to the workings. Dykes intruded at the same time as the sill are unlikely to act as conduits.

At the colliery under investigation two dyke infilled faults have been intercepted; minor ground water seepage is evident at the dyke contacts. The seepage was noted however not to be continuous over the entire strike length of the dyke contact.

Effect of Mining on Water Resources

All mining methods induce stress and cracking in overlying strata. Severe stress and cracking may open up existing conduits eg faults and dykes. If these features intersect an aquifer or surface water body, depletion of the water source and inflow to the mine will occur.

Different mining methods have a greater or lesser impact on the overlying strata. In general, bord and pillar mining induces minimal stress on the overlying strata and therefore reduces the potential for surface drainage. Increased extraction methods such as stooping can have a variable effect which is predominantly controlled by the variation in thickness of the overlying strata and the choice of panel width.

In this case study the very thick dolerite sill overlying the workings will prevent mine induced surface cracking and subsidence. A combination of bord and pillar and stooping mining methods for the more sensitive areas is planned.

Increased extraction methods can affect the surface and ground water regimes as well as water quality.

Effect on surface water

There are three ways in which stooping can affect surface run-off. Firstly, the infiltration of rain water increases in areas where mining induces cracking at surface. Secondly, in flat areas, pans will tend to develop above the areas of stooping and these depressions will intercept surface runoff. Thirdly, in severe cases, a reversal of the natural flow gradient may occur. In all cases less run-off will be available for use downstream.

In the existing works at the colliery only one incidence is known where fracturing occurred through the dolerite sill to surface and resulted in cracks appearing in a stream bed. An influx of ± 5ℓ/sec was measured seeping through goaf material. These cracks are now sealed and the streamflow diverted through a pipeline over the affected area. Stooping had been practised in this area and the fracturing is believed to have occurred because of the very thin (less than 10 m) dolerite cover and proximity to the seam outcrop.

Effect on ground water

Stooping can result in the flow of ground water directly into the mine workings through artificially induced fractured rock and goaf. Stooping over a large area can result in the drainage of ground water from fissures and weathered zone aquifer/s into the underground workings.

Effect on water quality

As a result of fracturing of the strata overlying the mine workings, the ground water can be exposed to shale, sandstone, dolerite and coal particles. Sandstone and dolerite are inactive chemically and have minimal effect on ground water quality.

However, when ground water comes into contact with shales and coal, preferential ion exchange occurs between the clay particles and the ground water. Such base exchange is often rapid. This results in the ground water becoming enriched in sodium and potassium ions and depleted in calcium and magnesium ions. Other anions such as chloride, sulphate, carbonate and bicarbonate will also go into solution. An effective way to reduce any pollution of ground water is to prevent all inflows to the mine. If inflows are unavoidable the water should be moved quickly from the mine to minimise the contact time with the coal and shale sediments.

CONCLUSIONS

The investigation of the study colliery was conducted at a preliminary level using readily available information and previous experience on the Natal Coalfields. The information collected by the mine will go towards a major catchment study in Natal. The conclusion of the Phase 1 and Phase 2 study was that the surface and ground water systems at the colliery are of limited extent. The ground water is predominantly perched above a competent dolerite sill. If the integrity of the sill can be maintained during mining there will be minimal inflow of water to the workings and a limited effect on the surface and ground water resources. The inflow will be restricted to the existing faults and dykes which intersect the workings and are fed by surface water bodies. Minor inflows may be possible from the sill's lower contact, specifically at low points.

The colliery has a choice of mining methods, each having a different impact on the overlying strata in terms of induced stress and cracking. Several areas were identified where geological lineaments may connect surface and ground water storage areas to the underground workings. Extra care should be taken in these areas to minimize any mine induced stress, prevent any cracking and sill breakage.

To assess the actual impact of mining on the ground and surface water systems over time, a monitoring programme will be implemented along with an ongoing review of all the monitored data.

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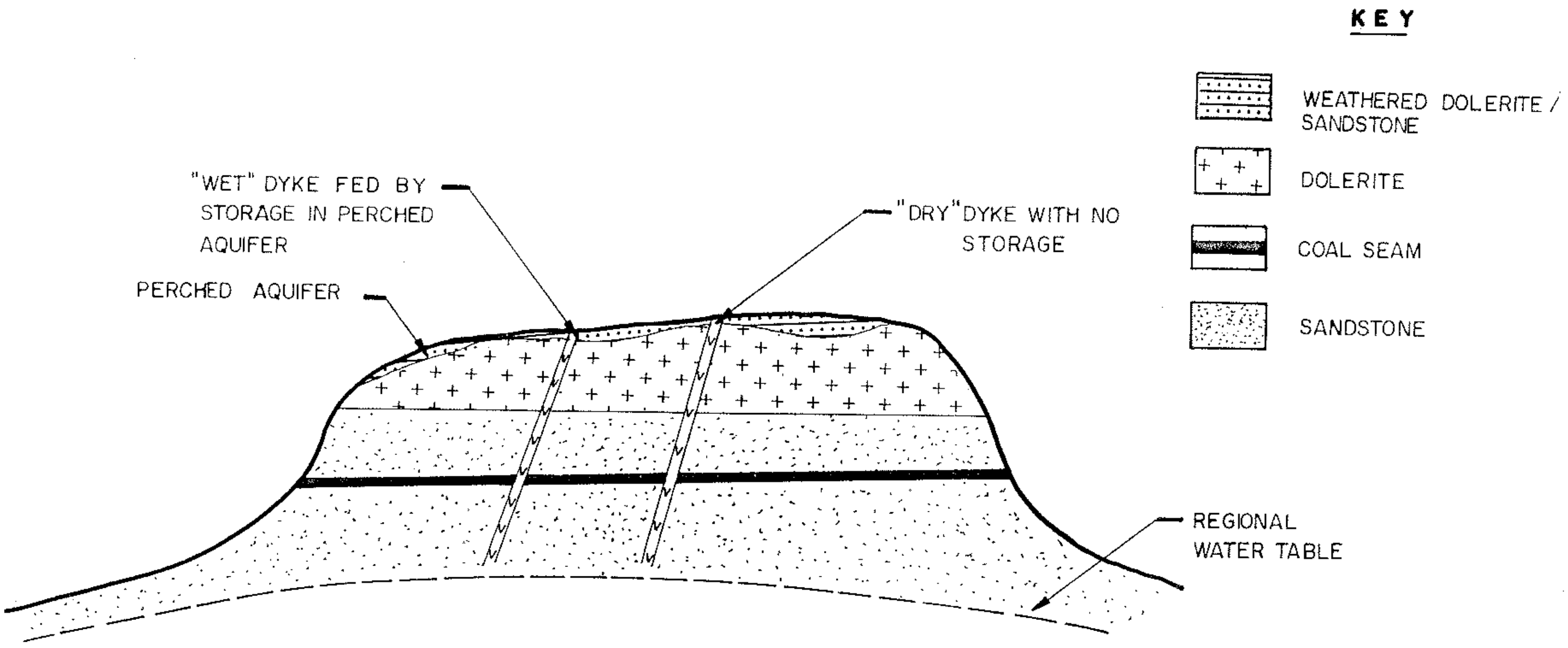

FIG. I SCHEMATIC CROSS SECTION OF PLATEAU

NOT TO SCALE

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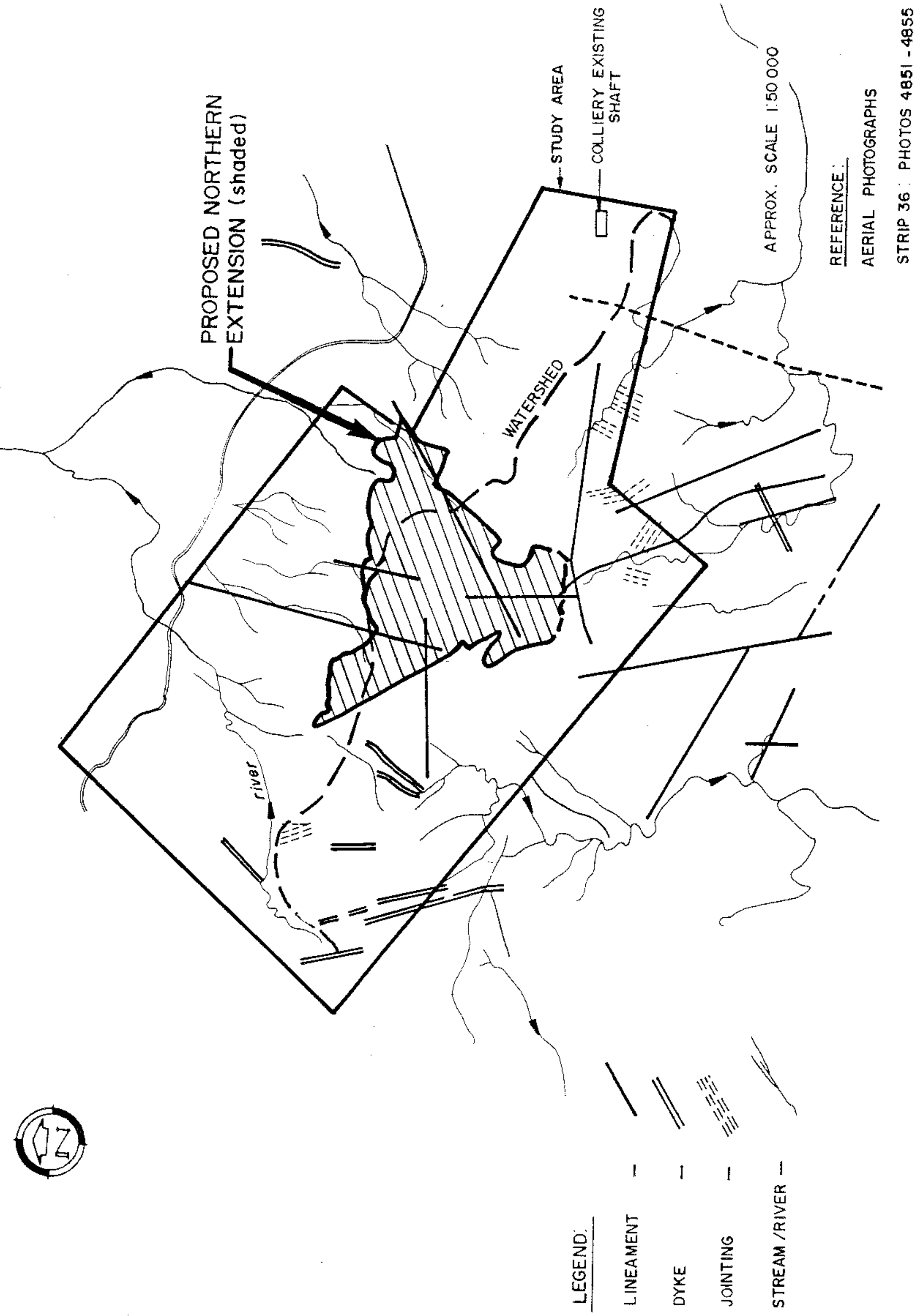

FIG. 2 AERIAL PHOTO INTERPRETATION OF MAJOR STRUCTURAL FEATURES

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