79-EC-EPS-AR-5B3

Environment Canada
Environmental Protection Service

Environnement Canada
Service de la Protection de l'environnement

ENVIRONMENTAL EFFECTS OF SURFACE MINING FOR COAL IN EUROPE SUMMARY OF OBSERVATIONS

Surveillance Report EPS-5-AR-79-3

Atlantic Region

ENVIRONMENTAL PROTECTION SERVICE REPORT SERIES

Surveillance reports present the result of monitoring programs carried out by the Environmental Protection Service. These reports will usually be published on a regular basis.

Other categories in the EPS series include such groups as Regulations, Codes and Protocols; Policy and Planning; Economic and Technical Appraisal; Technology Development; Briefs and Submissions to Public Inquiries; and Environmental Impact and Assessment.

Inquiries pertaining to Environmental Protection Service Reports should be directed to the Environmental Protection Service, Department of the Environment, Halifax, Nova Scotia. B3J 1M5.

ENVIRONMENTAL EFFECTS OF SURFACE MINING FOR COAL IN EUROPE

SUMMARY OF OBSERVATIONS

by

D. A. LORD

Environmental Protection Service
(Atlantic Region)
Halifax, Nova Scotia

June, 1979

EPS-5-AR-79-3

ABSTRACT

Surface mining techniques are presently practiced on a large scale in the United Kingdom and West Germany for the recovery of coal. At all mines visited during 1977, no deleterious environmental effects were observed either during mining or subsequent to mining.

Experience indicates that environmental problems associated with the mining operation itself (noise, dust, water pollution) are able to be controlled to meet all regulatory requirements. In addition, procedures have been developed in both these countries for the complete restoration of mined land and the reclamation of derelict land. Of considerable importance in restoration is the proper handling of soil materials before, during, and after mining, and the establishment of suitable drainage in restored lands. In most cases, careful tending of lands for up to five years after cessation of mining is required to ensure re-establishment of soil profiles and to guarantee complete restoration of use.

Incremental costs associated with restoration seldom exceed 5% of the total coal recovery costs. These costs are more than offset by the improved land value of restored areas, and the public acceptance of surface mining operations.

From an environmental point of view, properly conducted surface mining, including complete restoration of mined lands, provides better safeguards against long term environmental degradation than does underground mining.

RÉSUMÉ

Les techniques de récupération du charbon par l'exploitation minière en surface sont présentement pratiquées de façon intensive au Royaume-Uni et en Allemagne de l'Ouest. Aucun effet nuisible à l'environnement, pendant ou après l'exploitation minière, n'a été observé aux mines visitées.

La pratique nous indique que les problèmes environnementaux, tels que le bruit, la poussière et la pollution de l'eau, normalement associés à l'exploitation minière, peuvent être maîtrisés et rendus conformes aux niveaux réglementaires. De plus, différents procédés ont été mis au point dans ces deux pays afin de restaurer complètement les terres exploitées et de regénérer celles qui ont été laissées en friche. La restauration des terres exploitées dépend largement du traitement que l'on fait subir au sol avant, pendant et après l'exploitation minière. Un système efficace d'assèchement des terres restaurées est également d'une grande importance. Afin d'assurer la restauration du sol et d'en garantir une ré-utilisation complète, un entretien soigné des terres s'est révélé essentiel dans la majorité des cas. L'entretien a dû être effectué pendant une période pouvant aller jusqu'à cinq ans après l'arrêt des activités d'exploitation minière.

Les coûts associés à la restauration des terres dépassent rarement cinq pour cent des coûts totaux de récupération du charbon. Ces coûts sont largement compensés par la valeur marchande accrue des terres restaurées et par l'accueil favorable du public aux opérations minières en surface.

Du point de vue environnemental, les opérations minières en surface, exécutées selon les normes et comprenant la restauration complète des terres exploitées, fournissent de meilleures garanties contre la dégradation environnementale à long terme que l'exploitation minière souterraine.

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

During October, 1977, arrangements were made by the Coal Association of Canada for a group to visit surface coal mining operations in Europe to view mining methods and to inspect restoration and reclamation* procedures. Twenty persons, representing industry and various provincial and federal government agencies in Canada (the bulk of whom were from Western Canada), participated in the tour.

In the two countries visited, West Germany and the United Kingdom, sophisticated restoration and reclamation programs of mined land are practiced. However, the mining practices in the two countries are completely different, this due primarily to the geology of the areas in which coal is surface mined, and the types of coal mined.

In Germany, the bulk of the coal mined by surface methods is soft low-grade lignite, which can occur in seams up to 100 m thick. Overburden is loose unconsolidated material. Both the overburden and coal can be readily excavated. Mines are few in number, are extremely large, and have high rates of production (more than 110 million tons of lignite in 1977). In contrast surface mined coal in the U.K. is high grade anthracite or bituminous occurring entirely in consolidated rock, and generally in narrow seams. As a result, rock overburden must be drilled and blasted to facilitate removal before the coal can be mined. Mines are small but high in number (64 such mines operating in 1977), with total production from these mines being about 12 million tons in 1977.

Footnote:

* In order to avoid ambiguity, the following meanings of these words will be used throughout this report.

Restoration - recreating the original topography and re-establishing the previous land use, as part of the mining operation.

Reclamation - activities other than restoration (including re-establishment of land use patterns on derelict land, and alteration of land use patterns substantially).

2 SURFACE MINING FOR COAL IN WEST GERMANY

2.1 Major Surface Coal Mining Areas

West Germany enjoys vast coal reserves, including lignite (termed "browncoal" in Germany), as well as bituminous and anthracite coal (termed "hard coal"). The bulk of the hard coal is mined using underground methods, while all the lignite is mined using surface mining techniques. Of the 157 x 10^9 tons of lignite reserves in Europe, 60 x 10^9 tons occur in West Germany. Of this 55 x 10^9 tons occur in the Rhineland, and the remainder in Bavaria. The locations of these deposits are shown in Figure 2.1.

In the Rhineland, the massive lignite fields are located in a triangular area between the cities of Cologne, Dusseldorf, and Aachen, extending over an area of 2500 km^2. In Bavaria, deposits are not as extensive and occur in the Schwandorf area. The bulk of this lignite (85% of the 1975 production) is used as a fuel source for thermal power stations and forms an important base for power (27% of W. Germany's power derived from lignite in 1974).

Mining and restoration techniques in these two areas are very similar; any differences will be noted in the following narrative accordingly.

2.2 Planning and Implementation of Mines

In West Germany, private companies own and operate these surface lignite mines for the prime purpose of providing fuel for thermal power stations. These companies undertake the complete planning, mining, and restoration phases of the operations, all of which require prior approval by local planning authorities. Before such an approval is granted, a total operational plan is required to be submitted. Such a plan would address every detail of the operation from start to finish, including the relocation of settlements, details of the mining operation, environmental controls, as well as an

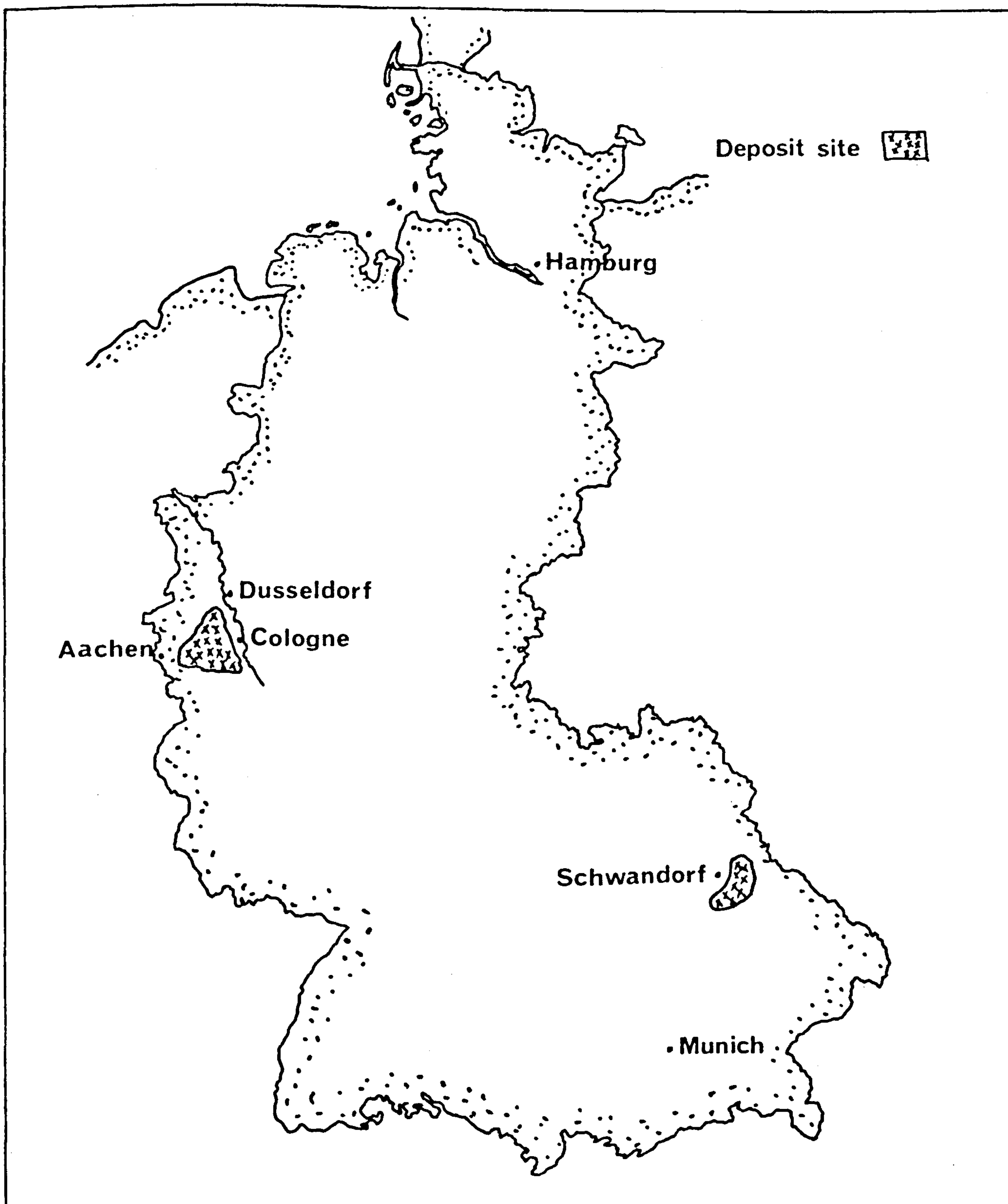

FIGURE 2.1 LOCATION OF LIGNITE DEPOSITS IN WEST GERMANY

ultimate site disposal plan. For ultimate site disposition, nothing less than complete and total restoration is considered acceptable.

Because of the high population densities in mining areas, the proper execution of this planning phase is considered absolutely essential for acceptance by the local population, and, therefore, for the success of the mining operation. In order to fully address all considerations, it is recommended that even with experience, planning should start at least 3-5 years before mining commences. It is during this stage that involved citizens, regulatory authorities, and interested persons participate in various aspects of plan preparation.

2.3 Description of Mining Operation

Areas mined for lignite are overlain with loose unconsolidated material of glacial origin, while the lignite, which is fairly soft and friable, may occur in seams up to 100 m thick. Consequently, removal of overburden and coal is a relatively easy task mechanically, this being performed almost entirely using giant bucket wheel excavators. Excavated material is transported from within the mines on conveyor belt systems. Using these techniques, mining takes place in depths up to 300 m, and mines are being planned to a 500 m depth. Experience indicates that depths greater than 600 m may be economical in the near future.

As mining proceeds and the initial trench dug, mining occurs at one end of the mine, and the overburden removed is then conveyed to the rear of the mine to restore the previously mined area. At the same time the coal is conveyed directly to power stations on conveyor belt systems which may be up to 20 km distant. In this manner these open cast mines progress along the coal seams in the shape of a jagged - V, mining at one end and reclaiming immediately at the other. Figure 2.2 depicts this process, and the types of equipment used.

Depending on the nature of the mine, the entire mining operation over a given point of land (overburden removal, mining, return to original contour) may take anywhere in the order of 1 to 13 years, and is usually at the lower end of this estimate.

2.4 Environmental Controls During Mining

Detailed pre-planning as well as the careful preventive measures taken during the mining operation, ensure that environmental effects observed at these mines are minimal, being reduced primarily to those that are unavoidable (e.g. land disruption during mining).

No noticeable noise problems are generated in the mines due to the absence of haulage vehicles and of drilling and blasting operations. In the past noise was generated by the conveyor systems which are used to transport coal overland to the power stations. This problem was reduced by the selection of suitable materials used in the construction of these conveyor systems (bearings, suspension system) and by providing vegetation or earth mound baffles on either side of the conveyors.

The construction of topsoil banks around the mine sites act as a total visual barrier to the sites, while dust is controlled by the use of water sprayers mounted around the rim of each mine site. These sprayers are operated during dry periods to produce a curtain of spray downwind from the mine site, which effectively damp out the bulk of airborne dust particles. All vehicles leaving the mine site are spray washed to remove dust.

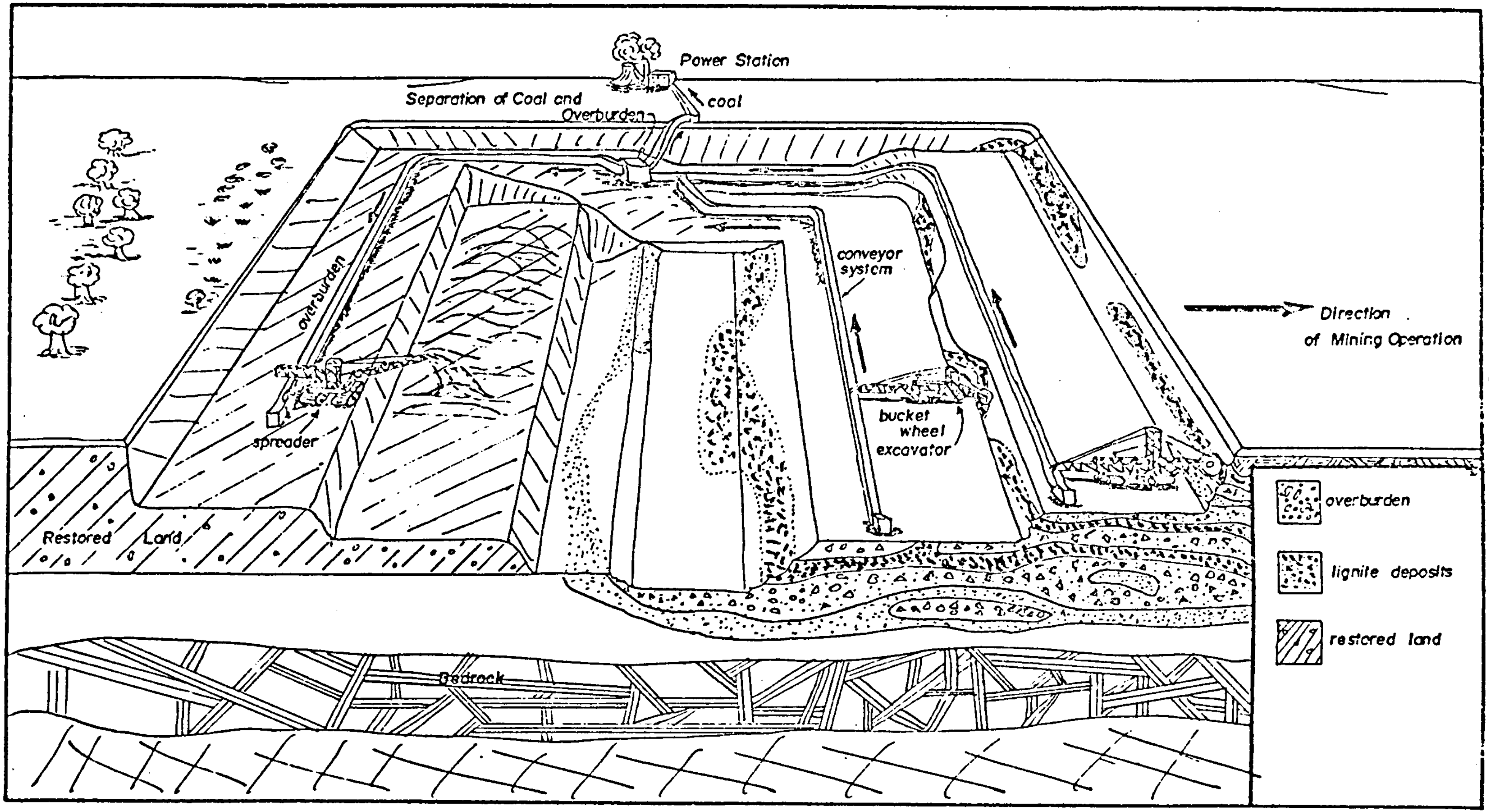

FIGURE 2.2 PICTORIAL REPRESENTATION: OPEN CAST COAL MINE OPERATION WEST GERMANY

Throughout the mining operation, considerable effort is expended to keep the mine sites dry and free from surface water by lowering the water table in the area below the maximum depth of the mine. This is particularly important in order to maintain the mechanical stability of the steeply sloped mine sides. Mine sites are surrounded by wells dug to depths greater than that of the mine, and are continuously drained with the use of submersible pumps. The high soil porosity results in water table depths being lowered for distances of up to 35 km from the mine. However, no adverse effects on agricultural production were reported.

This operation of maintaining a lowered groundwater level requires massive sustained effort, as for example, more than 900 such wells are in permanent operation in the Rhineland area alone. Nonetheless, the elimination of any possibility of contamination of groundwater maintains its quality such that it is allowed to be discharged directly to canal systems. In addition in Northern Germany, minewater is sometimes used as a drinking water supply as it requires far less pretreatment for potable end uses than do waters from the Rhine.

In Bavaria, some pyritic materials are found in the coal seams (coal contains up to 2% sulphur as pyrite). Before discharge, effluents are required to meet guidelines established for the protection of local freshwater streams. These guidelines require discharges to have a minimum pH of 5, and a maximum iron concentration of 15 mg/l. To minimize volumes of water requiring treatment care is taken to separate contaminated mine waters and uncontaminated (particularly surface drainage) waters. Treatment of contaminated waters is by collection of these waters in ponds in areas destined to become lakes as part of the ultimate restoration plan, and subsequent liming to maintain a pH of 7 within the lake. Apparently, once pH levels are established there is no difficulty in maintaining these at a stable level. A vigorous plant growth and a substantial water fowl population was observed in these ponds. At the time of the visit, virtually no discharge of these treated waters had occurred. It will be another ten or more years before lakes will be sufficiently high to overflow. No water quality problems are anticipated at that time.

2.5 Restoration of Mined Lands

Ultimate site disposition plans are formed well in advance of mining and are an integral prerequisite for approval for mining to be obtained.

As previously mentioned, overburden is replaced as part of the mining operation itself, and mining ceases when the mined area has been returned to its agreed contour. At that point, restoration commences. Land may be restored back to agriculture, forestry and recreation, or urban and industrial, with stringency of requirements for topsoil decreasing in that order. All final site disposition plans that were reviewed included a combination of each of these end uses in a properly integrated manner making the fullest use of natural features.

It is worth mentioning here that the lignite removed constitutes 25-30% of the total volume of material from the mine; consequently once mining is complete, insufficient overburden remains to completely fill the mined area. By necessity then, lake areas are generally included in the final site restoration plans, in areas designated for forestry and recreation.

For agricultural end use, topsoil is replaced to a depth as specified in original plans, and planting commences as soon as possible. In the Rhineland which is the prime agricultural area of West Germany, topsoil is required to be replaced to a depth of two metres. In Bavaria, where soil is far poorer quality (30 out of 100 on German scale) topsoil is replaced to only about ten centimetres.

Topsoil may be distributed by 2 methods. In hillier or more contoured areas the topsoil is generally distributed using spreaders or stackers, after which it is levelled by bulldozers. A second method of applying topsoil is by forming a slurry of the topsoil with water, and pumping this mixture into small polder dams prepared on the surface of the overburden. The slurry is then allowed to dry. This method is particularly useful in flatter areas, where, by adjusting the sizes and elevations of these polders, gentle contouring to promote proper drainage can be established.

As soon as topsoil is in place planting commences. For areas to be restored to agriculture, a strict crop rotation system with the addition of fertilizer is practiced to re-establish soil properties and soil profiles. Farms are rapidly established on these lands, and are worked either under contract to the mining company or are repossessed immediately. Equally, areas to be restored to forestry and recreation are planted and worked on appropriately, before being disposed of to communities or local authorities.

2.6 Benefits of Restoration

In the current economic climate where coal is re-emerging as an important fuel, restoration practices have enjoyed greater levels of funding, and have seen tremendous improvements in both quality and intensity of implementation. Coupled with increasing public concern over land use patterns, over the last 25 years, West Germany has developed sufficient expertise and skill to ensure that excellent results with reclamation programs are obtained. In addition, current mining practice has enabled land previously left derelict after surface mining (surface mining for coal has been occurring in West Germany for more than a century) to be fully reclaimed.

The techniques of surface mining are such that any given portion of land is removed from use while being mined for relatively short periods of time (less than 5 years), before being returned to use. Ultimately, no traces of mining are left, and the landscape remaining can be selected to ensure maximum use and versatility of the land. As a result, public attitudes towards surface mining are quite positive, with the realization that the environmental penalty which must be paid for a major undertaking such as a surface mine can be minimized with careful planning, and that ultimate land use patterns subsequent to mining can be selected according to future needs.

3 SURFACE MINING FOR COAL IN THE UNITED KINGDOM

3.1 Open Caste Coal Mining in the United Kingdom

A number of open cast mines were visited in the U.K., primarily in the Northumberland Region, the Nottingham Area, and Southeast Wales. Open cast mining in the U.K. is performed by private operators under contract to the National

Coal Board; in 1977, there being in excess of 60 sites being worked in this manner. Most of the operations are fairly small (less than half a million tons of coal per year), with the total yield of coal by open cast methods in the United Kingdom in 1977, being about 12 million tons. Most of this coal is high grade bituminous or anthracite, occurring primarily in finegrained sedimentary rock (shales, siltstone, mudstones). Mining techniques consist of drilling and blasting, and removal of overburden and coal in trucks. Coal seams of as little as two inches are removed, while seams separated by partings as narrow as one inch are removed separately. As a result, mining is highly manpower and machine consumptive, which is repaid by the excellent price this high grade coal commands. For example, in 1976, the National Coal Board in the U.K. ended the year with a profit of $44 million. The underground mines which produce 85% of Britains' coal, had a deficit of $100 million. Open cast mining, producing only 15% of the total coal, made a profit of $144 million!

3.2 History of Restoration and Reclamation in the United Kingdom

Open cast mining for coal commenced in the U.K. during the 1940's to help meet Britains' energy shortage problems. From the start there was agreement that topsoil removed from farmland would be preserved so that upon completion of workings, it could be replaced on top of the restored overburden. Initial restoration attempts were unsatisfactory, in particular, too thin a layer of topsoil mixed with boulders and rocks prevented thorough cultivation. As a result, land production fell off drastically within a few years.

This experience, and a review of the technical methods then in use resulted in the Ministry of Agriculture generating an improved code of restoration which became effective in 1951. The new code provided for significantly higher standard of restoration, the main provisions being:

(a) The separate stripping, storing and replacement of topsoil (ideally 12 inches) and subsoil (24 inches) on a much more extensive scale at each site, and their replacement over a 3 foot depth of overburden free of broken rock, boulders, shale and blue clay.

(b) A five-year period of management and treatment of restored lands by the Ministry of Agriculture before their release.

(c) The rehabilitation of woodlands, where previously no after-treatment had been given.

(d) The installation of permanent under-drainage on restored land and the replanting of hedges.

Further changes have subsequently been made to these codes of practice, with impressive results continually being obtained from restoration and reclamation programs.

3.3 Planning of Mines

Under the Opencast Coal Act 1958 the National Coal Board cannot work any coal by opencast methods without first obtaining from the Secretary of State an authorization to do so; this is really equivalent to planning permission. Each site must be individually authorized.

Under the formal procedure of the Act, the local planning authority, other local authorities, various ministries and the statutory bodies concerned must be notified of the proposals for working the site. Matters affecting their interests are discussed with them and as far as possible, their requirements are incorporated in the working proposals. It is at this stage that environmental matters are addressed by specific responsible agencies.

When these discussions and negotiations for rights in the land are completed an application for authorization is prepared for submission to the Secretary of State. This is again a formal document and its format is largely prescribed. It consists of three schedules:

(a) The first schedule describes the situation of the site, its extent in acres subdivided in various ownerships, its nature (whether agricultural or otherwise) and details of all buildings, structures and services on, over and under the land.

(b) The second schedule sets out details of the proposed working and includes such items as stripping and segregation of topsoil and subsoil, diversion of streams and services, working hours and the control of blasting.

(c) The third schedule gives details for the restoration of the site after completion of extraction of coal including five years' agricultural rehabilitation.

Once complete, the application is circulated, and provided no major objections are raised (for which a Public Inquiry is mandatory), the authorization to mine is granted.

3.4 Description of the Mining Operation

All work on opencast sites is carried out by contract. The contractor conducts the entire mining operation, under supervision from the Coal Board.

Before mining commences, topsoil and subsoil are stripped from the operational areas and stored. During excavation, any additional suitable soil-making materials found (for example, glacial till), are separated. Topsoil and subsoil are normally stored as mounds close to the perimeter of the mine site, and serve as baffles against noise and dust as well as a visual screen to the site. These mounds are kept grassed during the duration of the site.

Once coaling has been completed, overburden is replaced and the land graded to contour, to await subsoil and topsoil addition. Coal removed from these mines generally comprises less than 10% of the total volume of the mine. Rock removed has a bulking factor usually in excess of 1.2. As a result, at most sites, the resultant land form will not differ greatly from the original contour. In fact, the bulking of the overburden allows land contours to be slightly exagerated, ultimately leading to better drainage; an important asset in flat poorly drained lands such as North East England.

Before subsoil is replaced, overburden is scarified to break up surface compaction caused by the passage of heavy vehicles. The previously saved and stacked subsoil is then replaced to a depth of at least 46 cm (18 inches), after which it too is thoroughly rooted to remove stones and other large objects. Finally, the topsoil is replaced accordingly.

All officials continually stressed the importance of careful handling of topsoil and subsoil, particularly to ensure that no loss or mixing of topsoil, subsoil, and overburden occurs during stripping, and to ensure that a proper distribution of soils is replaced to ensure the establishment of good drainage and a suitable soil profile. The ultimate successful establishment of growth is highly dependent on these operations being properly carried out. As a result, these works are normally only undertaken in dry weather under constant supervision. Should surface ponding occur (a sign of poor drainage) on any reclaimed land, these areas are immediately stripped and regraded.

With topsoiling completion, restoration by the site contractor is complete, and the site is handed over to the Ministry of Agriculture to commence a five-year period of agricultural rehabilitation.

3.5 Environmental Controls During Mining

During the mining operation, environmental controls are exercised particularly towards noise and dust suppression, and to the treatment of any water discharged from the mine property.

Noise is kept to a minimum level within the mine itself by fitting all machinery with oversize mufflers, and by appropriately timing louder activities such as drilling and blasting. Mounds around mine sites further contribute towards sound baffling. With the proper application of these controls, measurements conducted by local regulatory authorities showed that at none of the mine sites visited did the noise level in the mine exceed that of local traffic.

Dust suppression during dry weather is maintained using bowser trucks in the mine, and all vehicles leaving a minesite (especially haulage trucks) are spraycleaned with water at the point of departure.

Effluent guidelines are established during the planning stages of the mining operation by regional Water Authorities, and include three parameters; pH, suspended solids, and total iron. For discharges to freshwater, pH levels are required to be in excess of 6, maximum suspended solids loads allowed vary from 25 to 200 ppm depending on the sensitivity of the receiving waters, while total Fe levels in the final effluent are restricted to maxima from 7-15 mg/l. For mines discharging to marine environments, only total suspended solids are controlled. For example, at the Butterwell operating site, which discharges effluent into the North Sea, the only effluent component regulated is total suspended solids (max. 200 mg/l).

It is not possible to maintain dry conditions in mines such as these, and minewaters are generally collected at the base of the excavated mine, before being pumped to the surface for treatment. The amount of surface water entering the mine is reduced to a minimum, in particular, by diverting surface waters away from the perimeter of the mine workings.

Treatment of minewater to meet guidelines usually involved no more than passing the effluent through a series of small settling ponds, with the addition of flocculent (alum) and lime when required. No serious acid mine drainage problems were encountered, due in part to the efficient control of drainage and rapid treatment of impounded waters, minimizing contact time with any sulphidic materials.

3.6 Restoration of Mined Lands

Ultimate restoration of lands is conducted by the Ministry of Agriculture, over a minimum of five years. With the bulk of land in the U.K. being of low permeability and moderate to poor farming quality (Grade iii or lower out of vi), adequate drainage is stressed as one of the most important aspects to be considered.

At the commencement of restoration, drainage from the site is by open ditches and the use of natural water-courses which serve to collect and remove surface water, but which have no effect in controlling the water table within the land. If land is being restored to grassland or agriculture, a comprehensive system of crop rotation is followed, which includes extensive fertilization and liming. During the spring of the fourth or fifth year, by which time a stable soil profile has been established, a complete system of under-drainage is installed which is led to properly constructed ditching. During this period the land may be worked or grazed under contract to farmers.

Restoration to woodland is only undertaken to any significant extent in South Wales. The selection of species to be planted depends on a variety of factors including slope of land, precipitation, and proximity to significant sources of atmospheric pollution. Deciduous trees are included in most plantings, particularly grey and common alder which establish themselves rapidly. More recently, considerable success has been achieved with direct planting of coniferous trees, particularly lodgepole pine. Generally heavy fertilization and liming of land is required prior to planting to ensure successful establishment of vegetation.

3.7 Benefits of Restoration

Unlike most industrial operations, opencast workings involve only temporary occupation of land which is then fully restored on completion of mining. Planning, implementation and restoration of these opencast mines has come under tremendous public scrutiny within the last decade, this concern no doubt assisting regulatory authorities and planning bodies in ensuring appropriate protective measures are followed.

Most of the dereliction of land in the U.K. as a result of coal mining, has been from underground mining, from poor practices for more than a century, such as the storage of waste piles on the surface with no runoff control, and from the subsidence of underground workings. Opencast mining frequently occurs in these areas of dereliction and the clearing and reclamation of derelict land has become an integral part of the opencast mining operation, and at little extra cost. This was particularly noticeable in South Wales, where spoil tips, which are unsightly and dangerous because of a tendency to slide downhill, and are environmentally degrading (as they are sterile and allow long term leaching of toxicants) are systematically being recontoured, back-filled, and reclaimed.

4 SUMMARY AND CONCLUSIONS

In Europe, surface mining for the extraction of coal is becoming an increasingly attractive method of exploiting this resource. The development of heavy and specialized machinery is enabling surface mining to be undertaken at depths greater than 500 m, substantially increasing the amount of coal exploitable. Surface mining techniques enable smaller mines to be economically operated and narrow seams to be mined, while coal recovery is total (100%) as compared to rates of 50-60% normally associated with underground mining.

The prime motivating factors which have led to this sophisticated approach to surface mining are both economic and legislative. According to figures supplied by the National Coal Board (U.K.) and by Rheinbrau (W. Germany), incremental costs associated with restoration seldom exceed

5% of the coal recovery costs. High land values in Europe, particular in mining areas close to habitation, further encourages restoration to full use to recover initial costs.

Legislative procedures are in place in both the U.K. and W. Germany to ensure adequate restoration, while public involvement at all stages of planning restoration programs is considerable.

In Canada by comparison, the same social pressures, legislative requirements and economic advantages are not as developed or as persuasive. Legislative requirements relating to land use is primarily a provincial jurisdiction, and in the provinces where such mining activities are undertaken, considerable advances have been made in recent years increasing restoration requirements for new mines. However, differences in the stringencies of various provincial requirements exist, while minimal attention is being paid to derelict mines.

In general, surface coal mines in Canada are situated distant from dense habitation. Property values are usually low with little opportunity for cost recovery after mining, while land use patterns prior to mining are frequently wilderness or recreation. This situation is changing in Alberta and Saskatchewan. The proper restoration of some of these areas is complex, and is hindered by harsh climatic conditions, inaccessibility, as well as lack of suitable soil making material to promote vegetative growth. Despite these disadvantages, incremental costs for restoration of surface mines is still relatively low, estimates being generally in the order 2-10% of coal recovery costs.

From an environmental point of view, properly conducted surface mining activities have minimal environmental effects during mining, and should result in no permanent environmental degradation after restoration has been completed. Implicit in this statement is the understanding that mining includes restoration. In fact, surface mining can provide better safeguards against long term environmental degradation than underground mining. Unresolvable problems traditionally associated with deep mining, such as storage of waste rock, sealing of underground workings and subsidence in excavated areas are all avoided.