POWER PLANT WASTES DISPOSAL IN SURFACE MINES

Z. GODLEWSKI,J.LIBICKI,L. SEWERYN,B. WOJTKOWIAK

POLTEGOR-engineering Ltd.,
Powstańców Śląskich 95
53-332 Wrocław
POLAND

ABSTRACT

Lignite-based electric energy production results in obtaining by-products such as fly ash and bottom ash, which is 9-10 percent of fired lignite. In power stations provided with flue gas desulpherization facilities, gypsum is also obtained. Use of fly ash or gypsum for construction and agriculture is possible to very small extent only. Most of wastes must be disposed on special designed sites providing ground water protection against pollution.

The paper presents the alternative methods of the above waste disposal with the main aim - ground water protection. The following methods will be discussed in the paper:

- waste disposal on spoil dumps below and above ground water table, to be recovered after some times,
- waste disposal on the ground surface,
- various measures of wastes insulation providing ground water protection.

INTRODUCTION

Lignite – based electric energy production results in obtain by–products, such as fly ash and bottom ash. In power stations provided with flue gas desulphurization facilities, gypsum is also obtained. However, a major volume of wastes to be managed is fly ash and bottom ash, which are 9-10 percent of fired lignite.

Large amounts of fly ash and bottom ash produced at one point bring about that the only method of their management is storage. Practical methods of ash management for construction or agriculture used in this country and world-wide allow to make use of their inconsiderable portion only (from 10 to 20 percent at most). The remaining portion of ashes must be disposed on special isolated sites.

LIGNITE – FIRED POWER PLANT WASTES DISPOSAL METHODS AND TECHNOLOGIES

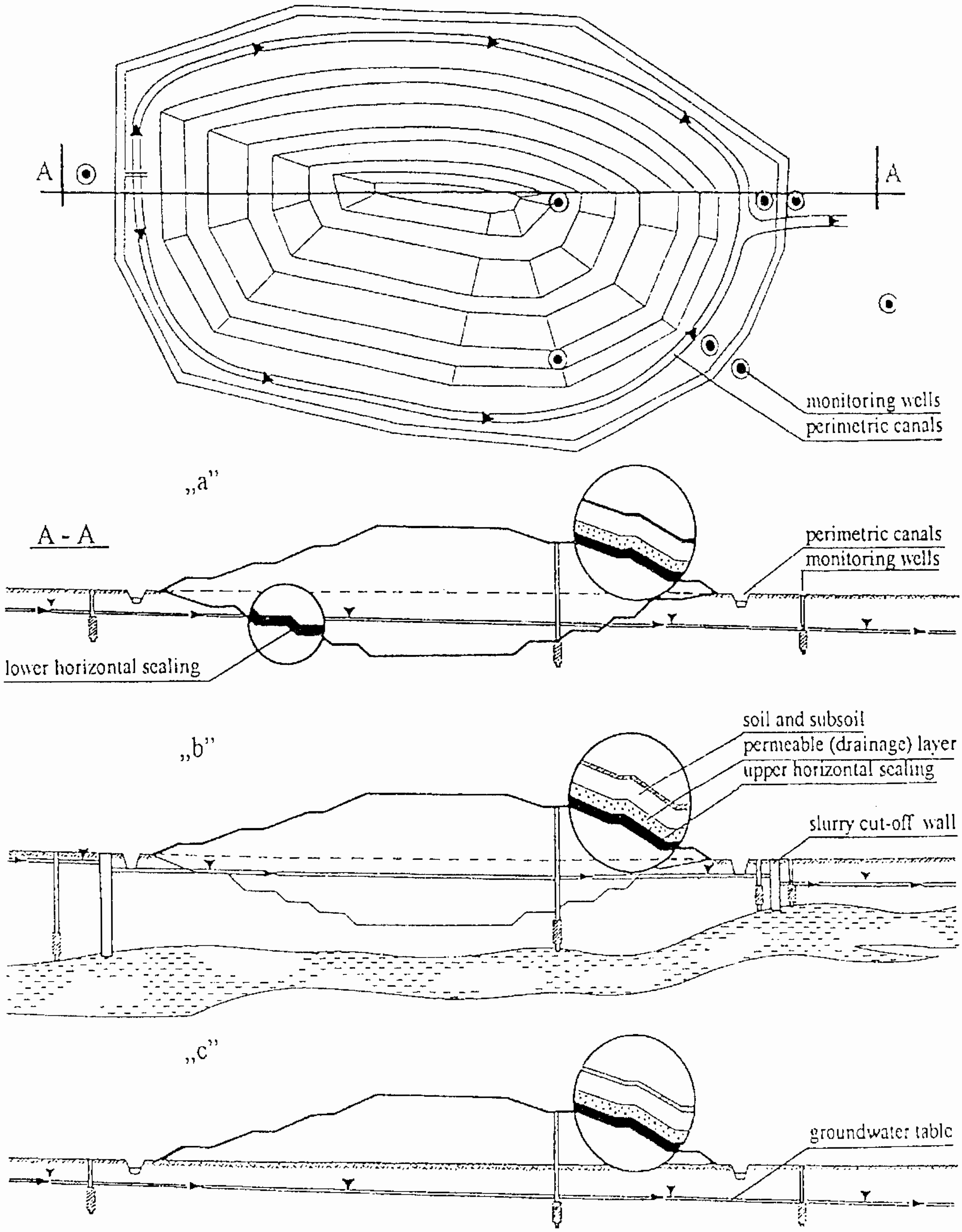
In the recent Polish practice, most of power plant wastes was dumped by a hydraulic methods on high–disposal (Konin, Pątnów, Belchatów Power Plant's) or low disposal (e.g. in the final excavation of Adamów Open Pit) dumping sites and also, in a separated portion of Adamów Open Pit.

Another method has only been used from the very beginning in Turów Power Plant – fly ash and bottom ash are here disposed mixed with the overburden on external dumping site. Joint ashes and overburden dumping technology is also used now in Belchatów Lignite Mine, but on the internal dumping site only.

Good land for fly ash disposal effect that at present, design work is run to a change power plant wastes disposal sites, or with a change of disposal technology in the following power plants:

Pątnów Power Plant –	hydraulic or dry disposal as a suspension or stablisate, respectively, within area of Pątnów Open Pit internal dumping site, starting from 2000, or so;
Turów Power Plant –	dry disposal of ashes wetted and conditioned at Turów Open Pit, after 1998;
Belchatów Power Plant –	Options used to protect water environment against pollution are shown in fig. 1. They depend on a degree of wastes harmfulness and on the location of disposal site relative to aquifers.

Problems associated with the impact of power plant wastes disposal methods on water environment, evolution of used options and protection methods have been discussed in the paper taking Belchatów Power Plant and Surface Mine as example.



a) disposal below groundwater table
b) disposal below groundwater table
c) disposal above groundwater table

Figure 1: Groundwater protection

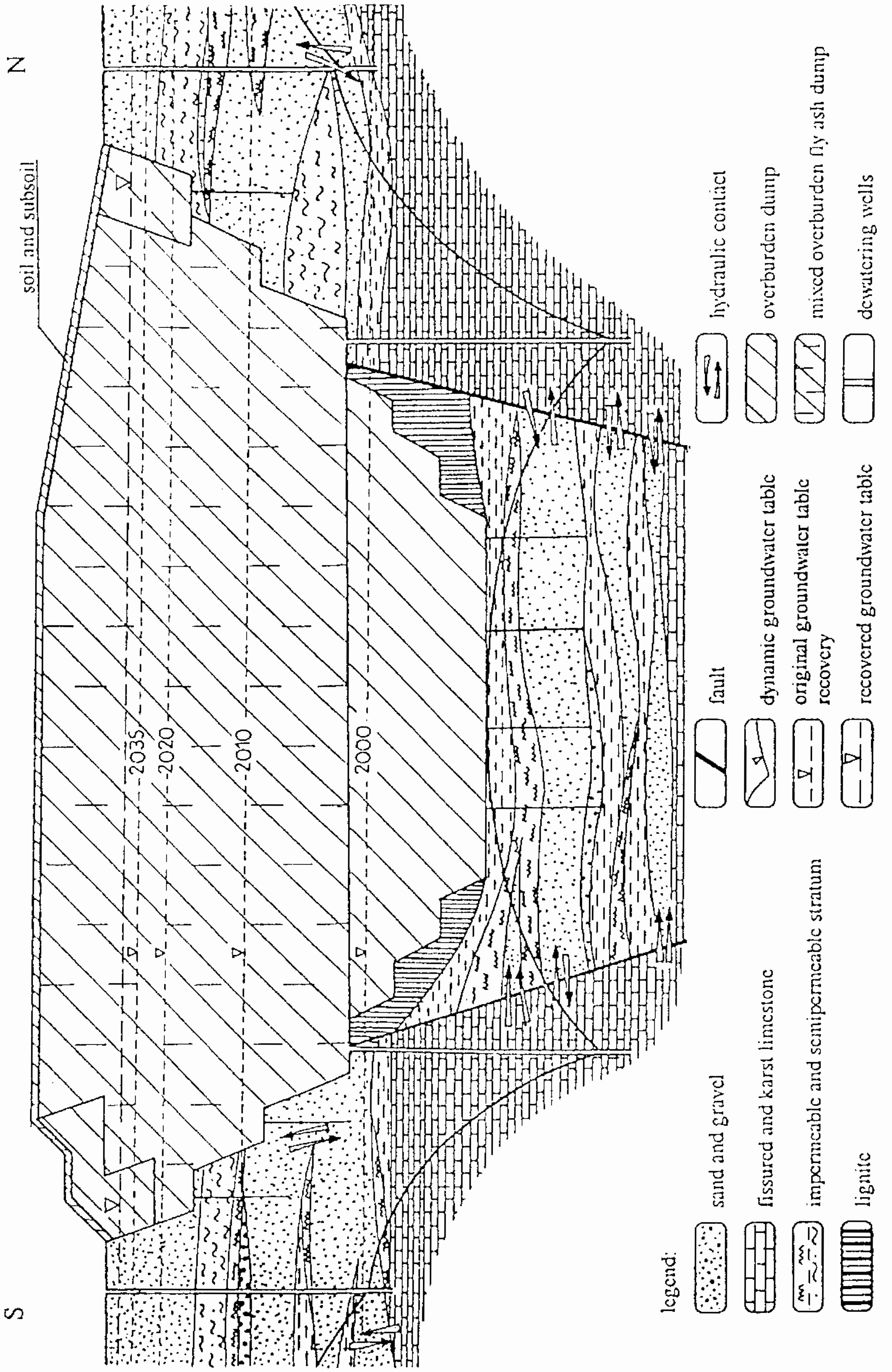


Figure 2: Hydrogeological section of Belchatów Lignite Mine internal dump. Present fly ash disposal.

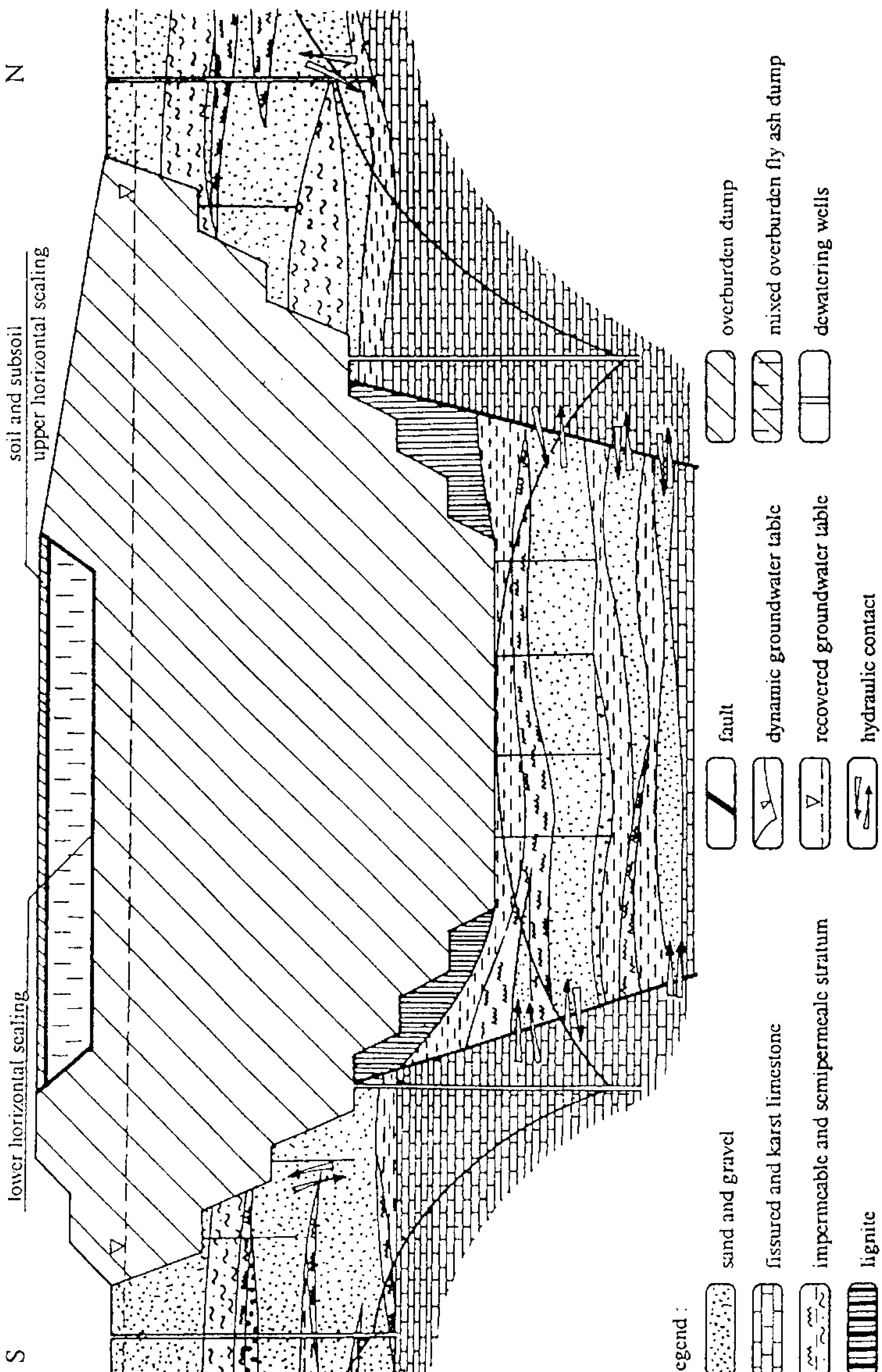


Figure: 3 Hydrogeological section of Bełchatów Lignite Mine internal dump. Future fly ash disposal.

HAZARDS TO WATER QUALITY AND PROTECTIVE MEASURES USED ON BEŁCHATÓW POWER PLANT WASTES DISPOSAL SITES

Yearly fly ash and bottom ash fallout from Bełchatów Power Plant varies between 3.3 and 4.6 million Mg. These wastes were wholly located on Lubień disposal site with a hydrotransport method. Due to a considerable filling of this disposal site and nuisance for natural environment, it was necessary to limit its operation and find a new place for wastes disposal. The other disposal technology used since the second half of 1993 consists in that fly ash is mixed with the overburden and disposed on Bełchatów Open Pit internal dumping site on three uppermost dumping benches. On Lubie dis-posal site, the whole bottom ash fallout and, in emergency, fly ash is still disposed hydraulically.

The main components of furnace wastes (fly ash and bottom ash) are aluminium silicate (about 70 percent) and calcium oxide (from 10 to 20 percent). The trace elements (Cd., Cr, Cu, Mn, Ni, Sr, Pb, Zn, F) are encountered in small amounts. The solubler content in wastes is about 3 % on the average, and main components passing into the water are calcium and sulphate ions. Despite low TDS content in the wastes, factors decisive of hazardous impact on underground waters are mostly amount of wastes and method of their disposal.

Apart from ashes the products from FGD process are also obtained. With a „wet" technology in use, the prevailing component is gypsum $CaSO_4\ 2H_2O$ (more then 95 percent). Independently from plans of making commercial use of this material, a reservoir has been prepared for its disposal on the top of Bełchatów Open Pit external dump.

An additional problem is utilisation of power plant waste water (mostly sewage from water treatment plant after neutralisation, industrial wastewater and desalting products from cooling tower). At present, they are used in the hydrotransport system of bottom ash to Lubie disposal site. Such a wastewater is produced at a rate of about 700 m^3/h, and its average quality is characterised by the TDS, sulphate and chloride contents which vary between 4500-5500 mg/dm^3, 600 and 700 mg SO_4/dm^3, 800 and 1000 mg Cl/dm^3, respectively.

Lubień Disposal Site

The disposal is located on the Northern side of Bełchatów Open Pit at a distance of about 200 m from gallery of dewatering wells. It consists now of four settling ponds with a total area of about 440 ha. The site has been established in a local land depression from where water was flowing by nature towards the valley of Widawka River. The surface waters were contacted here with shallow Quaternary aquifer and also, with lower aquifers.

Some 65 mill m^3 of ashes have been disposed on this site until now. During the disposal process, about 50 m^3/min of oversediment water is infiltrating into the base of disposal site: It contains 1260 mg/dm^3 of TDS, 160 mg of SO_4/dm^3 and 80 mg of Cl/dm^3, against the natural water clarity TDS content 300 mg/dm^3, sulphate content 40 mg SO_4/dm^3 and chloride content 15 mg Cl/dm^3.

The area of disposal site is within the impact of mine dewatering operations which resulted in that the direction of groundwater flow has been changed to the South i.e. to the dewatering system.

Under present-day circumstances, the water environment protection against pollution of this disposal site can only consist in as quick as possible completion of disposal operation and in its sealing and reclamation. The safety measures should include shaping of the surface and reclamation in such a way that rainwater infiltration is limited to a minimum extent. Consequently, the disposal site impact would be minimalised. To avoid completely the disposal site impact it will be necessary to cover its surface by an impermeable material (see protective measures shown in fig. 1). This problem should be ultimately solved shortly.

Disposal on Bełchatów Open Pit Internal Dumping Site

Presently, the ash is disposed non–selectively on three uppermost dumping benches, fig. 2. The total amount of disposed ashes is about 6.6 mill m^3. The pollution of water will run in two phases:

- until year 2001, or so – in the zone above groundwater table where pollutants would be leached by rainwater only,
- after year 2001 – partially below recovered underground water table due to pollutants migration in the aquifers, with still continuing leaching by rainwater.

The range of water saturated zone of the internal dump body will extend every year as a result of groundwater regression. Until 2020, about 40 percent of soil–ash mixture will be within the recovered aquifer. Full regression of groundwater table will occur not before 2060, or so and then approx. 75 percent of ashes mixed with the overburden will be below groundwater table.

The groundwater pollution will mostly be manifested by an increased TDS content up–to about 2140 mg/dm^3; heavy metals could be leached in trace amounts. After 2010, or so, the pollutants can occur in the water pumped from the mine dewatering system and on completion of open pit operations, in the water reservoir which will be in the abandoned open pit.

The transitional technology (in the years 1993-2000) of ash disposal by mixing with the overburden provides no practical possibility to avoid pollution of groundwater. However this impact will be limited by making changes in the structure of ashes (conditioning) before their disposal so as to minimise leaching process.

Different procedures have been applied for building new waste disposal on the crown surface the dump site. In each considered alternatives, it is assumed to use power plant waste water for production of emulate, granulation or hydrotransport. The disposal site will be covered by 3 m thick overburden layer including forest reclamation.

The reservoir for power plant wastes is located on the bench formed at a height of about 20 m above ground level, fig. 3. Therefore, wastes disposed in the reservoir will always remain above groundwater table. The base and slopes of reservoir are made from the overburden formations where sands are prevailing, and the dump as a whole is water–permeable. Water from the rainfall will only flow through the wastes and consequently, it would be possible to pollute ground water as a result of two types of leaching:

- leaching limited in time for the storage period, but of a high intensity depending on the disposal technology (process water and rainwater being in contact with the wastes without any restrictions),
- leaching of low intensity, but long–lasting, for decades after completion of disposal.

In this case to avoid pollution the reservoirs on the dump top are to be sealed bottom and on slopes by making a watertight liner on the dump top (protective measures shown in fig. 1a or 1 c).

Gypsum Disposal on Bełchatów Open Pit External Dumping Site

A problem of disposal of gypsum from FGD process in Bełchatów Power Plant has been solved by location of this disposal site in a reservoir on the external dump top which is about 150 m above ground level. A direct basement soil for gypsum disposal is material of external dumping site, i.e. sandy overburden. Gypsum will be disposed on two benches of the dump with total capacity of about 3.7 mill m^3.

Owing to the location of gypsum disposal site on the top of external dump, possible contact of disposed material with ground water has been avoided and thus, harmful substances will not penetrate directly into this water. The impact of disposal can only be manifested by the leaching of pollutants by rainwater. Due to flowing through the gypsum, water would increase its TDS content up to 2200 mg/dm^3, and sulphate and chloride contents would be increased up to 1450 mg SO_4/dm^3 and 4.5 mg Cl/dm^3, respectively. The pollutants would move down through the dump vertically during the period of some 15 years and then, towards the aquifer.

A package of measures has been predicted to limit pollution of the water environment. A main one will consist in making on the top of disposal site, directly after the dumping face, a watertight liner along with the draining layer land reclamation on the top and slopes (as shown in fig. 1 c). They also include soil compacting at the base of gypsum disposal, and drains and ditches to intercept water after being in contact with gypsum during the storage.

MONITORING OF DISPOSALS IMPACT ON WATER ENVIRONMENT

To control impact of waste disposals on the water environment a monitoring system of ground and surface waters and also mine water is carried out. Each of disposals has its own local observation system which is a part of the Bełchatów Open Pit external monitoring network. It comprises 679 monitoring wells (for groundwater) and 80 monitoring stations of surface water, including mine water, too.

The water environment monitoring includes:

- ground water table head measurements,
- quality tests of ground and surface waters including mine water,
- special site and laboratory tests related to the specific nature of waste disposals.

Lubień Waste Disposal

The ground water monitor system consists of 12 wells of depth down to 50 m situated around the disposal site at a distance ranging from 50 to 350 m. Furthermore, at the base of waste disposal site embankments, there are located shallow control piezometric tubes which allow to control quality of the above–deposit water seeping through the embankments.

Scope of measurements and tests:

- ground water table head is measured four times a year,
- quality tests of water samples are made also four times a year.

Physical properties, anions, cations and heavy metals – thirty eight features in total are determined each time.

Waste Disposal on Belchatów Open Pit Internal Dumping Site

The groundwater observation system incorporates eleven facilities - eight piezometers and three drainage wells all being a part of observation networks of the mine. The surface water observation system includes thirteen control stations. The observation wells 160 to 260 m deep are located North, East and South of dumping site. The drainage wells are situated at the bottom of the open pit, on the Western side of dumping site, along the underground water flow direction. The surface water is controlled in pumping stations at the open pit, in ditches and channels and also, in rivers which receive mine water.

Scope of measurements and tests covers:

- groundwater table head measurements once a month,
- quality of water extracts from ashes twice a year.

Fourty six components are determined each time.

Gypsum Disposal on Belchatów Open Pit External Dumping Site

The ground water observation system consists of six piezometers being a part of the external observation network of the mine. The surface water is monitored at eight control stations.

The monitory wells of depth ranging from 30 to 200 m are located within the disposal site and in its vicinity at a distance from 30 to 500 m. The surface water measurement–control stations are located on the disposal site and an the ditches of surface drainage within dumping site.

Scope of measurements and tests:

- ground water table head is measured three times per year,
- chemical tests of water samples are performed eight times per year,
- leachate tests at the site station once a month.

Physical properties, selected anions and cations, and some heavy metals; thirty six determinations are performed each time.

The results of all tests together with and short–term forecasts of possible solution as well, are presented in the yearly reports.

CONCLUSIONS

1. The power plant wastes disposal within the open pits and within the overburden dumps is advantageous because it does not bring about new land.
2. The nuisance of power plant wastes for the environment is the case when they are disposed without appropriate protective measures, or when technological possibilities (e.g. emulgates) have not been utilised, and natural conditions (impermeable bed) have not been turned in advantage.
3. The technical and technological solutions of water environment protection presented in the paper provide an essential reduction of ash and gypsum impact on the ground and surface water quality.