Conceptual dewatering project for closed hard-coal mines of the Sosnowiec sub-system

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Abstract. The paper presents the results of studies carried on in the frame of conceptual, multi-variant dewatering project for the hard-coal mines of the so-called Sosnowiec sub-system. The project ensures the safety existence of the adjacent mines. Several hydrogeological and mining-engineering factors have been taken into consideration, the multi-year inflow statistics were analyzed for the individual mines together with the technical conditions of existing dewatering systems and hydraulic connections between the mines.

The project contains the concept of an in-coming dewatering system of the Sosnowiec Mine referred to the changes in dewatering systems of the Saturn and Paris mines, and to the results of closure of the Porąbka-Klimontów Mine.

The mathematical model was applied to calculate the prognosed inflow rates. Results of three selected variants were characterized in details and preliminary timing of mine flooding was calculated.

The best solution of dewatering problem of the mines belonging to the so-called Sosnowiec sub-system is the variant 1. In comparison with the current system, the solution proposes the replacement of stationary dewatering installations at the Paris, Sosnowiec and Porąbka-Klimontów mines by the submersible pumps installed in the shafts. The main dewatering system of the Kazimierz-Juliusz Mine would remain unchanged.

The volume of waters derived from the regional dewatering of mines and discharged to surficial flows will decrease. Also the costs of dewatering of the closed and remediated mines will be significantly reduced. The submersible pumping system will enable the reduction of the staff which will be employed on the surface and the ventilation of closed mine will be eliminated.

1 INTRODUCTION

The conceptual project of dewatering of the Sosnowiec Mine and adjacent mines belonging to the co-called "Sosnowiec sub-system" is a successive stage of the implementation of the grant No. 9T12A03896C/3006 entitled "Central dewatering system of closed mines in the northern and northeastern parts of the Upper Silesian Coal Basin with the reference to safety operation of the working mines". The project has been run at the University of Mining & Metallurgy in Kraków. The proposed dewatering system includes several mines in the region: Saturn, Siemianowice, Jowisz, Grodziec, Paryż, Sosnowiec, Porąbka-Klimontów and Kazimierz-Juliusz. After completion of the grant the new events have taken place which significantly affected the proposed solutions. The principal factor

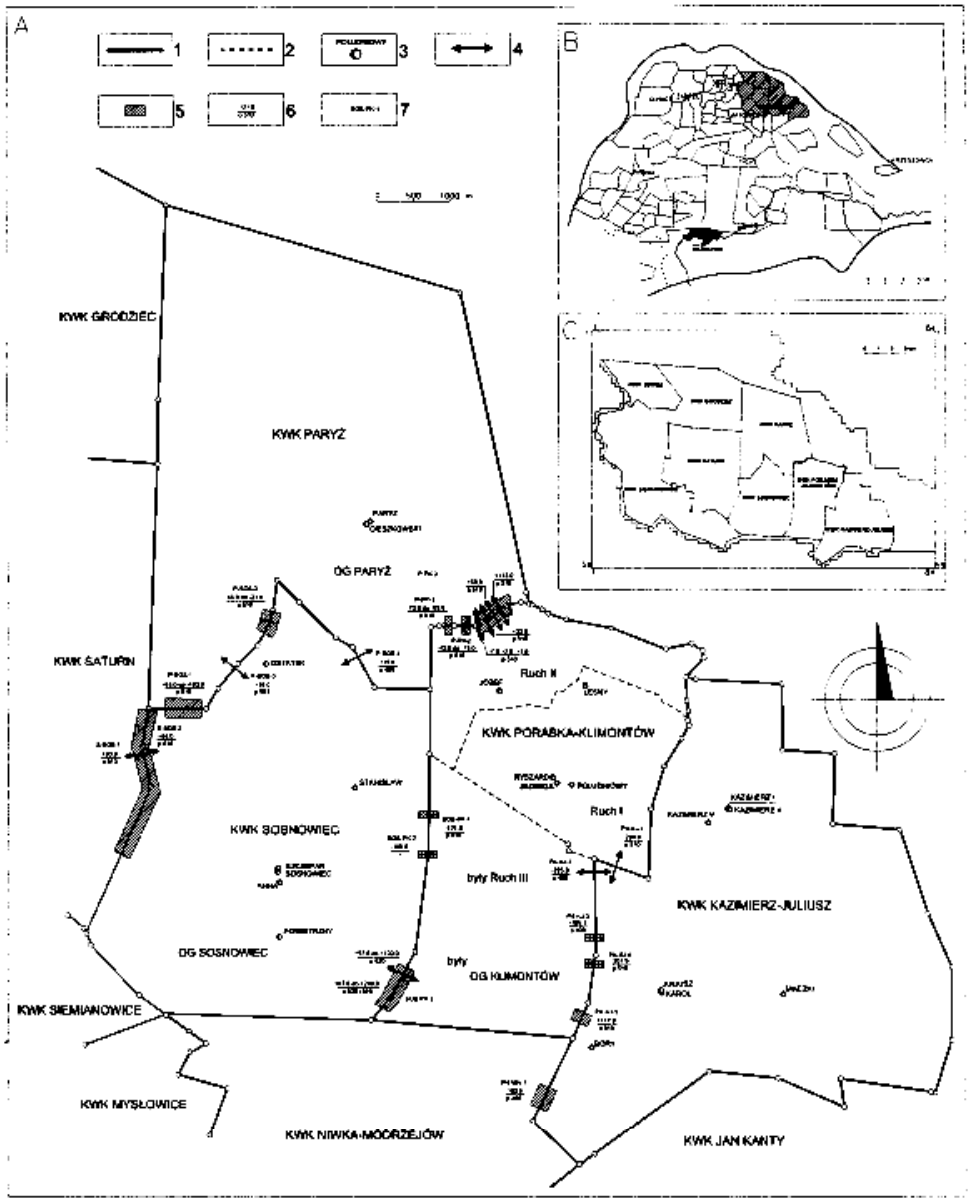

Figure 1. Map of the mines belonging to the Sosnowiec sub-system (A) with the localization in the Upper Silesian Coal Basin (B) and subdivision into calculation blocks (C):

1 – boundaries of mine areas, 2 – boundaries of mining fields, 3 – shafts, 4 – direct hydraulic connections, 5 – indirect hydraulic connections, 6 – altitude of connection in meters a.s.l. and the number of coal seam, 7 – symbol of connection.

was the decision of the closure of Grodziec Mine, which was made at the General Meeting of the Owners on June 30, 1998. This decision provided a chance to simplify the dewatering system proposed in the grant final report.

The project presented below is, to some extent, a continuation and extension of the multivariant "Project of conceptual dewatering model of the Saturn Mine and adjacent mines belonging to the so-called Saturn sub-system (Szczepański et al., 1998b). The project combines dewatering of the Sosnowiec Mine with the changes in dewatering systems of the Saturn and Paris mines, and refers it to the closure and remediation works run at the Porąbka-Klimontów Mine.

2 GENERAL ASSUMPTIONS

1. If the proposed concept is applied the dewatering systems of the Sosnowiec Mine should be based upon submersible pumps installed in the selected shafts.
2. Water table rise at the Sosnowiec and adjacent mines must not cause the water hazard in any of the operating mines.
3. The existing infrastructure should be a decisive factor in selection of equipment and objects.
4. The solution proposed for the Sosnowiec sub-system should take into consideration the applied dewatering system of adjacent mines run in the frame of the "Saturn sub-system" (Adamczyk et al., 2000).
5. Solutions proposed for both sub-systems should enable the development of in-coming central dewatering system (Szczepański et al., 1998b).

3 GENERAL TECHNICAL CHARACTERIZATION OF CENTRAL DEWATERING SYSTEMS OF THE SOSNOWIEC SUB-SYSTEM

Basing upon the present field observations made in the second half of 1998, inflows to the Sosnowiec sub-system mines: Sosnowiec, Paris, Porąbka-Klimontów and Kazimierz-Juliusz are listed in Table 1.

The Sosnowiec Mine

The Sosnowiec Mine has a single, stationary, main dewatering system located at the mining level 450 meters (data for December 31, 1998) (Figure 2).

Waters inflowing to the 280-meters level are transferred with pipeline through the Anna Shaft down to the water galleries at the 450-meters level. The main dewatering system uses the pump station located at the shaft bottom of 450-meters level. The station has 11 pumps of deliveries 7.5 m^3/min each.

From the pump station at 450-meters level water is pumped to the surface through the two pipelines in the Szczepan Shaft and one in the Anna Shaft. At the surface all three pipelines are connected to a single collector which discharges waters into the settlement pond and then to the Czarna Przemsza River.

The Paris Mine
In the vicinity of the Cieszkowski Shaft the pump chamber called "XVI stage" is localized. The pumps of rated output 45 m^3/min drain the 250-meters level. Waters are pumped to the surface through the Paris Shaft.

Table 1. Inflow rates to the studied mines for proposed dewatering variants

Mine	Period	Measured natural inflow rates	Variant 0 (balanced)	Variant 1	Variant 2	Variant 3
		m^3/min				
Jowisz	I-VI 1998	1.62	1.64	0.66	0.67	0.68
Siemianowice	I-VI 1998	22.70	22.52	23.64	23.67	23.73
Grodziec	I-VI 1998	7.00	6.82	3.87	3.88	3.90
Saturn	I-VI 1998	35.48	35.88	36.91	37.49	37.75
Paris	VII-XII 1998	13.80	14.00	13.85	13.00	13.23
Sosnowiec	VII-XII 1998	9.30	9.48	9.09	9.22	7.79
Porąbka-Klimontów	VII-XII 1998	3.90	4.11	4.52	4.59	5.36
Kazimierz-Juliusz	VII-XII 1998	4.10	4.15	4.89	4.89	4.98
Total		**97.90**	**98.60**	**97.43**	**97.41**	**97.42**

The pump chamber receives also waters from the auxiliary station located in No. 49 Incline, at altitude -70 meters above sea level (a.s.l.) (sub-level part). Dewatering of this incline must be continued due to the safety operation of the adjacent Porąbka-Klimontów Mine which is in directly hydraulic connection with the western part of the Paris Mine through bore-holes and fractured boundary pillar.

The Porąbka-Klimontów Mine
Dewatering workings and installations are located at the main shafts: Ryszard and Jadwiga. The installations include settlement workings, water galleries and pump chambers sited at levels 470 and 550 meters. Total delivery of pumps at 470-meters level is 30.0 m^3/min and that of those at 550-meters level is 48.2 m^3/min.

The Kazimierz-Juliusz Mine
This mine has two independent dewatering systems. In the Kazimierz field the four drainage levels are in operation: 470 meters (altitude -203 m. a.s.l), 573

meters (-306 m a.s.l.), 677 meters (-410 m a.s.l.) and 737 meters (-470 m a.s.l.). Waters collected from the levels 737, 677 and 573 meters are transferred to the water galleries at 470-meters level. The total delivery of pumps is 48.5 m^3/min.

In the Juliusz field a single drainage system operates (altitude -123 m a.s.l). Waters from this field flow gravitationally to water galleries located close to the Karol Shaft. Pump chamber has total delivery 36.0 m^3/min.

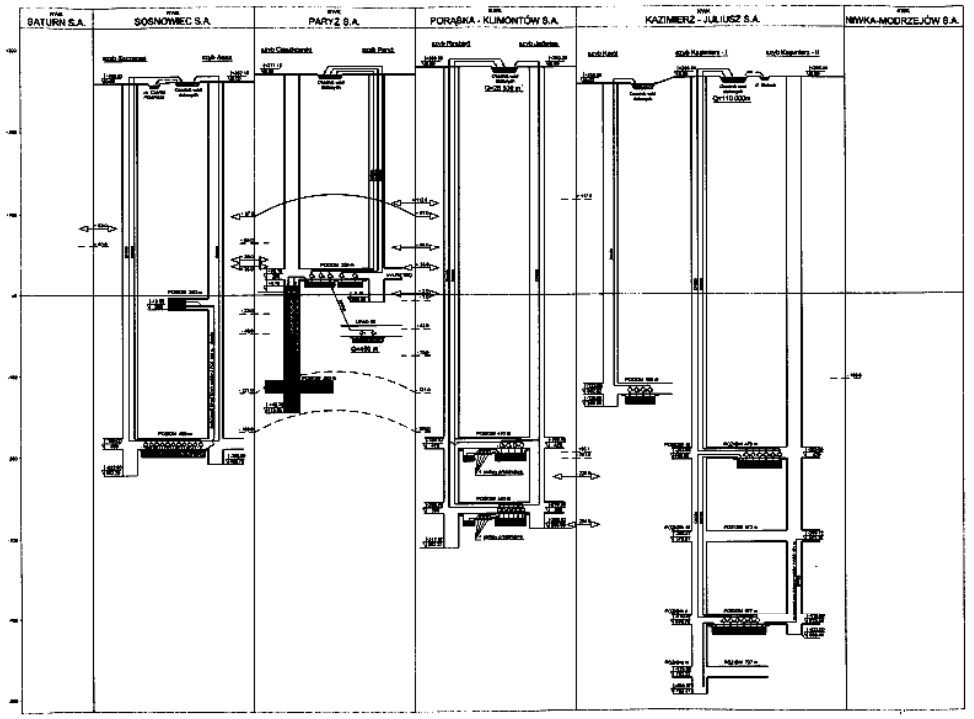

Figure 2 Dewatering scheme of the mines belonging to the Sosnowiec sub-system (data for 31.12.1998).

4 CHARCTERIZATION OF PROPOSED VARIANTS AND RESULTS OF MODELLING

In order to drain all the water which inflows to mine workings and, simultaneously, to optimize the structure of dewatering systems in accordance with current regulations the multivariant project has been designed for the so-called Sosnowiec sub-system. The proposed variants differ in technical solutions which decisively controls the investment (modernization) and running costs foreseen after implementation of the system. The variants were referred to the current "state of the art" (variant 0) of central dewatering system of the mines belonging to the Sosnowiec sub-system.

Similarly to the grant and the conceptual project for the Saturn sub-system, the designed solutions were verified with the hydrogeological model. Particularly, the foreseen inflows to mine dewatering systems were tested. These inflows were, in turn, the basis for cost calculations of the variants. Finally, the variant I was selected as a best solution and described in details whereas the remaining variants were only generally characterized.

The variant 0

The hydrodynamic conditions described as variant 0 (which corresponds to the recent inflows) allow to determine the consistency of mathematical model of the filtration area with the field observations and measurements made at the studied mines. The variant 0 results from the arduous verification procedure (balancing) of the model i.e., fitting the simulation results to the real values. The verification procedure aims to achieve high confidence level of the prognosed results. The confidence is higher if higher is the concordance between modeling results and the real values.

The mathematical model of studied area was verified using the data on drainage and the inflow rate values measured in the second half of 1998 as initial values. The high correspondence of calculated and measured values was obtained (Table 1).

Variant 1

The four dewatering systems are proposed to operate at the mines belonging to the Sosnowiec sub-system: Paryż, Sosnowiec, Porąbka-Klimontów and Kazimierz-Juliusz. However, three of them will be changed from stationary pump chambers to submersible pumps. Simulated changes in dewatering systems are as follows:

- **The Paris Mine –** 250-meters level (altitude +25.1 m a.s.l.) – submersible pomps installed in the Cieszkowski Shaft beneath the altitude +25.1 m a.s.l. The highest permissible altitude of water table is +30.0 m a.s.l.
- **The Sosnowiec Mine –** drainage at 381-meters level (altitude -121.0 m a.s.l.) will be continued with submersible pumps installed in the Szczepan Shaft beneath the altitude -121.0 m a.s.l. The highest permissible water table altitude (-80.0 m a.s.l.) will be determined by the altitude at the Porąbka-Klimontów Mine (Rogoż et al. 1998). Waters from the natural inflow at 280-meters level (altitude -10.60 m a.s.l.) will be transferred to the Anna Shaft and pumped out with submersible pumps.
- **The Porąbka-Klimontów Mine** – 470-meters level (altitude -190.0 m a.s.l.) – submersible pumps will be installed in the Ryszard Shaft below the altitude -190.0 m a.s.l.). The highest permissible altitute of water table (-185.0 m. a.s.l.) will be determined by the altitude at the Kazimierz-Juliusz Mine.
- **The Kazimierz-Juliusz Mine –** the existing, main dewatering system will be continued with stationary pumps working at levels 383, 470 and 677 meters.

Comparing with the currently operating system, the closure of stationary pumps at Paris, Sosnowiec and Porąbka-Klimontów mines is proposed due to

their high running costs. Instead, the submersible pumps will be installed in the Cieszkowski. Szczepan and Ryszard shafts. The main dewatering system at the Kazimierz-Juliusz Mine will remain unchanged.

At the Paris Mine the total simulated inflow rate to the Cieszkowski Shaft at stabilized filtration conditions is 13.85 m^3/min (Table 1) which means a small increment in comparison with measurement results for November 1998. The simulated inflow rate is lower by 0.15 m^3/min than that obtained during model verification (14.00 m^3/min). Hence, the insignificant decreasing trend occurs with the rising draining altitude. It must be emphasized that the simulated inflow will be achieved at the given drainage altitude, i.e., after some time.

At the Sosnowiec Mine the prognosed inflow rate is 9.09 m^3/min which is less by 0.21 m^3/min than the measured values and by 0.39 m^3/min than the balanced ones. The prognosed inflow will be obtained after some time, when the mine will be flooded to the water table altitude -80 m a.s.l.

At the Porąbka-Klimontów Mine the inflow rate simulated for the variant 1 is 4.52 m^3/min. That means an increase in comparison with both the natural conditions (by 0.62 m^3/min) and balanced model (by 0.41 m^3/min).

For the Kazimierz-Juliusz Mine the existing, main dewatering system will be operating. The calculated total inflow rate is 4.89 m^3/min which means and increase by about 0.8 m^3/min in comparison with both the measured values and balanced conditions.

The important advantage of such solution is its flexibility, which allows modification of parameters at any stage of implementation. The successive steps can be optimized which is particularly important because the role of direct and indirect hydraulic connections between the mines as well as the real inflow rates to the designed pumping sites cannot be *"a priori"* determined.

The submersible pumps installed earlier in the selected shafts after evacuation of the crews will ensure safe operation of the system.

The following arguments advocate the variant 1:

- At the flooding stage – the possibility of operation tests in order to determine the hydraulic connections and inflow volumes which is crucial for application of optimum pumping procedures and elimination of water hazard.
- Reduction of running costs of both the draining and the maintenance of installations. Economically reasonable is pumping from as shallow depth as possible and application of underground workings as water reservoirs in order to limit the pumping rates during the daily peaks of energy consumption.

Variant 2

At the Paris Mine the altitude of simulated groundwater table will rise to +35.0 (+39.0) m a.s.l. in comparison with the variant 1 (i.e. to the altitude of the direct connection with the adjacent Sosnowiec Mine through the "Ostatek" cross-cut. After achieving of this altitude and installation of submersible pumps at the Porąbka-Klimontów Mine the drainage of the Paris Mine can be stopped. Water

from this mine will supply the dewatering system of the Sosnowiec Mine through direct hydraulic connection. According to variant 2, total inflow rate to the Paris Mine will be 13.00 m^3/min. This volume will be taken by the by the Sosnowiec Mine drainage system through the "Ostatek" cross-cut. Hence, the water balance should include the sum of inflows to the Paris and to the Sosnowiec mines.

At the Sosnowiec Mine now changes are foreseen in comparison with variant 1. Total natural inflow rate to the drainage system at the flooding altitude -80 m a.s.l. and at stabilized filtration conditions will be 9.22 m^3/min.

The Porąbka-Klimontów Mine plays the same role in the regional dewatering system as in variant 1, i.e. drainage will be run to the altitude about -190 m a.s.l. The prognosed inflow rate for variant 2 will be 4.59 m^3/min.

The role of the Kazimierz-Juliusz Mine also remains unchanged. The results of modeling allow to expect the same inflow rates as in variant 1 (4.89 m^3/min).

Variant 3

At the Paris Mine no changes are proposed in comparison with variant 2. The altitude of water table will rise to +35.0 (+39.0) m a.s.l. and gravitational flow will be maintained. At the Sosnowiec Mine the simulated water table in the Szczepan Shaft will rise to the altitude -10 m a.s.l., which will limit the inflow to the mine. Natural inflow rate from the area of Sosnowiec Mine will be 7.79 m^3/min. However, the inflow rate from the Paris Mine will increase to 13.23 m^3/min in comparison with variant 2. Thus, the total inflow rate to the Sosnowiec Mine will be 21.02 m^3/min.

At the Porąbka-Klimontów Mine dewatering system will not be changed but the inflow rate will increase to 5.36 m^3/min due to the rising water tables in the surrounding areas.

The dewatering system of the Kazimierz-Juliusz Mine will operate at the parameters prognosed for previous variants. The expected inflow rate will be 4.98 m^3/min.

6 TIMING OF FLOODING OF THE SOSNOWIEC SUB-SYSTEM MINES

The vital problem in the re-organization of dewatering systems in closed mines is the timing of flooding of the Paris, Sosnowiec and Porąbka-Klimontów mines to the designed, safety water table altitudes. Such flooding will not cause water hazard to the operating Kazimierz-Juliusz Mine and to the other mines located south of the study area.

The flooding times were calculated for the studies mines (Table 2). These results are only estimations due to the lack of credible data on the volume of free spaces in the rock formations involved. For the particular mines the calculations were based upon means of measured and simulated inflow rates. It is understandable that the inflow rates will decrease during the filling of workings and resulting rise of water table.

Flooding time of underground workings and rock formations at the Paris Mine

According to the considered variants, the following flooding scenarios were taken into account (Table 3):

- for the range of water table altitudes +7.6 m a.s.l. (recent level) to +25.1 m a.s.l. (250-meters mining level):
  - exclusive migration of waters from lower levels (including 2.5 m^3/min from the 390-meters one). Submersible pumps installed in the Cieszkowski Shaft will allow to control the water table altitude at 390-meters level in the range of values +3.2 do +7.6 m a.s.l.
  - full volume of waters inflowing to the mine at the rate 13.8 m^3/min.
- for the range of water table altitudes +25.1 ÷ +33.5 m a.s.l. (altitude of indirect hydraulic connection with the Porąbka-Klimontów Mine) – full volume of water inflow at the rate 13.8 m^3/min.
- for the range of water table altitudes +33.5 ÷ +35.0 m a.s.l. (+39.0 m a.s.l. – altitude of direct connection with the Sosnowiec Mine) – full volume of water inflow at the rate 13.8 m^3/min.

Flooding time of underground workings and rock formations at the Sosnowiec Mine

Calculations of flooding time (Table 2) were made for the following water table altitudes:

- -121.0 m a.s.l. (altitude of direct connection with the Porąbka-Klimontów Mine):
- -121.0 ÷ -80.0 m a.s.l. (range of altitudes for operating tests aiming to stabilize the hydraulic connection between the mines).
- -80.0 ÷ -10.6 m a.s.l. (280-meters level):
  - flooding exclusively with waters inflowing to 450-meters level at the rate about 1.0 m^3/min.
  - flooding with waters inflowing to 450-meters level and transferred from upper levels (including 280-meters one) at the 9.3 m^3/min.
  - flooding with full volume of waters inflowing to 450- and 280-meters levels, and transferred from the Paris Mine, at the rate 23.1 m^3/min.
  - flooding with waters inflowing to 450-meters level and transferred from the Paryż Mine, at the rate 14.8 m^3/min.
  - additional calculations were made for maximum considered flooding altitude -5.0 m a.s.l., considering the current inflows to both the Sosnowiec and Paris mines.

Table 2 Cumulative flooding times [24 h] of mines of the Sosnowiec sub-system

Paris Mine		Sosnowiec Mine					Porąbka-Klimontów Mine			
Flooding altitude	Inflow rate 13.8 m^3/min	Flooding altitude	Inflow rate [m^3/min]				Flooding altitude	Inflow rate [m^3/min]		
			1.0*	9.3**	23.1***	14.8****		3.9	4.7	5.5
+39.0	285	+0.0	6 365	684	276	430	–150.0	3 065	2 542	2 174
+35.0	246	–5.0	6 049	650	262	409	–185.0	2 327	1 930	1 651
+33.5	234	–10.6	5 695	612	247	385	–190.0	2 222	1 843	1 576
+30.0	205	–34.0	4 218	454	183	285	–200.0	2 011	1 668	1 426
+25.1	165	–50.0	3 209	345	139	217	–250.0	922	765	654
+7.6	22	–70.0	2 814	303	122	190	–269.0	509	422	361
+4.93	0	–80.0	2 616	281	113	177	–284.0	182	151	129
		–100.0	2 222	239	96	150	–400.0	0	0	0
		–121.0	1 264	136	54	85				
		–150.0	838	90	36	57				
		–200.0	104	11	4	7				
		–250.0	0	0	0	0				

Remarks:
* flooding with waters inflowing to 450-meters level, exclusively
** flooding with waters inflowing to 450-meters level and transferred from 280-meters level
*** flooging with waters inflowing to 450-meters level, and transferred from 280-meters and from the Paris Mine
**** flooding with waters inflowing to 450-meters level and transferred from the Paris Mine

Flooding time of underground workings and rock formations at the Porąbka-Klimontów Mine

For the Porąbka-Klimontów Mine the variants include the following ranges of flooding altitudes (Table 2):

- up to -269.0 m a.s.l. (550-meters level).
- -269.0 ÷ -190.0 m a.s.l. (470-meters level).
  - flooding with the whole volume of waters inflowing to the mine (550 + 470-meters levels) – at the rate 3.9 m^3/min,
  - prognozed volume of inflowing waters (550 + 470-meters levels) including the rates 4.7 and 5.5 m^3/min, i.e. exceeding the current rates,
- calculation were made also for the maximum considered flooding altitude -185.0 m a.s.l. (until the closure of the Kazimierz-Juliusz Mine).

7 SUMMARY

The optimum solution of dewatering problems of the Sosnowiec sub-system mines is provided by the variant 1. The Paris Mine will be drained with submersible pumps installed in the Cieszkowski Shaft at the altitude +25.1 m a.s.l. Expected inflow rate is 13.85 m^3/min. At the Sosnowiec Mine submersible pumps will be installed in the Szczepan Shaft at the altitude -80 m a.s.l. which will enable the draining rate 9.09 m^3/min. The Porąbka-Klimontów Mine will also be drained with submersible pumps placed at the altitude -190 m a.s.l. at the expected inflow rate 4.52 m^3/min. Finally, the Kazimierz-Juliusz Mine will apply the unchanged, stationary dewatering system. The prognozed pumping rate will be 4.89 m^3/min.

The principal advantage of the proposed dewatering system is the control of the rise of water table when further mines are successively closed and, consequently, the mining conditions in the operating mines are changed. Thus, the volume of waters obtained from the regional dewatering system and discharged into the surficial flows will be reduced, particularly during the flooding of the mines and stabilization of water table. Important feature of the proposed system is the removal of underground workers, closure of underground pump chambers, workings and parts of the shafts, removal of shaft and ventilation equipment as well as central control and management of the system with the application of the existing infrastructure (including the discharge system). Therefore, significant economic and ecological improvements will be achieved which would compensate in short time the necessary expenditures.

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Koncepcja odwadniania KWK Sosnowiec i kopalń sąsiednich w warunkach ich likwidacji

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Streszczenie: W pracy syntetycznie przedstawiono projekt docelowego systemu odwadniania kopalni Sosnowiec i kopalń sąsiednich (Paryż, Porąbka - Klimontów) w warunkach ich likwidacji, tworzących podsystem Sosnowiec. Stanowi on kolejny etap prac wdrożeniowych związanych ze zrealizowanym dla tego obszaru projektem celowym. Projekt został opracowany na podstawie analizy wyników obliczeń modelowych przepływu wód podziemnych, uwarunkowań technicznych, górniczo - geologicznych i hydrogeologicznych, analizy kosztów oraz warunków bezpieczeństwa. W modelu uwzględniono konieczność minimalizacji zagrożeń wodnych dla kopalń sąsiednich, w tym w szczególności kopalni Kazimierz - Juliusz. System odprowadzania wody oparty będzie na pompach głębinowych zabudowanych w wytypowanych szybach kopalń Sosnowiec, Paryż i docelowo Porąbka - Klimontów. Szczegółowo przeanalizowano połączenia hydrauliczne między kopalniami, które warunkują przyjęty model odwadniania.