5.2 SOIL AND GROUNDWATER

5.2.1 ACTIVITIES AFFECTING SOIL AND GROUNDWATER

(1) Mineral Resources, Mine Activities and Geothermal Energy

Study Area is famous for its rich mineral deposit, mining works have been conducted in this area for long years. In general, such mineral resources and mining works have affected soil and groundwater conditions. Based on the collected data, main metallic mineral resources and its location in the Study Area are summarized in Figure 5.2-1 and Table 5.2-1.

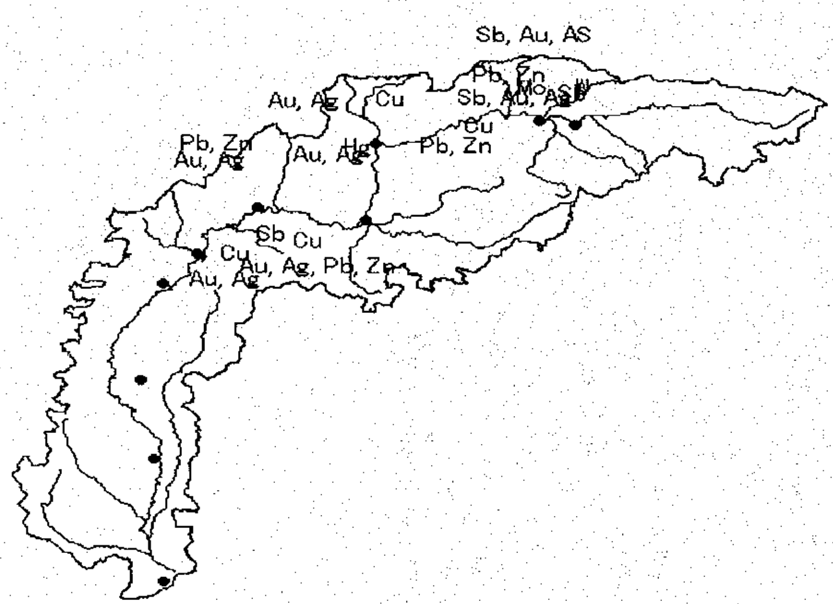


Figure 5.2 - 1 Location of Mineral Resources in the Study Area

As shown in these tables and figures, there are two types of mineral deposits in the Study Area. One of these deposits is developed in the Central Western Carpatians such as Jasenie-Soviansko and Horna Lehota. In this deposit, Sb, Au, Ag Pb, Zn is the main mineral. Another one is the deposit which is developed in the Central Slovakis Volcanic Field such as Banska Stiavnica and Kremnica. In this deposit, Au, Ag and Cu are the most dominant minerals and Pv, Zn and Sb are also produced.

Table 5.2 - 1 Main Mineral Resources in the Study Area

Area	Mineral	Name
Stivanicke Vrchy	Iron	Vyhne-Klokok
Stivanicke Vrchy	Copper	Skelene Teplice
Stivanicke Vrchy	Copper	Zalatno
Stivanicke Vrchy	Copper	Sementlov
Stivanicke Vrchy	Gold, Silver	Hodrusa-rozalia
Stivanicke Vrchy	Gold, Silver	Hodrusa
Stivanicke Vrchy	Gold, Silver	Banska Bela
Stivanicke Vrchy	Golod, Silver, Lead, Zinc	Banska Stiavnica
Stivanicke Vrchy	Lead, Zinc	Hodrusa-Rozalia
Vtacnic	Gold, Silver	Nova Bana
Vtacnic	Gold, Silver	Rudno nad Hronnon
Vtacnic	Gold, Silver	Pukanec
Kremnicke Vrchy	Gold, Silver	Kremnica
Kremnicke Vrchy	Gold, Silver	Remata
Kremnicke Vrchy	Mercury	MakachovpVelka studna
Velka Fatra	Copper	Spania dolina
Veporske Vrchy	Copper	Lubietova
Veporske Vrchy	Lead, Zinc	Drienok
Nizke Tatry	Gold, Antimony	Medzibrod
Nizke Tatry	Lead, Zinc	Jasenie-Soviansko
Nizke Tatry	Molybdenum, Tungsten	Jasenie-Kysla
Nizke Tatry	Antimony	Horna Lehota-Lom

Source : Chechoslovakia-Metallogenic Map,1981 and Mineral of Slovakia, 1997

Mining activities in Slovak have been on the decline since early 1980's. Almost all mines have been closed in the Study Area. However, old mining works such as shafts, adits, pings, pit heaps and sludge pits are still remained and may affect the surrounding environment.

Some study papers regarding contamination of the soil and water in Banska Stiavnica area have been collected. Based on these study papers, highly polluted soils by heavy metals (Pb, Zn Cd, As and Se) and high acidic soils are found to be distributed in the Alluvial soils in this district. These phenomena are related to the polymetallic character of mined ores in this district.

Partial copy of "Atlas of Geothermal Energy of Slovakia" and explanation memo were collected from GSSR. A project entitled "Regioanl Hydrogeological Assessment of the Ziar Depression" was realized and one exploration borehole was drilled to the depth of around 2 000m to find out the potentiality of supplying heat to the living quarters in Ziar nad Hronom.

(2) Industry

A list of sources of pollution in Hron basin was collected from SVP state enterprise OZ PH

Banska Bystrica. The detail information of this list are described in the Section 5.1. The pollution sources are classified according to the types of industry stipulated in the regulation of groundwater preservation in Japan. The number and types of the contamination sources in the Study Area are shown in Table 5.2-2.

Table 5.2 - 2 Types and Numbers of the Industrial Pollution Sources

Type of industry	Number
Wood processing	12
Machinery	14
Paper factory	2
Smelting	4
Iron factory	1
Mining	5
Petro-chemical	1
Agricultural products	14
Ceramic	1
Pharmacy	1
Cement	1
Textile	2
Electronic	1
Quarry	2
Army	3
Metal coating	2
Fuel station	3
Airfield	1
Brick production	1
Poultry	1
Energetic industry	1
Automobile industry	1

Source : Povodie Hrona

Based on the "Air pollution in the Slovak Republic, 1996 and 1997, SHMU", emissions of heavy metals from various types of sources in the whole Slovak territory are summarized in Table E-1 in the Supporting Report, according to which, heavy metal emission in the whole Slovakia is decreasing in recent years.

(3) Agriculture

Based on the Statistics book : Agriculture in the Slovak Republic (selected indicators in 1970-1997) and Proceedings of Soil Fertility Research Institute, consumption of fertilizers and pesticides, and agricultural output are summarized in Table 5.2 - 3.

Table 5.2 - 3 Fertilizer consumption and agricultural Output in Slovak

Year	unit	1970	1975	1980	1985	1990	1995	1997
Nitrogen Fertilizer Consumption	kg / ha	111.3	130.1	165.9	155.9	138.1	60.6	
Pesticide Consumption	ton						6,438	3,512
Gross Agricultural Output	M. SKK*	67,147	77,334	78,810	80,877	79,064	55,530	56,047
Gross Crop Output	M. SKK*	36,716	43,776	40,142	39,923	34,933	23,632	23,338

*constant prices : year 1995

Source: Agriculture in the SR from 1970 to 1997, selected indicators, Statistical Office SR (Ref. 14 - 37)

As shown in the Table 5.2-3, nitrate fertilizer consumption per unit area of agricultural lands (Total N consumption = mineral fertilizers + organic fertilizers) reached more than 160Nkg/ha/year in the 1980s. In the recent years, the specific consumption has been drastically decreased. This volume become stable around 60 Nkg/ha/year. This figure is comparable to the average N fertilizer consumption in Japan (46 – 106 N kg/ha/year in cereals, beans, wheat, forage field). It can be said that the N fertilizers were manured excessively in the past.

5.2.2 STATE OF SOIL AND GROUNDWATER

(1) Soil

Digital soil type map is shown in the Map 5.2-1Soil Type Map. From this digital soil map, the area occupied by each soil type is calculated and summarized in Figure 5.2-2 Soil Type in the Study Area.

As shown in the Map 5.2-1 and Figure 5.2-2, Cambisol is the most dominant soil type in the Study Area. This soil covers wide area of the upper and middle part of mountain area. Rendzina is the second dominant soil type in the mountain area. This soil type is mainly distributed in the part of Nizke Tatray mountain.

Luvisol is the most dominant soil type in the Danube basin area. This soil covers the high hill area of the Danube basin. Fluvisol is the second dominant soil type and is distributed in the Hron alluvial valley. Chernozem is the third dominant soil type and is distributed in the terrace of this area.

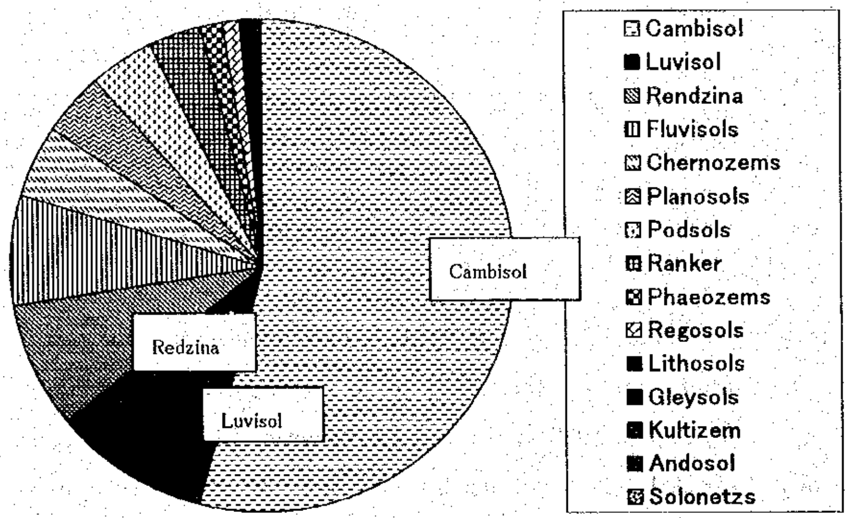


Figure 5.2 - 2 Soil Type in the Study Area

Most extensive investigation related to soil in Slovak was conducted during 1991 – 1995 as the "Geochemical Atlas Project : Soil". The part of the result of this project was provided from VUPOP to the Study team. Further, soil monitoring for whole Slovak has been conducted and summarized in the report "Monitoring of Soils in SR, Present Condition of Monitored Soils" (Ref.16 - 3).

Table 5.2-4 shows the limit values of risk elements as provided by the Resolution 531/1994-540, MP,SR which is very similar to the Dutch ABC limits,1991 (Ref.16-3).

Table 5.2 - 4 Hygienic Limit Values of the Soil (mg/kg)

Elements	As	Cd	Cr	Cu	Ni	Pb	Zn
A limit	17.4	0.46	90	18.6	15	56	66.5
B limit	30	5	250	100	100	150	500
C limit	50	20	800	500	500	600	3 000

Source: Based on the Data provided by VUPOP

Note: A limit value: the soil is not contaminated if the concentration of an element is below than this limit

B limit value: the soil contamination has been analytically proven

C limit value: if the concentration of an element reaches this value, it is necessary to carry out an immediate definitive analytical mapping of the range of damage in a specific site and to decide on the form of adopted corrective measures.

Geochemical Atlas data were reassessed by the help of GIS presentation techniques. These GIS maps are summarized in the Map 5.2-2 Soil Contamination Map in Hron River Basin and the results are summarized Table 5.2 - 5.

Table 5.2 - 5 Number of the Points Exceeding the Limit Values

	As	Cd	Cr	Cu	Ni	Pb	Zn
Limit A	235	342	194	620	832	223	660
Limit B	108	5	1	44	20	41	7
Limit C	37			9			

Based on this map, table and the report of soil monitoring (Ref.16-3), state of the soil contamination in the Study Area can be summarized as follows.

As a whole, soil contaminated area is distributed in the mountainous area of the upper and middle region of the Study Area. The contamination in the plain area of lower region is relatively low. This coincides with the description of soil monitoring report (Ref.16-3), "the risk trace elements content in the soils of Slovakia lowlands has been indicated as non-contaminated ".

In the upper area, as shown in the Map 5.2-2 and Table 5.2-6, As and Cu are the most remarkable contaminant and Ni, Pb, Hg, Zn and Cd exceed limits in some part. The contaminated area is mainly distributed in the Bystrica valley surrounding of Spania Dolina, near Dolina Lehota and Cierny Baloq.

In the middle region, contaminated area is distributed at the mountain area surrounding of Banska Stiavnica and Hron Alluvial Valley. The main contaminants are the same as upper region as As and Cu, further Pb, Hg, Zn and Cd exceed limit in some part.

In the lower region, faint contamination can be observed at confined area of Hron Alluvial valley. The main contaminants are As and Cu same as the upper and middle region.

Contents of polycyclic aromatic hydrocarbons (PAHs) in agricultural soils of Slovakia are summarized in the Soil monitoring report (ref.16-3). Based on this report, the average content of PAHs (sum of 12 components from EPA standard PAHs) has been indicated 387 μg/kg in soils of Slovakia. This one is low and occur under A hygienic limit.

In the soil monitoring report (Ref.16-3), the condition and reason of the soil contamination in Western Carpatians are summarized as follows :

The prevalent part of risk trace elements of Slovak territory occurs in mountainous region of Western Carpatians as the result of following emission sources:

- global emissions transport from foreign countries
- local emission sources from industry and energetics
- natural geochemical anomalies with very often occurence in Western Carpatians

As shown in the Map 5.2-2 and description above, most of the soil contamination can be found surroundings of the old mining area. In general, As, Cu, Pb, Cd and Zn are known as the typical discharged elements from mining activities. Especially, As is known as the problematical element typically discharged from Cu and Ag mine activities. There had been vital mining activities and many mineral sources of Ag and Cu in the contaminated area of upper and middle region of the Study Area. The main reason of the contamination can be concluded as the local emission resources from mining activities and natural geochemical anomalies.

The analysis of mobile and potential mobile forms of trace elements are very important in relation to the risk assessment of their possible penetration entry into the food chain and biological circulation with negative impacts on mankind and environment. However, comparing the land use map 1998 and Soil contamination map, most of the contaminated parts in the Study Area are situated in the forest area. Further, as the problem of mobile and potential mobile forms of risk trace elements in soils, the report (Ref.16-3) describes as follows:

"in slightly contaminated soils as well as in soils which have been evaluated as non-contaminated is determined low correlation between total content of risk trace elements content and with their content in plants. The higher correlation is determined only in strongly contaminated soils where the risk trace elements content is over B, or C hygienic limits"

There are only limited areas where exceeds hygienic standard C or B in the agricultural land. It can be concluded that soil contamination by risk elements in the Study Area is not so crucial and urgent matter but the investigation and monitoring shall be continued.

There is not so much information for the erosion of the soil. Based on the study of VUPOP (Ref.16-2), potential wind erosion risk on agricultural soils in the whole Study Area is relatively low as 0 – 0.7 t per 1 ha/year soil loss. Further potential of water erosion risk on agricultural soils in the Study Area is generally low as 0 – 4 t per 1 ha/year soil loss and 4 – 10 t per 1 ha/year soil loss partially. However, at the hilly and mountain side in the Study Area, there are some high soil loss intensity area such as 10 – 30 t per 1 ha/year to more than 30 t per ha/year soil loss can be found. However, the area of these high intensity parts is not so wide.

(2) Groundwater

1) Quality of Groundwater

In part-1 Groundwater – of the Project Geochemical Atlas of Slovakia, a total of 16 359 samples in the first aquifer were collected and analyzed in the summer during 1991 – 1994. In the Study Area, 1,965 samples were collected and analyzed. The sampling locations are shown in the Figure E.1 Groundwater Sampling Location of Geochemical Atlas Project in the Supporting Report. The samples were collected from the medium groundwater level under stable climatic conditions, and were analyzed for the content of 32 variables (elements, anions, chemical oxygen demand and aggressive CO).

These data were reviewed and compared with the drinking water quality standard of Slovakia STN 75 7111 and assessed by using GIS method. These results are summarized in Table 5.2-6 and Map 5.2-3 Ground Water Evaluation Map.

Table 5.2 - 6 Number of Samples Exceeding the Slovak Standard

Elements	Standard (mg/l)		Number of the samples exceeding the Slovak standard		
	Slovak	WHO	Spring	Well	Total
PH	>6	>6.5	49	4	53
PH	<8	<8.5	45	10	55
Ca	<20	-	669	615	1284
Mg	<125	50	1	30	31
Fe	<0.3	0.3	23	25	48
Mn	<0.1	0.1	25	60	85
NH4	<0.5	-	13	6	19
F	<1.65	-	2	0	2
Cl	<100	200	1	92	93
SO4	<250	200	10	41	51
NO3	<50	-	24	279	303
Cu	<0.1	1.0	1	3	4
Zn	<5	5.0	2	4	6
As	<0.05	0.05	20	5	25
Cd	<0.005	0.005	11	3	14
Pb	<0.05	0.05	0	2	2
Hg	<0.001	-	0	3	3
Al	<0.2	-	0	2	2

Source : Geochemical Atlas of Slovakia, Groundwater

Based on these results, the current condition of the groundwater quality can be summarized as follows.

It is remarkable that lower region of the Study Area is widely contaminated. The main contaminants of this contamination is NO3, Ca and TDS. Further, heavily contaminated area are interspersed along the Hron Alluvial valley. The main contaminants of the additional contamination are Cl and Mn. As a whole, Ca and TDS contamination is not so crucial for the human health but NO3 contamination is becoming big social problem for the human health in the world. Because NO3 is reduced to NO2 in the human body and union of NO2 and hemoglobin cause anoxia of the infant. Further, it is very difficult to take measures for this contamination because agriculture and livestock farming is the main source of NO3 and widely spread the area.

60 to 100% of the land in lower region is used for agriculture. Further, as shown in Table 5.2-3, fertilizer consumption was very huge in the past and contamination of Cl is closely related with agricultural activities. It can be concluded that the contamination in the lower region is attributed to the agricultural activities.

There are two remarkable contamination areas in the middle region. One is the contamination along Hron Alluvial valley such as Nova Bana and Zarnovica. Fe, Al and Ca are the main contaminants in this region. Most of the factories in the Study Area are concentrated in the Alluvial valley and Fe and Al are typical contaminants caused by industrial activities. Further, metal rich sediments from mining may be accumulated in the Hron valley. It may affect the groundwater quality of the region.

Another one contamination site in the middle region is the contamination in the mountain area such as Banska Stiavnica and west mountain of Badin. Main contaminants of this area are Ca, Mn, Al and Cd at the surrounding of Badin. Mn and Cd are the typical mining origin contaminants. As shown in the Figures 5.2-1 and Map 5.2-3, most of the contamination can be observed surrounding mining site. These contamination in this region are attributed by the mining activities.

Groundwater contamination in upper region is relatively vague compared with other regions. However, some contamination by Zn and Al can be found in the mountain area. The contamination in this region can be attributed to the natural geochemical anomaly or mining activities. However, NO3 and NH4 contamination can be found at Brsno. Quaternary terrace and plain are distributed in this area. This area is used for agriculture and inhabitation. Further connection rate for public sewerage system is relatively low. Agriculture activity and sewage effluent are the cause of contamination in this area.

SHMU is conducting groundwater monitoring for long years. Sixty six monitoring points are located in the Study Area. Location and items of the monitoring points are shown in the Figure E.4 SHMU Sampling Points of Groundwater Qualityin the Supporting Report. The monitoring data for 47 locations in the Study Area were available in the study. These data are summarized in Figure 5.2-3. As shown in this figure, the results are quite similar with Geochemical atlas project one. Contamination is observed in the Danube basin and Hron Alluvial valley. Main contaminants in Danube basin are NO3, Mn, Ca, Fe and Cl. Main contaminants in Hron Alluvial valley are Mn, Ca and Fe.

The groundwater quality change over time based on the SHMU data is arranged in the Figure E.5 Groundwater Quality Change in the supporting report. As shown in this figure, there is not so much change over time. However, some items such as Ca and Cl in Danube basin are slightly increasing.

These evaluation results are summarized in Table 5.2-7.

Table 5.2 - 7 Summary of SHMU Groundwater Monitoring

Area	Al	Mn	NO3	Ca	Fe	Cl
Upper Region (Central Western Carpatians)	A2	A1	A2	D2	C2	A2
Middle Region (Central Slovakia Volcanic Field)	A2	A2	A2	D3	A2	A2
Upper to middle Hron Alluvial Valley	B1	C2	B1	D2	D2	A1
Lower Region (Danube Basin)	B2	C2	C2	D4	D3	B4

Note:
A : all data dose not exceed standard — 1 : Value is decreasing
B : some data exceed standard — 2 : Value is stable
C : more than half data exceed standard — 3 : Value is slightly increasing
D : most of the data exceed standard — 4 : Value is increasing

2) Quantity of Groundwater

Spring rate and groundwater level have been monitored by SHMU. Ninety seven boreholes and 16 spring are available for the study.

The results of spring and groundwater level monitoring are summarized in Figures 5.2-4 and 5.2-5. From these figures, spring and groundwater level of each region can be summarized as follows.

Upper region

The average quantity of spring is large as 100 to 200 l/sec/spring and it is increasing these recent years. The average groundwater level is low as GL-25m but it is stable for years. Further, groundwater level in the Hron Alluvial valley of this region (Hron valley upper) is relatively low at GL-10 to -7m and it is slightly going up for years. However, there are some karstic aquifers in the region where discharge changes rapidly.

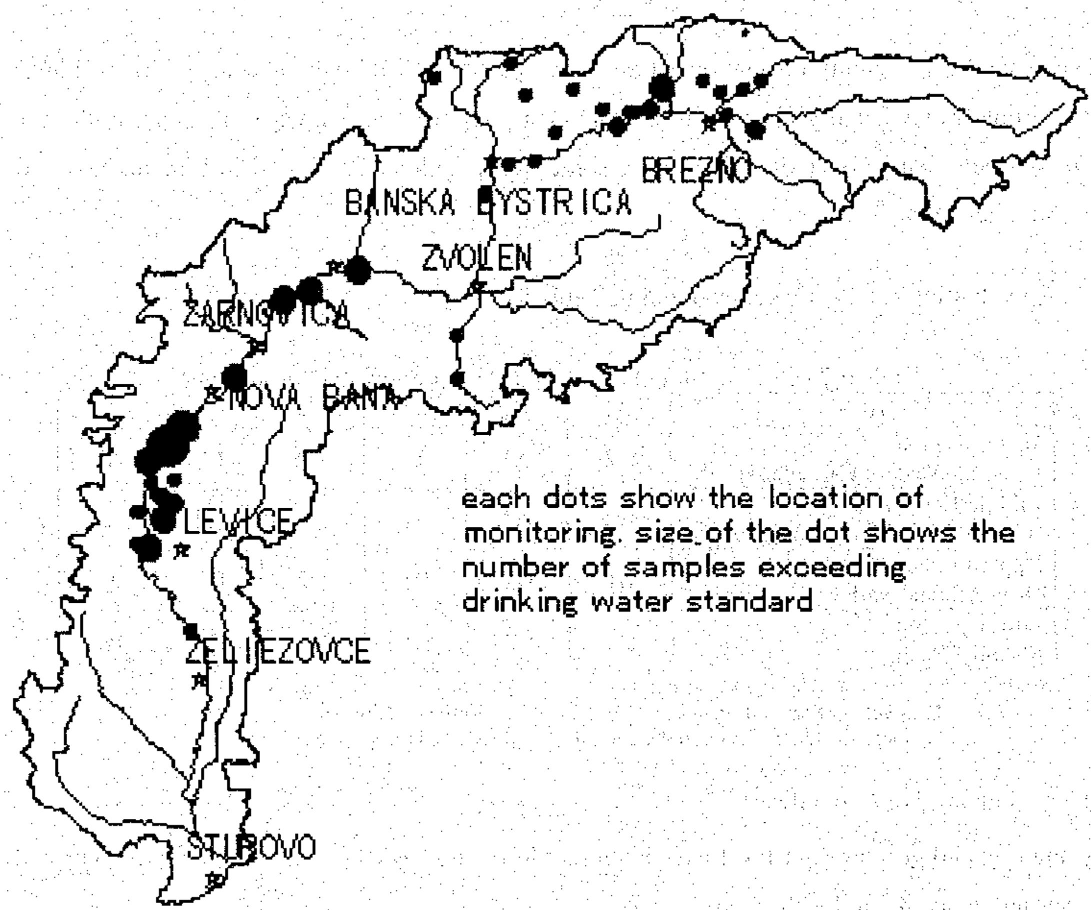


Figure 5.2-3 Groundwater Monitoring Points by SHMU and its Evaluation

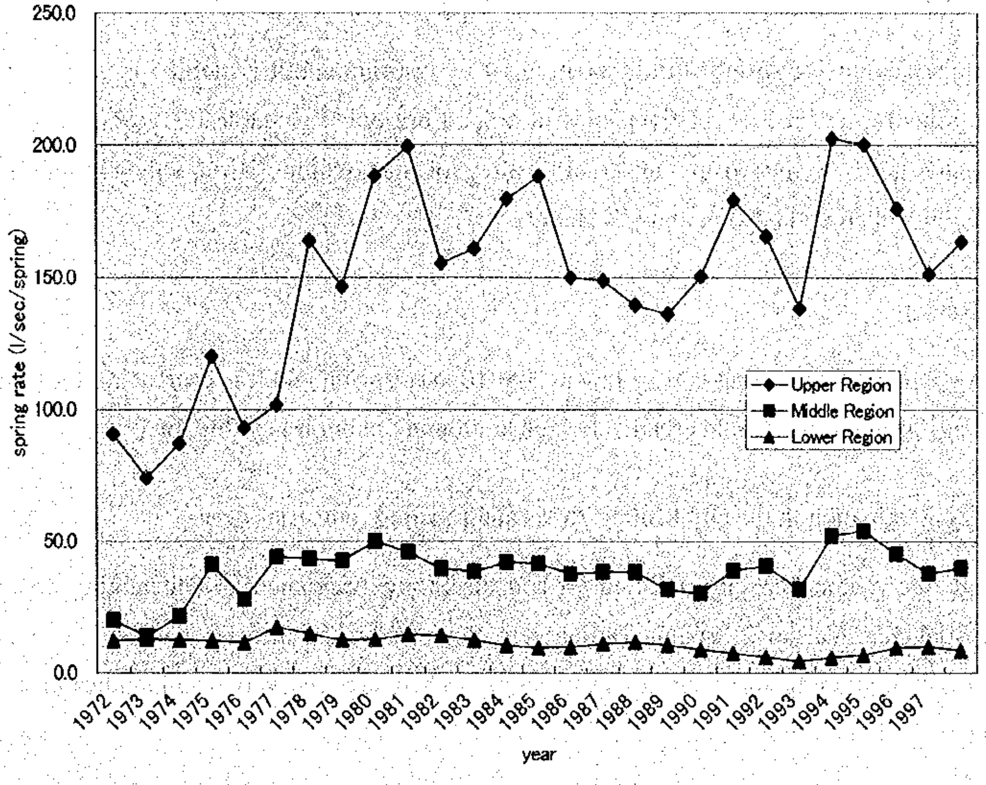


Figure 5.2-4 Quantity of Spring of Each Region

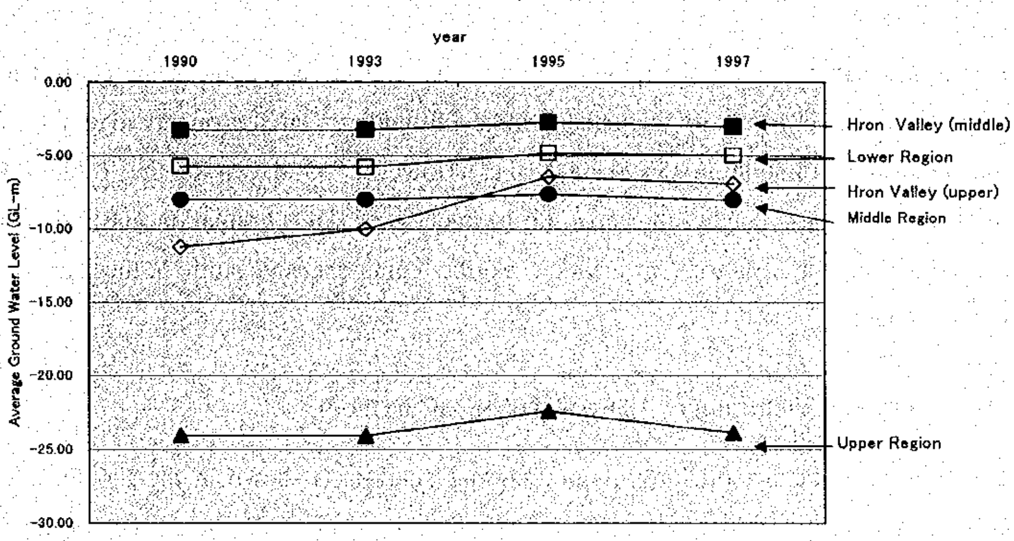


Figure 5.2-5 Groundwater Level of Each Region

Data source : SHMU

Middle Region

The average quantity of spring is little as 40 to 50 l/sec/spring and it is stable for years. The average groundwater level is relatively low at around 8m but it is stable for years. Further, groundwater level in the Hron Quaternary valley of this region (Hron valley middle) is relatively high at around GL-3m and it is stable.

Lower Region

The average quantity of spring is very few as 5 to 10 l/sec/spring and it is decreasing for years. The average groundwater level is relatively high at around 5m but it is stable for years.

3) Contamination in the Old Mining Areas and Existing Industrial Areas

There have been some heavily polluted area in the Study Area such as Old mining area of Banska Stiavnica, Vajskova, Spania Dolina etc., Soviet air base in Sliac and Vjaskova and vicinity of alluminium factory in Ziar nad Hronom. There are relatively detail studies in some areas and only simple studies in the others.

Based on the collected data, hearing and reconnaissance by the specialist in the Team, the situation in these areas was summarized in the Table E.2 Condition of the Old mining areas and existing industrial areas in the supporting report.

It may seem that most of the mining activities have been ceased and some control measures taken for major effluents by the present, mine and tailing related effluents may not be crucial for the water pollution in the Hron basin. However, as shown in the Table E.2, these information are too patchy and too little to understand collect situation and point our truly crucial and urgent areas to be measured. Further comprehensive study in these areas shall be recommended.

4) Physical Vulnerability Analysis (DRASTIC method)

The flow chart of methodology of groundwater analysis is shown in the E.6 Flow Chart of Groundwater Analysis Methodology on the supporting report. As the essence of the analysis, groundwater vulnerability map was prepared by DRASTIC method.

Although a number of spatial models designed to assess groundwater pollution hazard have been proposed, DRASTIC is the arguably model most widely used for such efforts (Committee on Techniques for Assessing Groundwater Vulnerability, 1993, USA). The acronym, DRASTIC, is derived from the seven factors considered in the model:

- Depth to water table (D)
- Recharge (R)
- Aquifer media (A)
- Soil media (S)
- Topography (T)
- Impact of vadose zone (I), and
- Conductivity of the aquifer (C)

The model is formulated as an equation using a linear combination methodology.

Vulnerability = DrDw + RrRw + ArAw + SrSw + TrTw + IrIw +CrCw

where r is the rating and w is the weight for each factor. Ratings, varying from 1 to 10, are intended to reflect the relative significance of classes within each factor. For example, fine texture (e.g. clay) soils are assumed to be less permeable to water than coarse (e.g. sandy) soils. Fine textured soils are, therefore, assigned to a lower rating than soils having a coarse texture because, all other things being equal, they are less likely than sandy soils to allow infiltration of a pollutant.

The values of weight and rating are changed for each area, project responding environmental condition and data availability. In this study, weight and rating were given for each categories by using collected data. The details of the weighting and rating procedure are shown in the Table E.3 Detail DRASTIC Rating Table in supporting report. The summary of this weighting and rating value and consideration is shown in the Table 5.2-8.

The result of DRASTIC analysis is summarized in the Map 5.2-4 Groundwater Vulnerability Map.

As shown in this map, vulnerability of Hron Alluvial valley is very high. The reason of this high vulnerability is mainly attributed to its high transmissivity, topography and soil condition. As described in the section before, remarkable contamination can be found at many places in the Hron Alluvial valley. It can be said that the vulnerability analysis result is in good agreement with the actual condition of Hron Alluvial valley.

Table 5.2 - 8 Summary of Weight and Rate for DRASTIC Analysis

Item, data source and consideration	Weight	Unit	Rate					
			10	8	6	4	2	1
Depth to the Water Table (1)	3	GL-m	<1	1 – 3	3 – 5	5 – 10	10 – 20	20<
Recharge (2)	4	mm/year	<600	600-900	800-1000	1000-1200	1200-1400	>1400
Aquifer media (3)	3	-	given for each geological type (see supporting report for the detail)					
Soil media (4)	2	-	given for each soil type (see supporting report for the detail)					
Topography (5)	3	degree	<5	5 - 10	10-15	15-20	20-30	>30
Inpact of Vados Zone	5	-	given for each geological type (see supporting report for the detail)					
Conductivity of Aquifer (7)	4	m^2/sec	$>3x10^{-3}$	$3x10^{-3}$- $1x10^{-3}$	$1x10^{-3}$ $3x10^{-4}$	$3x10^{-4}$ $3x10^{-5}$	$3x10^{-5}$ $1x10^{-6}$	$<1x10^{-6}$

Note: 1) Borehole data base by GSSR (Groundwater level for whole area was estimated from static water level of borehole data base)
2) Rainfall data by SAZP Danube Project (rainfall data was used because rack of recharge dat)
3) Digital geological map by GSSR and Study team
4) Digital soil map by VUPOP (see supporting report for the detail)
5) Topographical data by SAZP Danube Project (inclination was calculated by using elevation data)
6) Digital geological map (see supporting report for the detail)
7) Digital hydrogelogical map by GSSR and Study team (Transmisivity was used for the rating)

In the lower region, most part of the area is rated as moderate to high vulnerability. NO3 contamination is widely spread in the whole area of this lower region. It can be said that the vulnerability analysis is in good agreement with actual groundwater condition.

In the middle region, the vulnerability is relatively low on the whole. However, Hron Alluvial valley has high vulnerability and Quaternary deposited area has relatively high vulnerability. In this area, actual contamination can be found at Hron river valley and the surroundings. It is good agreement with the vulnerability analysis. Some contamination in mountain region can be found in this region. The location of the contamination area does not coincide with the vulnerability analysis. This means that the contamination in low vulnerability area can occur when the contamination source is very heavy.

In the upper region, some areas are rated as high vulnerability but contamination can not be found in most of the part. This means that if pollution source is not distributed in the area, contamination will not happen even when it is high vulnerable area. As described in the former section, contamination by agriculture and sewage source pollutants can be found near Brsno, this area is evaluated highly vulnerable area in the whole. It must be noted that when the pollution source located in the vulnerable area, contamination will spread rapidly. Further, in the high vulnerability zone of upper region, Middle and Upper Triassic limestones and dolomites is distributed. It must be noted that these formations play important role for water resource in the area. If the groundwater in this region is contaminated, it affects supply of the drinking water condition.

5.2.3 MANAGEMENT - LEGAL AND INSTITUTIONAL SYSTEM

(1) Soil

Current legal and institutional system for soil is aiming to protect human health from heavy metal contamination and there is no legal and institutional issues for POPs contamination. Soil quality standard is defined in the SR Agriculture Ministry resolution, no.531/1994 and the values of this standard are shown Table 5.2 - 4 in section 5.2.2.

Soil property monitoring in Slovakia has been conducted for years. Soil monitoring system in Slovakia consists of 3 subsystems:

a) the basic network of monitoring sites (650) at 5 years regular interval
b) the key monitoring sites (21) at 1 year regular interval
c) the area soil of soil contamination survey which has been realized on 19 257 agricultural plot

The results of soil monitoring is expressed in categories by the limits of Harmful Substances Agriculture Ministry Resolution, No.531/1994 :

o : Non-contaminated soils
A1, A : Risk soils
B : Contaminated soils
C : Strong contaminated soils

In the legislative standard, it is determined that the soils categorized as C shall be reclaimed and strictly checked at their entrance into food chain.

(2) Groundwater

Drinking water supply is one of the most important issues in the groundwater management. In the Slovak standard STN 75 7111, drinking water is defined as follows.

Drinking water is a healthy and accurate water, which doesn't cause any disease or health problems by the presence of micro-organisms or substances influencing health of users by a chronic or later disease and its characteristics don't prohibit its utility and edibility. The drinking water quality standards of Slovakia were shown in Table 5.2 - 7 in Section 5.2.2.

In Slovakia, 80.84% of the total number of inhabitants are supplied by public water supply. The Water and Sewerage Companies supply drinking water to 77.19% of the inhabitants. The rest are the municipal water supply systems run by the municipal (Obec) office.

The providers of public water supply systems – Water and Sewerage Companies assure the controlling drinking water quality from the source to the distributing network The organization body for health protection – State Health Institute – control a drinking water quality at clients. The catering and analysis of drinking water samples can be provided only at properly equipped laboratories which are able to show the accuracy of laboratory results. The frequency of sampling and range of designated indicators are set by the Slovak Technical Standards according to the source size and the amount of supplied inhabitants.

The data are processed twice a year for the need of Ministry of Agriculture SR, where they evaluate the occurrence of indicators exceeding the limit values according to STN 75 7111.

5.2.4 SOIL AND GROUNDWATER ISSUES AND RECOMMENDATIONS

(1) Summary of the Existing State

From the foregoing discussions, the situation concerning the soil and ground water in the Study Area can be summarized as follows.

1) Soil

a) In the Lower Hron region, Chernozem, Fluvisol and Luvisol are the dominant soil types and most parts of this region are used for agriculture. Fertilizer consumption in the agricultural land was high in the past but it has decreased to the level of one third by now. In the middle to upper mountainous region, Cambisol and Rendzina are the dominant soil types and fluvisols can be found in the Hron Alluvial valley.

b) In the geochemical atlas project, 660 soil samples were taken and tested between 1991 and 1995. The results have been analyzed and are shown on the soil evaluation map in the main report. Since then, soil monitoring, soil sampling and testing at a small number of locations (less than 30) has been conducted in the Study Area by VUPO.

c) The limit values of potentially toxic elements in the soil (hygienic limit values) for As, Cd, Cr, Cu, Ni. Pb and Zn are decided by the Resolution 531/1994. The evaluation of current soil condition in this report was mainly conducted by comparing this limit value with soil test results.

d) Contaminated areas of soil are mainly distributed in the mountainous areas of the middle to upper region of the basin. Most of the areas are located in the surroundings of the old mining areas. As and Cu are the notable contaminants in this area. Furthermore, Ni, Pb, Hg, Zn and Cd exceed limits in some places. Mining activities and natural geochemical anomalies are the leading cause of this contamination.

e) In the lower region, As and Cu contamination can be found in the Hron Alluvial valley. But the contamination is not so heavy and the area is limited.

2) Groundwater

a) In the geochemical atlas project, 1 965 groundwater samples were taken and tested between 1991 and 1994. For regular groundwater monitoring, 66 points for groundwater quality, 97 boreholes for groundwater level and 16 points for spring flow rate have been selected, with monitoring being conducted by SHMU. Further, additional 20 samples were taken in the most polluted parts of Levice district by GSSR. The analysis will be completed by the end of 2000.

b) The drinking water standard, Slovak standard STN 75 7111 is still applicable in Slovakia and the groundwater quality is mainly evaluated by comparing this standard and groundwater chemical test results.

c) It is significant that the lower region of the Study Area is widely contaminated. The main contaminants are NO3, Ca and Total Dissolved Solids (TDS). Furthermore, areas heavily contaminated with these contaminants and with Cl and Mn can be found along the Hron Alluvial valley. This contamination in the lower region is attributed to agricultural activities, especially fertilizer use and possibly from OELs (Old Environmental Loads) at some locations. (Ref. to Map 7.5.4 Groundwater Pollution Thematic Map).

d) In the middle region, two significant areas of contamination can be found. One is along the Hron Alluvial valley, where Fe, Al, As and Ca are the main contaminants. The concentration of factories and the accumulation of metal-rich sediments are the main causes of this contamination. The other contamination area consists of the surroundings of the old mining sites; Mn, Al, Ca, As and Cd are the main contaminants in this area. Mining activities are the main cause of this contamination

e) Groundwater contamination in the upper region is relatively light compared with the other regions but Zn and Al contamination can be found in the mountain area. Old mining activities or natural geochemical anomalies are the causes of this contamination. NO3 and NH4 contamination can be found in the Hron Alluvial valley. Agricultural activity and sewage effluent is the cause of this contamination.

f) Vulnerability analysis was conducted using the DRASTIC method. The contaminated areas of the alluvial valley and the lower region are in good agreement with the highly vulnerable areas as estimated by this vulnerability analysis.

g) The reserves of groundwater are relatively stable. In the upper region, the average flow of spring is high and groundwater levels are slightly increasing. In the middle to lower region, the groundwater level is stable. The flow of the springs is stable in the middle region and slightly decreasing in the lower region. However, there are some karstic aquifers in the region where discharge changes very rapidly.

h) The Public water supply (PWS) connection rate in Banska Bystrica Kraj part of the Study Area is relatively high at more than 90%. However, the PWS connection rate in Nitra kraj part of the Study Area is relatively low at around 70%. Most of the households which are not connected to the PWS use shallow groundwater from their own wells.

i) Priority ares for improving the public water supply connection rate was studied based on the PWS connection rate, current groundwater quality, groundwater quality trends and physical vulnerability. From this result, Levice and Nove Zamky Okres are ranked of very high priority for the PWS connection rate improvement.

(2) Soil and Groundwater Issues, Targets and Recommendations

Remediation of polluted soil and groundwater is not an easy task. Even when contaminated soil is limited to a small area, its remediation needs a very long time and a large cost, and the effect of the remediation may not be so reliable. Furthermore it is sometimes difficult to point out the definite cause of the pollution and to specify measures to eliminate the pollution source.

The main goal of environmental management in relation to soil and groundwater shall be the protection of human health against the pollution. In other words, the issues of utilized groundwater and soil shall be given high priority in the environmental management plan.

Although the overall soil and groundwater of the Study Area is not in a crucial state, there are localised problems or 'hot spots'. The following are identified as the major issues concerning soil and groundwater field.

(SG1) Information on quality of shallow groundwater incomplete and out of date.

The geochemical atlas project for groundwater was conducted during 1991 – 1994. This is the most comprehensive groundwater study in the Study Area. Groundwater monitoring has been conducted for many years by SHMU. This monitoring is the very useful information to understand groundwater quality and quantity condition in the Study Area. Based on this information, endangered areas and vulnerable areas have been pointed out in this report.

However, more than 5 years has passed since the geochemical atlas project was conducted. Furthermore, the number of SHMU monitoring points is too small to understand the situation with respect to groundwater changes, especially since there are only a few points in the more vulnerable areas.

It is recommended to conduct a rapid assessment survey of groundwater quality by the end of 2000. The survey shall be conducted in those areas which are 'physically' vulnerable, because of the local hydrogeology, (Ref. to Figure 5.2.9), which are endangered/threatened (because contamination and or contamination sources have been identified (Ref.Map 5.2 - 3) and where groundwater is utilized.

(SG2) Groundwater quality monitoring system

As described above, the number of groundwater monitoring points by SHMU is too small to understand groundwater quality trends correctly, especially in the high vulnerability area of the lower region. It can be recognized from the limited SHMU monitoring data that is available, that the contamination by NO3 in groundwater in the lower region was highest in 1989 to 1991 and is gradually decreasing. However, because there are only a few monitoring points, it is very difficult to obtain a clear picture of groundwater quality changes in this lower Hron region.

The establishment of a sufficient number of monitoring points in the vulnerable areas is recommended. Additional monitoring points in Levice and Nove Zamky Okres are an urgent matter and it is recommended that they are established by the end of 2001. In other vulnerable/contaminated areas, it is recommended to establish new monitoring points by the end of 2002.

(SG3) Some settlements/households not connected to safe drinking water supply

In some parts of the Study Area, especially in the lower region (Levice and Nove Zamky Okres) many settlements/households are not connected to a safe drinking water supply. The groundwater in this region is moderately to highly polluted and physical vulnerability to the pollution is generally high.

To supply clean drinking water for the settlements/households in the endangered and vulnerable areas, by the construction of public water supply, is recommended.

It is recommended to establish a local task force "Safe Drinking Water in the Hron Basin" by the end of 2000, to facilitate investigation of the issue and co-ordinate an action programme. Furthermore, a system to help determine priority areas for connection to a public water supply should be established.

The priority areas for installation of public water supply shall then be defined. A series of feasibility and detailed design studies for the priority areas should then be conducted, by the end of 2002 in Levice and Nove Zamky and by the end of 2003 elsewhere.

Based on these studies, water supply systems shall be constructed, with implementation by the end of 2003 in Levice and Nove Zamky and by the end of 2004 elsewhere.

(SG4) Suspected contamination of soil and groundwater with POPs

There is no comprehensive study, investigation or monitoring of contamination of soil and groundwater by POPs (Persistent Organic Pollutants). Nowadays POPs contamination is considered to be one of the most serious issues in developed countries in the field of soil and groundwater environment. There are few data for POPs contamination in the Study Area, but a certain degree of POPs contamination may have occurred in the Hron alluvial valley, because factories are concentrated in this valley and the soil and groundwater are highly vulnerable to pollution. At least, it is expected that the POPs contamination may occur in the future in response to changes in industry.

To grasp the current condition of POPs contamination in the Study Area and to prepare measures for this type of contamination, it is recommended to conduct sampling and testing programmes for POPs in vulnerable areas by the end of 2002. Based on the results, endangered and vulnerable areas shall be defined and preparations for appropriate remediation should be made by the end of 2002. According to the severity of the problems identified, the remediation shall be conducted between 2003 to 2010.

As a basis for the above surveys and to prevent further POPs contamination of soil and groundwater, a survey/audit of industries and other potential sources of POPs shall be conducted by the end of 2001. This would involve the checking of old maps, records etc to understand better the history of industrial development and activities at 'suspect' locations.

(SG5) Quality of soil and groundwater in polluted areas

Sites exist which have been heavily polluted, such as the old mining areas in Banska Stiavnica, the Soviet air base in Sliac, the environs of the aluminum factory in Ziar nad Hronom, etc. There have been detailed studies in some areas and only simple studies in others. The pollution may not be crucial at present for the health of people in the surrounding areas, but it should be realized that groundwater contamination proceeds slowly but continuously.

The study team could not collect enough information to judge the importance and urgency of pollution issues in these areas. However, the groundwater vulnerability of these areas is generally high. It is recommended to conduct further investigations and studies of soil and groundwater in these areas.

There is considerable, but 'patchy' information on the soil and groundwater condition in these areas. It is very difficult to determine those areas which are endangered, highly vulnerable and in need of urgent attention. First, it is recommended to conduct a comprehensive review of existing studies and databases on contaminated sites by the end of 2002. Based on this study, the endangered and vulnerable sites shall be selected. A site investigation programme and design studies for remediation and protection measures shall be conducted for these sites by the end of 2003. Execution of these remediation and protection programmes at the most vulnerable and endangered sites shall be conducted from 2003 to 2010.

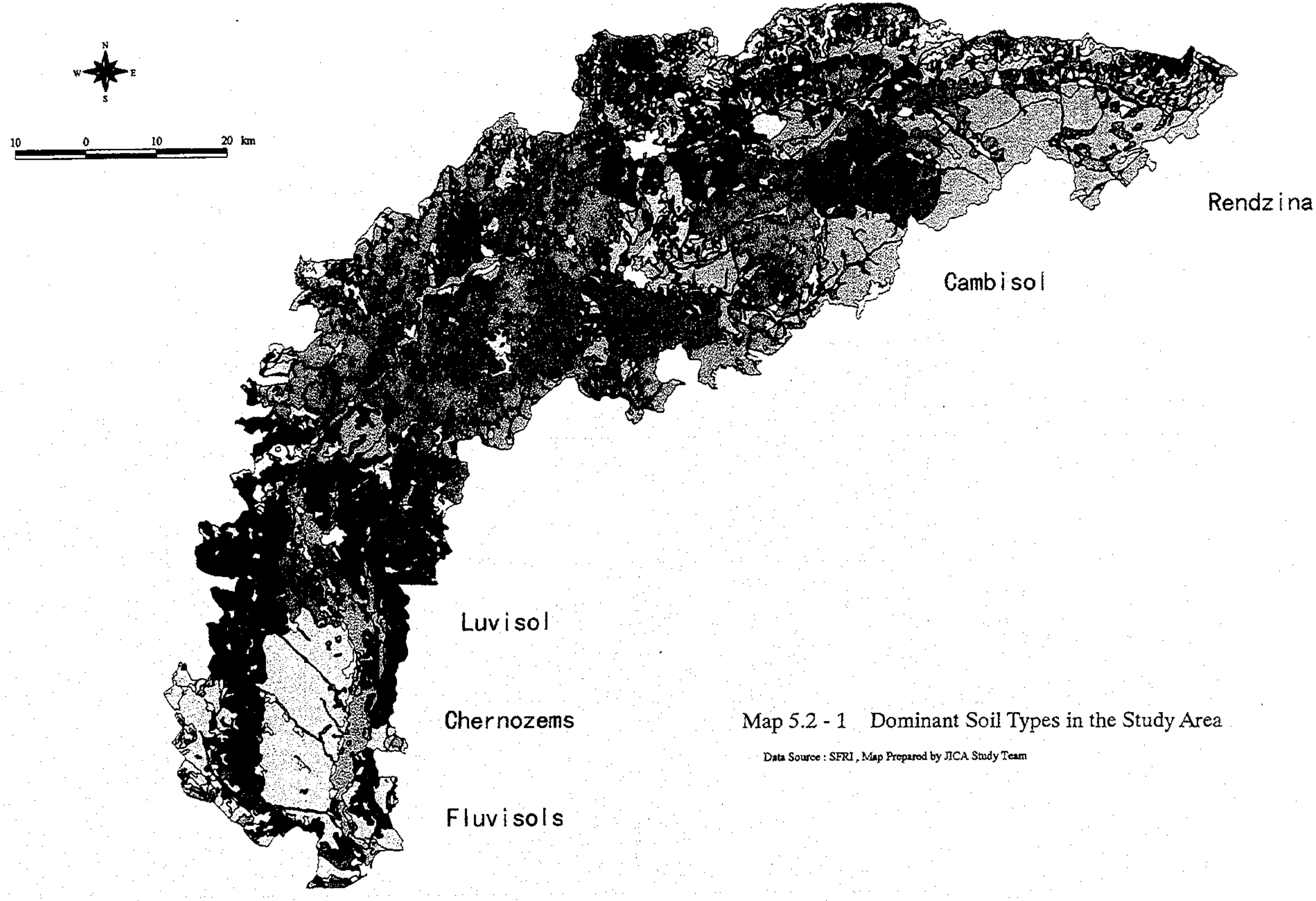
(3) Summary of Objectives and Recommendations

The overall Goal is to ensure that the quality of groundwater used for drinking water and other purposes is in compliance with Slovak Standards in order to protect human health and allow economic development of this resource on a sustainable basis.

Table 5.2 - 9 Summary List of Recommendations

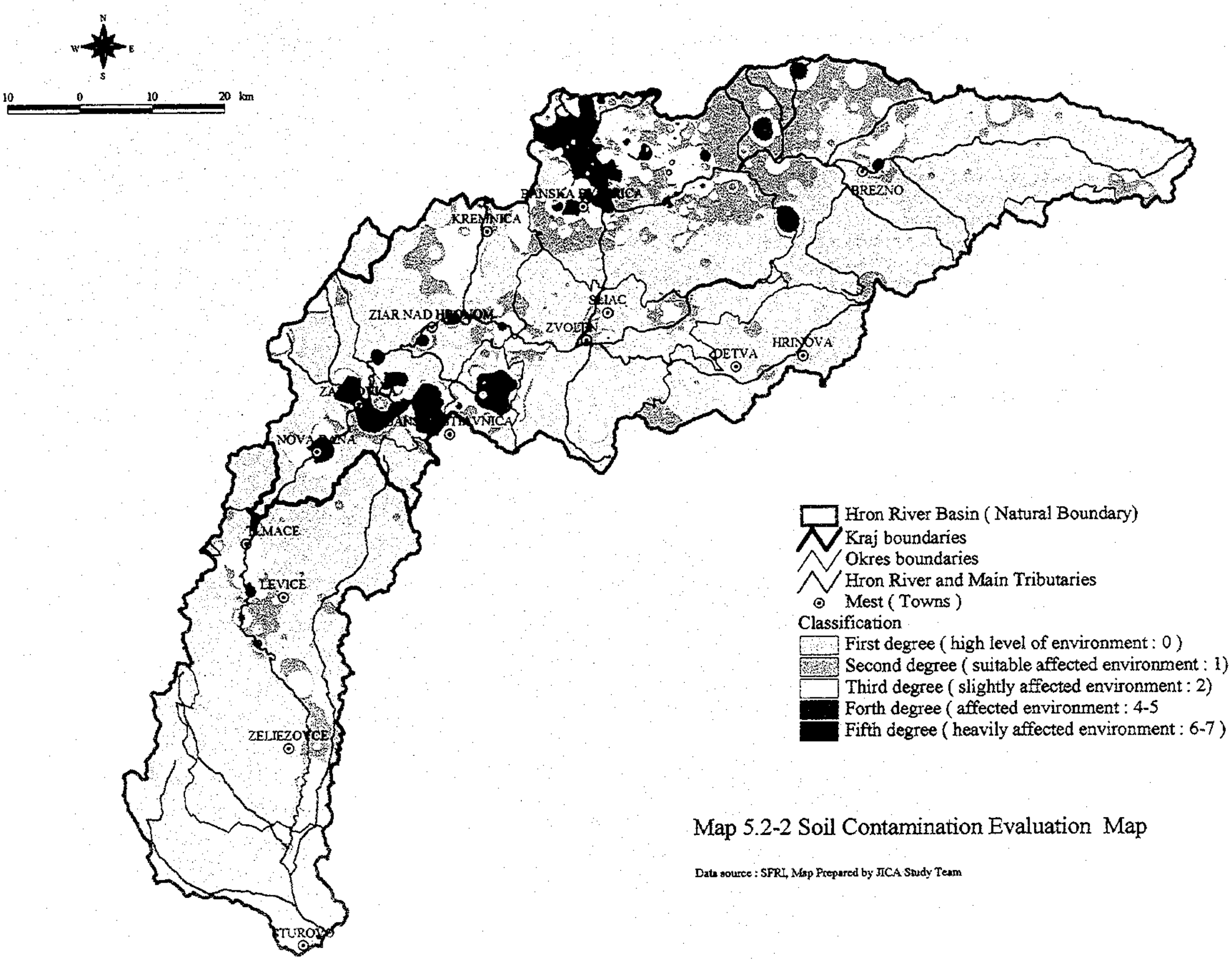
Issue	Objective	Target	Recommended Measures	Key Agency
(SG1) Information on quality of shallow groundwater incomplete and out of date	Provide an up-to-date definition of those areas, where groundwater is used for drinking, that do not comply with Slovak Standards for Drinking Water	By end of 2000	SG1.1) Conduct rapid assessment survey of shallow groundwater in Priority Areas as determined by 'physical' vulnerability and previous contamination	GSSR, SHMU, StVaK, ZsVaK, State Health Institute
(SG2) Groundwater Quality Monitoring System Inadequate (for detection of trends in vulnerable/ contaminated areas used for drinking and other purposes)	Improve groundwater quality monitoring network and reporting system in those vulnerable areas where contamination has been identified	By end of 2001 in Levice and Nove Zamky areas, end of 2002 elsewhere	SG2.1) Establishment of New Groundwater Monitoring Points in Priority Areas as determined by (SG1), along with System to Analyse, Interpret and Report Monitoring Data – to Provide Feedback to Task Force (see SG3.1 below)	SHMU
(SG3) Some Settlements/Households not Connected to Safe Drinking Water Supply	Determine Priority Areas for Upgrading Public Water Supply to meet Slovak Standards	By end of 2000	SG3.1) Establish Local Task Force 'Safe Drinking Water in the Hron Basin' to facilitate investigation and co-ordinate action	Municipalities, Okres, ZsVaK, StVaK, SHMU, State Health Institute, SAZP
	Determine Priority Areas for Upgrading Public Water Supply to meet Slovak Standards	By end of 2000	SG3.2) Development of System to Prioritise Areas for Connection to Public Water Supply; Gather Data and Apply the System to Hron Basin	SAZP, Municipalities, Okres, ZsVaK, (StVaK), SHMU, State Health Institute
	To install Public Water Supply in Priority Areas	By end of 2002 in Levice and Nove Zamky areas, end of 2003 elsewhere	SG3.3) Conduct Series of Feasibility and Detailed Design Studies for Water Supply to Priority Areas	StVaK, ZsVaK and Municipalities
	To install Public Water Supply in Priority Areas	By end of 2003 in Levice and Nove Zamky areas, end of 2004 elsewhere	SG3.4) Construct Water Supply Systems in Priority Areas	StVaK, ZsVaK and Municipalities

Issue	Objective	Target	Recommended Measures	Key Agency
(SG4) Suspected contamination of soil and groundwater with POPs	To determine the current condition of soil and groundwater with respect to contamination with POPs	By end of 2002	SG4.1) Sampling and testing programme for POPs in soil and groundwater in vulnerable areas	SHMU, GSSR, VUPOP, State Health Institute, SIZP, Banska Bystrica and Nitra Kraj offices
	As above and the prevention of further soil and groundwater contamination with POPs	By end of 2001	SG4.2) In conjunction with SG4.1), a Survey/Audit of industries and other potential sources of POPs	Industries, SIZP, State Health Institute, Kraj offices and/or Okres offices
	The remediation of soil and groundwater contamination with POPs	Preparation by end of 2002, implementation phased 2003 to 2010	SG4.3) Preparation and implementation of programme of POPs remediation measures in vulnerable areas (eg where water supplies are at risk)	Ministry of Economy, Ministry of Environment, Industries, SIZP, Kraj and/or Okres offices
	The prevention of soil and groundwater contamination with POPs	Preparation by end of 2002, implementation phased 2003 to 2010	SG4.4) The preparation and implementation of measures to prevent soil and groundwater contamination with POPs	Ministry of Economy, Ministry of Environment, Industries, SIZP, Kraj and/or Okres offices
(SG5) Contamination of Groundwater and Soil in existing industrial areas and at Old Environmental Loads (OEL)	Remediation of contaminated soil and groundwater in vulnerable areas and protection from further contamination	By end of 2002	SG5.1) Comprehensive Review of Existing Studies and Databases on Contaminated Sites	Ministry of Environment (GSSR, SIZP, SHMU), Ministry of Economy, Industries
		By end of 2003	SG5.2) Site Investigation Programme of Most Contaminated Sites and Design of Remediation (Clean-Up) and Protection Measures	Ministry of Environment (GSSR, SIZP, SHMU), Ministry of Economy, Industries
		Implementation phased 2003 to 2010	SG5.3) Execution of the Remediation and Protection Programme at the Most Contaminated Sites	Ministry of Environment (GSSR, SIZP, SHMU), Ministry of Economy, Industries



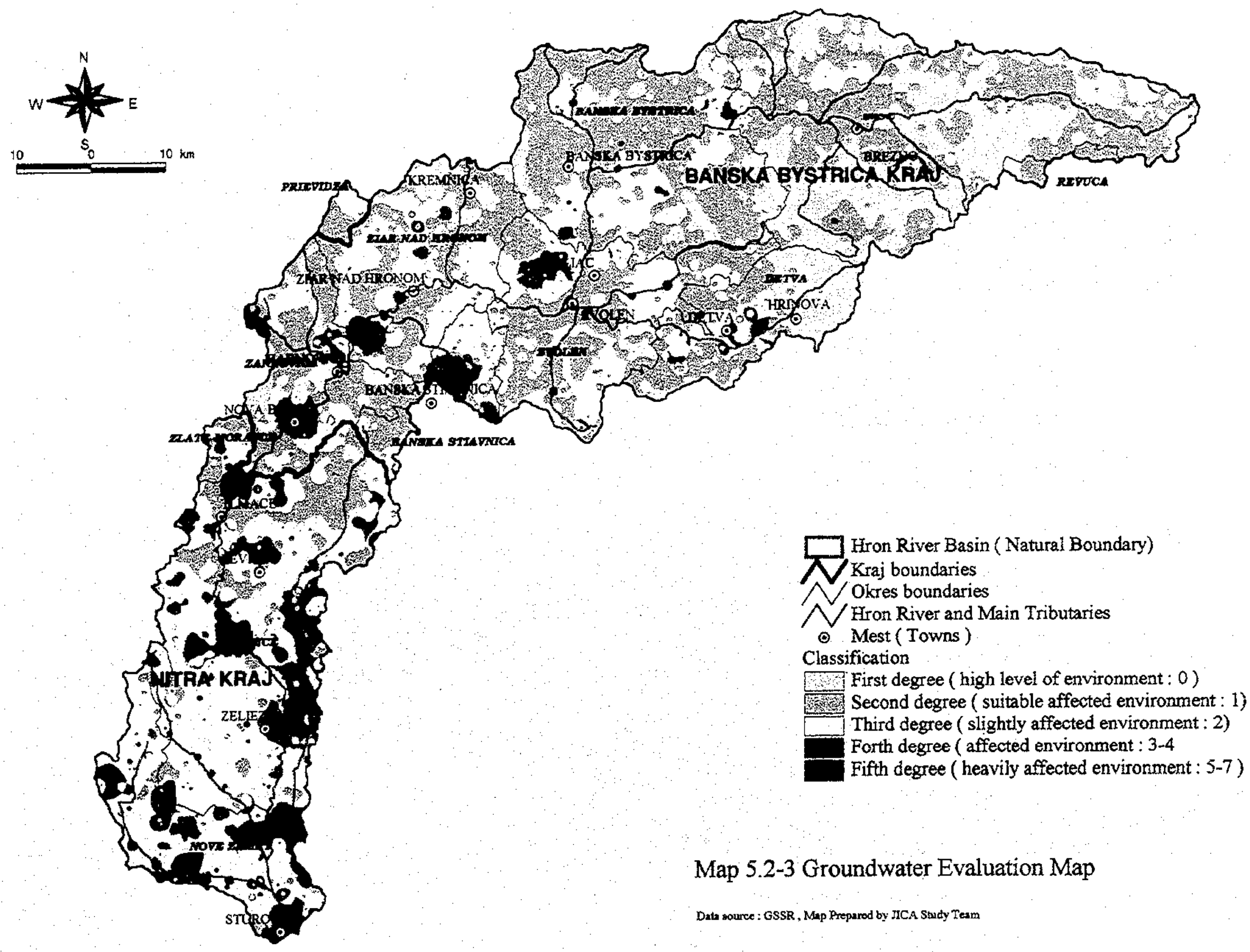
Map 5.2 - 1 Dominant Soil Types in the Study Area

Data Source : SFRI, Map Prepared by JICA Study Team



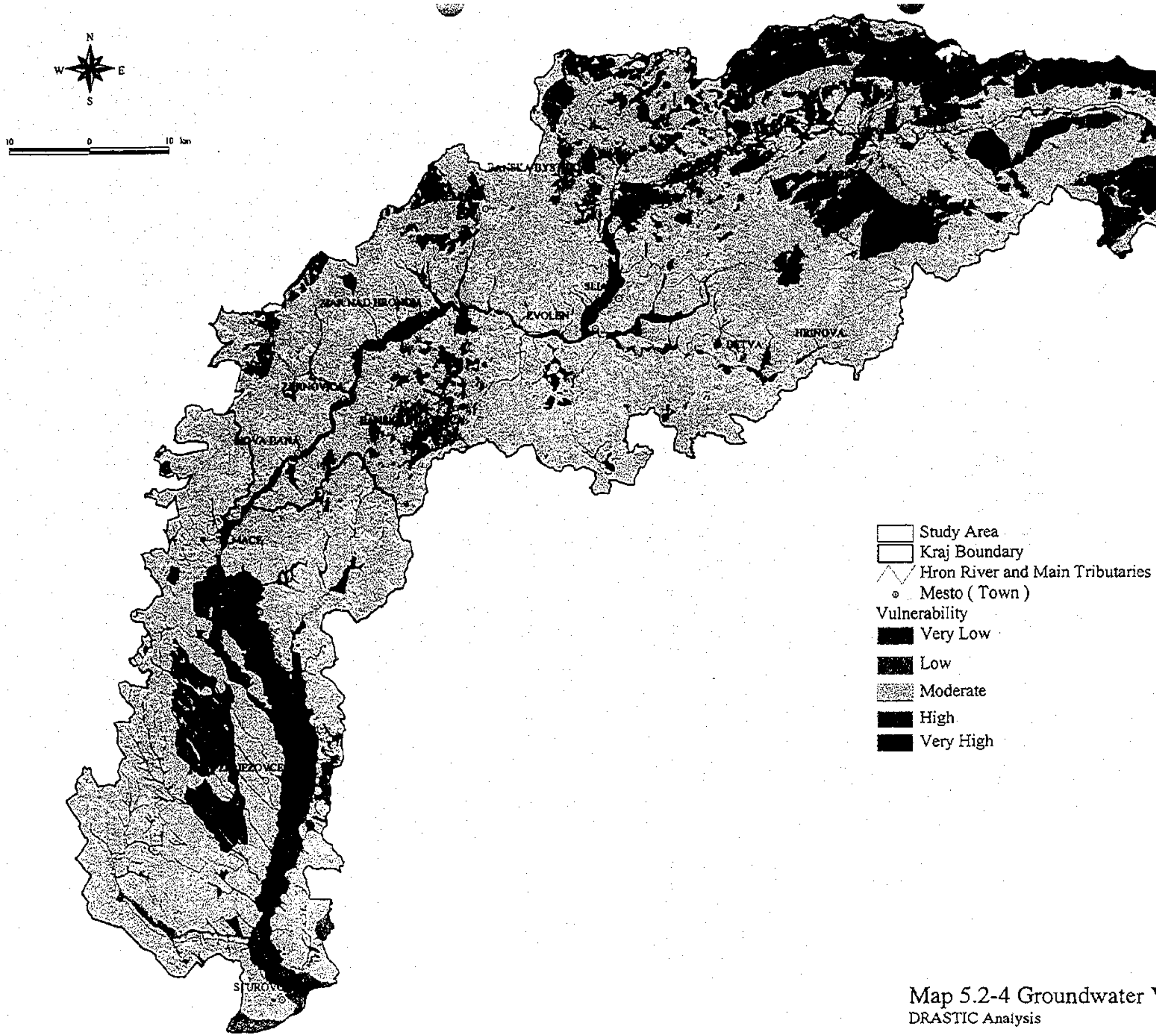
Map 5.2-2 Soil Contamination Evaluation Map

Data source : SFRI, Map Prepared by JICA Study Team



Map 5.2-3 Groundwater Evaluation Map

Data source : GSSR , Map Prepared by JICA Study Team



Map 5.2-4 Groundwater Vulnerability Map
DRASTIC Analysis

5.3 AIR QUALITY

5.3.1 FACTORS AFFECTING AIR QUALITY

The major factors affecting the ambient air quality of the Study Area may be broadly categorised as follows:

a) Emission of pollutants

i) Fuel combustion at stationary sources
ii) Industrial processes
iii) Transportation (automobiles, non-electric locomotives)
iv) Solid waste disposal (landfill, incineration)
v) Miscellaneous (forest fires, agricultural burning, removal of vegetation, etc.)

b) Meteorological conditions

vi) Winds
vii) Atmospheric stability (influenced by several meteorological factors)

c) Topography

As regards emission of pollutants, categories i), ii) and iii) listed above are considered to be the major sources in the Study Area. Their emission data are available from SHMU and presented below, although the data for category iii) and medium to small sources of categories i) and ii) are limited

The wind characteristics and topography of the Study area were described in the earlier chapter, and additional details are included in the Supporting Report.

(1) Air Pollution Source Inventory in Slovakia

The principal source of data on air pollutant emission is the Emission and Air Pollution Source Inventory (abbreviated as REZZO "**R**egister **E**misii **Z**drojov **Z**necistenia **O**vzdusia in Slovak). This inventory is classified into the following 4 components:

REZZO 1	Stationary sources of the heat output over 5 MW and selected technologies
REZZO 2	Stationary sources of the heat output 0.2 - 5 MW and selected technologies
REZZO 3	Stationary (local) sources of the heat output below 0.2 MW
REZZO 4	Mobile sources, regardless of the heat output

In 1990 and 1998 at the national level, the shares of the above 4 components in the emissions of 4 principal pollutants were as those shown in Tables 5.3 - 1 and 5.3 - 2.

Table 5.3 - 1 Emission of Pollutants in Slovakia in1990

Unit: ton (%)

Source Category		NOx	SO_2	PM	CO
Stationary sources	REZZO 1	146 474 (65)	421 981 (78)	208 075 (68)	162 047 (33)
	REZZO 2	4 961 (2)	37 509 (7)	36 425 (12)	27 307 (5)
	REZZO 3	6 783 (3)	79 487 (15)	54 868 (18)	143 633 (30)
	Sub-total	158 218 (70)	538 977 (99)	299 368 (98)	332 987 (68)
Mobile sources	REZZO 4	67 090 (30)	3 614 (1)	4 758 (2)	154 397 (32)
Total		225 308 (100)	542 591 (100)	304 126 (100)	487 384 (100)

Source: SHMU (Ref. 8 - 11)

Table 5.3 - 2 Emission of Pollutants in Slovakia in 1998

Unit: ton (%)

Source Category		NOx	SO_2	PM	CO
Stationary sources	REZZO 1	74 322 (58)	153 723 (86)	31 168 (54)	118 581 (38)
	REZZO 2	3 960 (3)	10 577 (6)	9 478 (16)	12 037 (4)
	REZZO 3	5 177 (4)	12 087 (7)	14 166 (25)	38 027 (12)
	Sub-total	83 459 (65)	176 387 (99)	54 812 (95)	168 645 (54)
Mobile sources	REZZO 4	44 858 (35)	2 393 (1)	2 698 (5)	144 244 (46)
Total		127 944 (100)	178 780 (100)	57 508 (100)	312 889 (100)

Source: SHMU (Ref. 8 - 11)

The emissions of four major air pollutants from the REZZO 1 sources have dominant shares among the 3 stationary source categories. Except for CO, their share is also the largest among all the 4 categories including mobile sources (REZZO 4). For SO_2 and PM, the shares of emissions from mobile sources are negligible.

Comparing the 1990 and 1998 emissions, drastic decrease in all substances is evident (- 43 % for NOx, - 67 % for SO_2, - 81 % for PM, and - 36 % for CO). Although the emissions from traffic had decreased in quantity, the relative contribution of traffic related pollutants to the total increased significantly (from 30 % to 35 % for NOx, and from 32 % to 46 % for CO). The traffic emissions had decreased despite the growing traffic fleets, due to the increasing share of modern cars equipped with a three-way catalytic converter. However, the contribution of traffic is expected to grow also in the future.

(2) Air Pollutant Emissions in the Study Area

1) Total Emissions of Major Pollutants

Emission data of REZZO 1 on individual pollution sources in and around the Study Area are extracted from the REZZO database. As these sources are associated with geographical grids, extraction of sources located in and around the Study Area is possible. The original SHMU data for emissions of REZZO 2 and REZZO 3 sources are aggregated data for each Okres. Therefore, emissions in the Study Area were estimated according to the percentage of the area included in the Study Area to that of the total area of respective Okres.

The total emissions of NOx, SO_2, PM, and CO from all the sources in the Study Area in 1990 and 1998 are shown in Tables 5.3 - 3 and 5.3 - 4, respectively. And the total emissions of the same from the REZZO 1 stationary sources in the selected years since 1990 are shown in Table 5.3 - 5.

Table 5.3 - 3 Emission of Pollutants in the Study Area (1990)

Unit: ton (%)

Source Category		NOx	SO_2	PM	CO
Stationary sources	REZZO 1	8 417 (28.3)	33 800 (65.4)	10 881 (83.7)	5 829 (12.7)
	REZZO 2	6 787 (22.8)	6 860 (13.3)	889 (6.8)	4 541 (9.9)
	REZZO 3	7 168 (24.1)	10 634 (20.6)	706 (5.4)	18 392 (40.1)
	Sub-total	2 372 (75.2)	51 294 (99.2)	12 476 (96.0)	28 762 (62.9)
Mobile sources	REZZO 4*	7 380 (24.8)	398 (0.8)	523 (4.0)	16 984 (37.1)
Total		29 752 (100)	51 692 (100)	12 999 (100)	45 746 (100)

Source: SHMU (Ref. 8-11)

*Assumed to be 11% of the Slovak total.

Table 5.3 - 4 Emission of Pollutants in the Study Area (1998)

Unit: ton (%)

Source Category		NOx	SO_2	PM	CO
Stationary sources	REZZO 1	2 906 (33.0)	9 039 (73.7)	1 444 (30.5)	13 536 (38)
	REZZO 2	426 (4.8)	1 375 (11.2)	1 133 (23.9)	1 633 (5)
	REZZO 3	535 (6.1)	1 594 (13.0)	1 862 (39.3)	4 970 (14)
	Sub-total	3 867 (43.9)	12 008 (97.9)	4 439 (93.7)	20 139 (56)
Mobile sources	REZZO 4*	4 934 (56.1)	263 (2.1)	297 (6.3)	15 866 (44)
Total		8 801 (100)	12 271 (100)	4 736 (100)	36 005 (100)

Source: SHMU (Ref. 8 - 11)

*Assumed to be 11% of the Slovak total.

Table 5.3 - 5 Emission of Air Pollutants from Stationary Sources of REZZO 1 in the Study Area (1990 - 1998)

Year	Number of Sources	NOx (ton)	SO_2 (ton)	PM (ton)	CO (ton)
1990	112	8 417	33 800	10 881	5 829
1993	119	7 438	19 941	5 276	3 450
1996	109	4 915	12 548	2 632	15 459
1997	104	3 511	11 105	1 703	14 403
1998	103	2 906	9 039	1 444	13 536

Source: SHMU (Ref. 8 - 11)

The emissions of major pollutants from the REZZO 1 sources have been drastically decreasing during 1990s except for CO which increased significantly due to the change in the production process in the aluminium factory in Ziar nad Hronom.

A comparison of the emission figures for whole Slovakia and the Study Area in 1998, as given in Tables 5.3 - 2 (Slovakia) and 5.3 - 4 (Study Area), shows that the share of the emissions of NOx , SO_2, PM and CO from the Study Area was 6.9 %, 6.9 %, 8.2 %, and 11.5 % of the emissions in Slovakia. In comparison to the shares of the Study area in the Slovak total population and land area, which are 9.9 % and 12.3 %, respectively, the shares of the emission of NOx , SO_2 and PM from the Study area are considerably smaller. The contribution of the emissions from the Study area to the national total decreased in 1998, except for CO.

Further comparison of Tables 5.3 - 2 and 5.3 - 4 shows that the contribution ratios of the pollutants emissions from large sources (REZZO 1) to the total emissions in the Study Area are less than those ratios in whole Slovaka, and the contributions of middle and small sized sources, as well as mobile sources, in the Study Area are above those in whole Slovaka. The higher contributions of middle and small sized sources may be partly due to the relatively low use of natural gas in the Study Area for heating. In Banska Bystrica Okres, for example, natural gas utilisation by small heat producing boilers (0.2 - 5 MW) is only 0.6 %, while brown coal utilisation is 74 %, liquid fuels 15 %, hard coal 6 %, and biomass 4 %, according to the data for fuel consumption in REZZO 2 sources.

Of the total emission of NOx in the Study Area, mobile sources account for 56 % while the Slovak average is 35 %.

2) Emissions from Large Stationary Sources

In 1998, the number of the REZZO 1 emission sources in the Study area was 103. From these 103, the ten largest emission sources of NOx, SO_2, PM, and CO, and their respective emission amounts are shown in Table 5.3 - 6. Locations of the REZZO 1 emission sources are shown in Map 5.3 - 1.

The large sources have dominant shares in the total emissions from the REZZO 1 sources in the Study Area as shown below:

	SO_2	NOx	PM	CO
Largest one	38 %	21 %	13 %	75 %
Largest three	68 %	51 %	34 %	85 %
Largest five	84 %	68 %	49 %	90 %
Largest ten	94 %	83 %	72 %	96 %

Table 5.3 - 6 Emission of Air Pollutants from Major Stationary Sources in the Study Area (1998)

Name		Obec / Mesto (Okres)	Emission (ton/year)				Rank (1 - 10)			
			SO_2	NOx	PM	CO	SO_2	NOx	PM	CO
1.	SSE SP	Zvolen (Zvolen)	3 393	604	37	86	1	1		
2.	Assidomain Packaging	Štúrovo (Nové Zámky)	1 489	597	185	170	2	2	1	7
3.	ZSNP, Energetické Hospodárstvo	Ziar nad Hronom (Ziar nad Hronom)	1 259	280	79	90	3	3	7	10
4.	ZSNP, Výroba Elektrolytického Hliníka	Ziar nad Hronom (Ziar nad Hronom)	907	17	106	10 202	4		5	1
5.	Harmanecké Papierne	Harmanec (Banská Bystrica)	529	102	34	8	5	7		
6.	Biotika	Slovenská Lupka (Banská Bystrica)	367	108	25	22	6	6		
7.	Petrochema a. s.	Dubová (Brezno)	296	69	94	14	7	9	6	
8.	Izomat	Nová Baňa (Zarnovica)	119	43	61	375	8		8	4
9.	ZSNP, Vyroba Vopred Vypálenych Anód	Ziar nad Hronom (Ziar nad Hronom)	101	24	8	297	9			6
10.	Stredoslovenská Cementáren	Banská Bystrica (Banska Bystrica)	60	261	47	149	10	4	9	8
11.	Bucina	Zvolen (Zvolen)	10	230	179	845		5	2	2
12.	Zelezlarne Podbrezová	Podbrezová (Brezno)	33	88	14	453		8		3
13.	Zlievarenska Spol.	Hronec (Brezno)	29	9	121	301			4	5
14.	Preglejka	Zarnovica (Zarnovica)	0.5	62	122	36		10	3	
15.	ZSNP, Zav. Kysličníkáren	Ziar nad Hronom (Ziar nad Hronom)	0	7	47	0			10	
16.	Pohronské Strojarne	Hliník nad Hronom (Ziar nad Hronom)	28	5	8	91				9
	Total of 10 largest sources		8 520	2 401	1 041	12 973				
*	Total of 8 ZSNP plants	Ziar nad Hronom	2 267	337	252	10 594	2	3	1	1

Source: SHMU (Ref. 8 - 11)

Note: * The total of 8 plants including 4 plants not appearing in the Table.

Under certain meteorological conditions, large emission sources located outside the Study Area may exert direct influence on the air quality in the Hron River Basin. In this respect following sources in the Horna Nitra area are of interest (data refer to 1998):

	Emission in 1998 (tonne)				Stack (m)
	SO_2	NOx	PM	CO	
Slovenske Elektrarne, elektraren Zem. Kostolany	41 300	4 973	939	635	300 115
Slovenske Elektrarne, teplaren Handlova	218	95	28	11	115

3) Other Pollutants

In addition to the principal pollutants, also pollutants listed bellow have been of interest. However, they have only a local influence and the situations have been improved considerably to date.

Volatile organic compounds	Together about 570 t of VOCs was emitted in the Study Area in 1998. The main sources were wood processing, furniture manufacturing, surface treatment and pharmaceutical industry.
Heavy metals	Together about 1.6 t of heavy metals such as Hg. Cr, Tl, Cu, Pb, Co, Ni, and As was emitted in 1998. The main source is the aluminium production. However, these emissions were drastically reduced in the latest years.
Persistent organic pollutants	The aluminium industry is also a source of polycyclic aromatic compounds. The yearly emission is assessed to be about 2.65 t in 1998. Before the reconstruction of the aluminium factory (currently pre-packed anodes are used), the emission level was 10 times higher than the present.
Fluorides	Fluorides are also emitted from the aluminium industry. In comparison to 337 t of the emission before the reconstruction (1993), the present emission (1998) is 58.3 t.

5.3.2 STATE OF AIR QUALITY

(1) Monitoring Activities

1) Local Air Quality Monitoring

Local air quality in Slovakia is regularly monitored by SHMU. The original plan for establishing the national network for monitoring local air pollution envisaged 60 automatic monitoring stations. But due to the budgetary constraints, the actual network consisted of 32 stations of which five were located in the Study Area.. The operation of the network started in 1993. With further budgetary shortage, the number of actually operating stations decreased to 24 in 1999. In the Study Area, 3 stations out of 5 original stations became inoperable in 1999 (Source: SHMU Banska Bystrica).

The names of the monitoring stations in the Study Area and their monitoring items as of 1998 are shown in Table 5.3 - 7.

Table 5.3 - 7 Local Air Pollution Monitoring Stations in the Hron Basin

Area	Station	Monitoring Item				
		SO2	NOx	TSP	O3	CO
Banska Bystrica	Namestie Slobody	x	x	x	x	x
	Sasova	x	x	x		
Ziar nad Hronom	Ziar nad Hronom	x	x	x	x	
	Lovcica	x	x	x		
	Lovca	x	x			

Source: SHMU (Ref. 8 - 11)

Note: 1) At stations Namestie Slobody and Ziar nad Hronom, concentrations of Pb and Cd in TSP are also measured.

2) Stations Sasova, Lovcica and Lovca are not operating in 1999.

Besides the regular automatic monitoring, SHMU also conducts spot monitoring of specific items as required.

2) Regional Monitoring and Other Monitoring Activities

In addition to the local air quality monitoring, SHMU has been operating 7 regional air quality monitoring stations in Slovakia, of which 4 belong to the monitoring network of Environmental Monitoring and Evaluation Program (EMEP) which is a co-operative programme in Europe. Among other 3 stations, one is located in the Hron basin at Mochovce. The EMEP network aims to monitor contamination of the atmospheric mixing layer of the thickness up to 1,000 m from the ground over the area of the European region. The EMEP stations are placed in rural areas sufficiently distanced from local air pollution sources. Therefore, the air quality observed at these stations may be interpreted as the background to the local air pollution.

State Institute of Health (SZU), Banská Bystrica also conducted some ambient air quality measurements for specific purposes in the last five years.

Besides above, the Forest Research Institute (LVU) in Zvolen measures tropospheric ozone concentration at three localities, as ozone is considered to be the main stress factor for the forests.

(2) Ambient Air Quality Standards and Air Pollution Indices

The ambient air quality standards of the Slovak Republic are shown in Table 5.3 - 8.

Table 5.3 - 8 Ambient Air Quality Standards in the Slovak Republic

Pollutant	Expressed as	Air quality standards (μ g/m^3)			
		AQSy	AQSd	AQS8h	AQSs
Total suspended particulate	TSP	60	150		500
Sulphur dioxide	SO_2	60	150		500
Sulphur dioxide and suspended particulate	SO_2 + TSP		250		
Oxides of nitrogen	NOx	80	100		200
Carbon monoxide	CO		5,000		10,000
Ozone	O_3			110	
Pb in TSP	Pb	0.5			
Cd in TSP	Cd	0.01			
Odorous substances	Concentrations must not be of public nuisance				

Note: AQSy: Annual average concentration of a pollutant.
AQSd: Daily (24-hour) average concentration of a pollutant.
AQS8h: Daytime 8-hour average concentration of a pollutant
AQSs: Half-hour average concentration of a pollutant
AQSd and AQSs for TSP, SO_2, NOx and CO must not be exceeded in more than 5 % of the cases within a year.

For the total assessment of three major pollutants, i.e., NOx, SO2 and TSP, the air pollution indices (API) are used. API is determined for the following three time scales:

APIy: long-term (annual) air pollution index
APId: daily air pollution index
APIs: short-term (half-hour) air pollution index

These are defined as follows:

$$APIy = \sum_{i=1}^{3} \left(annual\ average\ \ conc. / AQSy \right) i$$

$$APId = \sum_{i=1}^{3} \left(95\ percentile\ daily\ average\ \ conc. / AQSd \right) i$$

$$APIs = \sum_{i=1}^{3} \left(95\ percentile\ half-hour\ \ average\ \ conc. / AQSd \right) i$$

where, i (1, 2, 3) indicates each of 3 pollutants, i.e., NOx, SO_2, and TSP.

The degree of air pollution is assessed in terms of API values according to the following criteria:

API range	0.0 - 0.4	0.5 - 0.9	1.0 - 1.4	1.5 - 2.0	over 2.0
Air pollution degree	Not polluted	Slightly polluted	Moderately polluted	Quite polluted	Highly polluted

(3) Air Quality at Local Stations in the Hron Basin

1) Air Quality in Comparison with the Air Quality Standards

The results of the air quality monitoring in 1993, 1996 1997 and 1998 at 5 local stations in the Hron basin are summarised in Table 5.3 - 9. In general, the ambient air quality in the Study Area has been improving since 1993 when the automatic monitoring system began its operation.

Among the 5 local air quality monitoring stations in the Hron basin, the air quality observed at Station Namestie Slobody in Banska Bystrica has been the worst. Until 1997, the concentrations of NOx exceeded all of the standards for annual average, daily average, and half-hour average. However in 1998, the annual average standard was met for the first time, although the daily average and the half-hour average still exceeded the standards. The TSP concentration showed improvement in 1997 to meet the daily average standard for the first time, and further improved in 1998 to meet all the standards for the first time.

At Station Sasova in Banska Bystrica, the concentration of NOx did not satisfy the daily average standard in all of those 4 years although it improved in 1998. The half-hour average concentration of NOx also improved in 1998 to satisfy the standard, while it did not in the previous year. However, the annual average concentration of TSP in 1998 increased from the previous year to exceed the standard.

At Station Ziar nad Hronom, the daily average concentration of TSP exceeded the standard in 1993. But in the recent years, all the air quality standards for NOx, SO_2 and TSP were satisfied at all of the 3 stations in the area. Although CO has not been monitored on the continuous basis at these stations, a recent investigation by SHMU concluded that there was no significant impact of the emission of CO from the aluminium factory on the ambient concentration of CO in this area.

Table 5.3 - 9 Summary of the Results of Air Quality Monitoring at Local Stations in the Study Area (1993, 1996, 1997 and 1998)

(Unit: $\mu g/m^3$)

Averaging time	Pollutant	Air Quality Standard	Year	Banska Bystrica		Ziar nad Hronom		
				Namestie Slobody	Sasova	Ziar nad Hronom	Lovcica	Lovca
Annual average	NOx	80	1993	93.5	47.6	24	14.5	30.5
			1996	81.9	42	22.7	18	16
			1997	94.1	71.8	26.7	23.3	26.8
			1998	71.3	49.8	27.4	12.9	20.0
	SO_2	60	1993	45	49.3	25.6	20.6	41.8
			1996	31.6	18.9	21.7	36.4	20.1
			1997	26.3	13.9	26	28.2	21.6
			1998	24.0	11.6	17.8	20,8	16.1
	TSP	60	1993	80.6	-	51.5	45.6	-
			1996	82.9	-	57.1	15.8	-
			1997	60.9	37	46.9	14.5	-
			1998	45.4	64.8	38.0	26.8	-
	CO	-	1993	1 240	-	-	-	-
			1996	1 401	-	-	-	-
			1997	707	-	-	-	-
			1998	336	-	-	-	-
95 percentile of daily average	NOx	100	1993	254	114	62	21	73
			1996	200	108	49	32	31
			1997	238	200	60	47	60
			1998	219	118	68	31	47
	SO_2	150	1993	139	139	84	55	118
			1996	78	58	65	99	59
			1997	68	42	73	89	74
			1998	48	26	41	53	38
	TSP	150	1993	206	-	152	99	-
			1996	187	-	117	32	-
			1997	119	66	103	31	-
			1998	89	143	75	64	-
	CO	5,000	1993	3 230	-	-	-	-
			1996	2 887	-	-	-	-
			1997	1 730	-	-	-	-
			1998	975	-	-	-	-
95 percentile of half-hour average	NOx	200	1993	291	135	68	23	76
			1996	260	131	60	37	34
			1997	289	221	70	51	65
			1998	230	149	76	32	52
	SO_2	500	1993	160	161	91	62	135
			1996	85	60	68	107	66
			1997	78	50	76	94	78
			1998	59	29	46	61	46
	TSP	500	1993	232	-	161	116	-
			1996	212	-	143	38	-
			1997	143	86	120	38	-
			1998	105	173	91	76	-
	CO	10,000	1993	3 400	-	-	-	-
			1996	3 114	-	-	-	-
			1997	2 010	-	-	-	-
			1998	1 310	-	-	-	-
Daytime 8 - hour average (Apr. - Sept.)	O3	110	1993	66	-	65	-	-
			1996	58	-	80	-	-
			1997	78	-	83	-	-
			1998	83	-	84	-	-

Source: Data provided by SHMU (SHMU BB 6), Ref. 8 - 11

Note: The shaded figures indicate non-compliance with the air quality standard.

2) Air Pollution Indices

Table 5.3 - 10 shows the air pollution indices, as defined earlier, at Stations Namestie Slobody, Ziar nad Hronom, and Lovcica for the years 1993, 1996, 1997 and 1998.

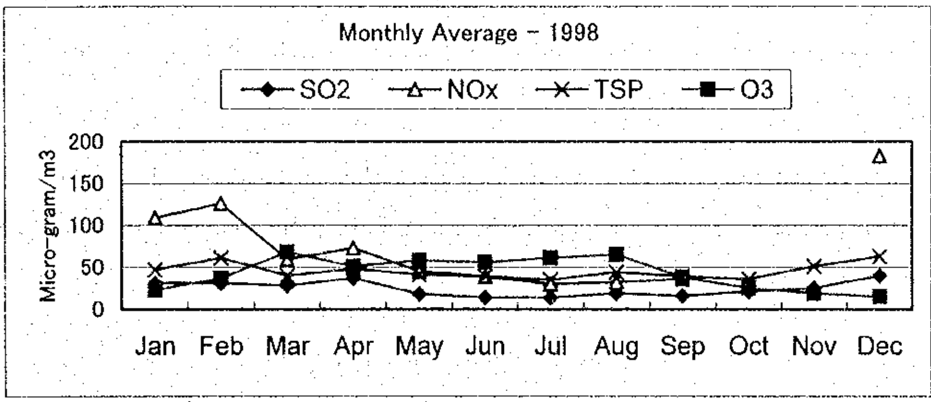
Table 5.3 - 10 Air Pollution Indices at 3 Stations in the Hron Basin (1993, 1996,1997 and 1998)

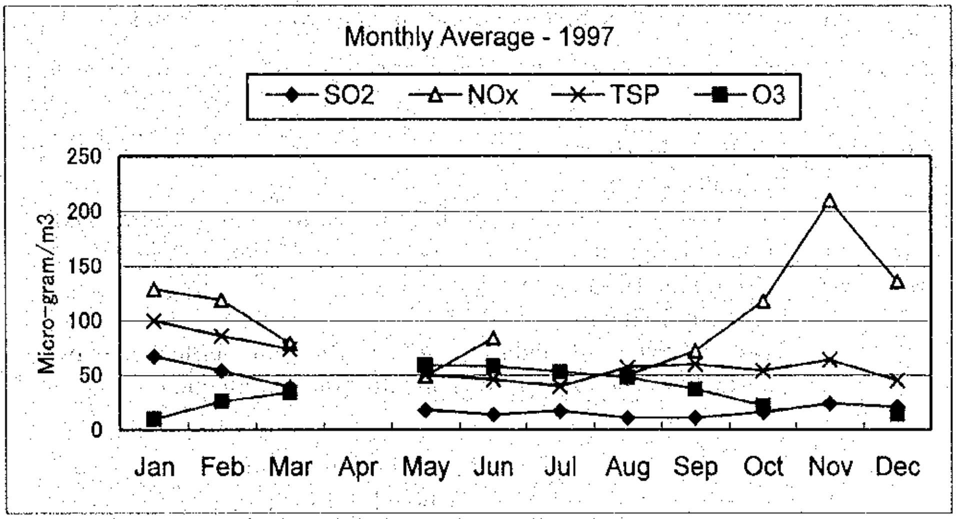
Area	Station	Year	APIy				APId				APIs			
			NOx	SO2	TSP	Sum	NOx	SO2	TSP	Sum	NOx	SO2	TSP	Sum
Banska Bystrica	Namestie Slobody	1993	1.2	0.8	1.3	**3.3**	2.5	0.9	1.4	**4.8**	1.5	0.3	0.5	**2.3**
		1996	1.0	0.5	1.4	**2.9**	2.0	0.50	1.2	**3.7**	1.3	0.2	0.4	**1.9**
		1997	1.2	0.4	1.0	**2.6**	2.4	0.5	0.8	**3.7**	1.4	0.2	0.3	**1.9**
		1998	0.9	0.4	0.8	**2.0**	2.2	0.3	0.6	**3.1**	1.2	0.1	0.2	**1.5**
Ziar nad Hronom	Ziar nad Hronom	1993	0.3	0.4	0.9	**1.6**	0.6	0.6	1.0	**2.2**	0.3	0.2	0.3	**0.8**
		1996	0.3	0.4	1.0	**1.7**	0.5	0.4	0.8	**1.7**	0.3	0.1	0.3	**0.7**
		1997	0.3	0.4	0.8	**1.5**	0.6	0.5	0.7	**1.8**	0.3	0.2	0.2	**0.7**
		1998	0.3	0.3	0.6	**1.3**	0.7	0.3	0.5	**1.5**	0.4	0.1	0.2	**0.7**
	Lovcica	1993	0.2	0.3	0.8	**1.3**	0.2	0.4	0.7	**1.2**	0.1	0.1	0.2	**0.4**
		1996	0.2	0.6	0.3	**1.1**	0.3	0.7	0.2	**1.2**	0.2	0.2	0.1	**0.5**
		1997	0.3	0.4	0.2	**0.9**	0.5	0.6	0.2	**1.3**	0.3	0.2	0.1	**0.6**
		1998	0.2	0.4	0.4	**1.0**	0.3	0.4	0.4	**1.1**	0.2	0.1	0.1	**0.4**

Source: Based on the data provided by SHMU (SHMU BB 6), Ref. 8 - 11

The air pollution indices at Station Namestie Slobody improved significantly from the level of 1993 when all the indices for annual, daily, and half-hour average were classified as "highly polluted." Despite the improvement, however, the daily average index in 1998 is still classified as "highly polluted." The NOx concentration is contributing most to the index values.

Station Ziar nad Hronom is classified as "moderately" or "quite" polluted and Station Lovcica is classified as "slightly" or "moderately" polluted in 1998 in terms of the annual average and daily average index values.





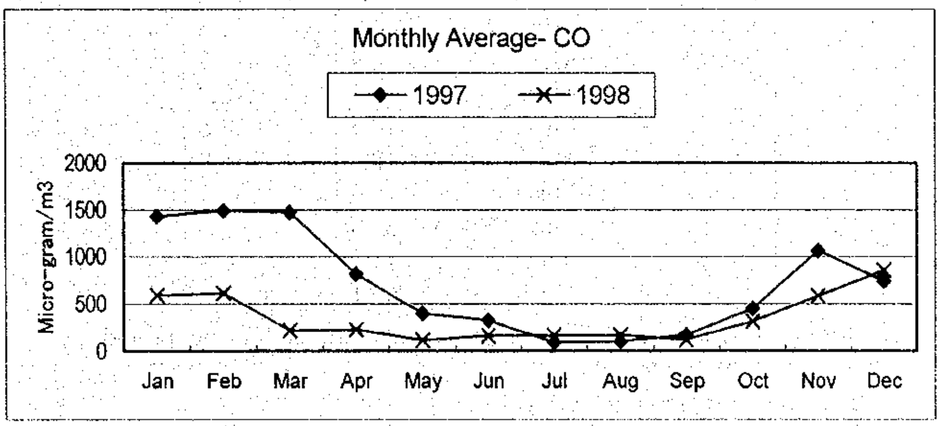


Figure 5.3 – 1 Monthly Average Concentration of Pollutants at Station Namesite Slobody, Banska Bystrica

3) Monthly Change in Air Quality

Monthly average concentrations of 5 pollutants at Station Namestie Slobody in Banska Bystrica in 1997 and 1998 are shown in Figure 5.3 - 1.

The concentrations of NOx and CO are significantly higher in the winter than in the summer. Although such pattern is not so obvious for SO_2 and TSP, their concentrations are generally higher in the winter than in the summer.

The concentration of ozone is higher in the summer than in the winter.

(4) Air Quality According to Regional Monitoring

Table 5.3 - 11 summarises the result of monitoring of SO_2, NOx, TSP, and O_3 at SHMU's regional stations Mochovce and Chopok. The characteristics of these stations are as follows:

Chopok	Outside the Hron basin Altitude at 2 008 m Without any influence of industry, traffic, agriculture, and domestic activities
Mochovce	Within the Hron basin Altitude at 260 m No influence of industry and traffic, but influenced by agriculture and local heating and hot water production

Table 5.3 - 11 Air Quality at Regional Stations

		Chopok	Mochovce
SO_2 ($\mu g/m^3$)	Min.	3.0	11.6
	Max.	3.7	15.2
	Mean	3.3	13.4
NOx ($\mu g/m^3$)	Min.	4.2	11.8
	Max.	4.7	13.7
	Mean	4.5	12.8
TSP ($\mu g/m^3$)	Min.	14.7	34.6
	Max.	18.6	38.9
	Mean	16.6	36.7
O_3 ($\mu g/m^3$)	Min.	62.3	-
	Max.	75.9	-
	Mean	69.1	-

Note: Based on annual average concentrations for the period 1990 - 1998.

Source: SHMU (Ref. 8 - 11)

The pollutant concentrations observed at Station Chopok can be interpreted as the transboundary air pollution, i.e., the background to the air quality of the Hron River basin. The air quality at Station Mochovce is affected by some local emission sources.

(5) Others

As far as is known from the results of particular monitoring projects or studies, no other pollutants were reported to exceed the ambient air quality standards or relevant norms in the last few years. These include volatile organic compounds (VOCs), persistent organic compounds (POPs), heavy metals and fluorides.

(6) Air Quality Modelling

1) Introduction

The results of the ambient air quality monitoring alone are not sufficient for the overall evaluation of spatial distribution of the air pollution and the influences of all types of air pollution sources.

Such an evaluation can be assisted by means of air quality modelling. Needless to say, the real monitoring data are essential for the calibration of the model.

In October 1996 MZP approved for the use in the Slovak republic a model which is fully compatible with the US EPA model ISC 2. It is represented by the software tool MODIM and is suitable for the following applications:

- Calculation of short time critical concentrations
- Calculation of long time average concentrations
- Applicability for point sources as well as area sources
- Applicability for gaseous pollutants as well as particulate matter

The method incorporates the following algorithms, needful for the mathematical modelling of air pollution:

- Pasquill-Uhlig classification of stability categories
- Different dispersion conditions for urban and rural areas
- Dispersion calculation according to Briggs (urban areas) or according to McElroy-Pooler (rural areas)
- Calculation of plume-rise according to Briggs
- Calculation of the dispersion of pollutants emitted from point sources as well as area sources
- Decreasing of pollutants concentration according to physical and chemical reactions in the atmosphere

- Influence of the mixing layer height on the dispersion
- Consideration for the effect of neighbouring buildings onto the dispersion

Following inputs (all from the data-bases of SHMÚ) were used for the model calculations:

- Stability categories
- Wind speed for the respective stability categories in the reference height 10 m
- Half-life period of pollutants
- Data of the reference points
- Wind roses
- Geographical positions of air pollution sources
- Area of the area sources
- Height of the pollutant release points
- Temperature of the released pollutants
- Temperature of the surrounding atmosphere
- Stack diameter
- Mass of the emitted pollutants
- Information about the surrounding buildings
- Differentiation of dispersion conditions (urban or rural)

The influence of orography is considered by using several wind roses, each representing the locality of the particular group of air pollution sources.

In this Study the area of the whole Hron River basin and the area of Banská Bystrica were considered. The model calculations for SO_2, NOx, particulate, and CO were conducted not only for the year 1998, but also for the year 1990, in order to demonstrate trends in air pollution of the study area. Detailed results of the modelling works are given in Reference 8 - 11. The modelling results for the air pollution index in the Study Area and for the NOx and dust concentration distributions in the area of Banska Bystrica are presented in the following sections.

2) Air Pollution Index in the Study Area

Maps 5.3 - 2 and 5.3 - 3 show the annual air pollution index in the Study Area according to the model calculation for the years 1990 and 1998, respectively.

Air pollution in the Study Area is shown to be improved significantly during the 1990s. In 1990 air quality in considerably large parts of the Study Area could be characterised as "moderately polluted (APC 1.0-1.4)" with a few spots being "quite polluted (API 1.5-20)." In 1998 the air quality in nearly the whole area could be characterised as "slightly" polluted with some spots being moderately polluted. It should be noted, however, that these maps intend to present a general view of the air quality in the Study Area, and do not necessarily agree precisely with the data observed at particular monitoring stations, eg the APIy value at Station Namestie Slobody in Banska Bystrica in 1998 was 2.0 (quite polluted).

3) Banska Bystrica Area

Map 5.3 - 4 shows the model computation area of Banska Bystrica.

Nox

Maps 5.3 - 5 shows the computed concentration distribution of NOx for the year 1998.

Although the ambient concentration of NOx generally decreased during the 1990s, according to monitoring as well as modelling results, the concentration may locally exceed the long-term and short-term standards. This will happen exclusively along the busy traffic roads and at their junctions.

According to modelling results, the concentrations of NOx on the regional level (Study Area) is contributed mostly (56 %) by the combustion and technology sources. In Banská Bystrica, however, contribution of these sources is lower at 27.6 %. The road transport contributes with 39.3 %, and rail transport with 24.1 %.

The model calculations were made for the cases when one or all f the following measures are taken:

a) Electrification of the rail section between Zvolen and Banska Bystrica
This measure will result in 100 % reduction of NOx emission from the railway.

b) Construction of a traffic by-pass in Banska Bystrica
This measure will result in 50 % reduction of NOx emission from road traffic.

c) Installation of a flue gas denitration system (selective non-catalytic reduction type) in the cement plant in Banska Bystrica

This measure will result in 66 % reduction of NOx emission from the cement factory.

Map 5.3 - 6 shows the computed result of the annual average concentration distribution of NOx for the case when all of above measures were taken. The ambient air quality standard will be satisfied in the whole area.