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GLOBAL ENVIRONMENTAL FACILITY

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MAROS AQUIFER INVESTIGATIONS

Final Report

VITUKI Plc.

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Summary

USAID has funded Transboundary Pollution Reduction Program in Hungary, Slovakia and Romania. One of the projects of the Program is Maros Aquifer Investigations with the objective to help the protection of the aquifer shared by the countries Hungary and Romania.

The Project was managed by Metcalf and Eddy Inc. which company subcontracted VITUKI Plc. via VITUKI Innosystem Ltd. to implement the following tasks:

- to summarize the previous studies done on the Maros aquifer;
- to determine the primary sources of pollution in Romania and Hungary, to determine water users and their locations in Hungary;
- to prepare a model of the Maros aquifer showing the current conditions of quality and quantity of withdrawals;
- to carry out additional analytical measurements for organic micropollutants in water samples taken from selected wells at or nearby potential contaminant sources located within recharge areas directly contributory to the underlying Maros aquifer;
- to simulate and summarize the anticipated changes in aquifer water quality with various conditions;
- to develop a formal protection program for the Maros aquifer.

Additionally Metcalf and Eddy Inc. contracted PROED S.A. (Romania) to provide hydrogeological and water supply data, and to carry out groundwater sampling and analysis of organic micropollutants.

The Maros alluvial deposit is a transboundary aquifer in south-eastern Hungary and western Romania. The overlying surface area is around 4500 km^2.
The Maros alluvial deposit is a geological term. It was developed mainly during the Pliocene, Pleistocene and Holocene geological ages.

The aquifer is recharged by direct rainfall infiltration in both countries.
The first exploitable aquifers are the Holocene deposits (at a depth of 20 - 40 m). The highest quasi continuous semi- (or quasi im-) permeable layer is at 40-60 m depth thus it is deeper than the first exploited aquifer. As a consequence, the highest exploited layer is vulnerable to pollutants from a geological point of view. From hydrogeological point of view, i.e. the direction of the vertical flow is also taken into account, aquifers with downwards flow are only vulnerable.
Important recharge occurs in the areas with sandy covering layer, where the minimum potential of the head can be found at medium depth, thus beside the downward percolation upwards flow occurs also from the deeper part of the aquifer. Important groundwater abstraction belongs to this area.

Extent of recharge areas with sandy covering layers are quite limited. Estimated potential recharge for this area in quasi natural situation is 80-100 mm/year, but considering the deficit in precipitation the actual value is estimated at 50-60 mm/year only.

The groundwater resource of the aquifer is utilized for public water supply in Hungary and also in Romania.
In the Hungarian part of the aquifer the water abstraction - by waterworks - increased from 25 000 m^3/d to 60 000 m^3/d in the recent two decades.
The estimation of other supplies (irrigation, agricultural-stock, industrial uses) is very uncertain. Around 20000-30000 m^3/d can be the amount of groundwater abstracted not by waterworks and used for the above mentioned purposes.
In the Romanian part of the study area Arad county`s regional drinking water facility and Arad town`s local water supply system altogether provides maximum 190 000 m^3/d drinking water from wells.

Groundwater quality has primary importance in the study area because the Maros aquifer is the only available good quality drinking water resource in this region. The Maros aquifer provides potable water through a regional drinking water supply system for neighbouring areas where deep confined aquifers have groundwater with high arsenic concentration.
The confined ground waters in the Maros alluvial aquifer belong uniformly to the sodium-hydrogencarbonate type. Higher calcium and magnesium content occur in the highly pervious layers close to the surface.
The highest nitrate concentrations in the production wells or observation wells of the waterworks are below 20 mg/l (half of the limit value for drinking water). Higher nitrate concentration can be found in the shallow phreatic groundwater which is the recharge source of the deeper groundwater in some regions of the study area.
Animal husbandry results yearly 6000 - 8000 t nitrogen load in the study area. Around 75% of this nitrogen originates in settlements, 25 % originates from large animal farms outside of settlements. The inappropriate storage of manure and liquid manure both in large and small animal farms outside and in the villages causes nitrogen loss polluting water resources. 5-10 % of the nitrogen content of the produced manure was assumed to pollute water owing to the inappropriate manure storage.
In the Maros aquifer project additional groundwater quality analysis was performed for organic chemical constituents, data for which were lacking. Determinands included pesticides (atrazine, simazine, lindane, 2,4-D, 2,4,5-T, methoxy-chlor), volatile and semi-volatile organic micropollutants (benzene, toluene, xilene, ethyl-benzene, dichlorobenzene, dichloroethene, trichloroethene, tetrachloroethene). Potential pollution source of pesticides is agricultural land use in the Maros region. The other analysed volatile and semi-volatile organic micropollutants can potentially originate from settlements of the region (operation of petrol filling stations, application of solvents).
The above discussed measurements indicated the moderate pollution effect of the agricultural pesticides application in the region. The other types of analysed organic micropollutants (volatile and semi-volatile aromatics, volatile chlorinated hydrocarbons) were found typically in insignificant concentrations.

One of the objectives of the project was to prepare a model of the Maros aquifer showing the current conditions of quality and quantity of withdrawals and to simulate and summarize the anticipated changes in aquifer water quality with various conditions.
A regional hydraulic model of the Maros aquifer was developed. The numerical model was based on Processing Modflow for Windows software.

The calibration of the model was done for the heads representing the typical groundwater abstraction.
The numerical model calculations indicated that in the studied region the vertical travel time of the infiltrating water (and pollutants) is less than 50 years only in very llimited area (altogether 40 km^2, see **Figure** Summary).
The simulation of different abstraction rates showed that the changes in pumping volume do not modify significantly the pollution pattern of the aquifer, because the horizontal flow is dominant in the aquifer compared to the vertical flow in the case of increased abstraction as well.

The water quality measurement data and also the modeling results revealed that the water quality management problems of the Maros aquifer are not very dangerous. However, a formal protection programme was needed and developed for the Maros aquifer.

The formal protection program for the Maros aquifer is based on the principle of allowing in the surface and subsurface safety zones activities which do not affect the quality and quantity of the sources of supply developed already, or designated for future development and do not interfere with the process of abstraction. The limitations imposed on the use of surface and subsurface safety zones have been specified primarily depending on the land use type.

In the area of the hydrogeological safety zone: (having less than 50 years travel time to the actual or potential abstraction):

- No facility must be sited, the presence or operation of which would affect the quality of groundwater;
- Any activity must be banned, by which
  - the natural protection of the water is impaired, or the vulnerability of the environment is increased;
  - harmful substances persisting for six months are introduced into the water,
  - a degradable substance finds access to the water, the quality, type of decay product of which is detrimental to groundwater quality.
- Operations with chemicals detrimental to water, or from which compounds affecting water quality may be leached must be confined to closed buildings;
- The method of crop farming on the fields must not cause any harm to the water;
- The wastes (manure) of animal farming must be handled and stored in a way suited to avoid soil and groundwater pollution (thus liquid manure must be collected and stored in impervious tanks or basins until disposal in a controlled manner outside the hydrogeological safety zone;
- Any substance detrimental to water quality must be stored at existing storage sites in a manner
  - making the storage vessel any time accessible to inspection for its state of repair even from the outside, or
  - obliging the operator to monitor the groundwater by a system designed and operated as approved by the competent authorities for the presence of any detrimental substance;
- A new facility intended for the storage of a liquid substance detrimental to water must be designed – with approval by the competent authority –

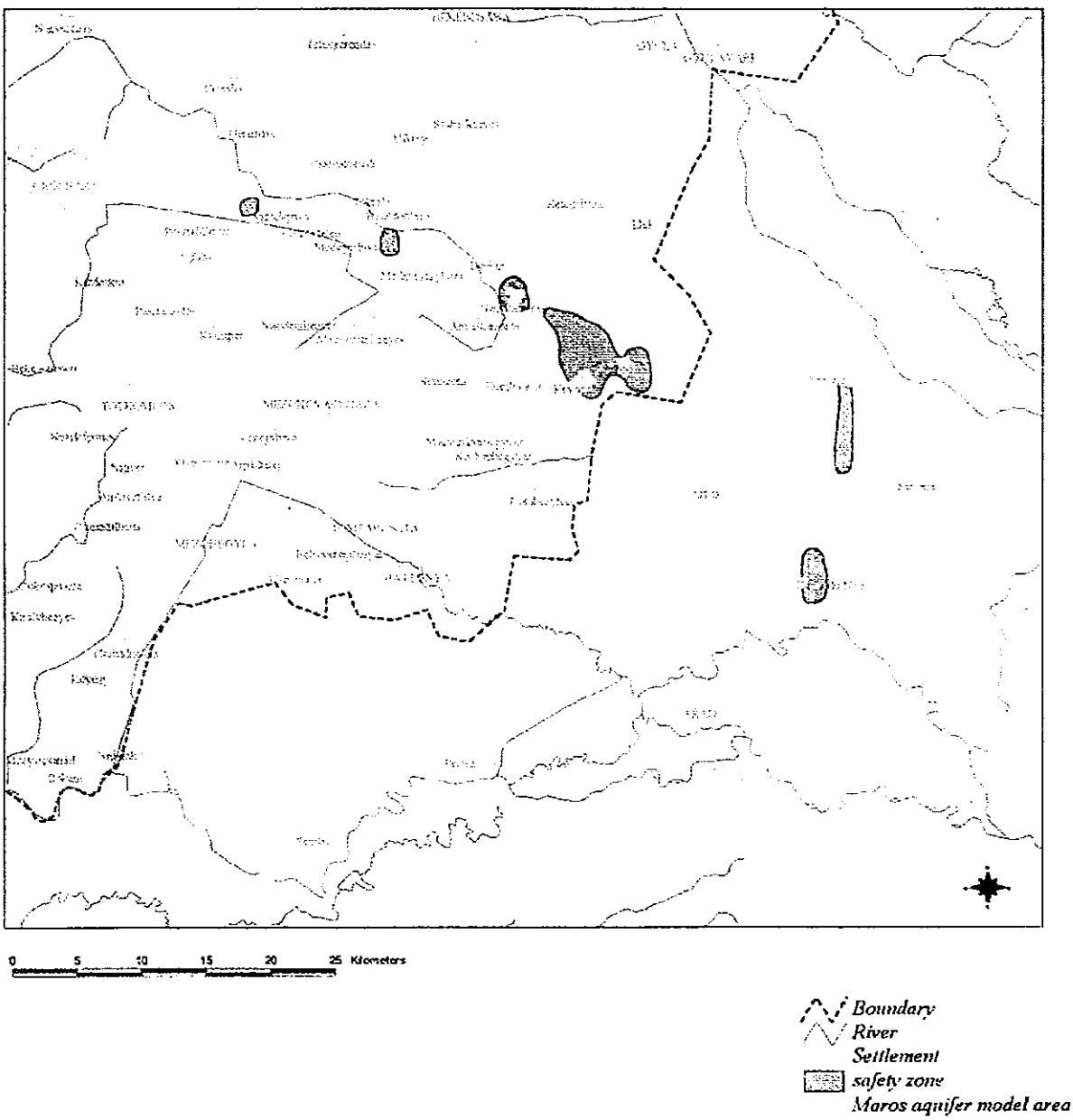

Figure *summary*
Hydrogeological safety zone of the Maros aquifer
(less than 50 years vertical travel time)

- to make the storage vessel any time accessible to inspection for its state of repair even from the outside,
- to confine the storage vessel in an impervious tank or basin large enough to retain the entire contents thereof in the event of failure;

- A pipeline conveying a substance detrimental to water (e.g. petroleum product) must not be allowed to cross the zone, unless it is made safe (e.g. by a casing pipe), inspected regularly and fitted with an automatic valve for the event of pipe failure.

It was concluded that:

- The Maros aquifer can provide good quality groundwater appropriate for drinking water supply. The additional water quality analyses revealed moderate pollution effect of the agricultural pesticides application in the region. The other types of analysed organic micropollutants (volatile and semi-volatile aromatics, volatile chlorinated hydrocarbons) were found in insignificant concentrations. The nitrate concentrations are below 20 mg/l in the production wells. Higher nitrate concentration can be found in the shallow phreatic groundwater which is the recharge source of the deeper groundwater only in some regions of the study area.
- The very long vertical travel times of the infiltrating water and pollutants in the dominant part of the study area refer to low vulnerability of the Maros aquifer. This was concluded from the numerical model calculations which indicated that no more than 40 km^2 is the area where the vertical travel time is less than 50 years.
- The Maros aquifer protection program should focus on the hydrogeological safety zone designated according to travel time (max 50 years). The proposed limitations would imply restrictions only in a minor part of the Maros aquifer region.

Budapest, August 2000.

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Introduction

The report on Maros Aquifer Investigations was prepared under subcontract to Metcalf and Eddy as part of USAID funded Transboundary Pollution Reduction Program in Hungary, Slovakia and Romania. The Maros Aquifer Investigations project aimed at the development of a formal protection program for the Maros Aquifer.

In August 1998 a Preliminary Report summarized the results of previous studies done on the Maros Aquifer by the Subcontractor and other agencies. The Preliminary Report compiled the available information on geology, hydrogeology, water supply, pollution sources, water quality of ground water and river water of the study area. VITUKI Plc., developed a regional hydraulic model of the Maros aquifer using Processing Modflow for Windows (PMWIN) software. The Preliminary Report outlined the capability of the model.

In the interim and the final phase of the project the Subcontractor

- carried out additional measurements to characterize water quality in wells at or nearby potential contaminant sources located within recharge areas directly contributory to the underlying Maros aquifer;
- upgraded the numerical hydrogeological model of the Maros Aquifer;
- simulated anticipated changes in aquifer water quality with various conditions of *spills and withdrawals;*
- developed a formal protection program for the Maros Aquifer.

The present Final Report summarizes all the relevant information, results, conclusions of the project.

Annex 1 contains the meeting notes which were produced during the implementation of the project.

1. Geography of the study area

The Maros alluvial deposit is a transboundary aquifer in Hungary and Romania. The overlying surface area is around 4500 km^2.

The area is located in the south-eastern part of Hungary and western part of Romania. It belongs to the southern Trans-Tisza region. The Maros alluvial deposit is a geological term. It is a thick alluvial deposit developed mainly during the Pliocene, Pleistocene and Holocene geological ages.

Geographically the area is bordered by the Körös river in the north-eastern and in the northern part while the Tisza river is the border in the western part in Hungary. The southern and the south-eastern part of the area is in Romania, the south eastern border is the bottom of the Transsylvanian Mountains while to south the area is open to the plain of rivers Bega and Temes.

The topographical map of ***Figure 1.*** shows the relatively flat relief similar to a slightly sloping fan. The density of the small water courses in the vicinity of rivers is the consequence of interconnected local depressions. On the other hand the map shows the general drainage conditions in these areas.

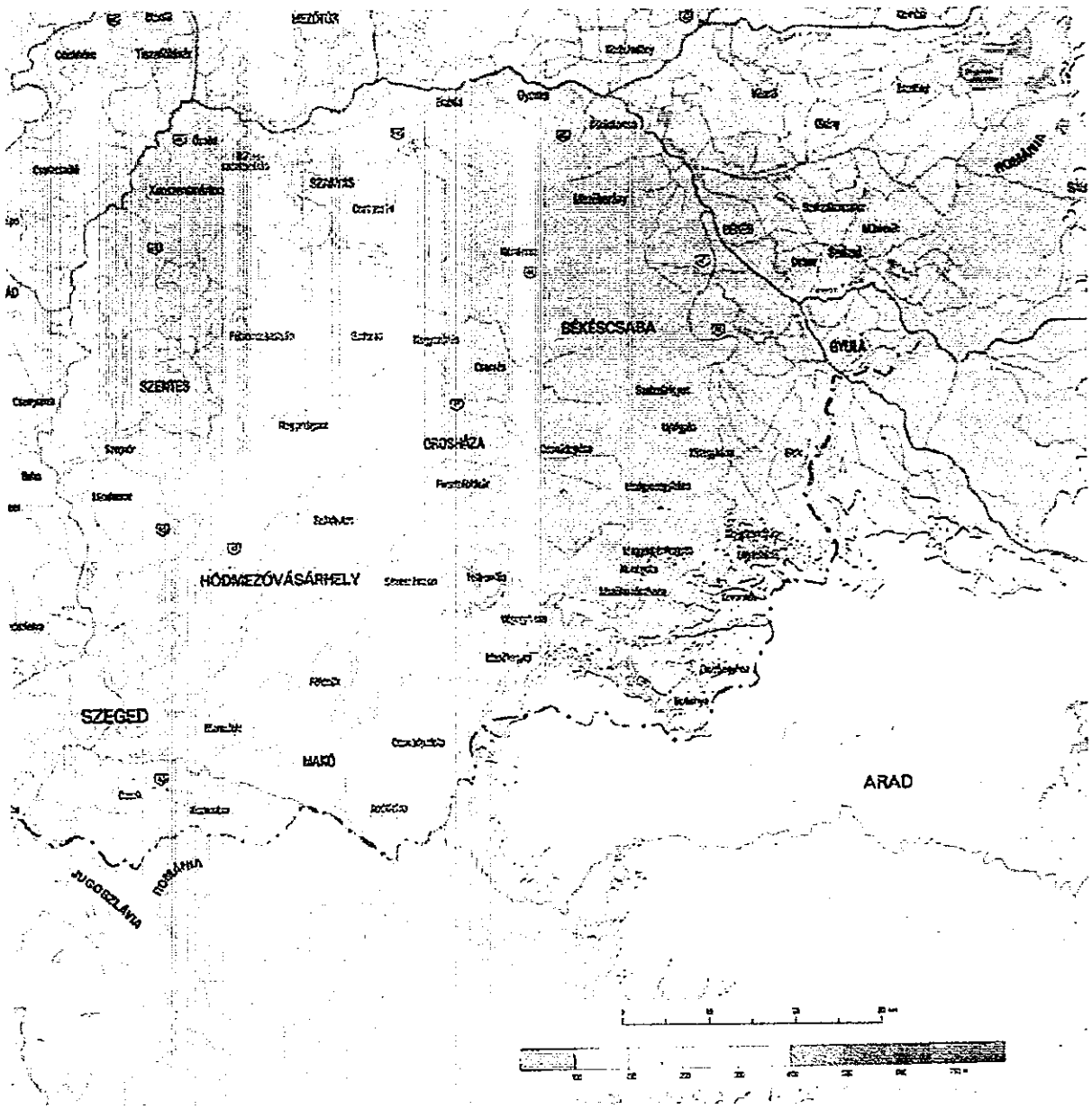


Figure 1
Geographycal map of the Maros alluvial area

2. Geology

From geological and morphological point of view the area is not uniform. In general it is a thick alluvial deposit and rivers have had basic role in the development, but because of the different depressions of subareas, the formation shows different characteristics: depression of Körös, depression of southern Tisza and in between the plateau of Békés. These subregions and the detected border of the Maros alluvial deposit is shown in ***Figure 2***.

After the Pannonian sea had drawn back, the formation of the alluvial deposit of Maros started, about 3 million years ago. Later on simultaneous depressions of the bottom of the basin and deposition of the sediment formed the inclined, densely varying layers. The deposition of the sediments in a given period was determined by the location of the river bed and by the extended inundations. The alteration of coarse and fine layers correspond to glacial and interglacial ages. During glacial periods the coarse material accumulated at the bottom of the mountains and at the beginning of interglacial periods great discharges transported the coarse sediment to long distances. Later on the sediments became finer and the energy of the river decreased thus the deposition changed from sandy material to silty clayey materials.

In Holocene Age the river moved from the North to the actual valley. The upper part of the alluvial deposit reflects this moving river bed. Lastly the alluvial cone was covered by finer material of the ancestral Tisza-Körös valley, it is mostly silty-clayey with very different thicknesses.

Two schematised cross-sections of ***Figure 3*** show the resulted strata of the above mentioned general development.

2.1 Pliocene strata

Pliocene gravel can be found on the surface at Lippa (***see Figure 2***). In the area towards the Great Hungarian Plain (the former Pannonian sea) the Pliocene (Pannon) layers show a considerable quasi continuous decline. The bottom of the Pannonian (Pliocene) strata can be found at a depth of 2000 m at the Körös river and even deeper in the depression of Southern Tisza river. The thickness show similar changes: insignificant at the bottom of the Transsylvanian Mountain - where the Pliocene layers are at the surface - while 1600 - 1700 m thickness is characteristic at the deepest part.

During the Mid-Pliocene the so called ancestral Temes-Maros river started to fill up the basin in the southern part and the ancestral Alföld-Maros river started to fill up the basin in the northern part.

2.2 Pleistocene strata

The map of ***Figure 4*** shows the bottom of the Pleistocene strata. At the changes of the Pannonian and Quaternary Ages, the climate was wet and as a consequence the discharge of the rivers was high, transporting a considerable amount of coarse material towards the ancestral Tisza. During the Pleistocene Age glacial and interglacial periods alternated. During glacial periods the accumulation of coarse material at the bottom of the mountains was characteristic. The transport of this accumulated sediment took place

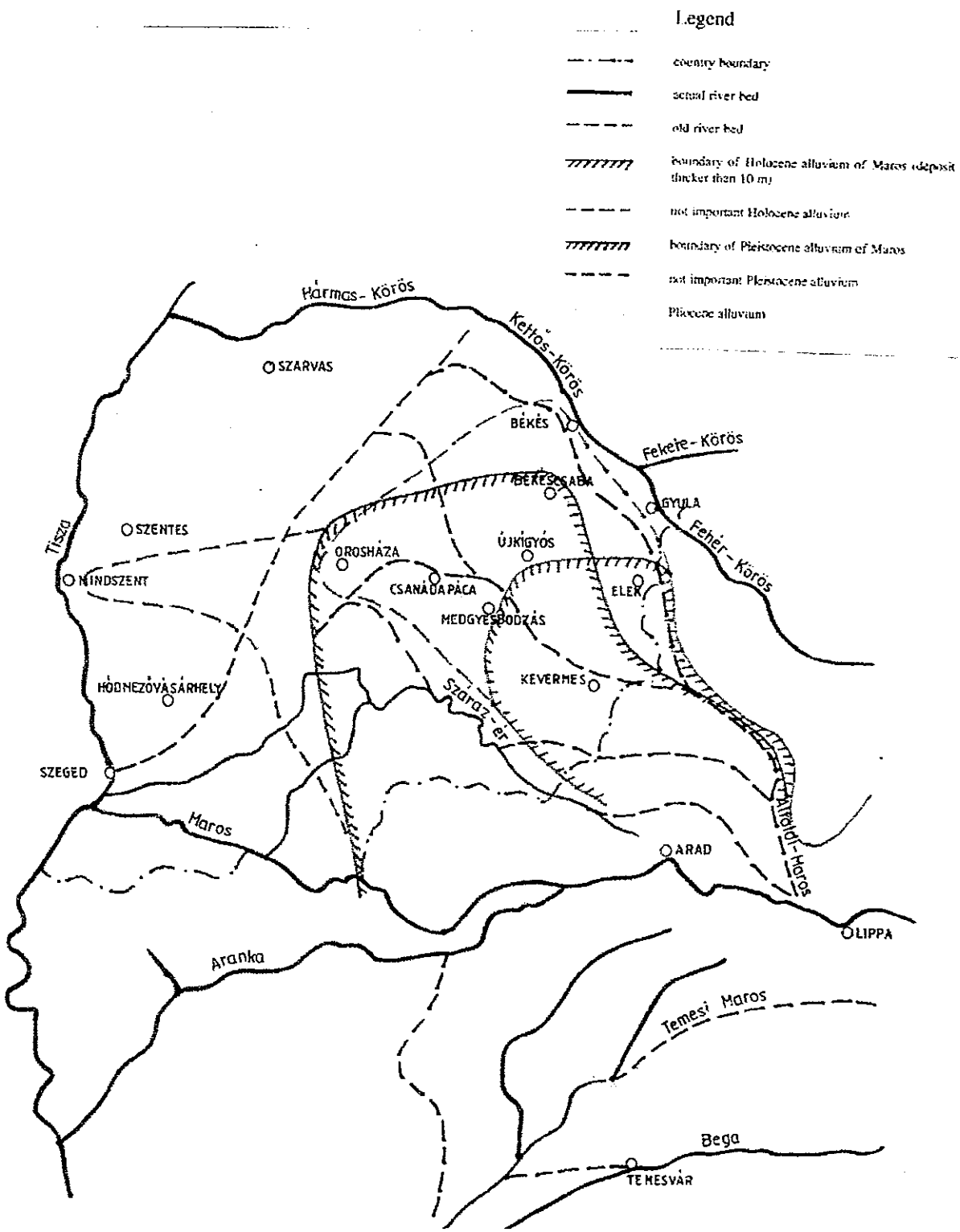
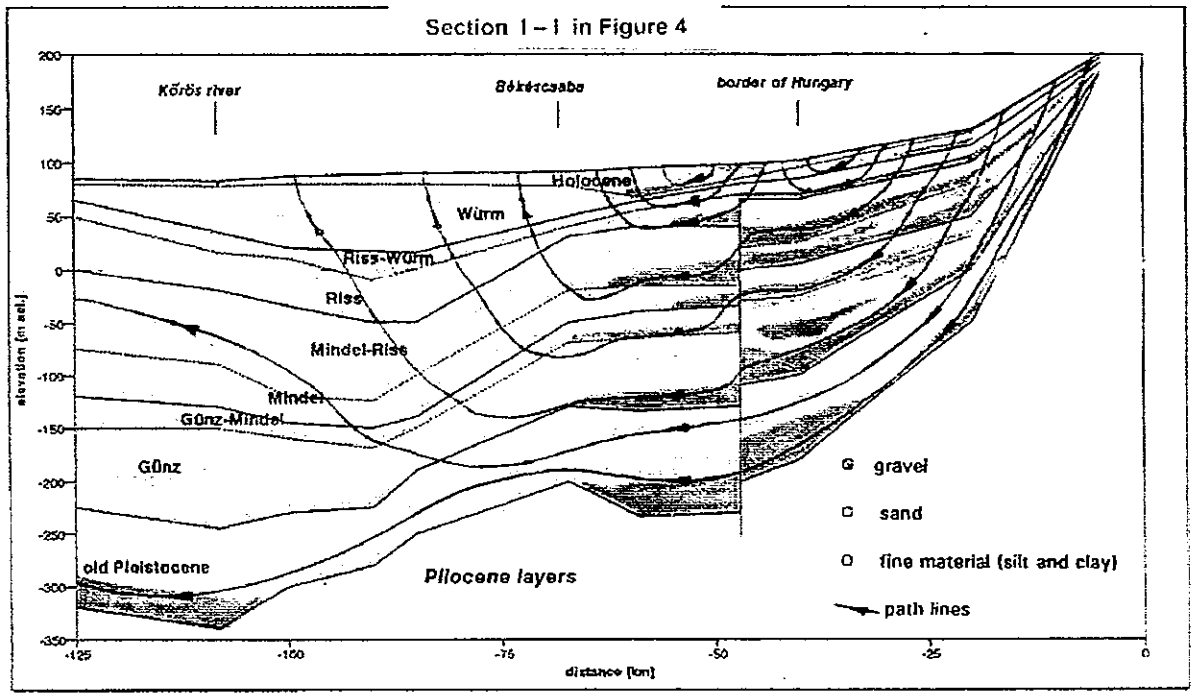
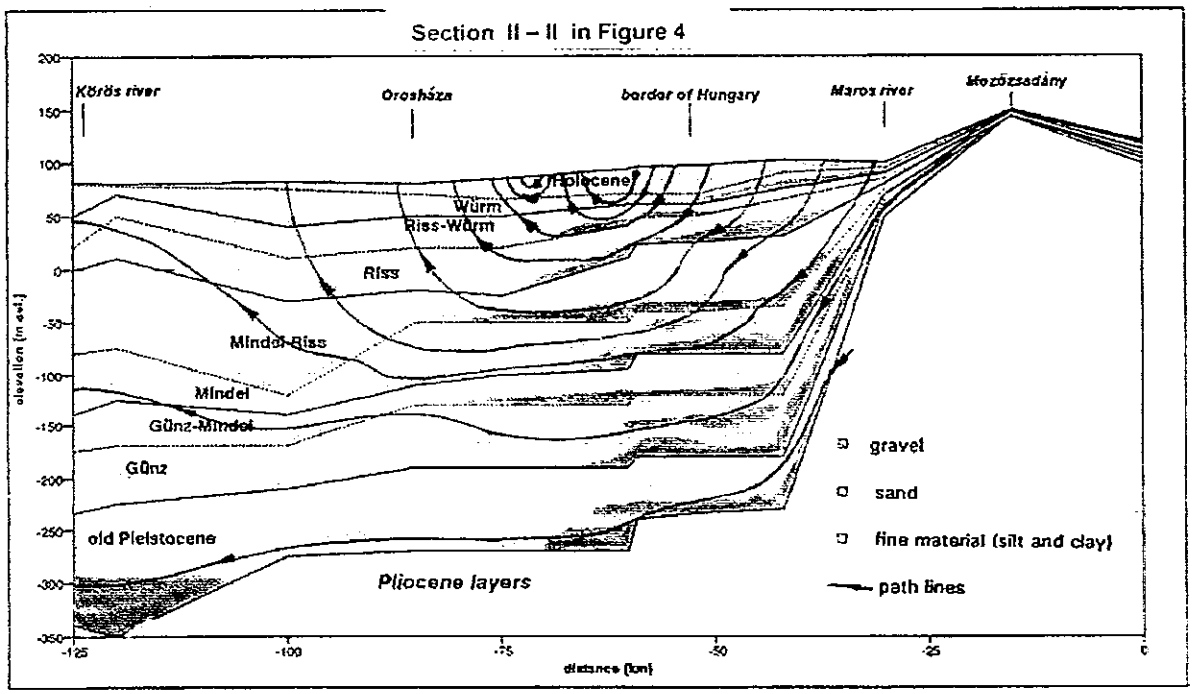


Figure 2
Boundary of the Maros alluvial deposit

8a





Remark: locations of gravely and sandy layers are imaginairy, but reflect the general character of the stratification

Figure 3
Characteristic cross-sections

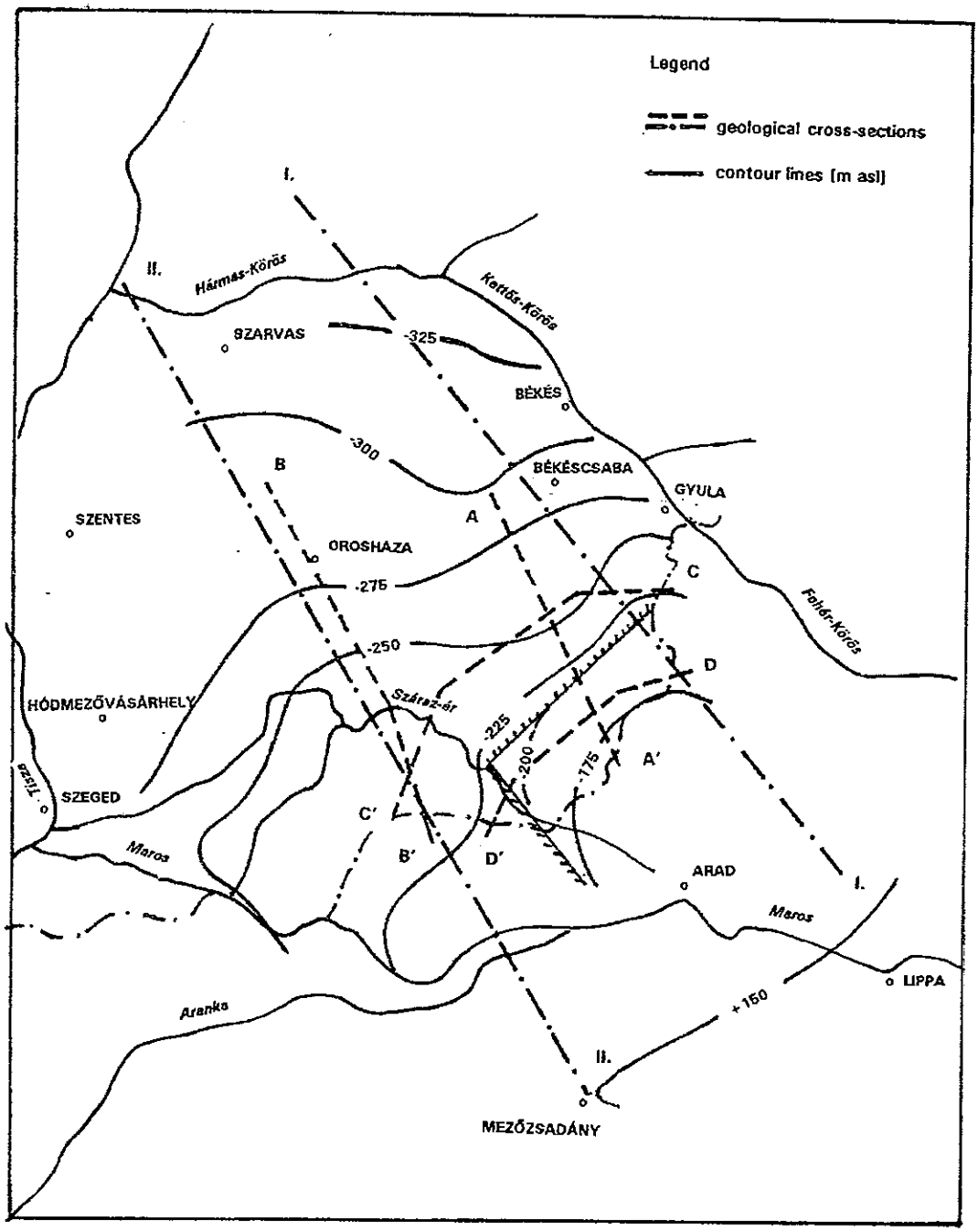


Figure 4
Bottom of Pleistocene aquifer and location of geological cross sections

8C

at the beginning of the interglacial periods since the rivers had large discharge because of the melting. Later on, until the next glacial periods a decreased amount of discharge transported finer and finer material on the top of the previously deposited coarse material, because the decreased energy of the river was not able to transport the coarser material and on the other hand during interglacials mostly crumbling of rocks is characteristic. Simultaneously a non-uniform depression of the basin along faults (***see Figure 4***) modified the line of main channel and provided a new depression for the filling up by transported sediments. ***Table 1*** summarizes the major glacial and interglacial periods and the estimated corresponding decline of basin (Mike, 1991).

According to ***Table 1*** the estimated average decline in the deeper part of the basin (Tisza valley) is approximately 600 m while 200 m drop is mentioned for the boundaries. These values obviously harmonize with the depth of the bottom of the Pleistocene layers (***Fig. 4***).

The Maros in the Pre-Günz Age had extremely high discharge and it transported its gravelly sediment towards Békéscsaba and even to the Tisza valley (Mindszent). During the Günz glacial and the subsequent interglacial period the main channel directed to Orosháza where gravelly layer of this age can be found at a depth of 140-170 m. Gravelly traces of Mindel glacial period can be found at Lökösháza (at appr. 70 m below the surface). At the beginning of the Mindel-Riss interglacial period the river deposited gravel sediment at Kunágota and Battonya and Bánkút. The sandy sediments of this period can be detected from Békéscsaba to Földeák and somewhere its thickness is 20 m. During the Riss glacial and the Riss-Würm interglacial period the Maros moved towards the south due to a slight rising effect in the vicinity of Battonya and Kétegyháza. Detected faults at Kevermes and Algy-Sándorfalva occurred also in this period. The river had been flowing in the line of the actual Aranka river until this valley was filled up. Later on, in the Würm the Maros was directed again towards Földeák along the northern boundary of the plateau of Békés (actual Száraz-ér) then it moved again to the line of the Aranka river. Due to the above mentioned limited movement the sediment of Würm is missing in the major part of the northern alluvial deposit.

Table 1. Major subperiods of the Pleistocene

time [10^6 year]	age	glacials/ interglacials	depressions [m]	
			at deeper part	at boundaries
0.1-0.2	upper Pl.	glacial (Würm)	30 - 80	10 - 20
0.2-0.25	upper Pl.	interglacial (R-W)		
0.25-0.3	mid Pl.	glacial (Riss)	90-180	30-60
0.3-0.4	mid Pl.	interglacial (M-R)		
0.4-0.6	mid Pl.	glacial (Mindel)		
0.6-0.8	lower Pl.	interglacial (G-M)	20-40	10-20
0.8-1.3	lower Pl.	glacial (Günz)	170-200	100-190
1.3-1.7	lower Pl.	interglacial (Pre-Günz)	40-80	-
1.7-2.4	lowest Pl.	?	100-200	-

2.3 Holocene layers

At the beginning of the Holocene Age the depression of Körös declined and the Maros turned again towards Kevermes and Békés. At that time the Maros reached the large ancestral Tisza and Körös rivers which followed approximately the line of Szeghalom - Gádoros -Hódmezővásárhely. These ancestral rivers eroded in their neighborhood the upper part of the former sandy deposits of the river Maros, that is why Maros-originated coarse sand deposits can not be found to the north from the line of Gádoros-Békéscsaba. Later on the Tisza moved towards its actual valley and the Maros followed this change by moving to the south. The latest Holocene Maros on the north-eastern side of the plateau of Békés can be detected in the vicinity of the actual riverbed of Száraz-ér. After that the river Maros gone round the plateau of Békés and occupied its actual valley. As a consequence of this "history" the Holocene layers are relatively thick (30 - 50 m) in the subregion of the depression of Körös (Kevermes-Medgyesbodzás-Újkígyós-Békéscsaba) containing coarse material (gravel at Kevermes and mostly sand in Medgyesbodzás and Újkígyós). The covering layer in this part of the region originated from the fine sediment of the ancestral Tisza and Körös. The material of the thin (1 - 3 m) covering layer is mostly silt (loess) or clay, only in the vicinity of Kevermes-Medgyesegyháza-Orosháza can be found fine sand covering layer in a relatively large one unit. At the plateau of Békés - where the Maros did not flow during the Holocene - the material of the filling up is clay (somewhere silt or loess) at a thickness of 20 - 40 m.

Based on shallow borehole logs (in a network of 1.5x1.5 km) a map has been prepared by the Hungarian Geological Institute (MÁFI) showing the spatial variability of the upper 10 m thick sediment (***Figure 5***).

3. Climate

The continental climate conditions of the Hungarian Great Plains dominate in the study area which is in the warm, moderately dry climate zone. Characteristic features are the wide temperature variation, shortage of precipitation, large number of sunny hours (around 2000/year). The annual mean temperature is around 10.5 ^{0}C, the annual mean amount of precipitation is 570 mm (calculated for the period 1951-1992). In the 1980s the precipitation decreased 90-100 mm. It is still not clear, whether the long term climatic conditions changed or only the duration of the dry period is longer than the usual 5-7 years.

The potential and real evapotranspiration are 1050 and 540 mm respectively. The precipitation exceeds the potential evapotranspiration only in winter. Even the real evapotranspiration is significantly higher than the precipitation between May and September, while for the whole year they are approximately the same.

4. Hydrogeology

Following the relief, the groundwater flows in a fan-like way to every direction from the south-eastern part of the alluvium. Towards the north-west the drop of the potential head is quasi uniform, while towards north and especially towards west an important drop of potential show less permeable strata, corresponding to the differences in the geological formation.

Figure 5
Covering layer types (MÁFI)

The strata are very variable, they can be characterized by medium - or somewhere - by high transmissivity and very high anisotropy.

The first exploitable aquifers are the Holocene deposits (at a depth of 20 - 40 m). The highest quasi continuous semi- (or quasi im-) permeable layer is at 40-60 m depth thus it is deeper than the first exploited aquifer. As a consequence, the highest exploited layer is vulnerable to pollutants from a geological point of view. From hydrogeological point of view, i.e. the direction of the vertical flow is also taken into account, aquifers with downwards flow are only vulnerable.
Important recharge occurs in the areas with sandy covering layer, where the minimum potential of the head can be found at medium depth, thus beside the downward percolation upwards flow occurs also from the deeper part of the aquifer. Important groundwater abstraction belongs to this area. Recharge area and areas characterized by upward/downward flow are presented in ***Figure 6***.

Extent of recharge areas with sandy covering layers are quite limited. Estimated potential recharge for this area in quasi natural situation is 80-100 mm/year, but considering the deficit in precipitation the actual value is estimated at 50-60 mm/year only. The potential recharge corresponds to the situation when the average groundwater level is below the depth of zero transpiration.

Areas with sandy loam and loess covering layer (area of Békés-plateau) can be characterized by a low rate of annual potential recharge (10 - 20 mm/year) under average conditions. In these areas the recharge can disappear during the dry period.
In the actual situation the groundwater level is still higher than the "zero transpiration" level in the majority of the area thus the evapotranspiration from the groundwater decreases the potential recharge, even in some area the amount of the evapotranspiration is higher than the recharge. The deficit is covered partly by infiltration from the neighboring recharge areas and partly from the regional flow system by upward flow or it is a component of the negative water balance and contribute to the groundwater decline. The regional flow system is maintained by the recharge in the upstream catchment area, in Romania.

4.1. Groundwater potentials

Figure 7 shows the contour lines of the shallow groundwater level for the period 1956-60 while in the map of ***Figure 8*** the piezometric situation of the second aquifer is presented (VITUKI, 1991). The first map is based on the data of the shallow groundwater observation but the second one has been drawn using the observed piezometric levels at the time of the construction of the wells, thus this map does not correspond to a given period, data were taken from the period 1960-1990. The uncertainty due to the inhomogeneity of the data (ignored trends) can be estimated at maximum ±0.5 m, thus the characteristics of the regional flow (direction, gradient) can be considered as reliable. Based on the analysis of time series, the period 1956-60 can be considered as an average period.

Figure 9 shows the differences between the piezometric levels of the shallow and the second aquifer. Considering the above mentioned uncertainty of the map on the piezometric levels in the second aquifer, only the differences higher than 0.5 m can be considered reliable. The majority of the area belongs to the quasi-neutral zone, i.e. the

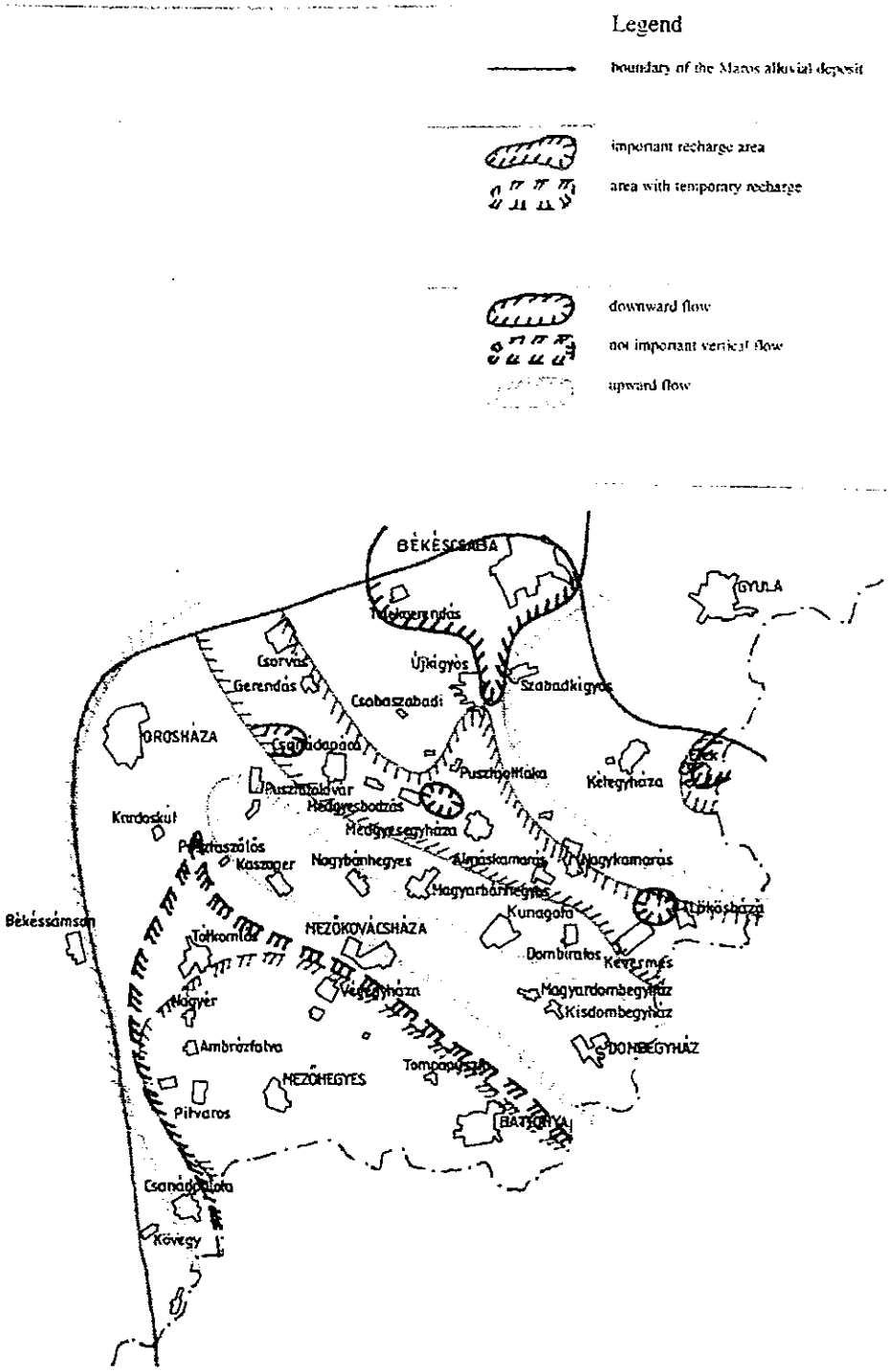


Figure 6
Recharge areas and areas with upward/downward flow

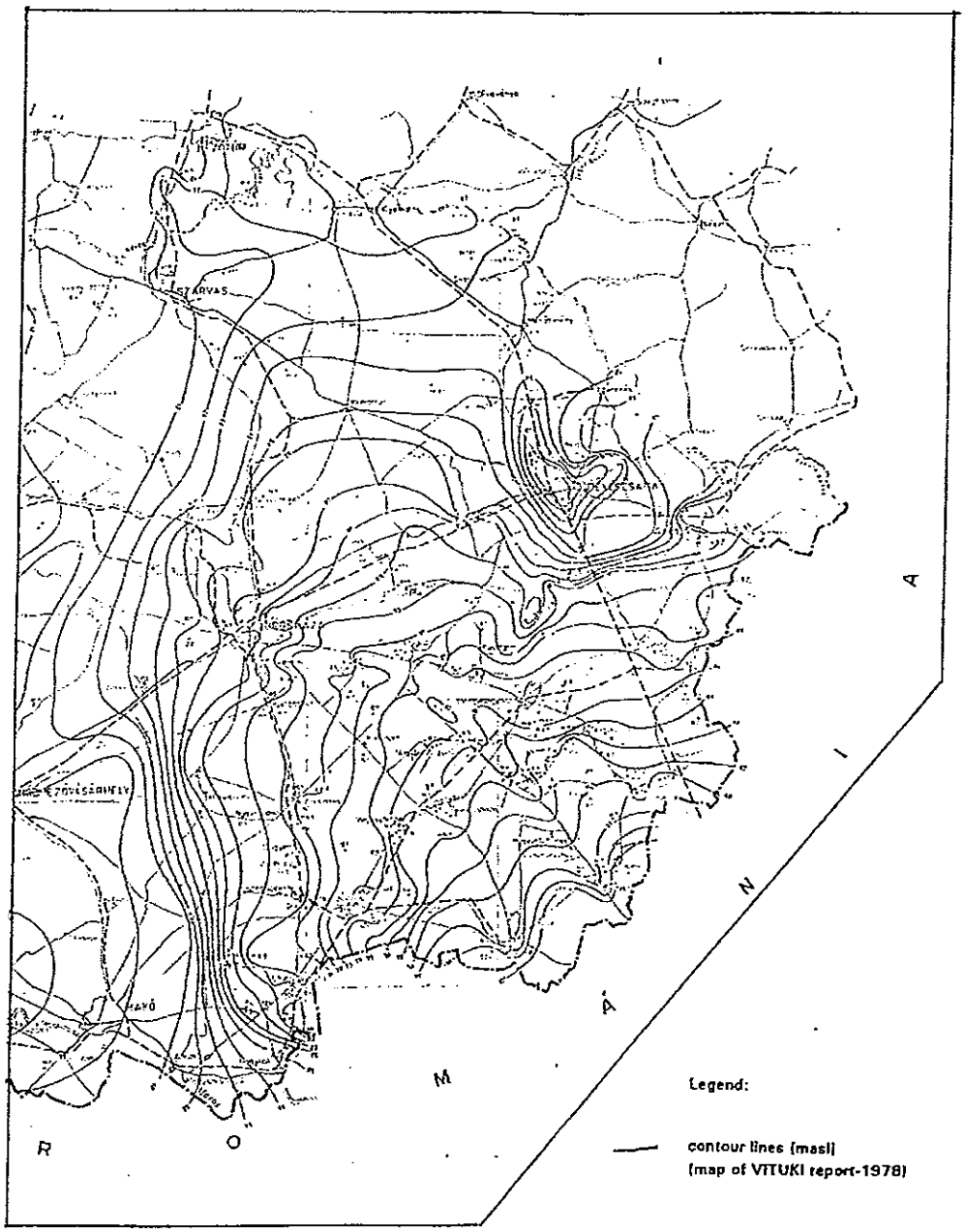


Figure 7
Average groundwater levels, period 1956-1960

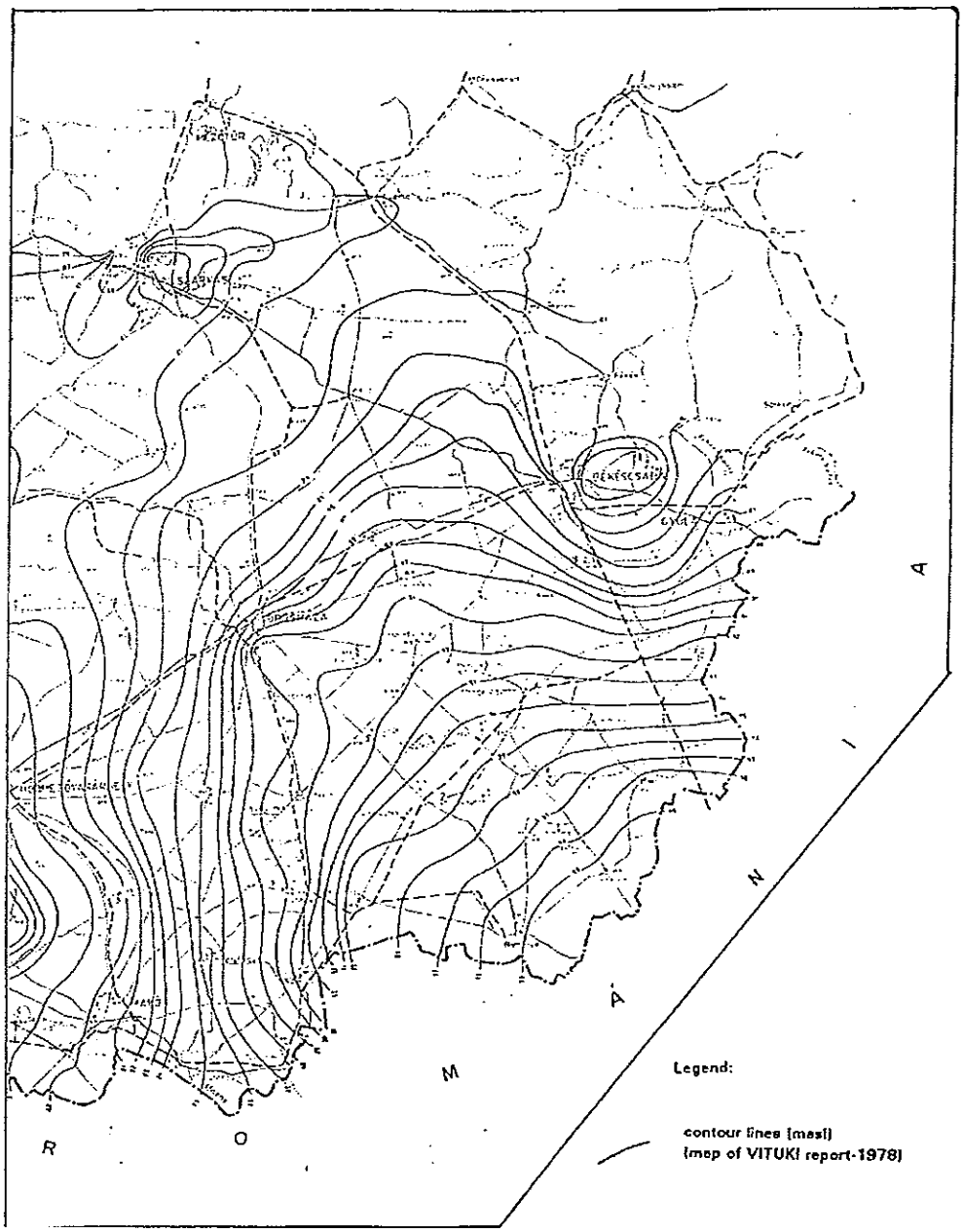
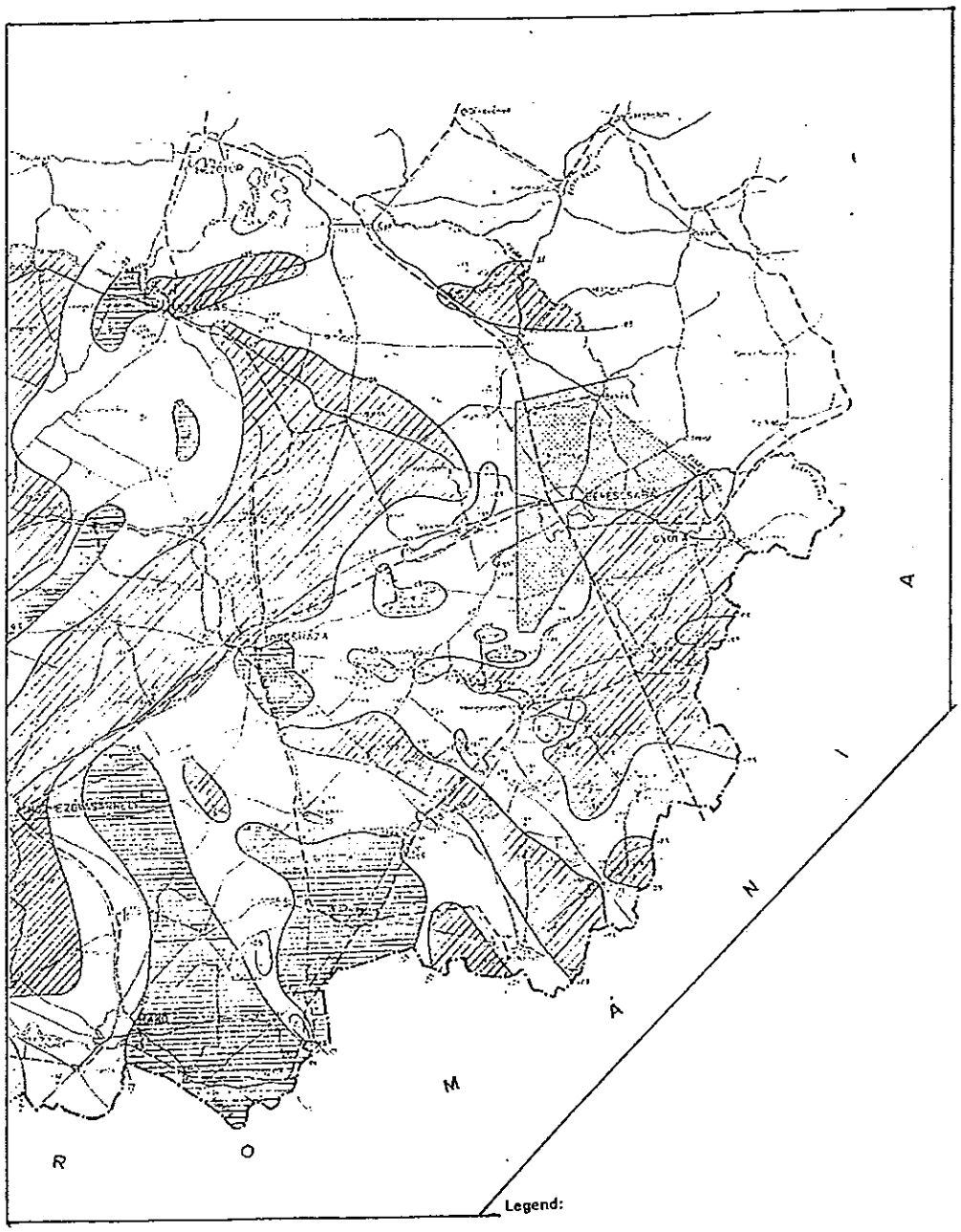


Figure 8
Piezometric levels in the second aquifer
(based on observation at the time of construction)



Legend:

- characteristic upward flow (difference > +0.5 m)
- neutral zone (difference between - 0.5 m and +0.5 m)
- characteristic donward flow (difference < - 0.5 m)

Figures 9
Differences between shallow groundwater level and piezometric heads of second aquifer

differences are in the range of -0.5 m – +0.5 m. In the neutral zone usually a slight downward flow occurs until a medium depth (100 -200 m below the surface) usually due to groundwater abstraction and below that the direction of the vertical flow is already upward (***see Fig. 10 c-f***). Characteristic downward flow occurs only in the plateau of Békés and in the surrounding of Békéscsaba (the latter is not under natural conditions, but due to the extensive water abstraction), while upward flow is characteristic in the northern part of the area (except the above mentioned region of Békéscsaba).

In order to evaluate the changes in time, groundwater time series have been analyzed. Long term time series are presented in ***Figure 10 a***. In case of Battonya no decreasing trend is observed since 1983, while in Kunágota a clear decline occurred, similar to that between 1942 and 1953. The cause of the differences could be the different location: Battonya is on the plateau of Békés, while Kunágota is on the depression of Békés. The well at Gerendás ((Between Orosháza and Békéscsaba) does not show important seasonal fluctuation, while at Nagylak it is higher than the average. Both wells show the characteristic decline since 1983. Two conclusions can be drawn: there are differences in the shape of hydrographes according to subregions and the observed decline during the last 13 years is not exceptional. ***Figure 10 b*** shows time series of shallow groundwater wells located in the vicinity of existing waterworks. A decreasing trend can be observed since 1983, but it is not higher than the observed decline in case of wells more far a way from waterworks (***see Figure 10 a)***.

Figure 10 c-f show hydrographes of observation wells of different depth at waterworks. It is to be mentioned that data are not always reliable but the decreasing tendencies are clear. The operation of waterworks has two impacts on the piezometric levels: decreased potential in the exploited layer and sometimes as a consequence changed vertical direction of the flow (Kevermes, ***Fig. 10 c*** - except the layer between 76-117 m, where since 1992 increasing trend has occurred, Medgyesbodzás, ***Fig. 10 e***, Tótkomlós ***Fig. 10 f***). Strange trends can be detected in the wells of Újkígyós: slight decreasing trend until 1988 and stagnant or slightly increasing trend after (probably due to the changes in groundwater abstraction). The vertical direction of the flow is also mentioned in the figures by small arrows in the "legend box".

As part of a project in 1994 the decreasing trend and the corresponding deficit in water budget was analyzed based on data of the period 1988-1993 (***Figure 11***). The rate of the deficit was determined as the product of the observed decrease in piezometric level and the specific yield. It is 10-20 mm/year in the south-eastern part, higher value than 20 mm is characteristic in the south-western part of the area and in the central part, while the decreasing tendency is not significant (less than 10 mm/year) north to the line of Kétegyháza-Csanádapáca. The decline could be a consequence of the deficit in precipitation and the corresponding less recharge of groundwater and on the other hand the increasing groundwater abstraction (both types of groundwater abstraction, for public water supply and for individual purposes are important).

4.2. Depth of the shallow groundwater table

From a transpiration point of view not the potential, but the depth of the shallow groundwater below the surface is important. The situation for the period 1993 is presented in ***Figure 12***. Shallow water table (less than 3 m) which is favorable for the crops can be found in the eastern part of the area only.

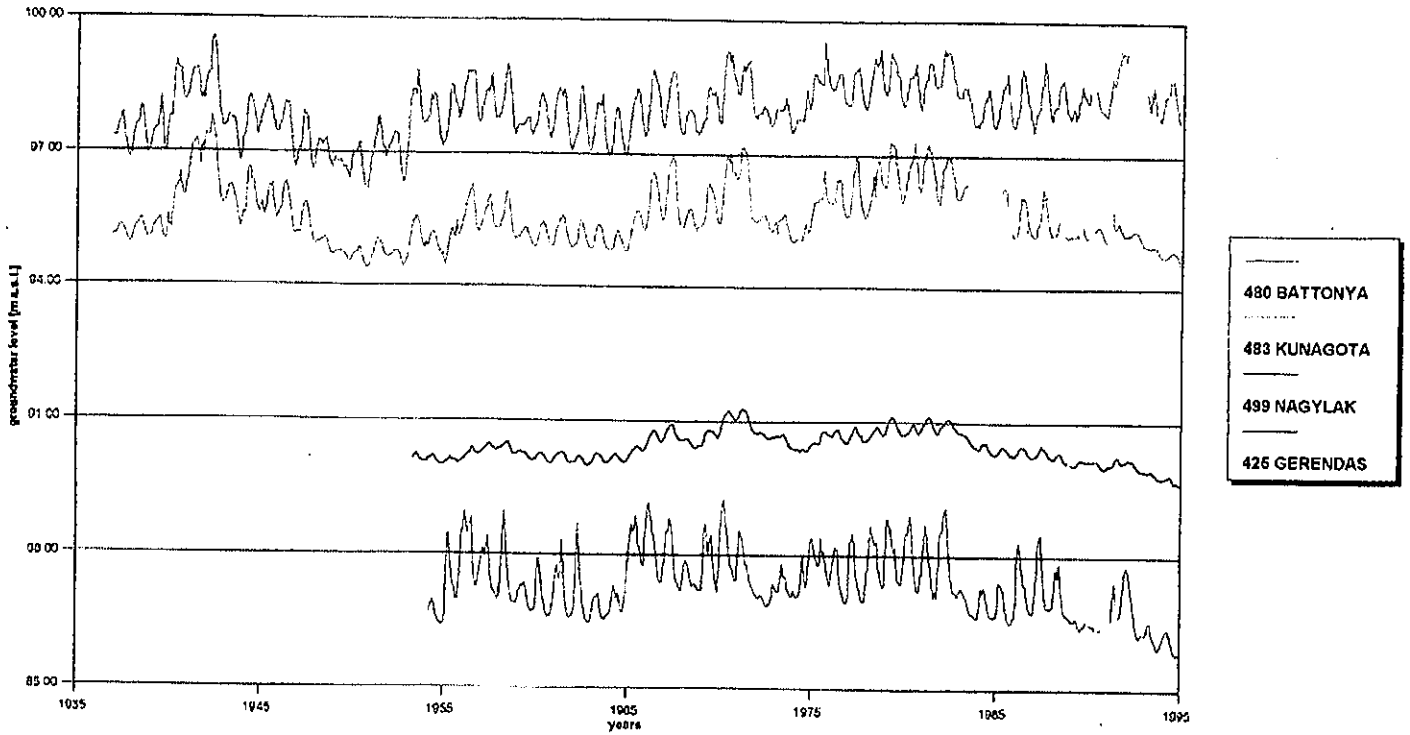


Figure 10/a.
Characteristic groundwater time series
Shallow groundwater time series

12a

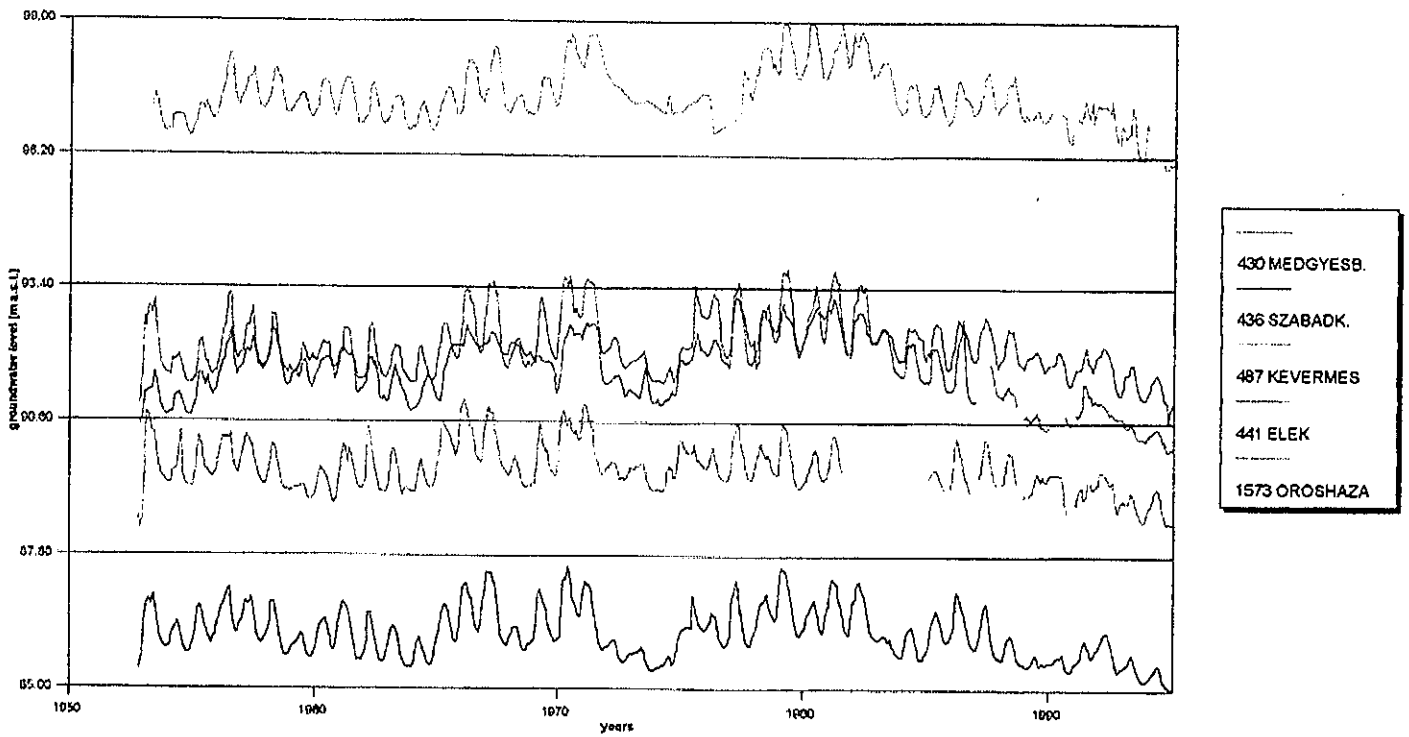


Figure 10/b.
Characteristic groundwater time series
Shallow wells in the vicinity of waterworks

KEVERMES

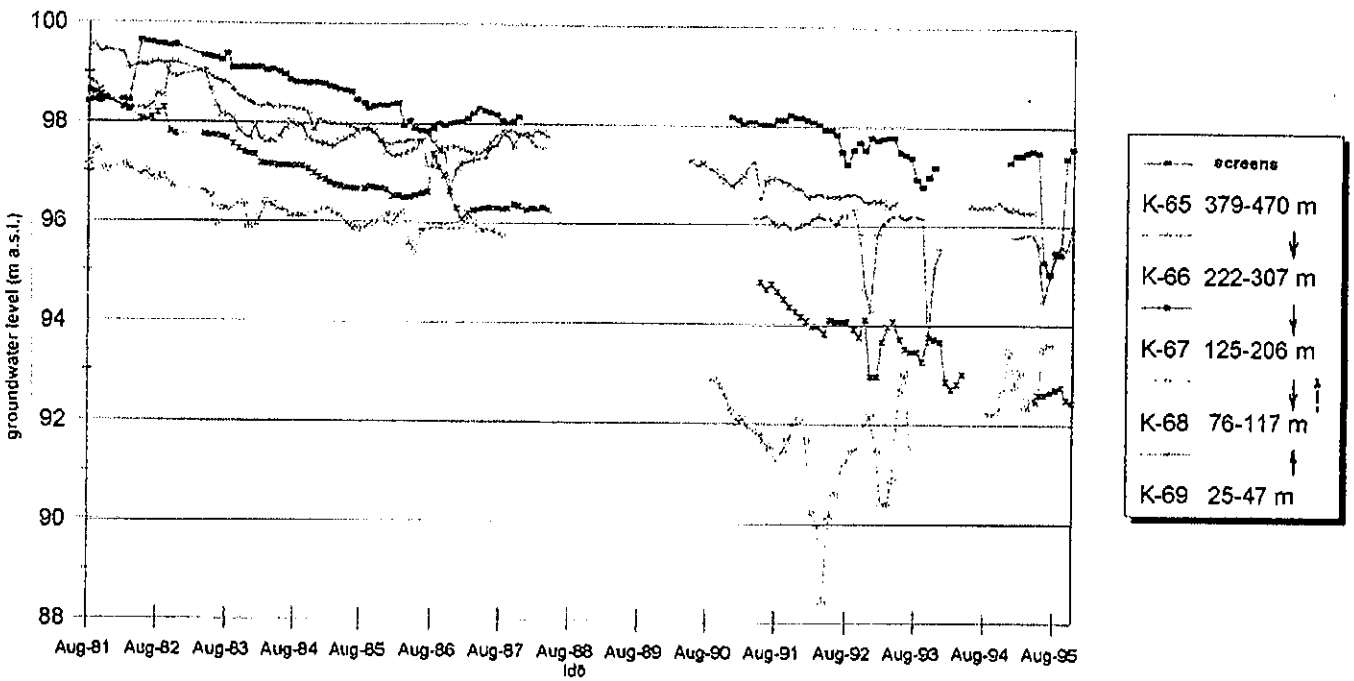


Figure 10/c.
Characteristic groundwater time series
Wells at Kevermes waterworks

12c

MEDGYESBODZÁS

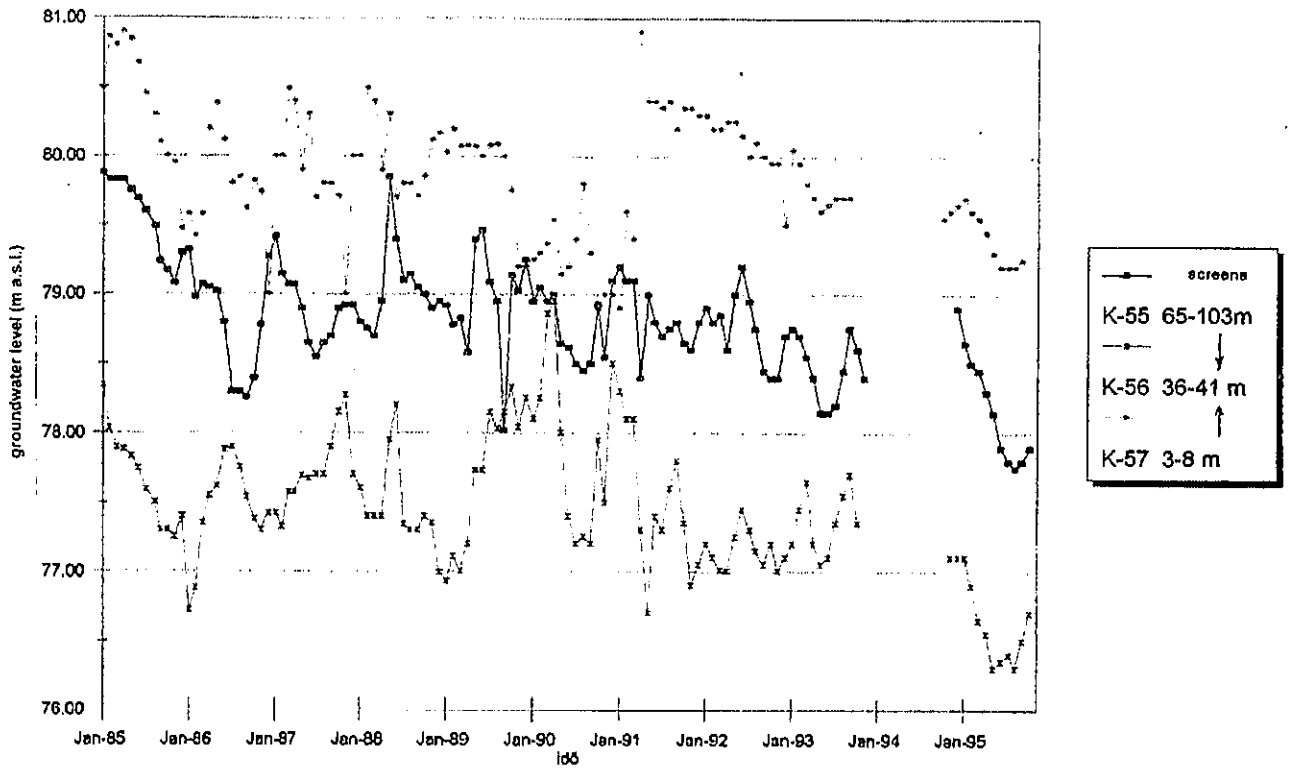


Figure 10/d.
Characteristic groundwater time series
Wells at Medgyesbodzás waterworks

12d

ÚJKíGYÓS

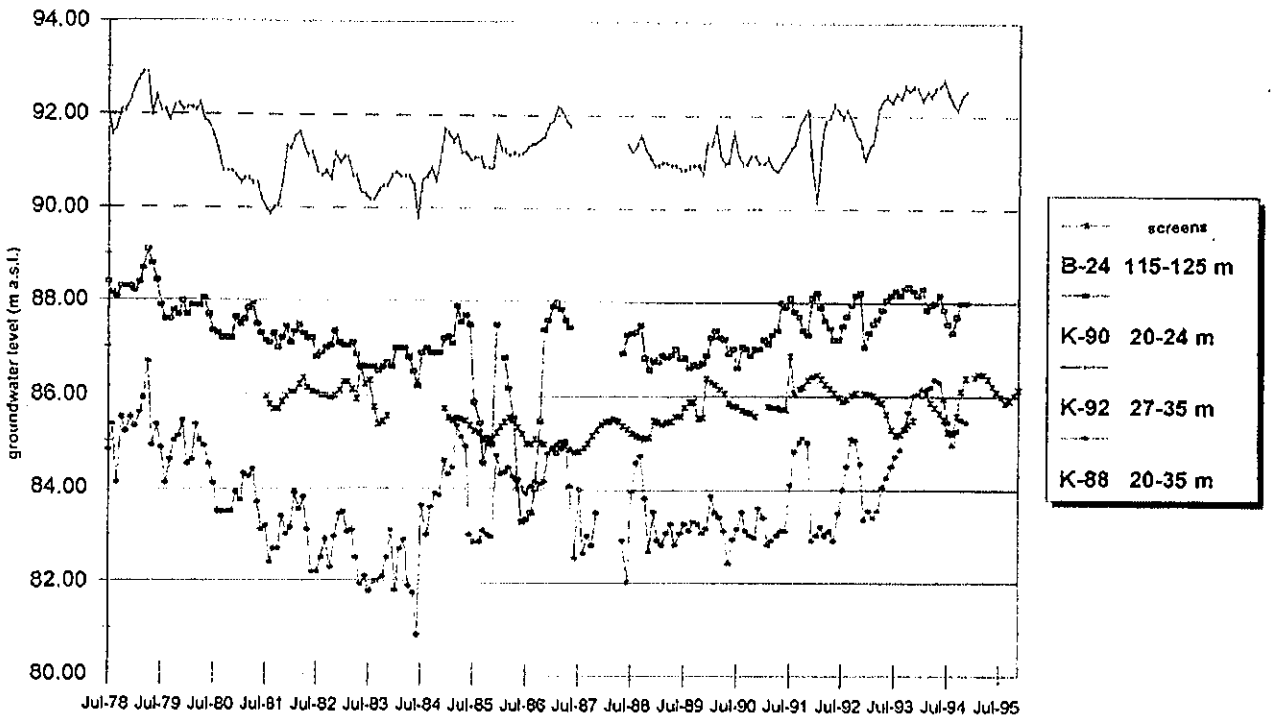


Figure 10/e.
Characteristic groundwater time series
Wells at Újkígyós waterworks

12e

TÓTKOMLÓS

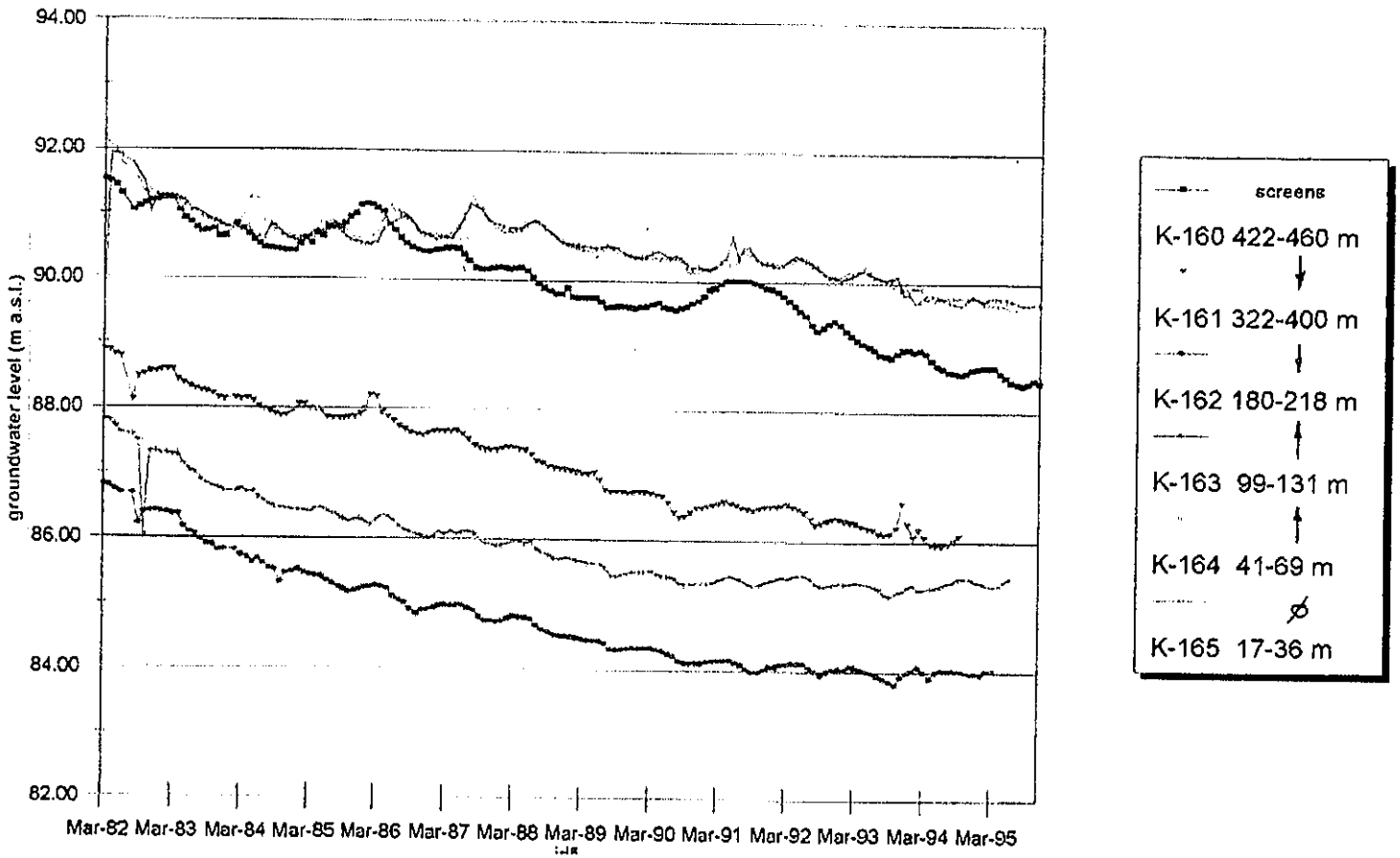


Figure 10/f.
Characteristic groundwater time series
Wells at Tótkomlós waterworks

12f

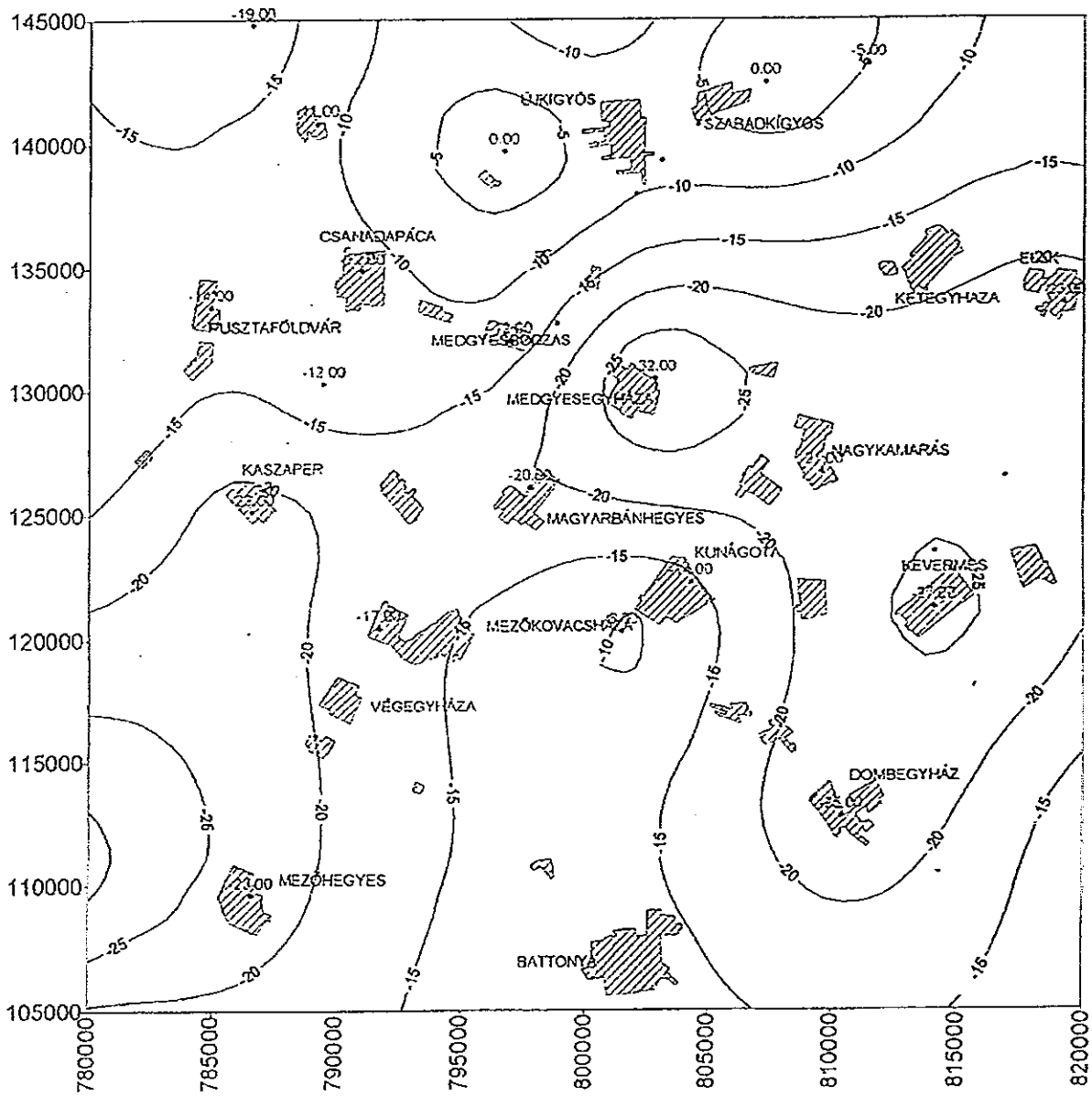


Figure 11
Deficit in groundwater reserve (mm/year)
Period: 1988-1993 (after VITUKI Report, 1994)

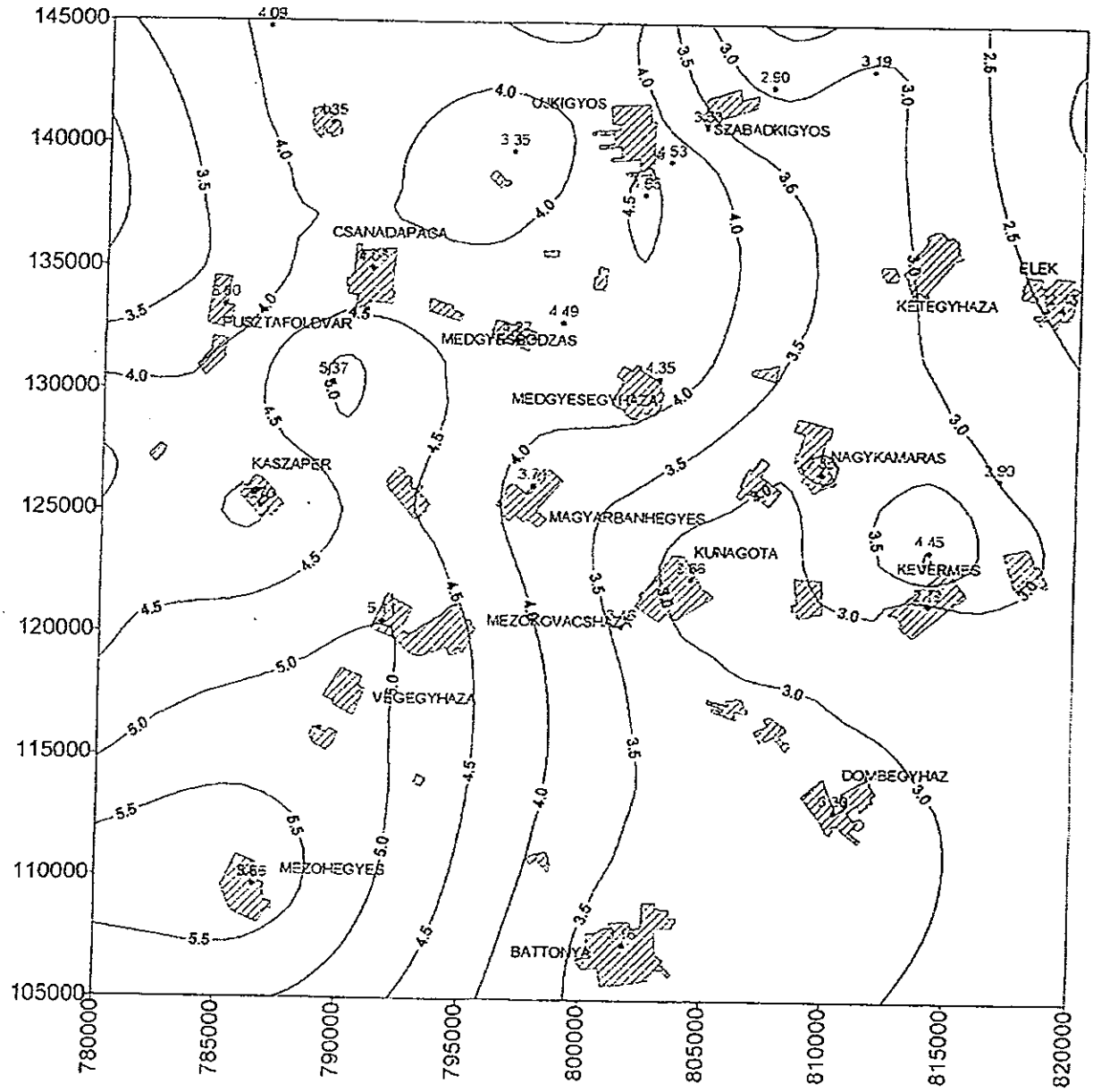


Figure 12
Average depth of shallow groundwater in 1993 (m)

In case of thin covering layer, deeper groundwater (especially in the south-western part where the water table is below 5 m) does not provide enough capillary rise to the root zone of vegetables, cereals and maize, consequently the irrigation becomes indispensable for economical crops production.

5. Water supply

Water supply in the study area is based on the local and regional waterworks abstracting groundwater from the Maros aquifer.

In the Hungarian part of the aquifer the water abstraction - by waterworks - increased from 25 000 m^3/d to 60 000 m^3/d in the recent two decades (***Figure 13***).

The estimation of other supplies (irrigation, agricultural-stock, industrial uses) is very uncertain. Around 20000-30000 m^3/d can be the amount of groundwater abstracted not by waterworks and used for the above mentioned purposes.

In the Romanian part of the study area Arad county`s regional drinking water facility and Arad town`s local water supply system altogether provides maximum 190 000 m^3/d drinking water from wells.

6. Pollution sources

6.1 Waste water collection and treatment

In Hungary 27 % of the dwellings are connected to the public sewerage system which operates mainly in the big towns (Békéscsaba, Gyula, Orosháza). Five other settlements have sewerage system with rather limited ratio of connected dwellings (Mezőhegyes 33 %, Mezőkovácsháza 14 %, Tótkomlós 9 %, Battonya 4 %, Elek 2 %). The total length of sewer system in the Hungarian part of the study area is 451 km.

Table 2 lists the wastewater discharges in the Hungarian study area. The total volume of effluent is about 34 000 m^3/d, the total amount of the treated wastewater is around 30 000 m^3/d. The total capacity of the treatment plants is around 50 000m^3/day. The plants have secondary (biological) treatment technology except a small (100 m^3/d) primary (mechanical) plant at Tótkomlós.

The ratio of treated and untreated communal wastewater is quite different in the settlements. The ratio is 45 % in the three big towns and only 5 % in the small settlements.

The information about the Romanian study area is very limited. In Arad county 14 settlements have public sewerage system, the total length of sewerage pipes is 428 km (Romanian National Commission for Statistics, 1996).

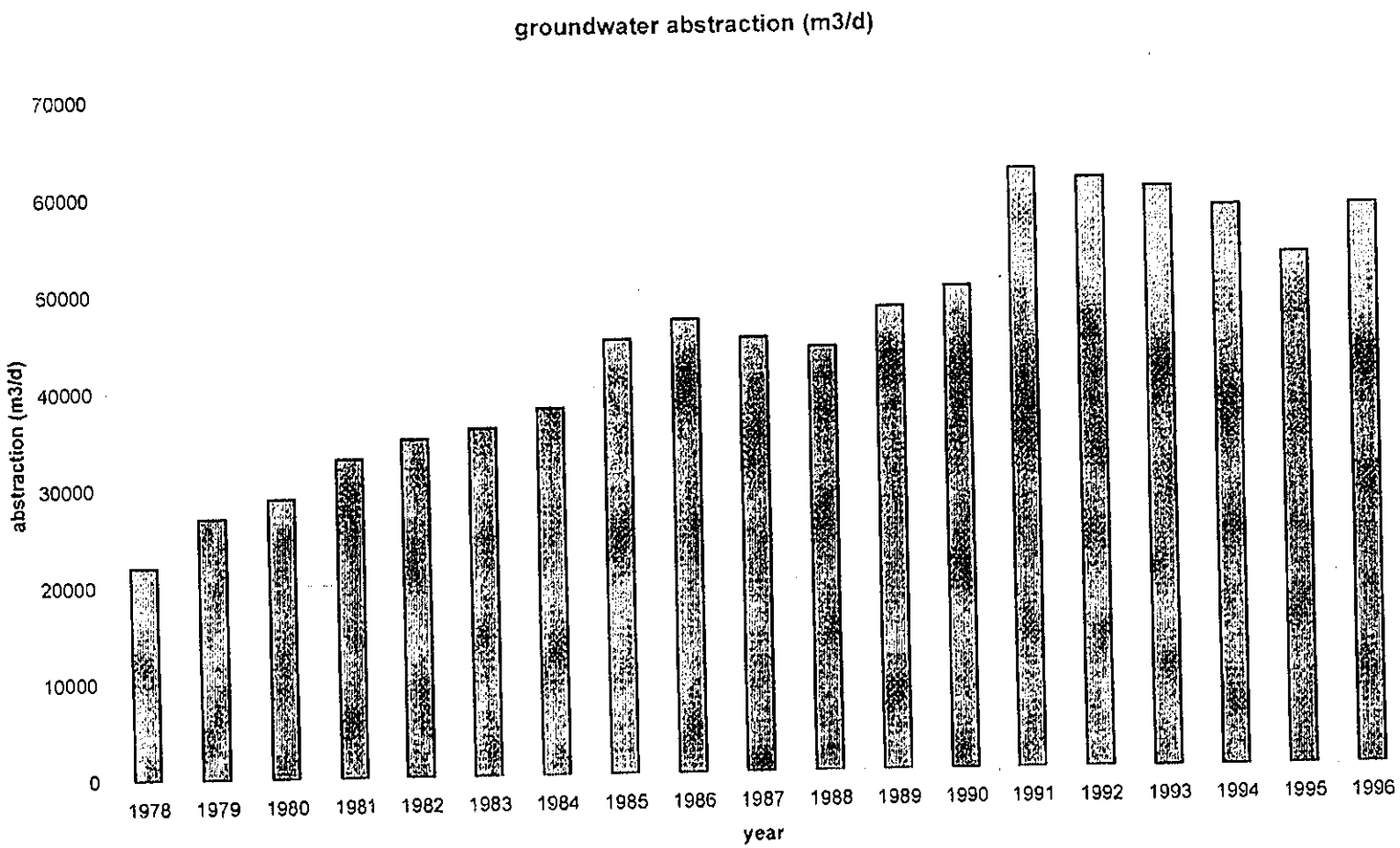


Figure 13
Water abstraction in the Hungarian part pf the Maros aquifer

Ba

Table 2. Wastewater discharges in the Maros study area in Hungary

Discharger	Settlement	Amount of discharged wastewater (m^3/day)
Békéscsaba wwtp.	Békéscsaba	15000
Árpád baths	Békéscsaba	550
Canning factory	Békéscsaba	45
District heating plant	Békéscsaba	50
Railway service plant	Békéscsaba	55
Gyula wwtp.	Gyula	3500
Gyula baths	Gyula	2300
Orosháza wwtp.	Orosháza	3800
PANNONGLAS Plc.	Orosháza	1200
Zalkatej (dairy)	Orosháza	65
Mezőhegyes wwtp.	Mezőhegyes	900
Sugar refinery	Mezőhegyes	4000
Mezőkovácsháza wwtp.	Mezőkovácsháza	850
NATURA Ltd. (feather processing plant)	Mezőkovácsháza	250
Tótkomlós wwtp.	Tótkomlós	110
Beer bottler	Tótkomlós	240
Elek wwtp.	Elek	50
Battonya wwtp.	Battonya	430
Nagyszénás wwtp.	Nagyszénás	110
Hemp industry	Nagylak	50

6.2 Industrial sources

Hungarian industrial wastewater discharges are listed in the above noted ***Table 2***. Agricultural industries dominate among the sources including sugar refinery, dairy, hemp industry, beer bottler, feather processing plant, canning factory.
Other industrial sources are glass-works, district heating plant, railway service plant.

In the Romanian part pollution source information is relevant to the Maros watershed (***Table 3***). From among the listed pollution sources only the Arad source is overlying directly the Maros aquifer, the others can have indirect effect through the recipient Maros river.

Table 3. Pollution sources in the Maros/Mures river basin in Romania

Pollution source	Recipient	Remarks
S.C. AZOMURES S.A.	Mures	chemical industry
S.C. BICAPA S.A.	Tirnava Mica	chemical industry
S.C. SOMETRA S.A.	Tirnava Mare	chemical industry
S.C. AMPELLUM S.A.	Ampoi	chemical industry
S.C. UPSOM S.A.	Mures	chemical industry
S.C. SIDERURGICA S.A.	Cerna	metallurgical industry
S.C. SIDERMET S.A.	Strei	metallurgical industry
E.M. ABRUD	Abrud	mining industry
E.M. BAIA DE ARIES	Aries	mining industry
E.M. RISIA MONTANA	Aries	mining industry
RAGCL TIRRGU MURES	Mures	municipality
RAGCL LUDUS	Mures	municipality
RAGCL ALBAIULIA	Sebes	municipality
RAGCÉ TURDA	Aries	municipality
RAGCL MEDIAS	Tirnave Mare	municipality
RAGCL DEVA	Mures	municipality
RAGCL ARAD	Mures	municipality

6.3 Agricultural sources

Agricultural water pollution sources are typically non-point sources.

Animal husbandry, manure and fertilizer application were considered as potential pollution sources. Nitrogen (ammonium, nitrite, nitrate, organic nitrogen) was taken into account as typical pollutant of agricultural origin.

Hungarian and Romanian agricultural statistics on agricultural land use and livestock in the concerned Békés and Arad counties were the primary bases to estimate agricultural nitrogen load.

Animal husbandry results yearly 6000 - 8000 t nitrogen load in the study area. Around 75% of this nitrogen originates in settlements, 25 % originates from large animal farms outside of settlements. The inappropriate storage of manure and liquid manure both in large and small animal farms outside and in the villages causes nitrogen loss polluting water resources. 5-10 % of the nitrogen content of the produced manure was assumed to pollute water owing to the inappropriate manure storage.

The application of the produced manure in the arable land of the study area covers round 30 kg/ha/year nitrogen nutrient demand of the cultivated crops. The agrostatistical data for Békés county indicate that the mean nitrogen fertilizer application rate was about 100 kg N/ha/year between 1988-1995. The nitrogen demand of the cultivated crops in the study area is much higher, around 200 kg N/ha/year, consequently all the produced manure can be applied in the arable fields of the study area without the hazard of excess nutrition.

On the other hand the application of fertilizer and manure is uneven, nitrogen loss can be expected first of all in irrigated fields. However irrigation is limited in the Hungarian and The Romanian part of the study area as well. Irrigation is applied in less then 10 % of the agricultural area.

7. Water quality

7.1. Groundwater

Groundwater quality has primary importance in the study area because the Maros aquifer is the only available good quality drinking water resource in this region. The Maros aquifer provides potable water through a regional drinking water supply system for neighbouring areas where deep confined aquifers have groundwater with high arsenic concentration.

The confined groundwaters in the Maros alluvial fan belong uniformly to the sodium-hydrogencarbonate type. Higher calcium and magnesium content occur in the highly pervious layers close to the surface.

The total dissolved solids (TDS) content of 200-300 mg/l - in the western part 500-700 mg/l - in these waters is less than in the interior parts of the Plains. The iron and manganese content is locally higher than 0.5 mg/l and was observed most frequently in the wells screened between 20 and 80 m, where the carbonic-acid content is usually higher.

The methane and arsenic contents of the groundwater in the Maros alluvial aquifer are below the limit values, except for the perimeter areas.

In the water obtained from the deeper than 20 m wells the component found most frequently objectionable is ammonium. The ammonium content in the aquifers is normally attributed to the decomposition of organics in the layers.

In the Hungarian part of the study area the nitrate concentration in the deep and shallow groundwater is typically less than 10 % of the maximum allowable concentration in drinking water (40 mg/l).

Figure 14 illustrates that the highest nitrate concentrations in the production wells or observation wells of the waterworks are below 20 mg/l (VITUKI 1994). The cited report indicates furthermore that there is no increasing trend of nitrate concentration in the Maros aquifer. The criterium of increasing trend was a minimum 1 mg/l per year concentration increment in the preceding 5 years before 1992.

Information is limited on the nitrate concentration in the shallow groundwater. A survey in the vicinity of the Újkígyós waterworks revealed a very wide range of nitrate concentrations (10 - 1000 mg/l) (VITUKI 1993). The highest concentrations up to 1000 mg/l were found under the two studied settlements. The mean value of nitrate concentration in the phreatic groundwater was 250 mg/l. Below the phreatic groundwater the mean nitrate concentration was 4.4 mg/l in the shallow groundwater (18 - 80 m) and 1.2 mg/l in the deep groundwater (>80 m). In this area the highly polluted phreatic groundwater can be a recharge source of the shallow groundwater.

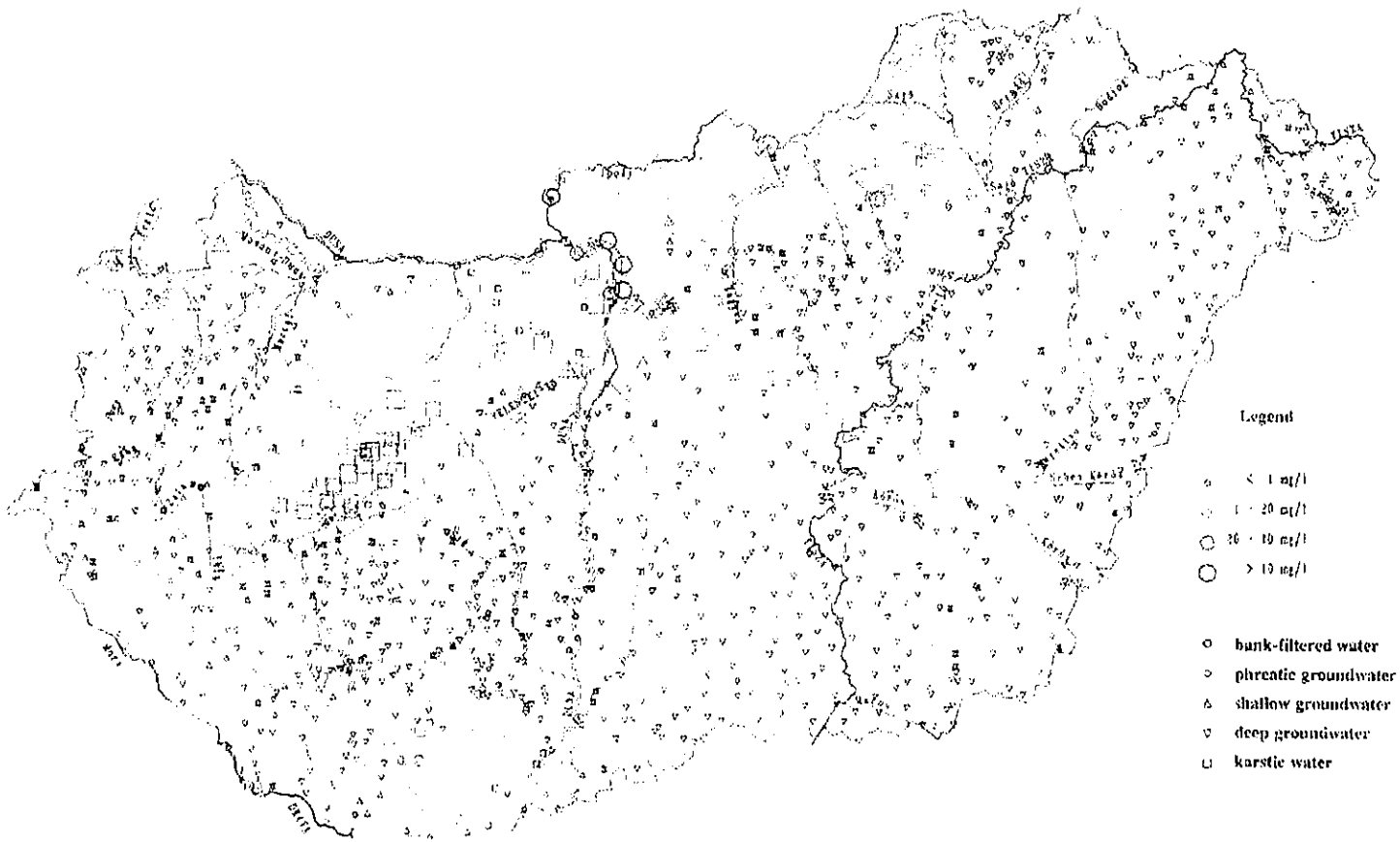


Figure 14
Mean nitrate concentration of well fields in 1992 (VITUKI 1994)

16a

In the Romanian part of the Maros aquifer high nitrate concentrations (exceeding maximum allowable limit value in drinking water) occured in wells at Arad and Horia (***Figure 15***).

7.2 Surface water

River Maros is the major water course overlying the Maros aquifer.
The river is polluted by industrial and communal wastewater discharges.

In the river basin the pollution loads from Romanian and Hungarian pollution sources are listed in ***Table 4*** for the period 1986-1995 (Maros/Mures Pilot Project, 1998). The data indicate decreasing loads in the last years of the analysed period.

Table 4. Pollution loads from Romanian and Hungarian pollution sources in the Maros river basin

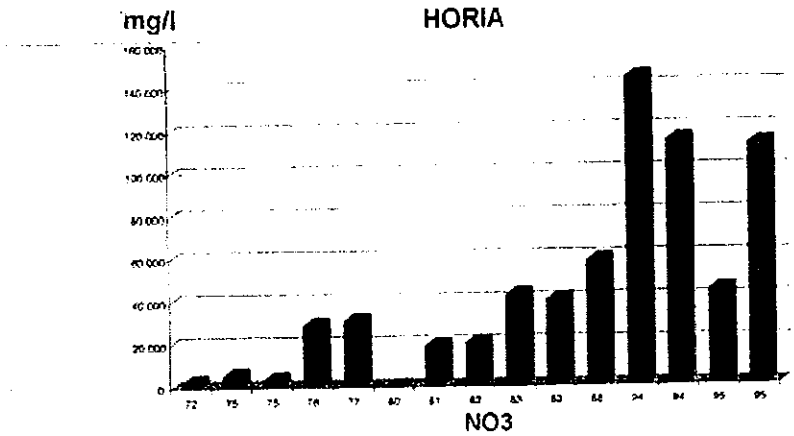
The total pollution load from pollution sources in Romania:

Year	COD (t/y)	TDS (t/y)	SS (t/y)	NH4 - N (t/y)
1986	28172	620917	131168	36658
1987	29673	517130	126194	18974
1988	15597	774057	98308	17448
1989	17138	725383	93050	15267
1990	19437	313316	102748	19557
1991	19127	301778	115565	5149
1992	18759	671907	335996	4391
1993	9379	745772	302495	5117
1994	8155	388913	105618	3754
1995	8607	314733	30745	3640

The total pollution load from pollution sources in Hungary:

Year	COD (t/y)	TDS (t/y)	SS (t/y)	NH4 - N (t/y)	Oil and grease (t/y)
1986	2350	7900		130 (total N)	40
1987	3160	9400		140 (total N)	27
1988	900	4300		68 (total N)	71
1989	1130	5900		68 (total N)	110
1990	850	4000		65 (total N)	55
1991	920	3300		52 (total N)	44
1992	650	3600		220 (total N)	62
1993	490	2700	180	38	45
1994	600	3000	160	48	47
1995	590	3200	210	54	40

The water quality (dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total nitrogen, phosphorus, cyanides, phenols parameters) along the Romanian river section is shown in ***Figures 16-20*** (Maros/Mures Pilot Project, 1997). The values of the parameters indicate significant pollution of the river water in the downstream section which can be a recharge source of the Maros aquifer.



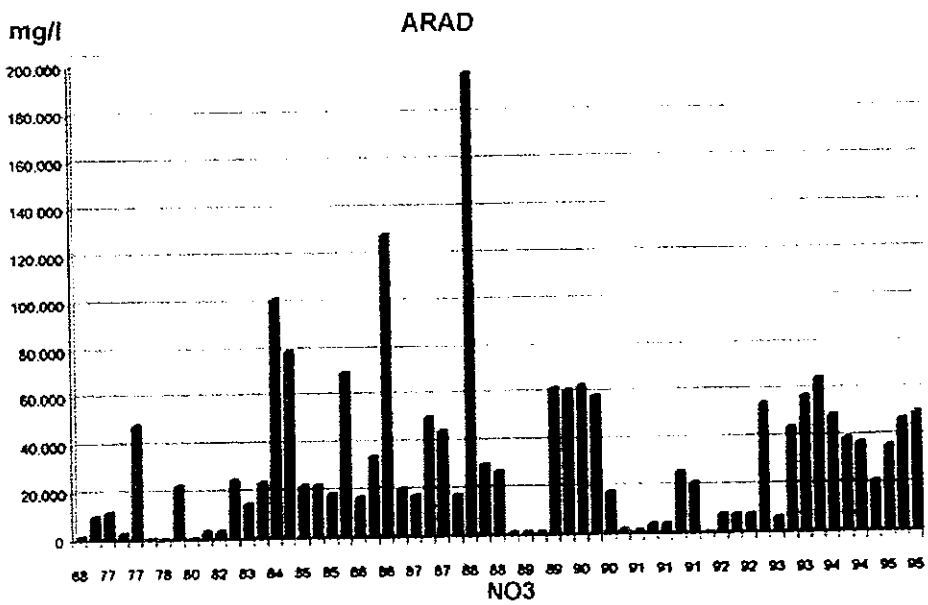


Figure 15
Nitrate concentrations in wells at Horia and Arad
(Popovici and Simionas, 1996)

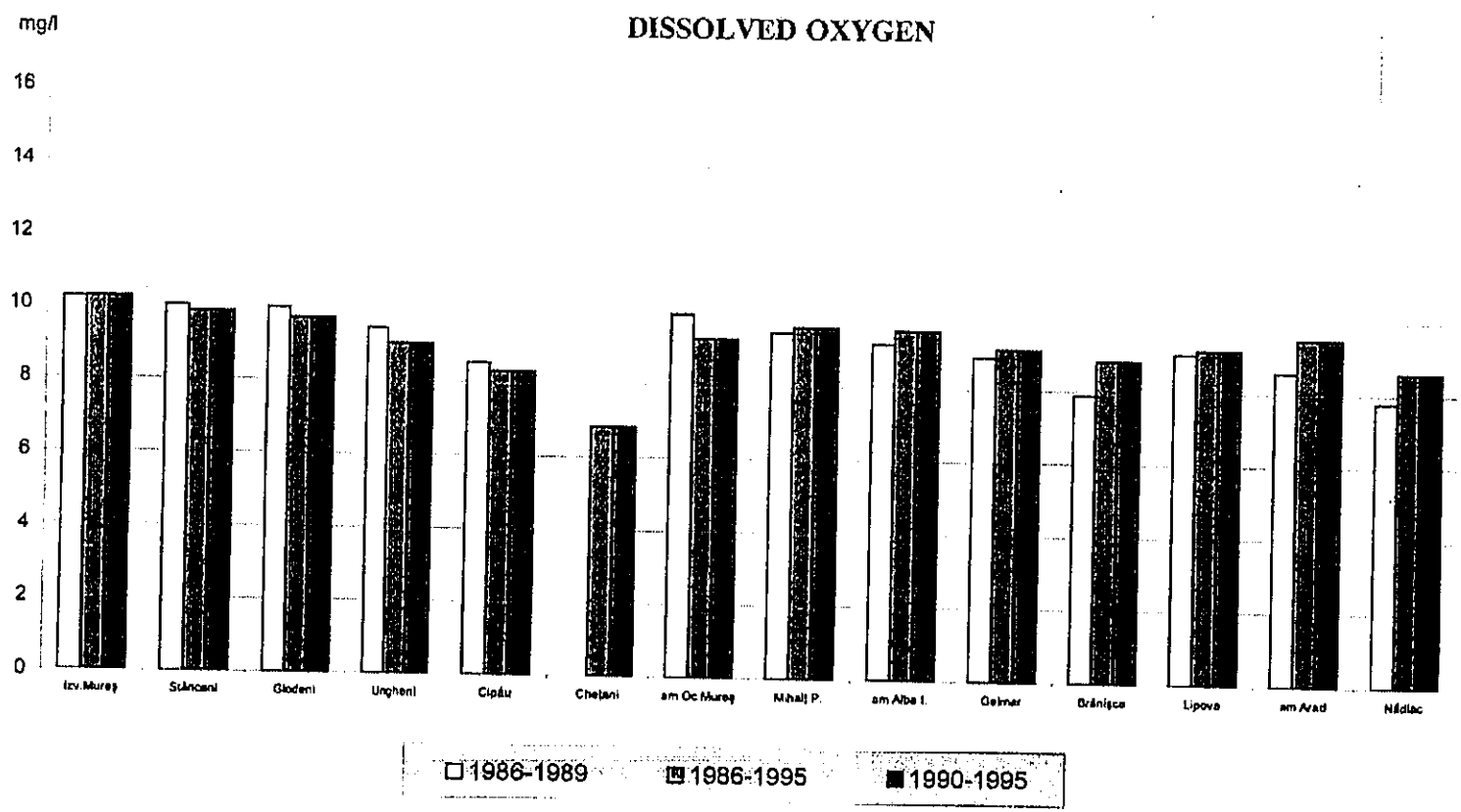


Figure 16
Water quality of the Maros/Mures river along the Romanian section
(Maros/Mures Pilot Project, 1997)

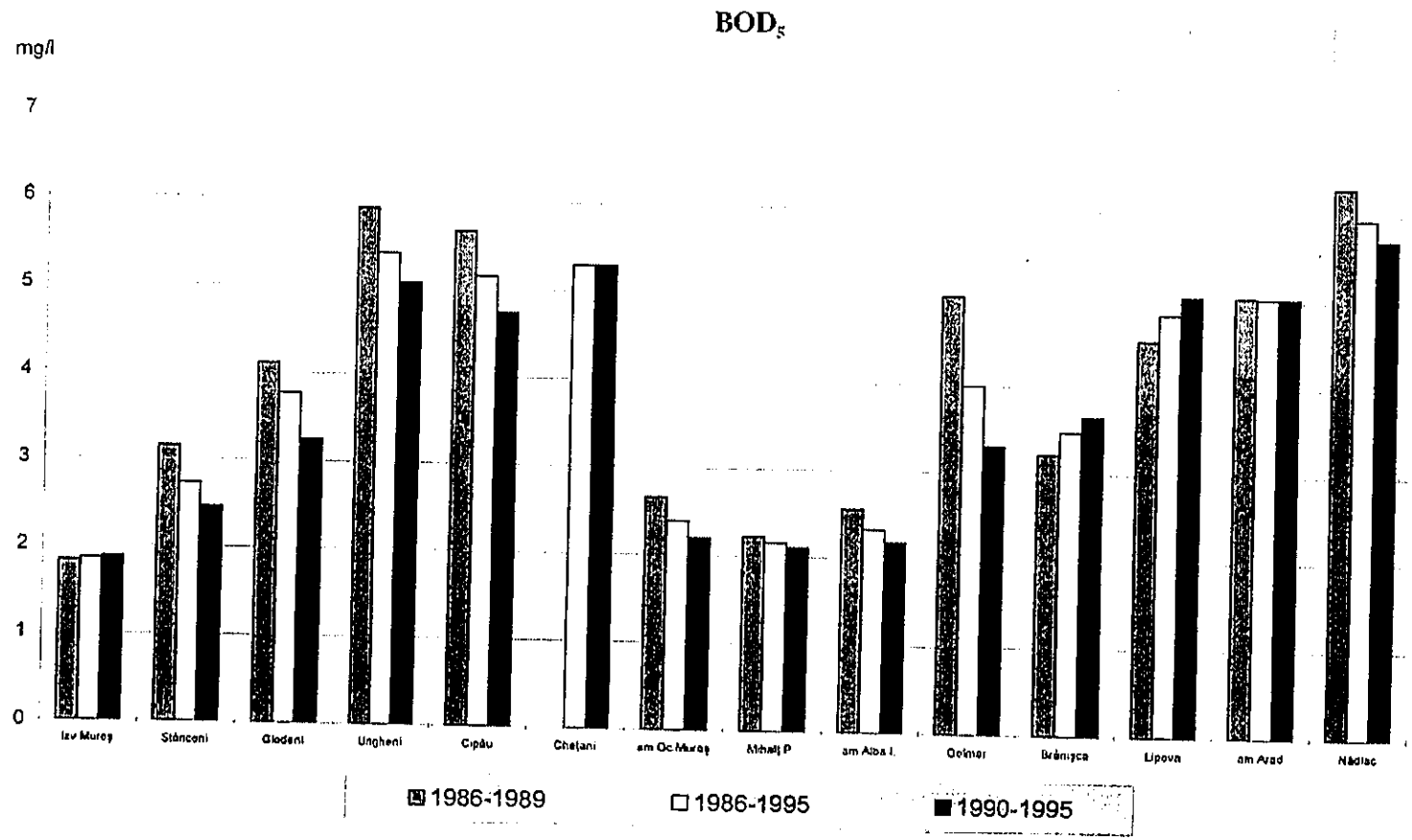


Figure 17
Water quality of the Maros/Mures river along the Romanian section
(Maros/Mures Pilot Project, 1997)

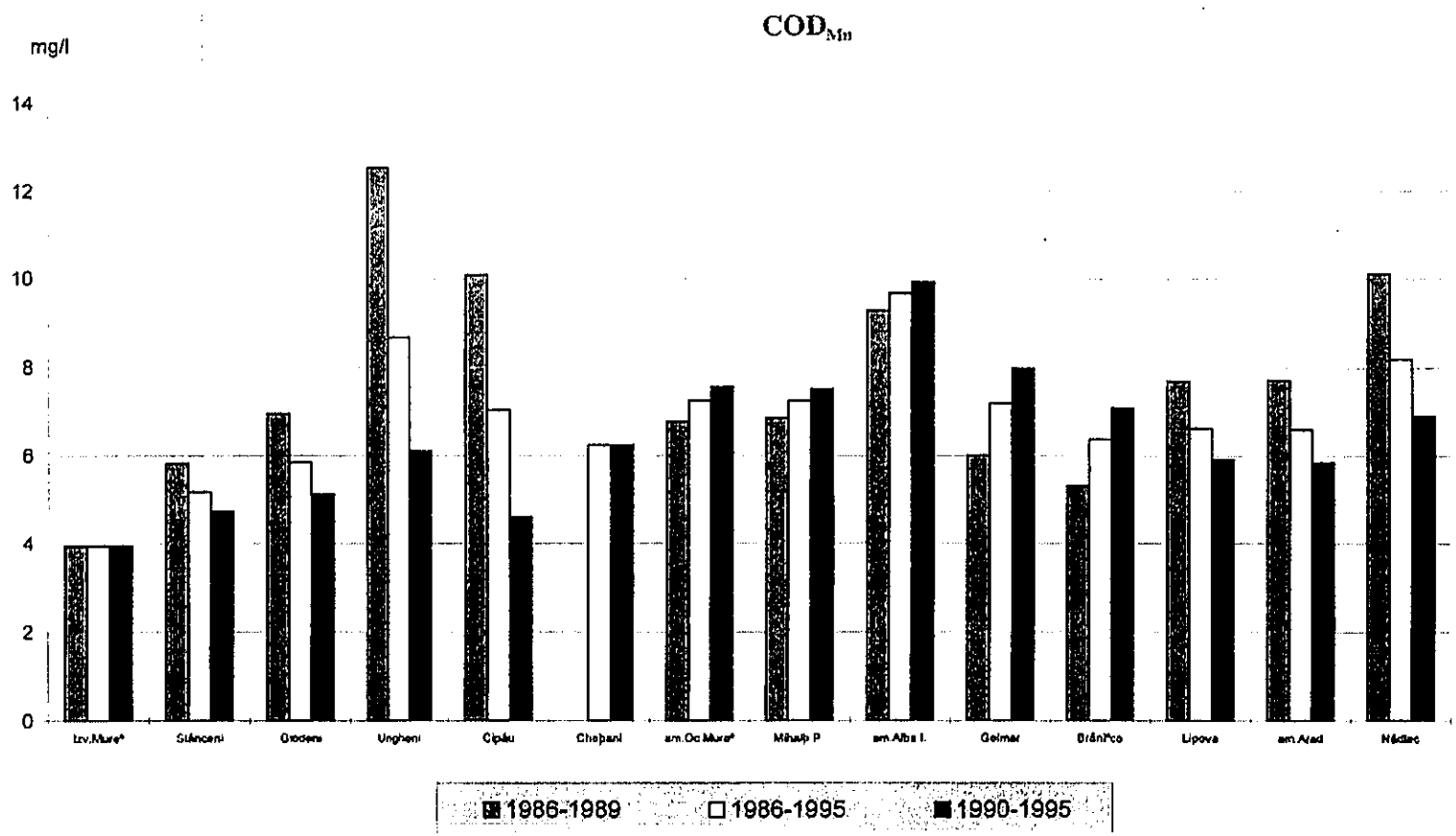
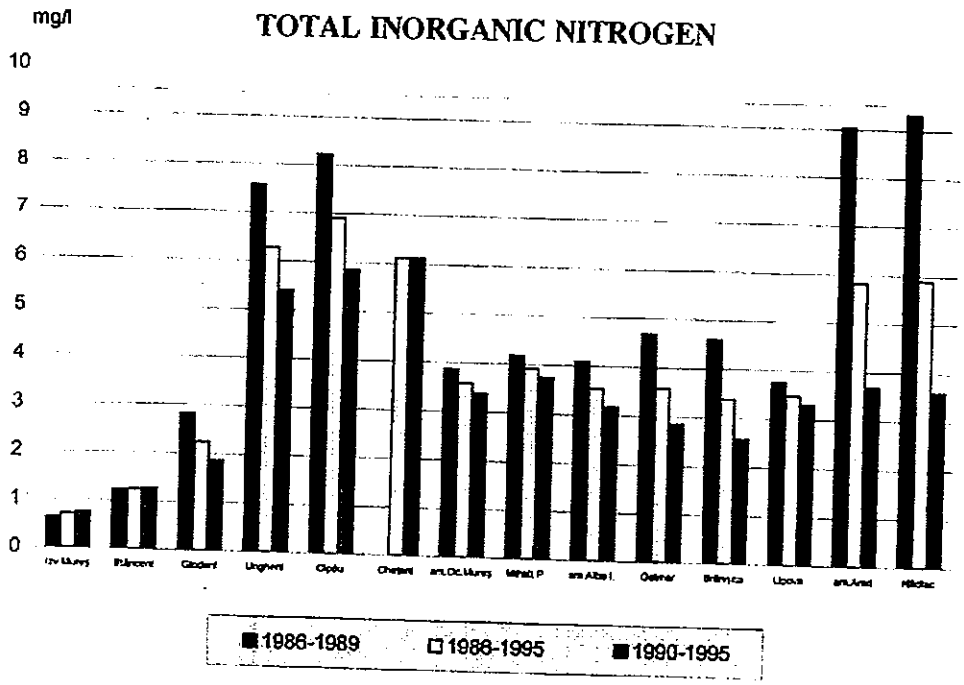


Figure 18
Water quality of the Maros/Mures river along the Romanian section
(Maros/Mures Pilot Project, 1997)



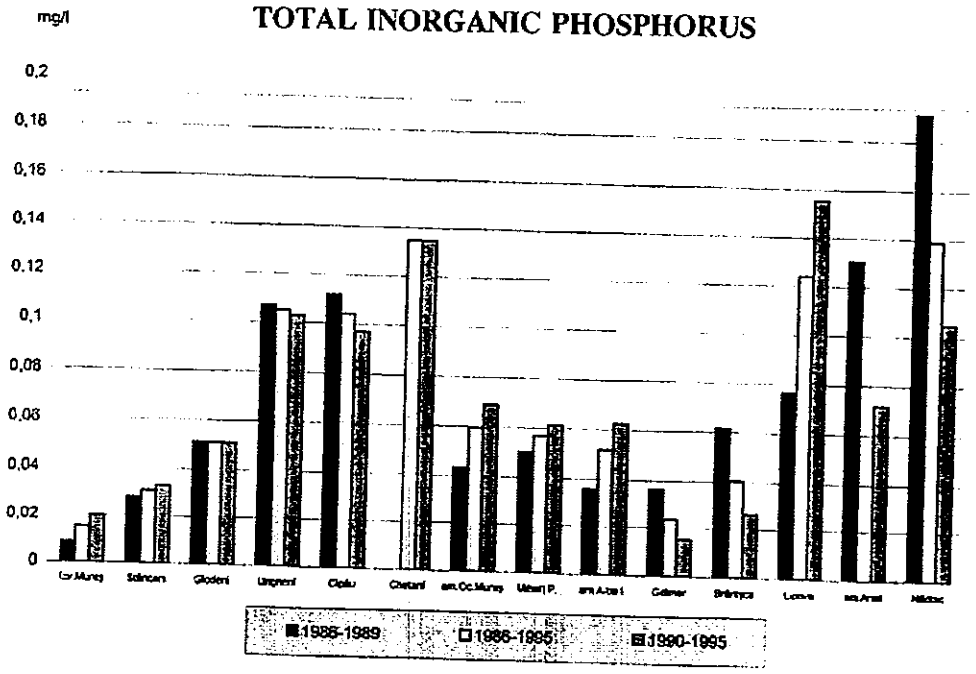
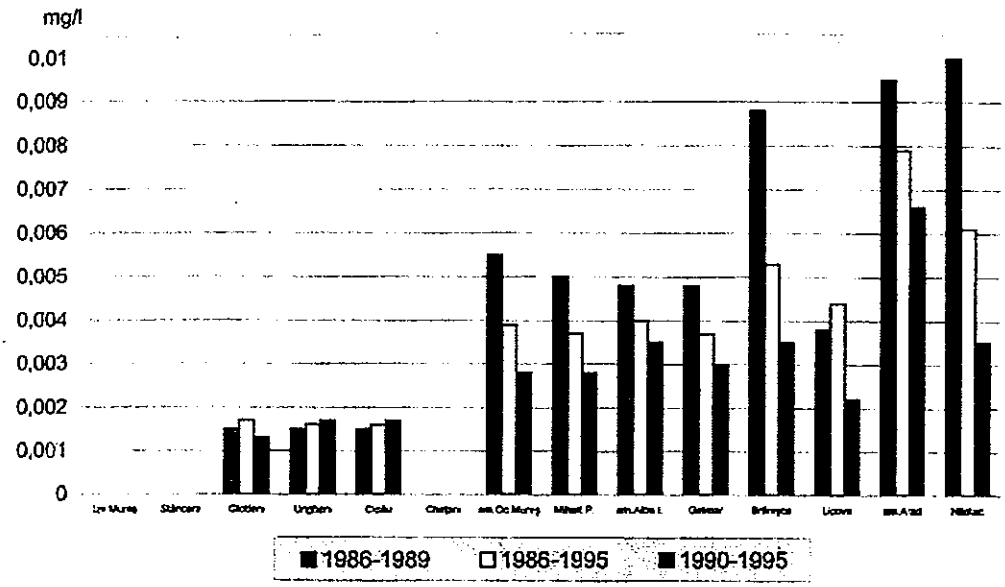


Figure 19
Water quality of the Maros/Mures river along the Romanian section (Maros/Mures Pilot Project, 1997)

CYANIDE



PHENOLS

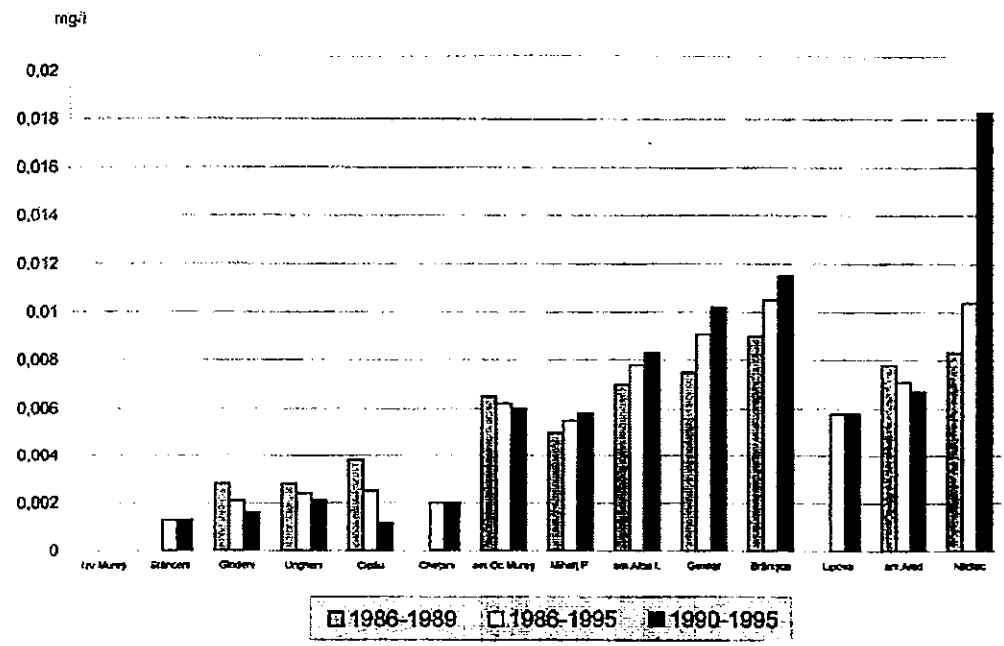


Figure 20
Water quality of the Maros/Mures river along the Romanian section (Maros/Mures Pilot Project, 1997)

However the trend of water quality was favorable in the studied 1986-1995 period; in the years between 1991-1995 the mean water quality values were better than in the 1986-1990 period with the exception of phenols.

Similar trend can be seen in ***Figure 21-22*** which show the time series of dissolved oxygen, COD, ammonium and nitrate components at Makó, Hungary (25 rkm), 25 km downstream of the Nagylak/Nadlac border station of River Maros.

8. Additional water quality measurements

In the first phase of the project a workplan was prepared for additional field and laboratory measurements. The objective was to take water samples from selected wells at or nearby potential contaminant sources located within recharge areas directly contributory to the uderlying Maros aquifer.

8.1. Sampling sites

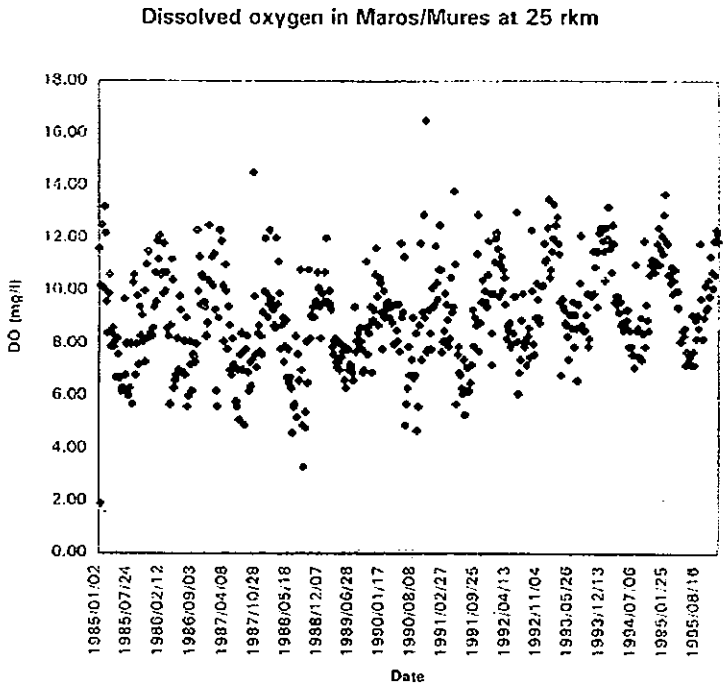
The proposed sampling sites in Hungary were selected in areas with downward flow at the settlements Békéscsaba, Telekgerendás, Újkígyós, Csorvás, Gerendás, Csanádpáca, Medgyesbodzács, Medgyesegyháza, Pusztaattlaka, Almáskamarás, Lőkösháza, Kevermes, Elek. In Romania 15 sampling sites were selected (Arad Chemical Factory, Variascu Mic, Macea, Zimandcuz, Horia, Lipova, Paulis, Mandruloc, Fintinele, Zadareni, Pecica, Semlac, Periam, Seitin, Nadlac). The above listed sampling sites are shown in **Figure 23,** which indicates – as background information the travel time of the infiltrating water from the ground surface to the groundwater (see Paragraph 2.1).

The water samples were taken from the upper part of the shallow (phreatic) groundwater in the year 1999.
VITUKI Plc., took the samples in the Hungarian part of the study area, PROED SA. collected the samples in the Romanian region.

8.2. The measured organic pollutants

Water quality analysis was intended for organic chemical constituents, data for which were lacking. Determinands included pesticides (atrazine, simazine, lindane, 2,4-D, 2,4,5-T, methoxy-chlor), volatile and semi-volatile organic micropollutants (benzene, toluene, xilene, ethyl-benzene, dichlorobenzene, dichloroethene, trichloroethene, tetrachloroethene). Potential pollution source of pesticides is agricultural land use in the Maros region. The other analysed volatile and semi-volatile organic micropollutants can potentially originate from settlements of the region (operation of petrol filling stations, application of solvents).

The determinands were analysed in VITUKI (Hungarian samples) and in the Agrochemistry and Pedology Institute, Bucharest (Romanian samples).



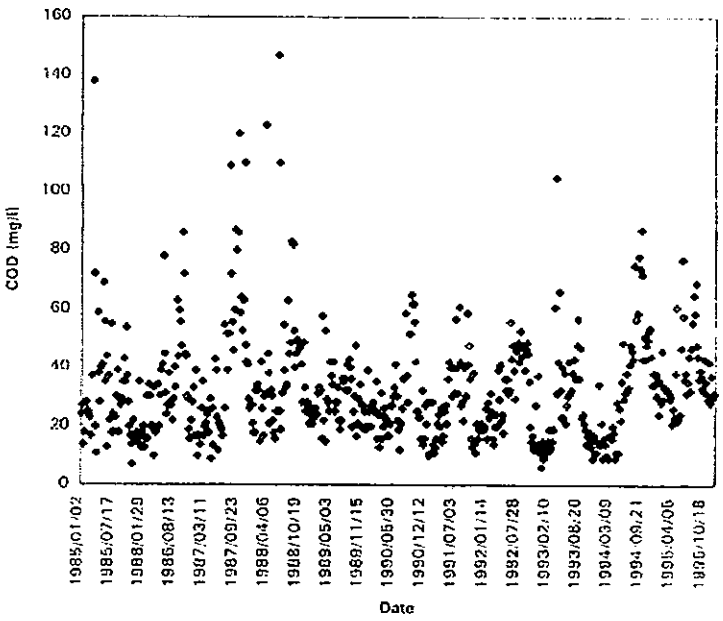
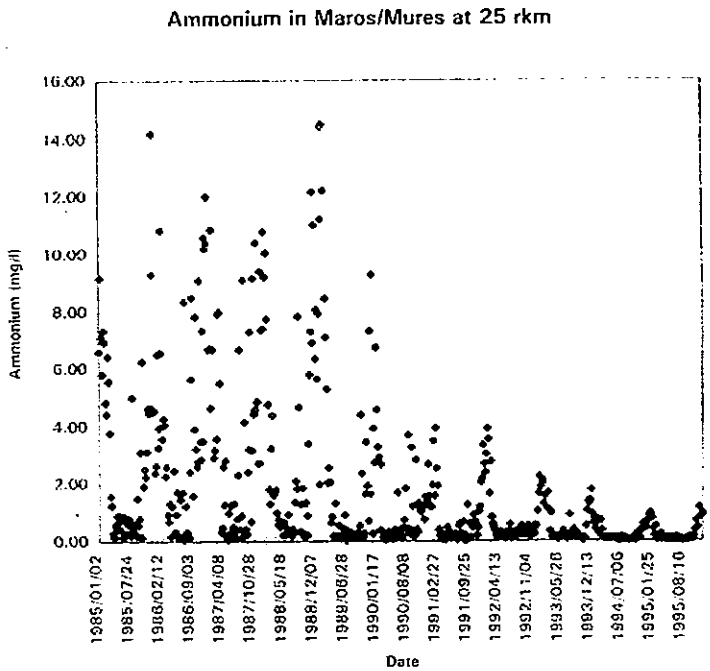


Figure 21
Water quality of the Maros/Mures river at Makó, Hungary



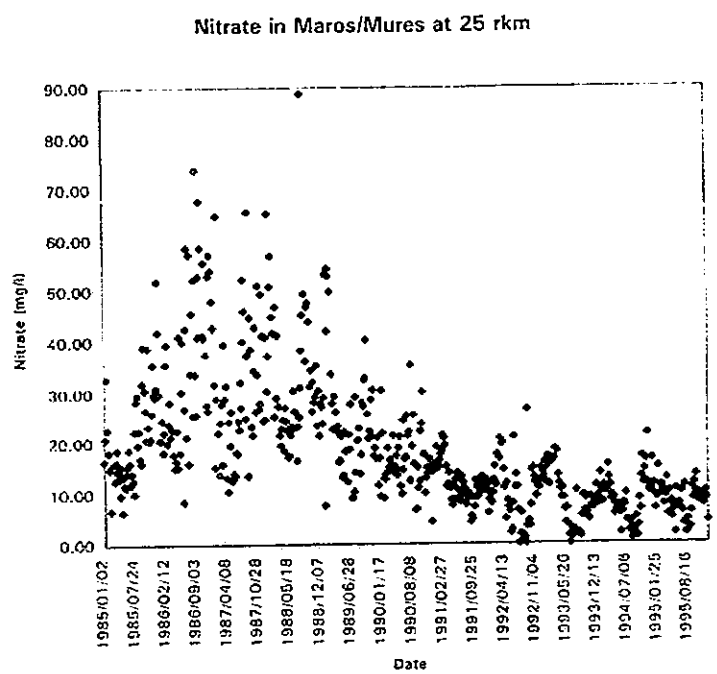


Figure 22
Water quality of the Maros/Mures river at Makó, Hungary

Areas on which the vertical travel time through the shallow aquifer less than 100 years

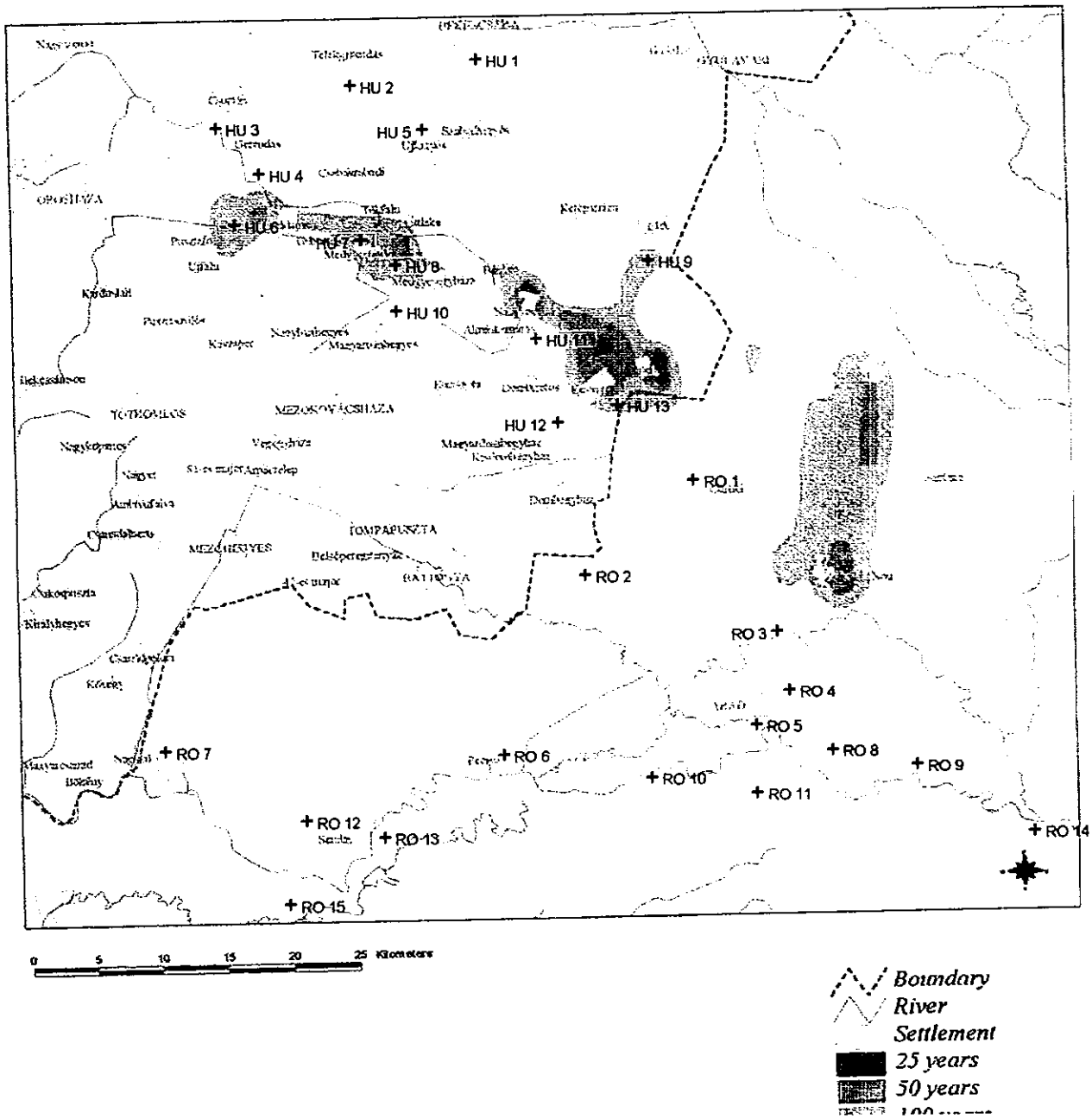


Figure 23
Sampling sites of the additional water quality measurements (sampling codes are identified in Table 5)

8.3. The applied analytical methods

8.3.1. Analytical methods in VITUKI, Budapest

8.3.1.1. Analysis of fenoxy-acetic-acid type pesticides

- Sample preparation
  - The pH of 1 l sample is adjusted to pH=2 by 6 mol/l HCl, than the sample is filtered through conditioned C18 ENVI disc$_{TM}$. (Conditioning: filtration of 5 ml dichloro-methane through the disc, 5 minutes drying. 5 ml ethanol and 5 ml water is poured onto the disc.)
  - After filtration of the sample, the ENVI disc is dryed in vacuum for 30 minutes. Dissolution by 5 ml ethyl-acetate and by 5 ml dichloro-methane.
  - The dissolved material is evaporated to dryness. 250 µl 1 % pentafluoro-benzil-bromide and 2 µl triethyl-amine is added to the residue.
  - The reaction mixture is warmed up to 70 °C for 30 minutes.

Analysis is carried out by GC-MSD.

- GC-MSD analysis
  - Instrument: HP-5890-5971A GC-MSD
  - Column: J & W DB-5ms, 20 m, 0.18 mm, 0.18 µm
  - Heating programme: 2 min 80 °C - 20 °C/min – 300 °C 4 min
  - Injector temp: 270 °C
  - Injected volume: 2 µl splitless

Monitored ions:

Compound	Quantificated ion (m/z)	Confirmed ion (m/z)
2,4-D	400	402
2,4,5-T	434	436

Lower detection limit: 0.01 µg/l

8.3.1.2. Analysis of triazine type pesticides

- Sample preparation
  - The pH of 1 l sample is adjusted to pH=6-8.
  - Appropriate amount of dibromo-octafluoro-biphenyl and d10-fluoranthene is added, dissolved in methanol. The sample is filtered through conditioned C18 ENVI disc$_{TM}$. (Conditioning: filtration of 5 ml dichloro-methane through the disc, 5 min drying. 5 ml ethanol and 5 ml water is poured onto the disc.)
  - After filtration of the sample, the ENVI disc is dried in vacuum for 30 minutes. Dissolution by 5 ml acetonitril.
  - The dissolved material is dried by sodium-sulphate, evaporated to dryness. Bromo-naphtalene and dibromo-biphenyl (ISTD) is added, the volume is completed to 250 µl by acetone.

Analysis is carried out by GC-MS.

- GC
  - Instrument: HP-5890/A/II
  - Column: DB-5ms, 30 m, 0.25mm, 0.25 µm
  - Injector temp: 280 °C
  - Injected volume: 2 µl splitless
  - Carrier gas: He, 15 psi
  - Line: 250 °C
  - Heating programme: 2 min 60 °C - 10 °C/min – 300 °C 5 min

- MS
  - Instrument: VG Autospec-S
  - Operation: EI/SIR, 70 eV, 250 µA
  - R= 4000

Masses of the monitored ions:

Compound	Detected ion m/z
Atrazine	215.094
Simazine	201.070

Lower detection limit: 0.002 µg/l

8.3.1.3. Analysis of chlorinated hydrocarbon type pesticides

- Sample preparation
  - The pH of 1 l sample is adjusted to pH=2 by 6 mol/l HCl.
  - Appropriate amount of dibromo-octafluoro-biphenyl, dibromo-biphenyl and d10-antracene is added, dissolved in methanol (surrogate standard).
  - The sample is filtered through conditioned ENVI disc™. After filtration of the sample, the ENVI disc is dried for 30 minutes.
  - The components are eluted by 5 ml ethyl-acetate and 5 ml dichloro-methane.
  - The composite fractions are dried by sodium-sulphate, then the solvents are evaporated by nitrogen.
  - Bromo-naphtalene, d_{14}-terphenyl, d_{12}-benzo(a)pyrene (ISTD) is added to the residue, dissolved in 50 µl dichloro-methane.
  - The volume of the sample is completed to 250 µl by dichloro-methane.

- GC-MS analysis

  GC
  - Instrument: HP-5890A/II
  - Column: DB-5ms, 30 m, 0.25mm, 0.25 µm
  - Injector temp: 285 °C
  - Injected volume: 2 µl splitless
  - Carrier gas: He, 15 psi
  - Line: 250 °C

MS
- Instrument: VG Autospec-S
- Operation: EI/SIR, 70 eV, 250 µA
- R= 4000

Masses of the monitored ions:

Compound	Detected ion m/z
Lindane	220.9086
Methoxychlor	227.1070

Lower detection limit: 0.002 µg/l

8.3.1.4 Analysis of alkyl-benzenes and chlorinated benzenes

- Sample preparation
  - Bromo-benzene and bromo-naphtalene - dissolved in 50 µl acetane – is added as recovery standard to 100 ml water sample stored at 4-5 °C.
  - The sample is agitated with 1 ml n-hexane for 5 minutes.
  - Calibration series is prepared, bromo-benzene and bromo-naphtalene (recovery standard) is added to it, dissolved in 50 µl acetone.
  - The mixture is added to 100 ml distilled water, then it is agitated with n-hexane for 5 minutes.
  - The samples and the calibration series are cooled during the preparation processes.

- GC-MSD analysis

  - Instrument: HP-5890-5971A GC-MSD
  - Column: J & W DB-5ms, 10 m, 0.18mm, 0.18 µm, 2.5 m precolumn
  - Heating programme: 45 °C 2 min., 20 °C/min – 100 °C - 3 °C/min-110 °C - 20°C/min-300 °C
  - Injector temp: 250 °C
  - Line: 300 °C
  - Injected volume: 2 µl splitless
  - Carrier gas: He, 7 psi
  - Operation: EI+/SIR,

Monitored ions:

Compound	Quantificated ion	Confirmed ion
Benzene	78	77
Toluene	91	92
Xylene	91	106
Ethyl-benzene	91	106
dichloro-benzene	146	148

Lower detection limit: 0.05 µg/l

8.3.1.5. Analysis of volatile halogenated hydrocarbons

- Sample preparation
  - 1,2-dibromo-3-chloro-propane - dissolved in 50 µl methanol – is added as recovery standard to 50 ml cold water sample.
  - The sample is agitated with 1 ml n-pentane for 5 minutes.
  - Calibration series is prepared in 50 ml distilled water.
  - Recovery standard is added to the calibration series, which are agitated with 1 ml pentane for 5 minutes.
  - The samples and the calibration series are cooled during the preparation processes.

- GC analysis
  - Instrument: HP-5890/II or HP-5790
  - Column: VOCOL (Supelco), 30 m, 0.25 mm, 1.5 µm,
  - Heating programme: 45 °C (4 min) - 5°C/min – 200 °C
  - Injector temp: 240 °C
  - Carrier gas: hydrogen, 10 psi
  - Detector: ECD (300 °C)
  - Injected volume: 2 µl, splitless
  - Lower detection limit: 0.1 µg/l

8.3.2. Analytical methods in Agrochemistry and Pedology Institute, Bucharest

8.3.2.1. Analysis of volatile organic compounds

- Sample preparation
  - Glass vials with teflon-faced screw caps (20 ml) were used for the collection of water samples.
  - The vials were completely filled (zero headspace).
  - A 8 ml water sample was introduced into a 12 ml headspace vial and 5 g NaCl was added.
  - The vial was sealed and thermostated at 75 °C for 30 min.
  - After equilibration, 250 µl of the headspace gas was injected into the GC by using a headspace autosampler (Fisons HS 800).

- GC (FisionsGC 8000) parameters:

- Injection port	splitless
- Injection port temperature	155 °C
- Column:	CP-Sil 8 CB MS, 30m x 0.32 mm x 0.25 µm
- Oven temperature program	40 °C for 6 min, 40 °C to 70°C at 3°C/min, 70 °C for 1 min, 70 °C to 150°C at 40°C/min.

- MS (Fisons MD 800) parameters:

- Ionisation mode	EI^+
- Scan	35 – 185 amu
- Detector voltage	350 V

For quantitation, the following ions were used: benzene-78, toluene-91, ethylbenzene-106, dichloroethene-96, trichloroethene-130, tetrachloroethene-166, 1,2/1,3/1,4-dichlorobenzene-146. Calibration was made by analysing a blank water sample spiked with known concentration of analytes, using the same conditions as those for the samples.

8.3.2.2. Analysis of pesticides

- Sample preparation
  - The SPE cartridge with 500 mg C18 was conditioned by elution with 10 ml methanol and 10 ml water, without applying vacuum.
  - 1 l of filtered water sample, to which 10 ml of methanol was added, was passed through the precondition column in about two hours, by applying vacuum.
  - The SPE column was dried with nitrogen.
  - The SPE column, connected to another column containing 200 mg anhydrous sodium sulphate was eluted with 3 ml acetone.
  - The eluate was evaporated to dryness by using a gentle nitrogen flow.
  - The residue was redissolved in 500 µl acetone for determination of triazines or in 500 µl hexane for determination of organochlorines.

- GC parameters:

1. For organochlorine insecticides (Fisons- MEGA 5380 HRGC):

- Injection port	on-column
- Column:	SE 52, OV-1.25 m x 0.32 mm x 0.25 µm
- Oven temperature program	60 °C for 1 min, 60 °C to 150°C at 20°C/min, 150 °C for 1 min, 150 °C to 240 °C at 5°C/min, 240 °C for 5 min, 240 °C to 280°C at 20°C/min.
- Column flow rate	1.5 ml/min helium
- Injection volume	1 µl
- Detector	ECD
- Temperature	320 °C
- make-up flow	30 ml/min nitrogen

2. For triazine herbicides (CE Instruments Fractovap 2350 GC):

- Injection port	vaporization	
- Injection port temperature	250 °C	
- Column:	glass, 1.8 m x 3 mm id., packed with 3 % Carbowax on Gas Chrom Q 100-120 Mesh	
- Column flow rate	40 ml/min nitrogen	
- Oven temperature	195 °C	
- Injection volume	2 µl	
- Detector	NPD	
- Temperature	250 °C	
- Gas supply	35 ml/min nitrogen	250 ml/min air

8.4. Discussion of the results

The measured concentrations of the analysed organic micropollutants (***Table 5***) are compared with the limit values of the 98/83 EC Directive (water intended for human consumption) because Hungary and Romania intend to harmonise the environmental legislation with the requirements of the European Union. Consequently the national drinking water standards will follow the above noted EU Directive.

The maximum allowable pesticide concentration is 0.1 µg/l for each pesticide.

The triazin type herbicides (atrazine, simazine) are widely applied in the study area primarily in maize growing fields. Triazines are highly mobile components in groundwater and rather stable compounds. Neither atrazine or simazine was found in concentration exceeding the limit value, however the atrazine concentrations approached in some places (Horia, Mandruloc) the maximum allowable value. The spatial concentration distribution indicated no typical areal concentration pattern.

The analysed chlorinated hydrocarbon type insecticides (lindane, methoxichlor) were also found in concentration below the limit value. Methoxychlor concentrations were very low, lindane concentration was significant (0.09 µg/l) in the groundwater near Almáskamarás.

The herbicides MCPA, 2,4-D and 4,4,5-T were measured only in the water samples from the Hungarian part of the Maros aquifer. MCPA exceeded the limit values in two adjacent sampling sites (Békéscsaba, Telekgerendás). In other places the MCPA concentration was under the detection limit.

The phenoxy-acetic acid type 2,4,5-T pesticide content of the shallow groundwater was very low everywhere. 2,4-D (also phenoxy-acetic acid herbicide) concentration exceeded the limit value at Almáskamarás where other pesticides also had significant concentrations.

The analytical result of the volatile chlorinated hydrocarbons (dichloro-ethene, trichloro-ethene, tetrachloro-ethene) did not refer to pollution; the measured values were below the detection limits.

From among the analyzed aromatic components (benzene, toluene, xylene, ethyl-benzene, dichloro-benzene) toluene, xylene and dichloro-benzene concentrations were below the detection limits. Ethyl-benzene was found in concentration above the detection limit at one site (Maceg). At the same sampling site the benzene concentration (42.8 µg/l) was also very high. The benzene concentrations were under the 0.1 µg/l detection limit in all the Hungarian sampling sites, on the other hand all the Romanian groundwater samples had very high – exceeding the maximum allowable limit value – benzene content. These results seem to be questionable.

The above discussed measurements indicated the moderate pollution effect of the agricultural pesticides application in the region. The other types of analysed organic micropollutants (volatile and semi-volatile aromatics, volatile chlorinated hydrocarbons) were found typically in insignificant concentrations, except in the case of benzene (the benzene concentrations seem to be unreliable).

Table 5. Concentration of organic micropollutants in groundwater samples of the Mures/Maros aquifer (1999)

Sampling		Concentration (µg/l)						
site	code in Figure 1.	Atrazine	Simazine	Lindane	Methoxichlor	MCPA	2,4-D	2,4,5-T
Békéscsaba	HU 1	< 0.001	< 0.001	0.010	< 0.001	0.20	0.038	< 0.005
Telekgerendás	HU 2	< 0.001	< 0.001	0.020	< 0.001	0.16	0.027	< 0.005
Csorvás	HU 3	< 0.001	< 0.001	0.053	< 0.001	< 0.005	0.020	< 0.005
Gerendás	HU 4	< 0.001	< 0.001	0.036	< 0.001	< 0.005	0.029	< 0.005
Újkígyós	HU 5	< 0.001	< 0.001	0.007	< 0.001	< 0.005	0.021	< 0.005
Csanádapáca	HU 6	< 0.001	< 0.001	0.032	< 0.001	< 0.005	0.017	< 0.005
Pusztaattlaka	HU 7	< 0.001	< 0.001	0.047	< 0.001	< 0.005	0.025	< 0.005
Medgyesbodzás	HU 8	0.003	< 0.001	0.019	< 0.001	< 0.005	0.033	< 0.005
Elek	HU 9	< 0.001	< 0.001	0.008	< 0.001	< 0.005	0.055	< 0.005
Medgyesháza	HU 10	< 0.001	< 0.001	0.039	< 0.001	< 0.005	0.016	< 0.005
Almáskamarás	HU 11	0.040	< 0.001	0.092	< 0.001	< 0.005	0.200	< 0.005
Kevermes	HU 12	< 0.001	< 0.001	0.014	< 0.001	< 0.005	0.039	< 0.005
Lőkösháza	HU 13	0.017	< 0.001	0.021	< 0.001	< 0.005	0.057	< 0.005
Maceg	RO 1	0.065	0.040	0.015	< 0.005	-	-	-
Variasu Mic	RO 2	0.030	< 0.020	0.020	< 0.005	-	-	-
Zimandcuz	RO 3	< 0.020	< 0.020	0.015	< 0.005	-	-	-
Horia	RO 4	0.080	< 0.020	0.015	< 0.005	-	-	-
C.I.C. Arad	RO 5	< 0.020	< 0.020	0.027	< 0.005	-	-	-
Pecica	RO 6	0.030	< 0.020	0.022	< 0.005	-	-	-
Nadlac	RO 7	< 0.020	< 0.020	0.030	< 0.005	-	-	-
Mandruloc	RO 8	0.080	0.060	0.033	< 0.005	-	-	-
Paulis	RO 9	< 0.020	< 0.020	0.021	< 0.005	-	-	-
Zadareni	RO 10	< 0.020	< 0.020	0.016	< 0.005	-	-	-
Fantanele	RO 11	< 0.020	< 0.020	0.018	< 0.005	-	-	-
Seitin	RO 12	< 0.020	0.040	0.033	< 0.005	-	-	-
Semlac	RO 13	< 0.020	< 0.020	0.022	< 0.005	-	-	-
Lipova	RO 14	< 0.020	< 0.020	0.027	< 0.005	-	-	-
Periam	RO 15	< 0.020	< 0.020	0.018	< 0.005	-	-	-
Parametric values (maximum allowable limit values) in water intended for human consumption (98/83 EC Directive)		0.1	0.1	0.1	0.1	0.1	0.1	0.1

Sampling site	code in Figure 1.	Concentration (µg/l) Benzene	Toluene	Xylene	Ethyl-benzene	Dichloro-ethene	Trichloro-ethene	Tetrachloro-ethene	Dichloro-benzene
Békéscsaba	HU 1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Telekgerendás	HU 2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Csorvás	HU 3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Gerendás	HU 4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Újkígyós	HU 5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Csanádapáca	HU 6	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Pusztaattlaka	HU 7	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Medgyesbodzás	HU 8	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Elek	HU 9	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Medgyesháza	HU 10	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Almáskamarás	HU 11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Kevermes	HU 12	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Lőkösháza	HU 13	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Maceq	RO 1	42.8	< 2	< 5	10.6	< 2	< 5	< 5	< 5
Variasu Mic	RO 2	11.1	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Zimandcuz	RO 3	16.1	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Horia	RO 4	6.7	< 2	< 5	< 5	< 2	< 5	< 5	< 5
C.I.C. Arad	RO 5	10.5	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Pecica	RO 6	8.6	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Nadlac	RO 7	10.8	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Mandruloc	RO 8	11.7	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Paulis	RO 9	11.0	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Zadareni	RO 10	8.9	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Fantanele	RO 11	9.8	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Seitin	RO 12	8.5	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Semlac	RO 13	8.1	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Lipova	RO 14	10.6	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Periam	RO 15	10.5	< 2	< 5	< 5	< 2	< 5	< 5	< 5
Parametric values (maximum allowable limit values) in water intended for human consumption (98/83 EC Directive)		1.0					10	10	

9. Hydrogeological modeling and simplified transport simulation

The objective was to prepare a model of the Maros aquifer showing the current conditions of quality and quantity of withdrawals and to simulate and summarize the anticipated changes in aquifer water quality with various conditions.

A regional hydraulic model of the Maros aquifer was developed. The numerical model was based on Processing Modflow for Windows software.

9.1 The regional hydraulic model of Maros aquifer

9.1.1 Horizontal extent

As mentioned in Chapter 1 the studied area belongs to the southern Trans-Tisza region.

In the Romanian part of the studied area the eastern border is a natural geological formation, the Transsylvanian ore mountains. The two rivers - river Maros in the south, river Fehér-Körös in the north-east -- are given as fixed head border. In the Hungarian part the model boundary is fixed in areas where the vertical flow is dominant, consequently there is no significant outflow from the model area. This border is given with a line across settlements Gyula, Csorvás in the north, and a line across settlements Tótkomlós, Csanádpalota in the west (***Figure 24***).

The whole model area in the direction from north to south is about 65 km and in the direction east-west is 70 km, that is about 4500 km^2 lateral extension.

9.1.2. Vertical extent

The purpose of this modeling work is to show the changes in the water quantity of the aquifer, and to provide some estimation of the exploitable water resource of the Maros alluvial fan. Therefore the first model layer is the shallow groundwater aquifer which is the most important from recharge point of view. The deeper pleistocene stratum is divided into 5 model layers on the basis of characteristic water supplies. The whole model consists of the following 6 layers:

1. model layer	shallow aquifer	0 - 15 m from the surface
2. model layer	1. aquifer	15 - 80 m from the surface
3. model layer	2. aquifer	80 - 140 m from the surface
4. model layer	3. aquifer	140 - 220 m from the surface
5. model layer	4. aquifer	220 - 340 m from the surface
6. model layer	5. aquifer	340 - 500 m from the surface

The upper horizontal discretisation is used in the Hungarian part of the model area. In the Romanian part the layers continuously become thin from the country border to the border of the Transsylvanian Mountains, where the total thickness of the alluvial layers is about 50 meters.

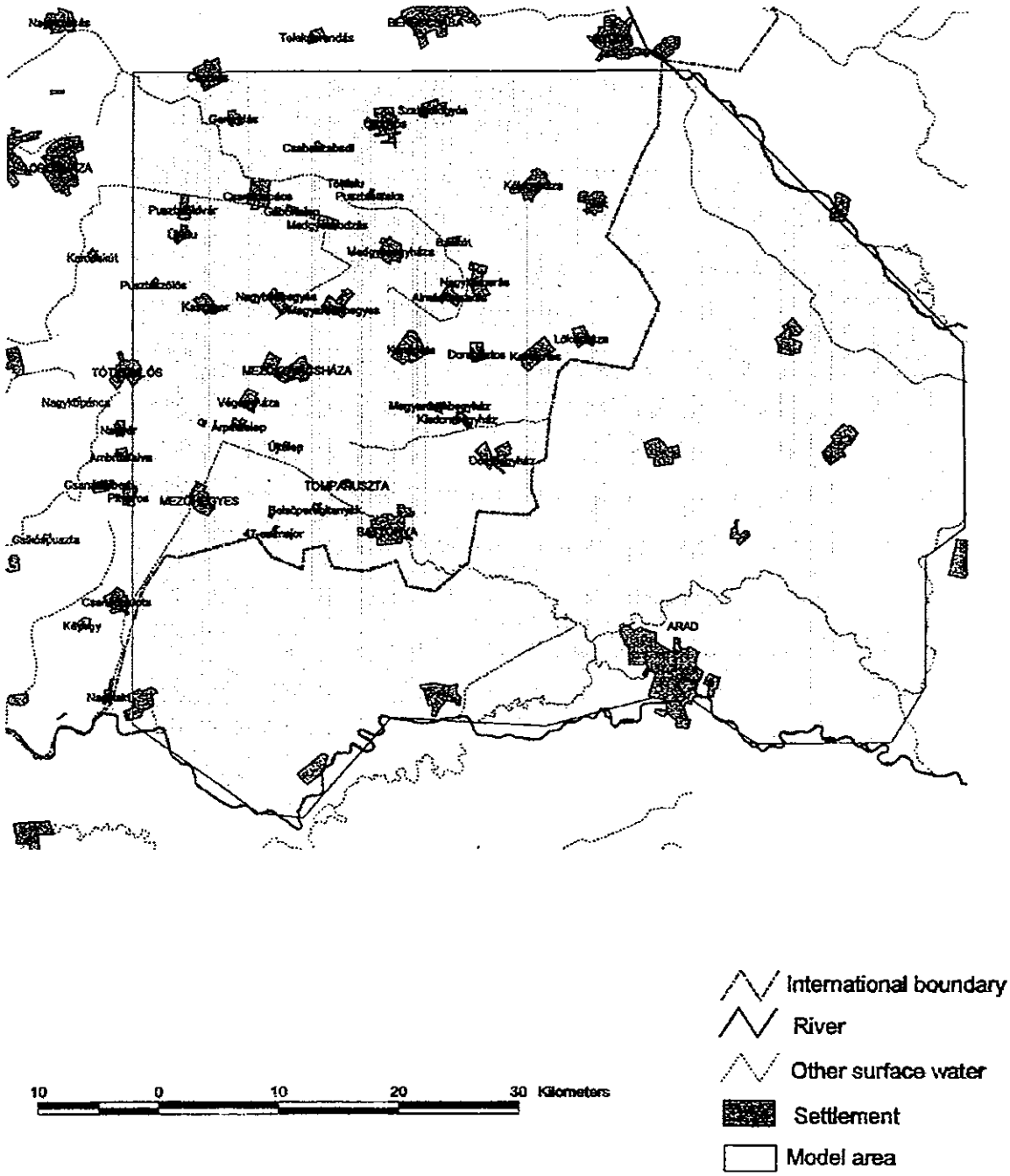


Figure 24
Model area

9.1.3. Mesh

The calculations were carried out by Processing Modflow for Windows (PMWIN) software. PMWIN is a simulation system for modelling groundwater flow and transport process with the three-dimensional finite-difference groundwater model MODFLOW, particle tracking model MODPATH and the solute transport model MT3D.

For the numerical calculations the studied area has been covered with 1000 m x 1000 m mesh.

9.1.4. Hydraulic parameters

The hydraulic parameters of a multi-aquifer groundwater model are horizontal (k_h) and vertical hydraulic conductivity (k_v) and storativity (S).

The estimation of the conductivity values for the Hungarian part is based on borehole logging dates. For the Romanian part of the model area the parameters were defined with information which can be found in the study "Overview of the hydrogeology of Arad county Mures alluvial cone – Romania" (Popovici and Simionas, 1996).

The characteristic parameter values are given in ***Table 6***.

Table 6. Hydraulic parameters of the regional model

	k_h (m/day)	k_v (m/day)	S
1.layer	5 - 20	0.001 - 0.05	0.1
2. layer	2 - 10	0.003 - 0.03	0.005
3. layer	1 - 5	0.002 - 0.03	0.005
4. layer	2 - 10	0.001	0.003
5. layer	1 - 5	0.001	0.0027
6. layer	1 - 5	0.001	0.0025

9.1.5. Boundary condition

For all layers the Direchlet type (prescribed piezometric head) boundary condition is defined. In the first model layer the fixed boundary head originates from the measured shallow groundwater levels, in the other layers from the measured deeper groundwater levels. Fixed head at the boundaries are determined according to contourline maps, which were drawn based on observed data (for the 1. layer data from shallow wells, while for the other data from deep wells were used.)

9.1.6. Recharge/discharge parameters

The long term average recharge which reaches the shallow groundwater and the evapotranspiration from the shallow groundwater can be calculated by using recharge/discharge characteristic curve. For this curve MODFLOW uses a linear approach with the following parameters:

$ET_{max, gw}$	- the maximum value of the evapotranspiration originated from groundwater ($Q_{shw}(h=0) = ET_{max}$)
H_{max}	- elevation of ET_{max} surface
$H_{0, depth}$	- extinction depth, the depth where evaportranspiration is zero
R_0	- recharge at deep average groundwater level, where $ET_{act,gw}=0$ ($Q_{shw}(h=\infty) = R_0$)
h	- long term average depth of shallow groundwater (calculated by the model)
Q_{shw} (h)	- water balance on the top of the shallow groundwater

The parameters of the recharge/discharge curve are calculated from long term average meteorological data, taking into consideration the covering layers and information about the landuse. In the conceptual model homogenous areas were defined using the soil types map of the Maros alluvial fan (made by the Hungarian Geological Institute) and landuse information from CORINE Land Cover Database (made by Institute of Geodesy, Cartography and Remote Sensing). From the covering layer point of view four types of areas are defined (***Figure 25***):

Sand in the upper 10 meters
Sand in the upper 5 meters
Thick loam covering layer
Clayey covering layer

From the point of view of landcover only the forests and the other areas are distinguished (***Figure 26***). In Fig. 26 only the forests are mentioned, the remaining part can be considered as arable land because other type of landuse cover insignificant areas.

In the meteorological data there are two typical periods in the modeled interval. The period 1950-80 had medium precipitation, while the period 1981-90 had low precipitation. That is why two series of recharge/discharge curves were determined for each homogenous area.

The parameter values of recharge/discharge curve are shown in ***Table 7.*** (The h_{max} value is the distance between ground surface and H_{max} surface.)

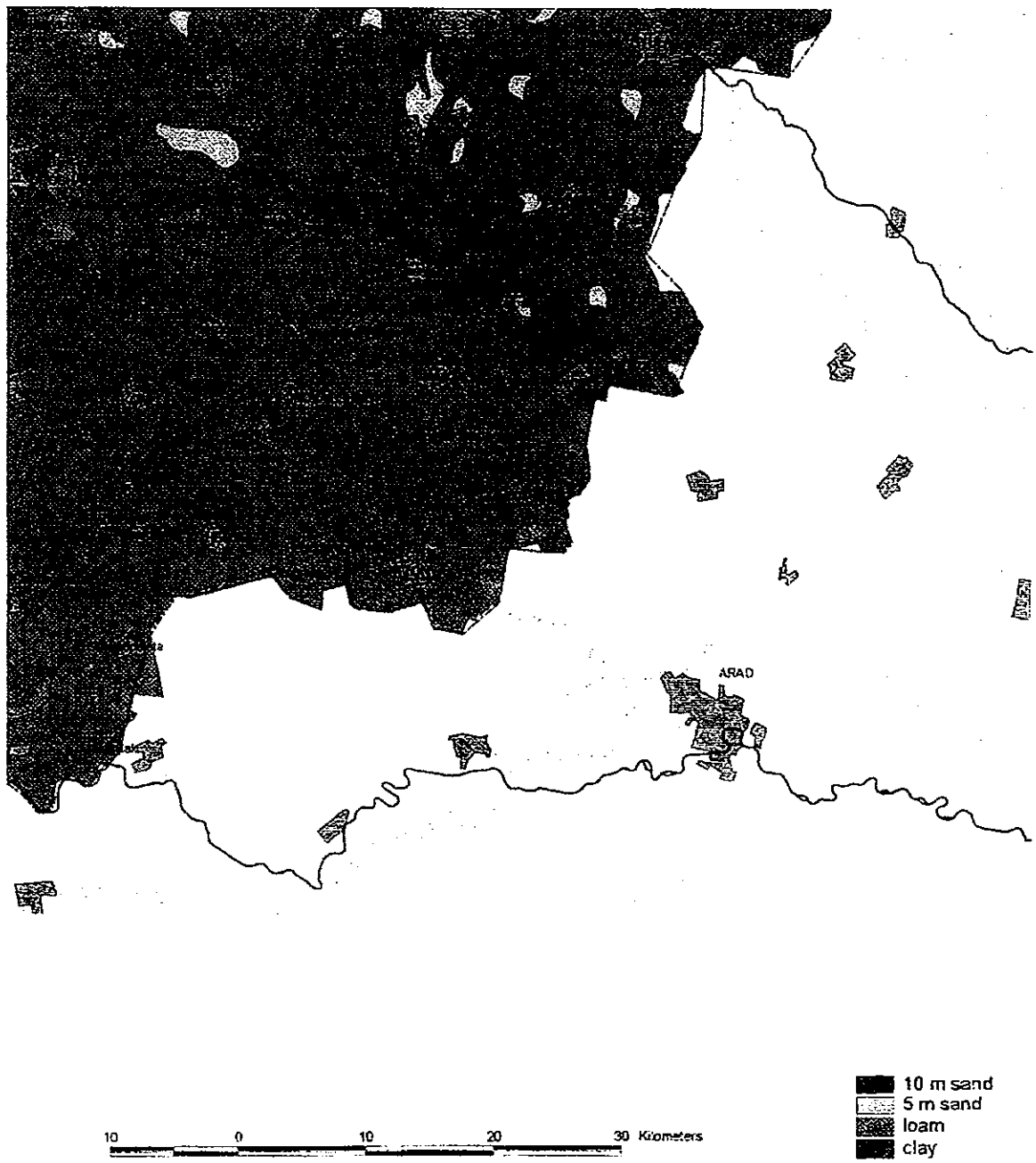


Figure 25
Soil types of the model area

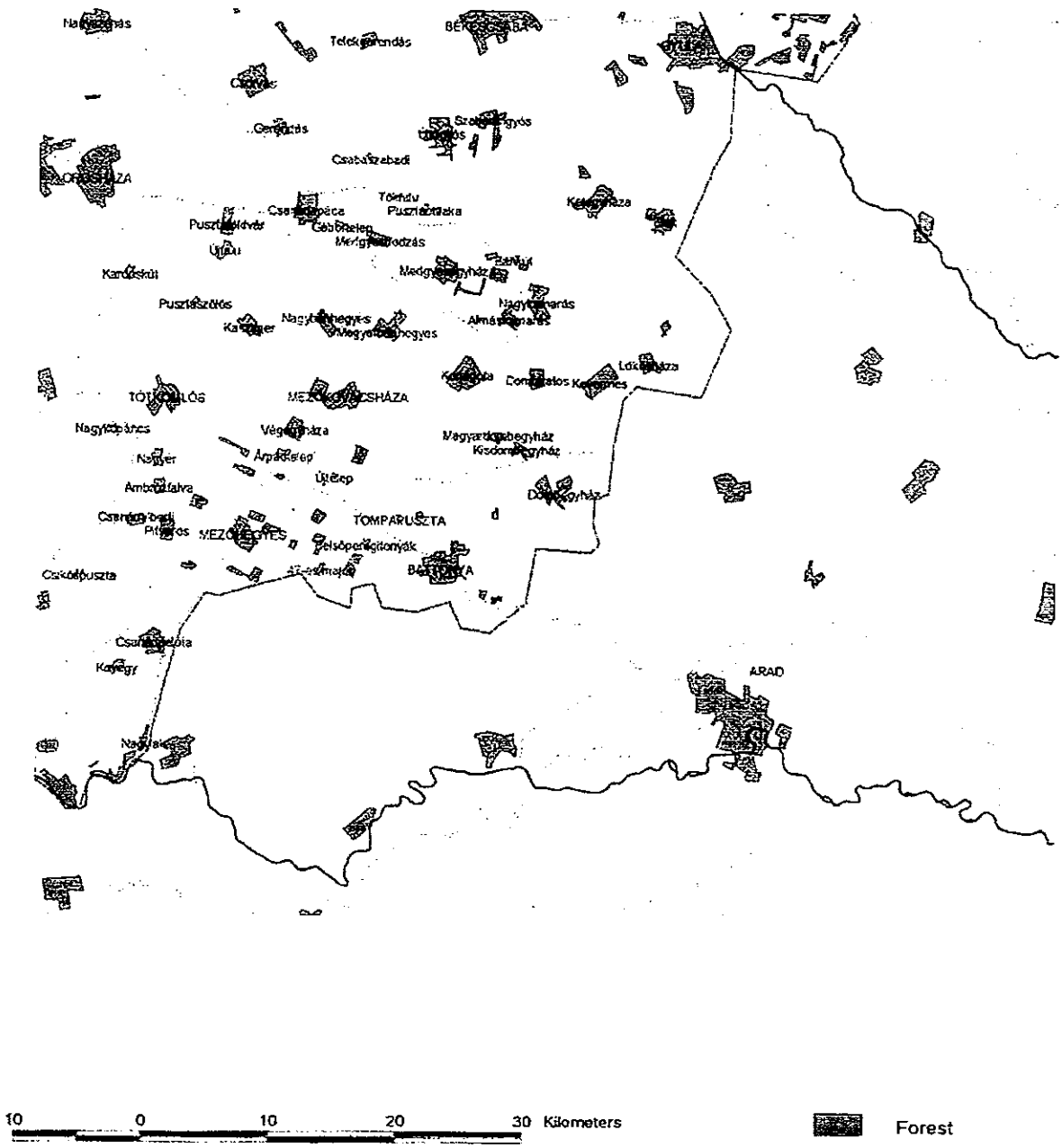


Figure 26
Land use in the model area

Table 7. The parameters of recharge/discharge curve

		ET_{max} mm/year)		R_0 (mm/year)		H_{max} (m)		H_0 (m)	
		1950-80	1981-90	1950-80	1981-90	1950-80	1981-90	1950-80	1981-90
Sandy covering	forest	-180	-180	0	0	3	3	2.5	2.5
	other	-250	-225	70	45	1	1	1.9	1.9
Clayey, loam covering	forest	-180	-180	0	0	3.5	3.5	3.5	3.5
	other	-190	-180	10	0	1.5	1.5	2.5	2.5

9.1.9 Groundwater abstraction

In VITUKI Plc. there is a groundwater abstraction database for the whole country for the last 40-50 years. This database includes the coordinates, depth and abstraction values which belong to the given point. Into the Maros model the groundwater production data were put from this database.

The total groundwater abstraction for the Hungarian part of model area is given in ***Table 8***, classified for each model layers.

Table 8. Groundwater abstraction in the Hungarian part of the Maros alluvial fan (m^3/day)

Time	2.layer	3.layer	4.layer	5. layer	6. layer	*Total*
1951-60	1123	1065	221	423	2966	***5798***
1961-70	5266	5371	3450	972	5440	***20499***
1971-75	9305	9520	6818	3067	5828	***34538***
1976-80	8336	9467	6116	3272	5596	***32787***
1981	9636	9285	7145	3345	4807	***34218***
1982	10573	10036	8090	4132	4543	***37374***
1983	13372	10762	8775	4374	3794	***41077***
1984	12069	12072	8996	4698	3467	***41302***
1985	11774	12855	7870	4708	3427	***40634***
1986	16147	13136	8184	4810	2915	***45192***
1987	17006	13916	8905	5345	2921	***48093***
1988	20015	15802	11745	5431	3684	***56677***
1989	18529	16715	13326	7422	6004	***61996***
1990	15340	16898	12660	7094	5766	***57758***
1991	20235	12214	8111	2958	1168	***44686***
1992	23986	14838	9162	3082	1610	***52678***
1993	26052	13884	10197	4203	1792	***56128***
1994	21315	14179	12100	4854	1996	***54444***
1995	20555	13887	9064	3415	960	***47881***
1996	19595	16288	14299	3720	599	***54501***

The studied area is an important agricultural area of Hungary. There are a lot of illegal shallow groundwater abstraction, but no reliable information is available about it's amount.
In the Romanian part of the Maros aquifer the abstraction is 180 000 m^3/day.

9.2 Model calibration

Model calibration demands much work in the establishment of a model. Model parameters, e.g. conductivity, storativity, groundwater recharge, etc. are usually measured only at particular locations and the estimates have a wide range of uncertainty.

During the procedure of model calibration, information about water levels respectively piezometric heads is utilized, to achieve a better estimate of the model parameters. The different parameters are changed until a satisfying fit between measured and computed piezometric heads is found.

Beside the adaptation of model parameters the model calibration phase has another important aspect. While evaluating the effects of changes in the model parameters, the sensitivity of the system to different parameters can be investigated. Furthermore, inconsistencies in the data base can be detached. It is a very common experience, that during the calibration of a groundwater model weak points in the existing interpretation of the hydrogeological system as well as erroneous data become evident. Thus the model calibration is an excellent opportunity to check and improve the knowledge of the groundwater flow system.

9.2.1 Initial conditions

Any transient problem requires the specification of initial conditions. In groundwater models, water levels respectively piezometric heads have to be defined at the start of simulation period.

It was decided to perform the model calibration over the period from 1950 to 1996. Groundwater levels of the year 1950 are considered as aproximately undisturbed natural conditions, as groundwater abstraction was negligible until this time. So the average groundwater levels - shallow for the first layer, deep groundwater for the others - of the years 1956-60 are described as initial conditions for all model aquifers.

9.2.2 Scope of model calibration

During the model calibration the following parameters were modified:

- horizontal hydraulic conductivity
- vertical hydraulic conductivity
- recharge/discharge parameters

All calibration runs were carried out over the whole period 1950 to 1996 with a computational time step of 1 year.

9.3. Results of model calibration

In the preliminary model the main purpose of the calibration was to enable the model to calculate the characteristic regional changes in water levels.

For the shallow groundwater aquifer the results of calibration are given for 10 observation wells. These wells were selected uniformly in the Hungarian part of the Maros alluvial fan, in different areas from the point of view of recharge/discharge (***Figure 27***). The calculated and measured time series are shown in the ***Figure 28/a. – Figure 28/e***. These time series show that the calculated water levels correspond to the measured values generally within 0.5 m. From the beginning of the 1980s a continuous lowering is measured in the shallow groundwater levels. The measured depression is about 1.5-2.5 m, but there are some places e.g. settlements Újkígyós, Szabadkígyós where the depletion of shallow groundwater is negligible. The highest depressions are found surrounding big waterworks e.g. Medgyesbodzás, Kevermes.
Figure 29. shows the calculated shallow groundwater levels for the present time in the whole model area.

For the deep groundwater ***Figure 30/a. - Figure 30/d.*** show the measured and calculated levels in the observation wells of the above mentioned two settlements Medgyesbodzás and Kevermes. The calculated levels for the wells of Kevermes correspond within 0.5 - 1 m to the measured values which can be considered as a good calibration result. In Medgyesbodzás the maximum differences between measured and calculated values are 2-3 meters. This is also an acceptable result because these observation wells are located inside the waterwork, so the measured values include local pumping influences. The applied model can calculate only regional influences.

9.3.1. Upgrading the hydrogeological model

The available Hungarian hydrogeological model of the Mures/Maros aquifer was modified with the supplementary information provided by the PROED report.

For the Romanian region of the model the following modifications were done:

- seepage parameters;
- heads in the aquifer (initial conditions based on data for the period 1971-1980);
- water abstraction in Romanian waterworks.

The calibration of the upgraded model was done for the heads representing the typical groundwater abstraction. The results of modeling are shown in the **Annex 2.** (Figures indicating the mean levels of shallow groundwater, the calculated heads in the 1st and 2nd layer of water abstraction, the calculated difference in heads between the first and second layer, the calculated flux from the shallow groundwater into the deeper aquifer and the travel times through the shallow aquifer. The map with the travel times shows that in the major part of the recharge area of the Maros aquifer the travel time is more than 100 years.

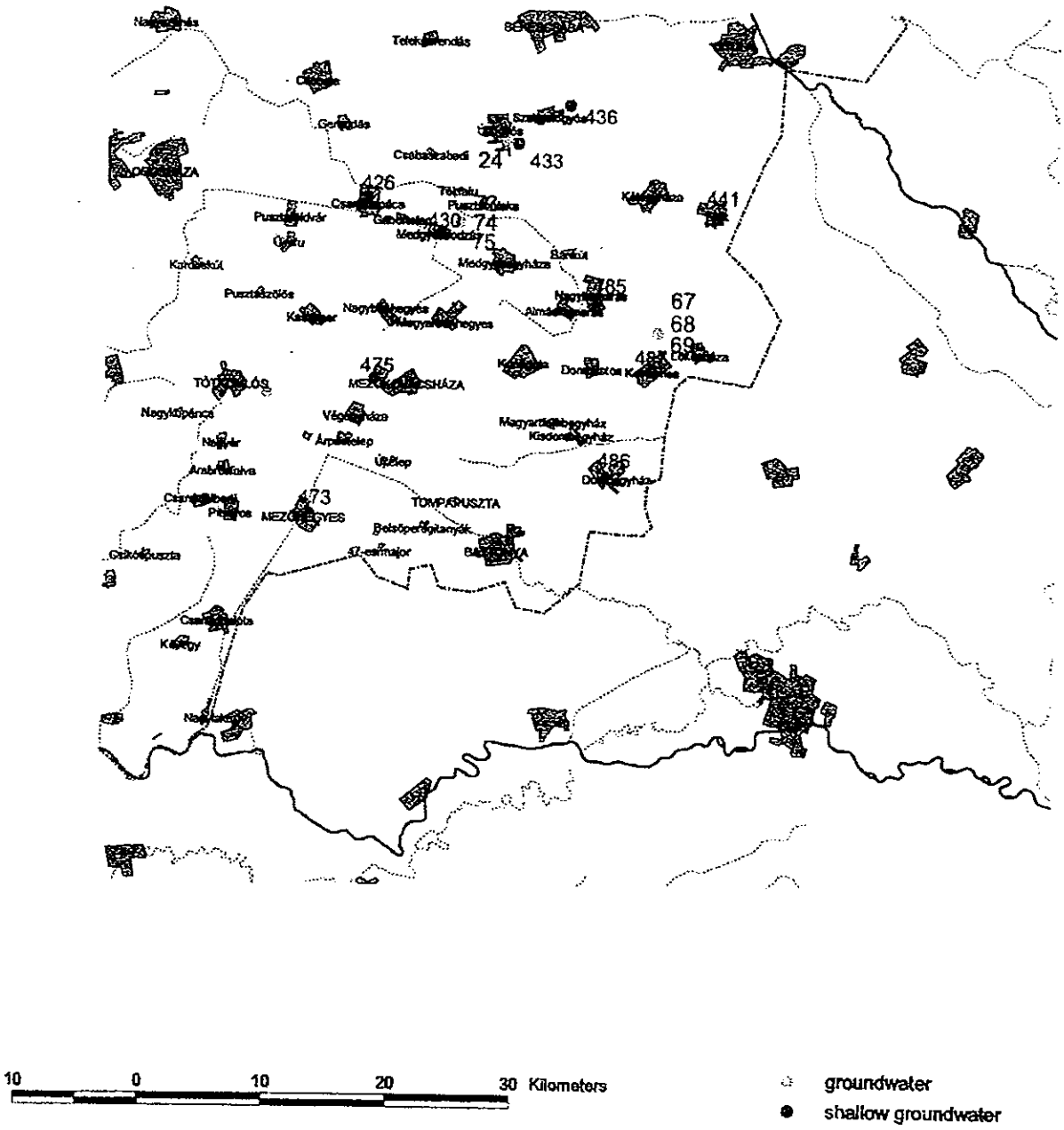
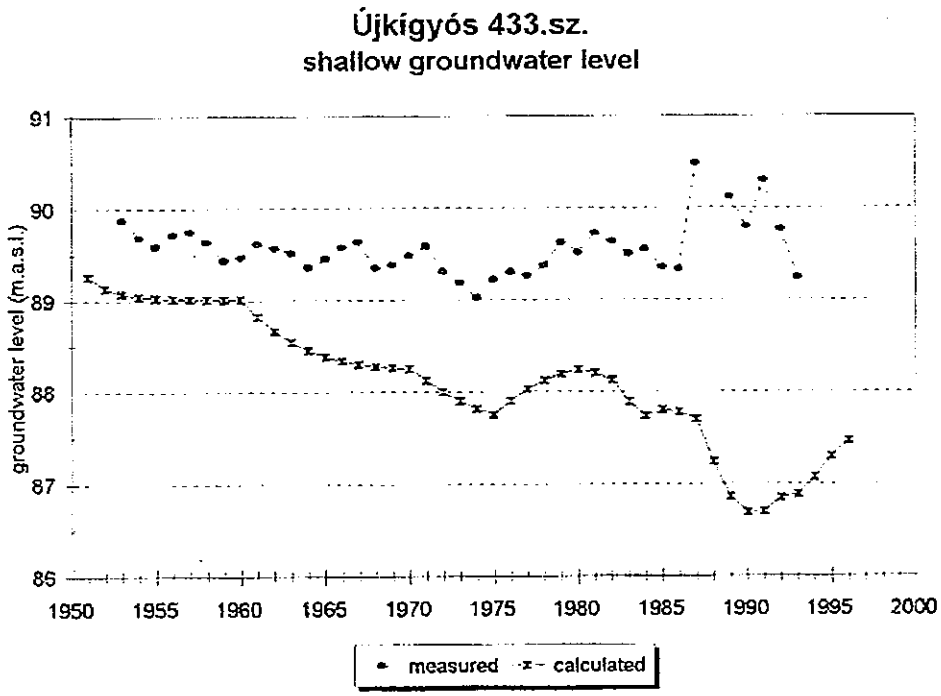


Figure 27
Observation wells used for calibration



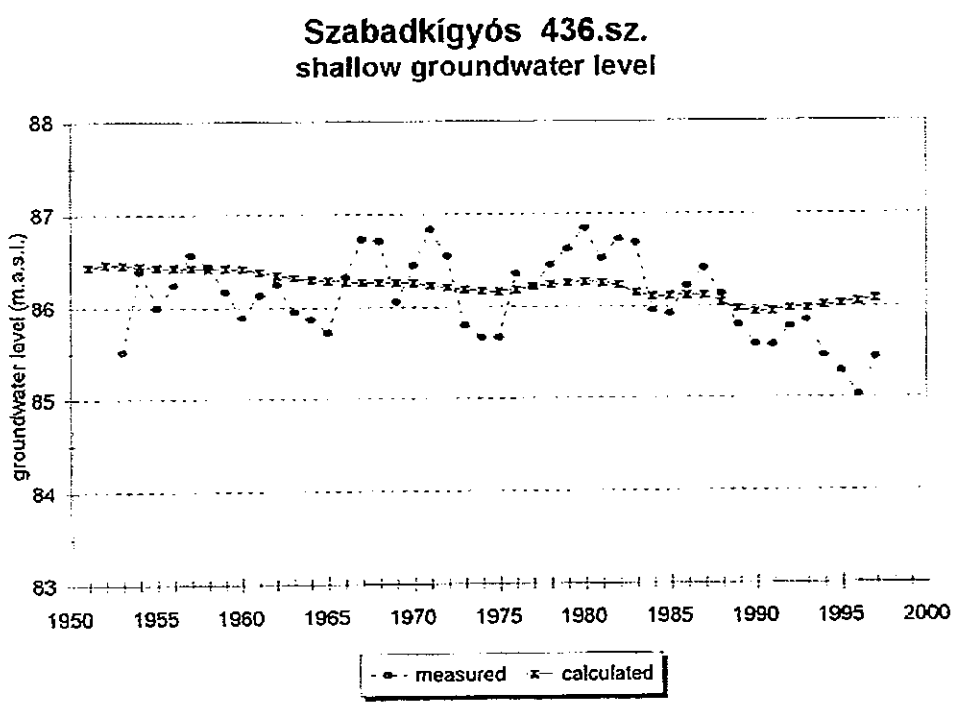
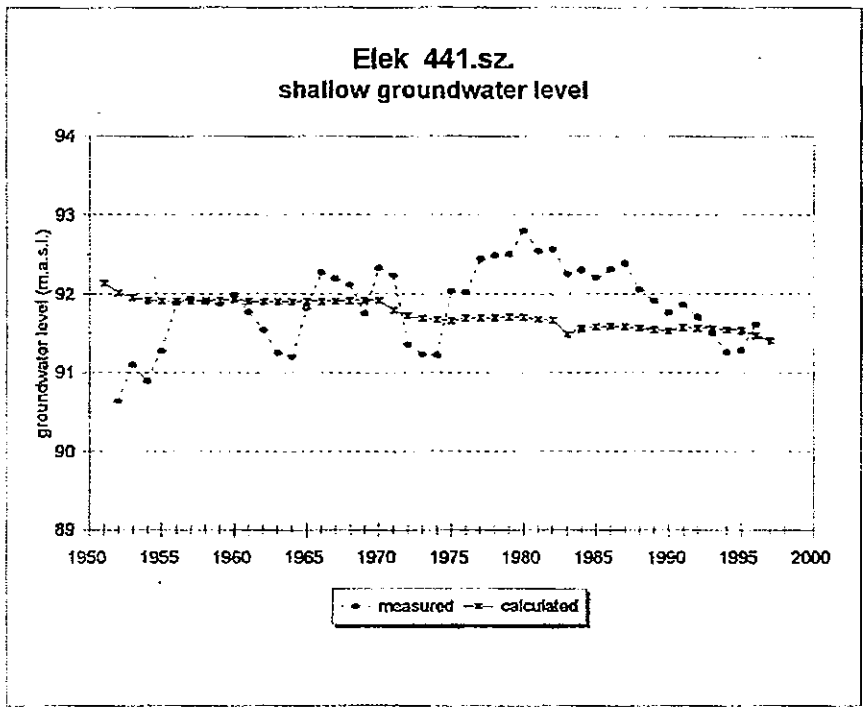


Figure 28/a.
Time series of shallow groundwater level



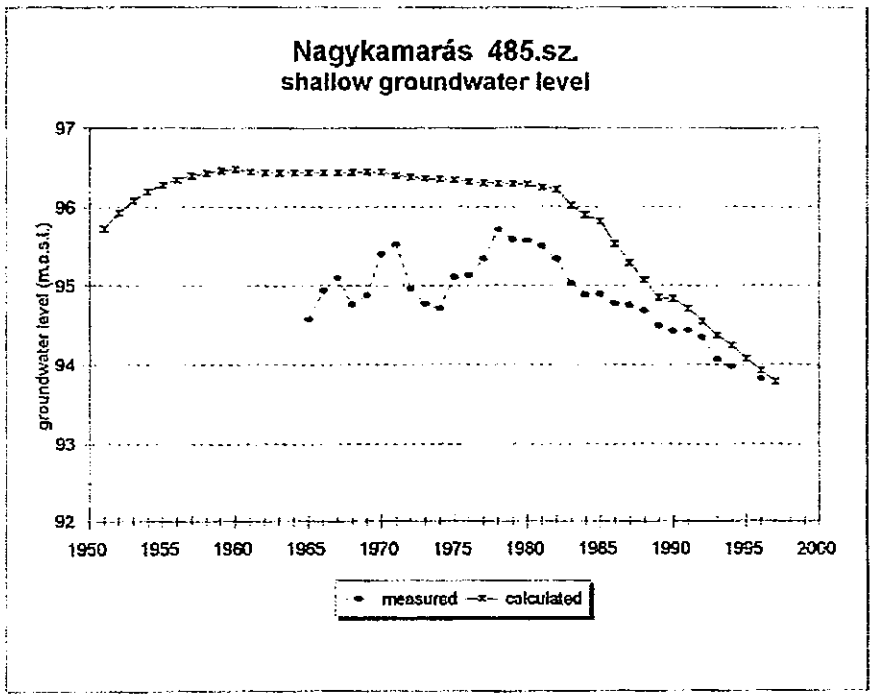
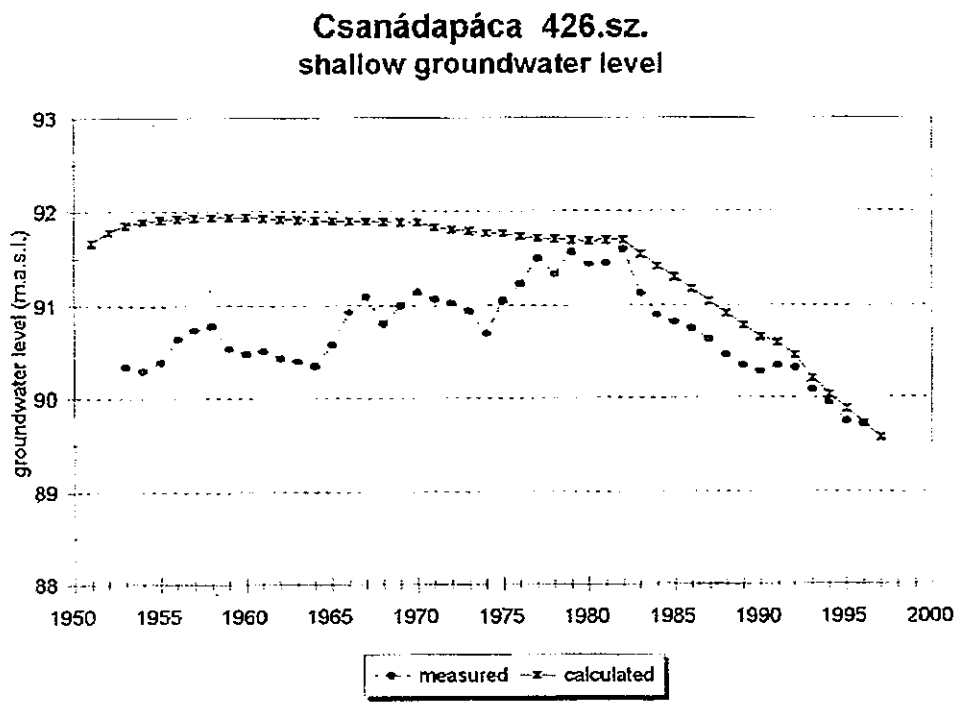


Figure 28/b.
Time series of shallow groundwater level



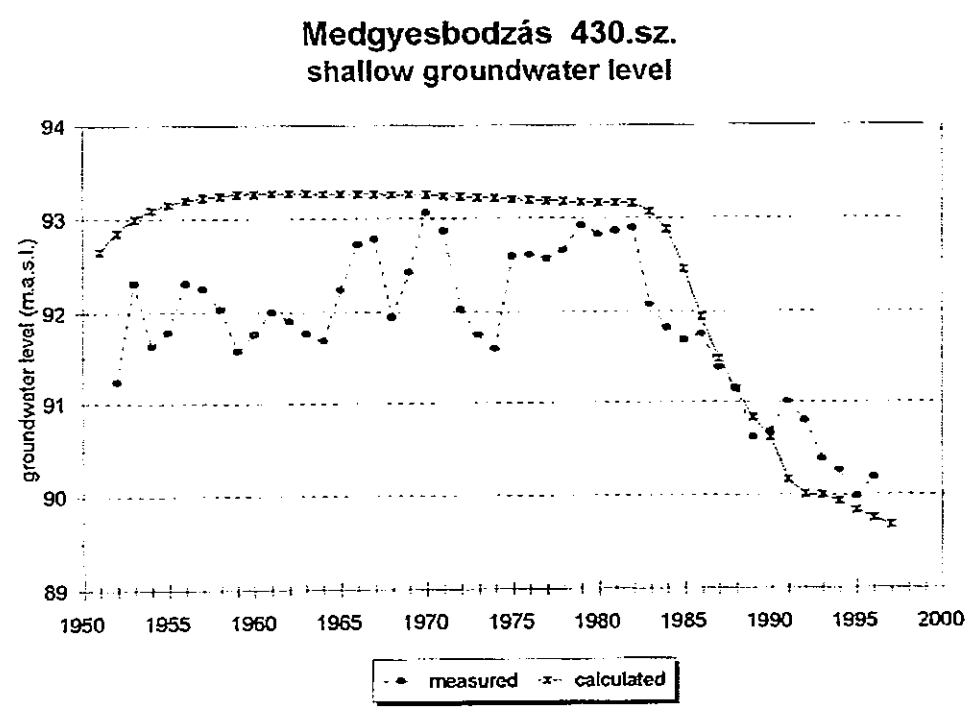
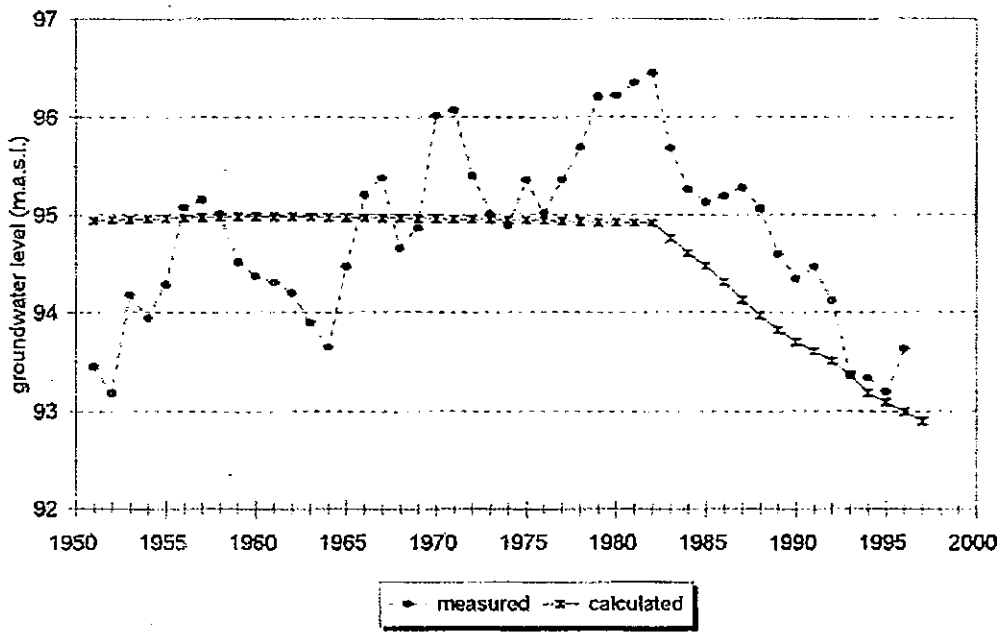


Figure 28/c.
Time series of shallow groundwater level

Mezõhegyes 473.sz.
shallow groundwater level



Mezõkovácsháza 475.sz.
shallow groundwater level

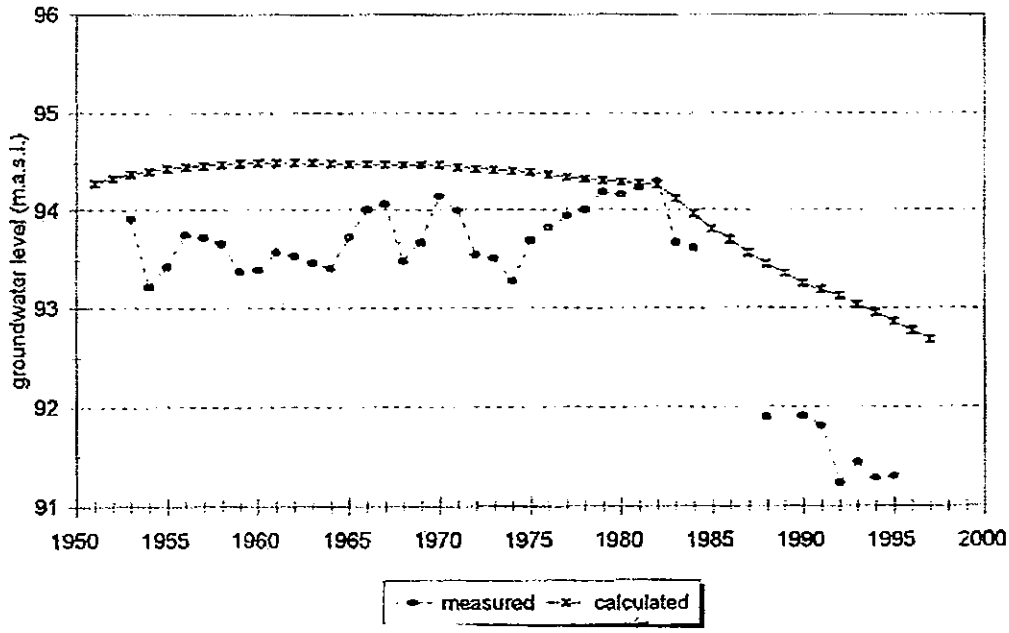
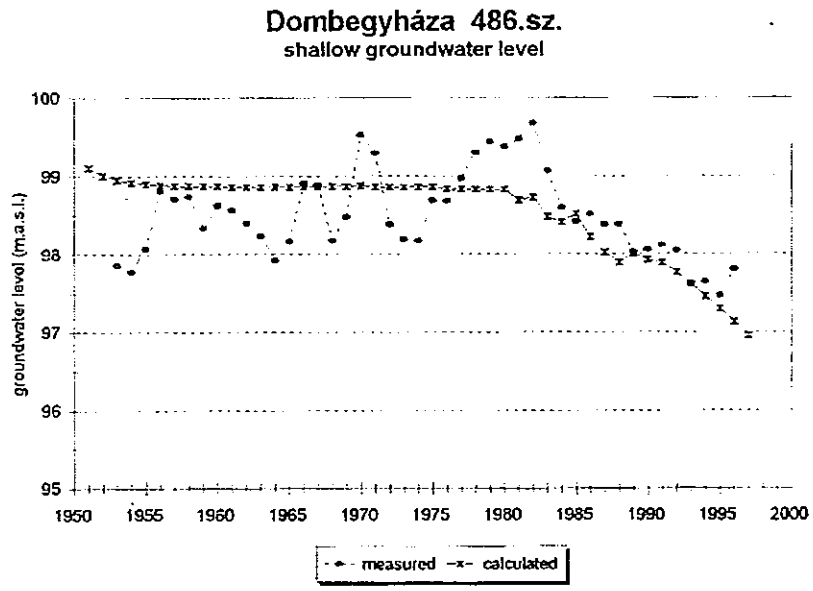


Figure 28/d.
Time series of shallow groundwater level



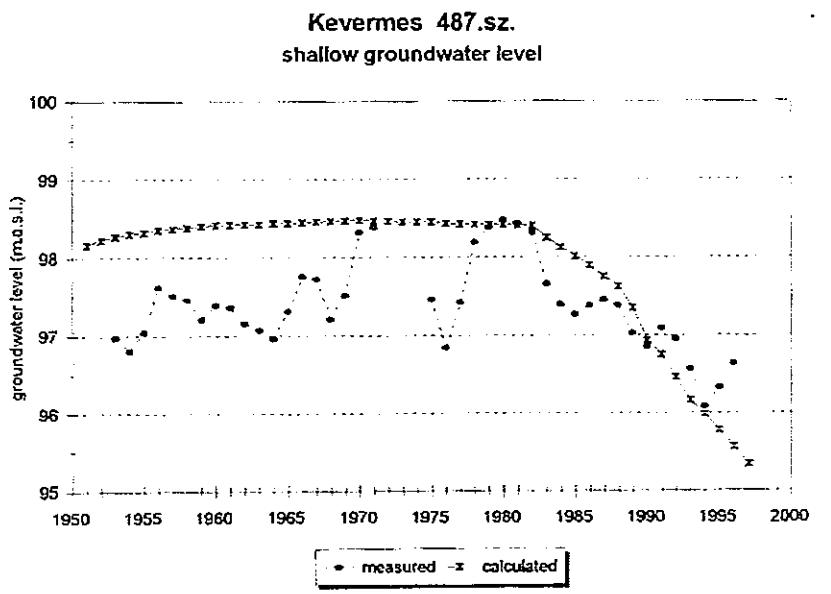


Figure 28/e.
Time series of shallow groundwater level

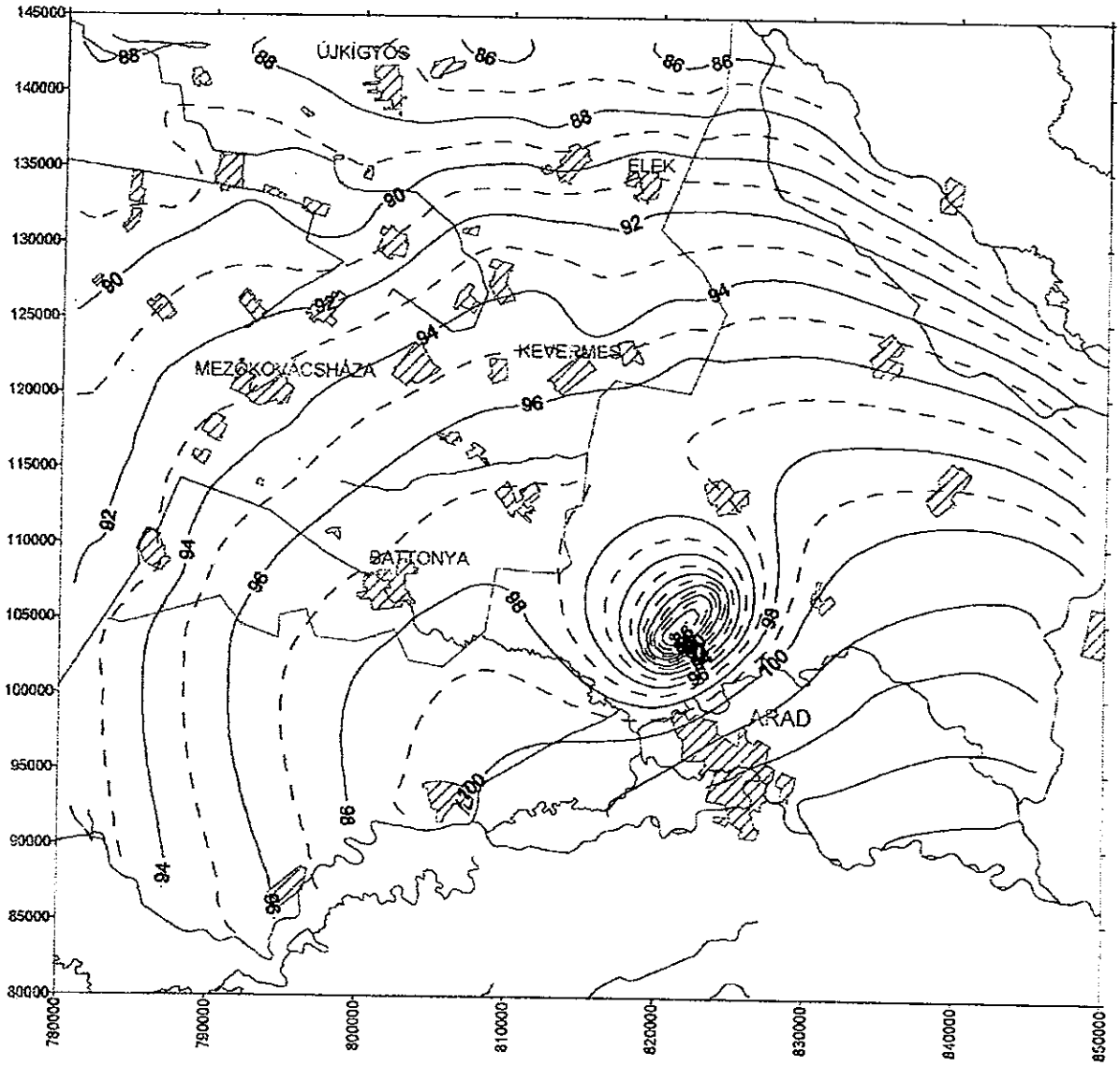
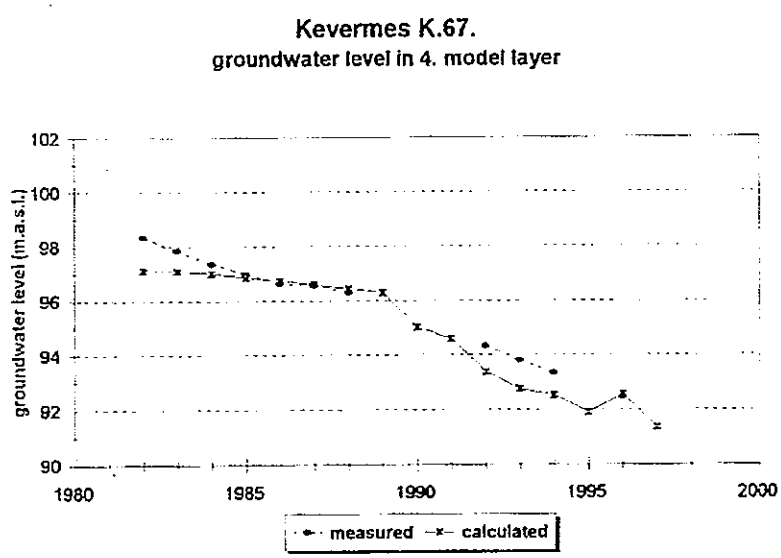


Figure 29
Calculated shallow groundwater level (m a.s.l.)



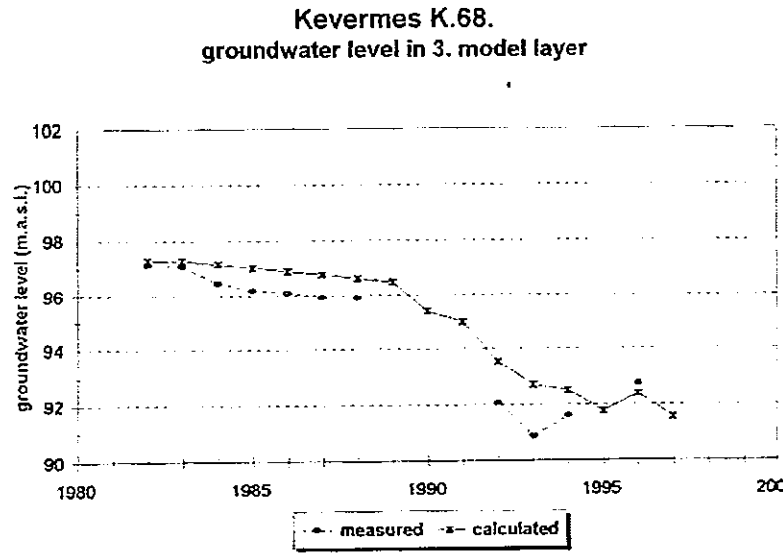
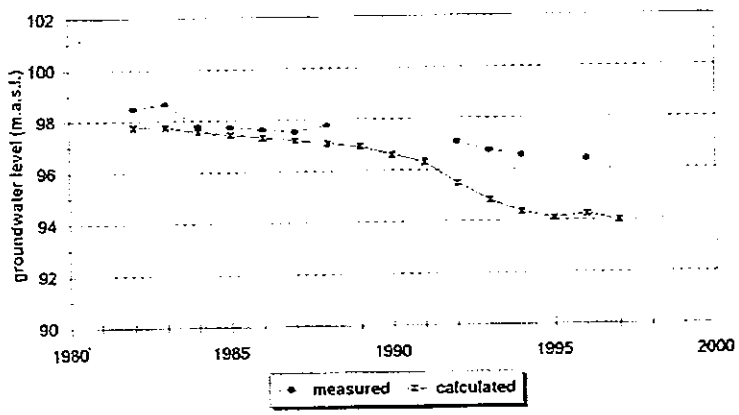


Figure 30/a.
Time series of deep groundwater level

Kevermes K.69.
groundwater level in 2. model layer



Újkígyós B.24.
groundwater level in 3. model layer

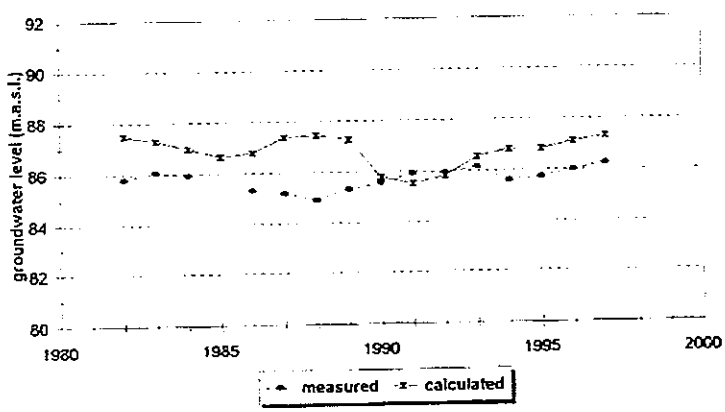
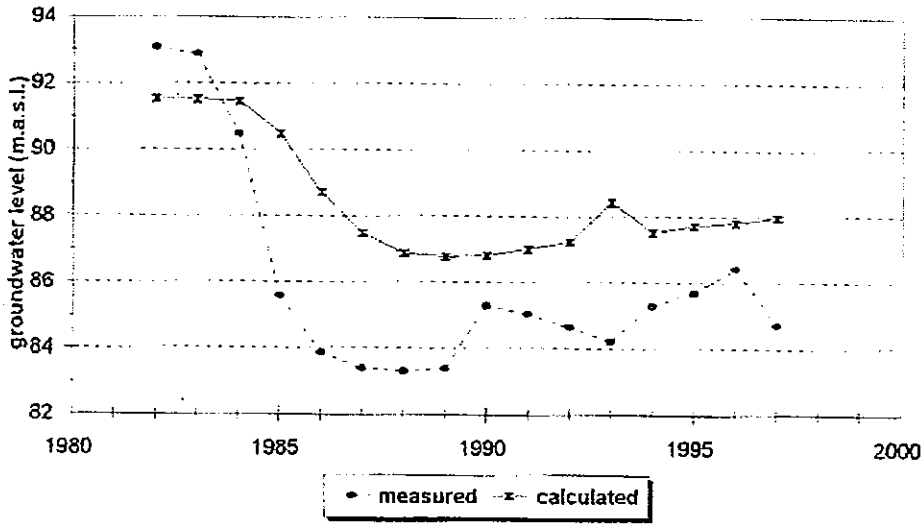


Figure 30/b.
Time series of deep groundwater level

Medgyesegyháza K.73.
groundwater level in 5. model layer



Medgyesegyháza K.74.
groundwater level in 3. model layer

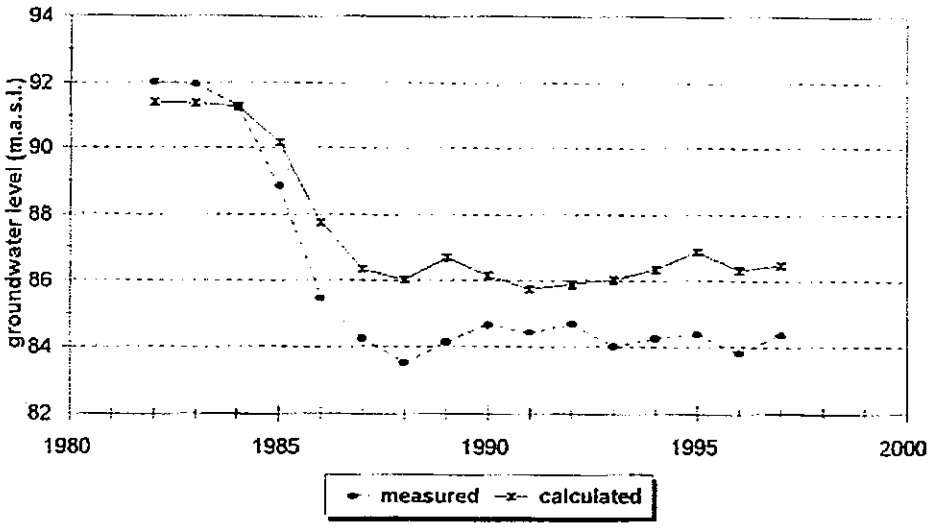


Figure 30/c.
Time series of deep groundwater level

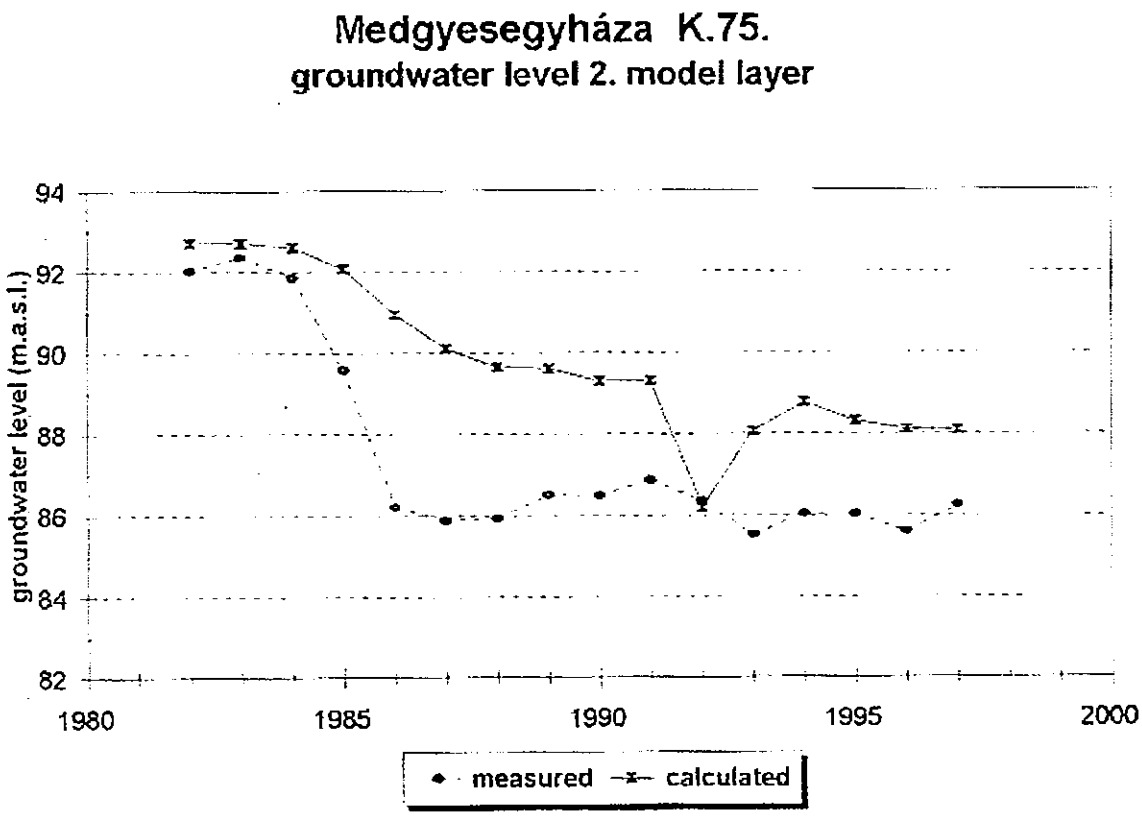


Figure 30/d.
Time series of deep groundwater level

9.4. Simplified transport simulation

The simulation was based on three different groundwater abstraction scenarios (first scenario: abstraction does not change within 10 years; second scenario: abstraction increases by 20 %; third scenario: abstraction decreases by 20 %.

It was assumed that potential pollution starts from the area of settlements by infiltration from the ground surface. It was assumed that the pollutant is non-degradable and non-adsorbable.

The results of the simulation starting year 1996 are shown in the Figures of **Annex 3.** The changes in abstraction do not modify significantly the pollution pattern of the aquifer, because the horizontal flow is dominant in the aquifer compared to the vertical flow in the case of increased abstraction as well.

10. Formal protection programme for the Maros Aquifer

The policy adopted for protecting the water resources in the alluvial fan of the River Maros is based on the principle of allowing in the surface and subsurface safety zones all activities which do not affect the quality and quantity of the sources of supply developed already, or designated for future development and do not interfere with the process of abstraction.

For the purpose of protection the surface and subsurface safety zones must be subdivided into, demarcated, designated and maintained as the core, the external and the hydrogeological zones.

The purpose of the core zone is to protect the abstraction works (wells) and the water against direct pollution and damage. The boundary of the core is at the distance, from which a water particle arrives at the well in 20 days time at the highest daily rate of pumping. The core safety zone is the intersection of the subsurface core zone with the terrain surface, the shortest radius being 10 m about the abstraction.

The purpose of the external safety zone is to afford protection against non-degradable (refractory) pollutants, bacterial and other contamination. The boundary of the external safety zone is at the distance, from which a water particle arrives at the well in six months at the highest monthly rate of pumping. The external safety zone is the intersection of the subsurface safety zone with the terrain surface, the shortest radius being 100 m about the abstraction.

The purpose of the surface and subsurface hydrogeological safety zone is to afford protection against refractory pollutants. The hydrogeological safety zone is subdivided into the zones "A" and "B", the boundaries of which are at the distances, from which a water particle arrives at the well in 5 and 50 years, respectively, at the annual average rate of pumping.

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Allowing in the surface and subsurface safety zones all activities which do not affect the quality and quantity of the sources of supply developed already, or designated for future development and do not interfere with the process of abstraction has already been mentioned as the principle underlying the general safety policy.

The core zone is reserved for the abstraction works and the equipment needed to operate the distribution network connected thereto. These facilities and equipment must be operated in a way to prevent any pollutant from reaching the water, the terrain surface or the soil, and from entering into equipment collecting, lifting and transporting water.

In the area of the core zone:

- The wastewater and effluents produced must be removed from the core zone in double-walled, pressure-tested sewers in a way to comply with the provisions prescribed for the external zone;
- The terrain must be graded to prevent any surface runoff from collecting. A possibly continuous grass cover should be planted, to which no fertiliser, manure or pesticide must be applied. The remaining area must be paved with durable, non-polluting material. In the vicinity of shallow aquifers, conduits and structures no trees, or shrubs must be planted which grow roots deep enough to reach these.

In the external safety zone:

- No activity must be carried out and no facility must be sited, the presence or operation of which is liable to impair the natural level of protection of the source, or to introduce into the water pollutants (taking more than 20 days to degrade) or live organisms;
- The terrain must be graded if necessary to prevent accumulation of surface runoff and ponds after inundation;
- Existing highways must be paved and road ditches must be lined with impervious material. Road ditches must be designed to remove the water collected from the external safety zone. No new public road must be built, nor must any road maintenance material be stored along the section across the external safety zone;
- A by-pass road must be designated around the external safety zone for vehicles transporting hazardous chemicals;
- The wastewater from facilities, like residential, sports-, leisure time buildings, industrial plants must be removed by closed, pressure-tested sewers;
- Crop farming must be examined for its impacts on the protected resource. Investigations must include the soil, the layers above the aquifer and the water. From the data obtained it must be ascertained whether, or not
  - crop farming had any detectable adverse impact on the water;
  - the soil and the layers above the aquifer show any signs implying that the water will suffer harm within a given period of time, or that the farming technology applied will not affect the water in the foreseeable future.

Insofar as the findings lead to the conclusions that

- crop farming has, or will potentially damage the water in the near future and remedial measures are warranted in the interest of continued abstraction, a technology approved by the competent authorities as appropriate must be introduced to eliminate the actual, or potential adverse impact on water;
- the applied agrarian technology has no adverse impact on water, any change thereof shall be subject to approval by the competent authorities declaring that neither the new technology will affect the water resources.

- The method of crop farming on the fields must not cause any harm to the water;
- No animal farming is allowed. (Limited poultry farming is possible with adequate precautions against soil and groundwater pollution.) In some cases (e.g. where the groundwater table is at depths greater than 2 m) monitored grazing is also allowable;
- No liquid fuels or chemicals must be stored. The metal and plastic containers holding the fuel and chemicals needed for operating the water works must be stored in watertight concrete basins large enough to retain to entire volume of fuel spilling from a failed container;
- No exploration hole, or any new water well must be sunk, unless it serves the purpose of augmenting the supply (without affecting the existing abstraction e.g. by developing another aquifer), replacement of a deteriorated well, or monitoring the quantity and quality of the water resources.

In the area of the hydrogeological safety zone:

- No facility must be sited, the presence or operation of which would affect the quality of groundwater;
- Any activity must be banned, by which
  - the natural protection of the water is impaired, or the vulnerability of the environment is increased;
  - harmful substances persisting for six months are introduced into the water,
  - a degradable substance finds access to the water, the quality, type of decay product of which is detrimental to groundwater quality.
- Operations with chemicals detrimental to water, or from which compounds affecting water quality may be leached must be confined to closed buildings;
- The provisions on external safety zones should be applied as appropriate to crop farming;
- Subsistence animal farming is acceptable, but larger animal and waterfowl farms can be operated in the "B" zone alone. The wastes (manure) must be handled and stored in a way suited to avoid soil and groundwater pollution (thus liquid manure must be collected and stored in impervious tanks or basins until disposal in a controlled manner outside the hydrogeological safety zone, or exceptionally in the "B" zone thereof);
- Any substance detrimental to water quality must be stored at existing storage sites in a manner
  - making the storage vessel any time accessible to inspection for its state of repair even from the outside, or

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- obliging the operator to monitor the groundwater by a system designed and operated as approved by the competent authorities for the presence of any detrimental substance;

- A new facility intended for the storage of a liquid substance detrimental to water must be designed – with approval by the competent authority –
  - to make the storage vessel any time accessible to inspection for its state of repair even from the outside,
  - to confine the storage vessel in an impervious tank or basin large enough to retain the entire contents thereof in the event of failure;
- A pipeline conveying a substance detrimental to water (e.g. petroleum product) must not be allowed to cross the zone, unless it is made safe (e.g. by a casing pipe), inspected regularly and fitted with an automatic valve for the event of pipe failure.

The limitations imposed on the use of surface and subsurface safety zones are presented in the following tabulations:

Limitations applying to the zones of surface and subsurface safety areas

Land use type	Groundwater safety zones			
	core	external	hidrogeological	
			„A"	„B"
Communal, recreation				
Housing estate, new subdivision, recreational development	-	-	-	o
Residential or office building with sewerage	-	x	+	+
Residential buildings without sewerage	-	-	x	o
Crossing sewer	-	x	o	o
Wastewater treatment plant	-	-	o	+
Leaching field for sanitary sewage	-	-	o	o
Construction and operation of pond for communal liquid wastes	-	-	-	x
Communal solid wastes landfill (non-hazardous wastes)	-	-	-	o
Rubble landfill	-	-	o	+
Cemetery	-	-	x	+
Home gardens, home orchards	-	-	o	o
Camping, bathing	-	x	+	+
Sports ground	-	x	+	+
Industry				
Production, processing, storage, disposal of highly toxic, or radioactive substances	-	-	-	-
Production, processing, storage of toxic substances	-	-	-	o

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Land use type	Groundwater safety zones			
	core	external	hidrogeological	
			„A"	„B"
Plants using no toxic substance, with appropriate sewerage	-	x	o	+
Production, transport, refining, storage of petroleum and its products	-	-	x	o
Neutralisation of hazardous wastes	-	-	-	x
Hazardous wastes landfill	-	-	-	-
On-site collection of hazardous waste	-	-	x	o
Infiltration disposal of food industry effluents, storage of such wastes	-	-	-	o
Infiltration disposal of other industrial effluents	-	-	-	-
Ash disposal	-	-	o	o
Agriculture				
Forest planting and management without chemical treatment	-	+	+	+
Crop farming*	-	o	o	o
Composting plant	-	-	x	o
Animal farming beyond subsistence level	-	-	x	o
Grazing, subsistence animal farming	-	o	o	+
Organic manure application*	-	o	o	+
Fertiliser application*	-	o	o	o
Farmland disposal of liquid manure and manure leachate	-	-	-	o
Liquid manure and leachate draining	-	-	-	-
Sewage irrigation*	-	-	-	o
Treatment plant effluent irrigation*	-	-	o	+
Pesticide application*	-	o	o	o
Pesticide application with aircraft*	-	-	-	o
Pesticide storage and residue disposal	-	-	-	x
Washing pesticide equipment, effluent disposal	-	-	-	o
Storage of organic manure and fertiliser	-	-	x	o
Sewage sludge storage	-	-	x	o
Farmland disposal of sewage sludge*	-	-	x	o
Burying carcasses, construction and operation of carcass pits	-	-	-	o
Fish farming, fish feeding	-	-	o	o

Land use type	Groundwater safety zones			
	core	external	hidrogeological	
			„A"	„B"
Transport				
Motorways, highways, runoff drainage via ditches with impervious lining	-	x	o	+
Other roads, runoff drainage via ditches with impervious lining	-	-	+	+
Other roads	-	-	x	+
Railway	-	-	o	+
Vehicle parking lot	-	-	o	+
Filling station	-	-	x	o
Vehicle washing, repair shop, salt pile	-	-	o	+
Other activities				
Mining	-	-	x	o
Drilling, sinking new well	-	o	o	o
Other activities affecting the cover or the aquifer	-	-	o	o

Legend:
- = forbidden
x = forbidden in new facilities, activities, existing ones may be continued depending on the outcome of an environmental investigation or impact assessment
• = permit may be granted for new, or existing facilities depending on the outcome of an environmental impact assessment, environmental investigation or an equivalent special investigation
+ = no limitation

• In a special investigation the provisions of the ECE Directive 91/676 on protecting water against nitrate pollution from agricultural sources should be taken into consideration.

11. Conclusions

- The Maros aquifer can provide good quality groundwater appropriate for drinking water supply. The additional water quality analyses revealed moderate pollution effect of the agricultural pesticides application in the region. The other types of analysed organic micropollutants (volatile and semi-volatile aromatics, volatile chlorinated hydrocarbons) were found in insignificant concentrations. The nitrate concentrations are below 20 mg/l in the production wells. Higher nitrate concentration can be found in the shallow phreatic groundwater which is the recharge source of the deeper groundwater only in some regions of the study area.

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- The very long vertical travel times of the infiltrating water and pollutants in the dominant part of the study area refer to low vulnerability of the Maros aquifer. This was concluded from the numerical model calculations which indicated that no more than 40 km^2 is the area where the vertical travel time is less than 50 years.
- The Maros aquifer protection program should focus on the hydrogeological safety zones designated according to travel time (max 50 years). The proposed limitations would imply restrictions only in a minor part of the Maros aquifer region.

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ANNEX 1

Meeting Notes

Annex 1/A.

Meeting notes of discussions at VITUKI/Water Resources Research Centre Plc.), Körös Valley Water Authority and Körös Valley Environmental Inspectorate, Ministry for Environment and Regional Policy, USAID Budapest Office during Mr. R. Lubke's visit to Hungary, 10 March 1998 – 13 March 1998.

A. 10 March 1998

(1) Meeting, 10 March 1998, p.m., at Vituki - (Water Resources Research Centre Place Institute for Water Pollution Control).

(a) Principal contact Dr. Ferenc Laszlo

(b) Mrs. Katalin Davidesz - Hydrogeologist

(c) Dr. Peter Literathy - Director

(d) Dr. Pal Benedek

General

(a) Discussed Water for People involvement - provided WFP - summary/proposal

(b) Provided revised Work Scope - prepared in Wakefield

(c) Briefly discussed Vituki subcontract. To discuss contract in greater detail Thursday.

(d) Dr. Laszlo provided my itinerary while in Hungary. Dr. Laszlo mentioned that Ms. Eszter Havas - Szilagyi would be unavailable this week (out of country) but expect someone from her department to be present at the Friday meeting.

(e) Informed USAID office of tomorrow's visit to Bekes County which James Djierwa plans to join.

Specifics

(a) Principle pollution problem is high nitrate in shallow phreatic aquifer. Sources according to Dr. Laszlo are primarily poor/inadequate sewerage systems in largely rural communities and wastes associated with animal husbandry. Fertilizers considered of lesser concern. Use of nitrogenous

fertilizers discontinued around 1990. Fertilizers currently used are phosphate based, phosphate being less mobile than nitrogenous fertilizers. Other sources/point sources are landfills, petrol stations, accidental spills.

(b) Additional studies/data needs

i. Field measurements emphasizing nitrates.

ii. Vertical transport/migration to deeper aquifers.

iii. Age dating of groundwaters - tritium tracing, C14, O isotopes - which provided a better handle to establish recharge quantity/sources - especially in Romania where most recharge is estimated to originate.

(c) Excessive groundwater extraction another possible problem. Hydrograph records suggest declining water levels in recent times, however, rainfall has also been below average.

(d) Geohydrologic setting

i. Maros aquifer - about 1/2 in Hungary other 1/2 in Romania. However Maros River watershed largely in Romania within mountainous terrain. Note river's watershed greatly exceeds area and extent of aquifer.

ii. Maros aquifer - alluvial fan deposits - 3 series - Holocene, Pleistocene, Pliocene.

iii. Extent of aquifer relatively well defined in Hungary but not in Romania.

iv. Aquifer appears to be largely defined as a geomorphological expression of an alluvial fan (cone) established by drainageways associated with the Maros river where it flows into the Panonian Basin in Hungary.

v. Deep aquifer containing high Arsenic associated with a separate depositional environment within the Basin with Arsenic more predominant to the north of the Maros aquifer.

vi. Maros aquifer boundaries do not appear to be well defined hydraulically in relation to adjoining water-bearing units within the Basin deposits.

(e) Management Objectives

i. Maintain quality (Maros aquifer) for public water use.

ii. Use surface water diversions for irrigation. Negotiating with Romania for surface water purchase at a diversionary point in Romania and utilizing existing network of canals which extend into Bekes County.

iii. Maintain water level heads with flow direction toward basin axis.

(f) Work done (Vituki) - from Dr. Pal Benedek

i. Design of instrumented monitoring station on Maros river at Mako, Hungary. Parameters to be monitored as associated with upstream pollutant releases.

ii. Vituki to furnish - Thursday

- Geohydrologic figures.
- Excerpt reports on Basin geohydrologic setting.

(g) Vituki has Romanian contacts.

B. 11 March 1998

(1) Premeeting notes - Regarding evidence for halogenated volatiles and pesticides/herbicides/insecticides, Dr. Laszlo provided that such compounds have not been identified in groundwater of the Maros Aquifer. Vituki's lab is capable of analyzing the full spectrum of these compounds.

(2) Meeting with Koros Valley Water Authority and Koros Valley Environmental Inspectorate

Meeting attended by:

(a) Dr. Ferenc Laszlo of Vituki

(b) Mrs. Zs. Kren and Mr. Bak Sandor, both hydrologists with the Water Authority

(c) Mr. L. Olah of the Environmental Inspectorate

Issues

(a) Primary concern - adequacy of groundwater quantities to meet demand. Maros aquifer currently meets the public water requirements of about 300,000 people. Water quality good, however, there is concern of future

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contaminants from upgradient locations in Romania. Water for public consumption obtained from Pleistocene units of Maros aquifer.

(b) Nitrates in the shallow aquifer are a localized concern associated with settlements having inadequate wastewater systems. In the past inadequate sewerage systems were not a priority concern. However impact on groundwater quality has become a more recent concern with greater emphasis on the need for upgrading sewer systems. Implementation of such improvement has been delegated to municipalities whereas formerly it was handled by national authorities. EU recommends that communities having populations greater than 2000 should be sewered.

(c) Bekes County is largely an agricultural community with no major industries. However agricultural activities including animal husbandry is on the decline.

(d) Small scale irrigation using well supplies is currently practiced for drip irrigation. Large scale irrigation users are prohibited from using groundwater. Such irrigation demands are to be met from surface water. Additional surface water impoundments to be constructed to provide irrigation during low flow periods.

(e) Use of the deep groundwater aquifer is limited by high arsenic levels requiring costly treatment for removal. Public health limits for arsenic are currently 0.050 mg/L to be reduced to 0.010 mg/L in the near future.

(f) Working relationships between the Water Authority and their counterparts in Arad County are poor in relation to groundwater issues although friendly personal relations exist. Technical cooperation between Hungarian and Romanian agencies should be fostered at a national level with subsequent channeling to the local municipalities. A problem is that Bekes County has a greater interest in fostering such cooperation whereas Arad County has a lesser interest for doing so being located in the upgradient reaches of the Maros aquifer, and also not being a major groundwater user. It was suggested that an immediate inducement for transboundary cooperation might be an agreement for Bekes County to provide laboratory services for water quality analyses on an agreed to

monitoring program with Arad County. Lab capabilities in Romania are somewhat limited in particular for analyses of organic constituents. Another item would be to establish a common data base available to both Bekes & Arad County entities.

(g) Arad County is reportedly engaged in largely agricultural activities with no major industries other than a former chemical plant (fertilizer - pesticides).

(h) It was suggested to utilize shallow groundwater particularly where impacted by nitrate contamination for irrigation. As noted in item d, large scale irrigation are to be met by surface water supplies. Not clear if shallow groundwater being used for small scale irrigation.

(i) It was also suggested that recharge enhancement be considered using surface water sources to offset excessive groundwater withdrawals.

(j) Vituki is proposing to develop a MOD-FLOW model the use of which will ultimately be for the Authority. However data from the Romanians is necessary to make the model more functional. Mr. Olaf mentioned that by common agreement the Romanians were to make such data available to the National Ministry for Environment and Regional Policy by February, 1998. He was not aware of status but suggested that we can find out during our March 13 meeting with Mrs. Szovenyi in Budapest. Another possibility may be for Vituki to directly contact the appropriate parties in Romania.

(k) Regarding the extent of the Maros aquifer, Mrs. Kren provided that the boundary between the Maros aquifer and adjoining sedimentary units is based on the mineral make up, age dating, and permeability contrasts, i.e. low permeability boundary. The boundary conditions, although irregular, are approximately known.

(l) Mr. Sandor added that a primary objective is to maintain the existing quality of the Pleistocene component of the Maros aquifer. However neither Mr. Sandor or Mrs. Kren seemed to be familiar with the well head protection program being proposed by Water for People nor were they aware of the May meeting sponsored by Water for People. Their

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only involvement with Water for People was to act as guides during a field trip performed during spring last year.

C. 12 March 98

(1) Meeting, 12 March 98, a.m. and p.m. at Vituki

(a) Attended by Dr. Laszlo, Mrs. Davidesz, Mr. Zoltan Simonffy, and Mr. Jozsef Deak all of Vituki.

Issues/Actions

(a) Mrs. Davidesz provided me with a list of required input data for the MOD-FLOW model from the Romanian side of the Maros alluvial fan which I will distribute to Romanian counterparts.

(b) Dr. Laszlo provided me with technical diagrams relating to groundwater conditions within the Maros aquifer part in Hungary. In addition, I requested that information on arsenic distribution, delineation of excess NO_3 areas and typical groundwater quality of municipal supplies under current conditions be addressed in Vituki's preliminary report.

(c) Mr. Simonffy provided that Romanian groundwater abstraction is of great concern as it impacts the quantity of groundwater available in the Hungarian portion of the Maros aquifer. Water quality on the Romanian side is of lesser concern since travel time within groundwater flow system can exceed 1000 years at Hungarian points of abstraction. This is based on C14 age dating. Contamination within Hungary primarily limited to defined recharge areas within Bekes County which contribute directly to the shallow portions of the Maros aquifer. Such contamination are related primarily to NO_3 originating from human wastes in settlement areas, fertilizer application and animal wastes (cattle pens). Groundwater from the shallow aquifer is currently used for irrigation (small scale) and stock watering.

90% of the population in the area is supplied by a piped water system. Effects of surface contamination, i.e. NO_3 limited to depths of largely 15 m or less although above normal NO_3 levels can occur at depths of 40 - 50 m. Deeper aquifer portions as yet unaffected.

(d) Mr. Deak provided that natural occurring ammonia and arsenic exist within the Maros aquifer flow system. In the case of arsenic, the sources are arsenic bearing minerals within sediments originating from the adjoining highlands in Romania. Due to relatively slow leaching processes, arsenic in groundwater is associated with ancient groundwater aged approximately 30,000 years that discharges in areas where permeability is relatively low. The occurrence of high arsenic concentrations in these areas appears to be localized.

(e) Again reviewed Water for People meeting for May and requested that Vituki be represented there.

Actions agreed upon or to be settled following return to States

(a) Limited water sampling program by Vituki for problem definition stressing organic contamination. A number of samples to be collected within contaminant susceptible areas in Hungary (recharge areas) and the bulk to be sampled from selected monitoring wells in Arad County in cooperation with Romanian agencies. I'll try to arrange for this during my trip to Romania and inform Dr. Laszlo of the results.
Dr. Laszlo said money currently funded under this program (approximately $10,000) may be available for a limited sampling program. Cost per complete analysis is $400 or less per sample.
Mr. Deak also suggested that age dating be performed on selected samples.

(b) Reviewed subcontractual terms - see marked up contract copy (Attachment C). Need to discuss with Wakefield. Will inform Dr. Laszlo of outcome.

(c) Some concern about proprietary status of Vituki's model which is based on an existing regional model of which the Maros aquifer represents a sub-area. It was pointed out that the model as it applies to the Maros aquifer will be required by local water agencies in both Bekes and Arad counties if it is to be used as a management tool. Legal wording could be applied to assure that the model be used for that purpose only The model could also be provided for local use whereby parameters relating to

changes in abstraction/water quality be input for cause/effect relations with any changes in hydraulic parameters of the model (fine tuning) performed at a National level, i.e. Vituki. For use other than water management by other interested parties, model could be provided at cost (model use other than for project requirements).

(d) I indicated that I'll discuss with Romanian agencies the issue of providing data directly to Vituki as part of this project by establishing a direct liaison between Vituki and the Romanians. Informed Dr. Laszlo that I'll provide him the results of this effort which could result in an initial cooperative program and serve for developing a common data base available to both Romanian and Hungarian entities. To this extent Dr. Laszlo will try to set up a meeting tomorrow with Mr. Pal Liebe of Vituki. Mr. Liebe is director of the Institute of Hydrology at Vituki and is responsible for establishing contact with the Romanians.

(e) Subject to the results of initial the modeling, recommendations would be made to address date deficiencies (assuming transborder model is developed to include Romanian data), and identify additional study requirements such as contaminant characterization, source control measures, source removal, etc.

D. 13 March 1998

(1) Meeting, 13 March 1998, morning 8:30 a.m. at Ministry for Environment and Regional Policy, Budapest

(a) Attended by Mrs. Eszter Szovenyi, Dr. Balashazy Laszlo, Rozalia Kisgyorgy, Zsuzsa Steindl, all of Ministry for Environment and Regional Policy; Mr. James Djierwa of USAID, and Dr. Ferenc Laszlo of Vituki.

Discussion

(a) ERL provided a synopsis of his activities in Hungary and his remaining schedule in Romania and Vienna.

(b) With regard to the status of Romanian data, a bilateral agreement is to be agreed upon between an Hungarian and Romanian Technical Commission for interchange of information between the two countries as it relates to the Maros Aquifer. A working group will meet during April at

which time information exchange procedure will be discussed and/or information will be provided. The key Hungarian agency involved is the Ministry of Transport, Communication and Water Management.

(c) Dr. B. Laszlo asked how non PCU participating donor founds would affect funding from PCU. Non-related issue - no follow up.

(d) Mrs. Szovenyi asked whether recent USAID - Romanian agreement includes funding for Maros Aquifer. Upon review of agreement, Maros Aquifer was not identified as one of the funded projects.

(e) Dr. B. Laszlo provided some insight on Arad County.

i. He recommended contacting the assistant mayor of Arad, Mr. Romulus Tasca. Since this is an elected position, there is some uncertainty if Mr. Tasca still occupies this position.

ii. Regarding Arad County land use, primarily agricultural although an industrial chemical complex is located near Arad. This complex has not been in use since 1990. Former chemical manufacture included fertilizers, pesticides, and other chemicals.

(f) Ms. Kisgyorgy also provided another Romanian contact - Ms. Maria-Beatrice Popesen of the Romanian Water Authority.

(2) At the end of the meeting, I set up an appointment to see Mr. Djierwa at the USAID office.

(3) Following the meeting at the Ministry, Dr. Laszlo and I proceeded to Vituki. Dr. Laszlo informed me that Mr. Liebe didn't think it necessary to get together since issues were well discussed at yesterday's Vituki meeting. Dr. Laszlo provided me with a report describing the hydrogeology of the Maros aquifer and maps describing nitrate, ammonia, and arsenic distribution in the Maros aquifer. Note ammonia and arsenic are naturally occurring. Dr. Laszlo also provided costs on the discussed initial sampling program intended to be performed under this contract. The program assumes 30 sample locations for purposes of age dating.

- Age dating components

- Horizontal flow conditions

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C14 @ $130/sample

O18 @ $45/sample - total cost per sample $200 x 30 $6000

- Vertical movement

  Tritium $45/sample

  Nitrate $5/sample

  Pesticide $45/sample - Total cost per sample $130 x 30 $3900

Before proceeding need to reconsider the number of samples in relation to available funds. The need for selected organic analyses, however, should take priority. Estimated cost $400/sample.

On other issues, river/surface water-groundwater interactions are to be a part of the modeling effort. Information on surface water quality in Hungary and Romania readily available from PCU as well as from in-country agencies.

(4) Meeting at USAID at 2 p.m. attended by Mr. Djierwa, Christopher Frost, and Craig Coulter all of USAID and Dr. Laszlo.

(a) I provided the objectives of this study, a brief review of work performed, and work to be accomplished in Romania as well as explaining Vituki's subcontractual relationship with M&E.

(b) Regarding data retrieval in Romania, Mr. Frost indicated that this be more of a political rather than a technical problem because Arad County is inhabited by a largely Hungarian ethnic population. He indicated that we may get more cooperation from NGOs to assist obtaining data. He suggested that we review this with Mr. Figueredo. He also didn't think that Vituki's assistance in data collection and proposed sampling program would be welcomed in Romania.

Upon concluding our meeting Mr. Djierwa and I arranged a meeting with Phare's Mr. Botterweg/Josef Turcan on Thursday @ 2:30 p.m. in Vienna. Mr. Djierwa also mentioned that M. Latif will phone him this Monday and probably Mr. Figueredo as well.

(5) Following our meeting with USAID, I told Dr. Laszlo that I'll phone him Friday, 20 March from Vienna and follow up with particulars by either FAX and/or FEDX.

Meeting Notes

Annex 1/B.

Meeting notes of discussions at VITUKI, Water for People Workshop, USAID Budapest Office during Mr. R. Lubke's visit to Hungary, 25-29 May 1998.

1) Called USAID mission in Budapest. Received no reply. Assume office closed because of Memorial Day holiday.

2) Met with Dr. Ferenc Laszlo and Mrs. Katalin Davidesz at Vituki. Dr Laszlo provided me with the draft copy of Preliminary Report on Maros Aquifer Investigations. The report was mostly prepared by Mrs. Davidesz. We discussed briefly the content of the report and, subject to further review, agreed on providing a section on Conclusions and Recommendations for further actions required for improving the model, which is based primarily on information available in Hungary. We also discussed section 9 of the report - Plan of additional field and laboratory measurements. This section requires further elaboration. In general agreed upon following:

   a) All samples to be analyzed for nitrates and commonly used pesticides/herbicides as identified in the report.
   b) Analyze for gasoline related compounds only in those areas located near potential release sources, i.e. gasoline stations, fuel tank farms, vehicle repair/maintenance facilities.
   c) Analyze for VOC constituents associated with solvent use including Arad Chemical plant site and selected location(s) in Bekescsaba. Other potential sources are landfills, railroad and vehicular maintenance facilities.

3) I mentioned that the intent of the limited sampling program is to sample near potentially significant contaminant sources which may have used other chemicals in addition to solvents, i.e., transformer storage areas (PCBs), rail tie/lumber preparation, (creosote and other wood preservatives). Scheduled another meeting on Friday, May 29 to discuss my review comments. It was agreed to provide a draft copy of the preliminary report to Peter Tell of Water for People (WFP) and Mr. Tasca, Vice President of Arad County for their information and comments. Dr. Laszlo and Mr. Liebe of Vituki are to attend the Water for People meeting as observers under Ms. Eszter Havas-Szilagyi's sponsorship. Ms. Szilagyi, who works at the Hungarian Ministry of Transportation, Conservation and Water Management is one of the invited members for Water for People's workshop.

4) Following the Vituki meeting attended Water for People's pre-dinner meeting at the Danubius Grand Hotel where I met Peter Tell, Julie Baker and Kevin Kotun as well as some of the Hungarian and Romanian invitees to the workshop. I was informed that the workshop meetings will be held at the Thermal Hotel, which is located next to the Danubius Grand Hotel on Margit Island.

B) May 26, 1998

1) Called USAID mission in Budapest. No reply.

2) Called Dr. Laszlo to inform him of WFP meeting location.

3) Water for People meeting at Thermal Hotel.

a) Attendees - see attached list (Attachment A). In addition, Dr. Ferenc Laszlo, Mr. Liebe and Mr. Deak of Vituki were present at the meeting as well as Dr. Laszlo Kardoss, a consultant representing PCU.

b) During the introduction of attendees (Note no USAID people at the meeting) the following remarks/responsibilities were identified.

(i) Dr. Florin Dumescu involved in reports relating to water management in Arad Country. Acting as consultant to Mr. Tasca.

(ii) Dr. Mihai Bretotean involved in modeling of the Mures aquifer in Arad County.

c) Opening Remarks

(i) Mihaela Popovici - Key issues regarding Arad water management/transboundary cooperation.

- Legal
- Administrative
- Technical-including training
- Financial and finding sources for funding

(ii) Mr. Miltialde Tataru

- Need to coordinate with Romanian and Hungarian proponents on management issues
- Romanian participation will require fast track approach to match Hungarian involvement on resource management

(iii) Ms. Eszter Havas-Szilagyi

- (Need input from Water for People since comments in Hungarian were inaudible in English translation)

d) Additional comments provided by Mr. Tasca regarding water management

(i) Amplify technical discussions.
(ii) Explanation of USAID function and program.
(iii) Concerns relating to pollution and need for water quality

monitoring of Mures River and Mures Aquifer as well as expanded laboratory facilities.

(iv) General feeling that Romanian involvement is lacking.

(v) Program should stress local participation rather than National "Ministerial" Participation.

(vi) ERL requested Arad County critique of Vituki's Preliminary Report and that Arad County identify their requirements for a water management program.

e) Vituki representatives requested to summarize their activities regarding the Mures aquifer on technical issues.

(i) Mr. Liebe provided following comments:

- Need for information from Romania.
- The Mures aquifer should be investigated as a unit.
- Monitoring system in Hungary of shallow/phreatic aquifer and in areas of heavy groundwater abstraction is well established.
- Plan to install additional monitoring points
- Current groundwater abstraction from Hungarian portion of Mures aquifer totals 56000 m^3/day.
- A maximum 2 to 3 m decline in water levels observed in the shallow aquifer although water level declines also noted in deeper aquifer.
- Causes for decline include climatic changes, i.e. prolonged dry period and/or overexploitation.
- Modeling required to determine causative effects of pumping on water level decline. Model to consider shallow and deep aquifers as a single hydraulic unit. Note phreatic portion (delineated by water table) not considered in model.
- Inflow from Romania as determined by modeling under predevelopment conditions is 30000 m^3/day.
- Additional data needs including Hungarian portion of Mures Aquifer are:

  → Additional geologic data
  → Geometry of geologic units
  → More detailed information on spatial and temporal changes of water table and potentiometric head of deep aquifer
  → Isotope data to verify transport model
  → More exact quantities of groundwater extracted in both Hungary and Romania
  → Precipitation data
  → Future development plans

(ii) Mr. Deak provided following comments:

- Model investigated that portion of the groundwater flow system within a depth interval of 0 to 500 m. Highest hydraulic conductivity occurs within shallow portion of flow system, starting at depth of about 30m.
- Model calibration performed for both pre-and post development conditions.
- Flow transport verification performed by C14 age dating.
- Groundwater velocities determined by Modflow analysis were compared with actual age dating. Results of both showed close correlation.
- Groundwater flow velocity determined at 3 m/year with total flow in the order of 25,000 to 30,000 m^3/day.
- Upward flow velocity calculated at 20mm/year equivalent to 25000 to 30000 m^3/day in discharge area in Hungary. Discharge is by evaporation.
- Propose joint investigation on age dating to determine recharge component originating in Romania.

(iii) Dr. Laszlo provided following:

- USAID study focuses on qualitative and quantitative aspects of groundwater conditions.
- Pollution problems associated with lack of infrastructure, i.e. inadequate or lack of sewage systems, high wastewater infiltration.
- Phreatic water contains high nitrate content, which is the no. 1 problem in recharging waters.
- Pesticide associated with agricultural application.
- Other pollutants associated with chemicals originating in settled and industrial areas.
- Need for investigating micropollutants, i.e. pesticides, VOCs, SVOCs, as part of USAID program.
- Need for joint Romanian/Hungarian data collection.
- On-going numerical modeling for both Hungarian/Romanian portions of Maros aquifer.
- Above efforts all part of USAID study.

f) Additional comments on technical issues by Romanian participants

(i) Dr. Mihai Bretotean (Institute of Meteorology and Hydrology)

- Institute has prepared a preliminary flow model of the Romanian portion of the Maros aquifer using a 2 dimensional model of the upper 110m of aquifer.
- Modeling effort has included flow and transport simulation.
- Have also used Modflow.
- Have performed contaminant dispersion studies at Arad Chemical Plant for shallow and deeper aquifer portion. Pollutants studied are nitrate and ammonia.
- Lack data on piezometric surface of deeper aquifer.
- Equipment needs include:

  → Sampling equipment for deeper layers
  → Spectro photometric analyzer
  → Computer-Pentium 2 or better
  → GIS assistance

- Intent is to develop the same modeling capability as in Hungary, following which the Romanians would coordinate their efforts with their Hungarian counterparts.
- Propose joint modeling cooperation.
- Propose joint monitoring program utilizing observation wells located near the border.

(i)

(i) ERL requested a position paper regarding equipment needs from Dr. Bretotean.

(ii) Dr. Florin Dumescu

- Former studies on water situation in Arad County available.
- Have new results on pumping effects by the existing 100 public supply wells located along a 22 km line aligned along a north/south axis.
- Study area of the Mures aquifer encompasses 18000 km² within which a cone of depression associated with public supply pumping has an area of 850 km² with a maximum drawdown of 18 to 20 meters. These are observed values.
- Changes in hydraulic properties exist in the aquifer system.
- Total pumpage 2300l/sec (198720 m³/day).

- Existing problems include:

  → Wells are old, unsuitable equipment.
  → High system losses of 30% of system flow.

→ Well rehabilitation is required to optimize pumpage for future needs.
→ System rehabilitation is required for leakage reduction.
→ Need to improve the municipalities monitoring system.
→ High system losses resulting in an elevated water table and attendant drainage problems in towns; shallow groundwater is aggressive and attacks concrete in building structures.

- Water management problems associated with both water extraction and delivery system, however, the municipality doesn't have sufficient funds to correct the problem.
- Immediate need for modeling and cooperative program at county level.
- Water quality problems similar to those in Bekes County and include nitrate and ammonia pollutants and other unidentified organic chemicals.
- 10% of land use in Arad County is for housing, remainder largely agricultural.
- Before 1990, the county was intensively cultivated.

(iii) Mr. Tasca

- Monitoring water quality and quantity an important management objective.
- Water supply is the responsibility of the county.
- Municipalities responsible for water systems investments and maintaining water quality standards.
- No record of public supply well having been shutdown because of poor water quality.

(iv) Dr. Bretotean

- Groundwater monitoring performed by the Water Authority and the Romanian EPA.

g) I requested Arad County officials to provide a list of problems and requirements for water management.

h) Dr. Laszlo Kardoss, consultant to PCU suggested that funding for implementing measures for realizing needed aquifer protection and management objectives may be available from Cross Boundary Commission (CBC) and/or European Union (EU). He told me that the Maros aquifer cross-boundary cooperation is not of sufficient priority to receive assistance under PCU's Phares

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program since the Maros aquifer is not a significant component for pollution within the Danube river basin.

i) Comments by Ms. Eszter Havas-Szilagyi

(i) A legal basis for aquifer protection exists within the Hungarian National Plan.
(ii) Central government funding exists for water quality impairment by micro pollutants and for expansion of the monitoring network.
(iii) Guidelines for aquifer protection-management approaches to be completed by next year.
(iv) Recommendations have been made for using the Maros aquifer as a pilot study for establishing guidelines. Ms. Havas-Szilagyi to provide a copy of the recommendations to WFP.

j) Julie Baker of WFP to prepare a trip report, a copy of which will be sent to me.

C) May 27, 1998

1) Contacted Dr. Ferenc Laszlo of Vituki to request two copies of the Draft Preliminary Report, one copy of each to be provided to Peter Tell and Mr. Romulus Tasca for their review and comments. Dr. Laszlo stated that during yesterday's WFP workshop meeting, Dr. Bretotean mentioned his interest in the Maros aquifer modeling work by Vituki. Dr. Laszlo suggested a technical meeting with him at which time they can discuss their modeling effort on an information exchange basis. Although agreeable, Dr. Bretotean will require permission to do so from his superiors.

2) Attended WFP workshop meeting on legal issues relating to joint cooperation on aquifer protection and management.

a) Initial discussions related to issues on joint environmental management by Bekes and Arad counties. It was agreed in general that there exists a legal framework for such joint efforts without requiring new legislation.

b) The Hungarian participants were the first to comment on legal issues as follows:

(i) The Maros aquifer is an important source of water supply and serves 70% of Arad County's population of 400,000.
(ii) The Aquifer should be managed as a single unit under a cooperative program with Arad County to be implemented as soon as possible.
(iii) A new environmental act relating to the protection of water and soil is in place and can serve to assist in implementing a joint management program.
(iv) The act provides for the division of responsibilities on a national

and local basis. It allows local municipalities to develop their own environmental policies. In Bekes County such policies would focus on the management and protection of the Maros aquifer.

(v) Standards adopted would be similar to those adopted by the European Union.

(vi) Funding to implement the management/aquifer program would be a problem. However some funding sources are available from the National budget such as the National environmental fund.

(vii) For budgetary purposes it would be more effective to combine certain joint county functions in order to avoid duplication.

(viii) Administrative functions include licensing of water use and disposal which involves several authorities.

(ix) Maros aquifer is considered vulnerable and unprotected from point source and non point sources of pollution. Past agricultural practices were a major source of pollution involving nutrients and pesticides. By 1989 on, collectivized farming was replaced by small farms, which use less nutrients, pesticides, and chemicals mostly through lack of technical knowledge as well as costs. Although there has been a substantial reduction in the amount of pesticides applied, predicted near future agricultural growth is expected to result in greater use of pesticides. As opposed to past collectivized agricultural practices, current inventories on chemical uses are poorly maintained.

c) Ms. Eszter Havas-Szilagyi identified the following Acts which can provide the legal basis for establishing joint cooperation.(Note list incomplete - but to be identified in WFP trip report)

(i) 1990 Municipality Act
(ii) 1994 Act for the protection of arable land
(iii) 1995 Water Management Act
(iv) 1996 Act for Regional Planning
(v) 1996 Regional Development/Housing Act

d) The acts contain legal provisions for local municipal cooperation including transboundary cooperation by municipalities. Such provisions are as provided by European Union guidelines to promote cross-boundary cooperation. Although the use of EU guidelines is voluntary, EU funding is more readily available if cross-boundary cooperation is implemented.

e) Municipalities have the flexibility to establish their own rules within the framework of National objectives and guidelines.

f) There exists a Hungarian-Romanian bilateral agreement (1986) on surface water and a more recent environmental bi-lateral agreement.

g) The following comments on legal issues were made by Romanian participants.

(i) Policy is formulated at the ministerial level
(ii) Strategy is a ministerial function implemented by legislation
(iii) Legislation includes:

- 1996 Water Law whereby Water Authority at county to national level implements/monitors and provides database funds. The Regional Water Authority that is responsible for the Mures aquifer includes all of the Mures River basin. The Water Authority has regulatory authority including licensing and permitting.

h) Bilateral agreements are a result of the Danube Convention.

i) Romanian-Hungarian bilateral agreement on water resources including groundwater and problems associated with cross-boundary cooperation are being analyzed by the government's cross-boundary commission.

j) Next commission meeting to be held in June at which time groundwater issues to be discussed. According to Mr. M. Tataru only following agreement on groundwater bilateral issues can joint management of the Mures aquifer be established. He was not familiar with cooperative mechanisms on a local scale.

k) The County Council Waterworks buys water from the State, which it then charges its customers.

l) A Romanian proposal on their participation in a joint management program was then provided.

D) May 28, 1998

i) Attended Final Water for People Workshop Meeting; subsequently joined by Dr. Laszlo of Vituki during afternoon. No one from USAID mission attended any of the workshop meetings.

a) Annex 2 of the Proposal submitted during yesterday's meeting by the Hydrotechnological Joint Commission as prepared by the Romanian Water Authority was presented for discussion.

(i) Mr. Miltialde Tataru provided the opening comments as follows:

- It is the intent that the proposal will provide the legal basis for bilateral cooperation.

(ii) Dr. Laszlo Balaghazy replied on behalf of the National Hungarian Participants

- He felt that revisions are necessary to the proposal.
- Proposal as written suggests that Hungary has all requirements in place for bilateral cooperation. This is not true since Hungary may require donor funding to achieve a cooperative agreement.
- The proposal only relates to Romania to the exclusion of Hungary and is therefore unilateral in nature.
- The proposal does not consider local agency requirements.
- Municipality requirements should be considered not just those which are of national interest.
- Regional land use planning and protective measures in recharge areas are an important component of municipal planning and are not addressed.
- In Hungary the municipality has a significant role in water resources planning as well as other related functions while the National agencies role is to help them. This approach is in keeping with EU objectives.
- In summary the proposal should include municipal and local interests.

(iii) Mr. Tataru's reply was as follows:

- The proposal is designed to bring Romanian efforts to the same level as those in Hungary.
- Specifically need to upgrade the Romanian monitoring effort and modeling capabilities.
- Once Romania reaches the same technical level as Hungary, then efforts for joint cooperation could begin.
- The study of the groundwater resources is the State's responsibility because the water belongs to the State.
- The municipality's responsibility is to provide drinking water to the consumer and treat waste water which when disposed belongs to the state.

(iv) Dr. Balashazy replied as follows:

- In Hungary the water also belongs to the State but drinking water supplies belong to the municipality.
- Aquifer protection is a shared responsibility by both the State and the municipality.

- Aquifer protection zones are defined by the Water Authority whereas land use planning and special development programs are the responsibility of the municipality.
- Municipal water works are responsible for monitoring.
- In Bekes county, both the county and municipalities own water works.

(v) Mr. Tataru's reply:

- Arad County is responsible for water studies and have their own monitoring system. Data developed by the county is then input to the National Data Bank data from which also is available to the county.
- Arad County has the same responsibilities as Bekes county
- Both counties have a common interest to set up a joint cooperative program.

(vi) Mr. Tasca of Arad County replied as follows:

- The proposal should include county interests.
- New data and knowledge should be made available to the county. This requires close cooperation between the county and National agencies.
- The county has a direct responsibility to its inhabitants not the Central government
- The county has finalized a contract for its own groundwater study financed by the county. Preliminary results of this study indicate that only 50% of the water available 5 years ago is now available for future use, indicating that the quantities of groundwater resources are also an important issue in Arad County. Upon receiving the study's final results, meetings with Bekes county would be undertaken to establish needed measures to maintain supply sustainability.
- The county also needs to improve their monitoring system.

(vii) Dr. Bretotean of the Romanian National Institute of Meteorology and Hydrology replied:

- Because the National Water Authority is the owner of the groundwater, it is his opinion that the Authority should have made the study rather than the county. The municipality's responsibility is for land use planning and aquifer protection only. [It was pointed out that the Authority has not taken the initiative to perform such studies]

(viii) Mr. Tataru added that if the study is to be used as a development

plan, the study results would have to be approved at a national level. Mr. Tataru then requested for concrete comments on their proposal. He felt that a memorandum of understanding is not necessary.

(ix) Subject to comments by the Hungarians a revised copy of the proposal annex 2 will be made available to the meeting participants.

(x) It was agreed by the Hungarians and Romanians representing national interests to revise the proposal in under to obtain financing in preparation for ultimate bilateral cooperation. It was agreed that the Romanian interests at a national level would only be represented in the proposal. The county representatives, however, disagreed.

b) County reaction to proposal.

(i) Mr. Laszlo Szelekovszky from Bekes County

- Bekes County encourages joint cooperation and implementation.
- The county will provide a draft county agreement within two weeks time.
- The county doesn't want to get involved or sign a national proposal which has nothing to do with the county. The county expects to find sources of financing if requests are made under a joint agreement.

(ii) Mr. Tasca from Arad County

- Arad County is agreeable to a joint agreement with Bekes County and would like to see continuing US involvement.
- The joint agreement would have as its objective to protect and maintain the water quality and quantities of groundwater for future use.
- The counties will jointly handle management issues. Should such handling be beyond their competency they will inform higher levels and discuss with the bilateral commission.

c) NGO response to proposal.

(i) Dr. Pal Cserai

- A joint agreement and cooperation by the two counties will benefit the natural and economic conditions of each, particularly in maintaining good quality drinking water.

- Should make the results of the meeting known to public with WFP to be informed of the progress of the agreement proposal.

(ii) Mrs. Mihaela Popovici

- An added objective of the meeting and its results is to foster changing attitudes (political attitudes), develop team work between all interests concerned and to assign and share responsibilities.

d) Other issues privately discussed are

(i) It was Kevin Kotun's opinion that modeling expertise is well developed at a National level in both Hungary and Romania. On a local level some modeling training may be required. It was my opinion that such training could be performed by in-country specialists in their own native language but perhaps with some funding support by a donor agency, i.e. Romania's lack of suitable computer equipment.

(ii) In my discussions with Dr. Klein and Dr. Bretotean, they indicated a willingness to provide me with groundwater related reports. I plan to follow up on this as a means to assist Arad county in establishing priorities necessary for implementing aquifer protection and management measures to realize joint county objectives. Further I offered our services through Vituki for performing a limited sampling for micro-pollutant analysis costs for which would be provided under our existing USAID program. Dr. Klein appeared to be receptive to this and I suggested to both him and Dr. Ferenc Laszlo to work out the technicalities of the sampling effort in Arad County.

E) May 29, 1998

1) Reviewed Vituki's deliverable Draft Preliminary Report.

2) Sent fax of Water for People Workshop Summary results to Mohammed Latif. To fax copy to John Chalas/Brian Harrington following my return stateside.

3) Arranged meetings with Dr. Ferenc Laszlo of Vituki and with Mr. James Djierwa of USAID.

4) Met with Dr. Ferenc Laszlo and Mrs. Katalin Davidesz of Vituki to discuss my review comments on the Draft Preliminary Report. Dr. Laszlo and Mrs. Davidesz will make necessary changes for the Final Report submission. Dr. Laszlo also mentioned that Brian Harrington had no comments on the Draft Preliminary Report. We discussed Vituki's subsequent actions as follows:

a) Vituki to perform sampling program as identified in the Preliminary Report. I told Dr. Laszlo to contact Dr. Klein of Arad for sampling on the Romanian side. I've previously discussed this with Dr. Klein who indicated an interest for sampling and analysis of micropollutants. Sampling results are to be reported in Vituki's Interim Report submittal due 60 days from now.
b) Informed Dr. Laszlo that I'll forward any reports or information that I might receive from Dr. Klein and/or Dr. Bretotean. If this information becomes available within the next month or so, then Vituki can incorporate both the sampling results and the Romanian data into a final report without the need of an interim report. This would save some time for completing the Maros aquifer assignment.

5) Subsequently met with Mr. James Djierwa of USAID. Mr. Marc Ellingstad was unavailable for our meeting. I provided Mr. Djierwa a debriefing of the results of WFP's workshop meeting the highlights of which are the preparation of a joint agreement on transboundary cooperation between Bekes and Arad Counties and the proposal prepared by the Hydrotechnological Joint Commission of the Romanian Water Authority. As to funding mechanisms via USAID, Mr. Djierwa indicated that such funds might be available from the USAID mission in Romania. Mr. Djierwa also mentioned that their office will have a Regional Environmental expert on their staff within a week or so who could review the merits of such assistance requested by both the Romanian Water Authority and Bekes/Arad counties as it relates to cross-boundary cooperation for management and protection of the Maros aquifer. He further added that the environmental expert comes from the USEPA. I told Mr. Djierwa that I would discuss assistance issues with Mr. Latif. Mr. Djierwa also received a copy of WFP's Final Agenda for the Romania-Hungary Conference/Workshop for the Mures/Maros Alluvial Cone Aquifer (Attachment A).

Meeting Notes

Annex 1/C.

Meeting notes of XI. session of the Hungarian-Romanian Hydrotechnical Commission (item 5: co-operation in water management) (in Hungarian with English translation of the relevant paragraph) 2-5 November 1998,

Excerpt from the meeting notes of the XI. session of the Hungarian-Romanian Hydrotechnical Commission

5. Cooperation in water management

The Committee states that – in the present meeting – the Romanian delegation provided documents and materials dealing with the assessment and management of the groundwater resource of the Maros aquifer. The selection of the documents was done in the protocol of session X.

J E G Y Z Ő K Ö N Y V

a Magyar - Román Vízügyi Műszaki
Vegyesbizottság XI. ülésszakáról

A Magyar-Román Vízügyi Műszaki Vegyesbizottság XI. ülésszakát Románia területén, Oradea-n (Nagyváradon), 1998. november 2-5. között tartotta, a határt alkotó és a határ által átmetszett vizekkel kapcsolatos vízügyi kérdések szabályozásáról 1986. november 20-án hatályba lépett Egyezmény alapján.

Jelen vannak:

A magyar Fél küldöttsége:

Dr. Hajós Béla	meghatalmazott
Dr. Szlávik Lajos	meghatalmazott-helyettes
Domahidy László	szakértő, a Vegyesbizottság titkára
Dr. Baján László	szakértő
Simonfai György	szakértő
Dr. Pádár István	szakértő
Dr. Kováts Gábor	szakértő
Bak Sándor	szakértő
Vehman Ilona	szakértő
Boga Tamás László	tolmács

A román Fél küldöttsége:

Viorel Raicu	meghatalmazott
Prof. Dr. Gheorghe Baran	szakértő
Liliana Mâra	szakértő
Paul Popescu	szakértő
Adriana Hogea	szakértő
Miltiade Tătaru	szakértő
Ane Marie Ciurea	szakértő, a Vegyesbizottság titkára
Liviu Craciun	szakértő
Teofil Romocea	szakértő
Costică Sofronie	szakértő
Nicolae Munteanu	szakértő

A Vegyesbizottság a következő N A P I R E N D E T állapította meg:

I. Tájékoztató a X. ülésszak Jegyzőkönyvéből és az Egyezmény végrehajtására vonatkozó szabályzatok előírásaiból következő feladatok teljesítéséről, valamint a további szükséges teendők megállapítása

II. A Felek által 1997-ben teljesített szolgáltatások elszámolásának felülvizsgálata

sek egymásnak megküldeni legkésőbb a következő év első negyedévében,

- hogy 1999-ben a jelen Jegyzőkönyv 1. számú mellékletét képező tartalmi minta alapján kell összeállítani a helyszíni felülvizsgálatokról felvett jegyzőkönyveket,

- a helyszíni felülvizsgálatokról 1999-ben és a további években a felvett jegyzőkönyveket és a hozzájuk csatolt beszámolókat az Ár- és belvízvédelmi albizottság vizsgálja meg és terjeszt elő javaslatot e tevékenység javítására.

5. Együttműködés a vízgazdálkodás terén

A Vegyesbizottság megállapítja, hogy a Vízgazdálkodási albizottság találkozójára Satu Mare-ban (Szatmárnémetiben), 1998. augusztus 23 - 27. között került sor.

A Vegyesbizottság megállapítja:

- a két Fél szakértői kölcsönösen előterjesztették, az országhatárt alkotó vagy a határ által átmetszett vízfolyásokon kisvízi lefolyási viszonyok kialakulása esetén a helyi vízgazdálkodási szervek közötti együttműködés szabályzata tervezetének összeállításához szükséges alkotóelemekre vonatkozó véleményüket; a román Fél szakértői tanulmányozás céljára átadták az erre vonatkozó javaslataikat, míg a magyar Fél az ezekről alkotott észrevételeit és kiegészítő javaslatait 1999. január 10-ig küldi meg,

- az albizottság azt javasolja, hogy a kisvízi hozamok jellemző értékeinek meghatározását "Szabályzat a magyar-román határt alkotó vagy a határ által metszett vízfolyásokon végzendő rendszeres vízrajzi észlelésekről és közös készlet meghatározásról" című szabályzat alkalmazásával megbízott szakértő csoport végezze, a Vízgazdálkodási albizottság irányításával,

- a román küldöttség a jelen ülésszakon átadta a Maros hordalékkúp felszín alatti vízkészletének értékelésére, valamint a felszín alatti vizekkel való gazdálkodásra vonatkozóan a X. ülésszak Jegyzőkönyvében, illetve a szakértői jegyzőkönyvekben előírt anyagokat,

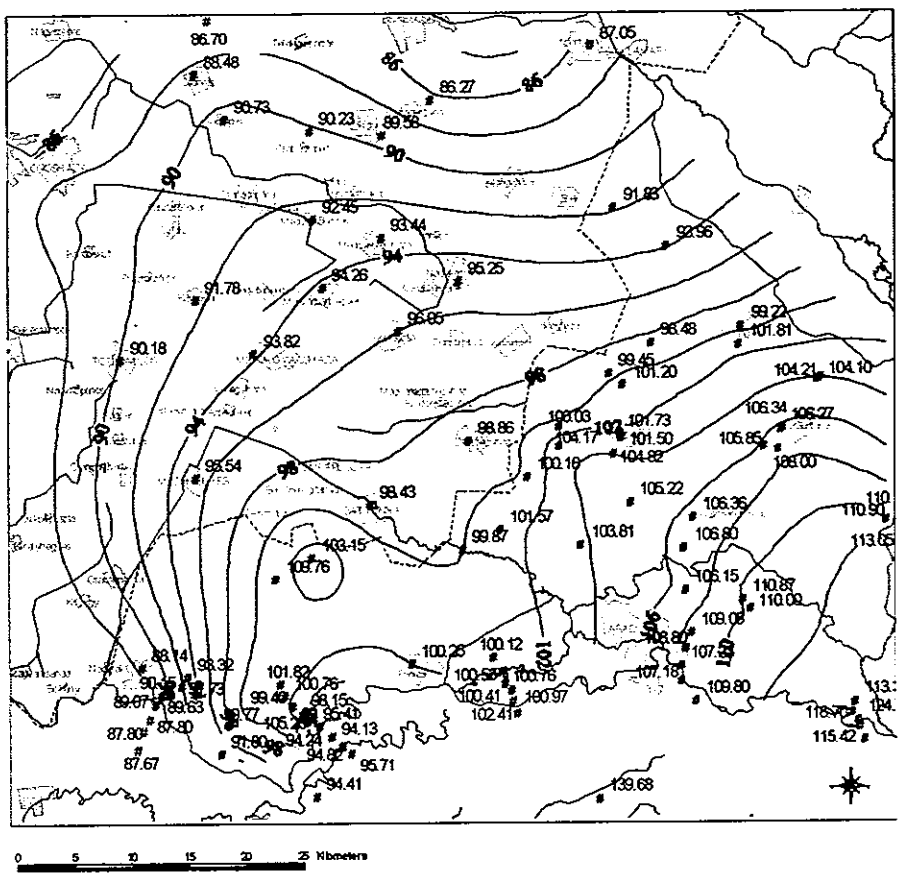
- a vízgyűjtők vízgazdálkodási-fejlesztési tervezésénél alkalmazott irányelvek és eljárások területén folytatott tapasztalatcsere hasznosnak bizonyult,

A Felek meghatalmazottai kölcsönösen megerősítették, hogy mindkét országban az Európai Unió irányelveinek és ajánlásainak megfelelő eljárásokat alkalmaznak a vízgyűjtők vízgazdálkodás-fejlesztési terveinek kidolgozása során.

87

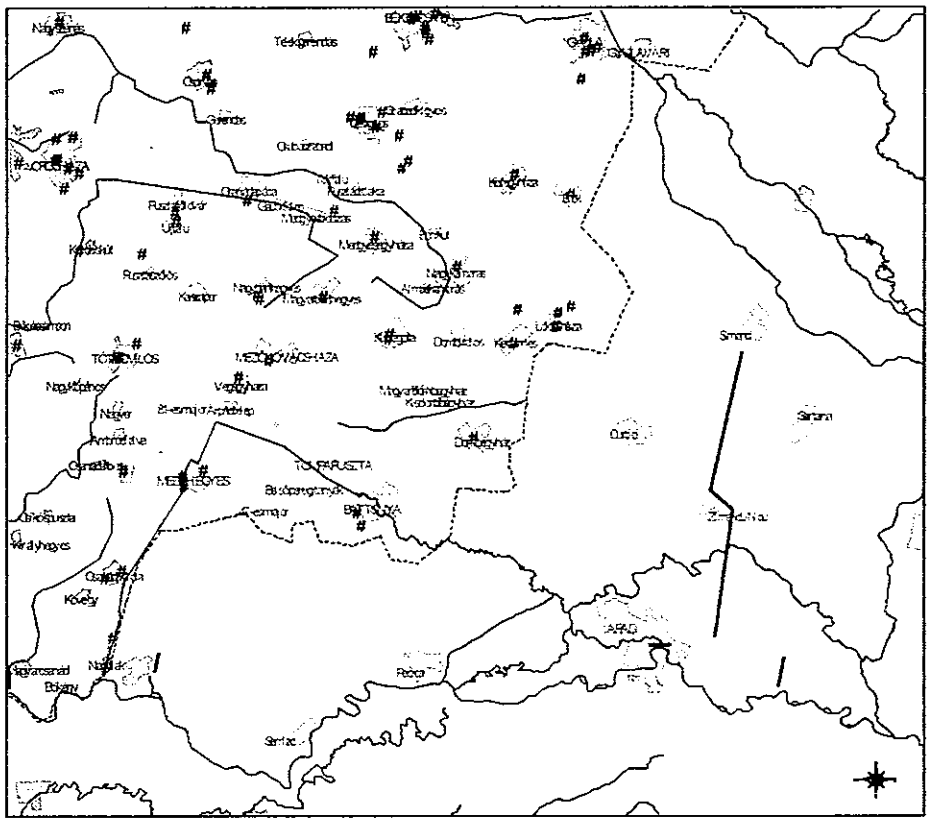
ANNEX 2

Medium shallow groundwater level in the years 1971-80
(m above Baltic see level)



- *Observation well*
- *Heads in the shallow aquifer*
- *Boundary*
- *River*
- *Settlement*
- *Modell area*

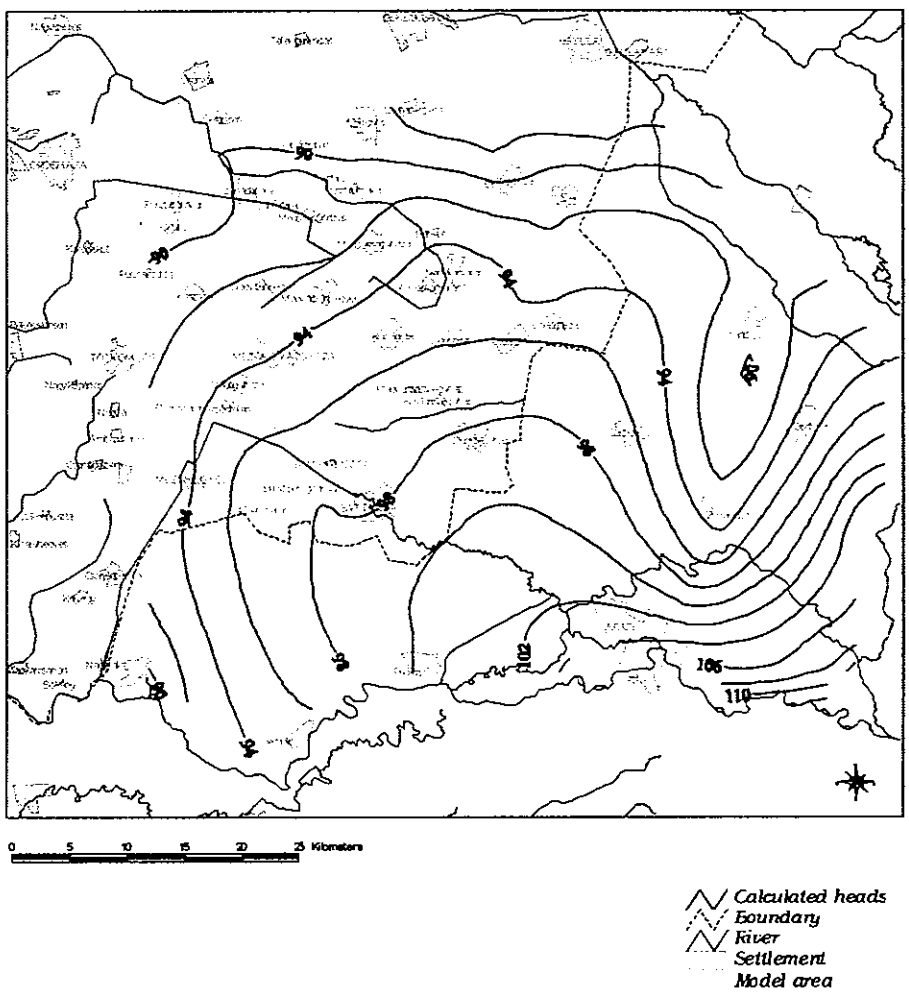
Water supply places in teh Maros alluvial cone



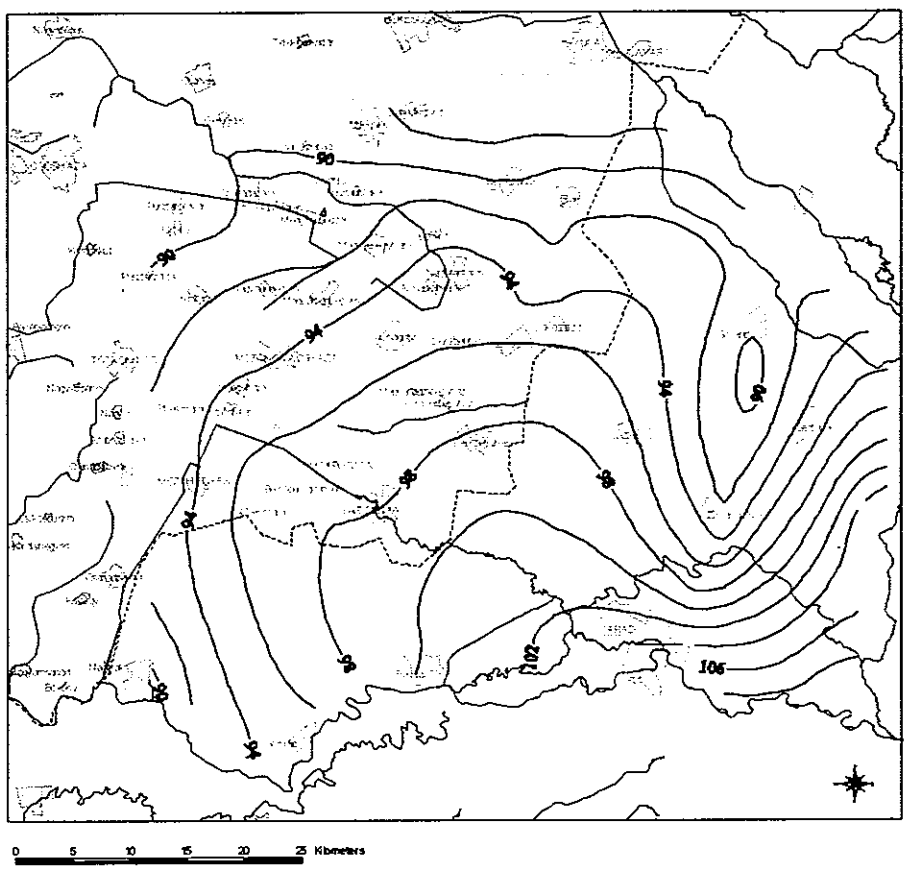
0 5 10 15 20 25 Kilometers

- # Group of supply objects in Hungary
- Water supply interface in Romania
- Boundary
- River
- Settlement
- Model area

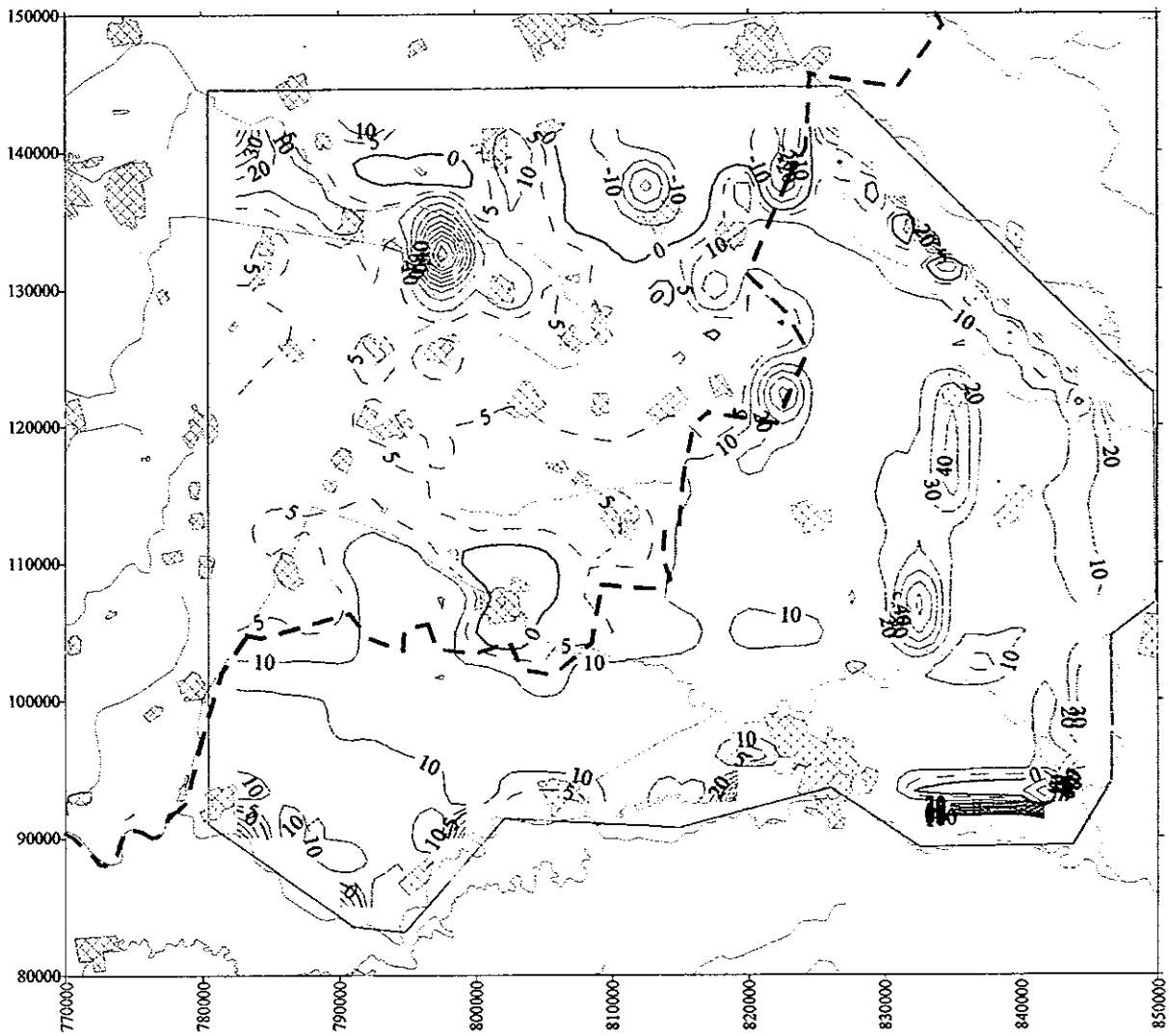
Calculated head in the 1st layer
the water abstraction doesn't change in the next 10 years
(m above Baltic see level)



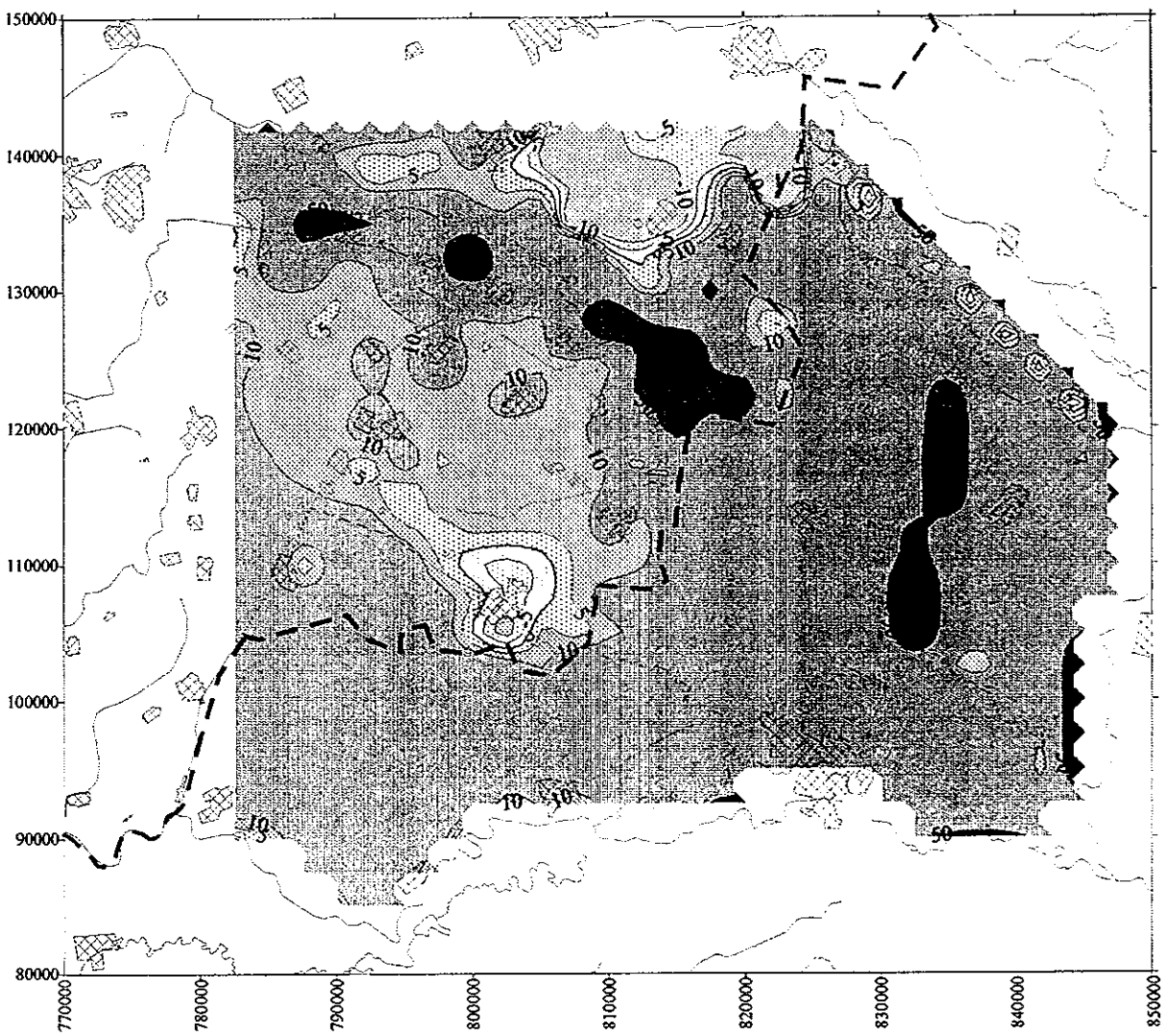
Calculated head in the 2nd layer
the water abstraction doesn't change in the next 10 years
(m above Baltic see level)



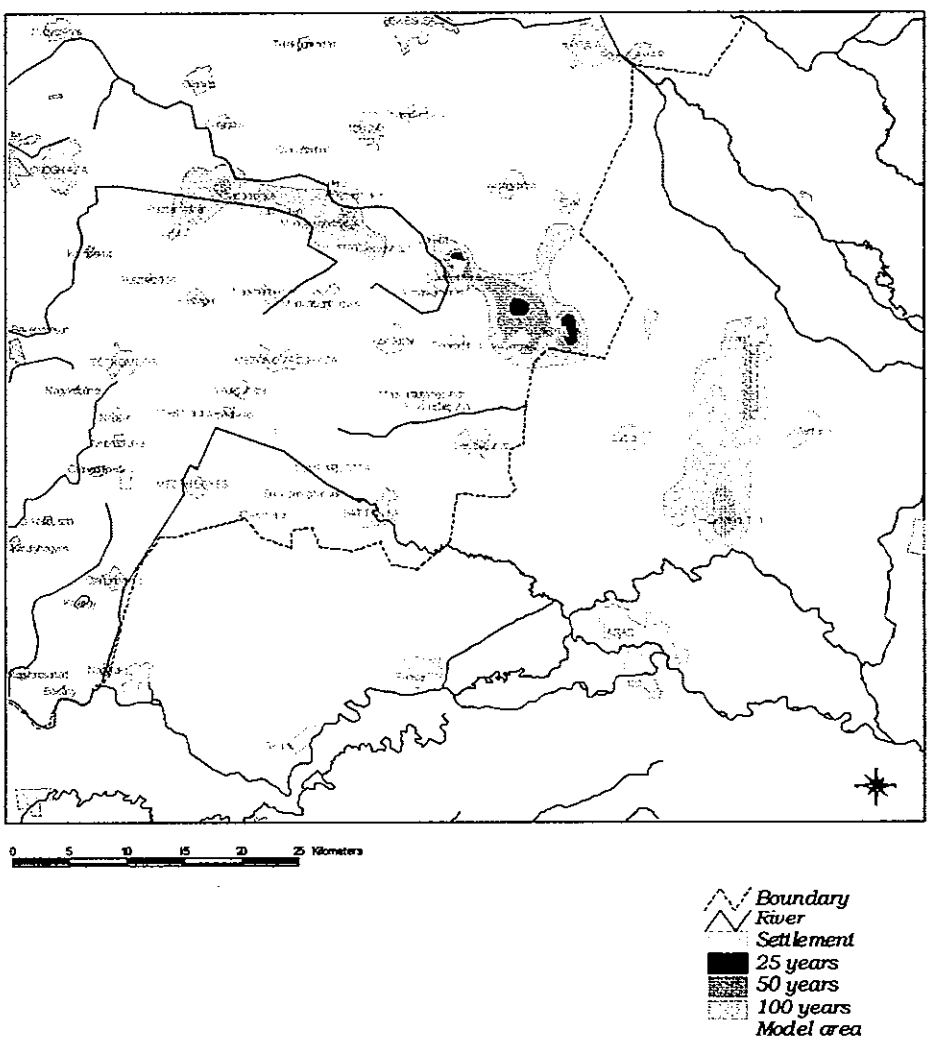
Calculated difference in the heads between the 1st and 2nd layer (cm)



Calculated flux from the shallow groundwater into the deeper aquifer
the water abstraction doesn't change in the next 10 years
(mm/year)



Areas on which the vertical travel time through the shallow aquifer less than 100 years



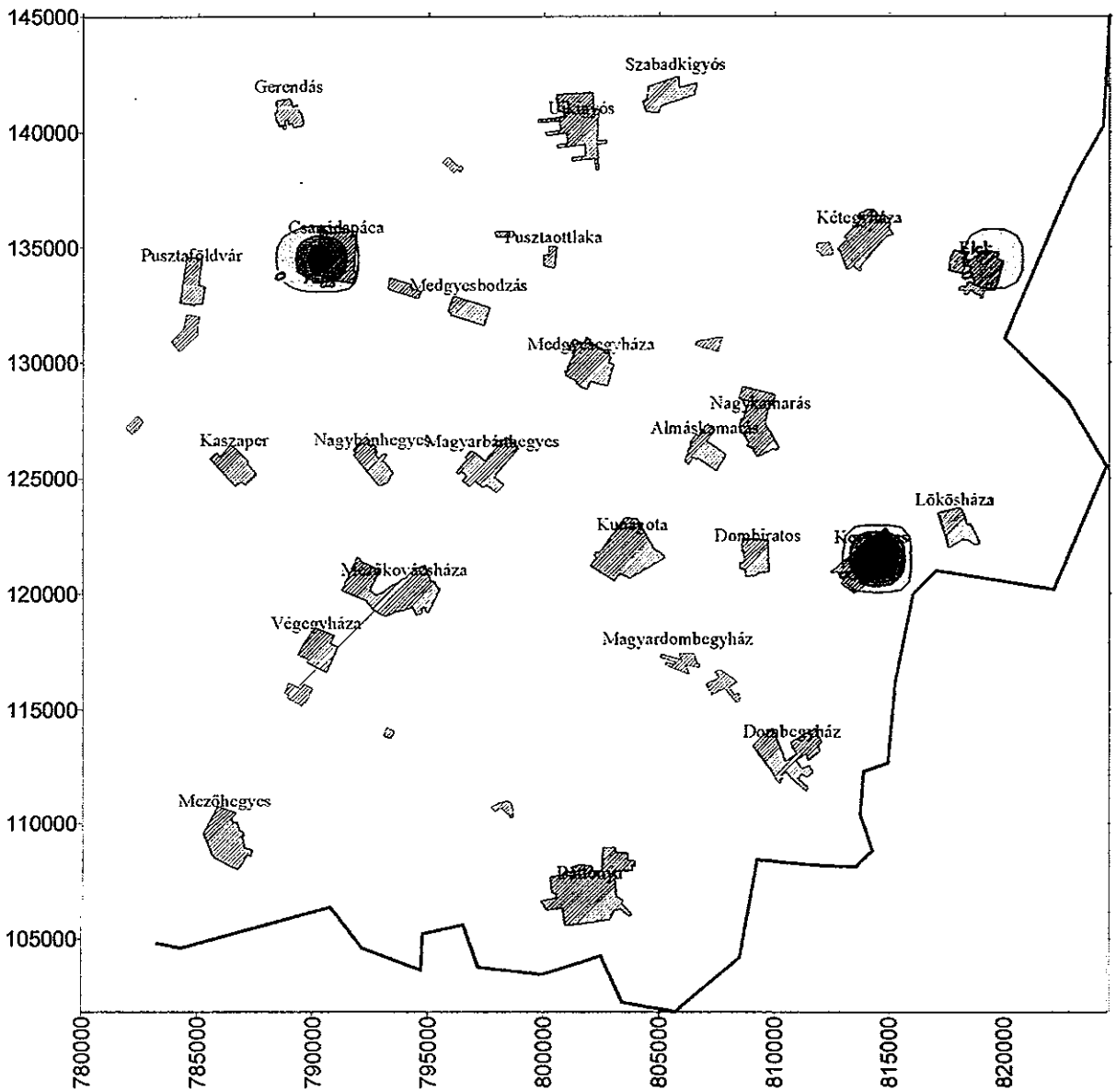
ANNEX 3

CALCULATED CHANGES IN THE POLLUTION CONCENTRATION BY 2006
IN THE 2ND MODEL LAYER

supposing that the abstraction of the groundwater doesn't change

1st scenario

(values show the % of the starting concentration)

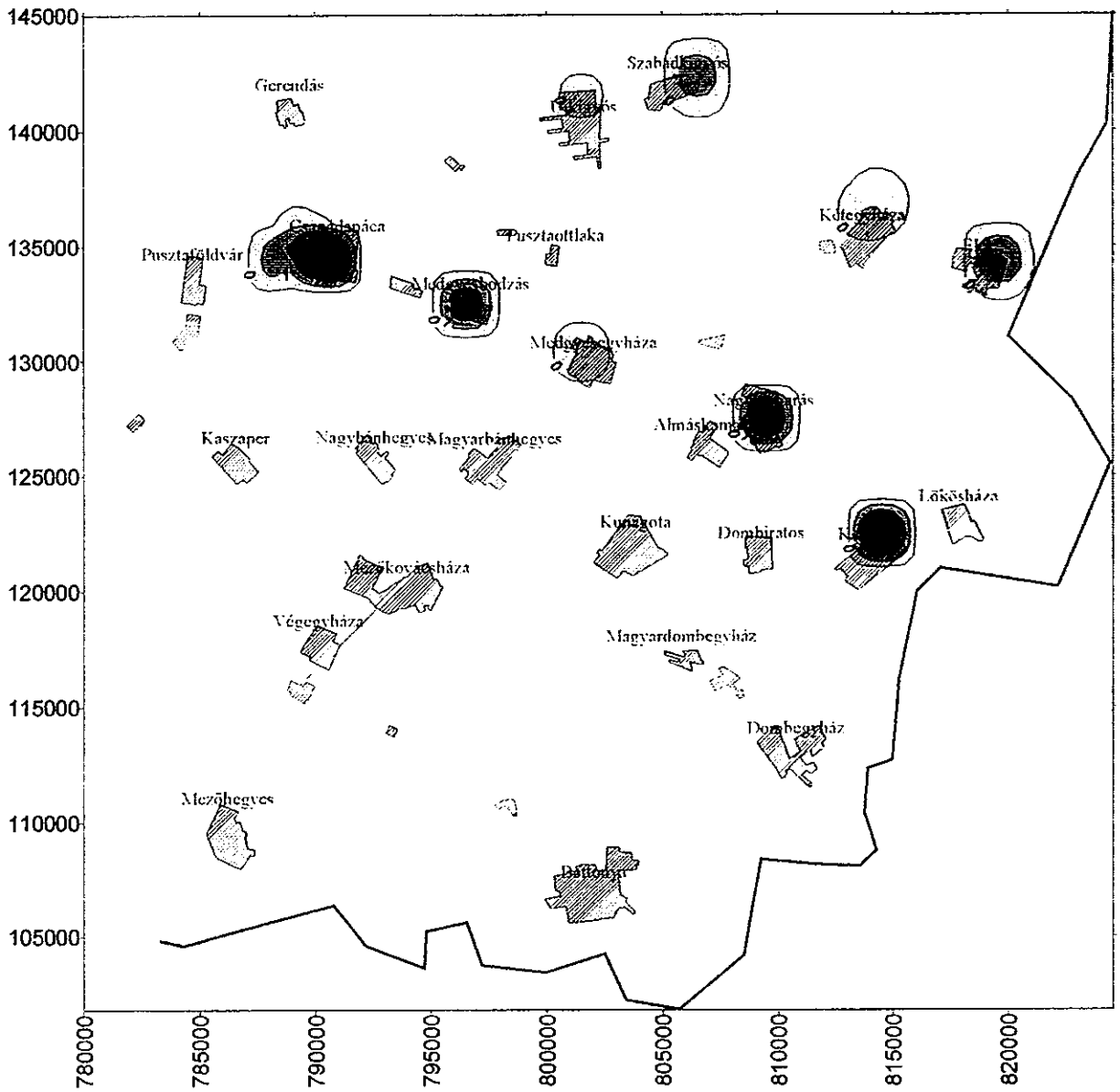


CALCULATED CHANGES IN THE POLLUTION CONCENTRATION BY 2006
IN THE 1ST MODEL LAYER

supposing that the abstraction of the groundwater doesn't change

1st scenario

(values show the % of the starting concentration)

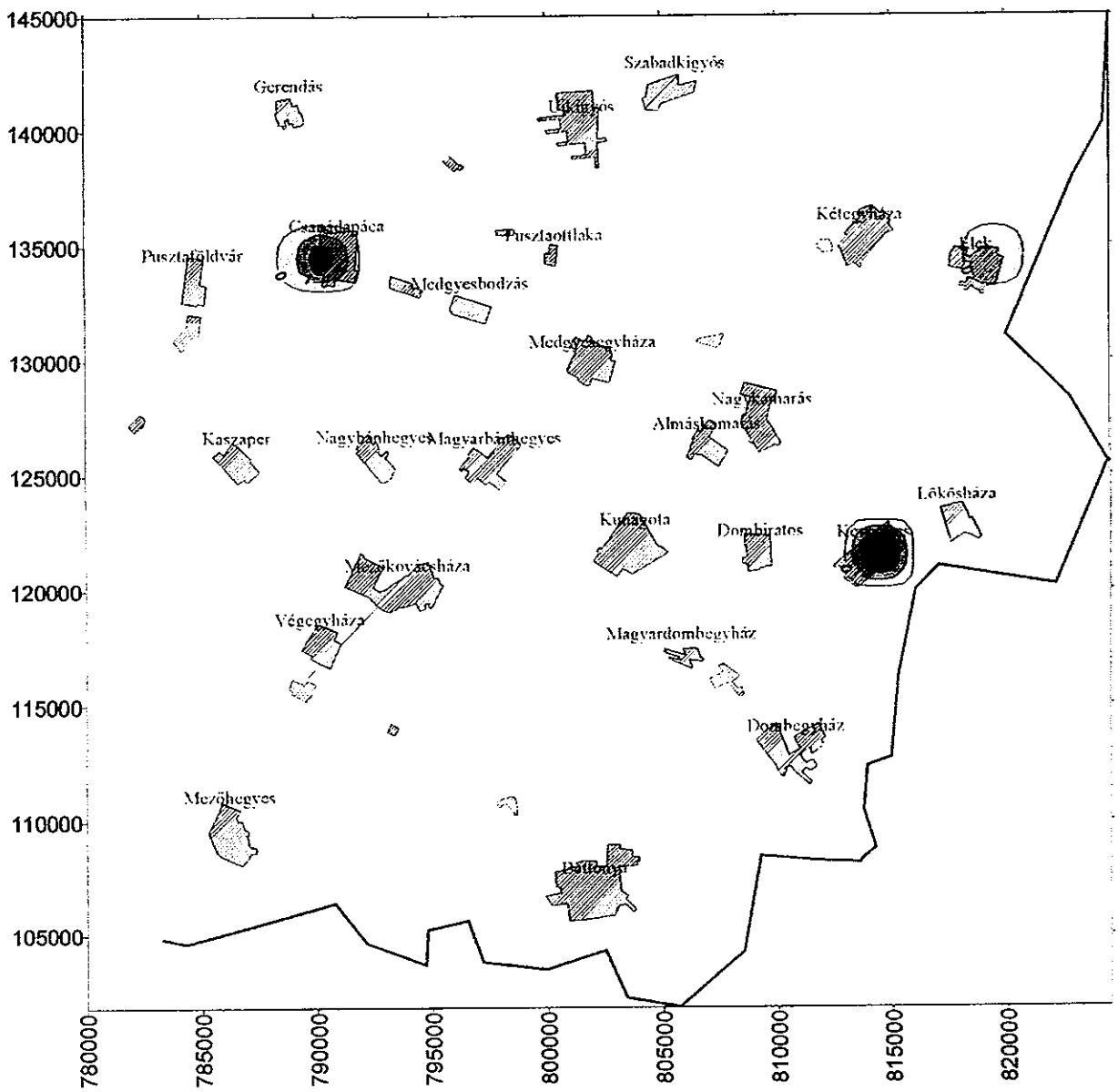


CALCULATED CHANGES IN THE POLLUTION CONCENTRATION BY 2006
IN THE 2ND MODEL LAYER

supposing that the abstraction is increasing with 20% in the next 10 years

2nd scenario

(values show the % of the starting concentration)

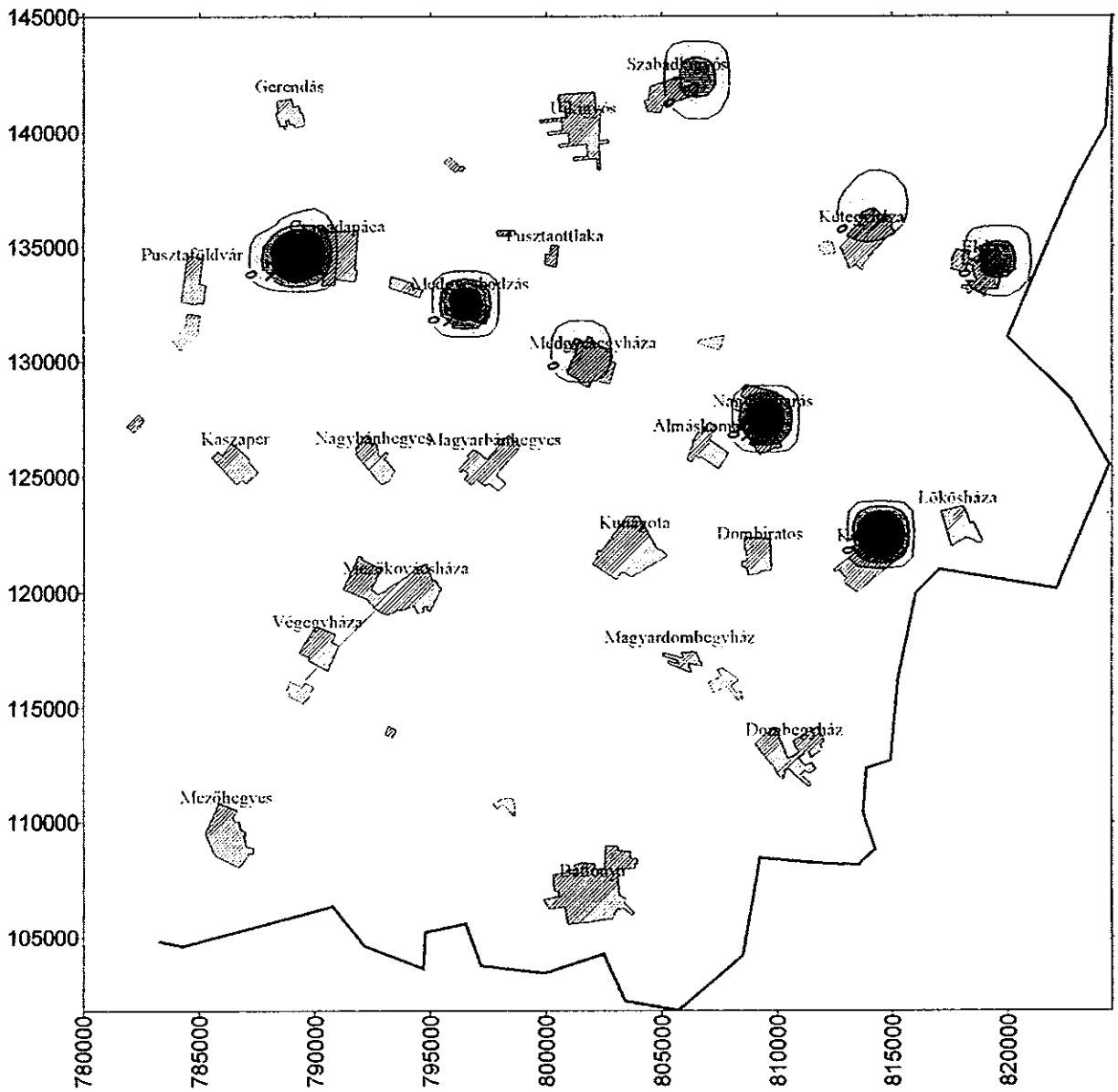


CALCULATED CHANGES IN THE POLLUTION CONCENTRATION BY 2006
IN THE 1ST MODEL LAYER

supposing that the abstraction is increasing with 20% in the next 10 years

2nd scenario

(values show the % of the starting concentration)

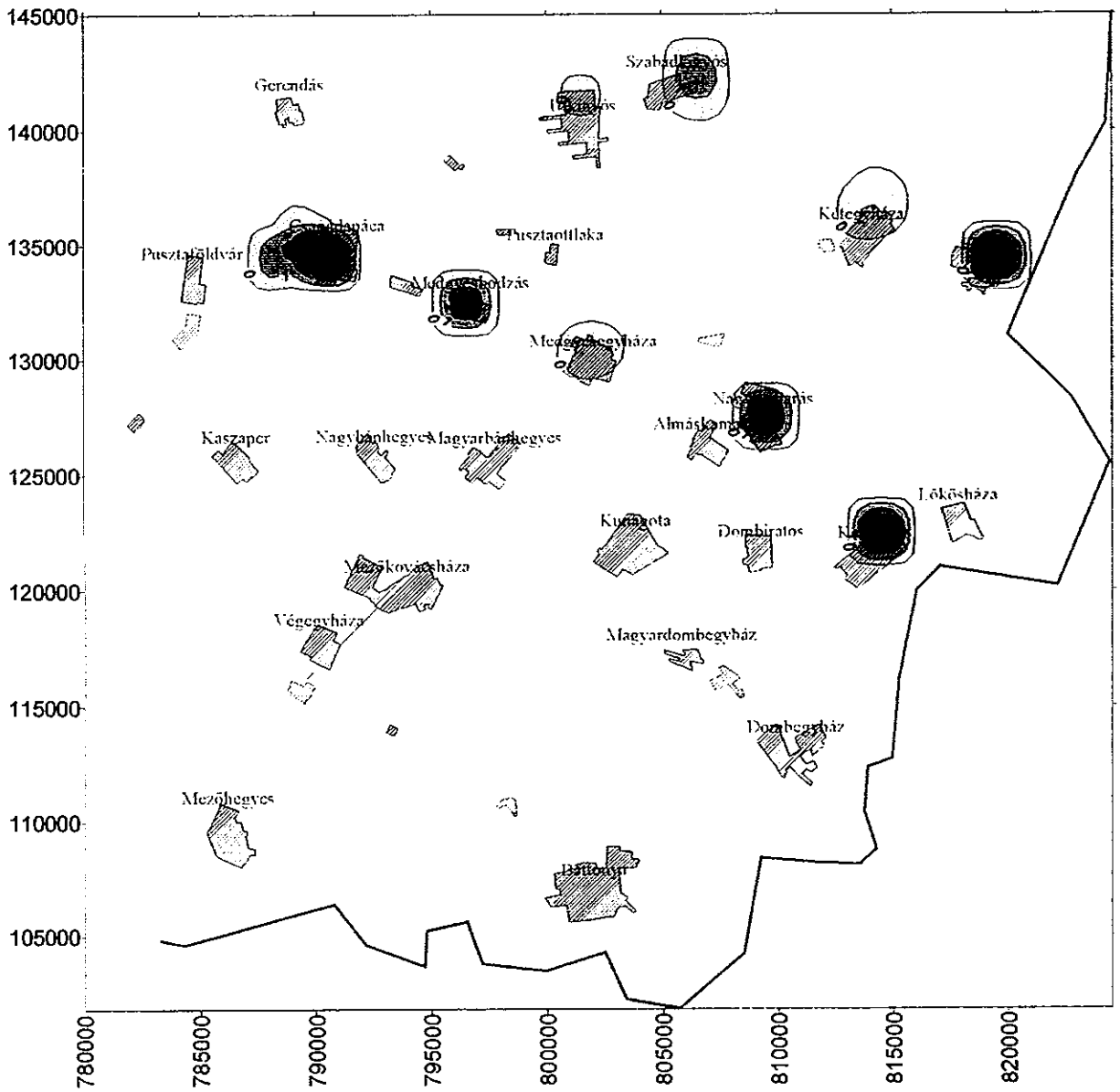


CALCULATED CHANGES IN THE POLLUTION CONCENTRATION BY 2006
IN THE 1ST MODEL LAYER

supposing that the abstraction is decreasing with 20% in the next 10 years

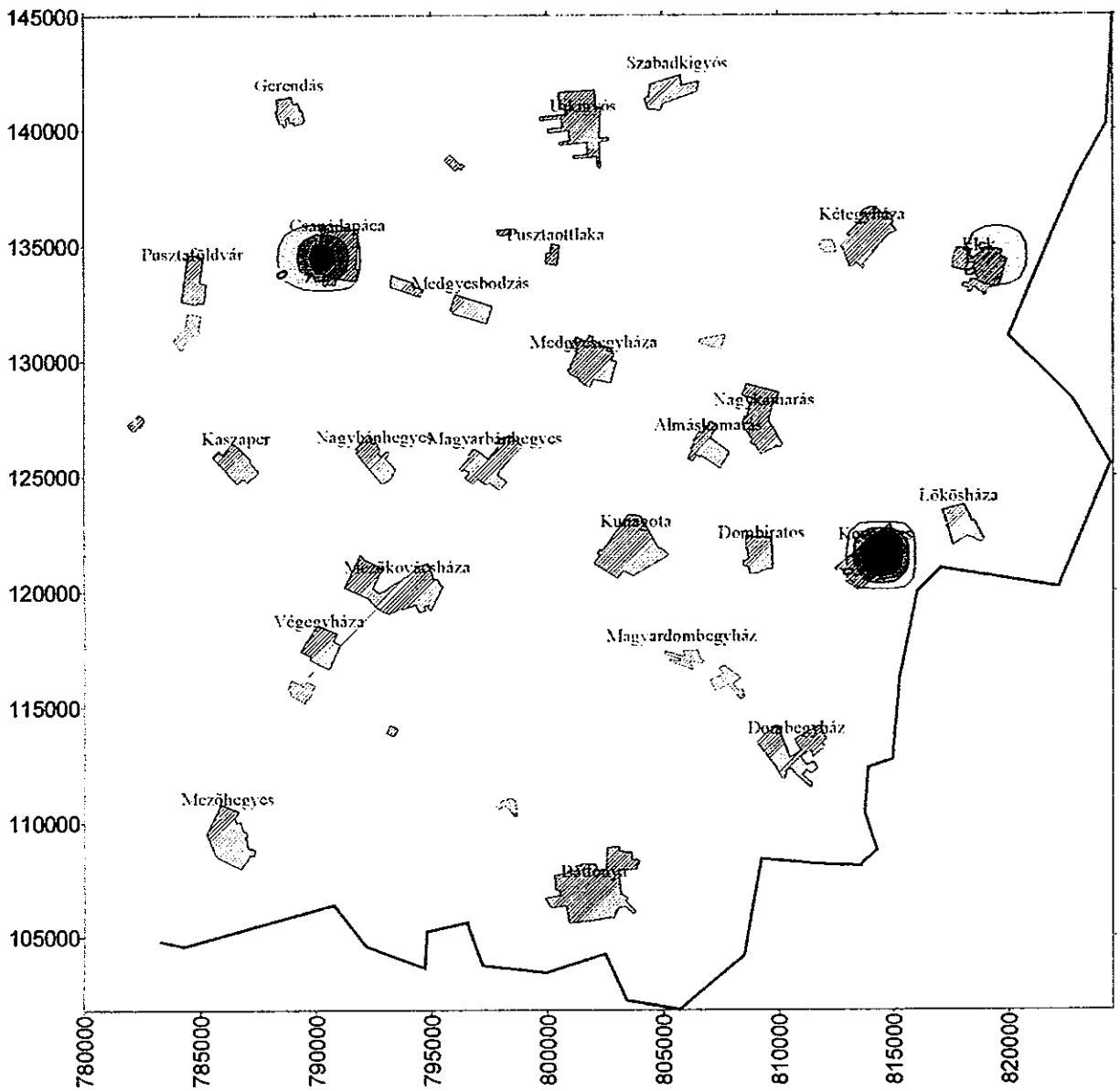
3rd scenario

(values show the % of the starting concentration)



CALCULATED CHANGES IN THE POLLUTION CONCENTRATION BY 2006
IN THE 2ND MODEL LAYER

supposing that the abstraction is decreasing with 20% in the next 10 years

3rd scenario

(values show the % of the starting concentration)