cherts that occur as lens-shaped inliers in Cretaceous and Jurassic limestones. The same may be said for the inhabited south-eastern part of Trnovski Gozd where modest farms are scattered on the border of the plateau from Predmeja, over Otlica, Kovk, Gozd and Križna Gora to Col, Podkraj and Vodice.

Some scattered farms may also be found to the north of the main ridge of the High Karst near Zadlog, Črni Vrh and Lomi. In the western border of Nanos the former Vast pastures are more and more overgrown by vegetation and only two farms remain there. Sparse population and low agricultural activity are relatively favourable to protecting the karst aquifer. But, together with endeavours to protect karst waters, there exists a wish to increase the economic development of these villages. In the past they mostly survived by cattle breeding and forestry. Later local people travelled to work in the valleys, and in factories in Gorica, Ajdovščina, Vipava and Idrija; in recent years they try to get work at home in craft and smaller industries. Former rainwater reservoirs are replaced by piped water supply; water is pumped from lower lying springs and increased quantities of waste water flow mostly untreated, underground. The economic development on Trnovsko-Banjška Planota must as soon as possible be co-ordinated with protection of this important karst aquifer which is capable of supplying the larger and more inhabited valley area of the High Karst around Vipava, Gorica and Idrija with drinking water.

2.2. HYDROLOGY (N. TRIŠIČ)

2.2.1. Basic description of the area

The area of the Trnovski Gozd, the Banjšice, the Nanos, and a part of the Hrušice plateaux hydrologically belongs to the Soča river basin extending over approx. 2000 km^2 in Slovenia, which is almost one tenth of Slovenian territory (Fig. 2.1). The river basin stretches from the central part of the Julian Alps over the pre-Alpine mountains, the territories of Cerkljansko and Idrijsko, the high karst area of the Nanos and the Trnovsko-Banjška Planota, the flysch area of the Vipavska Dolina, to the level gravel-sand accumulation of the Soča and its tributaries on Italian side. In Slovenia, the Soča river basin borders on the Upper Sava river basin, and the Ljubljanica and the Timava river basins, and on Italian side, on the Tagliamento river basin (Fig. 2.1).

The strongest tributaries of the Soča are two left tributaries, the Idrijca and the Vipava, which drain the area of Idrijsko and Cerkljansko, the high karst area of the Trnovsko-Banjška Planota, the Nanos, a part of the Hrušica, and the flysch area of the Vipavska Dolina valley. The entire area can be studied as two separate hydrological units, one of which as the catchment area of the karstic springs of the Vipava, and the other one as the catchment area of the karstic springs at the rims of the Trnovsko-Banjška Planota.

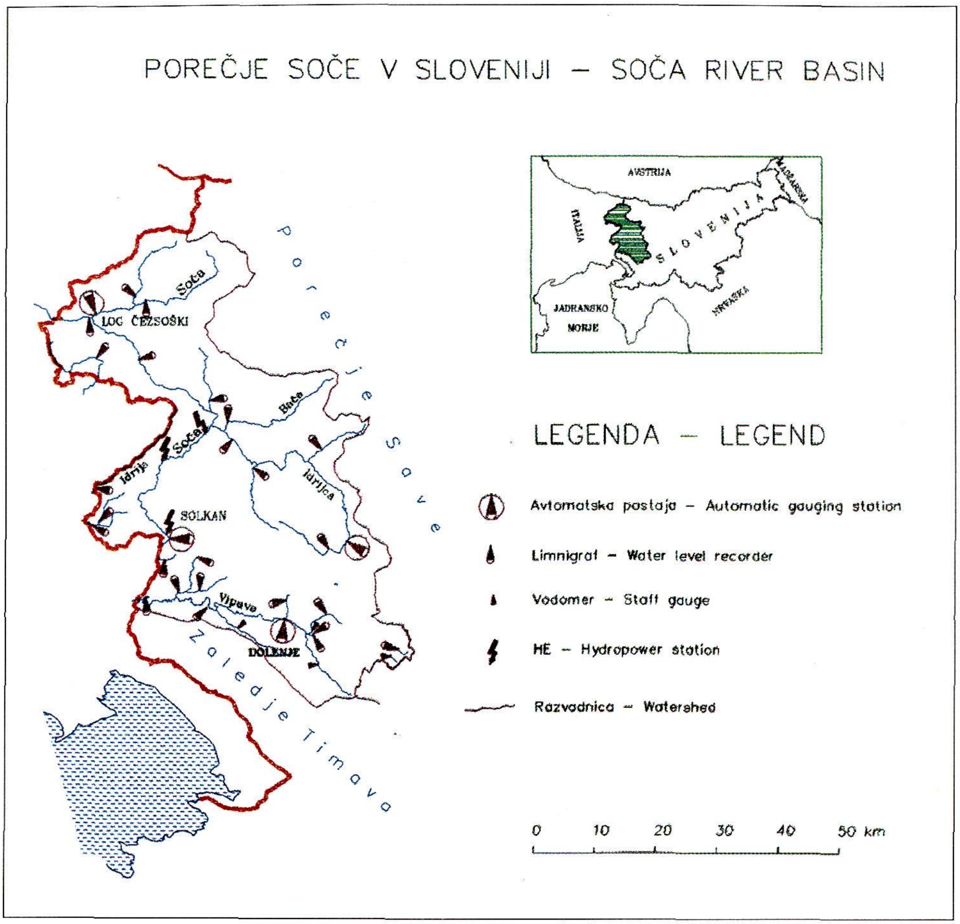

Fig. 2.1: The Soča river basin.

2.2.2. The springs of the Vipava

The karstic part of the catchment area of the Vipava springs stretches over the entire area of the Nanos and a part of the Hrušica, while the part with surface drainage stretches over the flysch river basins of the ponor streams in the basin of Postojnska Kotlina which gravitates towards the Vipava springs.

The size of the catchment area is not exactly determined due to the watershed between the Vipava and the Ljubljanica on the area of the Hrušica where it assumes the karstic features. For the river basin of the Pivka, a partial discharge of its waters to the Vipava springs has been established, which represents the bifurcation between the Adriatic and the Black sea basins

(P. HABIČ 1989). At high waters, the bifurcation was also noticed in the area of the Osojščica ponor stream (HABE 1976). A partial discharge of the Osojščica waters ends in the Belščica which runs towards the Vipava springs, and the other part of its waters drain to the Pivka, i.e. towards the Black sea. The watershed against the Trnovski Gozd is represented by the flysch part of the Bela riverbed, and also the watershed against the Močilnik is surface running and reliable. The catchment area of the Bela stretches over approx. 2 km^2. The low and medium waters of the Bela already sink in the area of Sanabor; only the high water waves run on the surface to the Vipava. The Vipava-0VP Vipava gauging station is located about 500 m downstream of the Vipava springs. This profile includes the discharges of all the permanent springs of the Vipava, and probably, also the medium and low waters of the Bela which sinks under the village Sanabor (Tab. 2.1). Only the high waters of the Bela and the discharges of periodical springs between Vipava (town) and Vrhpolje which are only active at high waters and join the Vipava river downstream from the town, are not included in the gauging profile.

Tab. 2.1: The Vipava-LP Vipava: the 1961-90 characteristic discharges and their ratio (m^3/sec).

Q_{min}	Q_{mean}	Q_{max}	Q_{min} : Q_{mean} : Q_{max}
0.727	6.78	70.0	1 : 9 : 96

Tab. 2.2: The average annual precipitation heights in the catchment area of the Vipava springs (mm).

Nanos-Ravnik	Podkraj	Hrušica	Razdrto	Slap p. Vipavi
1834	2179	2088	1678	1513

The total size of 125.25 km^2 of the catchment area of the Vipava springs also includes about 2 km^2 large catchment area of the Bela. Yet, the data on discharges at the gauging station do not comprise the discharges of the Bela. Since also the springs between Vipava (town) and Vrhpolje are active during the high water situation, the datum on the maximum discharge of the Vipava must be slightly higher than the quoted 70 m^3/sec. Besides, the quoted datum on the size of the catchment area of the Vipava springs is - considering the data on precipitation heights (Tab. 2.2) and runoff - also too small (Tab. 2.3).

Tab. 2.3: The 1961-90 data for the Vipava-LP Vipava profile.

F km^2	Precipitation Q (m^3/sec)	Evaporation (m^3/sec)	Precip. Runoff (m^3/sec)	Q_s (m^3/sec)	difference (m^3/sec)
125.25	7.98	2.51	5.47	6.78	+1.3

Three sides of the catchment area of the Vipava springs border on flysch layers (i.e. the areas of the Močilnik, the Pivka and the Bela), therefore, the only possible way of the catchment area expansion is the area of the Hrušica, at the cost of the catchment area of the Ljubljanica. Mathematically, the catchment area of approx. 150 km^2 would correspond with the data on precipitation (2024 mm) and discharge (6.78 m^3/sec).

A time distribution of the mean monthly discharges shows that two annual maximums occur, the first in April and the second in November, while the lowest mean discharges occur in July and August (Fig. 2.2 and Fig. 2.3). The first maximum of the monthly mean discharges occurs in April and it is higher than that of November, in spite of the fact that precipitation are more abundant in autumn; this is the result of snow melting in the spring months.

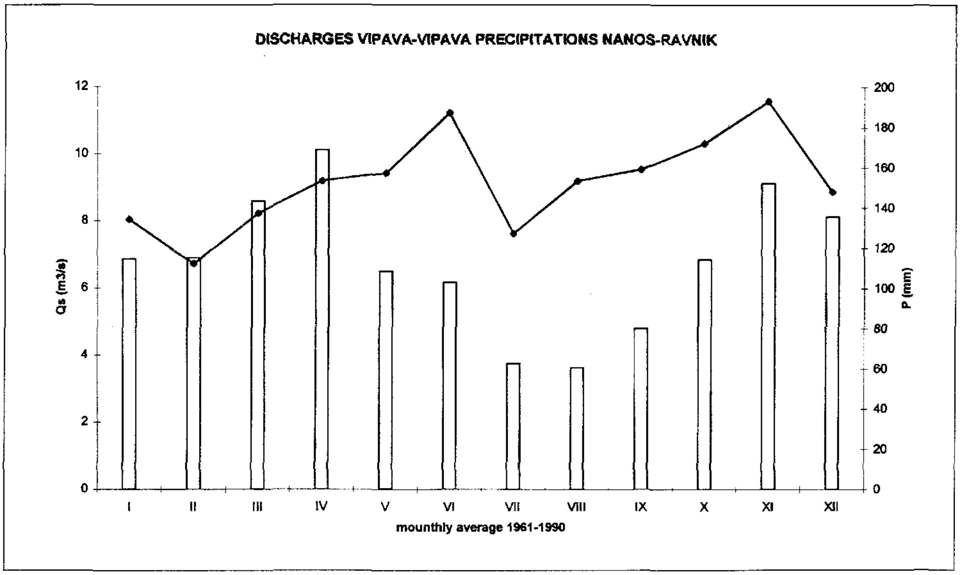

Fig. 2.2: The Vipava monthly mean discharges and monthly mean precipitation in the recharge area (1961-1990).

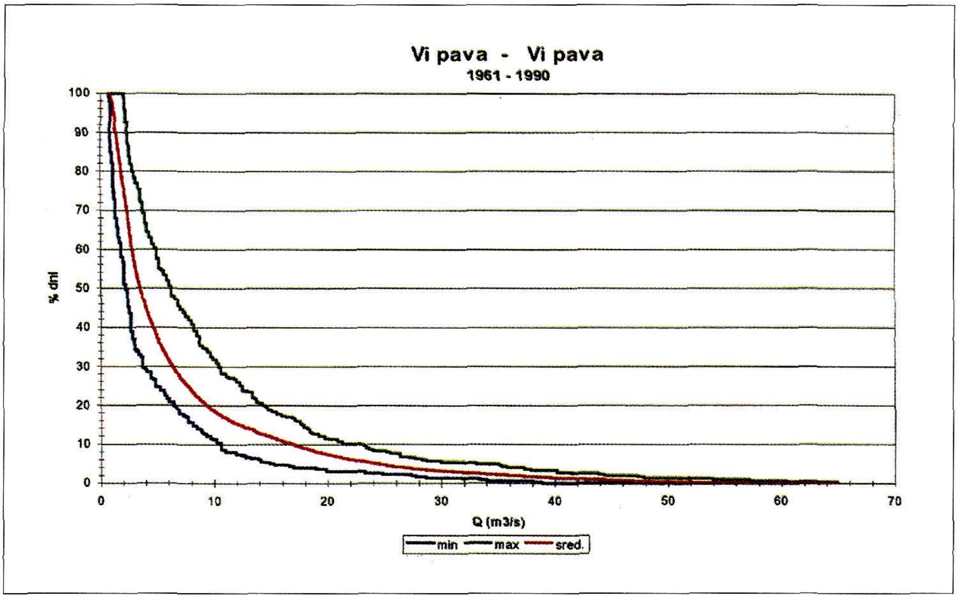

Fig. 2.3: The lines of the 1961-90 discharge duration of the Vipava at the gauging station Vipava.

2.2.3. The area of the Trnovsko-Banjška Planota

The area of the Trnovsko-Banjška Planota which can roughly be limited with the Hrušica area in the east, the Soča river in the west, the Vipavska Dolina in the south, and the valley of the rivers Trebuša, Belca and the Upper Idrijca in the north, stretches over approx. 490 km^2 of the territory. The area is bordered, except for the Hrušica area, with the steep and precipitous slopes. A permanent surface hydrographical network is only developed in the western part of the Banjšice which drains towards the Soča. This area of the so-called hanging barrier stretches over approx. 90 km^2 (see Chapter 2.6) The remaining central part consists of the high karst plateau where the precipitation immediately enter the unsaturated part of the karstic system where the vertical component of percolation prevails. Without the surface part of the catchment area of the Idrijca and the Trebuša, the area of the high karst plateau of the Trnovski Gozd, the Banjšice, the Črnovrška Planota, and a part of the territory towards Hotedrščica, stretches over approx. 350 km^2. The foregoing karstic areas drain entirely into the karstic springs which are arranged at the rims of these plateaux. The largest water quantities are drained by the springs Divje Jezero, Podroteja, Mrzlek, Lijak and Hubelj, and a minor share by the spring Hotešk ob Idrijci and the springs in the Soča valley (Vogrščɛk) and the Avšček valley (Bolterjev Zdenc and Kajža).

The gauging profiles for the registration of discharges from the karstic part of the plateau are fixed at the following locations:

Idrijca - Podroteja
Lijak - Šmihel
Hubelj - Ajdovščina

Idrijca - LP Podroteja

The Idrijca - Podroteja gauging profile comprises the discharges as from the springs Divje Jezero and Podroteja, as from the surface part of the catchment area of the Idrijca and the Belca (Fig. 2.4 and 2.5). The surface part of the catchment area stretches over approx. 50 km^2 and exerts impact on the water regime at the gauging profile to such an extent that the karstic regime of drainage is obliterated. The size of the catchment area of 112.84 km^2 taken into account for the gauging profile, is also mathematically too small (Tab. 2.4, 2.5 and 2.6). The karstic part of the catchment area spreads towards the area of Hotedrščica where bifurcation with the Ljubljanica was established (3.SUWT), and also in the Trnovski Gozd massif, the watershed cannot be determined since the bifurcations were established in the areas of Vodice and also of Črni Vrh (HABIČ 1987).

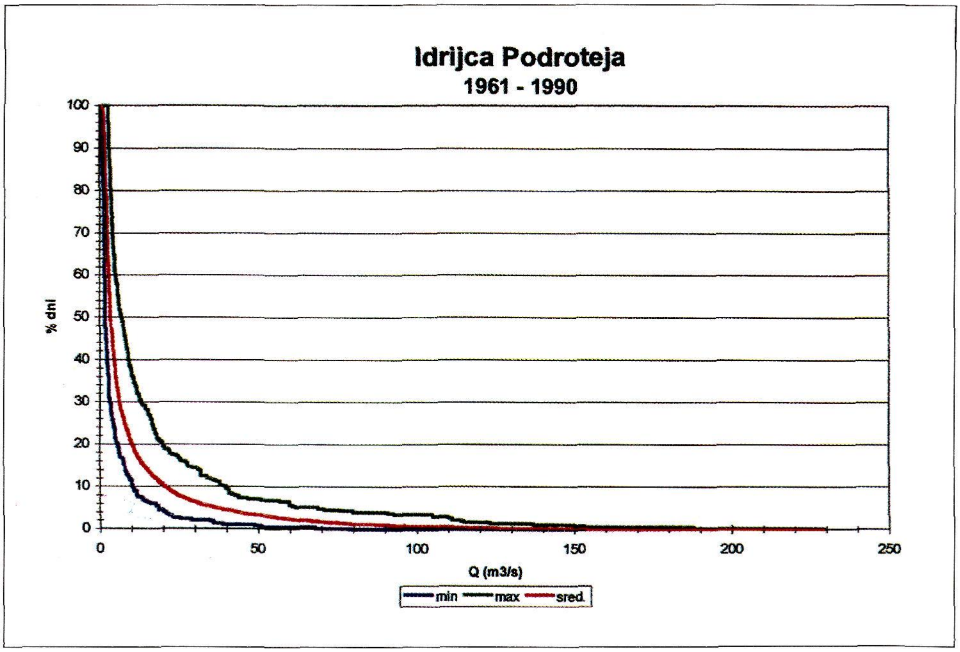

Fig. 2.4: The lines of the 1961-90 discharge duration of the Idrijca at the LP Podroteja gauging profile.

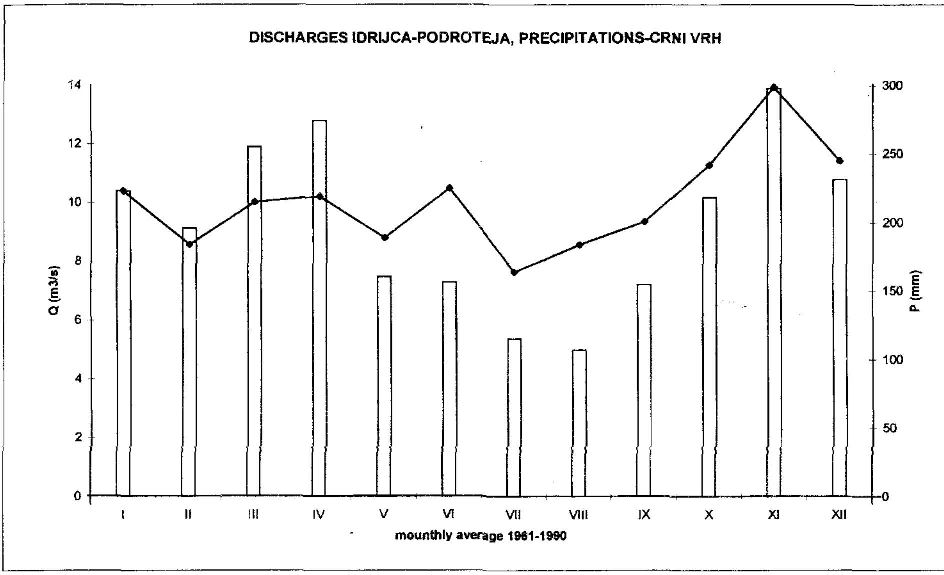

Fig. 2.5: The average monthly precipitation in the catchment area of the Idrijca and the mean monthly discharges (1961-1990).

Tab. 2.4: The 1961-90 data for the Idrijca - LP Podroteja profile.

F km^2	Precipitation Q (m^3/sec)	Evaporation (m^3/sec)	Precipit. runoff (m^3/sec)	Q_s (m^3/sec)	difference (m^3/sec)
112.84	9.20	2.21	6.99	9.75	+2.3

Tab. 2.5: The characteristic discharges of the 1961-90 period at the Idrijca-Podroteja, and their ratio (m^3/sec).

Q_{min}	Q_{mean}	Q_{max}	Q_{min} : Q_{mean} : Q_{max}
0.84	9.29	306	1 : 11 : 364

The ratio between the maximum and the minimum discharges of the Idrijca at the LP Podroteja gauging profile is so high exactly due to the surface part of the catchment area (Tab. 2.5).

Tab. 2.6: The average annual precipitation in the catchment area of the Idrijca (mm).

Črni Vrh	Idrijska Bela	Mrzla Rupa	Vojsko
2589	2623	2784	2450

Lijak - Šmihel

In the gauging profile at the Lijak - Šmihel station discharges are registered of the periodically active springs, which are only an overflow of high waters from the catchment area of the Mrzlek spring. The hydraulic link between these two springs has been confirmed. At low waters, the water level of the Lijak oscillates parallel to the oscillation of the water level in the Solkan hydropower-plant reservoir, and the gradient towards the Soča is minimal. When the spring Lijak is active, the water table in its karstic catchment area rises even more than by 40 m. There were no continuous observations of the spring in the 1961-90 period, therefore, the characteristic data for that period are missing. The highest registered discharge is 32.6 m^3/sec, but a greater part of a year the spring is dry.

The catchment area of the Lijak can also be considered as a bifurcation area since the high waters of the spring also gravitate towards the Vipava, and when the spring is not active, all the waters from the catchment area gravitate towards the spring Mrzlek, i.e., to the Soča. The regime of the Lijak spring demands a special interpretation of water balance, since the high water waves exert impacts on the discharge regime of the lower section of the Vipava, but the size of its belonging catchment area cannot be defined. The correlation with the Hubelj spring was studied for the Lijak spring; it shows a strong dependence between the regimes of both springs (MUŽIČ 1986).

Hubelj - Ajdovščina

The gauging station is located less than 2 km downstream of the Hubelj spring. At the spring itself, water is tapped for the water supply, which reduces the volume by 50 to 150 l/sec.

The orographically determined size of the catchment area (F = 85.25 km^2) for the gauging station on the Hubelj is too big, therefore the calculation of water balance gives so great a difference between the calculated and the gauged runoffs (Tab. 2.7). The theoretically calculated size of the belonging catchment area measures approx. 50 km^2 (STAHL 1994).

Tab. 2.7: The 1961-90 data for the Hubelj - VP Ajdovščina profile.

F km^2	Precipitation Q (m^3/sec)	Evaporation (m^3/sec)	Precip. runoff (m^3/sec)	Q_s (m^3/sec)	difference (m^3/sec)
85.25	6.64	1.76	4.89	3.03	-1.9

Tab. 2.8: The characteristic discharges of the 1961-90 period at the Hubelj - VP Ajdovščina, and their ratio (m^3/sec).

Q_{min}	Q_{mean}	Q_{max}	Q_{min} : Q_{mean} : Q_{max}
0.185	3.03	59.5	1 : 16 : 322

The Q_{max}/Q_{min} coefficient is high and speaks in favour of the fact that in the case of the Hubelj spring its maximum discharge is not suppressed (Tab. 2.8).

Tab. 2.9: The average annual precipitation heights in the catchment area of the Hubelj (mm).

Ajdovščina	Lokve	Otlica	Podkraj
1553	2381	2409	2179

The largest quantity of precipitation in the catchment area of the Hubelj spring falls in November, on average, while the mean monthly discharges of the Hubelj are the highest in April when snow begins to melt (Fig. 2.6 and 2.7, and Tab. 2.9).

The distribution of the maximum discharges in all three discussed gauging profiles do not offer any law; but from the distribution of the minimum discharges, the influence is clearly visible of the water reserves from the snow cover, even on the minimum discharges in the summer months. The minimum discharges of the Hubelj and the Vipava occur in February, and in September or October, and they are practically equal, while the autumn minimum discharges of the Idrijca are essentially lower than those in February (Fig. 2.8).

The quoted basic hydrological conditions of the discussed area and the springs already represent the hydrological problems which are typical of the karstic hydrological systems (Fig. 2.9). Besides the inaccurately determined sizes of the catchment areas and the directions of water streams in the system, an additional uncertainty occurs in the area of the Trnovski Gozd and the

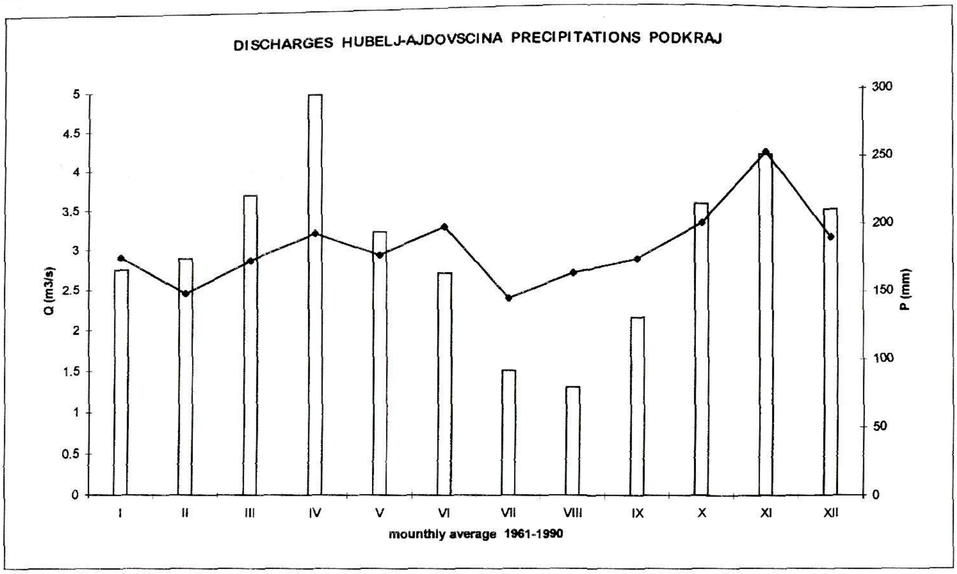

Fig. 2.6: Mean monthly discharges of the Hubelj and mean monthly precipitation in the 1961-90 period.

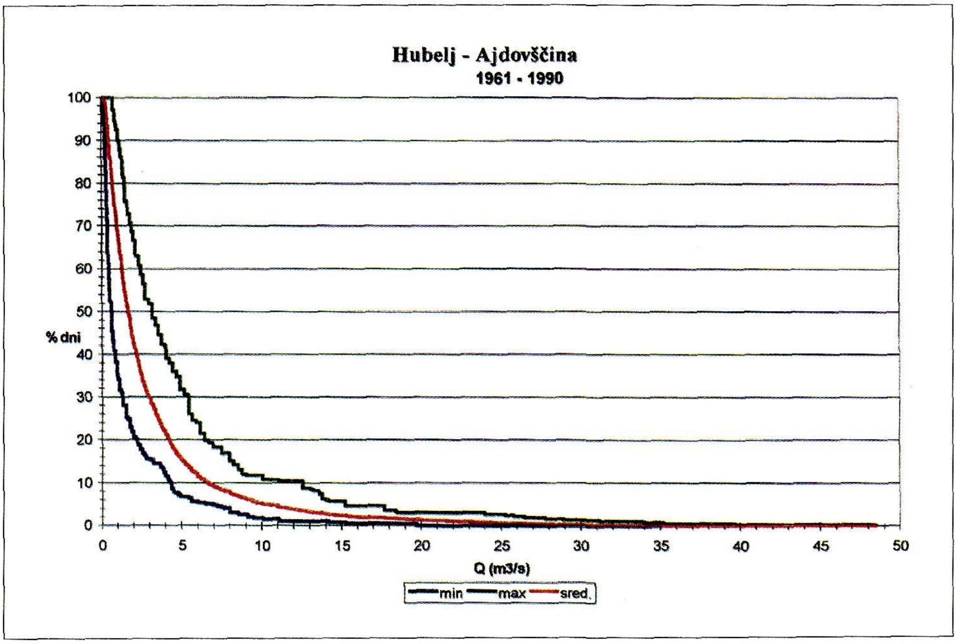

Fig. 2.7: The lines of the 1961-90 discharge duration of the Hubelj at the VP Ajdovščina gauging station.

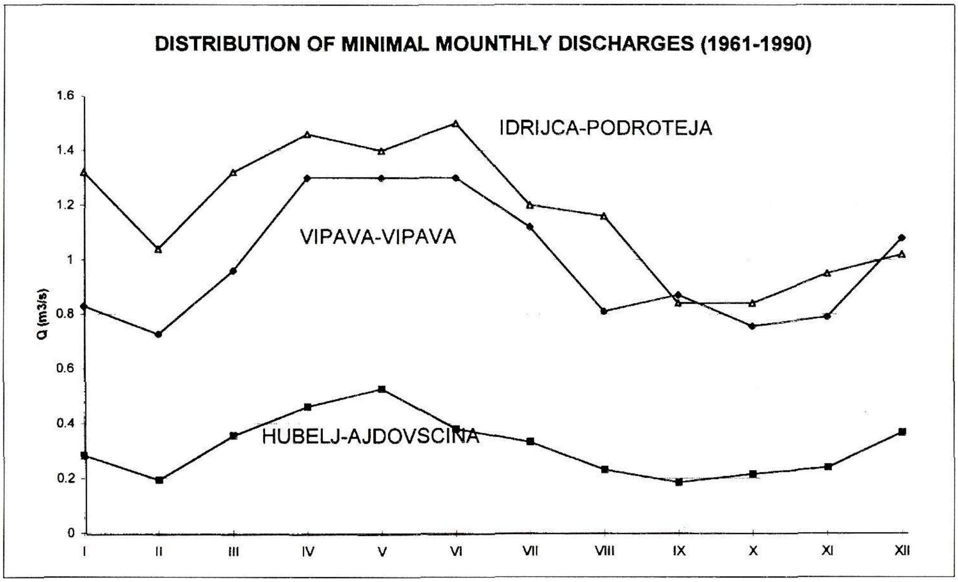

Fig. 2.8: The distribution of the minimum monthly discharges in the 1961-90 period.

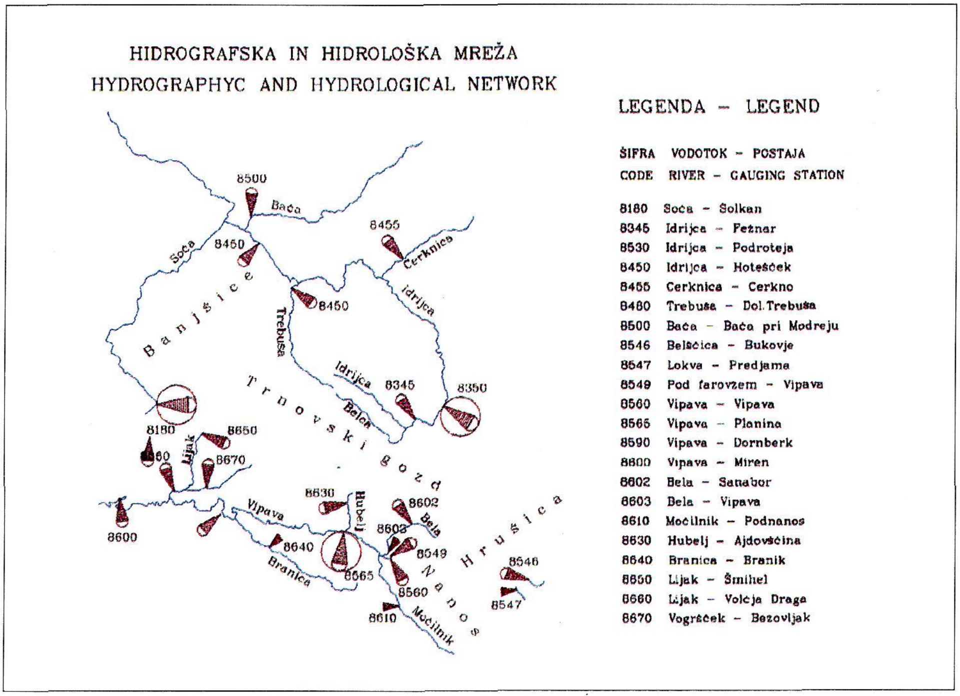

Fig. 2.9: Hydrographic and hydrological network.

Banjšice, which further aggravates the comprehension of hydrological conditions. These are the unspecified discharges of the Mrzlek spring which flows into the Soča in the area of the Solkan HPP reservoir and, thus, cannot be directly gauged.

2.3. THE CLIMATE OF THE TRNOVSKO-BANJŠKA PLANOTA (J. PRISTOV)

2.3.1. Meteorological conditions

The Trnovski Gozd, the Banjšice and the Nanos are the first mountain barrier (the altitudes of peaks between 1000 and 1500 m above sea level) on the way from the Mediterranean, or the Northern Adriatic, towards the north and the north-east. Naturally, there is the Kras plateau before it, yet, it mainly does not exceed the altitude of 600 m. Therefore, the orographic precipitation are modest on the Kras, but they already become rather abundant at the barrier running from the Banjšice to the Nanos, and they are the most abundant at the southern part of the Julian Alps. There, the altitudes of the peaks already reach approximately 2000 m, and the average annual precipitation already amounts to 4000 mm, which is the highest value in the Alps. This barrier represents a divide between the Mediterranean and the Alpine climates. The Vipavska Dolina and Goriško region, both located at the southern rims of the Trnovski Gozd, are under the intense influence of the Mediterranean climate. Yet, the Trnovski Gozd, the Banjšice and the Nanos already have the real Alpine climate with the abundant snow during the rather cold winters.

The precipitation are abundant all year round, with the explicit maximum in October and November. In the heart of the Trnovski Gozd, i.e. the area of Golaki, they exceed the precipitation average over the period of 30-years, which is 3000 mm, and also the entire area of the Banjšice, the Trnovski Gozd and the Nanos, annually receives over 2000 mm of precipitation, on the average.

The most intense precipitation very often occur in October, up to 900 mm (Vojsko 888 mm; Mrzla Rupa 855 mm; Otlica 702 mm), but on the average, October is not the wettest month. Namely, oscillations of precipitation quantity are extremely sharp in this month: on the one hand, the monthly precipitation extremes occur with heavy precipitation, and on the other, this month often receives the minimum precipitation and sometimes - although it happens rarely - they do not fall at all (in 1965). November is the month with the largest average quantity of precipitation, yet the oscillations are not as sharp as in October, and therefore, the annual extremes do not occur in this month. Although rarely, but very heavy precipitation also occur in the month of September.