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THE STRUCTURE OF THE WATER CONSTRUCTIONS IN THE SEBEŞ HYDROGRAPHIC BASIN AND THE STORAGE RESERVOIRS' EFFECT ON THE AVERAGE DISCHARGE

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Abstract

In the upper basin of the Sebeş Valley, the oldest storage lakes have been temporary artificial lakes, called "haituri" in Romanian. They were created within the forest exploitation areas. Inside the dams of those retention lakes, which dams are made of a wooden skeleton, filled with soil and stones, there have been weirs for the quick discharge of the water, having the purpose of creating some flood trends, capable of carrying over the logs, downstream the lake. At present, some of those temporary artificial lakes are used as trout farms, while others are damaged, or operate as basins for the sedimentation of the alluvial deposits. The difference of level between the springs of the Sebeş and the Mureş Rivers generates a convertible hydroelectric potential, having an average power exceeding 60,000 kW.

Keywords: reservoirs, discharge, Sebes River

STRUCTURE OF THE WATER CONSTRUCTIONS IN THE SEBEŞ HYDROGRAPHIC BASIN

The Chart of the hydroelectric construction of the Sebeş hydrographic basin contains a cascade of stations, as follows:
- Step I : Gâlceag Hydroelectric Power Station, and Oaşa storage reservoir;
- Step II: Şugag Hydroelectric Power Station and Tău storage reservoir;
- Step III: Săsciori Hydroelectric Power Station and Nedeiu storage reservoir;
- Step IV: Petreşti Hydroelectric Power Station and Petreşti storage reservoir;

Depending on how the waters of Sebeş River are employed, the existing uses of the hydrographic basin may be classified as follows:

- *Permanent storages* – Oaşa and Tău, intended to retaining water for a longer time, its normal use being to maintain the storage lakes full, and to reduce the eventual floods which might occur in the upper basin of the river;
- *Regulation storages* – Nedeiu and Petreşti, having the function to redistribute the flows regularized, to provide other conditions or effects downstream. Those correction storages, having the function of daily regulation are also called buffer storages (Teodorescu, 1976).
- *uses having a permanent or temporary regime* – water intake, bypassing and water consumers, having the function to regularize discharge, level and volumes of the storages or of the river;
- *energetic uses* - hydroelectric power stations - Gâlceag, Şugag, Săsciori and Petresti, which serve the Oaşa, Tău, Nedeiu and Petreşti storages, and take water from those storages, by means of penstocks, and discharge it by means of spillway tunnels.

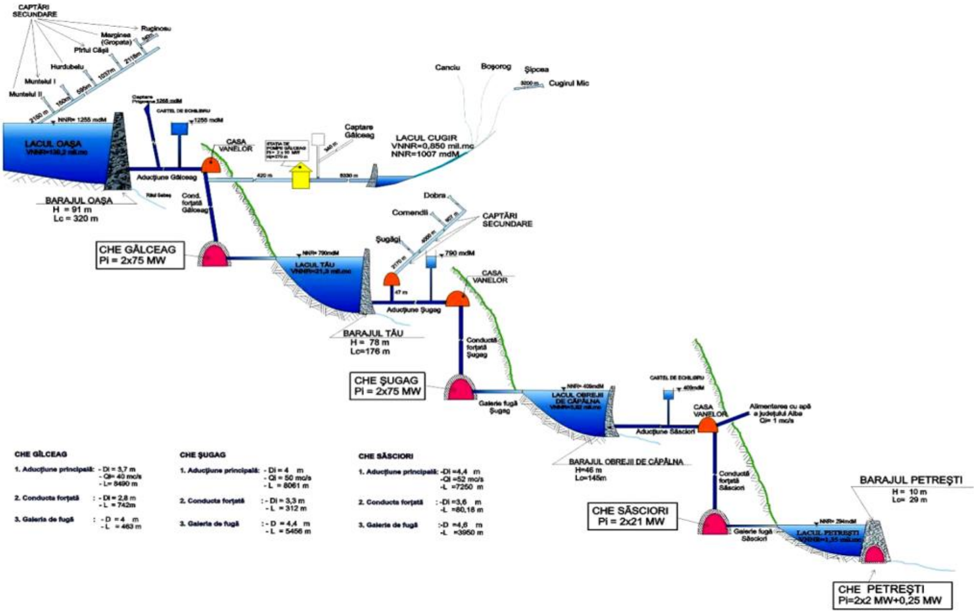

Fig. 1 Hydroelectric Constructions along the Sebeş River

Step I - Oaşa – Gâlceag is made up of Oaşa storage reservoir and dam, the main penstock, that is Oaşa – Gâlceag, the pressure joining point and Gâlceag power station, as well as Ciban secondary bypass, along with the secondary intakes, pertinent to: Mountain I, Mountain II, Hurdubelu, Pârâul Căşii, Marginea, Ruginosu.

Oaşa storage and dam, represent the main hydroelectric step of the Sebeş River, and has a total volume of 136.23 mil. m^3, an efficient volume of 121.23 mil. m^3, and a surface of 454.73 ha, at normal retention level. The main function of Oaşa storage is to produce electricity inside Gâlceag hydroelectric power station, served by the former.

Oaşa Dam (fig. 2) is a dam made of rock fill and a 91.0 m high concrete steel mask. The crest of the dam is about 320.00 m long and 10 m wide.

The main penstock of Oaşa Dam, namely Oaşa-Gâlceag, is built as a roughly 8.5 km long gallery, which penstock collects the waters of the Prigoana River, as well, which waters are taken for sampling by means of a secondary intake.

A major component of the Gâlceag hydroelectric power station is represented by Cugir storage, which is placed on the Cugirul Mare River, and the construction has a permanent character and a water volume of about 0.985 mil m^3.

Gâlceag power station is underground, being cavern-shaped, and is placed on the left bank of the Sebeş, 480 m away from the Sebes-Gilceag confluence. It is equipped with two hydro-generators, and its installed power is of 150 MW, and its installed flow is of 40 m^3/s, and the calculated waterfall is of 430 m.

Fig. 2 Oaşa dam and storage

The intakes adjacent to Oaşa storage are the following:

- *the Ruginosu secondary intake* - is placed around the thalweg level of 1,280 mdM. Within the emplacement area, the valley sums up a hydrographic basin of a surface S = 6.6 km^2, and a module flow Q = 0,136 m^3/s;
- *Ciban secondary intake* - is placed around the thalweg level of 1,273.00 mdM, and in the emplacement area, the valley sums up a hydrographic basin of S = 31.3 km^2 and has a module flow Qm = 0.72 m^3/s;
- *Pâraul Căşii secondary intake* - is part of the secondary intake group placed on the secondary penstock of Ciban. It is placed around the thalweg level of 1,277.50 mdM, and in the emplacement area, the valley has a surface of the hydrographic basin S = 4.2 km^2 and a flow Qm = 0.100 m/s;
- *Hurdubelu secondary intake* – has a surface of the hydrographic basin in the intake zone of S = 3.10 km^2 and a flow of Qm = 0.074 m^2/s;
- *the secondary intake of Mountain I* - is part of the secondary intake group placed on the secondary penstock of Ciban. It is placed around the thalweg level of 1,259.30 mdM, and in the emplacement area, the valley gathers the waters of a basin with an area of S = 0.7 km^2 and has a module flow of Qm = 0.043 m/s;
- *the secondary intake of Mountain II* – has a surface of the hydrographic basin of S = 2.10 km^2, and a module flow of Q = 0.043 m^3/s;

Step II – Tău-Şugag is made up of the Tău storage reservoir and dam, the main penstock Tău-Şugag, a pressure joining point and the Şugag power station, as well as the secondary bypass - Dobra, along with the relevant secondary intake: Şugăgi and Comendii.

Tău storage (see fig. 3) has been created on the Sebeş River, at its confluence with the Bistra River, and the storage dam is made of concrete, being arch-shaped and having a double bending. Tău Lake lies upstream from the Gâlceag power station.

Şugag power station is underground, being cavern-shaped and equipped with two Francis turbines of 75 MW each. The installed power is of 150 MW, and the installed flow is 50.0m^3/s.

The secondary bypass from Dobra collects the waters of the Dobra, Comedii and the Şugagi Rivers, by means of a secondary intake, and through a 50.0 m high connection well, it discharges its waters in the Tău–Şugag penstock.

Fig. 3 Tău dam and storage

The intakes adjacent to Tău storage are the following:

- *the Dobra secondary intake* has been built as an intake on the river, and, in the intake area, the valley has a surface of the basin of S = 39.2 km^2 and a module flow of Qm = 0.55 m^3/s;
- *The Comendii secondary intake* has a width of about 6.0 m, an area of the hydrographic basin of S = 1.42 km^2, and a module flow of Qm = 0.033 m^3/s;
- *The Şugăgi secondary intake* – has a width of about 14.0 m, an area of the hydrographic basin of S = 16.3 km^2 and a module flow of Qm = 0.226 m^3/s;

Step III, is represented by Nedeiu storage and the Săsciori hydroelectric power station.

Nedeiu storage (Obreja de Căpâlna, see Fig. 4) has a total volume of 3.92 mil. m^3, at normal retention level and an efficient volume of 1.80 mil. m^3. The area of the lake is of about 35.2 ha, at normal retention level.

Nedeiu Lake provides the raw water for the drinking water micro-system of Alba County (starting from June 29, 1996), according to the table below.

Table no.1

The main use of the water provided by the Nedeiu construction

POPULATION			
Name	Operation regime	Approved flows (m^3/s)	
		Average flow	Minimum necessary flow
Drinking water micro-regional system of Alba County	24h/day	1.00	0.80

Săsciori power station is underground, placed on the right bank of the Sebeş River, and is equipped with two Francis turbines, having an installed power of 42 MW.

Fig. 4 Nedeiu Dam

Step IV is made up of the Petreşti storage and Petreşti hydropower station.

Petreşti storage provides the raw water needed to supply Sebeş town and its industrial zone with drinking water. Petreşti storage reservoir has a gross volume of 1.35 mil. m^3, and its area is of about 25 ha, at normal retention level.

Fig. 5 Dam of Petreşti storage

Petreşti power station (fig. 5) is an overhead dam-type station, with a 22 m built height and a 9.5 m calculated waterfall. It is equipped with two aggregate equipments, each one having an installed flow of 26 m^3/s and a power of 2 MW, on each group.

INFLUENCE OF THE STORAGE RESERVOIRS ON THE AVERAGE DISCHARGE

The average discharge (water balance element) is directly influenced by the relief and by its slope. Therefore, the average discharge chart closely copies the relief map.

Analysing the map, it results that:

- the highest discharge is achieved in the basin's high zone – 30.0 l/s km^2, where the supply source of the hydrographic networks is richer: precipitations exceeding 1,200 l/m^2; a high snow layer, having a high water equivalent; a very high vegetation-covering degree (about 98%), which maintain a high discharge;

- an average discharge in terms of "value" (18 l/s km^2) is achieved for the hydrographic basin, and comes mainly from the middle waters of the hydrographic system. In those regions, the average annual precipitations are around 1,000 mm, and by its melting, the snow layer facilitates the formation of some significant flows, in spring.

- the lowest discharge values, of 2.0 l/s km^2 are achieved within the lower part of the hydrographic basin (the hilly and corridor zone, of the Sebeş-Mureş Rivers).

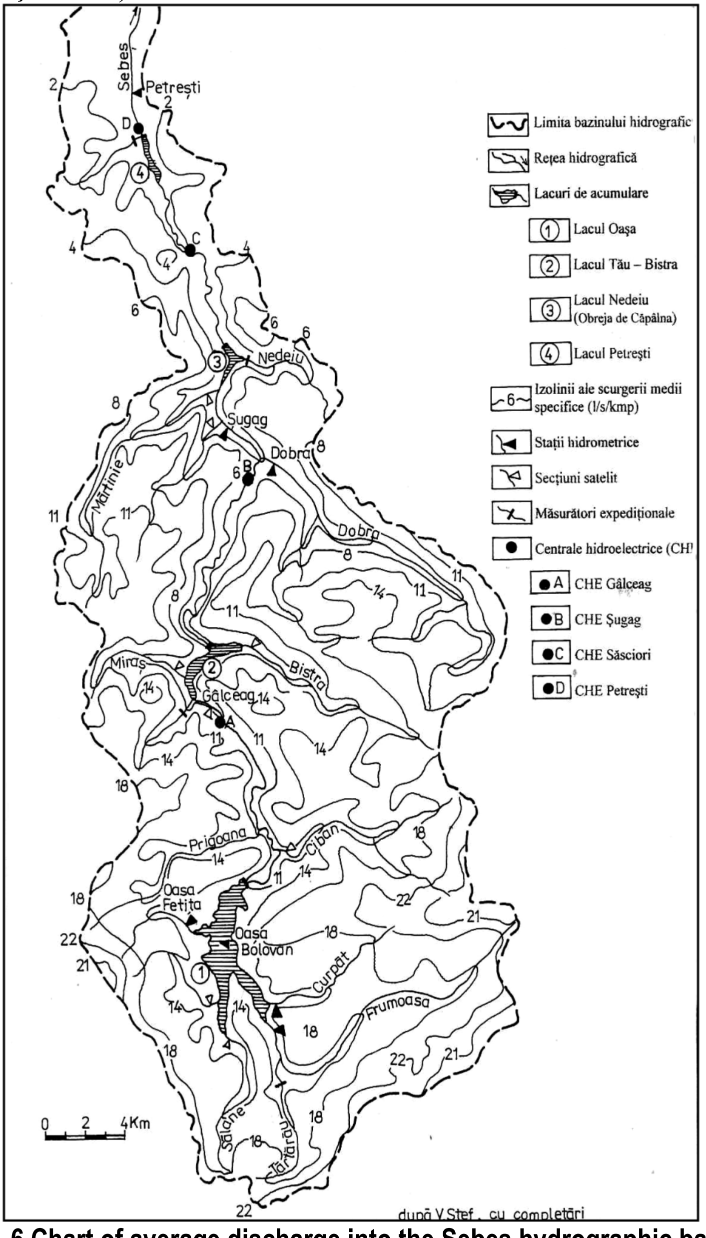

Fig. 6 Chart of average discharge into the Sebeş hydrographic basin

After the determination of the multiannual average flows, at the hydrometric stations in the hydrographic basin of Sebeş, the hydrological balance was elaborated, and the multiannual average flows for the difference in the basin are determined by means of the relation: q = f(H).

In the case of Oaşa Lake, the data made available by the Frumoasa hydrometric station on the Sebeş River, Curpăt hydrometric station on the Curpăt River, Oaşa Fetiţa hydrometric station on the Valea Mare River have been used.

Table no.2

Values of the specific average discharge, in Oaşa storage

Hydrometric station	F km^2	H m	Q m^3/s	q $l/s\ km^2$
Frumoasa	91.0	1,661	2.18	24.0
Curpat	23.0	1,576	0.480	20.9
Oaşa Fetiţa	8.2	1,442	0.120	14.7

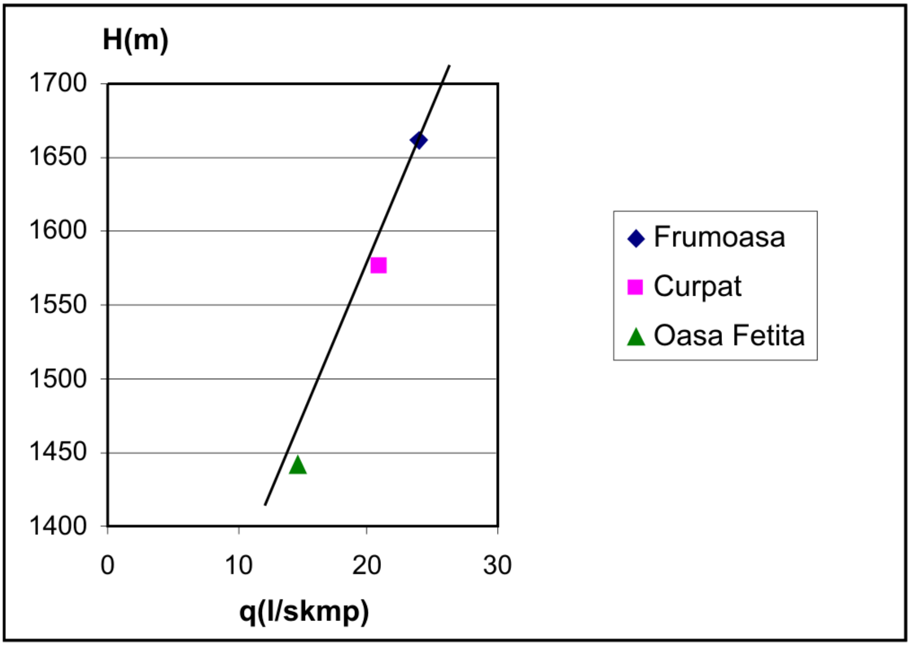

Fig. 7 Trend chart of the multi-annual average discharge in Oaşa storage

From the chart analysis, one can conclude that the highest discharge volume occurs at an altitude of over 1,500 m, and is determined by the occurrence of the highest volumes of precipitations, in the area of the hydrographic basin.

The discharge gradient at 100 m is of 5.5 l/s km^2, at an altitude over 1,600 m.

We can conclude that, by the creation of the storage reservoirs, a modification of the river's longitudinal profile, and a less severe modification of the flow regime have been noticed. The dynamics of the lake levels, in the Sebeş hydroelectric system, is almost entirely dependant on the confluent flow in the storage, and on the regularized flow (delivered to the hydraulic turbines – processed, and produced).

The cascade system of the storages on the Sebeş River makes the level regime highly depend on the hydropower stations' operation. The multiannual average confluent flow in Oaşa storage is of about 4.68m^3/s. In the storage lake, the level variation is influenced by the annual variation of the natural hydrological regime, and the lake's water volume is so high that the multiannual redistribution of the confluent flows is possible.

Oaşa storage was filled at full capacity in 1998, when the construction strength was checked, the lake's level being around the value of the extraordinary retention level (i.e. 1257.00 mdM). After that check, the normal retention level was never reached, and the filling factor of the storage was of about 60%.

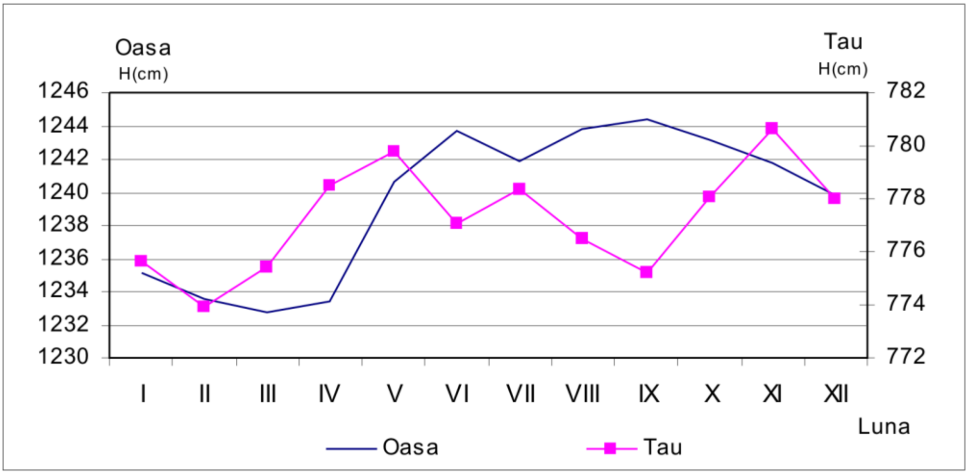

Fig. 8 Variation of the annual average levels in Oaşa – Tău storages, (2002 - 2007)

In the other storages, the level variations depend on Oaşa storage and on the amounts processed in the turbines of the upstream hydropower stations. The maximum levels in Nedeiu and Petreşti storages have been determined on the basis of the topographical-bathymetric mappings, done by STSDA in September 2007.

As Gâlceag, Şugag and Săsciori hydroelectric power stations are of a bypass type, in the bypass zone, the natural minor waterbed is maintained, and it takes over the maximum discharge of the river and of the flanks.

With this kind of construction, the problem of providing a “basic“ discharge on the minor river-bed becomes extremely important for maintaining the ecological balance in the constructed zone. The case is similar to that of the storage downstream from Petreşti and Petreşti power station, although the latter is not a bypass one.

The minimum necessary average flow in the minor riverbed, downstream the storage constructions must fulfil the following requirements:

- hygiene and health by: avoiding pool, marsh formation, dilution of harmful stuff; observing flora and fauna requirements;
- environment protection, riverbed stability;
- satisfaction of the following uses: water, animal raising, recreational facilities;

Table no.3

Monthly multiannual average flows in the Sebeş basin 1940 – 2005 (according to the studies done by Alba Iulia Station)

Hydrometric station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
Frumoasa	0.80	1.44	0.97	1.76	4.71	3.56	2.56	1.75	1.71	1.50	1.27	0.98	1.85
Curpăt	0.24	0.19	0.24	0.39	0.71	0.71	0.65	0.42	0.38	0.34	0.27	0.26	0.40
Oaşa Bolovan*	1.63	1.49	1.81	4.25	9.08	6.65	4.89	3.85	2.79	2.50	2.17	3.39	3.68
Oaşa Fetiţa	0.07	0.05	0.07	0.11	0.23	0.19	0.14	0.10	0.09	0.07	0.07	0.06	0.10
Gâlceag*	2.14	1.88	2.24	5.22	11.1	9.08	6.47	3.66	3.98	3.59	2.95	2.69	4.81
Dobra*	0.49	0.53	0.61	1.43	2.01	1.62	1.28	1.00	0.76	0.59	0.55	0.52	0.95
Şugag*	4.04	3.91	4.42	10.6	18.7	13.5	9.81	7.72	5.70	5.03	4.59	4.36	7.70
Petreşti	3.43	3.75	4.93	10.1	17.0	14.2	9.87	7.31	6.12	5.60	4.51	4.25	8.22

* stations having generalized data

The highest monthly average discharge often occurs in May-June, when the snow melting, precipitations and a combination of the two are the main phenomena contributing to the formation of the flow.

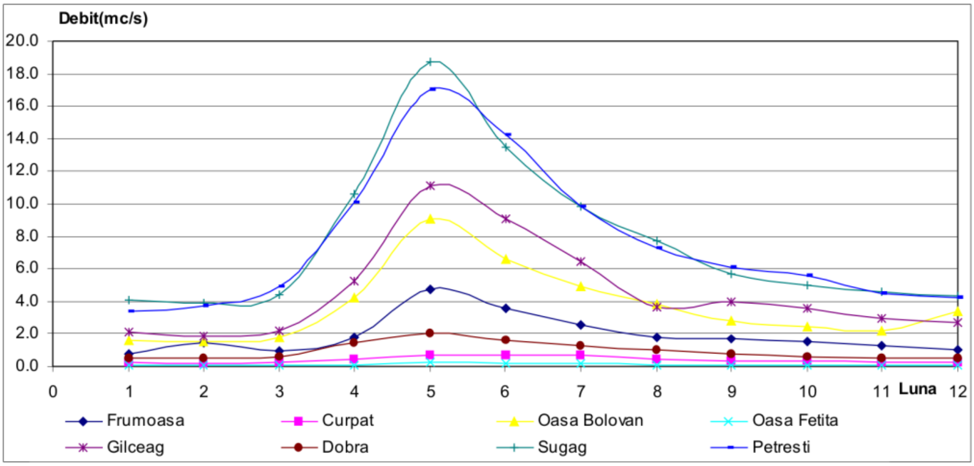

Fig. 9 Values of the monthly multiannual average flows (1940-2005)

The highest monthly average discharge occurs in May, at a frequency between 59% at Dobra and 72% at Oaşa Bolovan stations. In June, the average discharge drops to 16% at Oaşa Bolovan, and to 17% at the other stations. On most of the rivers in the Sebeş hydrographic basin, the highest monthly average discharge occurred in May 1958.

The lowest monthly average discharge often occurs between December and February. The low values are determined by a rich pluviometric regime, which however comes from snowfall stored into a snow layer. The lowest flows were recorded in 1963 (2.44 m^3/s at Şugag); 1964 (0.21 m^3/s at Dobra; 2.97 m^3/s at Petreşti); 1991 (0.310 m^3/s at Frumoasa); 1994 (0.066 m^3/s at Curpăt).

The average discharge is influenced by the existence of the hydro-storages, as well, which means that actually, downstream from the dams, on different zones, there is no discharge:

- downstream Oaşa dam - on about 500 m;
- downstream Tău dam - on about 1,000 m;
- downstream Obreja de Căpâlna dam, the circulating flow is the dilution one (at a 92 - 95% probability to occur), near the discharge of the dam. Its existence is absolutely necessary, for maintaining the biotic factor: fish and vegetation inside the water layer.
- at the closure of the weirs of Petreşti dam, downstream the dam, the flow was of m^3/s in 1984, at Petreşti hydrometric station.

The supervising chart, foreseen according to the project, is based on a great capacity to regulate the flows when winter draws near, when the needs of the energetic system are higher. Thus, because of the flows' regulation, a high transfer of water may be obtained, towards the winter semester.

The distribution of the average discharge, on seasons, is determined by how the main supply sources are combined throughout the year. We may notice a close connection between the discharge values and the average altitude of the receiving basins, throughout all the seasons.

Table no.4

Average values of the seasonal discharge within the Sebeş hydrographic basin *(according to the studies of Alba Iulia Station)*

Hydrometric station	F km^2	H m	Seasonal Flows %			
			Winter	Spring	Summer	Autumn
Frumoasa	91.0	1,661	14.0	32.4	34.2	19.4
Curpăt	23.0	1,576	14.7	27.4	37.1	20.8
Oaşa Bolovan*	172	1,592	14.8	34.0	34.5	16.7
Oaşa Fetiţa	8.2	1,442	14.9	32.4	34.1	18.6
Gâlceag**	189/ 311	1,540	11.5	30.4	39.5	18.6
Dobra*	90.0	1,167	13.5	35.6	34.3	16.6
Şugag*	527	1,401	13.5	36.5	33.5	16.5
Petreşti	679	1,241	14.4	36.8	32.1	16.7

*decommissioned hydrometric stations

** hydrometric stations with non-restructured flow

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