LOCAL HYDROLOGICAL CENTERS NETWORK OPTIMIZING MODEL

Dr Ion PASOI
National Institute for Meteorology and Hydrology and water Management, Romania, Bucharest, sos. Bucuresti – Ploiesti no 97, postal code 71552, e – mail : pasoi@meteo.inmh.ro

Abstract: In the case of the countries with advanced hydrographic and hydrometrical networks, it is necessarily to set up Local Hydrological Centers. These ones are created for the primary hydrometrical data processing up to the level of Annual Hydrometrical studies at hydrometrical stations and for current maintenance of the existing equipment within the hydrological network. To optimize the Local Hydrological Centers location HIDROLMA model is proposed, a model based on the travelling matrix, consisting in the travelling times between the hydrometrical stations and the Local Hydrological Centers and the stationing times at the hydrometrical stations.
Key word: Local Hydrological Centers, travelling matrix, travelling times, stationing times.

BESTMŐGLICHKEITS MODEL DER LOKALEN HYDROLOGISCHEN ZENTRUM-NETZE

Kurzfassung: Länder mit ausgebauter Wasser und Hydrometrische-Stellen Netze ist es noting Hydrologische lokal Zentren zu gründen Diese haben als Ziel die Ubersicht dass die primär hydrimetrische Daten bis zum Niveau der jährlichen hydrometrischen Studien von der Hydrometrischen Stellen überarbeiten werden, und die Instand-haltung der instrustung des Hydrologischen Netzes. Um die allerbest Plätze für die Hydrologische lokal Zentrum zu finden schlagen wir das Modell HIDROLMA vor das auf der Matrize der Hingänge nuht, die aus den Zeitdauren der Hingänge zwischen den Hydrometrischen Stellen und den Hydrologischen lokal Zentrum, so wie auch den Zeinträumen der Aufhälte bei den Hydrometrische Stellen besteht.
Schlüesselworte: Hydrologische lokal Zentrum, Matrize der Hingänge, Zeitdauer der Hingänge, Zeinträumen der Aufhälte

1. Introduction

The necessity of organizing Local Hydrological Centres occurs only in the case of advanced hydrometrical networks, placed on large territories. The Local Hydrological Centers function only in slow flux (hydrology in non-real time) and first of all, they have the mission of co-ordination, technically speaking, the activity developed by the employees of the hydrometrical stations (in the case of particularly unautomatic hydrometrical network) and of achieving the liquid discharge measurements program at hydrometrical stations (in the case of automatic hydrometrical network).

In the case of both above-mentioned hydrometrical network categories, the Local Hydrological Centres elaborate the annual hydrometrical studies at the hydrometical stations.

In the localities in which the Local Hydrological Centres are placed, the number of existing personnel is function of the possibilities to access from these ones to the subordinated hydrometrical stations.(means of road transport, railways etc.).

This is the reason why, the Local Hydrological Centers network structure can be modified with time.

The Local Hydrological Centers network dependency of the possibilities of access for these ones to the subordinated hydrological stations, allows the application in order to establish a technico-economic model optimal variant.

The costs for the Local Hydrological Centers functioning are useful for:

- travelling expenses to hydrometrical stations with the public transport (Ctc);
- accommodation expenses for the situations in which the public transport schedule does not permit a return travel, (local center-hydrometrical station-local centre), (Cc);

- expenses for the own transportation means (if exist); (Ctp);
- expenses with respect to the local centre headquarters (rent, telephone bill, electricity bill) (Cs).

The total expenses amount related to the Local Hydrological Centres, is the following:

$$C = Ctc + Cc + Cs \quad (1)$$

C - total expenses amount;
Ctc – public transport expenses;
Cc – accommodation expenses;
Cs – other expenses.

2. HIDROLMA MODEL

HIDROLMA model is proposed in order to establish the Local Centre Headquarters. This model also allows the territorial travelling itinerary optimization, to take observation and measurements. The model is applied for authorized hydrometrical networks, manual and semi-automatic networks. In the case of the automatic network, for the territorial travelling itinerary optimization, it is no need to take into account the subordination for hydrometrical data processing per technician. In the case of the manual and semi-automatic networks, it is necessary for the territorial travelling itineraries establishment to take into account the subordination procedure for processing per technicians within the stations and the local hydrological teams. Before applying HIDROLMA model, it is necessary to establish the station and the local hydrological centre locating scenarios and if necessary, the hydrometrical stations subordination per technicians. In establishing the station scenarios, the local hydrological teams, the local hydrological teams and the territorial travelling itineraries optimal variant, there are taken into account the following:

- the stationing time at a hydrometrical station (Tsi), this one differing from one gauging station to another function of the local conditions (necessary duration for taking measurements, gauging station employee surveillance).

The time Tsi (stationing time) can be replaced by the equivalent distance (Dsi).

$$D_{si} = T_{si}\, V_m \quad (2)$$

V_m – travelling mean speed in territory

- the travelling time between two stations (station or local hydrological centre, gauging station), (Td_j)

$$Td_{ij} = L_{ij}/Vm_{ij} \quad (3)$$

where:

L_{ij} – distance, on the basis of road or railway maps between two stations
Vmij – travelling mean speed; in a first stage, Vm_{ij} can be considered equal to 40 Km/hour.

The time Tdij can be replaced by the equivalent distance (L_{ij}).

- the daily time dedicated to t activities in territory is of about 12 hours; instead of the territorial travelling daily time, the equivalent distance can by used.

$$D = TV_m \quad (4)$$

where:

D – equivalent distance;
T – daily time dedicated to activities in territory;
V_m – territorial travelling mean speed.

- the cost per Km has a constant value independent of the area; consequently, the travelling costs are function of the number of days necessary for travel to all the gauging stations.

HIDROLMA model has as impute data the travelling matrix.

The travelling matrix includes the travelling consecutive order from the hydrological stations to the gauging ones.

In the matrix, for each gauging station, there are indicated the following: the previously controlled distance from the gauging station, di-1i - stationing time equivalent distance (one hour of stationing is considered to by equivalent with 40Km/h in the present application), d_i – distance between the gauging station and the hydrological stations ($d^{(j)}_{oi}$).

For a single day there is considered a maximal travel of about 500 Km representing in the conditions of a travelling mean speed of 40Km/h, an effective time of about 12 hours.

The algorithm of the travelling total equivalent distance assessment covers the following stages:

- there is calculated the sum (d_{i-1i}, d_j, d_{oi}) from the hydrological station to the "i" gauging stations;
- if the respective sum is smaller than about 500 Km, then "d_{oi}" is concealed and the sum one on the they pass to the station "i+1".
- there is calculated the (d_{ii+1}, d_{i+1}, d_{oi+1}) sum from the hydrological station to the "i+1" gauging station.
- if the respective sum is smaller than about 500 Km, then d_{oi} and the sum are cancelled and they pass to the "i+2" station;
- if at one of the stage, the sum exceeds the acceptable value, for the next step, the d_{ii+1} value is replaced by the d_{oi} value and the procedure is similar to the above-mentioned one.

This is the way in which we calculate the number of travelling day.

The kilometers totaled in all travelling days are divided by 40 and there are obtained the number of travelling effective hours.

The above-mentioned calculation is made for each hydrological scenario.

The calculation can be mode in the hypothesis that the gauging stations can be controlled by a single person per day independent of the subordination per technicians for processing (in conformity with the present case) or the travelling schedule is structured on hydrological station) local hydrological centers and technicians.

In the last case the gauging stations subordination per technicians must be performed by on expert on the basis of analysis of the necessary processing volume for each gauging station.

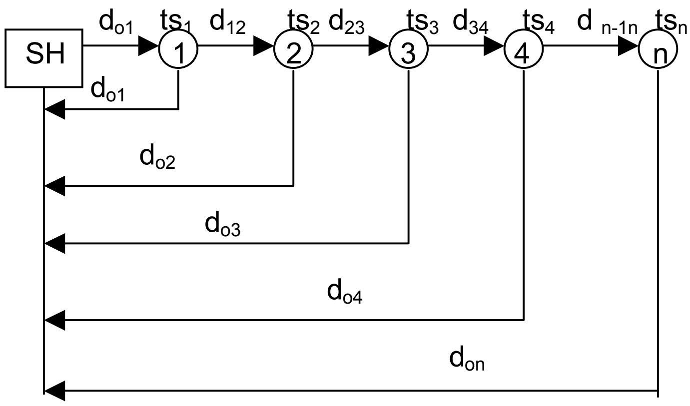

Figure 1. Travelling matrix

If between two structure scenario variants, with a different number of station and local hydrological center, the travelling days number is close, for the establishment of the optimal variant there must be compared the travelling costs resulted for the variant with a smaller number of stations and local hydrological center, with the travelling costs in the case of the scenario with a greater number of stations and local hydrological center to with there are added the expenses for the supplementary local hydrological center maintenance. The optimal variant is the one with minimum expenses. In the case of the subordination of a reduced number of gauging stations (requiring1 or 2 technicians), the local hydrological center headquarters con by placed at one of the technicians residence.

If there exist the possibilities to apply the methodologies based on GIS and GPS, the distances calculation and implicitly the travelling schedule, can be automatically made.

By the help of some adequate computing products the whole methodology exposed can by automatically applied, having as initial impute data the following:

- the hydrographic basin map;
- hydrological stations location, by geographical coordinates (latitude, longitude); gauging station subordinating scenarios on hydrological stations;
- gauging stations location by geographic coordination (latitude, longitude).

The calculation algorithm is schematically presented in Fig. 2.

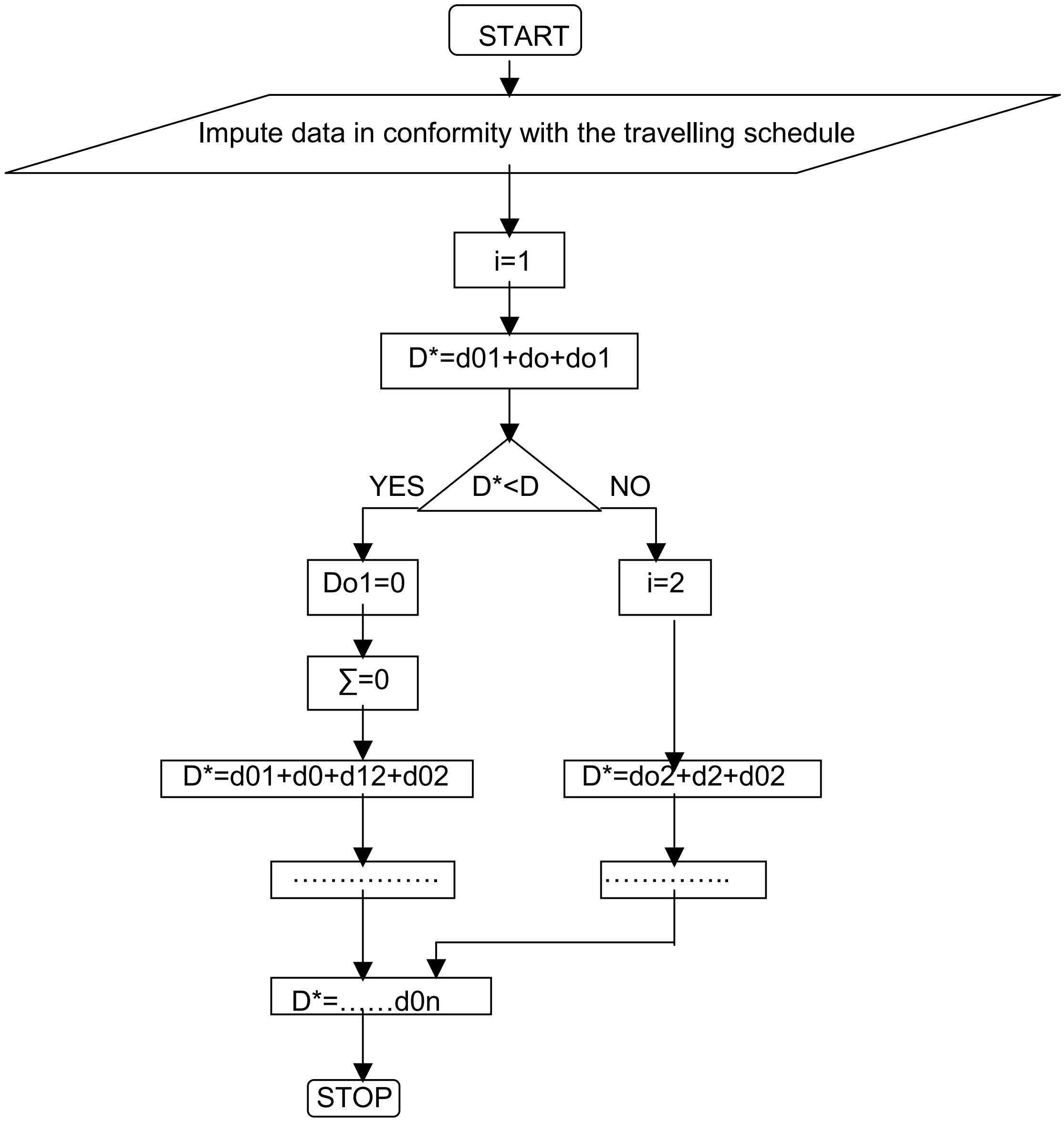

Figure 2. Travelling time (equivalent distance) calculation algorithm

3. HIDROLMA MODEL Application for the BISTRITA – SIRET basin

The Bistrita basin, the Siret River is tributary, has a surface of 7042 km^2. For the basin hydrological station headquarters, there was chosen Piatra Neamt town. The Bistrita basin scheme with the gauging stations network and the Local Hydrological Centres variants is presented in Fig. 3.

The hydrological station within the Bistrita hydrographic basin will function in Piatra Neamt town.

With this respect Piatra Neamt town complies with the following conditions:

- it is placed close to the hydrographic basin gravity;

- there are provided all the necessary logistic conditions (computers network, stationary and mobile phone coverage, possibility to hire personnel with an adequate professional training;
- there already exists a hydrological station, properly located and with a sp3ecialized personnel;
- there exists the headquarters of the principal teal time hydrological information beneficiaries: Bistrita Power Station Enterprise, Piatra Neamt Local District Council.

From the analysis of logistic availability and of qualified personnel it results that the potential Local Hydrological Center con by Vatra Dornei and Bicaz town.

For the establishment of the Basin Hydrological Station and the local hydrological centers optimal variant, there elaborated the following scenarios:

1). a hydrological station , Piatra Neamt (29 gauging stations)

2). a hydrological station , Piatra Neamt (15 gauging stations placed downstream Bistricioara confluence) and a Local Hydrological Center, Vatra Dornei (14 gauging stations);

3). a hydrological station , Piatra Neamt (10 gauging stations placed downstream Bicaz) and 2 Local Hydrological Centre, Vatra Dornei (12 gauging stations placed upstream Izvorul Muntelui storage reservoir) and Bicaz (7 gauging stations).

The Hydrological Station and the Local Hydrological Center scenario structure is presented in Table 1.

Table 1 Hydrological network scenarios structure

Nr	**Hydrometrical Station - River**	**Hydrological Station / Local Hydrological Centre**		
		Scenario 1	**Scenario 2**	**Scenario 3**
1	Cârlibaba – Bistrița	Piatra Neamț	Vatra Dornei	Vatra Dornei
2	Cârlibaba – Cârlibaba	Piatra Neamț	Vatra Dornei	Vatra Dornei
3	Dorna Giumalău - Bistrița	Piatra Neamț	Vatra Dornei	Vatra Dornei
4	Poiana Stampei - Dorna	Piatra Neamț	Vatra Dornei	Vatra Dornei
5	Coşna – Bancu	Piatra Neamț	Vatra Dornei	Vatra Dornei
6	Dorna Candreni - Dorna	Piatra Neamț	Vatra Dornei	Vatra Dornei
7	Gura Haitii – Neagra	Piatra Neamț	Vatra Dornei	Vatra Dornei
8	Gura Negrii – Neagra	Piatra Neamț	Vatra Dornei	Vatra Dornei
9	Barnar – Barnar	Piatra Neamț	Vatra Dornei	Vatra Dornei
10	Drăgoioasa – Drăgoioasa	Piatra Neamț	Vatra Dornei	Vatra Dornei
11	Broşteni – Neagra	Piatra Neamț	Vatra Dornei	Vatra Dornei
12	Sabasa – Sabasa	Piatra Neamț	Vatra Dornei	Vatra Dornei
13	Frumosu – Bistrița	Piatra Neamț	Vatra Dornei	Bicaz
14	Bistricioara – Bistricioara	Piatra Neamț	Vatra Dornei	Bicaz
15	Schit – Ceahlău	Piatra Neamț	Piatra Neamț	Bicaz
16	Poiana Largului - Bolătău	Piatra Neamț	Piatra Neamț	Bicaz
17	Cârnu Bicaz – Bistrița *	Piatra Neamț	Piatra Neamț	Piatra Neamț
18	Lacu Rosu – Bicaz	Piatra Neamț	Piatra Neamț	Bicaz
19	Bicaz Chei – Bicaz	Piatra Neamț	Piatra Neamț	Bicaz
20	Ardeluța – Tarcău	Piatra Neamț	Piatra Neamț	Piatra Neamț
21	Cazaci – Tarcău	Piatra Neamț	Piatra Neamț	Piatra Neamț
22	Oanțu – Oanțu	Piatra Neamț	Piatra Neamț	Piatra Neamț
23	Bâtca Doamnei - Bistrița *	Piatra Neamț	Piatra Neamț	Piatra Neamț
24	Cuejdi – Cuejdi	Piatra Neamț	Piatra Neamț	Piatra Neamț
25	Luminiş – Iapa	Piatra Neamț	Piatra Neamț	Piatra Neamț
26	Magazia – Cracău	Piatra Neamț	Piatra Neamț	Piatra Neamț
27	Slobozia – Cracău	Piatra Neamț	Piatra Neamț	Piatra Neamț
28	Borleşti – Nechitu	Piatra Neamț	Piatra Neamț	Piatra Neamț
29	Racova - Bistrița *	Piatra Neamț	Piatra Neamț	Piatra Neamț

Note: the gauging stations with "*" do not require travelling costs, the necessary data being obtained from Piatra Neamt Power Station Enterprise with the headquarters in Piatra Neamt.

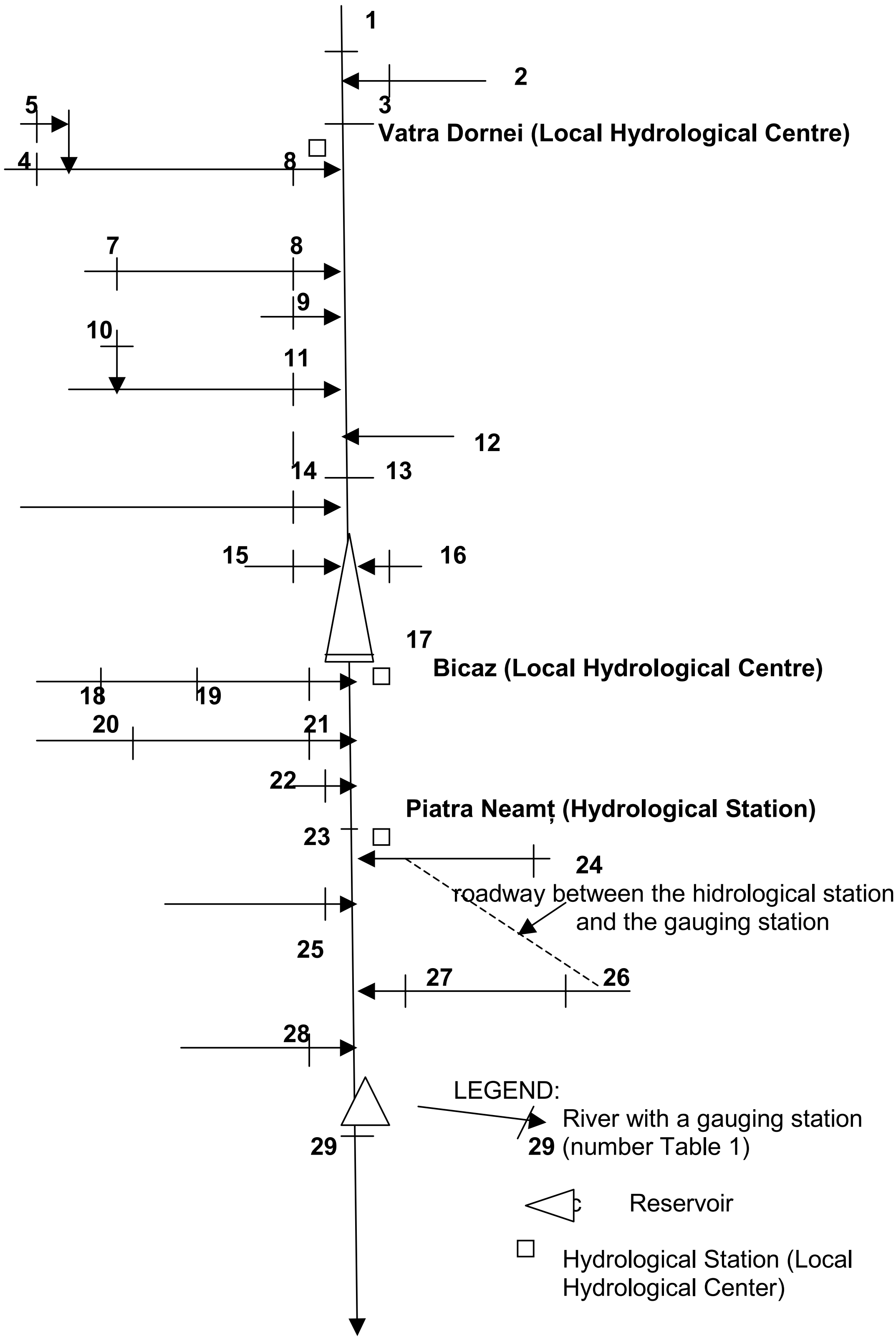

Fig. 3 Screech with the optimal hydrometric network and with the hydrological station and the local hydrological center scenarios

For each hydrological network scenario, a travelling matrix is made.

By applying HIDROLMA model, for the first scenario, there results the matrix in Table 2

Table 2 1st scenario: Piatra Neamt Hydrological Station

d28				**d27**				**d25**				**d26**			
o28	28	o28	∑	2827	27	027	∑	2725	25	o25	∑	026	26	026	∑
50	80	50	180	9	120	41	300	26	80	21	386	36	40	36	**489**
d24				**d22**				**d21**				**d20**			
o24	24	o24	∑	o22	22	o22	∑	2221	21	o21	∑	2120	2o	o2o	∑
19	40	19	78	20	40	20	158	13	120	31	302	18	80	49	**418**
d19				**d18**				**d16**				**d15**			
2019	19	o19	∑	1918	18	o18	∑	1816	16	o16	∑	1615	15	o15	∑
43	80	38	156	10	40	48	216	49	40	57	314	3	40	57	357
019															
38															
d14				**d13**				**d12**				**d11**			
1514	14	o14	∑	1413	13	o13	∑	1312	12	o12	∑	1211	11	o11	∑
8	120	65	**493**	6	160	58	276	8	40	66	332	16	80	82	**444**
				o13											
				58											
d10				**d9**				**d8**				**d7**			
111o	1o	o10	∑	109	9	09	∑	98	8	o8	∑	87	7	07	∑
56	40	132	304	58	40	68	338	42	80	110	**502**	23	40	123	286
o10												07			
132												123			
d6				**d5**				**d4**				**d3**			
76	6	o6	∑	65	5	05	∑	54	5	o5	∑	43	3	o3	∑
35	80	122	400	9	40	131	458	19	40	140	**526**	28	80	116	312
												o3			
												116			

d1+2			
32	1+2	o1	∑
18	80	134	**428**

By applying the some methodology for the next hydrological networks scenarios (2,3), there is finally obtained the following:

Table 3 Calculation of the travelling times to the gauging stations, on hydrological network scenarios:

Scenario/ Hydrological Station(Local Hydrological Center)		Piatra Neamț	Vatra Dornei	Bicaz	TOTAL
1	number of gauging stations	26	0	0	26
	number of days	6	0	0	6
	number of hours	83	0	0	83
2	number of gauging stations	12	14	0	26
	number of days	3	3	0	6
	number of hours	32	37	0	69
3	number of gauging stations	8	12	6	
	number of days	2	3	2	7
	number of hours	23	28	17	68

The optimal variant is the second one, with a number of 6 days for a travel to all the gauging stations and on effective number of 69 travelling hours. This variant is in service, at present.

4. Conclusion

1. In the case of countries with highly advanced hydrological and hydrometrical network, it is necessary to set up both Basin Hydrological Stations (especially used in the hydrological forecast activity) and Local Hydrological Centers (used in the activity of non-real time hydrometrical data processing and of the hydrometrical network equipment maintenance).
2. The establishment of the Local Hydrological center can be made by help of HIDROLMA model.
3. HIDROLMA model is based on the “critical itinerary” method between the Local Hydrological Center and the hydrometrical stations and has as input data the travelling matrix components: travelling and stationing times.
4. The HIDROLMA model application for a concrete case (Bistrita basin) yielded good results.

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