R E P O R T

over research project BSEC-HDF / RES 2011-02

TECHNOLOGICAL SYSTEMS BASED ON THE UTILIZATION OF WATER KINETIKAL ENERGY FOR RURAL CONSUMERS (TESUWKERC)

Phase I

GA1. PROJECT MANAGEMENT, COORDINATION AND COMMUNICATION ACTIVITIES (PARTIALY)
GA2. DETERMINATION OF SPECIFIC ENERGY NEEDS OF RURAL CONSUMERS AND PROSPECTING OF MICRO HYDRAULIC ENERGY POTENTIAL IN NISTRU AND PRUT RIVERS FROM OF REPUBLIC OF MOLDOVA AND ROMANIA (PARTIALY)

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Topic of the research project:

Technological systems based on the utilization of water kinetikal energy for rural consumers (TESUWKERC)

SCOPE:

Determination of the specific energy needs in the eligible regions and prospecting of micro hydraulic energy potential of r. Prut and Nistru in the Republic of Moldova**.**

Partners:

Technical University of Moldova:
Chişinău, 168, Ştefan cel Mare str.

“Stefan cel Mare” University of Suceava
Suceava, 13, University Street, Romania

Coordinator: PhD, Dr.Sc, Profesor Ion Bostan

GA1. Project management, coordination and communication activities (partialy):

Activity 1 Organization of Project Steering Committee meeting

15 October 2011.
10.00-12.00. Project Steering Committee meeting:
Location: Technical University of Moldova, Chishinau,

Participants:

Acad. Prof. Ion Bostan (TUM, MD);
Prof. Adrian GRAUR ("Stefan cel Mare" University of Suceava, RO)
Prof. Valeriu Dulgheru (TUM, MD).

Subjects of discussions:

1. Coordination and communication activities;
2. Discutions concerning the determination of the specific energy demand of rural consumers;
3. Discutions concerning hydroenergy potential's prospecting methodology of the of the r. Prut and Nistru;
4. Presentation of the website structure.

Activity 2. Development of the optimisation methodology for activities and project management and monitoring, for communication of partners (partialy)

To optimize the methodology for the activities, management and monitoring of project was proposed the following.The director will be assisted by a deputy director and will lead the action together with the Steering committee, comprising the project coordinators of each partner and by a Steering group, involving the coordinators of each group of activities. The coordinators of the group activities cooperate with the responsible for each group of activities from each partner university. At the level of each partner the activity is organized depending on the needs and possibilities. In principle, certain responsible persons for one or more activities will be appointed. They will present periodical reports and final reports for each phase to the responsible person. The responsible for each group of activities will present the reports to the coordinator of the group of activities at project level and to the coordinator of the activity at partnership level. All these reports will help to elaborate the reports that the Applicant will have to submit to the authorized bodies, in conformity with the requirements of the Programme and the agreed Contract. The links at all levels among partners will be ensured by scheduled periodical meetings or by extraordinary meetings. Permanent exchange of information will be done (by post, fax, phone and e-mail, online conference by Skype etc.).

The financial management will be carried out by project coordinators from the partner institution and by the supervisor of activities and will be supported by other staff from the involved institutions according to the Programme requirements and to the fiscal legislation of each country. Each partner will develop financial reports that will be presented to audit bodies and to the project coordinator.

Activity 3. Organization of the project web site design (partialy)

The applicant (TUM) and partner (University "Stefan cel Mare" from Suceava) elaborate the structure of website.

GA2. Determination of specific energy needs of rural consumers and prospecting of micro hydraulic energy potential in Nistru and Prut rivers from of Republic of Moldova and Romania

Activity 1 Determination of energy needs in the rural areas with micro hydraulic energy potential following the example of 2 settlements: some settlement on Prut river and one – on Dniester river.

To take decisions concerning the rural sustainable development based on the utilisation of hydraulic energy and observance of the ecological equilibrium is need to determinate the energy needs and test the methodology and instruments for supporting the rural local authorities.

Determination of joint strategies and methods for the promotion and development of:

- irrigation of agricultural land;
- heating of living space in the coldest period of the year;
- street lighting,

and other systems that can be distributed in regions with hydraulic potential by utilising means with reduced ecological impact. As well, the project aims at the promotion of experience and Know-How transfer among the partners in the cross border countries.

For this purpose have been established the basic energy needs of rural dispersed consumers from village Stoieneşti (Prut, Cantemir district) and village Ustia (Nistru river, district Criuleni).

These studies will help realise the configuration and adjustment to local requirements related to the technological systems integrated with the renewable energy conversion systems.

Activity 3 Prospecting of the micro hydraulic energy potential in two rural settlements on the territory of the Republic of Moldova (*Technical University of Moldova, month 1-4*).

The inevitable increase of global energy consumption and the risk of a major environmental impact and climate change as a result of burning fossil fuels open wide prospects for the exploitation of renewable energies. Hydropower, as a renewable energy source, will have an important role in the future. International research confirms that the emission of greenhouse gases is substantially lower in the case of hydropower compared to that generated by burning fossil fuels. From the economical point of view, the utilisation of half of the feasible potential can reduce the emission of greenhouse gases by about 13%; also it can substantially reduce emissions of sulphur dioxide (main cause of acid rains) and nitrogen oxides.

Hydraulic energy is the oldest form of renewable energy used by man and has become one of the most currently used renewable energy sources, being also one of the best, cheap and clean energy sources. Hydraulic energy as a renewable energy source can be captured in two extra power forms:

– potential energy (of the natural water fall);

– kinetic energy (of the water stream running).

Both extra power forms can be captured at different dimensional scales. Table 1 presents a simple classification of hydraulic plants according to the electrical energy output.

Hydropower, in general, has become now the most important source of clean renewable energy, economically feasible. Hydroelectric power plants, integrated in multifunctional schemes, have performed various works such as irrigation, water pumping, etc. It is clear that hydropower will play an important role in the future both in terms of ensuring energy supply and water resources development. Under these options, it is necessary to develop these resources in conformity with the social, economic, technical and environmental standards. It is easy to forecast that global energy needs, especially electricity, will grow significantly during the twenty-first century, not only under demographic pressure, but also because of rising living standards in the underdeveloped countries, which will be 7 billion people in 2050 (78% of total population). From the point of view of this situation more alternative energy sources will be required, however, for environmental considerations, an important priority must be given to developing, technically, the full feasible potential of environmentally friendly renewable sources, in particular, hydropower.

In order to determine the hydraulic energy potential of the selected place the existing methodologies was utilized. Measurement of flowing water speed for Nistru and Prut rivers was carried out in various zones and at various distances from the river banks. Measurements was also undertaken for various depths. To carry out measurements modern measuring equipment (FP201 Global Flow Probe) was utilized. This equipment exists in CESCER (TUM) and other partners laboratories.

Identification and evaluation of potential sites for SHP implementation (on river Prut). A special area of interest consists in a more detailed study of the kinetic energy potential of rivers of Moldova - Nistru, Prut and Raut, rivers with potential sites for SHP implementation. Given the importance of SHP implementation for Republic of Moldova, the Centre for Development of Renewable Energy Conversion Systems (CESCER) have been created at the Technical University of Moldova.

In order to perform the research on the rivers kinetic hydropower potential CESCER was equipped with a measuring water velocity device Flow Probe FP201. First measurements were made on the Prut River (figure 1). The choice of the sites was dictated by the following considerations:

– Prut river is the border river between Republic of Moldova and Romania, which in 2007 became a part of the European Union;

– on both sides of the Prut river towns are located fairly dense, which may allow expansion of field research in regional projects funded by the European Union.

Figure 1. Map of energetic potential on Prut:
● – Stoieneşti village, the site of micro hydro power station;
● – Areas with a measured flow speed *v>1m/s*.

Prut, the first tributary of the Danube, starts on the north - east coasts of the Carpathians at a height of 1580m and flows through geographic plateau of Moldova. The total length of the river is 950km with a water catchment area of 28,400km^2 and an average flow of 86m^3/s. The distance of 900km from its mouth, Prut river is a natural border between Republic of Moldova, Romania and Ukraine. Prut river section from its source through the mountains region has a relatively high flow.

Downriver the town of Chernivtsi (Ukraine) begins the portion of the river with an average flow discharge through a floodplain with width 5–6km. The river banks are low and floodable. River flow in the middle is strong and during the floods the river channel changes.

Average flow region extends to Ungheni having a length of 380km. Descending portion of the Prut River, from Ungheni to the river's mouth has a length of 396km. In this region Prut flows through several unimportant valleys with an average width of 10–12km. On a large portion of low flow discharge the river often floods. During the flooding on certain portions of the river multiple channels are formed and during the low flow periods drainage channels are subjected to erosion. Also, in this region, landslides occur often, sometimes quite serious, for example, in 1981, near the village Taxobeni a landslide almost covered the whole river channel. Sinuosity of the river is high, with an average sinuosity index equalling 2. River bed has an irregular pattern, sometimes covered with gravel, with sporadic stone accumulations or even boulders. The river's banks vegetation mainly consists of trees and bushes.

Temperature instability characterizes the freezing temperature of the river during the winter. On most of the river temporary plates of ice can be observed. Stable ice cover was observed 2–3 times in a ten year period. The ice usually begin to form in late November and breaks on average in late February. Average ice thickness is 0.26 to 0.35m, and during very cold winters can reach up to 60cm. On the average the river is navigable for a period of 266 days, 50–60 days of which correspond to the flooding period, and 190–210 days correspond to the average flow discharge period.

Average annual air temperature in mountainous areas of the river basin is about +7°C. In the hilly region of the basin average air temperature is +10ºC. Absolute Maximum is +40ºC, while absolute minimum is –31°C. In the mountainous area of the river the annual rainfall reaches the level of 800mm. In the other parts of the river, the rainfall varies from 600 to 300 mm. Most of the rainfall season is in spring–summer. Rainfall is the main source of water in the Prut River region. The water level in the river increases especially in the summer.

Water level oscillations on Prut river depend mostly on the fluctuations of precipitations throughout the year with some of them being recorded even in the winter months (not often). Spring floods are caused by snow melt in the mountain region as well as rains and usually end in February–April. Summer floods are more important quantitatively, with powerful overflows in July and August. According to the records provided by Republic of Moldova State Hidrometeorological Service (HidroMeteo) the highest topological level of the river portion in Republic of Moldova is at 55m (nearby Criva village). The kinetic hydropower potential can be explored on the part of the Prut River between Criva village in the north to Giurgiulesti village in the south.

Figure 2 - FP 201 Global Water Flow Probe.

In order to perform the water flow speed measurements a Global Water Flow Probe FP 201 Digital Velocity Meter (produced by IRIS Instruments, USA) has been used (figure 2). Its telescopic design allows the maximal and average flow speed measurements at different depths. *FP201 Meter* is calibrated and certified by Global Water Instrumentation Inc.

Prut River leaves the mountain region at Deleatin, where the valley widens to molasses Neogene formations, farther downstream enters the plateau area, being supplied with water on both sides by its tributary streams (figure 3). In its wide valley up to the border with Republic of Moldova, there is a strong alluvial meadow with an abundance of good quality groundwater.

Upriver from entering the Republic of Moldova, the river collects a number of important tributaries from the Beschido-Maramures Carpathians, such as Prutetul, Liucica, Pistinka, Rybnitsa and Ceremusul or Ceremsan (the largest mountain tributary, composed of Ceremusul Negru and Ceremesul Alb). The left bank does not have important Carpathians tributaries, but in turn develops more extensive associated rivers from Podolo–Moldav Plateau to the south (Turkey, Cerneava, Sovita, Sada, Rarancea, Rakitna and Ringaci).

In order to select the potential sites for micro hydro power station installation the following conditions must be fulfilled:

- the average water flow speed should be greater than 1m/s
- the presence of nearby villages and economic agents, potential consumers of converted energy;
- necessity of a minimal capital investment for the construction of the anchoring system for micro hydro power station.

In order to detect and evaluate the possible sites the following actions have been made:

- a comprehensive analysis of the data provided by HidroMeteo Service;
- several expeditions in order to perform measurements on Prut River.

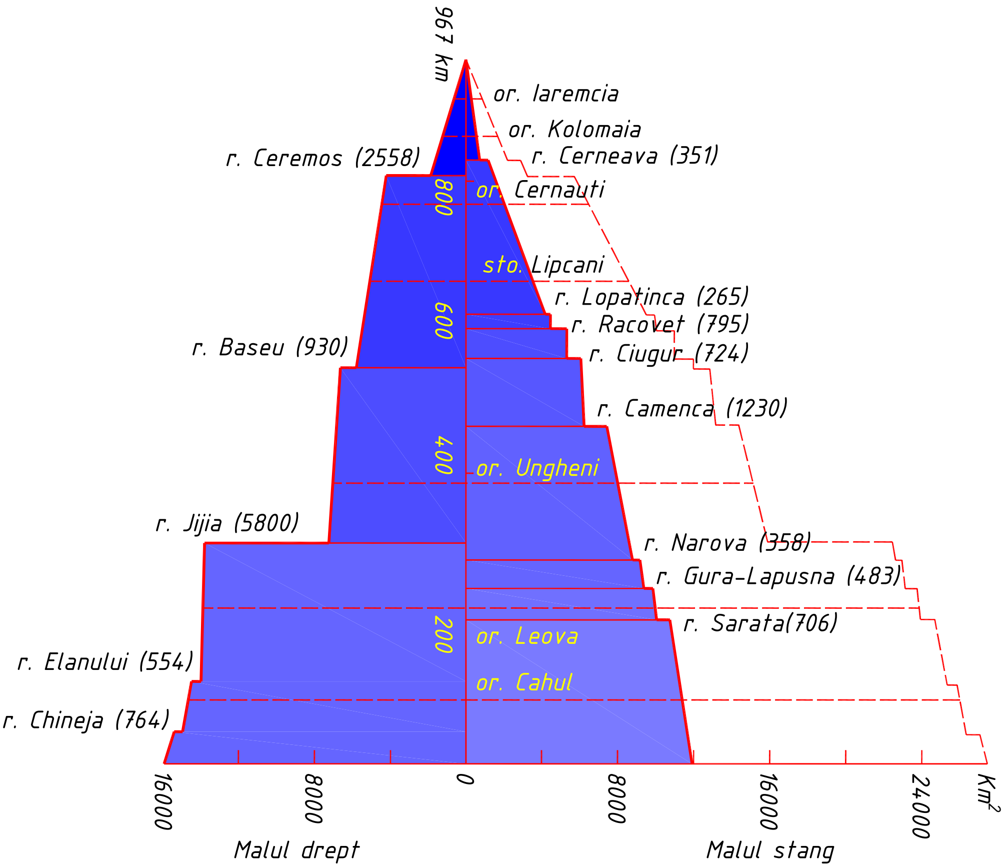


Figure 3. Alimentation sheme for Prut river from right and left banks with tributaries waters.

Using the data provided by HidroMeteo Service and other sourses, the following locations have been initially identified as portions of Prut river with the flow speed greater than 1m/s:

Criva – Costeşti Sector: Lipcani, Şireuți;
Costeşti – Ungheni Sector: Avrameni, Cobani, Taxobeni;
Ungheni – Leova Sector: Ungheni, Costuleni, Bărboieni, Grozeşti, Pogăneşti;
Leova – Giugiuleşti Sector: Châşlița – Prut, Colibaşi, Stoieneşti, Leca, Antoneşti.

Ungheni Sector. In Ungheni, nearby water intakes and pumping stations there have been recorded average flow speeds 0.75–1.05m/s at a distance of 2.5–4.5m from river banks and depth of up to 1.5m. The measurements have been made between villages Măcăreşti–Frăsineşti (Ungheni district) and Bălăureşti (Nisporeni district).

Grozeşti, Zberoaia, Bălăureşti Sector. The narrowest place of the river in this sector is located form village Frăsineşti downriver to village Bărboieni, where the flow speeds of approximately 2m/s have been recorded. Because of this narrowing during the increased flow discharge periods the floods often occur. In order to prevent flooding a bypass channel was build on the opposite bank. Electrical energy converted from the kinetic energy of water can be consumed by the nearby border guard station.

In the village Grozesti there were identified three possible sites with an increased flow speed, two of them near the pumping stations and the other one located nearby the water supply pumping station (currently out of use due to the lack of electricity). Also, areas with higher flow speeds (1.2–1.4m/s) are located in the downriver areas of the village Grozesti.

In the village Bălăureşti relatively high flow speeds were recorded in the area of river bends, where small bypass channels with a length up to a hundred meters can be build. Also, the site of nearby irrigation pumping station, located on the river bank, can be considered.

Cahul – **Giurgiuleşti Sector**. Prut river portion from the village Giurgiulesti (mouth of the river) up to village Manta (Cahul district) there was investigated in the following locations: villages Chişliţa-Prut, Slobozia Mare Văleni, Branza, Colibaşi, Vadul-lui-Isaac. Average flow speeds of 1.1–1.2m/s were recorded in the village Branza (at hydrometric station) downriver the mark nr.14. The river width at the measurement sites is approximately 40–60m. The observation and measurement of the flow speeds were performed in the places with potential consumers of either converted energy or water for irrigation and water supply purposes. Along the river banks were located pumping stations and water intake pipes. Measurements were made from river bank, river docks and boat (see figure 4).

The methodology of hydrometric observations and measurements. Water flow speed was measured with Flow Probe FP 201 device from the river bank shore at a distance of 3–5m, from a raft (in Leova, Ungheni, Taxobeni, Costesti, Bădrajii Vechi), from a river dock at a distance up to 15m from the bank (Duruitoarea and Stoieneşti) and from a boat at a distance of 25m (Colibaşi).

Measuring depth of water flow speed was limited to 1.5m, equal to the possible submersion height of the micro hydro power station blades. Water depth at the distance of 5m from the river banks in different places at the time of measurements varied between 1.8 to 3.8m.

Figure 4- Measurements of the flow speed on Prut river.

Investigations on the Prut River were made from its mouth on the Danube (village Giurgiulesti) upriver to the border with Ukraine (village Criva) over a distance of 685km in the locations shown in Table 1. From the observations and measurements it was found that higher than average water flow speeds are registered at the bends and in narrow places and some rare rapids. At the beginning and the end of measurements of the depth or flow speed the water level was measured that was correlated with previously recorded data from the hydrometric stations located in the area of interest. In Table 1 there were included sites on Prut River (nearby villages and cities) close to houses, gardens, agricultural lands, pumping stations, water storage tanks and other objectives, which may be potential consumers of energy converted from the kinetic river energy. In order to select potential sites for the installation of micro hydro power stations additional investigations were performed in the following sectors:

Sector: mouth of Jijia river–village Stoieneşti. River floodplain is weakly sinusoidal with a width of 7–8.5km, and in the village Tochile-Raducani has a width of 5.2km. Floodplain on both sides, up the village Pogăneşti is dammed. Downriver Sarata-Razesi village in the floodplain there are located small ponds and swampy areas, nearby the river banks dense forest changes in a bushy area. The soil consists predominantly of clay and sands. The river channel is strongly sinusoidal, at short distances smaller than 2-5km there are located sandbanks. Predominant width of the river is 50–70m, 2km downriver the village Sarata, the river width is 120m and in Broscăeşti village its width is 40m. The river depth varies from 0.7 up to 7.3m, with prevailing depth of 3–5m. The river banks are steep with a height of 3–4m. The vegetation mostly consists of forests and bushes.

Sector: village Stoieneşti–Prut mouth on Danube. On this sector 160 km long, the floodplain is weakly sinusoidal with an average width of 7–8.5 km, at times increasing up to 12 km. Left slope of the floodplain is convex with a height of 80–120m. In the village Branza left slope tends towards a more pronounced convexity and it is covered by steppe vegetation. Between village Zărneşti and city Cahul there were terraces with steep steps, with a width of 1–1.5km and length 6–12km. The slope and terraces are well formed mainly with clay soils.

Between villages Slobozia Mare and Cucoara the river channel is highly sinusoidal. Plain is mostly unbranched. Nearby village Branza there is an island with a length of 24m, width 6m, height 1m. The width of the river is predominantly 60–80m, the largest width being 104m in the village Crihana. Predominant river depth is 2–4m, the largest being 15m (2km upriver village Zărneşti).

Tab.: 1. Water flow velocity on Prut river in different areas.

Nr. crt.	***Location, village***	***speed , m/s***	***Border marks***	***Nearby reference points***	***Remark***
1	***2***	***3***	***4***	***5***	***6***
1	Giurgiuleşti	0.8/1.0	1329-1334	SpM, Spm, customs, bridge	Border guard station
2	Châşliţa – Prut	1.0/1.2	1323	Bypass channel	
3	Slobozia Mare	0.7/0.9	1320	Bypass channel	Border guard station
4	Văleni	0.8/1.1	1299/1300	Rapids, SpM	
5	Brânza	0.9/1.1	1296/1297	Spm	Hydrometric station
6	Colibaşi	1.0 /1.3	1291-1294	SpM, Spm, BA	Boat measures
7	Cahul	0.8/1.1	1270	SpA+inlet, bridge	Border guard station
8	Goteşti	0.9/1.2		SpM, Sp2, BA	
9	Stoieneşti	1.1/1.3		Spm–dock, bridge, customs	Border guard station
10	Cantemir	0.8/1.1		SpA+inlet	
11	Leca	1.0/1.2			
12	Antoneşti	1.1/1.3			
13	Leova	0.9/1.1	1188-	SpA,SpC,SE, raft	Border guard station,

			1192		hydrometric station
14	Sârma	0.8/1.0	1181		
15	Tochile–Răducani	0.9/1.1	1175, 1178	SpM	
16	Sărata – Răzeşi	0.8/1.0	1168-1174		Border guard station
17	Pogăneşti	1.0/1.3	1160-1167	SpM, steep bend	
18	Cioara	0.8/1.1	1156-1159	Sp1, Sp2	
19	Dancu,Călmățui	0.9/1.2	1153-1155	SpM, steep bend	
20	Leuşeni	0.8/1.1	1145-1152	SpM, steep bend, costums	Border guard station
21	Drănceni (Rom)	0.7/1.0		Bend	Hydrometric station
22	Cotul Morii	0.8/1.1	1137	Steep bank, Sp	Border guard station
23	Bălăureşti	0.9/1.2	1125-1126	Sp1+BA,Sp2+BA, bend	
24	Zberoaia	0.8/1.1	1120	Bend	
25	Grozeşti	1.0/1.3	1117, 1118	Sp1,Sp2,SpA, meanders	
26	Bărboieni (sus)	1.1/1.5	1110, 1111	Narrow width, meanders	Landslides
27	Frăsineşti	0.7/1.0	1109	Bend, bypass channel	Border guard station
1	***2***	***3***	***4***	***5***	***6***
28	Măcăreşti	0.7/1.0	1107	Meanders	
29	Costuleni	1.2/1.5	1101	Narrow width, meanders	
30	Valea Mare	0.8/1.1	1097	Sp9, Sp10, SE (Ungheni city)	Border guard station
31	Ungheni	1.0/1.3	1077-1079	SpA, STA, raft, bridge	Border guard station, punct hidrometric
32	Sculeni	0.8/1.1	1045/1051	Sp, bypass channel, customs, bridge	Border guard station
33	Medeleni	0.9/1.1	1055	Sp3, Sp4, meanders	
34	Gherman	0.9/1.0	1042-1044	Sp5+inlet, Sp6(hill)	
35	Taxobeni	1.1/1.4	1035-1037	SPA(Făleşti city), raft	Border guard station
36	Horeşti, Unteni	0.7/1.0	1031-1034		Landslides
37	Valea Rusului	0.8/1.2	1027, 1028	Sp, bend	Border guard station
38	Călineşti	0.7/1.0		SpM+BA	Border guard station
39	Chetriş	0.8/1.1	1007	Sp1, Sp2, Sp3	Bridge r. Camenca
40	Bisericani	0.9/1.2	1003	SpM+priză	Border guard station

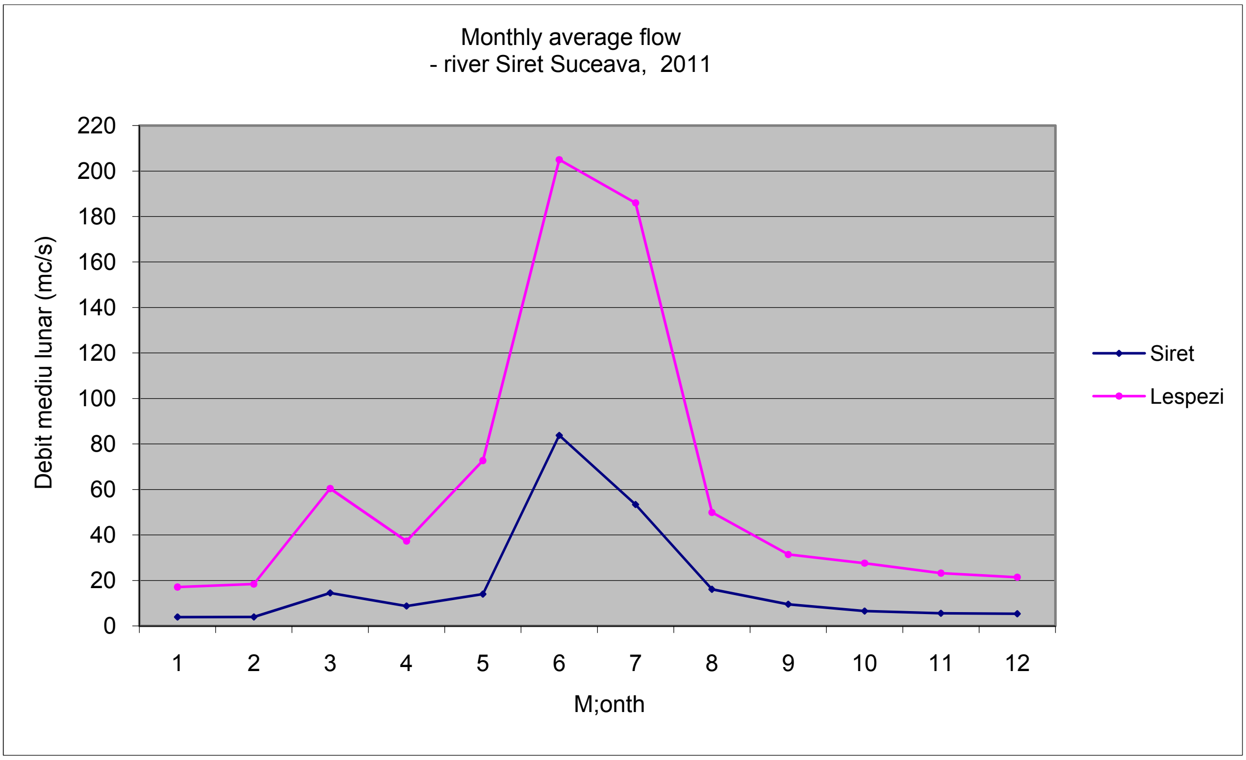
41	Cobani	1.1/1.4	988	SpA (Sugar factory Glodeni)	Border guard station
42	Avrameni	1.1/1.5	984	Steep bend	
43	Brăneşti	0.9/1.1	982	Sp1, Sp2+BA,	Hydrometric station
44	CHE Costeşti, downriver	0.9/1.2		2 turbines, small BA	Border guard station
45	CHE Costeşti, upriver	0		BA, dam, Sp, customs	Border guard station
46	Duruitoarea	0.1/0.2		BA, dock	Tributary r.Ciuhur
47	Bădrajii Vechi	0.2/0.3	960/961	Inlet SpAC+ST, AP	Dam r.Racovăţ, Sp
48	Bădrajii Noi	0.3/0.5	956	Border guard station, pond, plate bank	Border guard station
49	Viişoara	0.6/0.8	953/954	Bypass channel	Hydrometric station
50	Lopatnic	0.7/1.0	952/953	Bypass channel	Tributary r.Lopatinca
51	Bogdăneşti	0.9/1.1	951	Steep banks both sides	Border guard station
52	Gremeşti	0.9/1.2	948	Steep bank, quarry	
53	Teţcani	0.8/1.1	945	Mal abrupt, forrest	Tributary r.Vilia
54	Pererâta	0.9/1.2	938/939, 942	Steep bank, bypass, bend	
55	Şireuţi	1.0/1.2	934-936	Steep banks, meanders	Hydrometric station
56	Lipcani	1.1/1.3	933	Steep banks, bridge	
57	Drepcăuţi	0.9/1.1	926	Forrest	
58	Criva	0.8/1.0	924	Railway	Northern point of Moldova

Legend to Table 1: Sp – Pumping Station, SpA – Pumping Station for Water Supply, SpC – Pumping Station for Sewage, SpM – Pumping station for Irrigation, Spm – Mobile Pumping Station, SE – Water Cleaning Plant; STA – Water Treatment Plant, BA – Storage Pool. Flow speed in m/s is specified as follows: numerator at the depth of 1m; denominator at the water surface.

Tab.: 2. Water flow velocity on Nistru river in v. Ustia, district Criuleni.

Nr. crt.	***Location, village***	***speed, m/s***	***Nearby reference points***	***Remark***
1	Ustia, Criuleni district	1.2/1.2	Old bridge at Dubasari	

River flow and average speed for the county Suceava Siret (Siret village entrance, exit the town Lespezi)



(Large flows during the summer months due to floods)

Annual average flow 2011:

- Point as: City Siret – 18.8 m^3/s;
- Point as: City Lespezi – 52.5 m^3/s.

For the annual average flow the velocities were calculated:

- Point as: City Siret – 0.7 m/s;
- Point as: City Lespezi – 0.7 m/s