Regulations to Operate the Water Reservoirs of the HPP and PSPP Dniester Cascade with Buffer Reservoir Normal Headwater Level 77.10 m

Report and recommendations on the draft updated regulations

Pedro Serra

July-September 2018

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Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136
pedrocunhaserra@gmail.com

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Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136
pedrocunhaserra@gmail.com

Acronyms

GGE – Greenhouse Gas Emissions

GEF – Global Environment Facility

EU – European Union

EC – European Commission

NPP – Nuclear Power Plant

HPP – Hydropower Plant

OSCE – Organisation for Security and Co-operation in Europe

PSPP – Pumping Storage Power Plant

TPP – Thermal Power Plant

ToR – Terms of Reference

TWG – Technical Working Group

UNECE – United Nations Economic Commission for Europe

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

1. Introduction and ToR

The Dniester river basin is shared between Ukraine and Moldova, Ukraine being the upstream and also downstream country. The Dniester makes the border between the two countries for several hundred km before entering into Moldova and then returning to Ukraine at the entrance of its estuary.

The Dniester river flow is irregular, both seasonally and between years. This is general situation in any part of the world and any river. This is why governments decide to build dams: to regulate flows in order to have water (and hydropower, as is the case) all the year and every year (or something close to this). And by doing this they change the flow regime and impact on the environment and ecosystems (aquatic and riparian ecosystems):

- By causing deterioration of the habitat, migration and spawning conditions for fish by creating physical barriers (the dam) to fish movements and migration upstream-downstream (negative impacts);
- By retaining sediments in the reservoir and making river sand and gravel an attractive draw for businesses, thus destroying spawning grounds for fish (negative impacts);
- By reducing floods and droughts downstream (both positive and negative impacts);
- By creating conditions to the introduction of alien species (for fishing), to eutrophication due to the standing waters, to water quality degradation (temperature stratification, reduced oxygenation, both negative impacts);

And dams contribute to reduce the water available downstream if intensive and growing irrigation and urban and industrial water supply are part of the project, which is not the case with the cascade.

There are also indirect positive environmental impacts, such as reduction of greenhouse gas emissions (GGE) in case of HPP, as is the case with Dniestrovski. And, most of all, there are economic and social benefits coming out of the project: Stabilised urban water supply, water for irrigation, power production, water supply to industries, flood control, etc.

Some of the negative impacts can be mitigated by means of the adoption of operation rules: minimum flows should be guaranteed downstream, reservoir storage capacity reserved for flood protection and devices for fish migration such as fish ways or ladders can be installed, amongst other that can be considered. But we should not be tempted to ignore the benefits and aggravate costs in such a way that the project (the infrastructure) will no longer be of interest (will not pay itself, costs will not be recovered).

HPP is best used to produce energy and guarantee power in peak hours, which means that, unless otherwise decided for environmental or any other reasons, it will operate only during a few hours the day (4 to 8 hours). Immediately downstream flows will be very irregular but a few km downstream, depending on the valley's shape, flood routing occurs and flows will become more regular, and the hourly variation of flow will scarcely be noticeable. A different situation arises if the

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

HPP is out of service for days, in which case flows will become nil and impact in all activities downstream. This is one of the reasons why in many cases a smaller dam is built immediately downstream (most of the cases a small HPP), which is set in charge of re-regulating the flow.

Therefore, it is legitimate to impose some restrictions to the HPP activity and the way it is exploited in order to reduce its negative externalities. These restrictions must be balanced and justified by the impacts that are not considered acceptable or cannot be compensated or appropriately mitigated. The interests of all downstream stakeholders have to be considered when deciding upon the mitigation and compensation measures, as some of them may be conflicting.

The Dniester river is very important for the environment and biodiversity and as a source of water, both for Ukraine and Moldova, for hydropower, for urban water supply and irrigation, amongst other water uses. It is so quite understandable that all issues related to the river are considered to be important to both countries.

The total area of the Dniester Wetlands enjoying international recognition under the Ramsar Convention includes both Moldovan and Ukrainian parts of the Dniester estuary (with a total surface area of 150,000 ha). In 2005, the area along the Dniester and its Unguri-Holosnita valley on the Moldovan side were added to the Ramsar sites' list.

The scope of this report is the evaluation of the draft updated Regulations to Operate the Water Reservoirs of the HPP and PSPP Dniester Cascade (Figure 1), which consist of, from upstream to downstream, a dam equipped with a hydropower plant (HPP) and a large reservoir, Dniestrovski 1 HPP, a pump storage power plant (PSPP), Dniestrovskaya PSPP, and a second dam, Dniestrovski 2, also equipped with a HPP, the PSPP using the reservoir thus created between the two main dams as downstream reservoir, also referred herein as the buffer reservoir.

	Units	Dniestrovski 1	Estuary
Basin area	km^2	40500	72100
% total	%	56.2	100
River length	km	678	1362
Mean annual rainfall	mm	596	350-420
Average total annual flow	hm^3/year	8770	9000-10900
Module	m^3/s	278	300-344

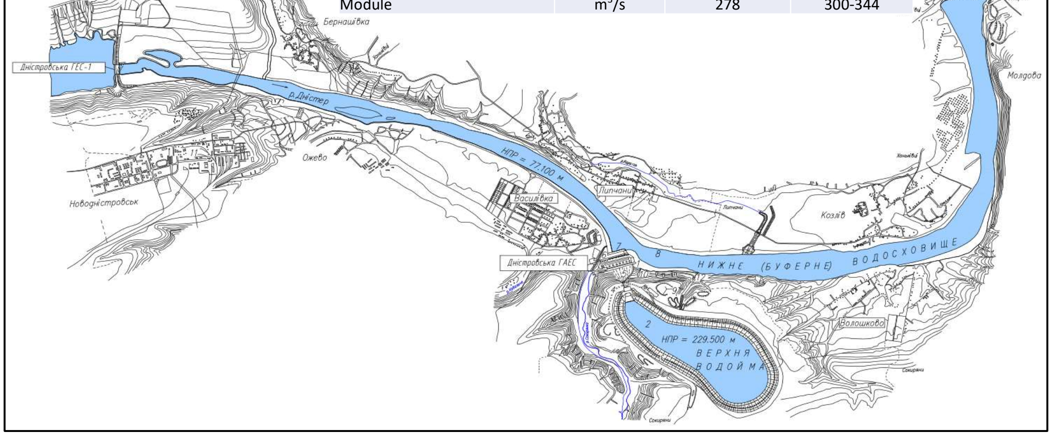

Figure 1 – The HPP and PSPP Dniester cascade

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1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

As was said before, the Dniester River basin is shared between Ukraine and Moldova, with Ukraine being the upstream country inasmuch as what concerns the Dniester cascade, and Moldova the downstream country. Dniestrovski 2 dam is built at the entrance of the Dniester in its border stretch and has its right abutment in Moldova and the left one in Ukraine. The Dniester runs into Moldova, a bi-lateral convention is in place that defines rules of behaviour, and as Dniestrovski 2 dam is situated in the border between the two countries the raising of NHL of waters in the buffer reservoir will permanently submerge some terrains in the right bank which are Moldovan territory (now flooded only in high flows).

The GEF project “Enabling transboundary co-operation and integrated water resources management in the Dniester River Basin” provides opportunities for information exchange, dialogue and drawing conclusions on:

- Overall impact of hydropower in the Dniester river basin;
- Revision of Rules of Operations for the Novodnestrovsk Hydropower stations and dams (the Dniester cascade);
- Future development of hydropower in the Dniester river basin.

The scope of this consultancy is the analysis of the draft New Regulations to Operate the Water Reservoirs of the Dniester Cascade HPP and PSPP (hereinafter the Regulations) which have been prepared by the JSC Ukrgidroproject in accordance with the Water Code of Ukraine and other relevant national environmental legislation.

The need to develop these new Regulations (the previous Regulations were published in 1987) was caused by changes in water engineering situation:

- Setting of the Dniestrovskaya PSPP for which off-stream storage reservoir on the Dniester right bank is used as the upstream reservoir and the reservoir of the Dniester HPP-2 is used as the downstream reservoir;
- Change of the design parameters and modification of the buffer reservoir operational mode to the conditions of the Dniestrovskaya PSPP seven-unit operation when the buffer reservoir NHL will be heightened to 77.10 m; the regime becomes dependent not only on the HPP-1 discharge, but also on the PSPP operation, which functions in pumping and turbine modes;
- Specification of hydrologic parameters due to the prolongation of the Dniester river calculated discharge parameters in years (from 90 years’ period, 1895/96 – 1984/85, to 119 years’ period, 1895/96 – 2013/2014);
- Accumulation of experience in actual operation of the Dniester reservoir and HPP-1 during the period 1987 – 2016;
- Taking into account the modern water engineering and environmental requirements, namely the requirements in the EU directives, to the operational modes of the Dniester cascade reservoirs.

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1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

Although several documents on the environmental impacts of the HPP and PSPP were reviewed, no such an assessment is attempted here as it is not part of the ToR (and the dams and power stations are already in place). In this report, only the efficiency and effectiveness of the new Regulations for the mitigation of hydraulic impacts downstream has been accessed.

A set of visits and meetings took place since the beginning of the assignment that were attended by the Consultant:

- A first meeting of the TWG on hydropower in the Dniester Basin was held in Chisinau, Republic of Moldova, on March 15, 2018. The objectives of the meeting were to learn about solutions in the field of hydropower, water distribution and environmental protection in different countries, discuss how the project can contribute to the development of the assessment of the impact of hydropower facilities in the transboundary diagnostic analysis (TDA), how it can help in developing operating rules, exchange information on the potential cascade of small HPPs on the Upper Dniester and agree on the next steps and the timing of the implementation of the activities of the WG. The meeting was attended by experts from the two Riparian countries and Transnistria, including representatives of public authorities in the field of environmental protection and water resources, hydrometeorological services, science, NGOs and Chisinau's water utility, as well as a number of representatives of international projects and donor organizations.
- In April 18 the consultant visited Ukraine and Moldova and made contacts with Lower Dniester's Ukrainian authorities. The Headquarters of Voda Canal were visited, as well as the intake and the water treatment plant that deserve Odessa metropolitan area. The Lower Dniester Park was visited, and the impact of the Dniester cascade was discussed with the authorities. The next day the consultant travelled to Novodnestrovsk to visit the cascade and attend the *Conference on Hydropower and Environment: Stable Development & Balanced Solutions*, organized by JSC Ukrgidroproject. The participants had the opportunity to visit the works that are going on at the PSPP in order to install 2 more units in the powerhouse.
- In June 12-14 the consultant had another opportunity to visit the Ukrainian and Moldovan authorities and discuss with them his preliminary findings. The visit started in Odessa and the local authorities were consulted and their complaints were registered. The consultant travelled in the morning of the 14th to Tiraspol and had the opportunity to talk to Transnistria's authorities and visit Dubasari powerplant and reservoir. In the afternoon he was received at the premises of the Ministry of the Environment of Moldova and discussed with the authorities present at the meeting his preliminary findings in what concerns the new rules. The next day the consultant travelled to Kiev and met the national authorities of Ukraine that afternoon, once again to discuss with them his preliminary findings.

In all these missions the consultant was accompanied by Ms. Tamara Kutonova whose presence and support were of great value for the fulfilment of the mission.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

Terms and definitions as in the draft Regulations are here considered.

2. Regional context

Between 2000 and 2007 the economic growth in Ukraine was a mixture of revival of old activities and emergence of new activities, both supported by access to inexpensive energy supplied from aging, inefficient, and often environmentally polluting sources through extensive electricity, gas and oil networks inherited from the former Soviet Union.

Developments in the energy sector mirrored these changes in the economy. The system faced serious challenges in maintaining security, reliability, and quality of energy supply because of the lack of investments and deferred maintenance in aging infrastructure, poor financial condition of energy enterprises and delays in sector reforms. These were far more than sector problems and it became clear that attracting investments, creating jobs, and increasing productivity, key drivers of sustainable economic growth, could not be effectively stimulated without improvements in the security, reliability and quality of energy supply.

Since then Ukraine has made considerable progress in the energy sector reform. As a result of its reform effort, Ukraine unbundled its power industry, introduced elements of competition on the wholesale electricity market and the coal market, opened the energy sector to private investors and liberalized the oil market [14]. As a result of restructuring, the power sector was reorganized and one hydropower company, JSC Ukrgidroproject, was created.

As a sign of the advanced state of the EU-Ukraine energy cooperation under the Eastern Partnership and the European Neighbourhood Policy cooperation, a Memorandum of Understanding (MoU) on energy cooperation was signed in 2005. This document now forms the principal basis for energy cooperation and sets out how the two sides plan to organise work to bring energy markets closer together.

Presently Ukraine depends from nuclear power plants and other thermal plants for most of its electrical production, with all the inconveniences associated: lack of flexibility as for peak power production, GGE, risks associated and dependence from suppliers of raw material. As stated in the Energy Strategy of Ukraine through 2035 [6], the obligations undertaken by Ukraine with respect to reducing the impact of the energy sector on the environment determine the need for additional investment. The priority here is limiting GGE by large power plants that can be achieved through the implementation of a whole complex of measures in the area of energy efficiency, energy conservation and increased use of renewable energy. The new operating rules can be seen as part of this effort, as PSPP and hydropower are themselves sources of renewable energy and are complementary to other renewables such as wind and solar which lack the level of guarantee of hydro.

As for the Republic of Moldova, its economy is dependent on foreign trade and affected by the economic performance of the country’s trading partners. In 2012, exports of goods and services accounted for 43.8% of GDP and 51.9% of the exports went to the EU area. Agriculture is one of

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

the main economic sectors and a major contributor to the economy. In 2011, agriculture employed about 27.5% of the labour force. Agro-food exports constitute about 45 to 50% of total exports and are backed by the export-oriented agro-processing industry, which produces approximately 7 to 8% of GDP. The unprecedented 2007 drought was a severe blow to the Republic of Moldova's economy.

Through the Energy Strategy adopted in 2007, the Republic of Moldova has for the first time in its history considered the use of renewable energy as a viable alternative to compensate for the critical absence of other indigenous energy resources. The global target for the use of energy from renewable sources in 2020 was determined by the Energy Strategy by 2030, thus harmonizing the provisions of the Moldovan legislation as a 20% contribution of renewable energy to the amount of energy consumption, with sectoral targets being equal to 10% renewable energy in electricity and 10% renewable energy in transport, renewable energy in heating and cooling resulting in 27%. The overall renewable energy target of 17% and the target of energy from renewable sources in transports of 10% are the obligations of the Republic of Moldova resulting from the quality of contracting party to the Energy Community. Under this Plan, renewable electricity will be generated predominantly by wind power plants from 2016 onwards.

3. Geography and hydrology of the region

Both Ukraine and Moldova are flat land, with rivers meandering in the territory. Landscape is dominated by large plots of land of good agricultural potential. This is the situation in what concerns the Dniester basin at its middle and lower parts. Total catchment area of the basin is of 72,100 km^2 and mean annual discharge at the estuary has been estimated to be 9,100 mln m^3 (which represents a module of 288 m^3/s).

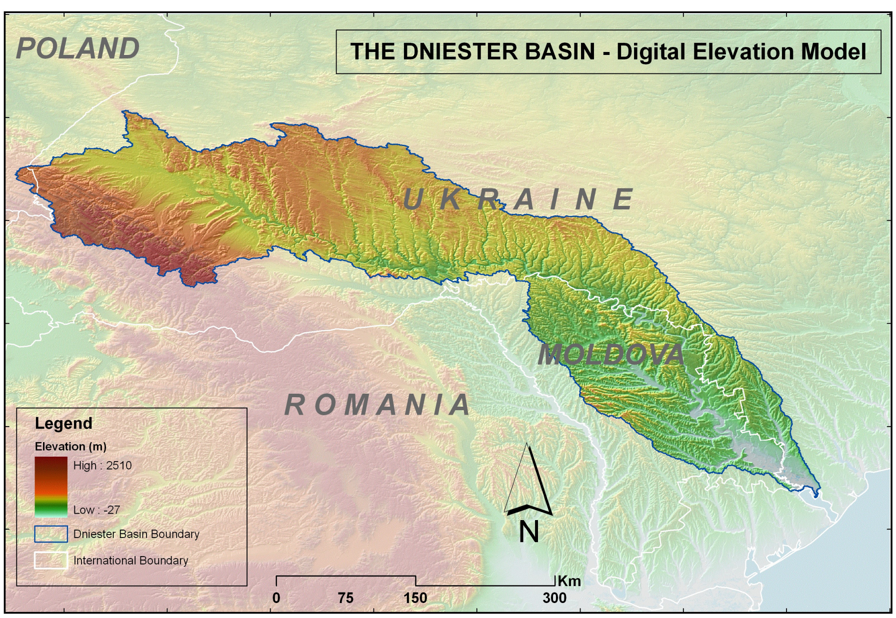

Figure 2 – The Dniester River Basin

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Moldova is a water scarce country with only two perennial watercourses, the Dniester at the West and the Prut at the East. The landscape of Moldova consists of plains and hills and the average altitude is 147 m above sea level. Its highest elevation is 429 m (in the central part of the country), and the lowest is 5 m (in the south). Current water availability in Moldova is estimated at around 500 m^3 per capita per year if the flows of these two rivers are excluded. This is well below the 1,000 m^3 per capita per year thresholds under which water scarcity begins to hamper economic development and human health and wellbeing, according to the Food and Agriculture Organization (FAO).

In Moldova in many regions, deep underground water resources have inadequate quality, either due to human pollution or due to geological formations that are not favourable and lead to "natural" contamination of the groundwater. Without specific treatment technologies, such as distillation or reverse osmosis, underground water is not suitable for drinking water and is only suitable for industrial and irrigation purposes. Due to the lack of sanitary protection zones, shallow aquifers in rural settlements are frequently contaminated by inadequate sanitation facilities, use of fertilizers and presence of animals, which jeopardize the ability to use these waters for drinking and other uses.

The Dniester (Nistru) basin at the East flows into the Black Sea, and the Prut at the West is a tributary of the Danube. Both rivers are perennial watercourses, but during the severe drought in 2012 the river flows dropped to 30-35% and 50-60 % of their average flow, respectively. Both rivers have small tributaries, but even the most important of them are not perennial watercourses. According to the United Nations Development Project (UNDP), climate change could even cause Moldova's surface water supplies to decrease by 16 to 20%.

Ukraine is more fortunate and besides the Dniester is crossed by several other important watercourses such as the Dnieper and the Bug.

The Dniester river drains the Eastern face of the Carpathian Mountains that separate Ukraine form Poland, Hungary and Romania. The highest pick in Ukraine is the Hoverla, which is 2061 m high.

The Dniester River is the main source of drinking-water in the Republic of Moldova, and it is no less important for a significant part of Ukraine, particularly in the Odessa region. Based on its flow collection pattern, water regime and physical and geographical characteristics, the Dniester River is generally divided into three parts:

- Upper Carpathian Dniester (286 km long). This section goes from the river source to the village of Nizhny and to the Tlumach River inflow (2 km downstream of the mouth of the Zolota Lypa River). Here is the densest and more abundant water network, where about half of the river flow is formed, a significant part of it coming in the form of snow.
- Middle Podol Dniester (715 km long). It stretches from the village of Nizhny to Dubasary. Middle Dniester is located on the Volyn-Podillya and Bessarabian Plateau before the influx

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

of the river Reut. At this site the basin is divided by numerous low-water tributaries and ground waters play a considerable role in the river alimentation.

- Lower Dniester (351 km long). This section goes from the Dubasary Hydropower Station dam to the estuary. The Lower Dniester, or Black Sea part, is characterized by weakly developed river network due to very flat terrain and unfavourable conditions for land runoff formation.

The basin has its heights in Ukraine's territory and most of Moldova's territory is flatland as can be seen in Figure 2.

The potential of the Dniester River for hydropower generation is considered to be relatively low owing to its flat channel slopes and, hence, the minimal fall of water flow produced in the river.

The Dniester river basin has a moderately continental climate, with relatively cold Winter and hot Summer. Average annual air temperature is +8.8 ºC, with maximum of +37.8 ºC and minimum -34 ºC. Precipitation in the basin ranges between 1,000 L/m^2 in the high mountains to 450 L/m^2 in the coastal area and it takes the form of Winter snowfall in the upstream part, in the Carpathian Mountains, and rainfall in the flat lands. Snow accumulates in the mountains and melts down with rainfall in Spring time, thus contributing to some form of flow regulation with many beneficial consequences (relatively high flows in Spring and Summer, as compared to other situations at the same latitude) and some negative ones (floods that are fed by moderate rainfall and snowmelt).

It is the Upper part of the Dniester basin that contributes the most for the river's runoff, as it is prone to very intensive rainfall and snowfall, with the snow melting in the Spring time contributing to high runoff and floods during this season (average multi-year precipitation of 596 mm). The precipitation occurs mainly in the warm season (April to October, up to 73% of the average, or 435 mm). This flow regime has modulated the ecosystems and the living patterns of the populations in the basin, the agricultural practices, land reclamation and occupation of the territory.

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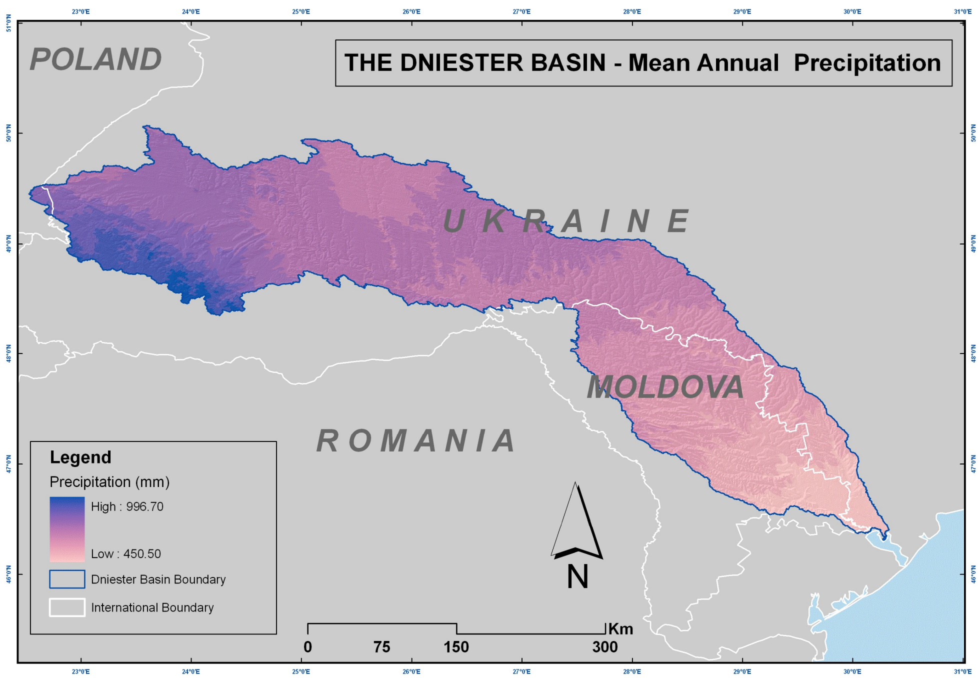

Figure 3 – Mean Annual Precipitation in Dniester River Basin

In the Dniester river there are very few hydraulic infra-structures that are able to interfere with the natural flow regime. From upstream to downstream we find: Dniestrovski 1 and 2, and Dubasary.

- Dniestrovski 1 is totally situated inside Ukraine and is the main HPP and reservoir.
- Dniestrovski 2 is at the border between Ukraine (left bank) and Moldova (right bank) and is the buffer reservoir in the Dniester and the downstream reservoir for the PSPP system.
- Dubasary (1954) is situated inside of Moldova several km downstream of the entrance of the river in Moldovan territory, all the reservoir being situated in Moldova.

Dubasary benefits from the regulation of Dniester's flows produced by Dniestrovski 1 (1983) reservoir and may further deregulate the flow regime or contribute to re-regulate it for the benefit of downstream users and environment.

The characteristics of these infrastructures are as can be seen in Table 1. Different sets of figures can be found in different papers but all of them can be read as follows:

- Dniestrovski 1 has the storage capacity to perform seasonal regulation of flows and some minimal interannual regulation, as well as to contribute to flood control.
- Dniestrovski 2 has only capacity for daily regulation and control of flows.
- Dubasary is apparently very much silted and from its original 600 mln m3 storage capacity only 214 mln m3 remain (eventually less, according to some sources), which render it of

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little use as for seasonal regulation of flows (can perform weekly regulation if appropriately run); can be used for the support of flood control if operated in coordination with the cascade.

Table 1 – Characteristics of the reservoirs in the Dniester River

Name of reservoir	Year commissioned	Distance from river mouth (km)	Drainage area (km^2)	Reservoir length at normal water level (km)	Reservoir area at normal water level (km^2)	Storage volume at normal water level (km^3)	Live storage volume (km^3)	Normal water level (m) ABD	Flood-control storage capacity (million km^3)
Dniestrovsky reservoir	1983	677.7	40 500	204	140.8	3.000	2.000	121	637
Buffer reservoir	1983	657.9	43 320	8	5.9	0.031	0.023	72	–
Dubossary reservoir	1954	351.0	53 590	128	67.5	0.486	0.214	28	–

lThe Dniester River flow regime is important to understand the impacts that can be expected on downstream stakeholders' interests by the running of Dniestrovski cascade. These impacts are to be assessed by comparing the *ex-post* situation with the *ex-ante* one, not necessarily with the expectations the stakeholders have in relation with the benefits from the running of the cascade. If there are any such benefits, then better for everybody. But if the output doesn't fulfil all expectations this doesn't forcibly means that the operating rules are not good, as benefits for all stakeholders have to be balanced among them and balanced also with the environmental impacts that have to be mitigated.

The Dniester flows are being measured since long at a set of gauging stations located in the main course of the river and some of its tributaries. As all we need to know are the flow regime characteristics, we selected the Mohyliv-Podilsky gauging station which is situated a few km downstream of the cascade and for which we have monthly data ranging from January 1950 to December 2010.

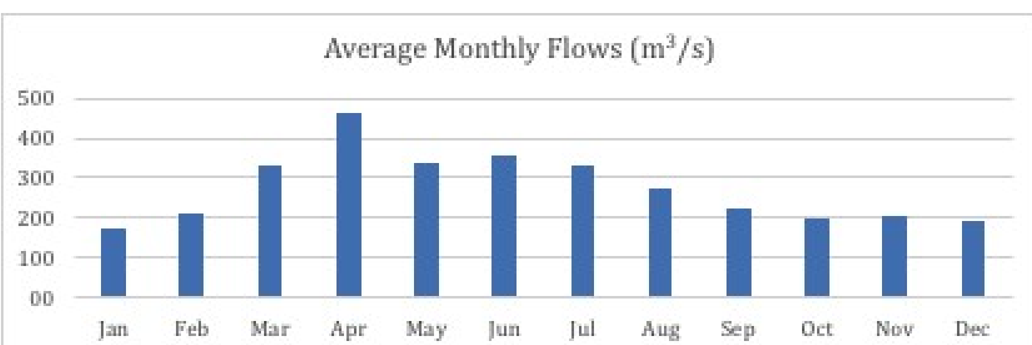

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Figure 4 – Average monthly flows at Mohyliv-Podilsky gauging station (1950-2010)

Interannual irregularity of flows is not very pronounced as can be seen in Figures 5 and 6. The average during the period was of 274.6 m^3/s and the minimum was registered in 1961 (131.4 m^3/s), the maximum in 1980 (490.3 m^3/s). The ratio between the maximum and the minimum is of 3.73:1.

Quarterly flows can be seen in Figure 7 bellow. This figure shows that Spring flows are really important under pristine conditions and Summer flows are also very important. It should be expected the ecosystems to be adapted to such a flow regime and therefore the operating rules must try and somehow mimic something similar in what concerns seasonal flows.

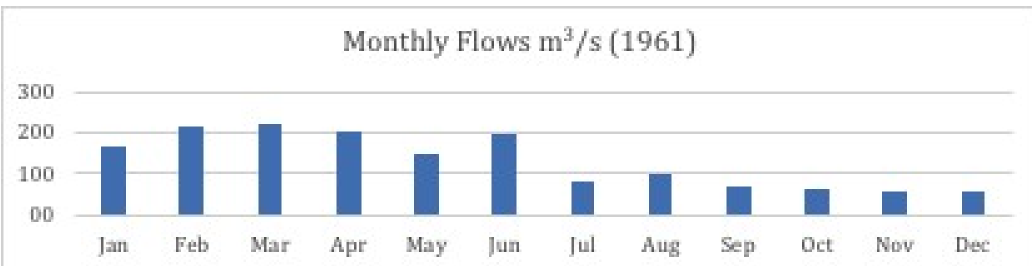

Figure 5 – Monthly Flows at Mohyliv-Podilsky gauging station in 1961 (very dry year)

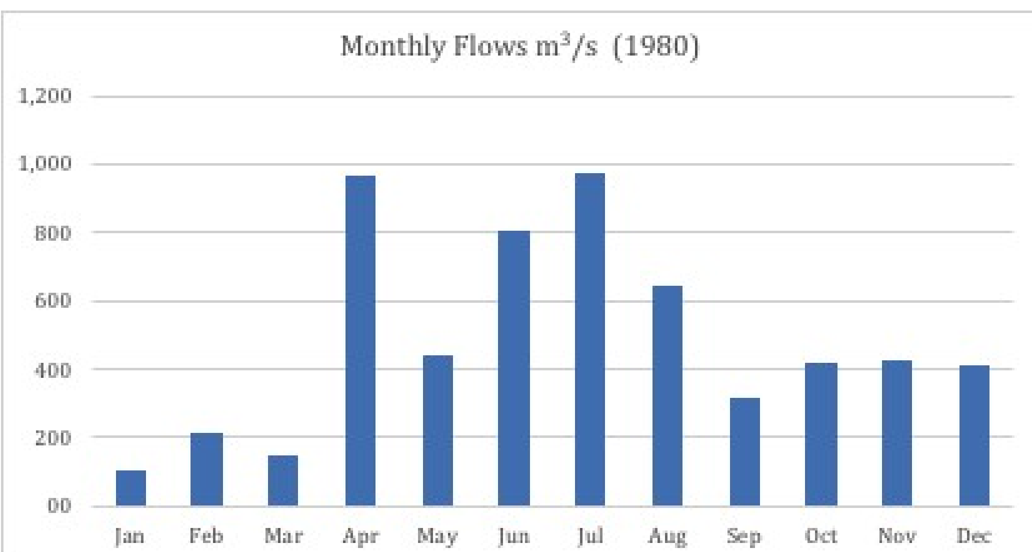

Figure 6 – Monthly Flows at Mohyliv-Podilsky gauging station in 1980 (very wet year)

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pedrocunhaserra@gmail.com

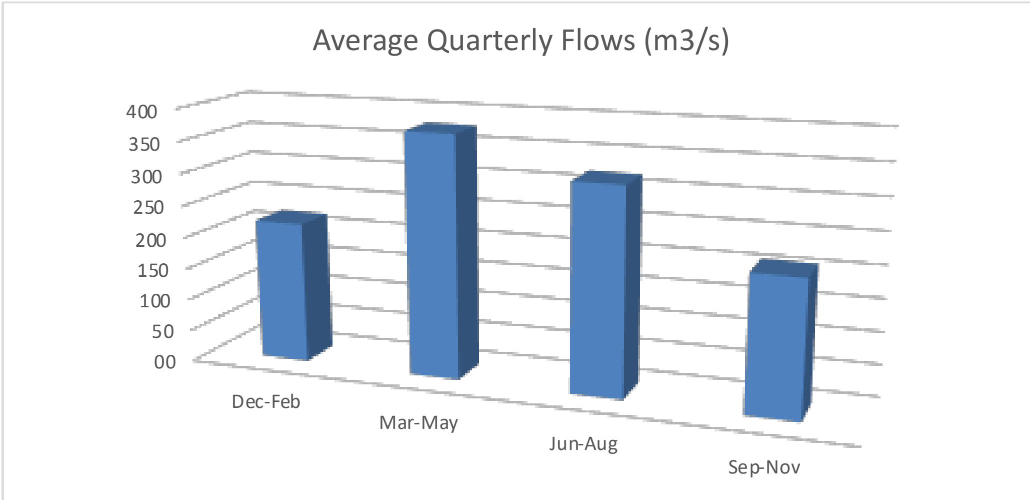

Figure 7 – Average quarterly flows at Mohyliv-Podilsky gauging station (1950-2010)

As for floods, flood peaks and flood volumes, the data show that several very severe floods occurred during the period (Table 2), at least 3 of them after the construction of Dniestrovski 1 dam:

Table 2 – Highest Floods Registered at Mohyliv-Podilsky gauging station between 1950 and 2010

Year	Starting in	Ending in	Maximum flow (m3/s)	Volume (mln m3)
1969	Jun-11	Jun-20	4,800	2,000
1980	Jul-25	Aug-04	3,530	2,000
1998	Jun-20	Jul-03	2,700	1,900
2008	Jul-28	Aug-06	4,510	3,000
2010	Jun-26	Jul-18	2,050	3,000

As can be seen it is quite common to have floods with quite high peak flows and large volumes, as large as the whole useful capacity of Dniestrovski 1 reservoir or even greater, once every ten years in average, usually during Spring and Summer months. Such flood volumes cannot be accommodated in the flood control volume of Dniestrovski 1 reservoir and have to be discharged downstream. Nevertheless, some routing takes place in the reservoir and peak flow will be smaller (and flood duration increased) downstream.

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Portugal
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Annual flows are shown in Figure 8, together with 5-year moving averages. These show that the announced impacts of climate change are not yet severely felt in the region.

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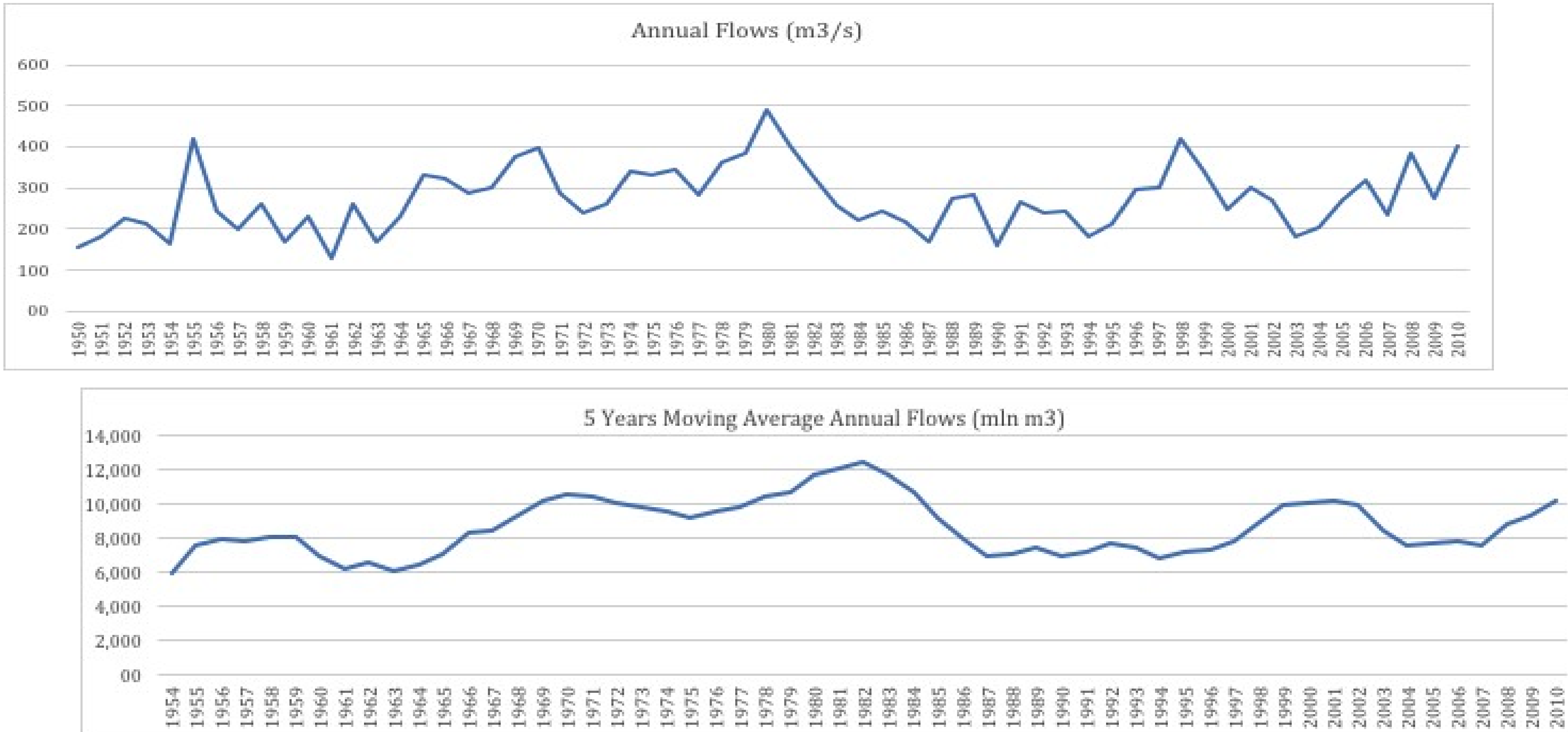

Figure 8 – Annual flows and 5 years moving average annual flows at Mohyliv-Podilsky gauging station (1950-2010)

In Table 3 the natural annual runoff of the Dniester River at Dniestrovski HPP-1 and Dubasary HPP sections are presented (it is assumed that the runoff at Dniestrovski HPP-2 is the same as for Dniestrovski HPP-1):

Table 3 – Annual runoff of the Dniester River (Table 2.1 in the draft Regulations)

Characteristics	Dniestrovski HPP-1 site	Intermediate basin between Dniestrovski HPP-1 and Dubasary HPP	Dubasary HPP site	Intermediate basin between Dubasary and Dniester mouth	The Dniester mouth
Catchment area, km^2	40,500	13,100	53,600	18,500	72,100
Average multi-year flow:					
- Water flow Q, m^3/s	278	31,1	309	34,9	344
- Discharge volume, mln m^3	8,770	980	9,750	1,100	10,900
Calculated discharge (km^3) percentile, P %:					
- 25 %	10.4	1.17	11.4	0.95	12.7
- 50 %	8.49	0.95	9.50	0.70	10.6
- 75 %	6.82	0.75	7.80	0.50	8.68
- 95 %	4.86	0.53	5.78	0.28	6.41
- 97 %	4.42	0.48	5.33	0.24	5.93

(this table reads this way: 25% of the years the Dniester discharge will be above 10.4 km^3 at Dniestrovski HPP-1 site).

Upper Dniestrovski basin is, by far, the most productive as for runoff. Average seasonal distribution of Dniester river flow at the Dniestrovski HPP-1 site in the multi-year period is as follows: Spring (March – May), when the major flow volume is formed at the expense of snow melting in the mountains – 38 %; Summer (June – August) – 27 %; Autumn (September – November) – 19 %; Winter (December – February) – 16 %.

4. Main features of the HPP and PSPP Dniester Cascade

The main features of the HPP and PSPP in the cascade are as follows (Table 4):

Table 4 – Main Features of the Cascade (from Table 2.2 in the draft Regulations)

Performance characteristics	Reservoirs		
	Dniestrovski HPP-1	Dniestrovski HPP-2 Buffer	Dniestrovskaya PSPP upstream reservoir
Name of the river	River Dniester	River Dniester	Artificial reservoir
Distance to river mouth, km	677.7	657.9	668.4
Reservoir type	Regulating type	Run of the river	Off-stream storage
Type of flow	Seasonal with	Weekly and daily	Daily

Performance characteristics	Reservoirs		
	Dniestrovski HPP-1	Dniestrovski HPP-2 Buffer	Dniestrovskaya PSPP upstream reservoir
regulation	shifting to multi-year		
Reservoir purpose	Multi-purpose: flood control, hydro-power generation, water supply, irrigation	Hydro-power generation (re-regulator of HPP-1 discharges and PSPP downstream reservoir)	Hydro-power generation
Commissioning year	Commissioning of the 1st two units after the reservoir got filled to the level of 95.0 m –Dec. 1981	Hydro-units commissioning: first unit – 8.09.1999	Stage-wise filling till the mark 229.5 m – October 2013
	Commissioning of the 3rd and 4th units at the level of 95.0 m – Oct. –Dec. 1982	2nd hydro-unit – 2 September 2000	Operation of the 1st hydro-unit in normal pump mode – since 01.10.2013; since 24.11.2013 – operation in the customary mode
	Commissioning of the 5th and 6th units at the reservoir dead storage level (DSL) =102.5m– Dec. 1983	3rd hydro-unit – 20 Dec. 2002	Operation of the 2nd hydro-unit in normal pump mode – since 08.09.2014; since 24.10.2014 – operation in the customary mode
	Reservoir filling till the level of 114.0 m – November 1985		3rd unit– 10.06.2016 start-up operations completed
	Reservoir filling		

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

Performance characteristics	Reservoirs		
	Dniestrovski HPP-1	Dniestrovski HPP-2 Buffer	Dniestrovskaya PSPP upstream reservoir
	till the level of NHL =121.0m – end of 1986		
Regulations for operating the reservoirs	Operating procedures for the reservoirs of the Dniester multi-purpose hydro-system, 1987	Provisional operating procedures for upstream and downstream reservoirs compositional to hydro-units №1, № 2, № 3 at the upstream reservoir NHL +229.500 м	
Hydro-system departmental identity	JSC " Ukrgidroproject "	JSC " Ukrgidroproject "	JSC " Ukrgidroproject "
In joint or separate use	Joint use	Joint use	Separate use

The cascade is very important for Ukraine, as Dniestrovski HPP-1 and the PSPP participate in compensating peak and half peak hours of daily loading schedule, serve as fast acting emergency reserves (and the need for emergency reserves will increase with the increasing of the share of renewables in the system, particularly wind and solar), and, together with Dniestrovski HPP-2, can be used efficiently for frequency regulation of the power grid.

The main characteristics of the three reservoirs are presented in Table 5.

Table 5 – Representative design levels and morphometric specifications of the Dniester cascade HPPs and PSPPs reservoirs

Indicator	Reservoirs		
	Dniestrovski 1	Buffer	PSPP upstream reservoir
Representative water design levels in the reservoir (near the dam), m:			
- normal headwater level	121.0	77.1*	229.5

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

Indicator	Reservoirs		
	Dniestrovski 1	Buffer	PSPP upstream reservoir
(NHL);			
- dead storage level (DSL)	102.5	67.6	215.5
- top of surcharge storage level (TSS) – flood routing level	125.0	82.0	-
Volume of reservoir, mln m^3: - at TSS;	3227	99.07	-
- at NHL;	2657	58.10	41.43
- at DSL;	750	6.50	8.73
- useful (between NHL and DSL)	1907	31.80**	32.7
- flood control (between TSS and NHL)	570	-	-
Surface area, km^2: - at NHL;	136	7,30	2.61
- at DSL	67.9	3.35	2.19
Length, km	194 (along the waterway at NHL = 121.0 m)	19.8	2.90
Average width, m	701	369	900
Depth, m: - maximum	54	17.1	29.75
- average	19.5	7.96	15.9

* New design parameter, as present NHL at Dniestrovski 2 reservoir is of 75.0 m.

** Data on volumes of the buffer reservoir doesn't seem to be very coherent, but they come from Table 2.3 of the Regulations and, nevertheless, are not very relevant.

The given draft Regulations are compiled for the conditions of the Dniestrovskaya PSPP seven units' operation when the buffer water reservoir NHL is equal to 77.10 m.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

5. Proposed Operating Rules

5.1 Proposed tasks to be performed by the cascade

The draft Regulations are a quite comprehensive normative document, mandatory for implementation by all the organisations and agencies involved in the operation of the Dniester cascade. It consists of the rules of operation that all the involved organisations must abide to when operating the reservoirs, the powerhouses and all the related waterways.

The main tasks that are to be performed by the cascade are described in the draft Regulations as follows:

- Flood control through using the flood control volume available in the Dniestrovski 1 reservoir;
- Power generation at HPP-1, HPP-2 and PSPP, HPP-1 and PSPP being the most valued power-stations as for energy production and HPP-2 being used for the creation of the buffer reservoir and reregulation of flows;
- Ensuring compensational releases for water supply, irrigation and navigation at the Dniester water-course from the cascade to the estuary;
- Ensuring the cascade's environment conservation function through increasing the Dniester's flows during abnormal dry periods by means of flow regulation, including Spring environmental releases;
- Stable provision of water to the downstream settlements and industries.

The draft Regulations take as starting point the evaluation of the hydrologic and climate of the Dniester river basin, including the main course at several sections and the main tributaries. This characterisation is done for several frequencies (probabilities of non-exceedance) not only for seasonal flows but also for floods and environmental water demand.

The draft Regulations consider also the demand, the so-called irretrievable water consumption, as presented in Table 6 (Table 2.4 in the draft Regulations):

Table 6 – Water consumption in the Dniester river basin according to the approved Dniester hydro-system project

Water consumers	Volume of water consumption, mln.m^3/year at the Dniester basin		
	Upstream of the Dniestrovski cascade	Downstream of the Dniestrovski cascade till the mouth	Totally in the basin

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

Industrial and municipal water supply, including: - transfer to Lviv city;	400 (182)	355 -	755 (182)
- transfer to Odesa city	-	(214)	(214)
Agricultural water supply	143	167	310
Fisheries	119	167	286
Watering	150	22	172
Irrigation (precipitation frequency P = 95 %)	49	2765	2814
Sanitary release into the Dniester estuary (80 m^3/s)	-	2520	2520
Total:	861	5996	6857
Evaporation from the Dniester reservoir	40	-	40
Evaporation from the Dubasary reservoir	-	29	29
Total with evaporation	901	6025	6926

These water consumptions are referred to as irretrievable in the draft Regulations because when the water is realised downstream at Dniestrovski 2, to be used for these purposes, it will not be available for further uses in the cascade (which is not the case with water that is pumped by the PSPP).

This water demand is by now significantly reduced, as one of the main users of water, irrigation, has been reduced since the collapse of the Soviet Union. This is not reflected in Table 6, apparently because it is be expected that irrigation will be resumed sooner or later.

The draft Regulations consider not only the operation of Dniestrovski 1 reservoir, the cascade's larger reservoir and the only one with storage capacity for seasonal (and a small portion of interannual) regulation, with capacity for flood control and supply of water for the fulfilment of all the objectives referred herewith, but also the rules for the operation of the buffer reservoir (including Dniestrovski 2 dam and powerhouse) and the PSPP. It is a very comprehensive document and one of some complexity, which makes it difficult to be apprehended by outsiders to the sector. Many comments on the document that were produced reflect this difficulty.

5.2 Operating curves

The draft Regulations consider and are set upon the Figure 9 (Figure 3.1 in the draft Regulations) where the operating curves, to be followed in the dispatch, are presented, and the zones are defined.

Figure 9 – Dniestrovski HPP-1 dispatch operating curves

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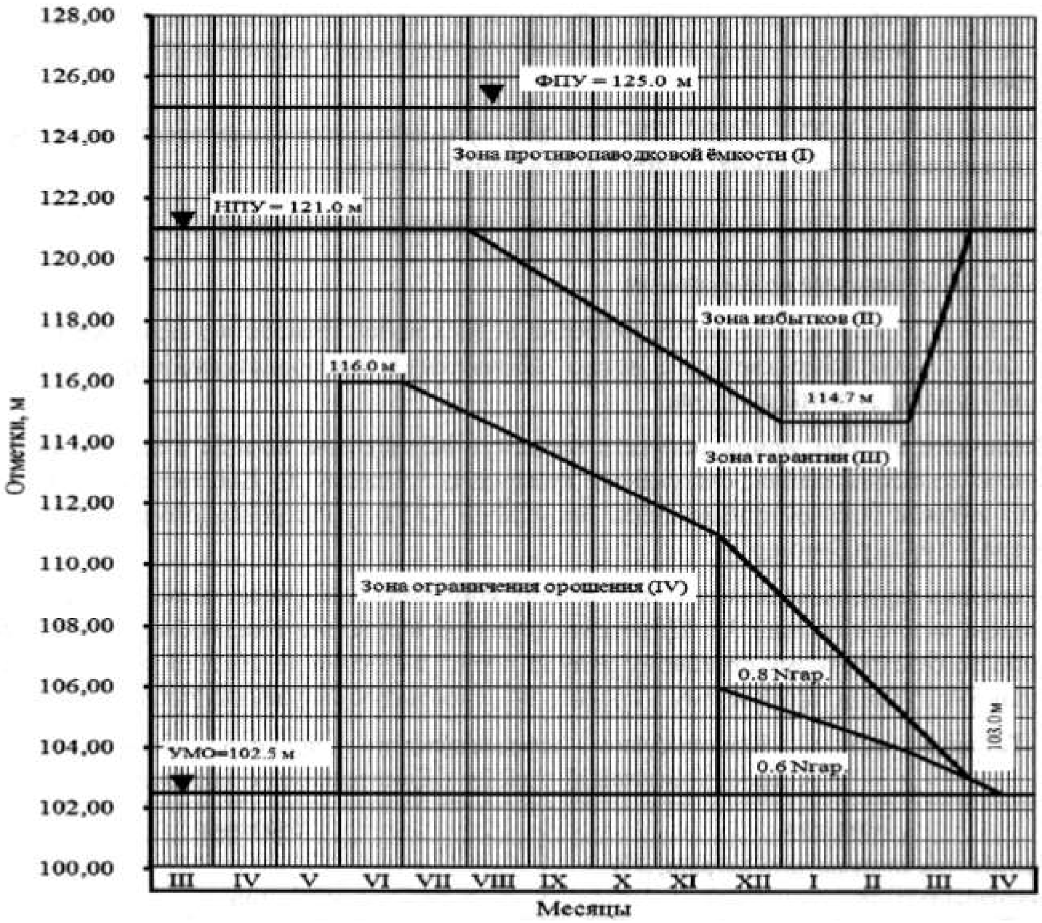
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com



Zone I – Flood control only zone. This zone is defined by the normal high level (NHL, 121 m) and the total surcharge storage (TSS, 125 m). This volume is of 570 mln m^3. Whenever a flood occurs the level of the waters will start raising and when the 121,0 m level is attained the gates will be opened so as to flush it downstream. It is mandatory to do so for safety reasons as the storage capacity available for flood routing is limited, so as for the dam not to be overtopped. Nevertheless, even when the gates are open the routing of the flood wave in the reservoir will always take place and the peak flood flow will be reduced when compared with what would have happened if the dam was not there.

Zone II – This is the so-called zone of increased, or excessive, yield. The top level is the NHL (121 m) and the bottom level varies with the month being as low as 114.7 m during January and February, the so-called normal pre-flood level in the reservoir. It is the same as the NHL from April to July, as this is the wet period when high inflow can be reasonably expected, it starts lowering from August to December, when water is required for different uses. And this is a volume of water that can be used for hydropower production with minimal restrictions, it being even considered adequate to lower the water level below this 114.7 m in the reservoir if the forecast volume of flows is above average (snow stocks evaluated) to increase the volume available for flood control,

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

as Spring flows will replenish it. When the reservoir is bellow 114.7 m it is necessary to consider minimum levels of water intakes in a set of cities referred to in the draft Regulations. First floods arriving in March will find the water level in the reservoir somewhere between 114.7 and 121 m and benefit from a larger volume available for flood routing.

Zone III – This is the so-called guaranteed yield zone. Volumes stored in this zone can be used to ensure irretrievable water consumptions as in Table 6 above. When the level in the reservoir is in this zone or above, the Dniestrovski 1 HPP can operate with the guaranteed capacity.

Zone IV– is a zone of decreased yield. Water in thiss zone can be used for hydropower production but only with severe limitations so as to prevent probable occurrence of disruption: not having enough water for primary uses downstream, such as the Spring releases required by the park and other downstream uses, in case upstream Spring flows are delayed. HPP-1 capacity should be reduced by 20% in case this happens from December to March and the waters are above the green line (zone V), and 40% if they are below the same line (zone VI), thus reflecting the priority attributed to those irretrievable uses and the environment.

During Summer and Autumn water needs are the highest (water for consumptive uses). Natural flows are quite high during Summer but decrease with Autumn. Water in zones II and III can be used to ensure irretrievable water consumptions. During Winter period the power engineering mode dominates, as downstream water needs are reduced, with pre-flood reservoir level set at 114.7 m as mentioned before. During Spring the main concerns are flood control, on one hand, and Spring releases as required by the park, on the other.

The draft Regulations are designed so as to balance several, in some cases contradictory, objectives. If energy production and power are the primary economic objectives, flood control and Spring flows and irretrievable water uses downstream are also considered important and condition the exploitation of the cascade and are, in many situations, contradictory: in order to cope with flood control the level of the waters in the reservoir must be kept low at the beginning of the Spring, when floods occur, which means that there is the risk that if Spring flows are below the expectations (for instances, below 90% percentile, see Table 3 above), the system will afterwards not be able to provide for all the downstream water requirements as set in Table 6, namely the Spring releases as required for environmental reasons.

All these uses depend also on average daily discharge. Emptying down to 102.5 m (TSS) is allowed to maintain guaranteed capacity in Winter low water periods and during power grid emergency situations (after the emergency the spent water stock should be restored in the shortest possible time, even at the price of decreasing power generation).

5.3 Flood control

According to [19], the Dniester river flooding cycle is one of its distinctive features, with up to five floods occurring each year, when the water level in the river can rise by 3 to 4 m and sometimes more. On the other hand, forecasts as for Dniester basin vulnerability to climate change [19] point

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

out to an increase in the height and intensity of floods in the next 30 years as compared with the 1971-2000 period, Ukrainian territory being the most vulnerable as for damage coming out from floods. So, the Regulations consider flood control as the first priority as for the tasks assigned to the cascade, as we have seen.

Dniestrovski 1 reservoir is to be used for flood control, besides seasonal flow regulation. The storage capacity that is considered to be used for flood routing is in the order of 570 mln m^3, the zone I volume. This volume can be increased up to 1400 mln m^3 in case zone II is also available. Precautionarily the draft Regulations consider the zone I volume only and therefore flood routing is of little use in case of very big floods, as could be expected. But even in this case some routing will take place in case the flood control facility (the volume between levels 121.0 m and 125.0 m) is not full. Anyway, the draft Regulations assume a conservative (pessimistic) scenario and assume that no routing will take place above 8320 m^3/s peak flow, which corresponds to the 1 in 100 years frequency. This can be argued as realistic as such huge floods represent very large volumes of water and when the peak flow arrives to the reservoir this is already filled to the top (125.0 m). In Table 7 (Table 3.2 of the draft Regulations) can be seen the expected routing for different flood frequencies.

Table 7 – Indicators of different frequency high waters routing through the Dniester hydro-system with regulating the process by the sequence without forecasts consideration

Indicator	High water frequency, P %								
	0.01	0.1	0.5	1	5	10	20	50	70
Maximum flow-rate at the Zalischyky gauging station data, m^3/s	13,260	8,320	6,000	5,140	3,400	2,750	2,130	1,330	1,000
Discharge maximum flow rate through the hydro-system, m^3/s	13,260	8,320	5,550	2,600	2,600	2,600	2,130	1,330	1,000
Maximum water level in the reservoir (near the dam), m	125.0	125.0	125.0	125.0	122.0	121.1	121.0	121.0	121.0
Decreasing maximum flow-rate (cutting) at the expense of regulation, m^3/s %	0 0	0 0	450 7.5	2,540 49.4	800 30.7	150 5.5	0 0	0 0	0 0

Apparently, design capacity of Dniestrovski 1 flood gates is of 13,260 m^3/s at 125.0 m (according to information in chapter 4.1.1 the water level in the reservoir needs to be 126.7 m for this exceptionally high flood to be discharged, which represents no problem as the dam's crest level is 127.0 m, this being such an exceptional situation). Spillway's crest level is of 110.0 m.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

It is considered that improving the routing for P > 0.5% (more frequent floods but with lower peak flows) is only possible if the water level in the reservoir is lowered before the wave arrives and this can only be done (without risking aggravating the situation) in case there is forecast 1 day in advance. Table 3.3 in the draft Regulations shows the benefits that can be expected as for peak flow abatement through flood routing. But forecasts are not the real thing and in case, later on, the flood is not as expected (smaller), the reservoir's stored water capacity to cope with Spring releases and Summer and Autumn irretrievable flow releases may be jeopardised.

Anyhow, only very exceptionally flood control mechanisms, as proposed, will in fact aggravate the situation (by flushing the waters downstream unnecessarily): this will happen in case the forecast error is in the order of +50% and the peak flow rate is in the order of 1,500 m^3/s. This is not something of great concern and the benefits that arise from using forecast are largely positive.

It has been suggested to have 48h forecast instead of 24 h. It is not clear if there is anything to be gained by using such forecast as, for very low frequency floods, routing will always be negligible if any at all; for frequencies in the range 0,5% < P < 5% the 24 hour forecast already produces a significant cut of the peak flow (although this reduction is already impacted by the forecast error), and for frequencies in the range P > 5% forecast error can severely impact (reduce) the expected benefits as for the cutting of the peak outflow (and forecast error increases with the forecast delay).

But “green adaptation” (coordination of flood protection plans, restoration of natural flood plains and riverbeds, monitoring, forecasting and real-time information sharing and emergency response plans) should be preferred to “hard” engineering measures, according to [19], as they will prove to be more effective.

No significant contribution as for flood routing can be expected from the buffer reservoir's storage capacity.

5.4 Monitoring and reporting

Monitoring and reporting must be looked at as a very important part of the transboundary dialog on the mitigation of negative impacts and the sharing of benefits. The creation of a joint Ukrainian-Moldovan platform for the exchange and dissemination of hydrometeorological data has been proposed [19] that could be extended to all Riparian and to further coordination of water resources management, including the running of all relevant infrastructure in the river.

The dams are fully equipped with monitoring instruments as for dam safety and the draft Regulations present a full description of how this monitoring is being performed, which seems quite good. The same with hydrometeorological support to the operation of the reservoirs, which includes gauging stations in all of them, both upstream and downstream and in the main tributaries. The main State agencies and departments are involved, according to their profiling. The Hydro-meteorological organisation of the State Emergency Service of Ukraine is involved in

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

the weather forecast regarding the management of floods but also the overall management of the cascade, as can be seen in Tables 5.2 and 5.3 of the draft Regulations.

This is a very thorough meteorological and hydrological information and forecast system. Even if 30 days ahead forecasts are not yet very reliable they can provide qualitative information on the weather that can be expected (temperatures, rain and snowfall).

The draft Regulations also include the description of the procedures to notify (mainly downstream stakeholders) about the water regime, including the hydro-meteorological forecasts, emergency alarms about exceptional hydro-meteorological events, pollution events, flood routing and so on. An account of water uses and water management is kept, that may be of use latter on for regular updates of these draft Regulations.

5.5 Environmental requirements

This chapter of the draft Regulations pertains to the environment protection requirements to be adopted all along the river and the coastal area concerning water contamination, water erosion prevention, coastal belt protection, protection of riparian vegetation and of native fish species (spawning areas), and the environment in general.

Rules are defined as for farming, disposal of effluents, water protection zones, introduction of alien species, bank alteration, housing development, roads and other man-made complexes.

The implementation of these measures is the responsibility of the national and local authorities and restrictions in the use of the reservoirs and their banks are introduced.

6. Expected downstream impacts

The mere existence of this cascade of two HPP, one of them with a large reservoir, and one PSPP that conditions the way the cascade is run, gives place to some impacts, mainly but not only, downstream. Some of these impacts are negative, other are positive impacts. Negative impacts can be mitigated, but not fully eliminated.

The main negative impacts include:

- River segmentation, that creates a barrier for fish migrations: if this is considered as a problem of some relevance then fish ladders and fish elevators could be considered (this is an issue to be discussed during TDA studies and is out of the scope of this report);
- Because of river segmentation, siltation downstream is drastically reduced, with all this means as for reduction of sand and silt arriving to the Ramsar areas and the coastal belt (and, eventually, erosion in the river bed); there is little or nothing that can be done to mitigate these impacts (some flushing happens during high flood flows); and this is a situation that was first created by Dubasary dam and is going on since 1950 (Dubasary rules of operation offer some solutions but these seem to have been of little use up to now);

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

- At the same time, river sand and gravel turned out to be attractive as a source of building materials and, a result, the river’s filtration capacity is declining, the stability of the river bed and banks is being undermined, and the remaining spawning grounds for fish, which use the sand and pebbles as a substrate, are being destroyed [19];
- Temperature stratification in the HPP-1 reservoir, which changes the temperature regime in the river and may have negative impacts on spawning areas; there is little that can be done as for the operation rules as the dam is not equipped with intakes for the hydropower equipment at different levels (and this is something that is really very difficult, almost impossible to change without putting the cascade out of service for many months and at a considerable cost), as can be seen below (Figure 10);
- Deregulation of the yearly flow regime (lower flows during the Spring and Summer periods and higher flows during Autumn and Winter); the draft Regulations have been designed in order to mitigate this impact, but, again, this is something that is unavoidable as the idea of building the cascade is precisely to regulate flows so as to have more water (and electricity production) during the dry period at the cost of reducing flows downstream during the wet period;

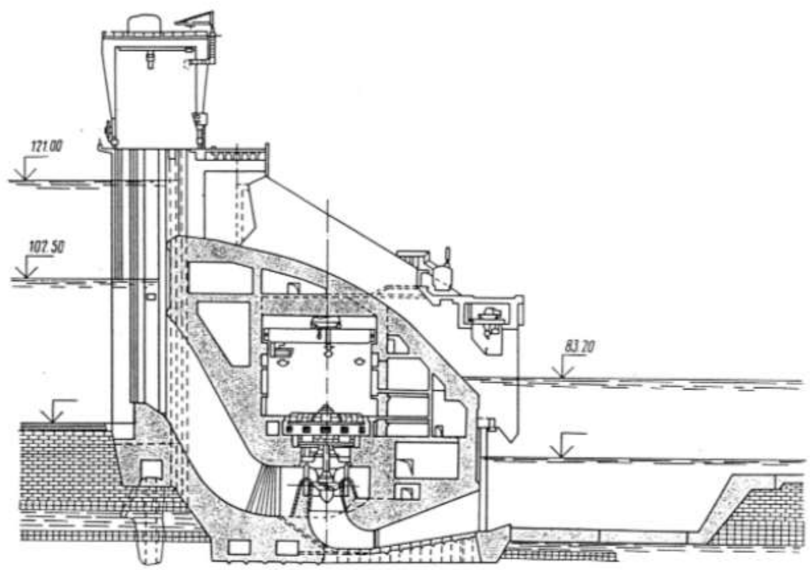


Рис. 2. **Поперечный разрез по зданию Днестровской ГЭС**

Figure 10 – Cross section through the building of the Dniestrovski 1 HPP [18]

- Deregulation of the daily flow regime; this is something the cascade can tackle with with appropriate measures introduced; the draft Regulations are somehow contradictory as in some places (page 13) say that the HPP-2 powerhouse is operated 24x7, which is good, and in other places (Table 2.5) refer that the number of hours of operation during the year is in the order of 2,316 hours (instead of the 8,760 hours the year has); nevertheless the impact will only be felt immediately downstream, as the wave thus created will be naturally routed along the river channel and after some tenths km downstream the impact will be negligible and the river will flow continuously; on the other hand, if the powerhouse is kept out of service during the weekends the impact will be felt all along the river downstream and the environmental impacts will be significative.

As for the positive impacts, besides the economic benefits for Ukraine and for the company in terms of energy production, which are very important and cannot be neglected, the following are identified:

- Flood control and mitigation of flood flows downstream of HPP-2; we are talking of mitigation, not of elimination as this is impossible to attain; mitigation of peak flows is quite important (up to 50% of natural flows for some frequencies, see above, Table 7);
- Reduction of GGE, not only due to the fact that energy is produced without any fossil fuels being burned (HPP-1 and 2) but also because the whole cascade can provide the guarantee that is needed if additional renewables are to be added to the electrical system of Ukraine (solar, but most of all, wind energy);
- Provision of water for irretrievable water consumption downstream with a level of guarantee that is not possible without the cascade and some regulation of flows; the draft Regulations respond to concerns of downstream water users, even if some additional rules can be added in response to some of the requests presented by the stakeholders during the consultation;
- Mitigation of dry periods; the cascade can provide some interannual flow regulation providing benefits for downstream water uses (urban water supply, irrigation, industry, fish farming, navigation);
- Control of siltation downstream, namely in Dubasary reservoir.

Some of these negative impacts can be mitigated but at a cost: by investing in the infrastructure, by reducing the flow of benefits for the country coming out of the operation, but also at the cost of increasing some other negative impacts and increasing the risks, and this must be considered when balancing the pros and the cons of the comments received (the benefits of some stakeholders are the impairment of others). For instance, flood control maximisation conflicts with some regulation of flows for the dry period as it requires lowering the water level in Dniestrovski 1 reservoir at the risk of the reservoir not being able afterwards to provide the required flows for the irretrievable water consumptions in case of lower than expected inflows occur later on, just to name one such situation.

7. The issue of seasonal flows

7.1 Spring flows

The Dniester floodplains provide habitat for a large number of rare and endangered species of plants and animals, including many species of birds [19]. Many of the protected species of birds

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

that nest in Ukraine feed in the fields and pastures of Moldova and the spawning grounds of fish populations in the Lower Dniester are in the Moldovan part of the river, while the mouth of the river, which is in Ukraine, is their main feeding area. One of the world's important corridors for the transboundary migration of migratory birds is along the Dniester and for this reason a large part of the delta and the Unguri-Holosnita are registered in the List of Wetlands of International Importance (Ramsar sites).

Because of this, the issue of seasonal flows is at the core of the draft Regulations and also of the comments received from many stakeholders. This issue is object of monthly Protocols that are signed by the participants in the Interdepartmental Commission in Kiev. In April mainly the Spring flows are at stake.

The first floods flowing into Dniestrovski 1 reservoir (peak flows above 1,000 m^3/s or something of the kind) usually occur in March and April, if we consider the available information (1950-2010), but can come earlier (February, as it was the case in 1961, 1966, 1968, 1977 and 1979) or later (July, in 1997, August, in 1991 and even September as it happened in 2009).There are actually historic floods registered in all seasons and every month, from January to December.

As for these first floods, 17 out of 61 are registered in March, 15 in April, 5 in February and May, each, 3 in June and other are scattered among the other months (in 12 years this peak flow was not attained). In one case, 2008, the first floods occurred in April, from the 20th to the 27th and in July and August huge floods happened with a peak of 4510 m^3/s in the 28th July. This huge flood lasted from the 22nd July to the 7Th August and its volume was something in the order of 3,200 mil m^3, 1.5 times the useful volume of Dniestrovski 1 reservoir (the dam was already in place and the flood was routed through its reservoir).

But flood routing and seasonal flows are two separate issues, even if the two have in common the fact that what is needed is to deal with these high flows and try to mimic them in the new situation created by the mere existence of the reservoir. The delta of the river requires some high flows if the ecosystems and the natural park are to be preserved.

In the beginning of March, the reservoir is recovering from the dry season demand of water and the minimum operating curve will be at its lowest (most probably operating in zone III or even zones IV, V or VI as defined above, in these last two cases with restrictions as for the demand that is attended). In March flows will start increasing (but this did not happen in every case in the past) and it is expected to have enough water in the reservoir in the beginning of April so as to mimic the first floods and release Spring flows according to what was the usual situation in 2 out of every 3 years in the past (if we consider that in 42 out of 61 years the first floods took place in between February and May). If 1,000 mln m^3 are available (coming from upstream during this month with some level of guarantee or available in the reservoir), them it is possible to discharge (turbine) some 400 m^3/s in average during this month so as to respond to the ecological needs of the delta (Dubasary is neither part of the problem nor of the solution, as the volume of its reservoir is in the order of a mere 214 mln m^3).

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

When we compare these figures with what was agreed in the Interdepartmental Commission the 13th April 2018, starting from the 14th April,

Day 1 - 350 m^3/s;

Day 2 - 400 m^3/s;

Day 3 - 450 m^3/s;

Days 4 to 13 - 500 m^3/s;

Days 14 to 15 - 450 m^3/s;

Days 16 to 20 - 400 m^3/s;

Days 21 to 23 - 350 m^3/s;

Days 24 to 25 - 300 m^3/s;

Days 26 to 28 - 250 m^3/s;

Days 29 to 30 - 200 m^3/s;

Day 31 - 150 m^3/s.

we find that the total volume that was discharged was of 1,040 mil m^3. But the starting point was:

- the level in the upper reservoir was then 121.37 (zone I, which means that some release of water should take place in order for the reservoir to be prepared to accommodate any flood that might come during Spring and Summer seasons);
- inflow to the reservoir was of 500 m^3/s at that time,

which of course made it easy to arrive to an agreement (water temperature in the Lower Dniester was 12ºC, which allowed to start the ecologic discharge). The possibility of having to stop the operations for unforeseen reasons (sharp decrease of flows, formation of rain floods) was agreed and the parties present in the meeting requested Apele Moldova to provide a transit passage of the ecologic flows through Dubasary.

The 500 m^3/s peak flow can be argued, and some experts point out to the need of having 700 m^3/s flows lasting at least some hours during the Spring, as it was the case almost every year in pristine conditions with very few exceptions (which is true, the most important of all exceptions having happened in 1990, when the maximum daily discharge at Mohyliv-Podilsky gauging station was 383 m^3/s only). It is possible this is so but what we must underline is that the procedure that was adopted this year can accommodate such changes if they prove to be right, and should even go beyond this 700 m^3/s from time to time, as it happened in pristine conditions: only in 4 out of 61 years of records (1950-2010) at Mohyliv-Podilsky gauging station highest daily flow inferior to 750 m^3/s have been registered and in 1 out of 2 years the maximum daily flow registered is above the 1500 m^3/s.

An issue of water abstraction for two Ukrainian towns – under higher levels in the Dniester reservoir has been raised during the consultations; we shall address this issue in the next version of the recommendations.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

We must not forget that even higher flood flows will regularly happen, independently of the will of all parties (regularly flooding the flood plains should be sought for the development of the ichthyofauna in the Dniester delta), and to the flow releases in the cascade must be added the contributions of the intermediate river basin. The issue is for sure a very complex one, as there are low water years when it will not be possible to provide such flows without jeopardising the irretrievable water uses (and under pristine conditions this flows would not occur) and the water flow rates must be also conditioned on water temperature, because of spawning.

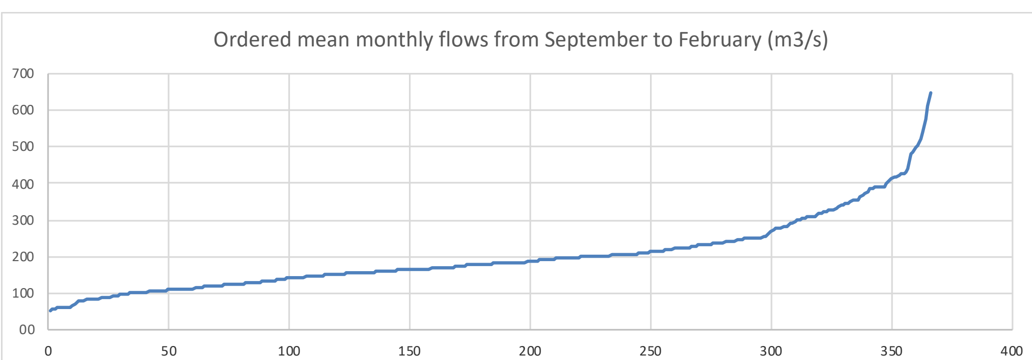
The Protocol considers also the need to inform the population and for monitoring of the hydrological situation in the Dniester basin.

This is an example of what can be done in what concerns Spring and Summer flow releases at Dniestrovski 1 reservoir: 1) it is in line with the draft Regulations, 2) provides for the involvement of the interested parties, 3) considers the specificities of the case (flows coming from upstream, water in the reservoir, needs downstream) and 4) can be adjusted to the needs.

7.2 Autumn and Winter flows

The issue of Autumn and Winter flows has been raised by several stakeholders and the request for a minimum outflow from Dniestrovski 2 of 100 m^3/s was presented. In the Regulations (General requirements, 3.1.2) it is said that, according to the PSPP project, the minimum average daily environmental water release during all seasons should be not less than 100 m^3/s. This value had been substantiated by the necessary sanitary river conditions in the water abstraction points used for drinking purposes and for food processing industry needs, as well as by the need to keep the corresponding depth for navigation purposes and for ships standing during repair period over Winter time.

If we consider the flow data from the Mohyliv-Podilsky gauging station (1950-2010), this mean monthly flow was not attained in 33 out of 366 months in the period September to February, i.e., 1 out of 11 months (and 42 out of a total 732 months, 1 out of 17 months, if we consider the whole period).



Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136
pedrocunhaserra@gmail.com

Figure 11 – Ordered mean monthly flows from September to February at Mohyliv-Podilsky gauging station (1950-2010)

But, most of all, it should be considered that, for the period 1986 to 2010, when the Dniestrovski 1 HPP and reservoir were already in operation, this mean monthly flow was exceeded in each and every month, which represents a benefit for all downstream water users and for the environment.

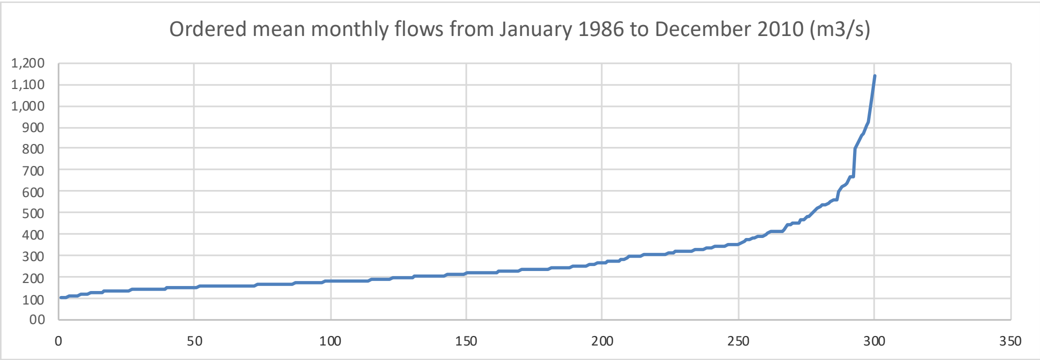


Figure 12 – Ordered mean monthly flows at Mohyliv-Podilsky gauging station (1986-2010)

As should be expected, the cascade regulates the flows that arrive downstream, reducing flood flows up to a certain level and increasing low flows.

8. Appraisal of comments produced by different stakeholders

A set of comments was produced by different stakeholders and institutions. These comments are appraised here.

8.1 Comments from the Moldovan Authorities

The Moldovan Authorities present a set of well-structured comments to be considered, as the Dniester runs into Moldova and a bi-lateral agreement is in place that defines rules for the cooperation between the two Parties.

The document starts with some comments on the Terminology section that can be accommodated according to the current legislation.

Then it proceeds with the request of a detailed description of how the irretrievable water needs have been defined as well as the consideration of impact of climate change on water resources. The latter should really be considered, bearing in mind the vulnerability study done for the basin (https://www.osce.org/secretariat/366721, https://www.osce.org/secretariat/260306). The issue of water consumptions (irretrievable water demand) is an entry data of the problem to be solved: are these draft Regulations fit to cope with the reasonable needs of all stakeholders without jeopardising the purpose for the construction of these dams.

The Moldovan Authorities propose a set of priorities for the cascade that are not that different from those set in the draft Regulations (flood control is proposed to be second instead of first priority).

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136
pedrocunhaserra@gmail.com

This will change very little in what concerns the draft Regulations, as they balance flood control and provision of water for irretrievable water demand by a set of rules that we believe fulfil both objectives inasmuch as physically possible: it is very difficult to further improve flood control beyond what is proposed and as for demand supply what is proposed is quite reasonable (and in line with an objective of power generation). Of course, Spring flows can be discussed as we showed.

Infiltration is mentioned, that we believe is not that relevant, i.e. water levels in the reservoirs are not that high so as to produce a significant increase in infiltration; if this was the case it would had been noticed already and anyhow groundwater levels would have raised around the reservoir, something that can be easily checked.

The Moldovan Authorities discuss the operating curves. It is the binding nature of these curves that seems to be at stake. The issue is a very technical one and we suggest it to be discussed among the Riparian. These or similar curves are used for the running of other HPP in other parts of the world and we believe them to be a very important, perhaps the most important, part of the draft Regulations and so it is crucial the Moldovan Authorities are given further explanations on this issue. But, for sure, these curves do not reflect the best requirements of energy production, contrary to what is said in the comments, as, in detriment to optimal power production, they reserve water for downstream uses and environmental flows and space to accommodate flood control up to what can be reasonably expected (both that would not happen in absence of Dniestrovski 1 reservoir).

As for the transboundary nature of the Dniester and equitable and reasonable use of the Dniester's waters, this is an issue that needs to be agreed between the two Parties to the existing bilateral agreement. The draft Regulations and this comments that have been produced by the Moldovan Authorities are a good starting point for the works that need to be done in order to accommodate the concerns and the interests of the Riparian. At the same time, and in parallel, the issue of no significant harm being caused to other watercourses States should also be discussed, bearing in mind that both Moldova and Ukraine are both the upstream and downstream countries in relations to each other, which perhaps will facilitate the discussion.

The Ukrainian intentions to build a new cascade are also commented. This is an issue that is out of the scope of this report but, as it is referred in several documents, it is briefly commented here bellow.

As for the issue of Dubasary and the impact that may come from the use of these draft Regulations in the running of the Dniester cascade, it must be said that Dubasary strongly benefits from it: reduced siltation, reduced peak flood flows, more regular inputs of water, all these allowing to increase energy production in this powerhouse.

As for Chisinau water intake needs (as well as for Odessa and other intake needs) it is mainly an issue of water level in the river and not one of flows (as we have seen, low flows have been increased by the running of the cascade, as compared with pristine conditions), i.e. engineering

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

solutions to increase the water level at the water intake may have to be considered. Eventually this is something that deserves a closer look by all parties involved, but it should be kept in mind that both Chisinau and Odessa intakes are situated downstream of Dubasary reservoir and, therefore, no significant impact can be expected coming from the way Dniestrovski 1 reservoir is being operated.

In what concerns the proposed increase in time delay of the forecast, we have already commented above that this will, most probably, not bring any benefits to flood control. Anyhow it can be tried as we believe that, if it proves useful it will be for the benefit of all parties and stakeholders, including Ukrgidroproject. As for joint monitoring, notification and exchange of information, whatever is done to improve the existing mechanisms will be welcome, if for no other reason because it contributes to increase confidence between the two Riparian (a joint monitoring programme could be appended to the Regulations).

A Methodology for Assessing Damage to the downstream Moldovan Party and Odessa oblast (Population, Economy and Water Ecosystems) as a Result of Violation of the Regulations to Operate the Dniester Cascade Reservoirs is proposed. We believe such a document would create the suspicion that these Regulations are not going to be implemented by its recipient and we suggest focusing on benefits of cooperation which are in the core of international water law, i.e. the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water Convention). However, a regular and joint follow-up of the application of the Regulations would be of value for future revisions.

In what concerns thermal condition of the waters there is little we can add to what we said before: this is not an easy problem to solve and we cannot offer a solution (see Figure 10 above).

As for EIA and SEA, it should be noted that these draft Regulations are part of the measures to mitigate the negative impacts and enhance the positive impacts of the cascade downstream, and it would be somehow unusual to have them subject to EIA. The infrastructure is already there and what can be discussed now is how best manage it for the benefit of all stakeholders. As for SEA, it is recommended for programs and plans, not for the assessment of project's impacts. The case of the new cascade is completely different, and an EIA should be performed before the decision to go (eventually a SEA also, as this is a cascade of new power stations and cumulative impacts should be assessed). But this is a very specific legal issue and a legal expert should have a say on it.

8.2 Comments by Odessa Regional Water Authorities

The Odessa water authorities are very much concerned with what may happen in the future, not only because of the new rules for the operation of the cascade but also because of the rules that will be set in practice by the Dubasary operator. Therefore, they request the authorities of all Riparian to arrange a solution for the running of all these infrastructures such that the needs of water users in the Lower Dniester will be attended. This solution should consider the contributions of the tributaries downstream of Dniestrovski 2.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

This Regional Authority believes that the daily average 100 m^3/s water release has not been methodologically justified. This is something that we believe can be accommodated in the Regulations with no difficulty (eventually associated to a certain probability of not being attained, see below), as it is already the situation (and it is also to the benefit of the company). We should bear in mind that the cascade is already supplying more water than the river would carry during many months in pristine conditions (see above).

The Regional Authority requests to be timely informed of the discharges from Dniestrovski 2 during high flow periods, namely when flood flows are expected that will have to be discharged downstream. And it asks for the rules in the Regulations on flood routing to be coordinated with the authorities that are operating the Dubasary hydroelectric power station and reservoir, which is quite reasonable and should be tried.

The inflows from tributaries should be considered also (as in the Regulations), as well as the coordination with Moldovan authorities as for forecast and evaluation of water needs. But as for the breaks in the discharge of flood flows, this is something that most of the time will be out of reach of the company, as there is the risk of overtopping of the dam (and it can be better coped with through coordination with Dubasary dam operator).

8.3 Comments by Infoxvodokanal (Odessa)

The Odessa water utility stressed that the water intake facility is very close to the Dniester liman which influences water level quite a bit: northern winds lasting for 5-7 days lowers water level in the river and the canals for 60-80 cm. It was also informed that the average annual water level in the Dniester next to Belyavskiy water intake dropped to 20 cm. Staff of the facility believes that construction of a new cascade of the HPP in the Upper course of the river will hamper water supply to Odessa and other settlements around. As said above, this paper does not touch upon the construction of a new cascade – this will have to be discussed once relevant technical documents become available for commenting by stakeholders.

As for the winds, they do not lower the water level in the river or the liman. The most they can cause is some waves at the entrance of the water intake and so cause some disturbance, but anyhow this is something that has nothing to do with the rules of operation of the cascade. As for the dropping of the water level at the intake that has been observed, it may be something that may come from retention of sands and silts upstream. It should be checked when this phenomenon started being felt, as the cleaning of the waters of the Dniester river, and therefore the increase of its erosive capacity, started in 1950, when of the construction of Dubasary. Technical feasibility study to address the water levels issue under current climatic, weather and hydropower facilities conditions should be considered.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

8.4 Lower Dniester Nature Park

The first comment is: despite the important role of hydropower in ensuring Ukraine's energy security, electricity generation should not be done at the expense of the main tasks that the hydropower complex should be called to perform:

- Flood protection;
- Provision of water for drinking water supply (incl. Odessa);
- Ecological water needs of the Dniester delta and Park, namely during Spring time.

The claimant comments on the wording of the Definitions in the document, that apparently needs to be fit to the Ukrainian legislation. Several comments pertain to fisheries and fish water needs in Table 6 (Table 2.4 of the draft Regulations), that we believe can be easily adjusted in the Regulations (claimant considers the 119 mln m^3 foreseen in Table 6 for fisheries upstream of Dniestrovski to be excessive). On the other hand, the Park comments on the need to adjust the irretrievable water consumptions to the new conditions that are expected due to climate changes such as water needs for irrigation.

Some specific comments:

- Data on irretrievable water consumptions in Table 2.4 of the Regulations are said to be outdated. Eventually this is so, but no alternative is offered in the comments (and apparently this comment goes to say that needs are higher, which is not in line with the fact that irrigation, the main water user, is not consuming such a huge amount of water these days).
- Recommendations on water levels in the reservoir of Dniestrovski 1 during Winter period in order to allow for spawning – there seems to be a misunderstanding in what concerns these data (the draft Regulations do not limit the Winter period levels in the reservoir to 118 m high) but anyhow it is difficult to consider that the exploitation of the cascade will be limited by such concerns – it would be very unusual. The fact that Winter levels in the reservoir are expected to be low results from the fact that some level of guarantee of energy output must be ensured by the cascade and therefore, starting at high level in the beginning of Autumn and because flows diminish during this season and during Winter, the level will be lowered due to turbinating. On the other hand, it is also a priority to control floods with the Dniestrovski 1 reservoir and for this to be possible it is required to have the level in the reservoir low at the beginning of Spring, when the floods occur most of the years.
- Spring flows – a optimum 700 m3/s discharge lasting several hours is required. The issue is common to other documents and was already discussed here above;
- Comments on the legal framework of the use of bioresources and the carrying out of economic activities in the reservoir. No comments, as this is not within the scope of this report.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

8.5 Comments and remarks of the specialized departments of Transnistria

Most of the comments refer to the wording of the document and therefore do not require any technical evaluation.

A minimum flow of 130 m^3/s is requested, which is in line with the requests from other stakeholders. This issue is analysed here below.

The main question that is raised by the claimant is the issue of the risk of the Dubasary dam being disrupted (overtopped) by the very large peak flood flows that have been identified (in the order of 13,260 m^3/s with a 1:10,000 years returning period, or 0.01% probability of occurrence).

The cascade does not contribute to aggravate the risk or its dimension, it simply cannot produce any significant reduction of the peak flows of such huge floods in the event they come to happen. So, the issue is not one of negative impact downstream but one of negligible positive impact for physical reasons that are out of reach of the Ukrainian authorities to control. It is possible that the routing of these huge floods can be improved by means of the proposed forecast but even in this case the impact downstream will always be felt.

We propose the two parties to meet and see what can be done to help solve the problem, by starting to correctly evaluate the risk and see what can be done to increase the Dubasary capacity to deal with the problem, e.g. increase the capacity of the spillways, increase the dam's crest level or both, but, most of all, to improve the alarm system and communication of hydro-meteorological situation among all the interested parties.

8.6 Comments by "Eco-TIRAS" International Association of Rivers Keepers

The Association of River Keepers, Eco-TIRAS International, has presented its comments to the draft Regulations. Many of these comments are common to those that were presented by other stakeholders and therefore we will abstain from entering into great detail whenever this is the case.

The comments start with a statement: The Rules should establish an expedient order of operation of reservoirs of HPPs and PSPs taking into account the interests of water users while respecting the requirements of environmental protection and ensuring accident-free work of the hydro-systems. Thus, the generation of electricity is only one of the functions of the reservoirs, and the main object of these is to be a reservoir, not a hydropower plant.

Even if this position is debatable, this is not that different from what is said in the draft Regulations as for the tasks the cascade is called to perform and the priorities that are set. And being reservoirs is not an accident, it really is what the company wanted to do and is not incompatible with electricity production, on the contrary: electricity production is valued according to the level of guarantee that is offered by the producer and increases with its capacity to inject power into the net whenever this is required. Having a reservoir is therefore part of the benefits the company can offer the society, not only by producing hydropower (and thus reducing GGE) but also by

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

regulating flows (reducing flood flows up to a certain level and providing more water downstream during the dry season, as we have seen).

The issue of the length of the time period of data used is also mentioned and the minimum daily average 100 m^3/s water release is also discussed. Once again what is being discussed is not really some negative impacts that the operation of the cascade may have downstream (yes, these exist, and the Regulations intend to mitigate them), but the limits of some positive impacts that eventually will not be there in some situations that are defined in the document (the average daily flows were in many months bellow the 100 m^3/s in pristine conditions, as can be seen in the flow records, and this is no longer the case thanks to the cascade). And data do not show any significant climate change impacts on the Dniester River flows up to now (Figure 8).

In the comments it is claimed to have a detailed description of the methodology and justification for the calculation of environmental and compensating outflows of water from reservoirs, based both on current run-off and current water consumption, and considering the expected climate change, at least in the coming decades. Having in mind the importance of environmental flows, this request seems to be reasonable and eventually the TDA will bring an answer to it.

The contents of Table 2.4 of the draft Regulations (Table 6 above) are challenged, namely if water needs of Chisinau have been considered. All we can say is that if they weren't they should be considered. A different issue is the one of water levels at the intake of Chisinau water utility. As we mentioned before, this issue should be addressed by the two Parties in some detail, and engineering solutions should be sought.

In the comments the use of the dispatch rules as stated in 3.2.1 (and Figure 3.1, the operating curves, Figure 9 above) is discussed and criticized. The comments seem to be based in a misunderstanding of what the company proposes, as what is proposed suits very much what Eco-TIRAS has in mind: To give priority to environmental flows and water uses downstream. Perhaps this can be better explained as most of the stakeholders do not realise what is being stated.

The alleged infringement of international water law is also mentioned, as this law is not mentioned in the draft Regulations (the right to an equitable and reasonable utilisation of the waters of the transboundary watercourse). The Regulations do not seem to be the appropriate instrument for this and should only reflect any agreement between the Riparian in what concerns the water rights. It is to the Dniester River Commission to clarify this point and solve it bi-laterally, as simply mentioning the Helsinki and the New York conventions in the new Regulations will add nothing to the benefit of the stakeholders. Again there is reference to the upper Dniester cascade and to the need of the draft Regulations being subject to SEA and EIA.

The need to counteract beach abrasion is also mentioned. This is for sure something the Riparian should try to deal with, but it is mainly dependent on the rules of operation of Dubasary dam and reservoir (see below), as any silts that may be released by the cascade will be retained in this reservoir (and the authorities in charge of managing Dubasary would be very happy to have a

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

solution for the reservoir siltation problem). Unfortunately, there is no easy solution to this problem, which is quite common in such situations.

These comments offer some proposals as for Spring flows: duration one month with a peak in the middle with a water flow of 700-750 m^3/s for 5 days as minimum. As we said here above, this was the case every year in pristine conditions with very few exceptions and therefore this proposal should be considered as was suggested before.

8.7 Comments by NGO National Ecological Centre of Ukraine (NECU)

The claimant starts by contesting (Procedural notes) the capacity of Ukrgidroproject for the initiative of preparing these new draft Regulations, as, in its opinion, it is the responsibility of the State Agency for Water Resources of Ukraine, the Ministry of Environment and Natural Resources of Ukraine and the Ministry of Health of Ukraine, since this is a cascade of reservoirs. Also, in its opinion, this is a document of strategic planning and therefore a SEA should be mandatory (see above) and the deadline for submission of comments should be sufficient so as to allow all stakeholders to comment and participate. This is a very specific legal issue and a legal expert should have a say on it.

Then the wording of the main covenants of the draft Regulations (comment 2.1) is contested, namely the legal framework that is called upon for the design of the new rules (includes the set of Ukrainian laws, EU directives and international conventions). Again, this is something that is out of the scope of this report but should be looked upon by the authority in charge. The same with the wording in the Terms and Definitions. Further definitions are proposed (comments 2.4 and 2.5) that, we believe, can be easily attended to.

NECU then questions the use of the long time series of flow records (comment 2.2) on the grounds that, under conditions of climate change this data series is no longer representative. It is suggested to use the last 30 years only. It can be seen from the data available that average annual flow of the Dniester from 1950 to 2010 is in the order of 274.6 m^3/s and from 1981 to 2010 is 271.6 m^3/s. The difference seems to be irrelevant, in the order of grandeur of the error committed in these computations. It is also suggested to have the Regulations set for the 3 operating units in the PSPP, not the complete 7 units (comment 2.3), thus providing a stage-by-stage forecast of changes in the hydrological and environmental conditions, impacts and risks. It is believed that this would not lead to any significant changes in the Regulations, but it is something that can considered.

The minimum daily average 100 m^3/s water release is questioned (comment 2.6), and it is requested to have it better explained in an annex. It should be noted that the minimum registered at Mohyliv-Podilsky gauging station during the period 1950-2010 is of 55.2 m^3/s. As we have seen before, the 100 m^3/s daily flow was not exceeded at that station (downstream of the cascade) many times in the past, mainly in the November to February period and before the cascade entered into operation.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

If we look at Table 3.1 in the draft Regulations we can see that the 100 m^3/s is proposed as compensating average monthly release from the Dniester reservoir in the Summer-Autumn (June to November) period to be exceeded 99% of the time, not really as something that will be there every time. The 50% frequency is of 213 m^3/s, which represents during that 6-month period a total of 3,200 mln m^3. The point is, what if this considerable volume of water is not available (neither coming from upstream nor stored in the reservoir)? But, as we mentioned before, we believe this is something that most of the time will be easy to attend with little impact in the operation. This can be easily understood as it is the interest of the company to regulate the seasonal flows and have more water running (being turbined) downstream during the dry period (this is why the dam was built in the first place). No alternative minimum flow is suggested in the comments and, apparently what is requested is to have some explanation in an annex to the draft Regulations.

The flood control mechanism is questioned (comment 2.7) but apparently the wording is the only problem (no real comment on the procedures that the company proposes to adopt is offered). It is commented that the cascade, both in terms of nature conservation and ecology, does not have any function that would provide something positive for ecosystems, which is an irrefutable fact – but that is in the nature of any such cascade and the benefits to the society and positive impacts that also exist cannot be ignored. And as for ecological flows, in case of water shortage there is little the company can do (comment 2.9).

Comment 2.10 questions the possibility of having the cascade operating in emergency situations within all zones of the dispatcher’s schedule. Clarification is requested if this will take place only at the request of the Interagency Commission and what will then happen to the interests of other stakeholders. We believe this can be easily answered by including in the Regulation a more detailed reference to what such emergency situations can be and who will be responsible for the decision. But it should not be forgotten that emergency situations usually require immediate action, something that is not compatible with delays for thorough consultation. And the volumes of water that are at stake are not relevant (4h of turbine at peak capacity at Dniestrovski 1 HPP represent some 28 mln m^3, out of 2,000 mln m^3 of the reservoir capacity).

As for comments 2.11 to 2.13, technicalities are considered that we are not in position to analyse.

It is commented that the draft Regulations present a biased view, favourable to the interests of the developer (comment 2.14), in what concerns the way the cascade is to be run, and the definition of Rules of Equality of the Parties is proposed to balance the interest of all the stakeholders (by parties it is believed NECU intends to refer all stakeholders). There is no such Rule of Equality of the Parties in International Water law (the rule of equitable (not equal) and reasonable use is something completely different). In this situation what is really required is for the Parties to cooperate in order to maximise the benefits coming out of the cascade and minimise the damages that it may cause.

The following comments refer to some very particular issues whose relevance we are not in position to comment on. They also refer to the obligations Ukraine has assumed by adhering to

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

international conventions, namely the Ramsar convention, but further suggestions to correct the situation should be proposed (most probably similar to those by the Lower Dniester Park administration). Absence of measures to prevent and eliminate pollution is also mentioned, which is something that is beyond the scope of the Regulations (and out of the reach of Ukrgidroproject).

9. The role of other hydraulic infrastructure in the basin

9.1 Dubasary dam and reservoir

Dubasary dam and power plant are situated in the Middle Dniester and are being operated now by Transdnister as a run-of-the-river hydropower-only facility: The water coming from upstream that enters the reservoir is turbined downstream, mainly. This way the energy output of the HPP is maximised as the water level (and therefore the head) in the reservoir is kept at its highest (NHL 28 m).

Even if this is not exactly as it is, the present use of the reservoir is limited by the intense siltation that took place in the past (the dam was built in 1950), that reduced the useful storage capacity from the initial 485 mln m^3 to some 261 mln m^3 that is its present estimated volume according to the information collected. The reservoir can be used to facilitate water abstraction (stable water level), for some weekly regulation of flows (or deregulation!) and for a modicum / minor magnitude of flood control (1000 m^3/s represent some 86.4 mln m^3 a day). The dam is situated upstream of Chisinau, Tiraspol and Odessa water intakes, the main water utilities using the waters from the Dniester for water supply.

The operating rules set to Dubasary were made available to us. It can be seen from this document that the reservoir started being filled in 1954 and was permanently commissioned in 1955. Dubasary reservoir operation modes consider the electricity and power daily and seasonal demand and are set in dependence to:

- Water users' requirements and conditions of their satisfaction; a very detailed description of these requirements can be found in the rules: list of water supply and industrial establishments, of irrigation water intakes, fisheries, etc., dating from 1982;
- Season, namely as for flood routing;
- Level of water in the reservoir;
- Forecast and inflow into the reservoir;
- Environmental requirements; water level and level increase and decrease in the reservoir required for spawning and hatchling maturing and to avoid grassland vegetation used by fishes for spawning being destroyed because of ice formation, namely.

Regulated releases in Dubasary reservoir required by the sanitary conditions and necessary to ensure navigation to the downstream river stretch is accepted in the rules to be 60 m^3/s.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

The rules consider also reservoir operating curves (were not made available) and the possibility of normal operation being superseded in emergency situations, as with the Regulations being commented. The throughput capacity was designed for 0,1% exceedance probability (2,100 m^3/s through the turbines and 11,160 m^3/s through the outlets) and is similar to the capacity at Dniestrovski 2. The risk of overtopping is minimal, and it does not seem dramatic as the dam is a concrete gravity one (and will most probably resist overtopping).

The rules date from 1983 (and were designed for a very different situation as compared with the present one (data on water uses and reservoir capacity date from 1982), not only in what concerns the existence of the cascade upstream but also as for the irretrievable water uses that have to be considered and priorities, as for the tasks assigned to the infrastructure, Spring flows of 400 m^3/s are mentioned.

As with Dniestrovski cascade operating rules, detailed irretrievable water uses have been considered: water need for irrigation, for sugar plants, water supply and sewage utilities, fish farming and so on. Flood control is not considered a priority, as could be expected having in mind the limited capacity of the reservoir. On the other hand, the electric power needs are one of the main drivers as for the operating rules, with Autumn-Winter high needs in electric power as top priority.

Great care is taken with the needs of water for fish breeding, not only seasonally but also daily, as daily fluctuations of water levels may entail the laid roe and larva killing. A 0.3 to 1 m per day reservoir drawdown intensity is considered adequate, depending on the season. The rules make no reference to the wetlands and other downstream water needs and Ukraine's interests are not even mentioned.

These rules are dated and most probably are no long being used. Anyhow, some coordination between the Riparian should be attempted, as it would be for the benefit of everyone.

9.2 Planned upstream cascade of small HPP

No information on the planned cascade was made available for this study and therefore it is not possible to comment on its impacts or whatsoever (and this is something that is out of the scope of the assignment).

Anyhow, it is clear that, previous to the decision to construct, an EIA should be performed according to EU legislation or Espoo and Aarhus Conventions (eventually a SEA, as this is a set of infrastructures in cascade and the cumulative impacts should not be neglected).

10. Conclusions and recommendations

The Dniester river flows are irregular, both seasonally and between years. This is why in due time it was decided to build the Dniestrovski cascade and HPP: To regulate flows in order to have water all the year and every year inasmuch as possible. This impacts on the environment and the ecosystems (aquatic and riparian ecosystems) by creating physical barriers (the dam) to fish

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

movements, by retaining sediments in the reservoir (negative impacts), by reducing floods and droughts downstream (both positive and negative impacts, as we saw).

There are also indirect positive environmental impacts, such as reduction of GGE (in case of HHP, as is the case with Dniestrovski cascade). There are clear economic and social benefits coming out of the project: urban water supply, irrigation, power production, water supply to industries, flood control, etc.

Some of the negative impacts can be mitigated by means of the adoption of operation rules: minimum flows should be guaranteed downstream, volume reserved for flood protection, devices for fish migration such as fish ways or ladders can be installed. But we should also consider the benefits and should not aggravate cost in such a way that the project (the infrastructure) will no longer be of interest (will not pay itself, costs will not be recovered).

We cannot expect to have downstream the same situation as in pristine conditions. And we must be prepared to accept some kind of diminished environment, mainly downstream, in exchange to what is gained (reduced floods, in frequency and severity, easier management of droughts, flows and water available for uses all the year).

The scope of the Regulations is to impose rules for the operation in order to mitigate the negative impacts and enhance the positive ones. It is a fact that the draft Regulations, in what concerns the dispatch criteria, are not easy to follow and many comments simply reflect the fact that they were not understood. We believe the draft Regulations do contribute to reaching this objective but some improvements can be introduced for the benefit of the downstream stakeholders:

- The priorities in what concerns the tasks to be fulfilled by the cascade as defined in the draft Regulations are in line with the concerns of most of the stakeholders that commented this issue, even if they do not completely acknowledge it, and are in line with the international best practices in similar situations.
- The reservoir operating curves that the dispatch must follow are as accurate as they can be, having in mind that it is not possible to enforce more binding conditions upon the operation of a hydraulic system whose behaviour is not predictable as it depends from the weather (random snowfall, rainfall, their quantity, spatial distribution and opportunity) and also from the demand (power and energy demand, demand of water for uses, etc., all of them the company does not control).
- As for flood control, the provisions are in line with the priorities defined, and it should not be forgotten that what has to be compared is not what best fulfils some stakeholders' wishes (no floods at all but some high flows during the Spring and Summer) but the reduction in flood peak flows that can be obtained by correctly operating the infrastructures in the cascade. Several days forecast will probably not bring the expected benefits but should be tried.

As for recommendations, we offer the following:

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

- We strongly recommend the issue of Spring flows in the order of 700-750 m3/s for several days, as was the case almost every year in pristine conditions to cope with the environmental requirements downstream, to be considered (regular flooding of flood plains should be sought). Simulation of what happened during Spring since the entrance into operation of the cascade can provide some scientific basis for decision making in the future by relating flow discharges downstream with snow volumes in the Carpathians, volumes of water stored in the reservoir and contributions from downstream tributaries. The Protocol that was agreed upon by the relevant stakeholders in April 2018 seems to be a good starting point for future situations, as a procedure for deciding on this issue. The Moldovan authorities should be involved.
- With regards to the minimum Summer flows, the 100 m3/s that are inscribed in the Regulations seem good and should be sought as a rule (and apparently this is not a problem for the running of the cascade, as it is something that is already being done). The 130 m^3/s should be sought as minimum, even if with a 84% only guarantee, as some irretrievable water uses seem to depend on them (Figure12).
- It is recommended to have the conditions and responsibilities for emergency operation of the HPP in the cascade to be further clarified: in what circumstances this can take place and who takes the decision (3.3.1.7 in the draft Regulations). A Protocol for notification to downstream authorities and interested organisations whenever this happens should be included in the draft Regulations.
- A detailed description of the methodology and justification for the calculation of environmental and compensating outflows of water from reservoirs, based both on current run-off and current water consumption, and considering the expected climate change, at least in the coming decades, should be presented to the stakeholders (eventually included in the Regulations as an annex).
- Because not only the operating rules for the cascade impact in the downstream flows, the Riparian authorities should meet to arrange a solution for the running of all relevant infrastructures, including Dubasary, so as to have timely flood alert and the needs of water users in the Lower Dniester being attended. This solution should consider the contributions of the tributaries downstream of the cascade. Monitoring of the water flow should also be arranged in a due joint manner, preferably in a real-time mode.
- The issue of water levels at the intakes of Chisinau, Odessa and other water utilities should be addressed by the Riparian in some detail. It seems to be mainly an issue of water level in the river and not one of flows, i.e., engineering solutions to increase the water level at the water intake may have to be considered (and there is little that can be achieved on this matter by changing the rules of operation of the cascade).
- There seems to be some limitations on the use of the storage capacity of Dniestrovski 1 reservoir between water levels 121 m and 125 m (zone 1 in the dispatch operation curves)

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

which is crucial for flood control (was mentioned in one of the meetings). If this is the case these limitations should be removed so as to allow for flood routing as in the draft Regulations.

- The issue of thermal stratification deserves some more attention, as it seems to be a serious obstacle to the mitigation of environmental impacts of the upper reservoir. Experts should be consulted and TDA may help to bring clarity and possibly a solution to this problem.
- The issue of EIA and SEA of the draft Regulations should be analysed, and it is suggested to hear the opinion of a legal expert. If the Regulations are themselves some kind of mitigation measure of the impacts of an existing infrastructure, then it seems not appropriate to have them subject to EIA, but eventually a legal expert may have a different opinion on this issue. But as for the new cascade of small hydropower stations that is foreseen to be installed upstream, at least an EIA is mandatory (possibly also a SEA), but this is something out of the scope of the Regulations.
- The Riparian should focus on benefits of cooperation which are at the core of international water law, i.e. the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water Convention). A regular and joint follow-up of the application of the Regulations would be of value for future revisions.
- A joint programme for measuring (monitoring) the water flow of the buffer reservoir dam at the gauging stations in Mogyliv (Ukraine) and Ungur (Moldova) should be agreed by the Riparian.
- Last but not the least, the Dniester River Transboundary Commission should be called to have a say on the new Regulations and Ukraine should try to obtain the agreement of the Riparian on the main solutions it proposes. We believe that it will not be very difficult to prove that Moldova (and Transnistria) have much to gain form the rightful operation of the cascade: more water most of the time, reduced floods, some mitigation of dry years low flows, etc. And all parties should bear in mind that they are both upstream and downstream of each other in the Dniester river at a certain point.
- The results of the consultation should be amply discussed with the stakeholders, made available to the authorities of all the Riparian and made public, according to the rules of the Aarhus and the Espoo UNECE conventions.

Some minor comments are not mentioned here but the Ukrainian authorities should try to provide answers to those comments, even if only to explain why what is proposed by the claimants cannot realistically be achieved.

Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

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Av. Duque de Ávila nº 64 - 7º A
1050-083 Lisboa
Portugal
Tel. +351 963 667 136 pedrocunhaserra@gmail.com

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