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WATER MANAGEMENT AND TECHNICAL SCHEME TO ENSURE ENVIRONMENTAL RELEASES FROM BARTOGAI RESERVOIRS

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Abstract

In the article the results of research of nature releases from Bartogay reservoirs and the water-technical scheme of providing. Studies have shown that the daily regulation waves of releases play a major role in the downstream channel regime in the first years of operation of the hydroscheme, then, as the general erosion of the channel develops, their influence is somewhat weaker. Since the flow velocities in the frontal part of the pop-up waves are very high (they may be 2-3 times greater than the velocities of the undisturbed flow), a wave of sediment moves along with the frontal part of the pop-up wave. In a fixed station, this is recorded as a sharp peak in sediment flow. Despite the relative briefness of such peaks, they lead to an overall increase in the mobility of bottom forms and cause intense drift of shipping gaps. High current velocities in the propagation of popup waves intensify coastal erosion.

Key words: flow regulation, water reservoir, hydroscheme, ecosystem, releases, Shelf River

ВОДОХОЗЯЙСТВЕННО-ТЕХНИЧЕСКАЯ СХЕМА ОБЕСПЕЧЕНИЯ ПРИРОДООХРАННЫХ ПОПУСКОВ ИЗ ВОДОХРАНИЛИЩ БАРТОГАЙ

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Аннотация

В статье приведены результаты исследования природоохранных попусков из водохранилища Бартогай и водохозяйственно-техническая схема обеспечения. Исследования показали, что волны попусков суточного

регулирования играют большую роль в русловом режиме нижнего бьефа в первые годы эксплуатации гидроузла, затем, по мере развития общего размыва русла, их влияние несколько слабеет. Так как скорости течения в лобовой части волн попусков очень велики (они могут быть в 2-3 раза больше скоростей невозмущенного потока), то вместе с лобовой частью волны попуска движется волна наносов. В фиксированном створе это регистрируется как резкий пик расхода наносов. Несмотря на относительную кратковременность таких пиков, они приводят к общему усилению подвижности донных форм и вызывают интенсивную заносимость судоходных прорезей. Большие скорости течения при распространении волн попусков усиливают размыв берегов.
Ключевые слова: регулирование стока, водохранилище, гидроузел, экосистема, попуски, река Шелек.

Introduction. Regulation of river flow by building reservoirs stabilizes seasonal and, to a lesser extent, multi-year flow volumes. The presence of reservoirs makes it possible to adjust the peaks of high floods and significantly minimize the harmful effects of water during floods. At the same time, a reserve is created to cover water shortages in the summer and autumn low-water periods. This function of hydrotechnical regulation is undoubtedly positive, especially for the rivers of arid zones, where it has been historically practiced for many centuries.

Negative consequences of disturbance of natural flow regime are observed and realized much later than benefits of hydrotechnical regulation. Consequences of ecosystem disturbance, in terms of natural flow, are less noticeable because they are partially compensated by economic releases. Salinization of floodplain soils, change of vegetation associations to less productive ones, reduction of biodiversity are not quite obvious and not noticeable, due to inertia of the process of degradation of river channels and adjacent floodplains.

The importance of economic losses from floodplain degradation becomes more noticeable in dry multi-year periods, and also as the imbalance between available water resources and increase in water intake for economic needs, first of all, for irrigation of agricultural crops, grows.

Economic water releases in this situation compensate ecosystem needs less and less, since they cannot meet them either in terms of the volume of discharged water or, what is more important, in terms of seasonal discharge regimes.

It is important from the ecological point of view to establish the optimal water discharge in rivers after withdrawal of runoff. Many works are devoted to the issues of water discharge in the rivers remaining after withdrawal of river flow. Ecological and sanitary flows are the main components of environmental flow [1–15].

Resalt and discussion. The overview map of the place of the considered water management object of the branch "BAC named after D. Kunayev" RGP Kazvodkhoz "Bartogai reservoir in Almaty region is shown in Figure 1.

Chilik (Shelek) River is one of the major rivers of South Kazakhstan. Its length - 240 km, the catchment area - 5350 km^2. The mountainous part of the Chilik basin is a broad longitudinal valley laid in the graben between Zailiisky (Ileisky) Alatau in the north and Kungei Alatau in the south. Its upper part, up to the mouth of the Karakiya river, is a well-defined trough. Below, the Chilik valley loses the shape of a trough and takes the form of a typical V-shaped gorge with steep slopes. Its depth in some places reaches 1,100-1,300 m. The Chilico-Kemin mountain chain of Zaili and Kungei Alatau join at the source of the Chilik and form the Chilico-Kemin cofferdam with heights of more than 4000 m. A number of high peaks on the ridge of Zailiisky Alatau begins in the west with Constitution Peak (4520 m). From here the main ridge extends to the northeast, reaching its highest height at Talgar Peak (4,978 m). To the east of it, the height of the ridge gradually decreases and east of the headwaters of the Odensay river it does not exceed 4000 m.

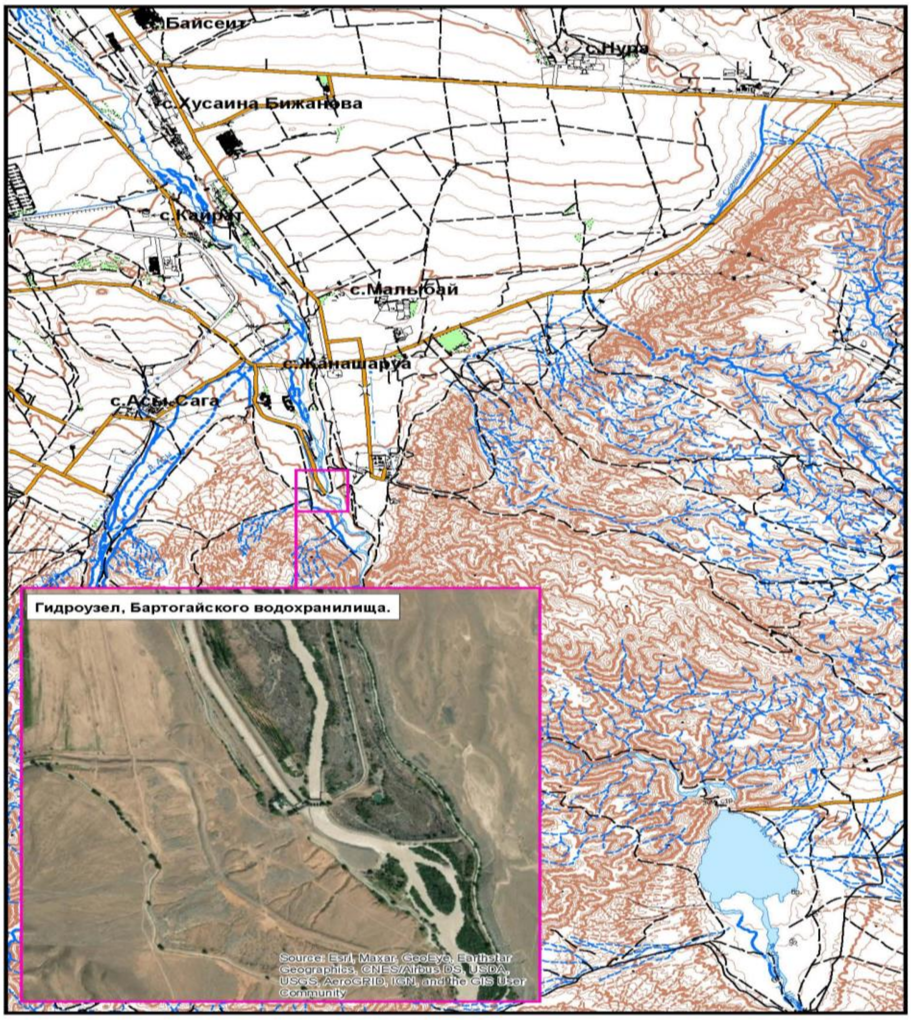

Figure 1 – Hydrounit on the Shelek river

Chemical composition: humus content in A horizon = 9-6% (at SCC:SFC = 1.5), nitrogen - 0.60-0.25% (at C : N- 11.5-12.3). Humus penetrates pretty deep; at the depth of 75 cm its content is 1.3%, gross P2O5 - 0.26-0.19%, K2O - 2.5-2.8%, $CaCO_3$ -25%; pH - 6.8-7.7. The sum of the absorbed bases is 40-23 mg-eq per 100 g of soil. The soil is highly provided with hydrolysable nitrogen (to 148 mg/kg) and ex-changeable potassium (to 702 mg/kg), but it has little assimilable phosphorus (8-16 mg/kg). Soil is medium in copper (2-5 mg) and manganese (57-65 mg), poor in zinc (0.1 mg) and cobalt (0.5 mg/kg), but rich in boron. The mass of chemical inputs to the Shelek River is given in Table 1.

Table 1 – Mass input of chemicals into the Shelek River

Name	SCV (II)	2013		2014		2015		2016		2017		2018	
		mg/l	t/yr	mg/l	t/yr	mg/l	t/yr	mg/l	t/yr	mg/l	t/yr	mg/l	t/yr
Nutrients													
BPC 5	3,00	1,37	-2,92	1,60	-0,08	1,50	-3,66	1,50	0,28	1,75	-4,50	1,16	-2,69
Heavy metals													
Manganese	0,02	0,01	0,00	0,01	0,00	0,02	0,01						
Copper	0,05	0,00	0,03	0,00	0,03	0,00	0,03					0,00	0,03
Total iron	0,20	0,08	0,04	0,06	0,05							0,14	0,07

The climate of the territory under consideration is mainly continental, but very heterogeneous due to the significant latitudinal extent of the basin and great differences in the structure of the relief.

The main features of the climate of plain and lowland areas are the significant annual and daily amplitude of air temperature fluctuations, cold winters and long, hot and dry summers.

Climatic features of mountainous areas are heterogeneous. The mode and value of precipitation, air temperature and humidity, wind speed and direction are largely determined by the altitude of the terrain and the forms of relief. The middle mountain zone is characterized by a temperate climate, and climatic conditions in the highlands are similar to those of the Polar region.

The area under consideration is exposed to northern, northwestern and western intrusions of polar, tropical and arctic air masses. Polar air masses have the highest frequency of occurrence, and arctic air masses have the lowest frequency. In spring cyclones are often observed, and humid air masses bring a lot of precipitation from Atlantic areas. In summer warm tropical air intrusions are frequent.

As it is known, releases are periodic or episodic water supply from the reservoir to regulate flow or water level in the downstream section of the watercourse or water level in the reservoir itself (GOST 19179-73).

During releases in winter time, water flow rates should be uniform. At the same time, in order to prevent ice formation in winter and excessive water losses, stable iced channel should be folded since autumn (at the beginning of freeze-up).

Researches showed that daily regulation releases play a big role in downstream channel regime in the first years of hydroscheme operation, then their influence weakens a little as general channel erosion develops. Since the flow velocities in the frontal part of the pop-up waves are very high (they may be 2-3 times greater than the velocities of the undisturbed flow), a wave of sediment moves along with the frontal part of the pop-up wave. In a fixed station, this is recorded as a sharp peak in sediment flow. Despite the relative short duration of such peaks, they lead to an overall increase in the mobility of bottom forms and cause intense drift in the channel. High flow velocities during the propagation of the pop-up waves enhance bank erosion.

According to calculations made on methodology of Rules of development and approval of maximum allowable harmful impacts on water bodies, approved by the order of the Minister of Agriculture of the Republic of Kazakhstan [3], the flow of the Shelek River in the years of 75% probability is 1164.24 million m3, of which the environmental flow – 931.39 million m3 allowable withdrawal probability is 232.85 million m3.

The results of calculations made in accordance with the recommendations and the Rules for the development and approval of standards of maximum permissible harmful impacts on water bodies, provide a preliminary assessment of the environmental flow. To plan further studies on the calculation of this important characteristic, it is necessary to assess the possible environmental consequences resulting from a range of water management measures. Taking into account the uncertainty in the values of changes in the flow of project rivers, the timing of this withdrawal (at relatively high water levels during floods and floods), the uniqueness of fauna and flora in the river valley, it is advisable to consider the full range of negative consequences of changes in the flow of the river. A comparative analysis of the average annual flow of the project rivers is shown in Table 2. These include the dangerous phenomenon can be associated with a change in the direction and intensity of channel reformation, due to the forced transformation of the regime of maximum flow rates and water levels. Another problem of reducing the water content of the river due to the withdrawal of part of its flow, is a reduction in the dilution capacity of the river water mass. In this regard, it is advisable to consider not only environmental but also geo-ecological changes in the state of landscapes of the river valley, which can be expected during the implementation of water management activities in its basin. In particular, they may be associated with changes in water quality as a result of reduced water flow and reduced diluting effect of river water (while maintaining or increasing the volume of wastewater).

Table 2 – Comparative analysis of mean annual flow of project rivers

River-post	**Qcr, m³/s**	**σQcp, %**		**Cv**		**σCv, %**		**ΔQcr, %**	**test for uniformity by mean**	**N of observations**	
	I	**I**	**II**	**I**	**II**	**I**	**II**			**I**	**II**
Shelek Maylybai River	31	1,77	2,56	0,09	0,12	1	2	-32		26	22
Shelek Bartogay reservoir;	32		2,77		0,13		2		100		22

The water management calculation of intra-annual flow distribution was carried out by the compartmentalization method. For the Shelek river in the alignment of the village. The observation period was divided into two periods: before the construction of the reservoir and after the construction of the reservoir.

The water availability curve was calculated by theoretical method. Using parameters Q0, Cv, Cs and kp%, we used Foster-Rybkin method. The probability curves were built according to average monthly and annual water discharges, making a composite table, where the water discharge and flow volume for P=5%, 50%, 75%, 95% were indicated.

The layout method was first proposed by A.V. Ogievsky and developed for Ukrainian rivers by G.I. Shvets; later this method was improved by V. Gandreyanov.

Calculation was carried out by water years (from the beginning of high-water season). Each year of the series under consideration is divided into two main periods: high-water (flood season) and low-water (low-water period, limiting period). Terms of seasons are the same for all years with rounding to a whole month. During water-management calculation of intra-annual runoff distribution by the layout method, it is assumed that the probabilities of exceeding the runoff for a water-management year, runoff for a limiting period and within the limiting period for a season are equal. Runoff values for a year, limiting period and limiting season are calculated by gradations of water availability: high-water (exceedance probability (P= 25%), average (P=50%), low-water (P=75%) and very low-water (P=95%). Runoff for a season not included in the limiting period, for example, spring, is determined by the difference between the runoff for the year and the runoff for that period, and the runoff for a non-limiting season included in the limiting period is determined by the difference between the runoff for the limiting period (summer-fall) and the non-limiting season (summer or fall).

For the obtained values of runoff of seasons and limiting period, we determined the shares of runoff from the annual runoff, that is, we establish the estimated relative distribution of runoff by seasons of the year of the given probability of annual exceedance.

Algorithm of water calculation:

1.We distinguish the seasons, the limiting period and the limiting season.

2.Calculate sums Qmes for water-management year, limiting period and limiting season.

3. Arrange the obtained sums in descending order, write out P%, calculate K and Cv.

4. Let us take Cs = 2 Cv.

5. All obtained results are presented in Figures 2-4.

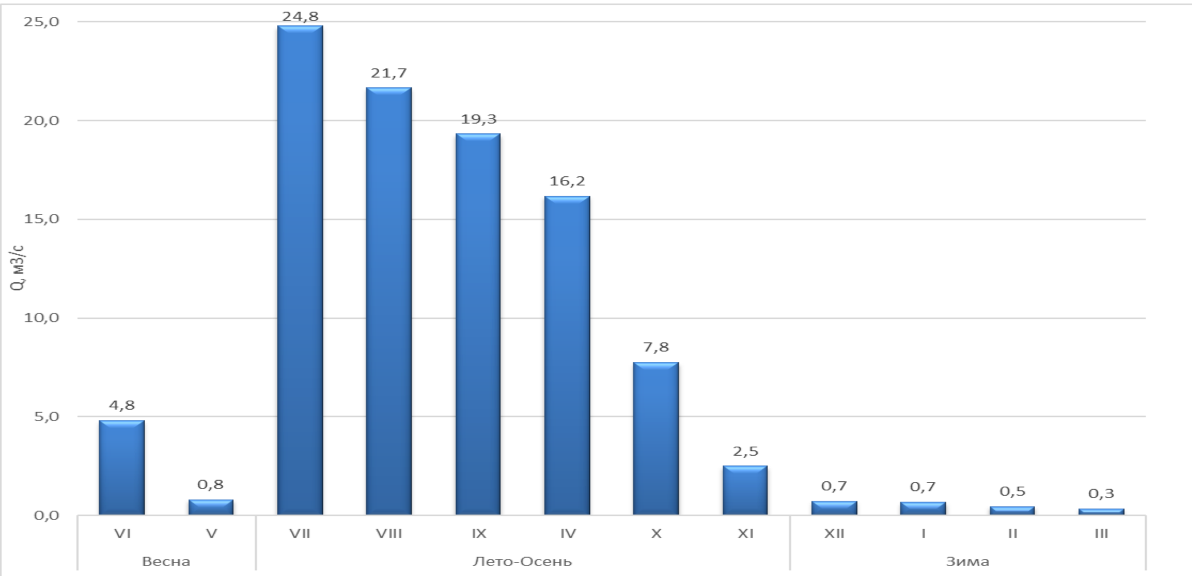

Figure 2 – Intra-seasonal flow distribution of Shilik River - Bartogay reservoir at P=75% (1997-2021)

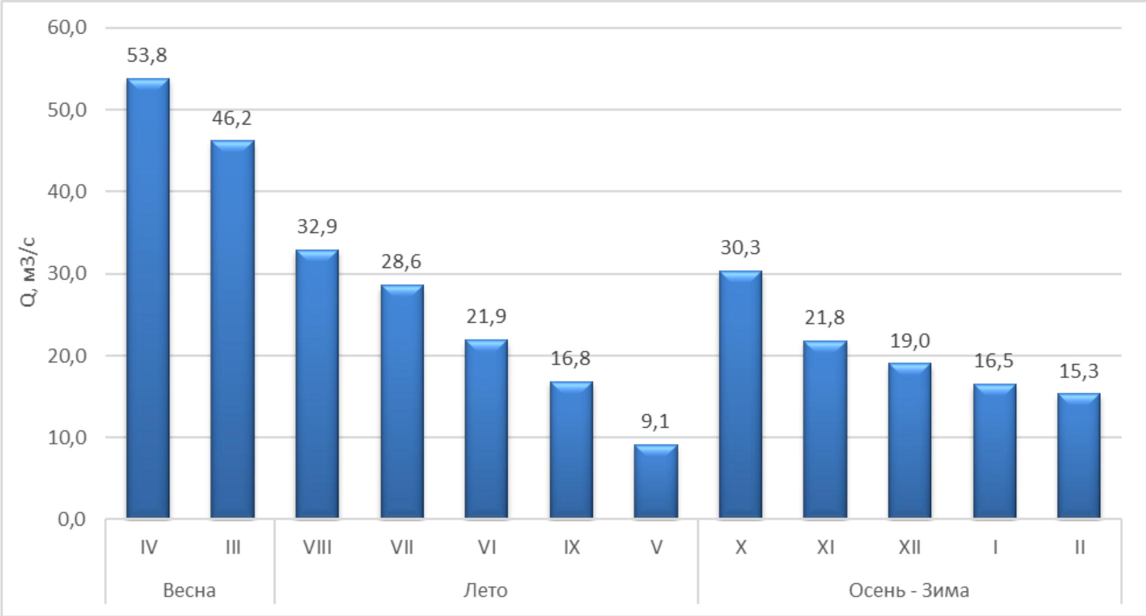

Figure 3 – Intra-seasonal runoff distribution of Shilik river - Mailybai river 1956-1982 (natural runoff)

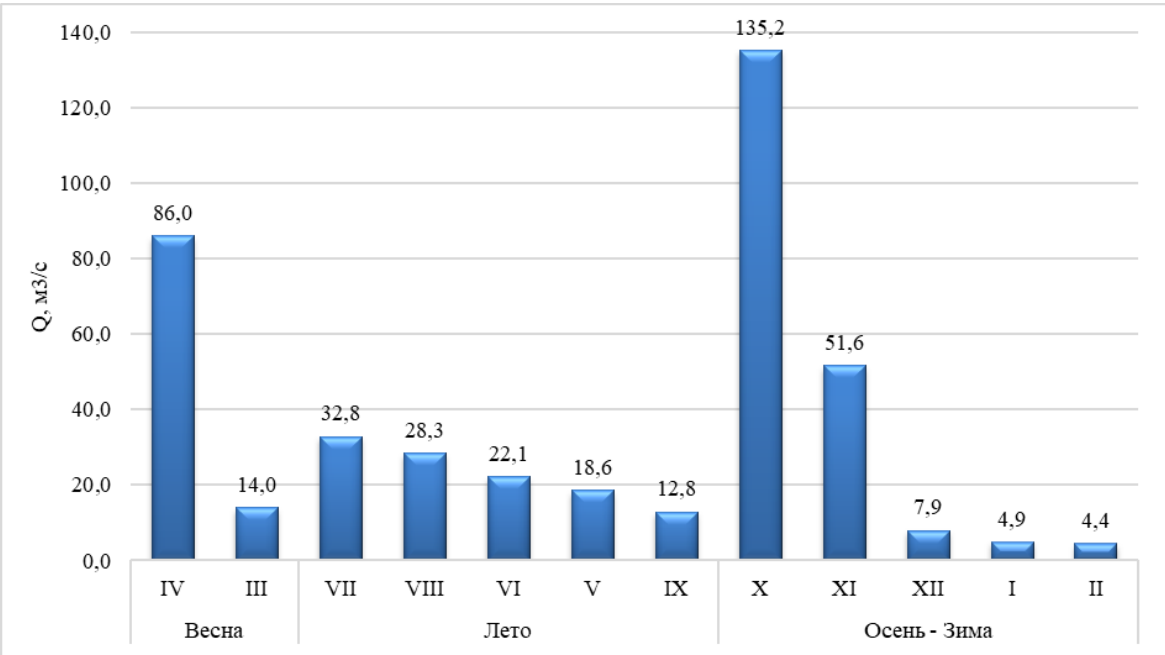

Figure 4 – Intra-season flow distribution of Shilik river-s.Mailibay 1997-2021 (regulated flow)

Conclusion. Conducted water-management calculation of intra-annual distribution of Shelek river flow by compartmentalization method showed that in the section of Bartogay reservoir within seasons redistribution of river flow goes in the direction of increasing the flow for agricultural needs for irrigation.

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ПРИМЕНЕНИЕ ГИС-ТЕХНОЛОГИЙ В РАЦИОНАЛЬНОМ ВОДОПОЛЬЗОВАНИИ И РЕГУЛИРОВАНИИ ГИДРОЛОГИЧЕСКОГО РЕЖИМА АЗЕРБАЙДЖАНСКОЙ РЕСПУБЛИКИ (НА ПРИМЕРЕ ГАРАБАГСКОГО И ВОСТОЧНО-ЗАНГЕЗУРСКОГО ЭКОНОМИЧЕСКИХ РАЙОНОВ)

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Аннотация

Охрана водных ресурсов и рациональное водопользование является одной из важнейших проблем современности. С этой точки зрения эффективное использование водных ресурсов – один из важных вопросов как в других регио-