Establishing construction of clarifiers for managing turbid sediments in flood reservoirs in mountain areas

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Abstract. The article presents the results of field research conducted in the Langar flood reservoir in the Kashkadarya region. Accumulation of large amounts of muddy sediments occurred in flood reservoir basins. The useless dead volume of the anchor flood reservoir is completely filled with silty sediments. As a result, storing the required volume of water in the flood reservoir is impossible when the flood flows occur. Therefore, building a two-chamber filter in the water-bearing basin of the flood reservoir is advisable. A two-chamber clarifier built in the catchment basin allows for the temporary settling of turbid sediments and improves the operational conditions of the flood reservoir. The construction of the flood reservoir is placed in the river bed of the flood reservoir. The 2nd chamber is connected to the first chamber, the length L_2 = 200 m, the width b_2 = 80 m, it is 1.25 times larger than the width of the natural bed, and the depth h_2 = 1.5 m. Both cameras are assumed to have the same longitudinal slope $i_1 = i_2$. Preliminary recommendations on the safety assessment of flood reservoirs have been developed.

1 Introduction

As a result of global climate change, the frequency of natural hazards in nature is increasing. An example of such natural phenomena is floods. In particular, in Central Asia, including the regions of the Republic of Uzbekistan, floods and other dangerous natural phenomena have been occurring frequently in the last decade due to climate change. As a result, short-term floods in tens of minutes or hours damage bridges, roads, canals, fields, cultivated areas, and hydraulic structures in water and flood reservoirs. Floods are mainly caused by the random occurrence of accelerated rainfall, resulting in continuous river flow combined with flood flow, causing immediate and short-term hazards [1-6]. Accumulation processes of solid flow in the upper reaches of the Selsuvombor hydroelectric dam consist of complex physical-hydraulic conditions and depend on several hydrological, topographical, hydraulic, hydrotechnical, operational, and other factors. There are no technically and economically effective measures for cleaning floodwaters from silt deposits today. In general, it is practically impossible to completely exclude the upper bed deposits from the floodplain. However, if appropriate measures are not taken to reduce their amount, hydrocells may become completely unusable after a few more years of use. To solve the problem, in addition to determining the volume of muddy sediment deposits in the upper basin, it is also important to study the characteristics of their location depending on the topographic conditions of the upper basin [7-14]. The parameters of turbid sediment deposits in Uzanli flood reservoirs, which have been used for several years, differ sharply from the design calculations. Research related to predicting the process of settling muddy sediments in flood reservoirs located in mountainous areas and ensuring their safe and reliable operation has been studied by several scientists, including A.N. Gostunsky, A.A. Sarkisyan, N.L. Kulesh, V.I. It was carried out by Tevzadze, Ts.E. Mirtskhulava, I.A. Mostkov, X. A. Ismagilov, A. Einstein, A. Daido, G'. Davronov and others, and to some extent, positive results were achieved [15-20].

The current state of the problem under consideration. Most large floods in our republic occur in mountainous and sub-mountainous regions. Therefore, it is considered one of urgent issues to carry out field research in existing flood reservoirs, to study their technical conditions, and to develop recommendations for their reliable and safe operation. In the Kashkadarya region, the Kashkadarya, Guzardarya, Tankhozdarya, and Yakkabogdarya basins, as well as the streams in the mountainous regions of the region, were considered the centers of major floods. This is the reason for the accumulation of muddy sediments in the basins of water and flood reservoirs built in the river basins. Below is information on flood reservoirs where field research was conducted.

Example casting. The continuous flow of the rivers combined with the flood flow creates great risks in the immediate and short term; that is, it causes many sediments to accumulate in the basins of water and flood reservoirs built in the river basins. Therefore, it is one of the most important issues to pass flood waters in flood reservoirs, to determine the sediment formation processes, the amount and composition of sediments, and to ensure flood reservoirs' safe and reliable operation. The main purpose of the research is to develop a system for solving the above problems scientifically.

2 Methods

Statistical data and field and theoretical research methods were used in the research.

3 Results and discussions

The following diagrams show data on flood flow volume in Langar, Kyzilsuv, Kalkama, and Dehkhanabad flood reservoirs for 2015-2021. As can be seen from the diagram, in the studied years, the arrival of flood flows in flood reservoirs is different, especially in Langar; in 2019 compared to 2015, 3 times more flood flows came. In 2020-2021, a decrease was observed (Fig. 1).

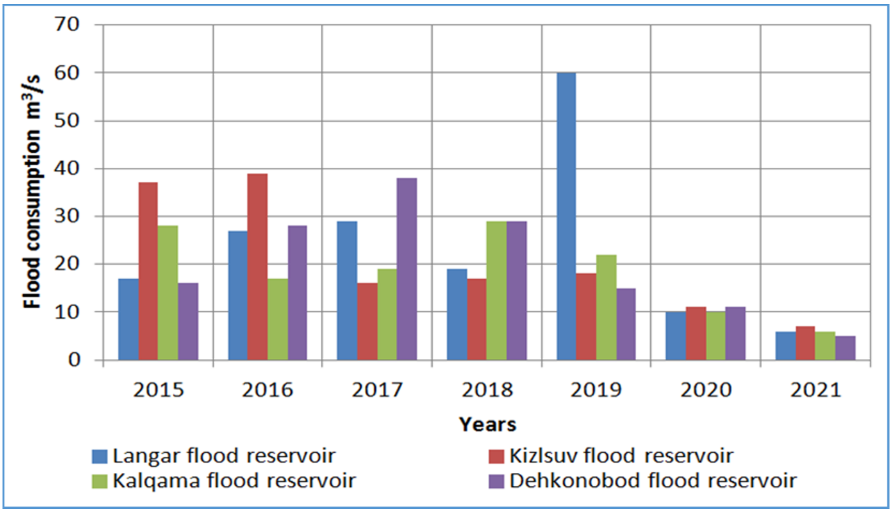

Fig. 1. Flood flows observed in flood reservoirs in Kashkadarya region in 2015-2021.

To determine and justify the dimensions of the buffers to be built in the area of the Angar flood reservoir, calculations were made to stop the connected flood flow in the expanded cone-shaped area [12]. Below is the calculation for stopping the flood flow in the Langar flood reservoir. Here are the initial parameters:V_0=3.87 m/s; λ = 0.04; b_0=25 m; $tg\theta=tg12°=0.21$;$tg\theta1=tg60°=1.73$;H_0=1m;ω_0=25·1=25m;=96.71·5=483.55m³/s; $i_{tr.z}$=0.16; $i_{К.В.}$=0.02; here K_{aver}=8.0.

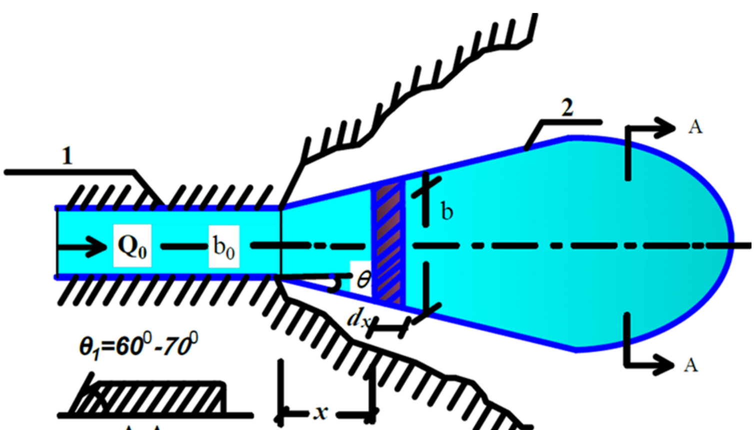

Fig. 2. Scheme of stopping flood flow in area of expanded cone in area of flood reservoir: 1 is Tarnsite zone; 2 is cone-shaped section;

According to the calculations, the flood flow parameters and zone dimensions at a distance of x1 = 100 m from the outlet of the flow transit zone are as follows [8]:

The flow rate in the wall:

$$V_1 = 5\sqrt{\frac{96.71}{0.04\cdot 8.0\cdot 25\cdot 100 + 0.04\cdot 10000\cdot 0.2 + 96.71}} = 1.57\ m/s$$

Current consumption in the wall:

$$Q_1 = \frac{483.55}{8.0\sqrt{\frac{96.71}{8.0\cdot 0.04\cdot 25\cdot 100+10000\cdot 0.04\cdot 0.21+80}}} = 192.08\ m^3/s$$

Conditional flood "expenditure" that flattens the cone section:

$$Q_{tek.} = Q_0 - Q_1 = 483.55 - 192.08 = 291.46\ m^3/s.$$

Average flow velocity in this section:

$$V_{1aver} = \frac{V_0 + V_1}{2} = \frac{3.87 + 1{,}57}{2} = 2.72\ m/s.$$

The mixing time of the stream:

$$t_1 = x_1/V_{1aver} = 100/2.72 = 36.74\ s.$$

Sediment volume at time T_1 in the first section:

$$W_1 = Q_{1aver} \cdot t_1 = 337.81 \cdot 36.74 = 12412\ m^3.$$

The average depth of the flow in the first section:

$$H_{1aver} = Q_{1s} / b_{1aver} \cdot V_{1aver} = 337.81 / 46.0 \cdot 2.72 = 2.12\ m.$$

The flow width, taking into account the angle of the natural slope of the flood flow, then:

$$\theta_1 = 60° \text{and} tg\theta_1 = tg60° = 1.73:$$

$$b_1^1 = b_1 + H_1 tg\theta_1 = 75.0 + 1.82\cdot 1.73 = 79\ m.$$

The above calculations show that the length of the first chamber of the planned clarifiers in the Langar flood reservoir was 100 m long and 79 m wide. It is advisable to have a width of 100 m and a depth of 2 m.

Based on the above calculations, it is appropriate to adopt the structural parameters of the sluices to be built in the entrance basin of the Langar flood reservoir as follows: L_1 = 300 m, width b_1 = 100 m, which is 1.5 times larger than the width of the natural bed, h_1 = 2.0 m; In the first chamber, according to calculations, stones smaller than 0.25 mm and turbidity with a diameter of 0.5-1 mm are deposited. In the second chamber, turbidity with a diameter of 0.05-0.5 mm is deposited. The dimensions of the second chamber are as follows: the second chamber is connected to the first chamber, length L_2 = depth h_2 = 1.5 m. Slurries smaller than 0.05 mm in diameter fall into the bowl of the flood reservoir and are transferred to the channel through the water outlet and used as fertilizer in the field.200 m, width b2 = 80 m, 1.25 times the width of the natural bed,

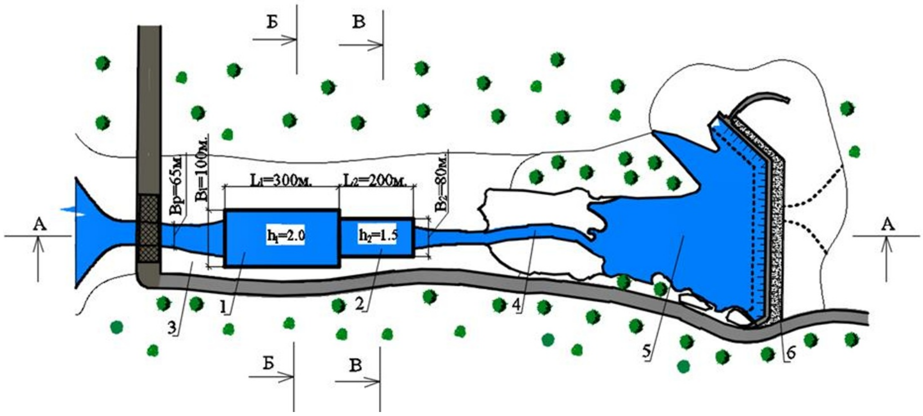

Fig. 3. Schematic plan of cooler

4 Conclusions

The results of the field research conducted in the Langar flood reservoir in the Kashkadarya region revealed the following:

1. Data on flood flow volume in the Langar, Kyzilsuv, Kalkama, and Dehkhanabad reservoirs in 2015-2021 are presented. As can be seen from the diagram, in the studied years, the arrival of flood flows in flood reservoirs is different, especially in Langar; in 2019 compared to 2015, 3 times more flood flows came. A decrease was observed in 2020-2021. As a result, the flood reservoir continues to fill with muddy sediments.
2. To determine and justify the dimensions of the flood barriers to be built in the basin of the Anchor flood reservoir, the calculations of the stoppage of the connected flood flow in the extended cone-shaped section were performed. Calculations show that the length of the first chamber of the planned clarifiers in the Langar flood reservoir was 100 m long and 79 m wide. It is advisable to have a width of 100 m and a depth of 2 m.
3. The design of the anchor for the anchor flood reservoir. The flood reservoir is placed in the water-bearing channel. The channel consists of two chambers with a rectangular cross-section: the 1st chamber has a length of L1 = 300 m and a width of b1 = 100 m, which is 1.5 times larger than the width of the natural channel. h1 = 2.0 m; The 2nd chamber is connected to the first chamber, the length L2 = 200 m, the width b2 = 80 m, it is 1.25 times larger than the width of the natural bed, the depth h2 = 1.5 m. Both cameras are assumed to have the same longitudinal slope i1 = i2.

References

1. Bakiev, M., Khasanov, K., Primbetov, I. "Vertical Accuracy of Freely Available Global Digital Elevation Models: A Case Study in Karaman Water Reservoir Territory" International Journal of Geoinformatics, 2022, 18(1), pp. 53–61
2. Bakiev, M., Babajanova, N., Babajanov, K., Khasanov, K. "Shear and filtration strength of foundation of channel type hydropower plant building" E3S Web of Conferences, 2023, 365, 03025
3. Bakiev, M., Yakubov, K., Choriev, J.Distribution of turbidity in flow constrained by transverse dam.IOP Conference Series: Materials Science and Engineering, 2020, 869(7), 072008
4. Bakiev, M., Khasanov, K. // Comparison of digital elevation models for determining

the area and volume of the water reservoir International Journal of Geoinformaticsthis link is disabled, 2021, 17(1), pp. 37–45

5. Bakiev, M., Yakubov, K., Choriev, J. "Field target dimensions of flow constrained by a transverse dam" IOP Conference Series: Materials Science and Engineering, 2020, 883(1), 012034
6. Bakiev, M., Babajanov, K., Babajanova, N., Khasanov, Kh. "Filtration in the Earth-Fill Dam in Reservoir Hydrosystem" AIP Conference Proceedings, 2023, 2612, 020008
7. Bakiev, M., Yakubov, K., Choriev, J.Distribution of turbidity in flow constrained by transverse dam.IOP Conference Series: Materials Science and Engineering, 2020, 869(7), 072008
8. Chou, F. N. F., & Wu, C. (2010). Reducing the impacts of flood-induced reservoir turbidity on a regional water supply system. Advances in Water Resources, 33(2), 146-157.
9. Eshev, S., Gaimnazarov, I., Latipov, S., ...Sobirov, F., Rayimova, I.// The beginning of the movement of bottom sediments in an unsteady flow// E3S Web of Conferences, 2021, 263, 02042
10. Eshev, S.S., Khazratov, A.N., Rahimov, A.R., Latipov, S.A.// Influence of wind waves on the flow in flowing reservoirs// IIUM Engineering Journal, 2020, 21(2), pp. 125–132
11. Mukhamedov A.M. Operation of low-pressure hydraulic units on rivers transporting sediments (on the example of Central Asia). Tashkent: Fan, 1976. 237 p..
12. Designer's Handbook. Hydrotechnical structures. Ed. Nedrigi V.P. Moscow: Stroyizdat, 1983. - 453 p.
13. KANTOUSH, S. A., & SUMI, T. (2010). River morphology and sediment management strategies for sustainable reservoir in Japan and European Alps. B= Disaster Prevention Research Institute Annuals. B, 53(B), 821-839.
14. Natishvili O.G., Tevzadze V.I. Fundamentals of mudflow dynamics. // Tbilisi 2007, 214 p.
15. Yangiev A., Adjimuradov D., Panjiev Sh.,Karshiev R. // Results and analysis of field research in flood reservoirs in Kashkadarya region/ E3S Web of Conferences 264, 03033 (2021)
16. Yangiev A.A., Panjiev SH., Adjimuratov D.S. //Recommendations for the analysis of safety and assessment of the formation of sludge in flood reservoirs. Journal of Irrigation and Melioration. Tashkent 2021. №1 (23). Pp. 29-33
17. Yangiev, A., Omarova, G., Yunusova, F., Adjimuratov, D., Risalieva, A.// The study results of the filtration process in the ground dams body and its chemical effect on piezometers/E3S Web of Conferences, 2021, 264, 03014
18. Cesare, G. D., Schleiss, A., & Hermann, F. (2001). Impact of turbidity currents on reservoir sedimentation. Journal of Hydraulic Engineering, 127(1), 6-16.
19. Yakubov, K., Mukimov, Z., Murodova, D.Forecast of Mud Silting of Vortex Zone behind the Transverse Dam.AIP Conference Proceedings, 2023, 2612, 020014
20. Yakubov, K., Khayitov, K., Abdurakhmonov, S.Suspension concentration distribution in a stream constructed by spur No. 19 on the Amu Darya river. E3S Web of Conferences, 2021, 264, 03043