PAPER • OPEN ACCESS

The dynamics of channel processes in the area of damless water intake

To cite this article: K Isabaev *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **883** 012033

IOP Conf. Series: Materials Science and Engineering **883** (2020) 012033 doi:10.1088/1757-899X/883/1/012033

The dynamics of channel processes in the area of damless water intake

K Isabaev[1], M Berdiev[1], B Norkulov[2], D Tajieva[2] and M Akhmadi[1]

[1]Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan
[2]Samarkand State Institute of Architecture and Construction, Samarkand, Uzbekistan

vohidov.oybek@bk.ru

Abstract. The paper analyzes the dynamics of channel processes in the Amudarya River section in the area of water intake in the Karshi Main Channel (Karshi region). The results of field studies of the state of the Riverbed environment of the Amudarya River in the area of damless water intake were studied. The course of channel processes in the River bed is studied. A recommendation has been developed to improve the water intake condition. According to the results of a field examination and research of the head section of the supply channel. The state of the River channel Amudarya in the water intake zone was assessed. The results of surveys of the hydraulic and alluvial regimes of sediments of the Amudarya River in the area ofdamless water intake are analyzed and summarized. The results of field studies of the Riverbed environment of the Amudarya River in the region of the Karshi head water intake were studied.

1. Introduction

The forecast of the effect of damless water intakes on the dynamics and hydrodynamic characteristics of the flow is one of the most important tasks of channel hydraulics. With damless water intake, the development of the channel process harms the reliability and functioning of damless water intake. The object of study was a section of the Amudarya River in the area of damless water intake in the Karshi Main Channel (KMCh).

In many countries, special attention is paid to ensuring reliable operation, the flow of less sediment with guaranteed water withdrawal to the head structure of damless water intakes. Based on the foregoing, we can state the fact that conducting a scientific study of the negative impact of the development of the channel process on the reliability and functioning of damless water intake, determining the intensity and direction of channel processes in River channels and developing an event to ensure a guaranteed volume of water intake with a minimum amount of bottom and suspended sediment during damless water intake is considered an urgent task. Most of the Rivers are regulated in connection with the construction of reservoirs for energy and agricultural needs; There are also a large number of damless water intakes. All this significantly changes the natural course of the channel process, and a forecast of this change is required. Therefore, the problem of studying and developing the theory of channel processes, as well as the dynamics of channel flows, has always attracted the attention of scientists [1–4]. An analysis of the results of a full-scale study of the state of the Riverbed environment of the Amudarya River, the head section of the damless water intake at KMCh and based on the results obtained, development of recommendations for improving its operation is defined as the main goal of this work [5, 6].

However, despite the abundance of works devoted to this problem, its solution is still far from practical completion [7, 8]. The reason for this is the complexity and multifactorial nature of channel processes in space and time. Particularly great difficulties arise in the design and operation of damless water intakes in Rivers, the channel of which, due to large slopes of the bottom, high flow velocities, and easy erosion of bottom sediments (represented by fine sandy soft soils), is subject to extremely complex intense planned and deep deformations. An example of such a River is the Amudarya [5, 6, 9, 10].

It can be noted the fact that only numerical or physical modeling can give a concrete forecast of channel deformations in the area of non-dammed water intakes. Currently, there are significant difficulties in both numerical and physical modeling [11–13]. To conduct the above experiments, data from field studies of the studied object will be required.

2. Methods

Studying the results of field studies on a section of the Amudarya River in the area of the damless water intake in the Karshi Main Channel and assessing the condition of the River channel the Amudarya in the water intake zone is a method for studying this work.

3. Results and Discussion

The passage of the Amudarya Riverbed on easily eroded soils contributes to the wandering of the main stream along a wide floodplain. High water levels during floods and alternation with low water levels during the low – water and dry years, the departure of the rod from the water intake site complicates the operation mode of the damless water intake at KMCh.

The unstable state of the Riverbed is caused by varying degrees of water availability in the year and other reasons require the application of prompt and long-term technical measures for the planned withdrawal of water for irrigation.

In the highly anticipated dry years and during the low – water period, at low water surface horizons, the water intake condition significantly worsens. Separate periods during the water content of the year, intensive movements of the River channel to the opposite bank from the water intake point were observed.

In such situations, the flow of water from the River to the main structure of the Karshi Main Channel can practically stop. In this regard, measures are constantly being taken to ensure normal water intake, by dredging and treatment works by dredgers [14–17].

The studied section of the Amudarya River is located in the area of the water-free water intake in the KMCh and is 22 km above the Kerk dam. The total length of the study area is 10 – 12 *km*. This area has two characteristic sections: the upper one is 6 km higher from the head water intake, and the lower one is between the head water intake and the Kzylayak post (fig. 1).

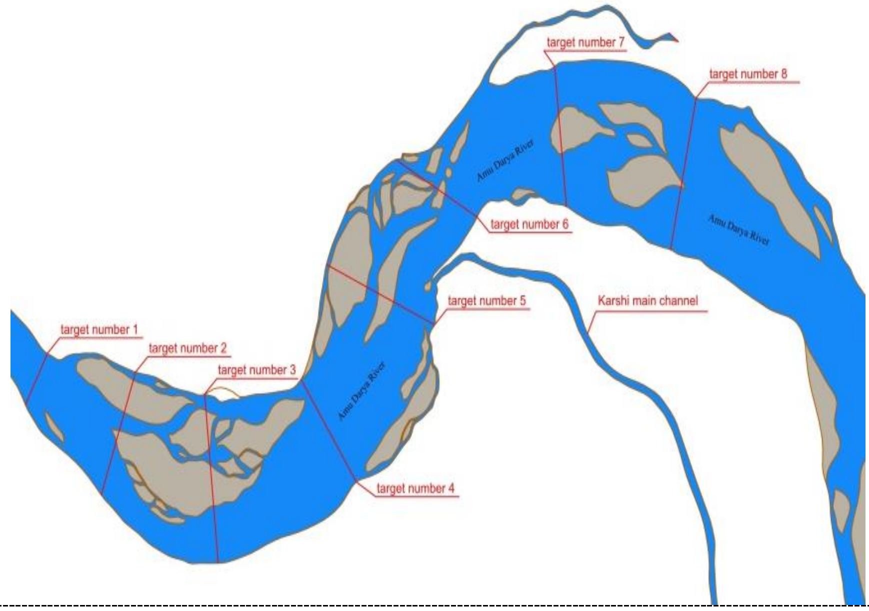

Figure 1. Amudarya River in the area of KMCh damless water intake

The upper section has an unstable channel. The River bed here is composed of sandy-silty soils, and the banks are alluvially loess like loams. The main channel runs along the middle of the River or along the right bank and sometimes deviates to the left bank.

This position of the channel is due to the formation of the island along the right bank. This island is flooded in high water but reappears at low water. The island to some extent deflects the flow in the direction of Cape Pulizindan. The stream formed along the right bank at Cape Pulizindan has the greatest depths, reaching 8 – 12 m, and sometimes up to 14 m. The head part of the water intake on the right bank has limestone outcrops of Mount Pulizindan, and the steep, not eroded, forms the Pulizindan narrowing with the smallest River width on all its middle course. The coastal zone of the village. Kzylayak is located in the second section 4...6 km below Cape Pulizindan on the left bank of the Amudarya River Kzylayak alignment the River floodplain is bilateral. On the approach to the left bank, the main stream flows along the left – bank channel. In winter, the main Riverbed decreases to 0.25 km. In the flood, not formed underwater shallows are flooded, the width increases significantly towards the right bank and reaches 1.5 km. The floodplain of the River during the spring-summer flood floods at a flow rate of 5500 – 6000 m^3/s or more.

An analysis of the Riverbed environment of the Amudarya River in the area of the KMCh head water intake indicates that large changes in deep and non–nasal deformations occurred in the Amudarya River section in the area of the KMCh head water intake in the River bed floodplain. Here, the main Riverbed wanders along a wide floodplain, forming a meandering channel.

The results of the planned surveys showed during the low-water period the main stream flowed along the left – bank channel, the water flow rate of the left – bank and right – bank channel was almost the same. In winter, the left-bank channel in the region 5 km above the head of the part of the water intake gradually shifted, completely headed towards the right bank, and hitting Cape Pulizindan headed towards the left bank. The main stream has completely moved to the coastal zone of the village. Kzylayak, forming a dump current, as a result of which there was an intensive erosion of the coastal territory.

The main channel flow of the Amudarya River at the head of the water intake during the flood recession wandered along a wide floodplain and the River flow was divided into two branches, thereby creating favorable conditions for the existing head water intake in the Amudarya River channel. As a

IOP Conf. Series: Materials Science and Engineering **883** (2020) 012033 doi:10.1088/1757-899X/883/1/012033

result, planned water intake was ensured in the Karshi Main Channel. This is due to the fact that over the years of observation they were full of water, significantly larger water flows passed in the Amudarya Riverbed.

The turbidity of the flow of the Amudarya River to the Kerky gauging station was overestimated by 1.25 times and moves to the left bank. In the middle of the floodplain, underwater shallows and islands formed.

The right – bank channel above Cape Pulizindan was drifted with sediment. As a result, the channel almost died out, here the channel flows to the main stream and moves to the left bank. Such a change in channel processes and the reorganization of the main channel of the Amudarya River contributed to unfavorable conditions for water intake at KMCh. During the winter low – water period, the observed minimum level of the water surface at Cape Pulizindan was 242.75 m, which complicated the condition of water intake. In this case, the planned water intake at KMCh is not ensured.

From 2000 to the present the main stream. The Amudarya River passes mainly along the right – bank channel. During floods in the winter, the main stream of the Amudarya River above the head water intake shifted towards the right bank.

The displacements of the main River bed, the wide floodplain, and the planned changes in the channel of the Amudarya River were compared for the observation period on the Amudarya River section in the area of intense erosion of the coastal territory of the village Kyzylayak. At this point, a current dump occurred and shore erosion (deigish) occurs, and the main stream is often cut off along the left – bank strip, where the cultural lands of the Kyzylayak post are laid out.

In addition, it should be noted that the wandering of the main channel of the Amudarya River occurs due to an increase in water intake, overloading the River is folded below the water intake site, due to frequent discharge of sediment during treatment into the floodplain of the River. This led to the deposition and rise of the bottom of the channel, then the intensive wandering of the stream, thereby partially affecting the displacement of the main stream to the left bank. As a result of changing the profile of the channel, the formation of dumping doctrine, the main channel wanders along a wide flood plain. A meandering channel forms in the area of water intake and coastal zones of intense erosion. To prevent this phenomenon, it is necessary to outline priority temporary measures, the construction of a system of short spurs, and a house of bunding. Given the high cost of manufacturing and transportation of reinforced concrete products in the future, it is necessary to strengthen and build dams (spurs) made of local squalls with reinforced concrete structures only pressure faces and heads of dams (spurs).

Changes in flow rates and water levels for conditions of the middle course of the River. The Amudarya River, where the damless water intake to the Karshi Main Channel (KMCh) is located, was studied on the basis of materials for measuring water discharges made on the alignment of Kerki and Pulizindan. In addition to them, field observation materials from the operational service of the KMCh and Uzhydromet channels were also used (fig. 1-2).

The highest average annual water discharge at the Kerky site was observed in the following years: in 2005 – 1722 m^3/s, in 2010 – 1822 m^3/s, in 2012 – 1691 m^3/s. In the period from 1980 to 2003, the lowest average annual water discharge was observed: in 2008 – 671 m^3/s; in 2011 – 929 m^3/s; in 2016 – 866 m^3/s.

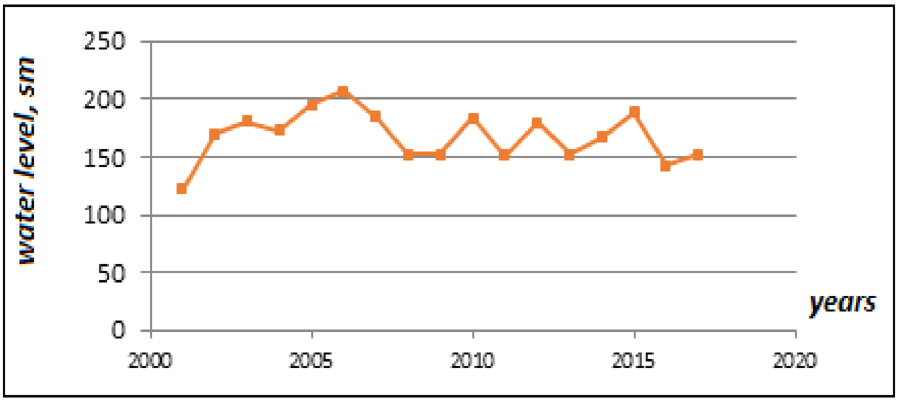

Figure 2. Change in the monthly average water levels of the Amudarya River – Kerki gauging station for 2001 – 2017

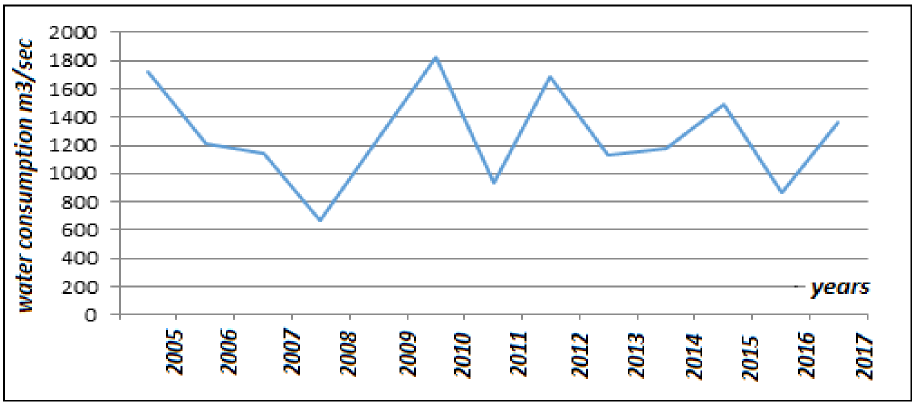

Figure 3. Change in average annual water flow Amudarya River Kerki gauging station

The floodplain of the Amudarya River was flooded. Due to increased channel deformation during the summer flood, the Amudarya River erodes below the water intake on the opposite channel on the left bank. Urgent measures must be taken to prevent further erosion of the shore, strengthening existing ones and building new ones along the River. On the Karshi Channel itself, due to insufficient volume of treatment works, siltation, bottom rise, and channel throughput decreased. An urgent measure to increase channel capacity is also needed here. Due to the difficulty of operating the damless water intake, it is clearly seen in the KMCh on the Amudarya River that the instability of the River channel on the approach to the head structure, which attracted a large amount of sediment into the canals, the inadequacy of flow rates and water levels in dry years and the difference in the winter low – water period leads to serious difficulties during their operation. Due to the difficulty in operating large damless water intakes depending on changes in channel processes and sediment regimes, it is necessary to consider in the future the possibility of transferring the head water intakes to their sovereign territory.

The main stream, depending on the course and approach, reflected from it at an angle, is directed to the opposite eroded shore, as a result of which the main stream forms a dump current and an intensive erosion of the coastal territory of the village occurs Kyzylayak. Channel processes of the Amudarya River during winter floods and their impact on the operation mode of the Karshi Channel (fig. 3).

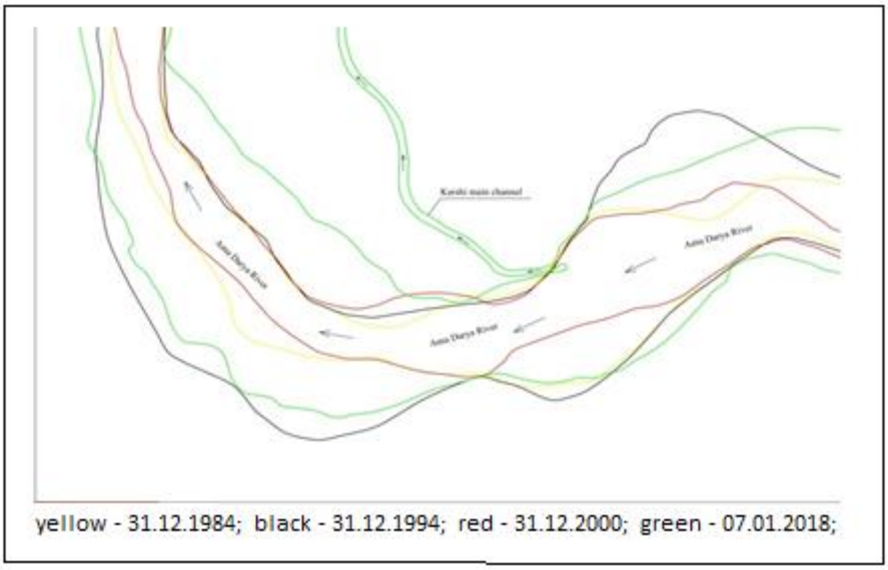

Figure 4. Change of the Amudarya coast in the KMCh damless water intake

After the commissioning of the Nurek reservoir, a significant change in the sediment regime was observed in the River channel, the size of the sediment load and their quantity increased significantly. During the observation period, significant changes in the regime of solid and liquid runoff took place in the River, as a result of which intense channel deformations of the Amudarya River are observed (figure), especially in the area of KMCh damless water intakes.

Due to channel deformation on the Amudarya River below the water intake, on the opposite channel on the left bank, intensive erosion occurs due to the formation of a dump current, which creates the conditions for the threat of washing out the coastal strip of the Kyzylayak village with a population of more than four thousand people.

As comparisons of planned surveys show, the main stream of the Amudarya River channel in the area of the Karshi Channel damless water intake mainly flowed along the right-bank channel, creating favorable conditions for the damless water intake. The head of the Karshi Channel is located on a stable coast near Cape Pulizindan. Under the conditions of the Amudarya River at damless water intakes, the design and calculation of regulation of channel straightening structures, as well as forecasting of channel processes, are one of the urgent issues. If we take into account the instability of the channel and the wandering flow, which impede water intake, then without regulating the channel or River, it is impossible to carry out planned water intake into irrigation canals[18–22].

In this regard, the purpose of this work is to substantiate the main parameters (estimated discharge, water level, and channel profile) for winter flood discharge for sections of the Amudarya River in the area of damless water intakes. Further research should be aimed at developing a set of measures for managing Riverbed processes in sections of the Amudarya Rivers in the area of damless water intakes.

Analysis of the dropped regime and water discharge of the Amudarya River in the area of KMCh head water intake

On the Amudarya River in the area of damless water intakes in areas of intensive erosion and in places where regulatory facilities are required, the establishment of estimated costs and the level of the water surface, as well as accounting for changes in channel profiles in a multi-year section, are of great practical importance. Calculation of the minimum water discharge for the KMCh and the cape. Pulizindan was made on the basis of a number of long-term observations of the Kerky gas station located 21 *km* below the head of the Karshi main channel.

Based on the hydrological sequence, the Amudarya River runoff was processed by the static method and the minimum monthly water discharge was calculated.

The water intake of the damless Karshi main channel was built without a regulator gateway, therefore the level mode in the fore chamber of the first pump station is determined by the level of the Amudarya River at the water intake point and pressure losses along the supply part of the KMCh.

The results of field studies of the Riverbed environment of the Amudarya River in the area ofthe KMCh water intake at the Amudarya River in the Karshi head water intake area were studied. The channel environment is characterized by inconsistent hydraulic characteristics in time for the same water flow rate i.e. at the same elevations of the water horizon, the discharge may differ from each other by about half, and at the same discharge and the elevation of the horizon can vary up to ± 0.6 m. This is explained by extreme instability and great mobility of the channel, and large deformations of the channel occur in a short time. The hydraulic regime of the River is characterized by a significant redistribution of speed, depth, and width of the stream. Their variation range is within: maximum speed V_{max} = 2 – 5 *m/s*; average speed V_m = 0.5 – 2.5 *m/s*; deep H_{max}= 4–14 m, H_m=1–5 *m*; width *B* = 300–2000 *m*; bias *i* = 0.00016 – 0.0003.

A characteristic feature of the River bed is that at a constant flow rate there can be different values of average velocities, depth and width of the River bed, for example, at Q_w = 1000 m^3/s, respectively, *V* = 0.6...1.7 m/s, *B* = 180...1030 *m*, H_m =1.1...4.3 *m*.

4. Conclusions

The analysis of the results of field studies, allowed us to draw the following conclusions:

- The highest values of average velocities and depths at any water discharge fluctuate in the curved sections of the channel, the smallest on the straight, and the width of the channel, on the contrary, the largest on the straight and the smallest on the curved.
- With an intensive increase in water intake, congestion of the River flow below the water intake site, due to private discharges of sediment during cleaning into the floodplain of the River and intensive wandering of the stream, thereby partially affects the displacement of the main stream to the left bank, as a result of the above phenomena leads to a change in plan, displacements of the channel profile of the Amudarya River in the area of damless water intakes and areas of intense erosion.
- The wandering of the main channel of the Amudarya River occurs due to an increase in water intake, River overload is piled below the water intake site, due to frequent discharge of sediment during treatment into the floodplain of the River. This led to the deposition and rise of the bottom of the channel, as well as to the intensive wandering of the stream, thereby partially affecting the displacement of the main stream to the left bank. As a result of changing the profile of the channel, the formation of dumping doctrine, the main channel wanders along a wide flood plain. A meandering channel forms in the area of water intake and coastal zones of intense erosion;
- As a result of these channel processes, erosion of the left bank of the River below the KMCh head water intake was observed. The erosion area for the period 2007 – 2015 makes 200 – 250 hectares with a strip width of 100 – 300 m. The erosion area of the floodplain of the Amudarya River in this area in the zone of the dump current of the coastal territory amounted to 170 – 200 hectares. The total erosion area is 300 – 450 ha. Based on the prevailing channel conditions in the area of the village. Kyzylayak on the rise and fall of the flood due to an intensive change in the planned position and deformation of the main channel, an emergency may arise, the destruction of the village of Kyzylayak.
- To prevent unwanted channel processes, it is necessary to note priority temporary measures, the construction of a system of short spurs, and a house of bunding. Given the high cost of manufacturing and transportation of reinforced concrete products in the future, it is necessary to strengthen and build dams (spurs) made of local squalls with reinforced concrete structures only pressure faces and heads

of dams (spurs). To date, spur 8 has been built with a length of 150 *m*, the channel part is 50 – 60 m, the coastal part is 100 – 80 *m*, and the spur 9 is 20 *m* long.

5. Acknowledgments

The authors of this work consider it their duty to express their gratitude to colleagues at work who have greatly helped in preparing the work for publication. And also, they express sincere gratitude to the Department of exploitation of the Karshi Main Channel of the Ministry of Water Resources of the Republic of Uzbekistan for their assistance in conducting field studies in the studied object. The authors are also grateful to the rector of the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Doctor of Economic Sciences, Professor Mr. U.P. Umurzakov for the financial support created in comfortable conditions when writing and publishing the work presented.

References

[1] Bazarov D R and Nishanbaev H A **2018** Mathematical modeling operating mode control of the Amu-Bukhara machine channel pp 26–32
[2] Bazarov D R **1991** The study of the alluvial and hydraulic regime of the River during damless water intake
[3] de Ruijsscher T V, Hoitink A J, Naqshband S and Paarlberg A J **2019** Bed morphodynamics at the intake of a side channel controlled by sill geometry *Adv Water Resour* **134** doi: 10.1016/j.advwatres.2019.103452
[4] Fiorotto V and Caroni E **2013** A new approach to master recession curve analysis *Hydrol Sci J* doi: 10.1080/02626667.2013.788248
[5] Klovsky A K **2015** Improving damless designs water intake facilities with bottom circulation thresholds of small mountain Rivers
[6] Lavrova M, Orlov E and Zabalueva V **2018** Operational dependability of water intake facilities *IOP Conf. Ser. Mater. Sci. Eng.*
[7] Abidov M M **2006** Regulation of the alluvial regime during water withdrawal in mountain-foothill sections of Rivers
[8] Altunin S T **1950** Regulation of Riverbeds during water intake.
[9] Khetsuriani E D, Kostyukov V P and Ugrovatova E G **2016** Hydrological Studies on the River Don around the Alexandrovsky OSV Water-Intake Facilities *Procedia Eng.* pp 2358–2363
[10] Mukhamedov A M **1974** Flattening Research Results bends in the Amudarya River
[11] Mukhamedov Y S **2011** Damless water intake from the Amudarya River to KMCh and measures to improve its operation
[12] Norkulov B E, Nazaraliev D V **2018** Hydrological change River regime with damless water intake *Agro-Ilm*
[13] Stepanovich BV **1975** Development and research of damless water intake for Rivers with heavy hydrological and sedimentary regimes 202
[14] Kartvelishvilli N A **1973** Flows in undeformable channels.
[15] Kuchkarov M **2017** Research of channel processes at ABMCh and development of an event to improve the conditions of damless water intake at ABMCh
[16] Lyatkher V M, Shkolnikov S Y **1981** Tensor structure of hydraulic friction coefficient *Water Resour* **5**
[17] Shkolnikov Y S **1999** Transformation of flood waves propagating in a dry channel *Hydraul Eng*
[18] Bazarov D R, Vokhidov O F, Lutsenko L A and Sultanov Sh **2019** Restrictions Applied When Solving One-Dimensional Hydrodynamic Equations *Proc. EECE 2019, Lect. Notes Civ. Eng.* **70** pp 299–305
[19] Bazarov D, Shodiev B, Norkulov B, Kurbanova U and Ashirov B **2019** Aspects of the extension of forty exploitation of bulk reservoirs for irrigation and hydropower purposes *E3S Web Conf.*
[20] Krutov A, Bazarov D, Norkulov B, Obidov B and Nazarov B **2019** Experience of employment of computational models for water quality modelling *E3S Web Conf.*
[21] Mamajonov M, Bazarov D, Uralov B, Djumabaeva G and Rahmatov N **2019** The impact of hydro-wear parts of pumps for operational efficiency of the pumping station *J Phys Conf Ser* **1425** 012123 doi: 10.1088/1742-6596/1425/1/012123
[22] Militeev A N and Bazarov D R **1999** A two-dimensional mathematical model of the horizontal deformations of River channels *Water Resour* **26** 17