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Article

USE OF MODERN TECHNOLOGIES IN DETERMINATION OF HYDRAULIC AND HYDROLOGICAL PARAMETERS OF WATER RESERVOIRS

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Abstract. In this research, an analysis of natural field research results, which was conducted in the Chartak River Reservoir was given. During the field research, different measurements were carried out to determine the useful volume of reservoirs using modern measuring instruments. The research was carried out as following: hydraulic parameters are studied in the aquatic part of reservoir using "SonTekS5" river surveyor doppler, and geodetic measurement were obtained in the waterless parts of the reservoir using "N-3" surveyor levelling tool. Measurements were taken in the defined characteristic cross section and the results on cross section were extracted. Conclusions on the amount of turbid sediments in the reservoirs were made through analyzing the results of the field research and statistical comparison of long-term data of the reservoir. Based on the measurement data, cross sections of the reservoir were formed, and comparing the obtained results with the design parameters of the reservoir, the volume usefulness was clarified. According to the pertinent results of the research, the current usefulness and sediment volumes were 20.81 million m^3 and 9.19 million m^3, respectively.

Keywords: reservoir, channels, stream, dam, sediment, water level.

1 INTRODUCTION

The Republic of Uzbekistan is located in the Aral Sea basin, and the main water sources in the country are the Amudarya and Syrdarya rivers, as well as inland rivers and streams and groundwater. The average long-term water flow from all sources in the Aral Sea basin is 116 billion m^3, of which 67.4% is formed in the Amudarya basin and 32.6% in the Syrdarya basin. In particular, the total groundwater reserves are 31.2 billion m^3, of which 47.2% fall into the Amudarya basin and 52.8% into the Syrdarya basin [1]. The area of irrigated land in the country is 4.3 million hectares. An average of 90-91% of the total water resources are used for agricultural activities, followed by 4.5%, in the utilities sector, 1.4% in industry, 1.2% in fisheries, 0.5% in thermal energy, and 1% in other sectors of the economy [1]. According to the UN classification, Uzbekistan is one of the countries experiencing water shortages, and the future balance of the country's water resources will be affected by the rapid melting of glaciers forming the main rivers of the region, other aspects of climate change and growing population needs for water and industry. It is estimated that a 10-20 per cent reduction in water supply could have serious consequences for the size of irrigated land and employment, resulting in a decline in gross national income. Effective management of water resources, which is intended meeting the needs of irrigated agriculture, utilities and industry and the environment, is crucial to ensure the sustainable economic development of the country [2,3].

In order to rationally use water resources, many reservoirs have been built, and the important tasks are the efficient and economical use of stored water, the uniform supply of water to consumers during the growing season, and increasing useful capacity as well as durability of hydraulic structures [4,5]. Considering these factors, it is vitally pivotal to improve operational reliability of reservoirs, to ensure hydraulic stability of hydraulic structure in reservoirs, and enhance calculation methods of usefulness capacity [6,7,8]. In particular, the rapid development of the agricultural sector and the development of new lands are leading to an increase in water consumption. Therefore, the construction of reservoirs in the country, prolonging their service life, saving water resources, rational and efficient use of available water resources is becoming a vital necessity [9,10]. In recent years, due to periodic water shortages as a result of global climate change, many problems have arisen in the agricultural sector during the growing season [11]. Therefore, improving the operation of reservoirs, increasing the operational reliability of hydraulics, preventing the reduction of the useful capacity of the reservoir as a result of turbidity and improving the calculation of water consumption are becoming vital necessity of water sector [12,13].

It is obvious that the reservoir meets the needs of several sectors of the economy (irrigation, water supply, electricity, shipping, fisheries, flood control, etc.) [15]. The reservoir regulates flow by season and year, allowing for redistribution of flow across regions along with canals and other drainage structures. According to preliminary research, the amount of turbid sediments in the reservoir, which is as a result of years of environmental changes and atmospheric precipitation in the upper reaches of the structure, is sharply increasing that creates uncertainties in the calculation of water consumption. As a result of such negative changes, the useful capacity of the reservoir is reduced, the efficiency of use is reduced, and the impact on the safety of the population and agricultural facilities is increasing [16,17]. One of the urgent tasks today is to accurately assess the useful volume of the reservoir and to solve problems such as accurate accounting of water consumption by means of modern measuring instruments. Additionally, the rapid decline in the useful capacity of stream reservoirs, it is necessary to conduct biometric surveillance surveys in stream reservoirs every five years. Therefore, this research is aimed at eliminating raised problems through conducting geodetic surveying at Chartak Stream reservoir using "SonTekS5" river surveyor doppler and "N-3" surveyor levelling tool [16].

2 MATERIALS AND METHODS

In this research, Chartak Stream Reservoir was taken as study site, where at the end of the growing season, field surveys were conducted using a modern measuring tool to calculate the useful volume of the Chartak River Reservoir. The modern measurement tools, "SonTekS5" river surveyor doppler and "N-3" surveyor levelling tool, were used in on field experiment (Fig. 1-2). Noteworthy, in developing a reliable and efficient mode of operation of reservoirs, it is necessary to have accurate information about the volume of water stored in the reservoir for the safe operation of facilities [16].

Fig. 1. "SonTekS5" river surveyor Doppler

According to the figure 1, "SonTekS5" river surveyor doppler consists of five main elements: The River Surveyor S5 doppler light-emitting medium, electronic software, a doppler-mounted boat, an adapter for transmitting and receiving GPS signals (antenna), and a power supply. Table 1 shows that in speed measurement, profile spacing (distance) is between 0.06-5 meters, followed by profile spacing (speed) with +/- 20 m/s, whereas profile spacing in depth measurement is around 0.20-15 meters. Errors in both measurements can be in between 0.25% and 1%, respectively, meanwhile accuracy of measurements is the same, accounting for 0.001 m/s (Table 1).

Table 1. Parameters of "SonTekS5" river surveyor doppler

Speed measurement		Depth measurement	
Profile spacing (distance)	0.06-5 m	Interval	0.20-15 m
Profile spacing (speed)	+/- 20 m/s	Error	1%

Error	Up to +/- 0.25% of measured velocity; +/- 0.2cm/s^{1}	Resolution (accuracy)	0.001 m/s
Resolution (accuracy)	0.001 m/s		

Fig. 2. “N-3” surveyor levelling tool

Table 2. Measurement parameters of “N-3” surveyor levelling tool

Technical characteristics of “N-3” surveyor levelling tool	
Average square error of measurement of excess, mm: - for 1 km of double travel - at the station with a sighting beam length of 50 m	 3 2
Magnification of the optic tube, by a factor of	30
Pipe field of view angle	1,3
Light diameter of the lens, mm	40
Minimum sight distance, m	2
The coefficient of the filament rangefinder	100
The price of dividing the level by 2mm: - cylindrical - round	 15 10
Operating temperature range, °C	from -40 to +50
Length of the telescope, mm	175
Weight, kg	2

According to the parameters of the above measuring instruments, the accuracy and effectiveness of the results of field research can be assessed. Before starting the measurements, the characteristic stoppers along with the length of the reservoir were determined [18]. For starting measurement experiments in the pre-defined characteristic cross section, “SonTekS5” river surveyor doppler was put into working condition, that was, all elements of the doppler were installed in a boat, and the power supply and GPS signals transmission were checked. It is evident that when all elements are connected correctly, green indicator light switches on, whereas if there is error in the process, red indicator notifies it [19]. After starting the software, it was necessary to make sure that the system was working properly before starting the measurement work. To do this, the location of the measurement was entered into the mirror formed on the screen, and before each measurement it was necessary to perform a compass calibration to eliminate magnetic interference, ensuring that the error for successful calibration does not exceed 0.1 degrees (Fig. 3).

Fig. 3. The first phase of research

The data related to the study site was inserted and the measurement process was started after the initial tests were completed. In the software, the measurement process was followed step by step, of which the basic concepts of the measurement process are shown in figure 4. The procedure for carrying out measurements is given in figure 5. When the Doppler measuring instrument is set to the working position, it is activated by pressing the Start Edge button as shown in the figure 5 on the left or right side of the set. During the measurement, the hydraulic and hydrological parameters of the shaft are directly monitored. When the measuring device reaches the end point of the shaft, the first measurement process is completed by pressing the End Edge button. Repeating the measurement once again increases the accuracy of the measurement data. The studies measure the minimum and maximum depth of the stratum, the width of the water table and bottom, the relief of the bottom and other parameters.

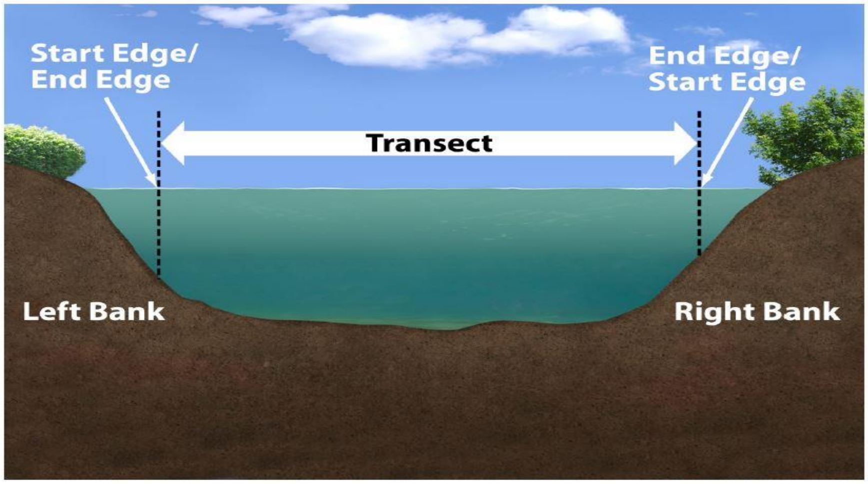


Fig. 4. Basic concepts of measurement process

The second stage of the study was carried out in the onshore (anhydrous) part of the reservoir, where geodetic measurements was carried out in the identified characteristic cross section of the study area using N-3 levels (Fig. 5). When performing measurements using "N-3" surveyor leveling tool, the highest boundary point was determined as the normal stagnant water level (NDS) of the reservoir, and measurements were made on both the right bank and the left bank to the NDS point. All data obtained during the measurement and the values of the measurement results were entered into a special calculation table [20].

Fig. 5. Geodetic survey work in the second phase of the research experiments

3 RESULTS AND DISCUSSION

At the study site, several characteristic constant cross sections were identified for carrying out measurements in natural field conditions. The first phase of the study was carried out starting from the cross section identified in the part near the reservoir dam (Figure 5).

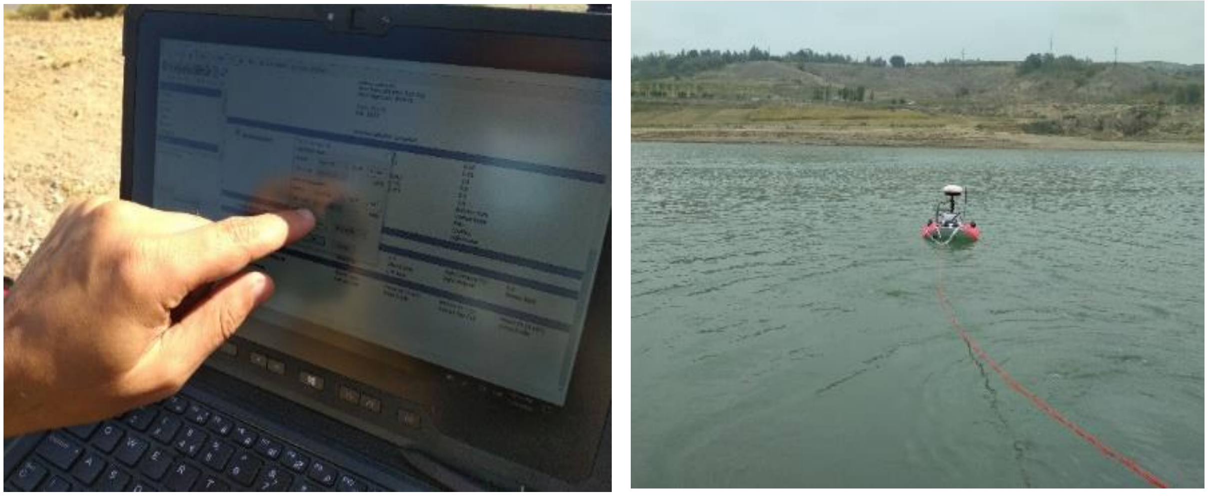
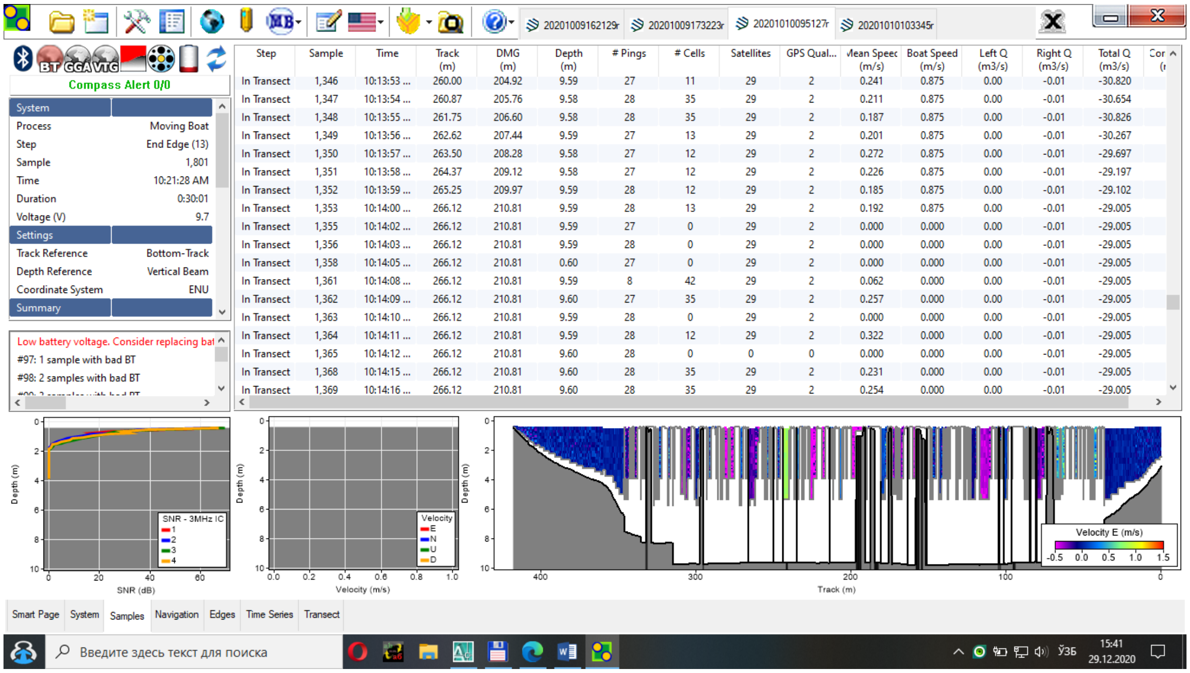


Fig. 2. Field research process

The measurement results were monitored using software, accordingly, the main data obtained during the measurement process was images of the depth of reservoir and cross-sectional area. Using Doppler data and images, changes in the parameters of the reservoir storages were observed (Fig. 6-7). It was possible to estimate the degree of turbidity of the reservoir by comparing the obtained results with the design parameters of the reservoir.

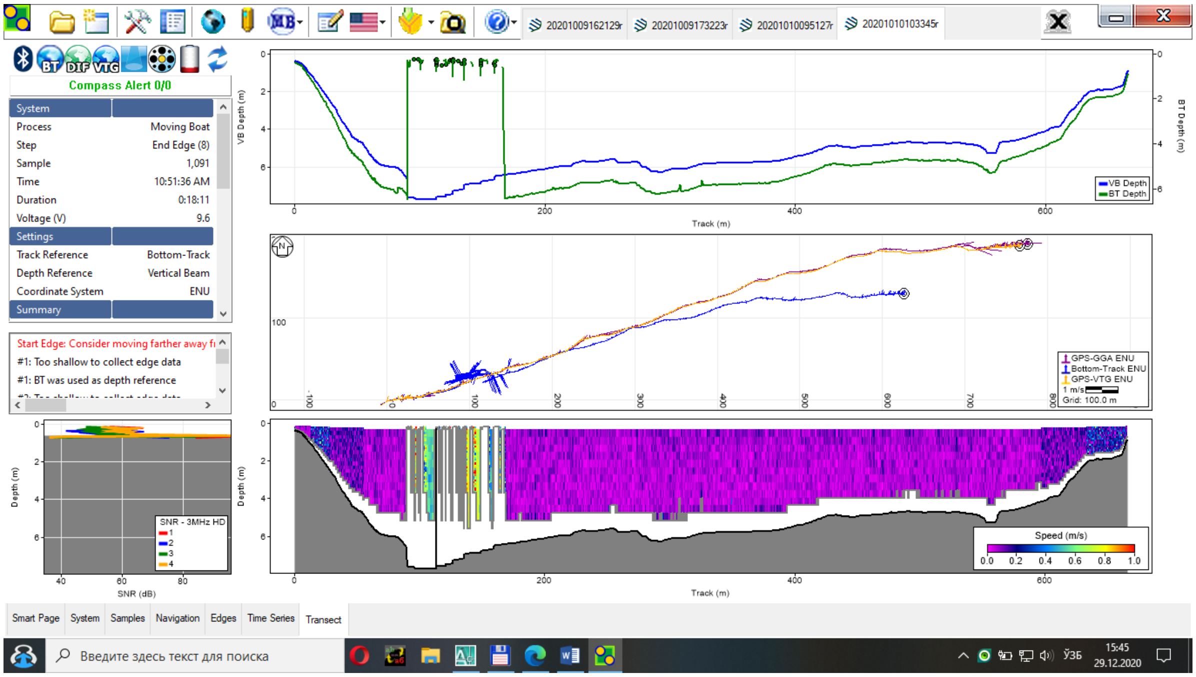


System	
Process	Moving Boat
Step	End Edge (13)
Sample	1,801
Time	10:21:28 AM
Duration	0:30:01
Voltage (V)	9.7
Settings	
Track Reference	Bottom-Track
Depth Reference	Vertical Beam
Coordinate System	ENU
Summary	

Low battery voltage. Consider replacing bat
#97: 1 sample with bad BT
#98: 2 samples with bad BT

Step	Sample	Time	Track (m)	DMG (m)	Depth (m)	# Pings	# Cells	Satellites	GPS Qual...	Mean Speec (m/s)	Boat Speed (m/s)	Left Q (m3/s)	Right Q (m3/s)	Total Q (m3/s)
In Transect	1,346	10:13:53 ...	260.00	204.92	9.59	27	11	29	2	0.241	0.875	0.00	-0.01	-30.820
In Transect	1,347	10:13:54 ...	260.87	205.76	9.58	28	35	29	2	0.211	0.875	0.00	-0.01	-30.654
In Transect	1,348	10:13:55 ...	261.75	206.60	9.58	28	35	29	2	0.187	0.875	0.00	-0.01	-30.826
In Transect	1,349	10:13:56 ...	262.62	207.44	9.59	27	13	29	2	0.201	0.875	0.00	-0.01	-30.267
In Transect	1,350	10:13:57 ...	263.50	208.28	9.58	27	12	29	2	0.272	0.875	0.00	-0.01	-29.697
In Transect	1,351	10:13:58 ...	264.37	209.12	9.58	27	12	29	2	0.226	0.875	0.00	-0.01	-29.197
In Transect	1,352	10:13:59 ...	265.25	209.97	9.59	28	12	29	2	0.185	0.875	0.00	-0.01	-29.102
In Transect	1,353	10:14:00 ...	266.12	210.81	9.59	28	13	29	2	0.192	0.875	0.00	-0.01	-29.005
In Transect	1,355	10:14:02 ...	266.12	210.81	9.59	27	0	29	2	0.000	0.000	0.00	-0.01	-29.005
In Transect	1,356	10:14:03 ...	266.12	210.81	9.59	28	0	29	2	0.000	0.000	0.00	-0.01	-29.005
In Transect	1,358	10:14:05 ...	266.12	210.81	0.60	27	0	29	2	0.000	0.000	0.00	-0.01	-29.005
In Transect	1,361	10:14:08 ...	266.12	210.81	9.59	8	42	29	2	0.062	0.000	0.00	-0.01	-29.005
In Transect	1,362	10:14:09 ...	266.12	210.81	9.60	27	35	29	2	0.257	0.000	0.00	-0.01	-29.005
In Transect	1,363	10:14:10 ...	266.12	210.81	9.59	28	0	29	2	0.000	0.000	0.00	-0.01	-29.005
In Transect	1,364	10:14:11 ...	266.12	210.81	9.59	28	12	29	2	0.322	0.000	0.00	-0.01	-29.005
In Transect	1,365	10:14:12 ...	266.12	210.81	9.60	28	0	0	0	0.000	0.000	0.00	-0.01	-29.005
In Transect	1,368	10:14:15 ...	266.12	210.81	9.60	28	35	29	2	0.231	0.000	0.00	-0.01	-29.005
In Transect	1,369	10:14:16 ...	266.12	210.81	9.60	28	35	29	2	0.254	0.000	0.00	-0.01	-29.005

Fig. 3. Results obtained using Doppler in the first cross section of the reservoir



Compass Alert 0/0

System	
Process	Moving Boat
Step	End Edge (8)
Sample	1,091
Time	10:51:36 AM
Duration	0:18:11
Voltage (V)	9.6
Settings	
Track Reference	Bottom-Track
Depth Reference	Vertical Beam
Coordinate System	ENU
Summary	

Start Edge: Consider moving farther away fı

#1: Too shallow to collect edge data

#1: BT was used as depth reference

Fig. 4. Results obtained by Doppler in the second cross section of the reservoir.

The results of field research showed that the cross-sectional surfaces of the reservoir were formed. Accordingly, the water level was 687.3 meters, and the deepest point of the measured section was 9.59 meters. According to the data analysis, the width of the measured sections was ranged from 447 meters to 1100 meters. The second stage of the study was carried out in the waterless parts of the characteristic cross-sectional using the level N-3. As a continuation of the results obtained through Doppler, the 687.3 height mark was defined as a rapper point and the measurement work was continued from the same height. Moreover, measurements were first made on the right bank and then on the left bank.To do this, the geodetic measuring instrument was set to the desired point and put into operation, and the research was carried out using a measuring tool.The results were entered into a pre-prepared calculation table.The measured results were processed using a computer program after the completion of the research and the following graphs were obtained (Fig. 8-12).

Table 3. Results measured by "N-3" surveyor leveling tool on the right bank of the first cross section of the reservoir

№	h	▲h	l	i	H
1	397.5				687.35
		380	36	0.10556	
2	17.5				691.15
2	136.2				691.15
		33.2	47	0.00706	
3	103				691.482

N	**41**	**10**	**551**		
E	**71**	**49**	**115**		

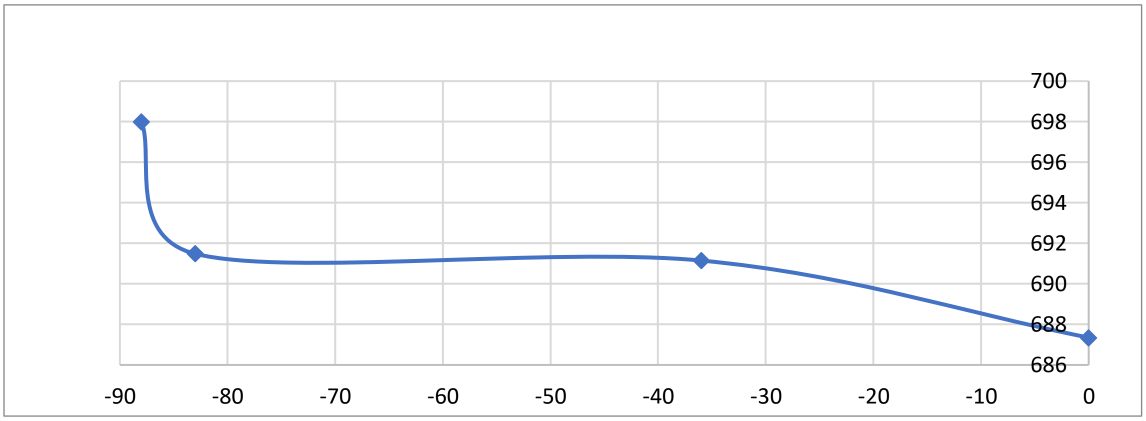


Fig. 5. Results measured by "N-3" surveyor levelling tool on the right bank of the first cross section of the reservoir

Table 4. Results measured by the leveling tool on the left bank of the first cross section in waterless part of the reservoir

#	#	h	▲h	l	i	H
1	1	251				687.32
			229	52	0.04404	
	2	22				689.61
2	2	180				689.61
			91.5	30	0.0305	
	3	88.5				690.525
3	3	228				690.525
			164	11	0.14909	
	4	64				692.165
4	4	67				692.165
			-66	52	-0.0127	
	5	133				691.505
5	5	131				691.505
			-17	48	-0.0035	

	6	148				691.335
N	41	10	617			
E	71	48	174			

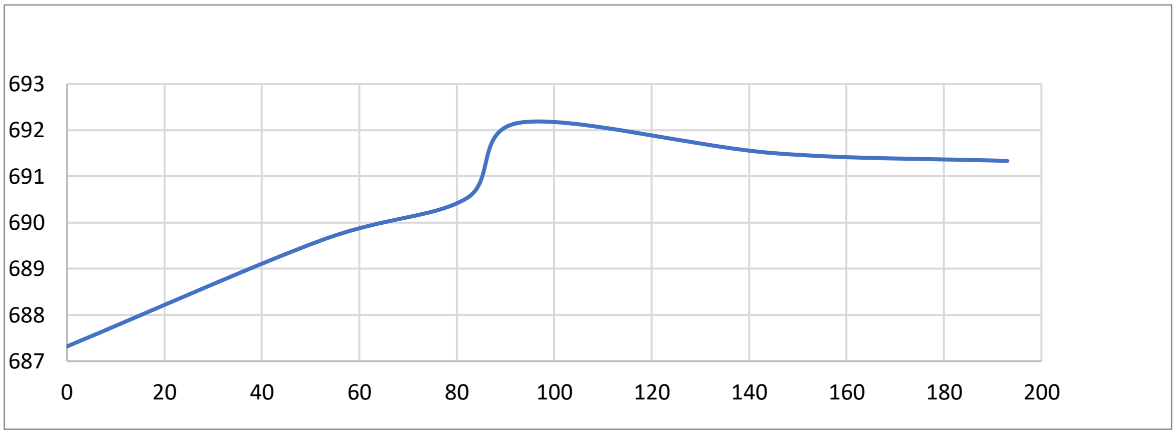


Fig. 9. Results measured by "N-3" surveyor levelling tool on the left bank of the first cross section of the reservoir

Table 5. Results measured by leveling tools of the second cross section of the reservoir (left and right bank)

#	**h**	**▲h**	**l**	**i**	**H**
1	400				687.35
		394	6.5	0.60615	
2	6				691.29
2	384				691.29
		370	52	0.07115	
3	14				694.99
N	**41**	**10**	**704**		
E	**71**	**49**	**166**		

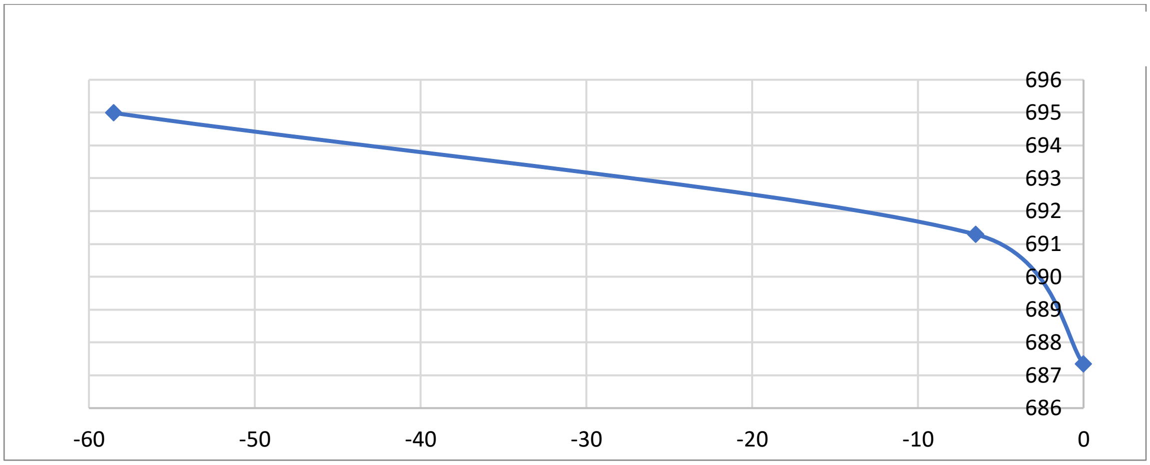


Fig. 10. Results measured by leveling tools on the right bank of the second cross section of the reservoir

Table 6. Results measured by leveling tools on the left bank of the second cross section

#	**h**	**▲h**	**l**	**i**	**H**
1	394				687.35
		372	30	0.124	
2	22				691.07
2	337				691.07
		311	16	0.19438	
3	26				694.18
N	**41**	**10**	**742**		
E	**71**	**48**	**266**		

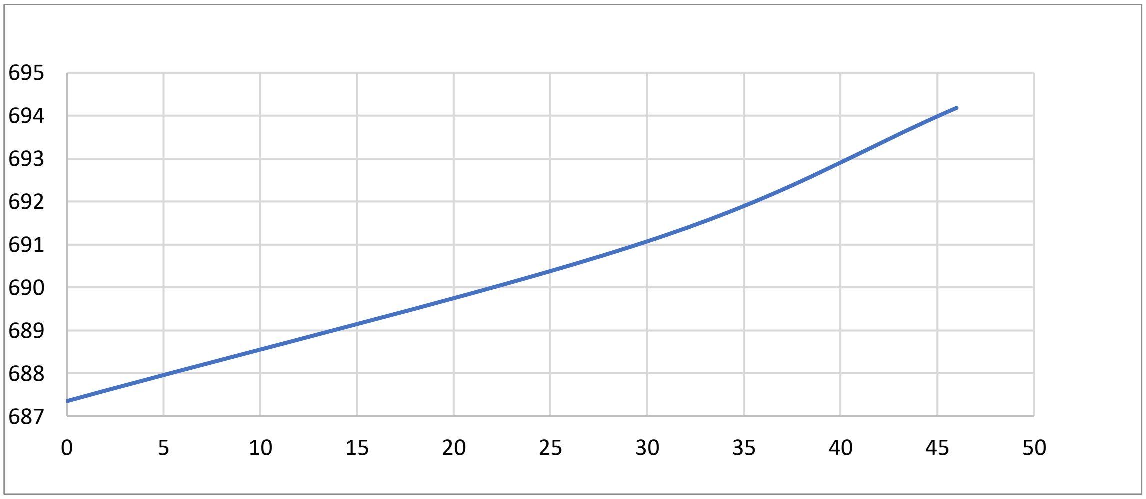


Fig. 11. Results measured by leveling tools on the left bank of the second cross section

Based on the re-analysis of the obtained results, the cross-sections of the reservoir were calculated. The volume of the reservoir was calculated using the results of each stvor cutting surface. On the day of measurement, the level of the water table in the reservoir was ∇ 677.8, the height of the water level was ∇687.5, and the average width of the water level was V = 550-870 meters.

The measurements were carried out in this order, and the cross-sectional area graphs of the reservoir were processed using a computer program to process the results measured by both measuring instruments as follows (Figure 10). During the field research, such measurements were made on the total length of the reservoir in all defined storages. Based on the results obtained, the current volume of water in the reservoir was clarified and changes in operation, turbidity of the reservoir and deformation processes on the banks of the reservoir and their negative effects were studied. Based on the results, conclusions were made on the assessment of changes in the useful volume of the reservoir, operational efficiency, the volume of turbid sediments and their impact on the environment. Of course, using the results obtained, it is also possible to observe the distribution of turbid sediments in the reservoir along the upper bef. By comparing the changes that took place during the operation of the reservoir, the design parameters of the structure, the data obtained from the study, statistical analysis and theoretical calculations, a large amount of turbid sediments was accumulated in the upper basin during half a century exploitation.

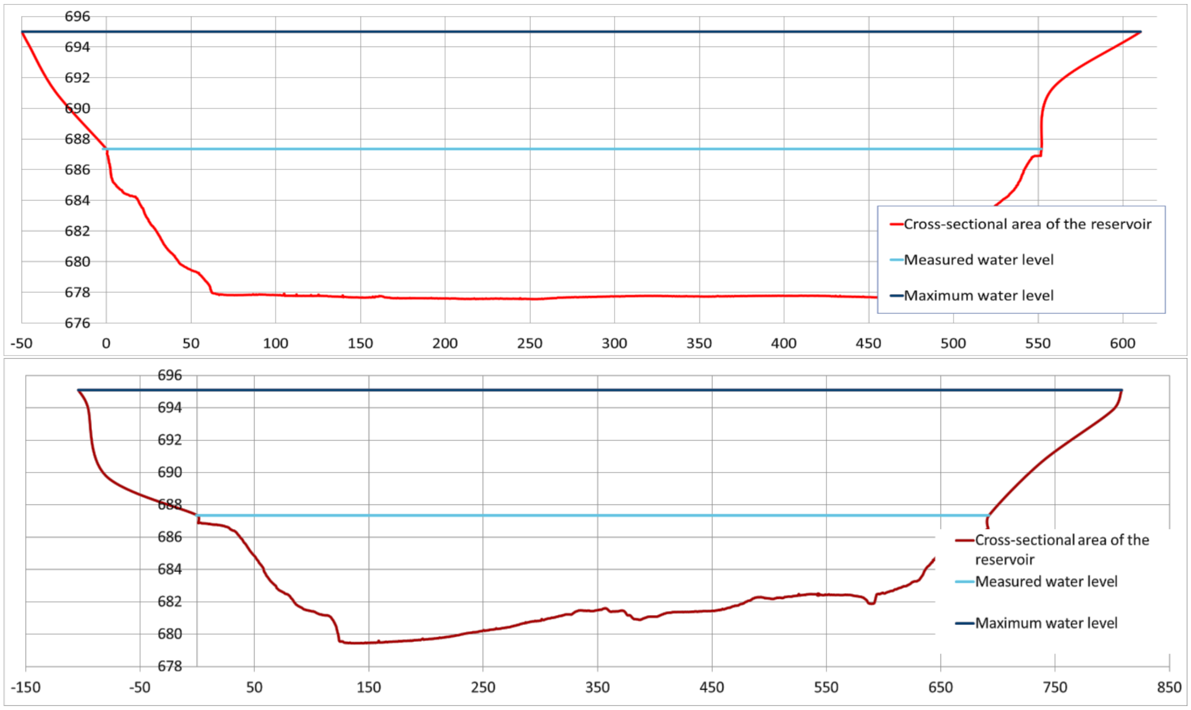


Fig. 12. Formation of the reservoir cross-sectional surface

4 CONCLUSIONS

Based on the results of research in natural field conditions, data on changes in the reservoir and its consequences were analyzed. During the research, based on the data obtained using “SonTekS5” river surveyor doppler and “N-3” surveyor levelling tool, changes in the current reservoir were identified and compared with the design parameters of the facility. The results were summed up on the duration of the reservoir operation, the efficiency of the operating mode, the reduction in useful volume, changes in water levels and the impact on the environment. Based on the measurement data, the cross sections of the reservoir were formed and the useful volume was clarified by comparison with the design parameters of the reservoir.

According to the analysis of the results, the current useful volume of the Chartak reservoir is 20.81 million m^3 and the turbid volume is 9.19 million m^3.The study drew conclusions on the factors affecting the useful volume of the reservoir, the role of modern measuring instruments in accurately estimating the amount of turbid sediments and determining the amount of turbid sediments, their ease of use in the field and the accuracy of the results.

REFERENCES

1. Merina, R. N., Sashikkumar, M. C., Rizvana, N., & Adlin, R. (2016). Sedimentation study in a reservoir using remote sensing technique. Applied ecology and environmental research, 14(4), 296-304.
2. Arifjanov, A., Gapparov, F., Apakxujaeva, T., & Xoshimov, S. (2020, December). Determination of reduction of useful volume in water reservoirs due to sedimentation. In IOP Conference Series: Earth and Environmental Science (Vol. 614, No. 1, p. 012079). IOP Publishing.
3. Jurík, Ľ., Zeleňáková, M., Kaletová, T., & Arifjanov, A. (2018). Small water reservoirs: Sources of water for irrigation. Water Resources in Slovakia: Part I, 115-131. DOI: 10.1007 / 698_2018_301
4. Honek, D., Michalková, M. Š., Smetanová, A., Sočuvka, V., Velísková, Y., Karásek, P., ... & Danáčová, M. (2020). Estimating sedimentation rates in small reservoirs-Suitable approaches for local municipalities in central Europe. Journal of environmental management, 261, 109958.
5. Mukhamedjanovich, A. A., Bakhtiyarovich, A. S., Nayimovich, S. L., & Apakxo'Jaeva, T. U. (2018). Choosing an optimal method of water extraction for arid regions in the case of Beshbulak and Yangiobod villages (Syrdarya provice, Uzbekistan). European science review, (3-4), 244-248.
6. Kaletova, T., Arifjanov, A., Samiev, L., & Babajanov, F. (2022). Importance of river sediments in soil fertility. Journal of Water and Land Development, 21-26.
7. Schleiss, A. J., Franca, M. J., Juez, C., & De Cesare, G. (2016). Reservoir sedimentation. Journal of Hydraulic Research, 54(6), 595-614.
8. Arifjanov, A., Samiev, L., Khaydarov, S., Kasimov, T., & Juraev, S. (2022, June). Increasing efficient use of water storage pools. In AIP Conference Proceedings (Vol. 2432, No. 1, p. 040037). AIP Publishing LLC.
9. Abduraimova, D., Rakhmonov, R., Akhmedov, I., Xoshimov, S., & Eshmatova, B. (2022, June). Efficiency of use of resource-saving technology in reducing irrigation erosion. In AIP Conference Proceedings (Vol. 2432, No. 1, p. 040001). AIP Publishing LLC.
10. Rakhimov, K., & Xoshimov, S. (2020, December). Theoretical bases of hydraulic mixture in round cylindrical pipelines. In IOP Conference Series: Earth and Environmental Science (Vol. 614, No. 1, p. 012095). IOP Publishing.

11. Sapaev, J. B., Arifjanov, A., Khudayarov, M. M., & Rozmetov, K. S. (2022, June). Smart technologies for determination of water consumption in irrigation systems. In AIP Conference Proceedings (Vol. 2432, No. 1, p. 040017). AIP Publishing LLC.
12. Xoshimov, S., Qosimov, T., Ortikov, I., & Hoshimov, A. (2022, August). Analysis of fractional and chemical composition of chartak reservoir sludge sediments. In IOP Conference Series: Earth and Environmental Science (Vol. 1076, No. 1, p. 012083). IOP Publishing.
13. De Vente, J., Poesen, J., & Verstraeten, G. (2005). The application of semi-quantitative methods and reservoir sedimentation rates for the prediction of basin sediment yield in Spain. Journal of Hydrology, 305(1-4), 63-86. doi: 10.1016/J.JHYDROL.2004.08.030.
14. Arifzhanov, A. M. (2004). Method for calculation of the distribution of drift particles in variable section beds (VSB). Gidrotekhnicheskoe Stroitel'stvo, 2, 44-45.
15. Alisher Khodjiev, Malika Ikromova, Ifoda Akhmedkhodjaeva and Sardor Xoshimov (2020). Calculation of accumulation volume and water loses in bottom sediments of bank reservoirs. IOP Conference Series: Materials Science and Engineering, 883(1), 012048
16. Ilhamov, K. S., Arifjanov, A. M., Narzullaev, D. Z., Abdurakhmanov, B. A., & Shadmanov, K. K. (2021, August). Determination of the formation model of the phase concentration field along the section of the turbulent flow of hydrotransport using information technologies. In Journal of Physics: Conference Series (Vol. 2001, No. 1, p. 012010). IOP Publishing.
17. Zhang, J., Shang, Y., Liu, J., Lu, J., Wei, S., Wan, Z., ... & Fu, J. (2021). Optimisation of reservoir operation mode to improve sediment transport capacity of silt-laden rivers. Journal of Hydrology, 594, 125951. https://doi.org/10.1016/j.
18. Togaev, I., Nurkhodjaev, A., Akmalov, S., Samiev, L., Otakhonov, M., & Atakulov, D. (2022, June). Structural interpretation of the allocated complexes based on remote sensing materials of the Earth and using in geological researches (Case of Southern Nurata Mountains). In AIP Conference Proceedings (Vol. 2432, No. 1, p. 030001). AIP Publishing LLC.
19. Rudiš, M., Valenta, P., Valentová, J., & Nol, O. (2009). Assessment of the deposition of polluted sediments transferred by a catastrophic flood and related

changes in groundwater quality. Journal of Hydrology, 369(3-4), 326-335. doi: 10.1016/J.JHYDROL.2009.02.023.