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Assessment of the ecological state and organization of works on cleaning the reservoir from siltation products

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Abstract. A project has been developed for the organization and production of works to clean the reservoir from siltation products. The analytical part contains an analysis of the initial data, an assessment of the ecological state of the reservoir and the choice of the method of work. The reservoir, after many years of operation, was silted up with products of water and wind erosion of the soil coming from the catchment area, river sediments and products of anaerobic decomposition of plant and animal origin. The assessment of the ecological state of the reservoir is presented in the article.

1. Introduction

Because water-storage infrastructure is aging, there is an increasing focus on reservoir siltation and related challenges. Simultaneously, the need for managed sediment regimes in river systems with regulated flow is being driven by the growing expectation of environmental improvement and the well-established knowledge of the hydrological and geomorphological modification caused by river damming [1]. Most of the small water bodies built back in the middle of the 20th century, mainly for the use of local runoff used for irrigation and fish farming, for fire-fighting purposes and recreation are currently in a deplorable state. Many of them are silted up and eutrophied, hydraulic structures are in disrepair. The progressive siltation of water reservoirs caused by deposits that continuously emerge in watersheds gradually reduces the effectiveness of reservoirs for water management and other duties over time. Small water reservoir siltation is a natural occurrence [2, 3], however it has undergone substantial alteration recently. Numerous writers from throughout the globe have noted that water reservoir siltation has escalated at a rate never seen before [4, 5]. This situation has developed mainly due to the restructuring processes in the economy: the collective farms and state farms on whose balance sheet they were liquidated, irrigated agriculture with the use of local runoff was reduced, and mainly the financing previously allocated for their operation was stopped [6-9]. Former fields are often built up, forests are cut down, swamps are drained, the coastal area is usually littered with garbage, which adversely affected the change in the water regime of many water bodies.
Nevertheless, despite the fact that many hydraulic structures of the 3rd and 4th classes of responsibility (reliability) have now become homeless, the territorial administrations of local self-government allocate funds to improve the ecological situation of such water bodies. One of the ways to improve the ecological situation is the cleaning of water bodies from siltation products, followed by repair and construction work to restore hydraulic structures and the arrangement of the coastal territory.

2. Materials and Methods

Based on the analysis of the literature [1], we have developed a methodology for organizing and carrying out work on cleaning the reservoir from silting products, which we will try to present with calculations in this article. The research methodology is proposed in Figure 1.
To begin with, a topographic plan of the reservoir is drawn up [2, 3]. We have chosen a scale of M1:5000, a reservoir under the designation P-1 is taken as the object of research. Based on the topographic plan of the reservoir, we selected a cross section along the dam alignment and proposed a design scheme for determining the volume of

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bottom sediments by section A-A (Fig. **2** and 3).Also, a cross-section was made along the dam alignment and a calculation scheme for determining the volume of bottom sediments along the B-B section.
All measurements were applied on millimeter paper for convenience. The text of the article was simplified by specifying in the form of sketches.

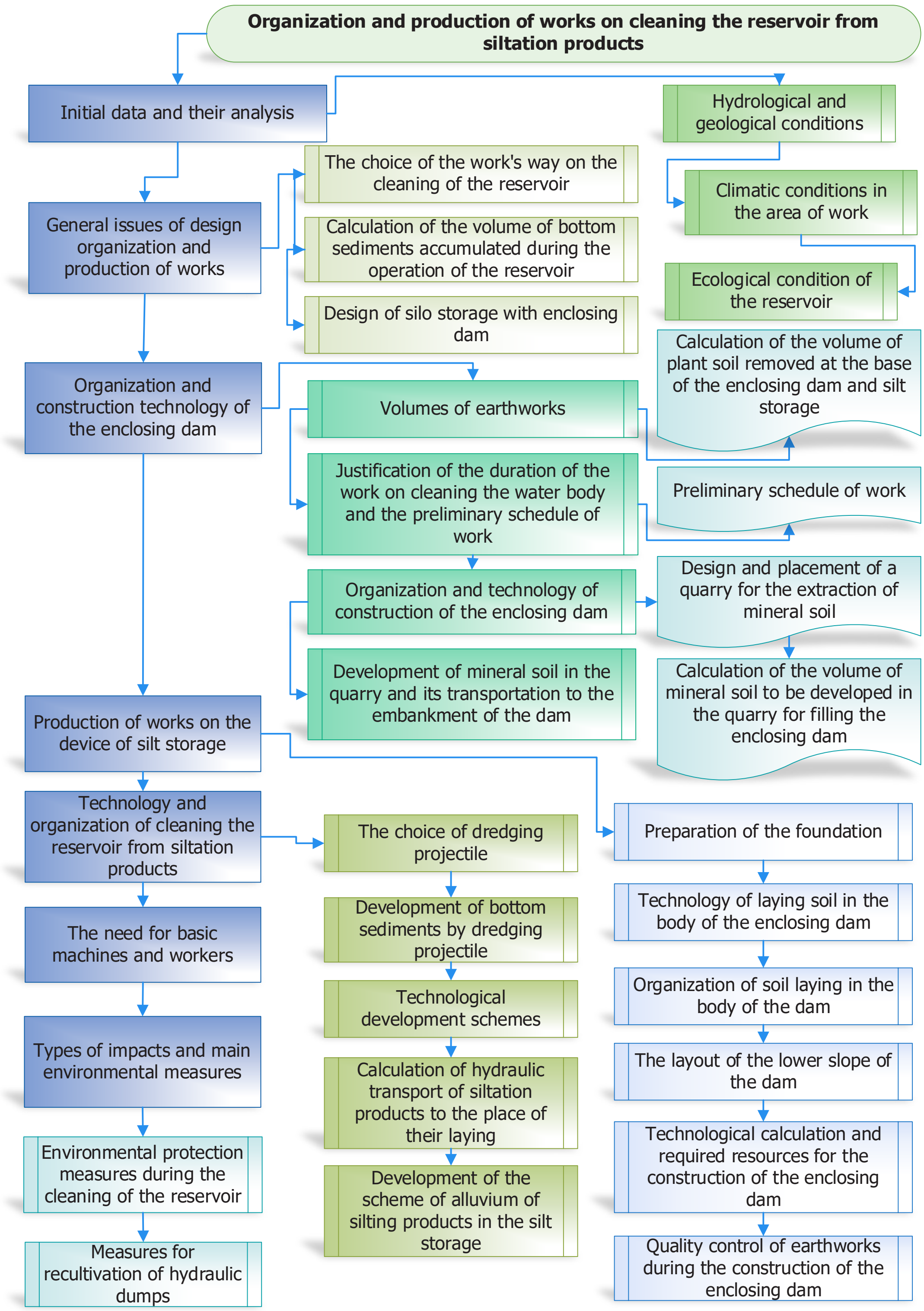

Fig. 1.The proposed methodology for the organization and production of works on cleaning the reservoir from siltation products

3. Results and Discussion

3.1 Hydrological and geological conditions

Hydrological conditions (the hydrological state of a water body) reflect a set of features characterizing the physical and chemical properties of a water body, the processes of their formation and spatial and temporal variability in a given place and for a specific, limited period (it is easy to notice an analogy with weather conditions) [4, 5]. The hydrological regime reflects a set of regularly recurring changes in the hydrological state of a water body, patterns of changes in time of the considered parameters of the aquatic environment due to physical and geographical, primarily climatic conditions [6, 7]. This is a kind of norm of the hydrological conditions of a given aquatic ecosystem (one can easily draw an analogy with the climate), established as a result of a long-term series of observations. The hydrological regime includes long-term, seasonal and daily fluctuations in the water level (level mode), the speed and direction of currents, vertical mixing (water dynamics mode), water flow rates (runoff mode, or water mode), water temperature (thermal mode), ice phenomena (ice mode), the amount and composition of solid transported by the flow material (sediment regime), composition and concentration of chemicals (hydrochemical regime), etc. The natural hydrological regime is often significantly disrupted by human economic activity, i.e. by the intervention of an anthropogenic factor [8, 9].

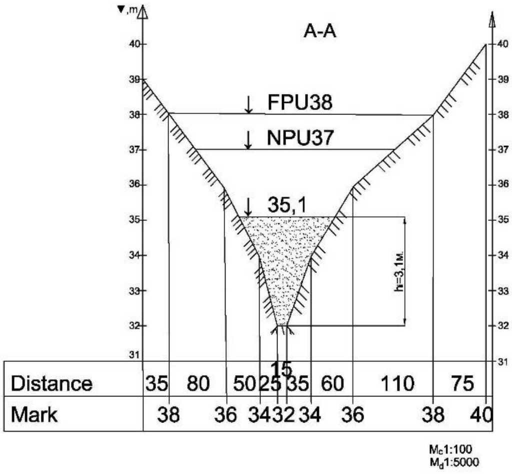

Fig. 2. A cross section along the dam alignment design scheme for determining the volume of bottom sediments

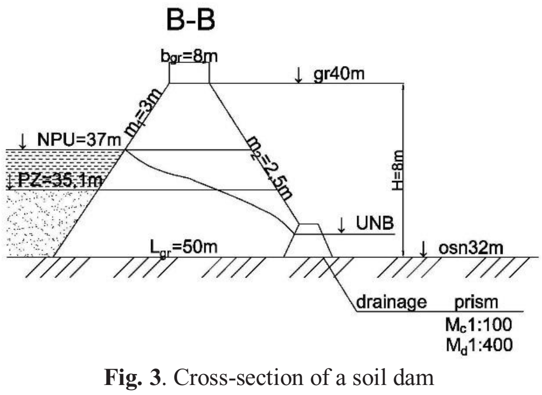

Fig. 3. Cross-section of a soil dam

3.2 Ecological condition of the reservoir

During the operation of a reservoir (reservoir), bottom sediments accumulate in a water body associated with eutrophication processes, the arrival of wind and water erosion products from the surface of adjacent lands, as well as due to the accumulation of river sediments, anaerobic decomposition of plant and animal residues [10].

With the accumulation of bottom sediments, the depth of water in the reservoir decreased, which contributes to the warming of water at great depths in the summer and the damping of convective processes in it. All this reduces the saturation of water with oxygen, accompanied by rapid overgrowth of the reservoir with blue-green algae, and the coastal zone with reed and other moisture-loving vegetation [11]. Favorable conditions for the reproduction and habitat of insects are being created, water quality is deteriorating, the ability of a water body to self-repair (self-regulation) is being lost, the ecological condition of the water body itself and coastal territories is deteriorating, the useful volume of water in it is decreasing. [12, 13]

In order to restore the ability of a water body to self-repair (self-regulation) and normalize water use processes for the needs of fish farming and fishing, irrigation, water supply and recreation, it is necessary to periodically clean water bodies from siltation products [14].

The study of hydrogeological conditions, climatic and environmental conditions is an important preparatory measure for the construction of large-scale projects [15]. To ensure the quality of the construction of the facility, engineering design and construction should be carried out on the basis of a comprehensive and detailed hydrogeological, climatic and environmental study [16].

General issues of design organization and production of works on cleaning the reservoir from siltation products [2].

The choice of the method of work on the cleaning of the reservoir.

The method of work is chosen depending on the topographic plan of the area, fluctuations in the water level in the river (river hydrograph), the composition of bottom sediments, the actual depth of water in the reservoir.

Of the three options considered, it is advisable to adopt a hydro-mechanized method of work for cleaning the reservoir from siltation products.

Next, we calculate the volume of bottom sediments accumulated during the period of operation of the reservoir and design a silt storage tank with an enclosing dam.

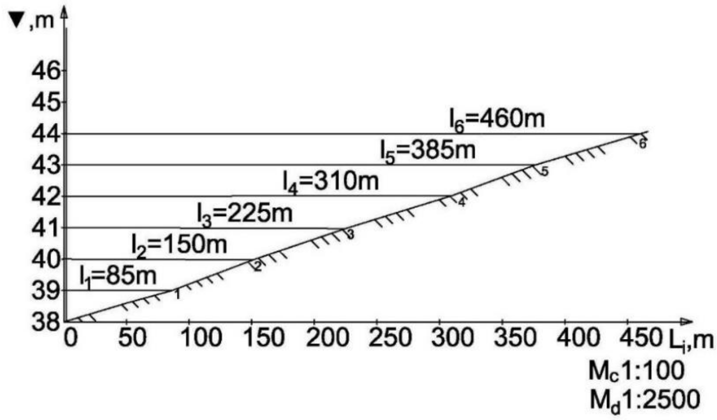

Fig. 4. Longitudinal profile along the axis of the silt storage

Determination of the crest mark of the enclosing dam

Using the longitudinal profile along the axis of the silt storage (Figure 4) and the topographic plan of the site (Figure 5) allocated for the placement of the silt storage, we calculate the change in the capacity of the silt storage from the height of its filling with bottom sediments from ▼38.0 m to ▼44.0 m.

Silo storage dimensions

The calculation of the elementary volumes of the silo is shown in Table 1.

According to Table 1, we construct an integral dependence of the change in the volume of the silo on the depth of its filling: Vi = *f* (*H*i) (Figure 5).

Table 1. Calculation of elementary silo filling volumes

№ points	MarksPZ. м	Depth H_i, m	Layer Sizes				Volumes	
			Filling interval, Δh , m	Length L_i, m	Width B_i, m	Square S_i, m^2	layered V_i, $m^{\#}$	Cumulative total $\sum V_i$, $10^3 m^3$
0	38	0	0	0	0	0	0	0
1	39	1	1	75	87,5	4375	2187,5	2,2
2	40	2	1	150	157,5	15750	10062,5	12,25
3	41	3	1	225	237,5	35625	25687,5	37,94
4	42	4	1	310	325	67166,7	51395,85	89,33
5	43	5	1	385	397,5	102025	84595,85	173,93
6	44	6	1	460	490	150266,7	126145,85	300,1

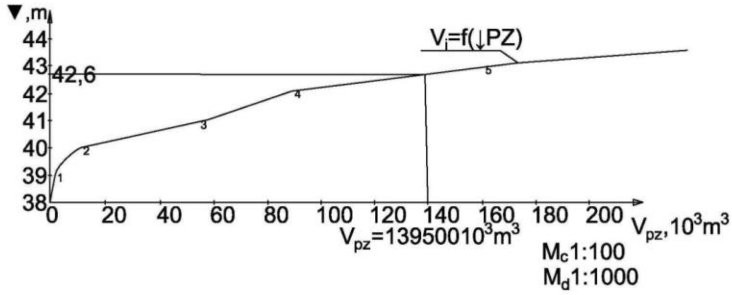

Fig. 5. Integral dependence of the change in the volume of silt storage as it is filled with siltation products

According to the schedule (Fig. **5**), with the volume of silting products of the V_{PZ} (V_{PZ} = 139500m^3), we determine the top's mark of the silt storage filling $\blacktriangledown_{ss}$.

The project of cleaning the riverbed from polluted bottom sediments should provide for the necessary measures to protect the reservoir from pollution during the period of work. The composition of water protection measures should include a set of organizational and technical measures that exclude unproductive losses and ingress of siltation products.

From the options considered, it is advisable to adopt a hydro-mechanized method of work [17,18] for cleaning the reservoir from siltation products [19].

We have proposed a calculation of the volume of bottom sediments accumulated during the operation of the reservoir. The project of a silo storage facility with an enclosing dam included the determination of the crest mark of the enclosing dam and the dimensions of the silo storage facility.

An enclosing dam is a structural element of a reservoir or dam for regulating the water level. Its construction includes a number of technological processes, including the preparation of the foundation, the installation of support walls, the device of sealed layers and the device of the surface for water retention.

The organization of the dam construction process is important to ensure high quality of work and compliance with deadlines. This may include the development of a detailed plan, the selection of contractors and suppliers, and quality control of work. The technology of construction of the enclosing dam depends on many factors, such as location, size, type of soil, climatic conditions and others. Methods such as excavation, concreting and cladding are commonly used.

The volume of earthworks. Calculation of the required volume of mineral soil for the construction of the enclosing dam.

For the construction of the enclosing dam, mineral soil is required, which is supposed to be extracted at the base of the silt storage. Taking into account the requirements of building codes, when carrying out earthworks before they begin, it is recommended to remove the vegetable (fertile) layer from the entire territory on which earthworks will be carried out. In this regard, the vegetation layer is removed at the base of the dam and the territory allocated for the silt storage itself, followed by its relocation to temporary dumps. Subsequently, the plant soil will be used for recultivation of the washed territory and fixing the outer slope of the dam by the method of tinning (by sowing grasses).

The volume of earthworks. Calculation of the volume of plant soil removed at the base of the enclosing dam and silt storage.

This amount of work consists of the volume of vegetable (fertile) soil removed at the base of the enclosing dam and the volume of vegetable (fertile) soil removed from the entire territory allocated for silt storage, including from the territory allocated for quarries.

Vegetable (fertile) soil cut from the silt storage area and at the base of the dam should be placed outside the silt storage in two dumps at a distance of 30 ... 50 m above the design mark of the silt storage (the edge of the washed bottom sediments).

The cross section of the vegetable soil dump can be taken in the form of a trapezoid. The formation of temporary dumps of vegetable soil is carried out according to the longitudinal scheme by the method of pushing soil according to the high-altitude scheme into the body of the dump with a front loader, scraper or bulldozer.

Justification of the duration of work on cleaning the water body and a preliminary schedule of work.

The construction standards of SNiP 1.04.03-85*[5], currently in force, do not provide for the cleaning of reservoirs. The closest in complexity and composition of work are works on the regulation of water intake rivers. The SNiP recommends the following standard duration of work, depending on the volume of excavation (siltation products): the total duration, including the duration of the preparatory period.

Preliminary schedule of work.

The main types of work performed during the cleaning of the reservoir from siltation products:
- preparatory period works (organization of a production temporary base, delivery of machines and mechanisms, installation of a dredger and laying of pulp pipelines, etc. - $T_{podg.}$);
- removal of vegetable soil and moving it to temporary dumps - up to 1.0 months;
- development of mineral soil in quarries and the construction of an enclosing dam - ≈ 1.5...2 months;
- development of bottom sediments and their alluvium in silt storage - months (period with positive average monthly temperatures);
- works of the final period and reclamation of disturbed territories, months;
- preparation of the facility for commissioning - up to 1 month.

The work schedule is presented in Table 2.

Table 2. Schedule of work on cleaning the reservoir from siltation products

Types of work	Duration, months.	Years															
		1												2			
		Months															
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	**4**
		Average monthly ambient temperature , tº C															
		-4	-3	2	9	15	20	20	16	10	4	2	-1	-4	-3	2	**9**
1 Preparatory period works	2,0	×	×														
2 Removal of plant soil and moving it to temporary dumps	1,0			×													
3 Development of mineral soil in quarries and construction of a fenced dam	2,0				×	×											
4 Development of bottom sediments and their alluvium in silt storage	7,0					×	×	×	×	×	×	×					
5 Works of the final period and reclamation of disturbed territories	4,0												×	×	×	×	
6 Preparation of the facility for commissioning	1,0																×

3.3 Organization and technology of construction of the enclosing dam

Design and placement of a quarry for the extraction of mineral soil.

We place the quarry within the area allocated for the placement of the silt storage, taking into account the following conditions: we place the quarries as close as possible to the enclosing dam; in terms of the quarry, we take a rectangular shape with an aspect ratio of 1:2 for the convenience of construction machines; to ensure the patency of construction machines along the bottom of the quarries, we place its sole 1... 2 m above the level ground water occurrence.

Calculation of the volume of mineral soil to be developed in the quarry for filling the enclosing dam

The volume of the soil is determined by the dependence:

$V_к = V_{d.s.} \cdot K_{scc} \cdot K_{pot}$

$V_к = 12566{,}4 * 1{,}675 * 1{,}02 = 21469{,}7\ m^3$

where $V_{d.s}$ - geometric volume of the enclosing dam, taking into account its precipitation (construction volume), m^3;

$K_{scc} = \dfrac{\gamma_н}{\gamma_e} = \dfrac{2{,}58}{1{,}54}$ =1,675 soil compaction coefficient; $\gamma_н$ - soil density in the dam after its compaction, t/m^3; γ_e - soil density in the quarry (natural addition), t/m^3; K_{pot} - coefficient that takes into account the loss of soil during transportation and laying (according to the SNiP [16] K_{pot}= 1,01…1,02).

After determining the required volume of mineral soil, we determine the size of the quarry and its location on the topographic plan.

The size of the quarry and its location on the plan.

It is advisable to design two quarries, since the dam in the plan includes three sections (2 end and middle part).

It is advisable to place quarries on the territory occupied by the silt storage. Such placement of the quarry will not require further work on the reclamation of land disturbed by quarry developments.

The balance of ground masses. This is a design and technological document showing the rational distribution of soil between recesses and embankments and its possible additional processing.

The balance is presented in Table 3. The condition of balance is the equality of the volumes of soil ($\sum V_r$) removed from the recesses to the volumes ($\sum V_m$) poured into the embankment and the washed soil in the silt storage, taking into account their additional reworking and losses:

$\sum V_r = \sum V_m.$

The choice of machines for the development of soil in the quarry and its transportation to the body of the dam.

First, we calculate the intensity of earthworks:

$J_z = \frac{V_k}{T_d} \cdot K_{ner},$

Where J_z – intensity of earthworks, m^3/month.;

$V_к$ - volume of mineral soil to be developed in quarries, m^3;

T_d - the duration of the dam construction, months, is determined according to the preliminary schedule of work;

K_{ner} – the coefficient of unevenness of work, equal to 1.2.

Based on the experience of excavation work and analysis of technical and economic indicators, it is recommended to use [6]:

- at J_z< 20,000 m^3/month - single-bucket excavators with bucket capacity q = 0.65 m^3
- at J_z = 20,000... 60,000 m^3/month - single bucket excavators with bucket capacity q = (1...1.25) m^3.

The required number of dump trucks per 1 excavator can be accepted according to the recommendation.

Table 3. Ground mass balance sheet

Recesses		Mounds				
Types of recesses	Volume of recesses, m^3	Temporary dumps of vegetable soil, m^3	Silt storage dam, m^3	Silt storage, m^3	Recultivation of silt storage, m^3	Total
I. Removal of plant soil at the base of the dam and silt storage	V_p 19302	19302	-	-	-	
II. Development of mineral soil in quarries	$2V_к$ 42939	-	42939	-	-	
III. Development of silting products	$V_{p.z.}$139500	-	-	139500	-	
IV. Development of plant soil in temporary dumps	V_p 19302	-	-	-	19302	
Total	$\sum V_r$ 221044 (recess)	$\sum$ 19302	$\sum$ 42939	$\sum$ 139500	$\sum$ 19302	$\sum V_m$ 221044 (mound)

With a range of soil transportation up to 500 m, for a single-bucket excavator with a bucket capacity q = 0.65 m^3, the number of dump trucks $n_{a/c}$ = 3 should be taken.

The average distance of soil transportation from the quarry to the dam is determined (at this stage of design) as the distance from the center of mass of the excavation to the center of mass of the embankment.

In relation to the specified conditions, the following options are possible for the development and transportation of soil into the embankment of the enclosing dam:

1. Single bucket excavators with bucket capacity with working equipment dragline or reverse shovel with bucket capacity q = 0.65 m3 with loading into dump trucks with lifting capacity G = 7 tons.
2. Single bucket excavators with bucket capacity q = (1...1.25) m^3 with the same working equipment and loading into dump trucks G = 12 tons.
3. Trailer scrapers with bucket capacity q = 7...8 m^3.
4. Self-propelled scrapers with bucket capacity q = 9 m^3.

The comparison of options is carried out at direct costs is presented in Table 4. The calculation was carried out at direct costs (in base prices of 2000) for the conditions: the range of soil transportation L_{cp}= 100, m; soil – sandy

loam, group on the difficulty of soil development: for single-bucket excavators during development–I; when developing scrapers-II [20].
First, we calculate the performance of the dump truck involved in the transportation of soil from the face to the maps of soil laying.
Having determined the performance of the dump truck, we determine the cost of transporting soil.
Considering that the range of soil transportation L_{cp} is up to 500 m, we accept option 3 option - a trailer scraper of the DZ-2 type with a T-100 tractor and a bucket capacity q = 8 m^3 [6]. Since this is an option with minimal direct costs and more output per worker-mechanic.
<u>Development of mineral soil in the quarry and its transportation to the embankment of the dam.</u>
The development of mineral soil in a quarry includes the process of extracting soil from the rock in which it is located and preparing it for transportation and use. This may include processes of crushing, sorting, cleaning and shaping the soil for better functionality.

Table 4. Technical and economic indicators of options for developing soil in quarries and transporting it to the dam

Indicators	Unit of measurement	Variants			
		EO reverse shovel		Scrapers	
		q=0,65 m^3 a/c G=7т	q=1,0 m^3 a/c G=10т	Trailed q=7…8 m^3 T-100	Self - propelled q=9 m^3
1. Set of machines: - number of earthmoving machines - number of dump trucks	 units units	 1 3	 1 4	 1 -	 1 -
2. Number of machine operators, N_p	people	4	5	1	1
3. The norm of time for cars	mach-h/m^3	$(H_{vr})_1$=2	$(H_{vr})_2$ =1,2	$(H_{vr})_3$=1,7	$(H_{vr})_4$ =2,8
4. Regulatory performance $P_н = \frac{100}{H_{вр}}$	m^3/h	$П_1$ = 50	$П_2$= 83,3	$П_3$ = 58,8	$П_4$ = 35,7
5. The price of a car hour according to FER-2001, C_{m-h}	rub./h	3559,82	2575,23	2143,76	2627,04
6. The cost of soil development $C_p = \frac{C_{м-ч}}{P_н}$	rub./m^3	71,2	30,9	36,45	73,6
7. The cost of transporting soil by dump trucks, $C_т^*$	rub./m^3	164,6	94,3	-	-
8. Direct costs $C = C_p + C_m$	rub./m^3	235,8	125,2	36,45	73,6
9. Output per worker $P_p = \frac{P_н}{N_p}$	m^3/people	12,5	16,7	58,8	35,7

The transportation of soil from the quarry to the embankment of the dam can be carried out using various methods, such as conveyors, dump trucks, railway wagons or trucks. It is important that the transportation of soil is carried out in compliance with all necessary safety measures and environmental requirements.

3.4 Production of works on the device of the silo storage

During the construction of the enclosing dam, we carry out the following construction processes - the preparation of the foundation and the construction of the enclosing dam.
<u>Preparation of the foundation.</u>
When preparing the base, we perform two construction operations: loosening the soil in the base and its subsequent compaction.
<u>Technology of laying soil in the body of the enclosing dam.</u>
Before laying the soil in the body of the dam, the dry base must be moistened.
When laying the soil in high-quality embankments (dams, dams), the following construction operations are performed: bulk soil, layer-by-layer leveling, bringing the soil to optimal humidity, layer-by-layer compaction of the soil.
<u>The choice of a soil compacting machine.</u>
To seal the soil in this project, we accept a pneumatic roller [1] of the type DU-39A with a tractor T-100, G = 25 t, h_{pl} = 0.35 m [21].
<u>Organization of soil laying in the body of the dam</u>
For the organization of continuous filling of the soil by the flow method, which requires mutual coordination of construction operations for bulk, leveling and layer-by-layer compaction of the soil, the dam being erected is

conditionally divided into tiers or calculated levels in height. Each operation is performed on a dedicated site, which is called a stacking map.
The number of cards is determined on each tier:

$$n_\kappa = \frac{F_i}{f_p} \text{ (accept an integer),}$$

whereF_i- the area of the calculated tier, m^2; f_p - estimated area of one card, m^2.
The estimated area of the map is calculated by the formula:

$$f_p = P_{NIK} \cdot N_3 \cdot t_{nepr}/h_{SL} = 58.8 \cdot 0.3 \cdot 8/0.35 = 403.2\ m^2$$

where P_{NIR} – normative productivity of an earthmoving machine during the development of soil in a quarry (P_{NIR} = P_Z), m^3/h; N_3 - the number of simultaneously operating earthmoving machines is determined from the condition $N_3 = \frac{J_z}{P_z} = \frac{17,9}{58,8} = 0,3$; t_{nepr} – the daily duration of continuous dumping of soil on one map (8 hours.); h_{SL} - the thickness of the soil filling layer on the map, $h_{SL}=h_{PL}=0,35$m; J_Z– intensity of earthworks, m^3/h.
To organize the work on dumping soil into the body of the enclosing dam, we conditionally divide it into tiers (levels) according to its height (see Table 5). The breakdown of the enclosing dam into tiers and laying maps is carried out in tabular form.

Table 5. Calculation of the number of soil laying maps on different dam's tiers, f_p = 403,2m^2, t_{ner} = 8 hours.

Tier number and mark	The dimensions of the tier in the plan			Estimated number of cards $n'_\kappa = \frac{F_i}{f_p}$	Accepted number of cards (integer, less), n_k, pieces	Actual map area, m^2, $f_\kappa = \frac{F_i}{n_k}$	Average thickness of the filling layer, m $h_{sl} = \frac{P_{ch} \cdot N_z \cdot t_{nepr}}{f_k}$
	Length, L_i, m	Width, B_i, m	Square, F_i, m^2				
▼1	75	21	1575	4	4	393,75	0,35
▼2	135	15	2025	5	5	405	0,35
▼3	195	9	1755	4,4	4	438,75	0,33

After determining the number of laying maps on the tiers, we draw a scheme for organizing the laying of soil with alternating and combining construction operations on the tiers (see Table , Figures 6 and 7):
1. bulk soil with trailer scrapers with bucket capacity q = 8 m^3;
2. layer-by-layer leveling of the soil with a bulldozer based on the T-130;
3. waterlogging of the soil with a PM-6 type irrigation machine;
4. layer-by-layer sealing with roller type DU-39 with T-100; 0 - cards are free from work.

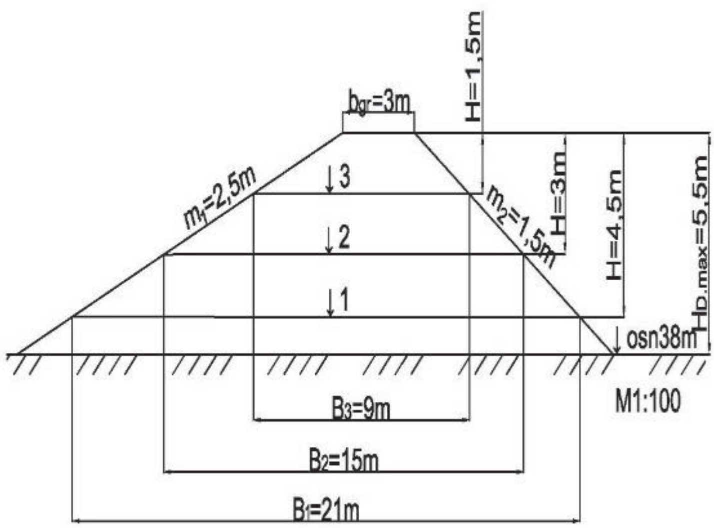

Fig. 6. The cross section of the enclosing dam and the dimensions of the three tiers

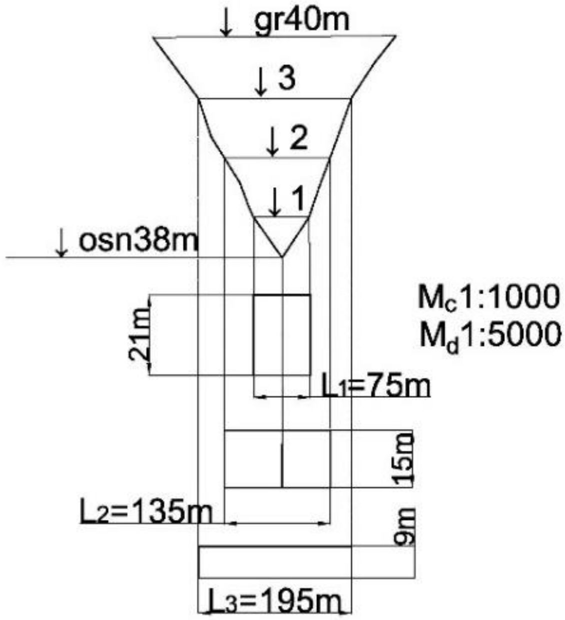

Fig. 7. The scheme of organization of soil laying with alternating operations during the construction of a protective dam: ▼1 – ▼3 - tiers of soil laying (levels); 1, 2, 3, 4 construction operations, respectively, bulk, layer-by-layer leveling, waterlogging and layer-by-layer compaction of soil

Technological calculation and required resources for the construction of the enclosing dam

In the resource and technological calculation, the following are determined: standard machine capacity (M_i), labor intensity (E_i) and direct costs of performing work in a mechanized way. The calculation is performed in tabular form. The costs (price) associated with the operation of Smash-h machines are accepted according to the appendix to FER-2001 "Collection of estimated prices for the operation of construction machines in 2000 prices".

Based on the performed resource and technological calculation, the required resources for the construction of the enclosing dam are presented (Table 6).

Table 6. Required resources for the construction of an enclosing dam $V_{p.d.}$ =12566,4m^3

Required resources	Unit of measurement	Value
1. Machine operation (machine capacity):	mash-h	
- trailed scrapers of the typeDZ -20, q = 8 m^3;	- " -	1409,6
- bulldozers of the DZ-28 type on T-130 and T-100;	- " -	82,7
- towed pneumatic roller type DU-39A with T-100, G = 25 tons;	- " -	16,8
- ripper type DP-15 with T-100	- " -	2,22
2. Labor costs of machine operators (labor intensity)	man-hour	∑E = 1522,7
3. The cost of earthworks in the base prices of 2000	rub.	∑C =208677

3.5 Technology and organization of cleaning the reservoir from siltation products

The choice of dredging projectile.

The choice of the dredging projectile is carried out from the condition: the productivity of the dredging projectile (shells) should ensure the design intensity of work on cleaning the water body from siltation products. The ground pump mounted on the dredger has three characteristic performance indicators: water, pulp and soil.

The choice of dredging projectile.

The dredger is selected according to the condition: $H_{gr.} \geq H$, where $H_{gr.}$ is the pressure developed by the ground pump. Otherwise, a pumping station is installed along the length of the hydraulic transport of bottom sediments. The technical characteristics of the accepted dredger are presented in the form of a table.

Development of bottom sediments by dredging projectile.

The technological scheme for cleaning the reservoir from siltation products by a dredging projectile is carried out on a topographic plan on a scale of 1:5000.

The calculation of pressure losses in the pulp ducts should be performed in Table 7.

Table 7. Calculation of pressure losses in pulp ducts during transportation of silting products

Indicators	sections of the pulp duct		
	floating	coastal	distribution
1. Pulp feeding by one dredger, Q'_n, m³/sec	0,4	0,4	0,4
2. The length of the pulp duct sections, m (according to the pulp transportation scheme)	ℓ_1= 175	ℓ_2=750	ℓ_3= 400
3. Design diameter of pulp ducts, m	D_{pl}=0,4	D_{ber} = 0,4	D_{raspr}=0,32
4. Actual pulp velocity:V = $\dfrac{4\cdot Q'_n}{\pi\cdot D_i^2}$ м/с	3,18	3,18	4,97
5. Reynolds Parameter: $R_e=\dfrac{V\cdot D_i}{\nu}$; $\nu = 2\cdot 10^{-5}$m²/sec	63600	63600	79520
6. Coefficient of resistivity: $\lambda_o = (0{,}55/\ell_g \frac{R_e}{8})^2$	0,02	0,02	0,019
7. Specific pressure losses along the length $i_n = \lambda_o \dfrac{V^2}{2g}\cdot\dfrac{\gamma_n}{\gamma_в}$, m, g = 9.81	0,012	0,012	0,011
8. Pressure losses along the length $h_e = i_n\cdot\ell_i$, m	2,1	9	4,4
9. Local pressure losses $h_м \approx 0{,}1\ h_e$	0,21	0,9	0,44
10. Total losses by area $h_i = h_e + h_м$, m	2,31	9,9	4,84
11. Total pressure loss $\sum h_i = h_{pl} + h_{ber} + h_{pac}$, m	$\sum h_i$=17,05		

3.6 Development of the scheme of alluvium of silting products in the silt storage

When the pulp exits the distribution pulp duct to the alluvial map, the pulp (hydraulic mixture) spreads along the alluvial beach with particle fractionation; first, large fractions are deposited near the pulp overflow; then small fractions are deposited in the settling pond; clay fractions are washed and discharged together with clarified water.

Calculation of discharge wells and their number.

The discharge of clarified water outside the silt storage is provided through discharge wells. The time of precipitation of suspended particles of siltation products can be adjusted by changing the size of the spillway front of the discharge wells and their number on the alluvial map.

The need for basic machines and workers.

The calculation of the need for basic machines and workers is presented in Table 8.

Table 8. Statement of requirements for basic machines and workers (M_i - mash-h; T_i - hour; N_i)

The name of the machines and their parameters	Estimated machine capacity, M_i - mach-h	Estimated duration of work, T_i - hour	Number of machines, N_i	Number of workers, N_p, unit.	
				for one car	only for 2 shifts
1. Trailed scrapers, q=8 m³	1409	704	2	1	4
2. Ripper with T-100	2,22	704	1	1	2
3. Bulldozer on T-130	82,7	704	1	1	2
4. Pneumatic tire roller withT-100	16,8	704	1	1	2
5. EO "reverse shovel", q=0,4m³	11	704	1	1	2
6. Dredger type 3GM-350	170	2464	1	5	10
Total			$\sum N_i$ = 7		$\sum N_p$ = 22

4. Conclusions

In this work, the organization and production of water reservoir desilting works was developed. In the analytical part, the preliminary data were analyzed, the environmental condition of the reservoir was assessed and the working method was selected. After many years of operation, the reservoir is covered with water and wind erosion products of the soil originating from the reservoir, river sediments, and anaerobic decomposition products of plants and animal. This situation arose mainly due to the structural changes in the economy: collective farms and state farms, which were on the balance sheet, and irrigated agriculture using local water flow were reduced. This has a negative effect on the change of the water regime of many water bodies. The main types of negative impacts during the performance of works on the cleaning of the reservoir: violation of the relief and landscape; violation of the soil cover; contamination of the territory with waste; pollution of surface and groundwater; pollution of the atmosphere. One of the ways to improve the ecological situation is to clean water bodies from silt, then repair and construction works on the restoration of hydraulic structures and regulation of the coastal area.

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