Development of new ways to preserve the water content of lake basins in the natural park of the Volga-Akhtuba floodplain

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Abstract. The article presents new modern ways to increase the receiving capacity and preserve the water content of lake basins on the territory of the Volga-Akhtuba floodplain natural Park. The main factor that caused the need for rehabilitation of the rivers and lakes of the Volga-Akhtuba floodplain is the change in the hydrological and ecological situation that arose as a result of the change in the hydrological regime by regulating the flow of the Volga River after the construction of the Volga hydroelectric power station. The rehabilitation of water objects is aimed at preserving and restoring the water objects to a state that provides environmentally favorable living conditions for the population; ensuring the protection of the population from low water (water scarcity), for the restoration and environmental rehabilitation of the water objects and the adjacent territory.

1. Introduction
The Volga-Akhtuba floodplain within the borders of the Volgograd region has a high biological and landscape diversity. A large number of water bodies are located on the territory of the floodplain: the Akhtuba river, 90 km long within the Volgograd region; the Krasnoslobodsky tract, 33 km long; the Kashirinsky tract, 99.3 km long; backwaters - 8 units; large channels - 6 units; shallow channels - 173 units; more than 200 large lakes representing unique accumulators of liquid and solid river flow; marshes - 2 units with a total area of 206.8 hectares [1].

The main factor that caused the need for rehabilitation of the rivers and lakes of the Volga-Akhtuba floodplain is the change in the hydrological and ecological situation that arose as a result of the change in the hydrological regime by regulating the flow of the Volga River after the construction of the Volga hydroelectric power station.

The fundamental element of the landscape complex of the Volga-Akhtuba floodplain is a complex hydrographic network of 6 shallow channels, channels, lakes, estuaries and other water objects. Currently, there are processes of deterioration of the water supply of the Volga-Akhtuba floodplain territory associated with the regime of releases of the Volga-Kama cascade of hydroelectric power plants and a set of local anthropogenic changes in the landscape. Under the influence of artificial regulation of the floodplain hydro regime, as well as the expansion of residential territories, the ecological parameters of reservoirs are transformed and they lose many ecosystem properties. Intensive and unregulated anthropogenic loads lead to violations of the natural physical and chemical parameters of reservoirs, loss of biodiversity, degradation of the structure and functions of biological communities and, as a result,
to a reduction in the range of potential ecosystem services [2]. In this regard, the work aimed at improving the state of water supply of degraded water objects is relevant and problematic. Such objects in the system of the Krasnoslobodsky water management tract include Lake Zapornoye and the Sudomoyka and the Sakharny shallow channels feeding it, located on a specially protected natural territory "The Volga-Akhtuba Floodplain Natural Park" on the lands of the Frunzensky rural settlement in the Sredneakhtubinsky municipal district of the Volgograd region.

2. Materials and methods
According to the data, Lake Zapornoye is a typical example of degradation due to high anthropogenic load: the reservoir is located near a busy highway, surrounded by the outer perimeter of the settlements of Gospitomnik, Sugar and dacha societies, it is collapsed, the land adjacent to the reservoir is used for agriculture (arable land). The pace and density of construction is constantly growing, which was facilitated by the commissioning of a bridge crossing over the Volga in 2010. The lake, as a natural object, is experiencing a powerful load that is destructive to the ecosystem. With the increase in the area of development and the construction of the highway, the lake lost its flowability. In the conditions of reducing the duration and scale of 7 floods, which accelerate the processes of siltation, the lake is quickly overgrown with air-water plants. Overgrowth accelerates the processes of silting of shallow waters and increases waterlogging, slows down the flow of water during high water, contributes to the decline in the diversity of flora and fauna both in shallow water and in adjacent meadows. Due to repeated depressions of the bottom of the northern part of the reservoir, the fauna of hydrobionts and aquatic flora, which should maintain water quality, are depleted in it. Fish productivity is steadily decreasing. The ground vegetation cover is strongly transformed as a result of high anthropogenic load. The animal population corresponds to the parameters of an anthropogenically disturbed landscape. The habitats of aquatic plants, benthic invertebrates and feeding grounds for juvenile fish have been lost. Thus, Lake Zapornoye has almost completely lost most of its ecosystem functions and needs to be restored through the implementation of special rehabilitation measures.

3. Results and discussion
Lake Zapornoye (Figure 1) is a depression in the relief, oriented in a north-easterly direction. The shoreline marks in the flood period of 2016 were minus 4.6 m, the depth of the lake is from 2 m in the southern 17 part to 4.5-5.0 m in the northern part. The territory adjacent to the lake has a mark of minus 4-minus 3 m, which indicates the drainless nature of the lake [3].

Carrying out geoplastics of the relief in the shallow part of the lake with a deepening in certain places up to 2.0-3.0 m will increase the water content of the object, ensure year-round preservation of water in it, create conditions for the development of aquatic organisms. During engineering and geological surveys, the groundwater level in the territory adjacent to the lake was fixed at about minus 6.0 m. Increase of the normal retaining level in the lake to the level of -4.5...-5.0 m will provide an increase in the groundwater level in the territory adjacent to the lake [4] (Figure 1).

When organizing works on the rehabilitation of water objects, the following features of the Volga-Akhtuba floodplain are taken into account:
• work is being carried out on a specially protected area - the Volga-Akhtuba Floodplain Natural Park;
  • from April to mid-July, the floodplain may be flooded by flood waters.
These features impose restrictions on the terms of work (July-March of the next year) and impose special requirements for environmental protection measures.

The main objectives of the project are:
• development of measures to restore the ecosystem of lakes Zapornoye and of the Sudomoyka and the Sakharny shallow channels during the discharge costs of the Volgograd hydroelectric complex provided for by the operating rules (at the level of 25,000-27,000 cubic meters at a second, lasting 5-7 days) and artificial pumping of water by the Head pumping station into the Krasnoslobodsky water tract during the low streamflow period;
formation of a complex lake relief to create habitats for typical groups of biodiversity;
restoration of typical groups of biodiversity in the formed habitats (tree-shrub and herbaceous vegetation);
water protection measures on the formed terrain (optimization of tree and shrub vegetation on coastal slopes);
development of a program of local (project-based) environmental monitoring to assess the effectiveness of measures taken for the environmental rehabilitation of Lakes Zapornoye and the Sudomoyka and the Sakharny shallow channels;
determination of the permissible withdrawal of water for economic needs without compromising the ecosystem of the reservoir.

Figure 1. Top view of Lake Zapornoye.

In the order of technical rehabilitation for the Sudomoyka shallow channel the following activities are planned:
- repair of three hydraulic structures (No. 55, 56, 46), which consists in restoring corroded steel pipes by sanitizing and installing valves;
- cleaning of the riverbed of the shallow channel in the head part of the hydraulic structures from trees - 220 pcs;
- clearing of bushes of 2.01 ha;
- cleaning of the riverbed at the hydraulic structures from sediment - 800 m³;
- cleaning of the riverbed from foreign objects - 2 railway supports with a volume of 0.94 m³;
- cleaning the Sudomoyka shallow channel from sunken logs during rafting - 700/178 pcs/t;
- cleaning the Sudomoyka shallow channel from floating garbage 36 t.

In the order of technical rehabilitation for the Sakharny shallow channel the following activities are planned:
- cleaning of the riverbed in the head part of the shallow channel from bushes of 0.3 ha;
- installation of gates of the hydraulic structures (release into Lake Zapornoye).

In the order of technical rehabilitation for Lake Zapornoye the following activities are planned:
- formation of the littoral and pelagial by geoplastics of the bottom relief with a profile volume of earthworks - 140,960 m³ (performed by a floating excavator and a dredger);
- related earthworks related to the construction of the base from geotubes, the collapse of the alluvial maps by an excavator, the alluvial maps by a dredger;
strengthening of slopes formed in the water area of embankments by planting perennial grasses and woody and shrubby plants.

This will allow for biological rehabilitation, which provides for the creation of a balanced ecosystem in which self-purification mechanisms operate and consist in the formation of littoral and pelagial, reducing the area of coverage with air-water plants (reeds, cattails), and restoring submerged vegetation of the littoral. In the coastal protective strip (width of 30-40 m), it is possible to restore tree and shrub communities [5] (Figure 2).

![Figure 2. Map-scheme of the area of planned work on the rehabilitation of lakes.](image)

According to the design solutions, the rehabilitation objects are simple (profile recesses and embankments). According to construction and installation processes, they refer to objects with construction and installation processes that are repeated in the same volumes and technological alignment on most grippers. According to the construction conditions, they are considered complex objects due to the hydrological and hydrogeological situation. The production of works can be started after the passage of the flood and the runoff of water from the lakes or the preliminary drainage. The work on the rehabilitation of Lake Zapornoye is carried out in the water area at a water depth of up to 1.5 m (with the discharge mode of the Volga hydroelectric power station according to the type of 2016, with the discharge modes of previous years, the water depth can be 0.21....0.5 m).

The peculiarities of carrying out work in the conditions of the Volga-Akhtuba floodplain leads to the adoption of the following organizational and technological decisions:

- taking into account the limited construction time between the flood period and the limitations of the requirements of the fisheries, special attention should be paid to the preparatory work that must be performed before the start of the main work;
- the production of basic works begins after the passage of the flood, the end of the fish spawning period, the decrease in the water level in the lake below 1.5 m.

The organizational and technological scheme of the lake rehabilitation includes:

- spatial division of the complex of works into sections – excesses and depressions;
- the sequence of the device of recesses and the construction of embankments;
- characteristics of the main methods of construction of objects – filling dams with alluvial maps with an excavator, making depressions with a dredger with pumping into alluvial maps, planting trees, shrubs and aquatic plants [6].
The work on the biological rehabilitation of the Sudomoyka shallow channel, which provides for cleaning the riverbed from floating debris, foreign objects, from bushes (in the head part), is performed at any time of the inter-flood period [7]. In the riverbed of the Sakharny shallow channel, it is planned to remove shrubs on an area of 0.3 hectares. Works on Lake Zapornoye are carried out during the inter-flood period on the territory flooded with water, after the level drops below 1.5 m [8] (Figure 3).

![Figure 3. Map of the flora of the studied area.](image)

Taking into account the above provisions, the ecological rehabilitation of water objects is carried out in two stages:
- technical stage;
- the biological stage.

4. Conclusion
The rehabilitation of water objects is aimed at preserving and restoring the water objects to a state that provides environmentally favorable living conditions for the population; ensuring the protection of the population from low water (water scarcity), for the restoration and environmental rehabilitation of the water objects and the adjacent territory. Rehabilitation will improve the state of aquatic ecosystems, as a necessary factor for restoring species diversity and providing conditions for the reproduction of aquatic biological resources. The quality of surface water in the water body is ensured by the annual flooding of the water area by spring floods and corresponds to the quality of the Volga water. The functioning of aquatic ecosystems to a certain extent will have a positive impact on the quality of surface water in reservoirs. Maintaining the water horizon in the lake at the levels of -5.5-5.0 m (the mark minus 5.0 m according to the Baltic Altitude System was taken as the normal retaining level) immediately after the flood will contribute to the supply of groundwater to the territory adjacent to the lake. The planned measures are not the object of capital construction, do not involve the implementation of any economic or other activities. Ecological rehabilitation of water objects is an environmental protection measure...
aimed at optimizing the hydro regime and restoring the normal functioning of the main links of the ecological systems of reservoirs. The indicator of the effectiveness of rehabilitation measures is high and amounts to 16,185 rubles per 1 ruble of investments in rehabilitation. Minimization of the negative impact on the environment during the short-term period of construction works on rehabilitation is provided by organizational and technical measures. In the project of rehabilitation of water objects, the costs are planned for: compensation for damage to aquatic biological resources from the production of works; compensation for environmental damage from the production of construction works.

Recommendations for monitoring the state of the environment. Environmental monitoring is carried out in order to ensure the environmental safety of the object during the implementation of an investment and construction project. Environmental monitoring includes monitoring of atmospheric air, land, water bodies, objects of flora and fauna. When implementing the project, you should be guided by: recommendations on environmental support for investment and construction projects; instructions for the implementation of state control over the protection of atmospheric air (approved by order of the Federal Service for Supervision of Natural Resources Management dated March 1, 2011 No. 112); regulations on the Unified State Environmental Monitoring System.

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