MODELING THE WATER RESOURCES CONTAMINATION LEVEL IN OPEN NODES

Oteniyazov Rashid Idirisovich[1], Xujakulov Toshtemir Abdixafizovich[2], Seytniyazov Davronbek Bayramovich[3], Atamuratov Aydos Turdimuratovich[4]

[1]Nukus branch of Tashkent University of information technologies named after Muhammad al-Khwarizmi, oteniyazov.rashid@mail.ru,
Nukus, Karakalpakstan, Uzbekistan
[2]Department of Information technologies, Tashkent University of information technologies named after Muhammad al-Khwarizmi,
mehr_toj@mail.ru, Toshkent, Uzbekistan
[3]Department of Computer systems, Nukus branch of Tashkent University of information technologies named after Muhammad al-Khwarizmi, dawranbek.ds@gmail.com,
Nukus, Karakalpakstan, Uzbekistan
[4]Nukus branch of Tashkent University of information technologies named after Muhammad al-Khwarizmi, a.atamuratov90@gmail.com,
Nukus, Karakalpakstan, Uzbekistan

Abstract. There will be studied modeling the water resources contamination level in open nodes. The mathematical formulation of the problem of calculating unsteady flows in an arbitrary system of river channels based on one-dimensional equations of the Saint-Venant type is given in this work. Wastewater in the basin is controlled by six indicators: BOD, petroleum products, suspended solids, total phosphorus and nitrogen, as well as iron. Four cleaning methods are considered: mechanical, chemical, biological and biochemical. In the calculation process, each of these methods of wastewater treatment can be compared with the rest.

Keywords: Saint-Venant type, approximate, one-dimensional equation, unsteady, hydrological, gauging stations, groundwater, wastewater.

The mathematical formulation of the problem of calculating unsteady flows in an arbitrary system of river channels based on one-dimensional equations of the Saint-Venant type is given in the work. Let us give a specification of this statement for the conditions of the passage of a spring flood wave along Tupalanga. The considered section of the river network (from the village of Sariasiyansky to the Termezsky waterpost) is schematized by an oriented flat graph (complex), shown in Fig.1.

The edges of the graph correspond to individual sections of the river network (including the Kumkurgan reservoir), and the vertices correspond to the nodal and end points of the river system under consideration. On each segment, the one-dimensional equations of unsteady slowly changing water flow in open nodes are fulfilled (equations of the Saint-Venant type):

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As functions characterizing the flow of water, the flow rate is selected hereand the ordinate of the free surface of water measured vertically from the horizontal axis .

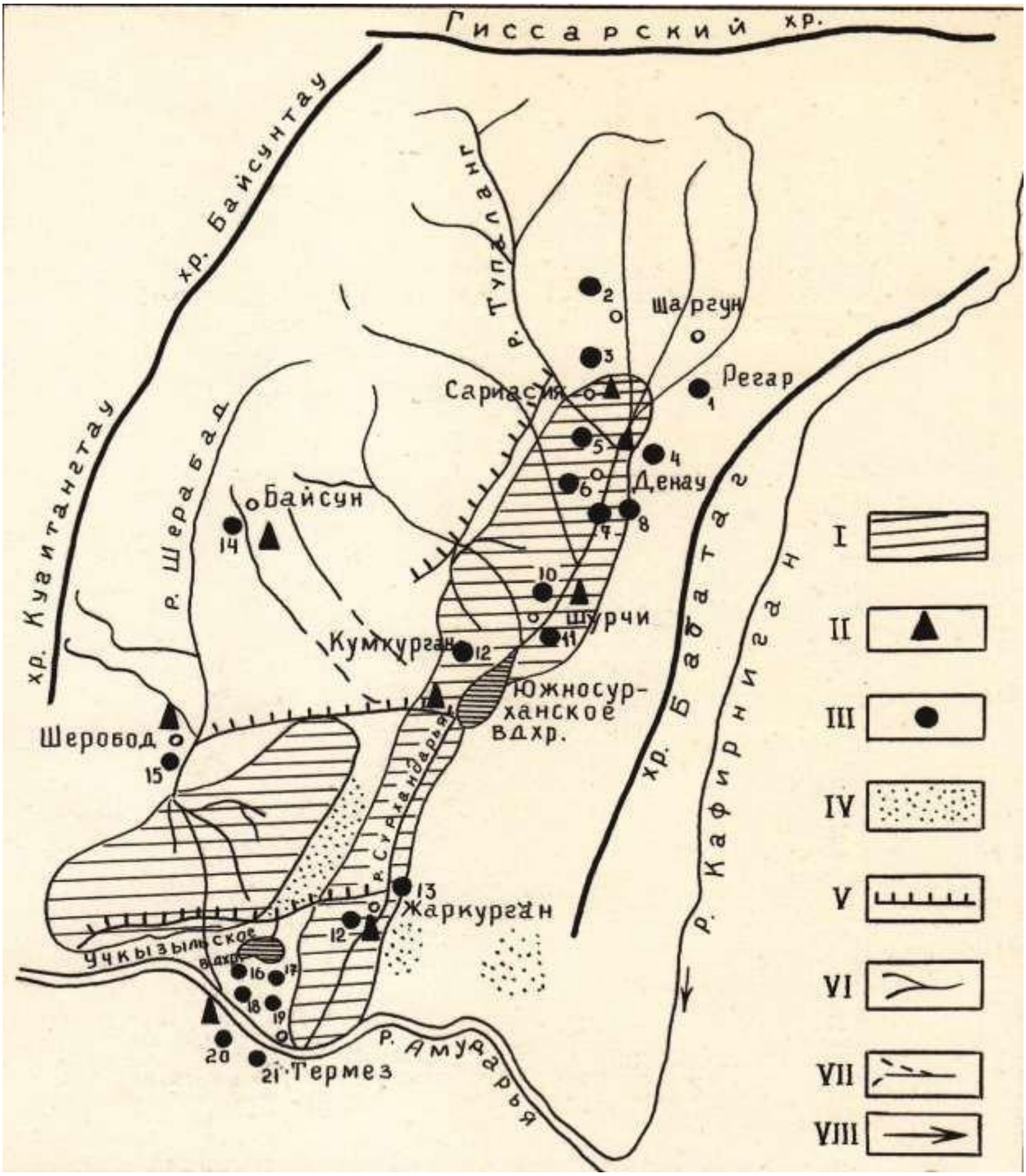

Fig. 1. Scheme of the considered Tupalang site

Independent variables are the longitudinal coordinate , directed along the corresponding segment from the vertex with the smaller to the vertex with the greater number, and the time t. The channel is defined by the ordinate of the bottom and the width of the cross section b at a distance (vertical) from the bottom of the channel. Then the depth of the flow is , the cross-sectional area of the flow is the width of the free surface of the flow – , the average cross section

$$\int$$

flow rate - . Other designations: is the flow path per unit length of the channel, for example, due to distributed surface runoff and return water , or due to filtration, evaporation, and small water consumers along the channel length ; is the acceleration of gravity; is the azimuth of the considered section of the channel; is the magnitude and azimuth of the wind (usually given by piecewise constant functions and);

$$\{ \quad | \, | \quad || \quad | \quad | \quad |$$

where is the density of air; is the density of water.

As boundary conditions at each vertex of complex , the relations of three types (in this case, the values related to the -the segment are indicated by the lower index m, and those related to the -the vertex by the upper index , for example, under should be understood as the flow rate at the endpoint of the -the segment adjacent to -the peak).

a). Expense balance:

$$\sum \qquad \text{—}$$

where is the set of numbers of segments adjacent to the pth vertex, - for the left end and 1 for the right end of the segment, is the free surface area of the concentrated capacitance at the -the vertex, depending on marks of the free surface at this vertex, if there is one at the vertex, otherwise is the influx from the outside to the pth vertex.

b). the relationship between the parameters at the top:

For example, unflawed outflow from a vertex capacity or a given inflow into a river network through a given vertex .

v). Adjacency Conditions:

$$(\qquad) \qquad)$$

For example a simple approach or automatic shutter that maintains a level in a given range . In addition, there must be given initial (in reclamation systems)

(at) conditions:

$$(\quad) \quad (\quad)$$

This completes the mathematical formulation of the problem.

The considered section of the river network does not contain looped sections and is schematized by a graph of the "tree" type, allowing the numbering of vertices and segments (Fig. 3), simplifying the numerical implementation of the problem.

In our case, in the input sections of the system (peaks 1, 2, 4, 6, 9, 13, 21, corresponding the gauging stations Uzun, Sariosiyo, Denau, Shurchi, Kumkurgan,

Zharkurgan, Termez), the flow values (observed or predicted) are set– relations (2) of the form , at other vertices the relations and simple adjacency conditions (except approaches to vertices 19 and 21) ( ). But the exit section (Tupalang water post), the reflector less condition (free flow condition) is set as the adjacency condition or the connection curve is used (21) Conditions are set in
the upper and lower pools of the Tupalang hydroelectric complex (approaches to peak 25). If the spillway works, then the flow rate is added to through this dam. It is possible to simplify somewhat the schematization of the river system under consideration by transferring the costs of the input gauging stations (peaks 4, 6, 9, 13, 21) to the mouths of the corresponding tributaries (peaks 5, 8, 11, 14) with correction factors that take into account the parts of the catchment area that are not illuminated by hydrological observations between by these gauging stations and the mouths of the corresponding tributaries.

Channel morphometric is set using a digital elevation model (DEM) or using pilot maps.

Accounting for the storage capacity of the Surkhoi Gulf is as follows: at the confluence of the river. Sariosiyo is not taken as a lateral tributary of the Tupalang gauging station , and the value ,– where) – the bathymetric characterization of Surkhon Bay (the dependence of its area on the level mark), and is the reservoir level mark in this place, which is equivalent to conditions (1.) and (2) with concentrated inflow to the corresponding peak. Levels and expenses at intermediate points (for example, Denau and Kumkurgan) can be used to adjust calculations.

In the floodplain area above the reservoir, other models can be applied that describe in more detail the behavior of the water on the floodplain, for example, planned models or the floodplain as a set of side tanks hydraulically connected to the main channel.

To form a short-term (operational) forecast of the process of passage of a spring flood wave, the following algorithm is proposed. As the value of the costs in the entry sections, the currently observed (or recalculated from the observed levels) values of the costs in the sections of the above gauging stations, continued by series of observations for the year-analogue, are taken.

After receiving new information on expenses from Uzhydromet services, these values are adjusted (part of the continued consumption values are replaced by those observed at this point in time) and the process is recalculated. As a result of such a daily adjustment of the calculations for the output target, a reliable forecast is obtained of the change in the process parameters until the wave reaches the nearest gauging station. Actually, the running time is significantly more than a day, which allows you to get a continuous reliable picture of the process in the site of the hydroelectric station and use it to make management decisions on the purpose of the release mode through the hydroelectric station target.

When developing a strategy for the rational use of water reserves of the Tupalang reservoir in winter, the key is to ensure uninterrupted water supply to meet the utility and production needs of Sariosiyo in the conditions of its spring deficit, which takes place mainly due to the small useful volume of the reservoir.

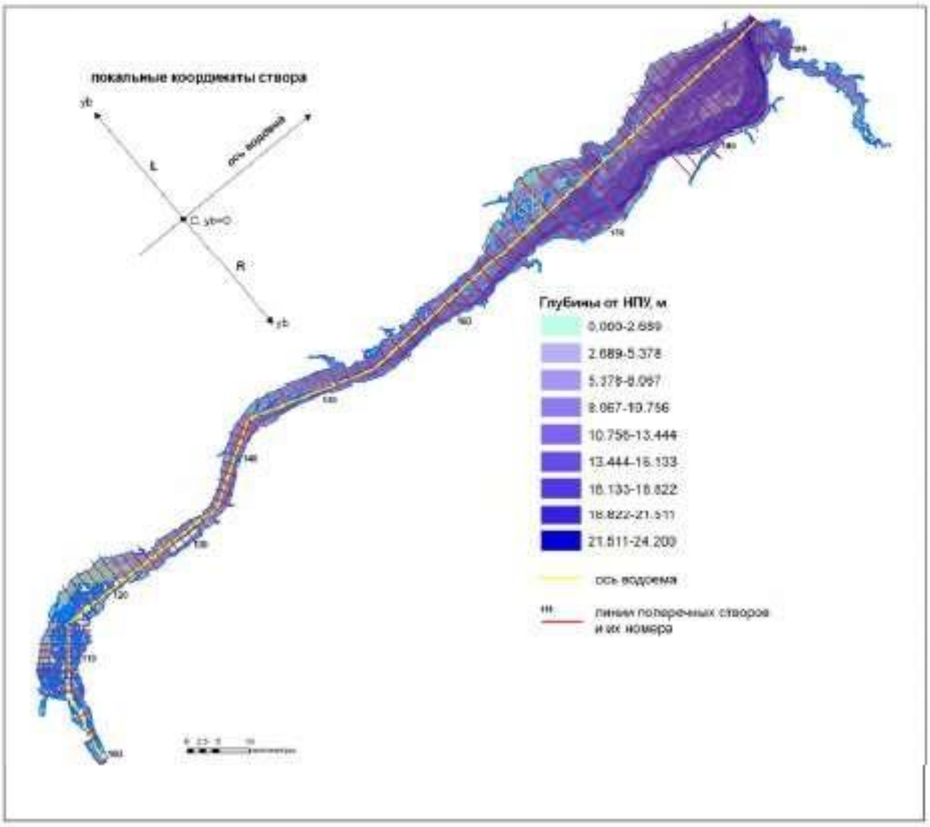

Fig. 2. Arrangement of diameters for one-dimensional model reservoirs

In addition, the aggravation of the water management situation in the downstream of the hydroelectric complex is a result of the deformation of the Tupalang bed, which arose by the end of the 1990s. On a stretch of river, several tens of kilometers long.

It was established by approximate analytical calculations and then confirmed by calculations according to the above model that, in the presence of ice cover, the dependence of the water level in the NFS-5 section on the flow rate supplied through the HPP target is not always monotonous, as is the case in open water. At some values of the weather conditions, the water level at the intake increases with an increase in the flow rate, starting from a certain flow rate value, and then increases again (Fig.3). This situation is explained by the variable influence of the moving ice cover (with a change in the discharge rate) on the overall roughness of the channel. To determine the amount of wormwood, a simplified analytical calculation formula is obtained:

confirmed by calculations on one-dimensional and planned hydrothermal models. Here is the area of wormwood; - specific heat flux due to weather conditions through the free surface of the water; in and – flow rate and temperature of the water dam discharged through the target, - water density; - its specific heat. Note that the influence of the entire set of standardly measured meteorological parameters with a rather high degree of accuracy reduces to a single parameter , which is the reciprocal of the specific heat flux through the free surface of the water at zero water temperature (more precisely, at a temperature of , which changes the value).

The following algorithm is proposed for obtaining a winter flow rate that guarantees a given water level. Based on the calculations under the Hydroledothermic-1DH program, the values of the level in the NFS-5 site and the area of the wormwood are determined depending on the supplied water flow and the length of the wormwood :

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Where is the water level in the range NFS-5. In principle, this can be done with any other program that implements a hydraulic calculation of the stationary flow in a real channel, characterized by a given DEM and roughness.

Eliminating the parameter from relations (2) and (3), we find the dependence as a solution to the nonlinear equation:

Followed by building the dependency .

Now, solving the equation for , we have:

(5)

Where – that critical point below which the water level at the NFS-5 water intake should not fall. Next, we find the desired value of the flow rate, providing this mark. At the same time, due to the possible non-monotonicity of the dependence of the water level on the NFS-5 on the flow rate discharged through the HPP target (Fig. 3), the function graph

, which is an approximate representation of this dependence based on relation (4) may also turn out to be non-monotonic.

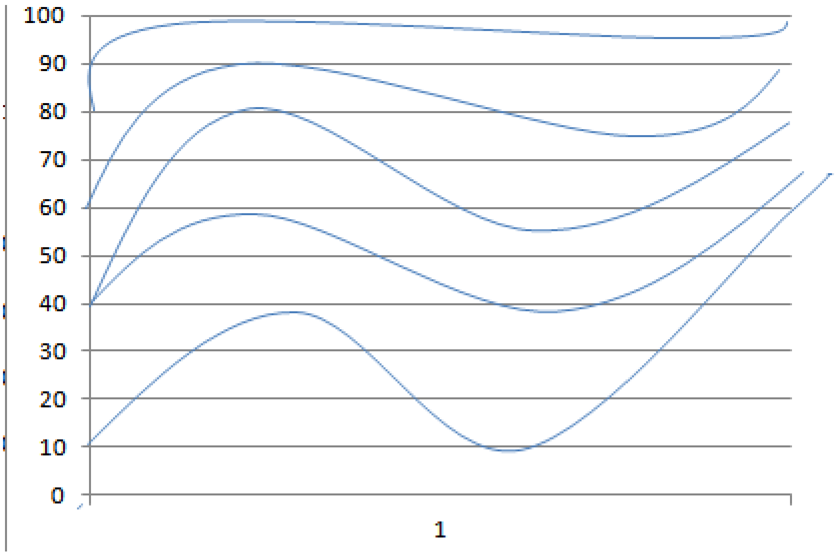

Fig. 3. The relationship of levels and costs in the alignment of the NFS-5 at different specific heat transfer of the free surface of the water:

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This will lead to the fact that the solution to equation (5) will not be unique. In this case, the largest root value is selected, because after the rightmost intersection point with the line

dependence becomes monotonously increasing. Therefore, the flow rate corresponding to this point will be the value of the flow rate in the dam section, guaranteeing a situation in which the condition ensures the fulfillment of the condition in the range NFS-5 .

Thus, based on the proposed algorithm, it is possible to determine the minimum flow rate to , at which the downstream level with the available set of weather data will correspond to water management requirements.

Now, based on a long-term forecast of weather conditions (or on average statistical values of these parameters), we can construct the dependence , usually piecewise constant with a monthly or decade resolution, for the entire winter period and according to the above procedure with the same resolution - the dependence .

Then, the person making the decision to control the operating mode of the Tupalang hydroelectric complex and having a forecast of inflow to the reservoir can determine the amount
of water in the reservoir at any time using the formula:

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where is the reserve (volume) of water in the reservoir at time .

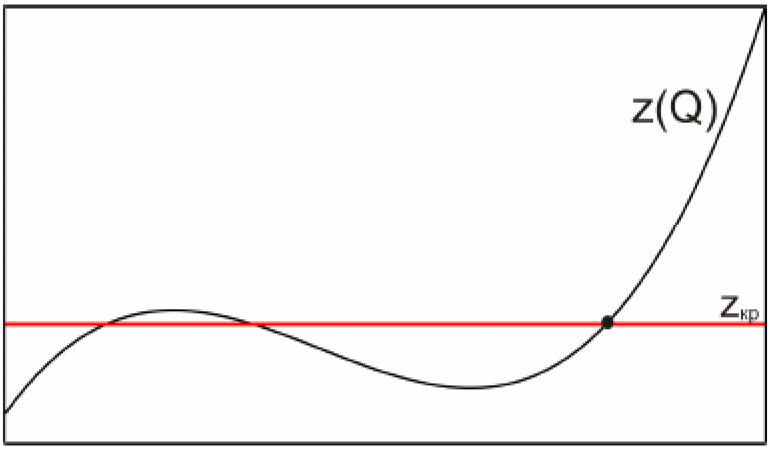

Fig. 4. Addiction of

It can get the value of the volume of water in the reservoir at any time *t*, if its value is known – is the initial filling of the reservoir, i.e. the water supply at time (the initial moment of the reservoir's run off or the next time when the available measurements allow this volume to be established) and – is the selected mode of releases through the dam target. It must be assumed that a decision will be made that , and how much more will depend on the forecast.

The quality of river water is determined by the interaction of simultaneously occurring processes of pollution, dilution and self-purification of water. On this issue depends on various factors, as appropriate costs (rivers, side tributaries, low-level and other polluted water).

When assessing the sources of pollution, it is assumed that the input of polluting pollutants into the river with groundwater and wastewater is static in nature and occurs equally throughout the year. From the catchment areas of polluted water lichens with melt and rainwater enter the water bodies. Subsequently, superfluous point-controlled sources of pollution were considered. A simplified model of pollution dynamics allows the detection of polluted water concentrations in text fields for which some hydrological and hydroxymical observations are known. The model correlates the emission of polluted watering each of the gates and their concentration in the point of taxation of observations and has the form:

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where is the transformation coefficient of pollutants in the stream.

The processes of absorption and reduction of oxygen in the river flow as a first approximation were described as early as the beginning of the 20th century. Their model is based on the assumptions that the rate of decomposition of organic pollutants is proportional to its concentration, and the rate of recovery of dissolved oxygen is proportional to its deficiency. The concentration of organic pollutants is measured in oxygen units and is called the biochemical oxygen demand (BOD).

Classical is effectively used for rapid assessment of water quality and at usual (fairly low) concentrations gives quite satisfactory results not only for BOD, but also for other types of pollutants (in particular, nitrogen, phosphorus, iron, and petroleum products).

The equation for the change in the flow of pollutants along the channel with a steady flow of water in it, taking into account natural decay and in the presence of diffuse sources uniformly distributed along the channel, has the following form:

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its decision under the initial condition will be:

— (—)

where -is the distance from the initial alignment along the length of the channel; – is the flow of pollutants through the cross section of the channel (the concentration of pollutants multiplied by the flow of water); – is the average velocity of the water flow over the cross section of the channel; – coefficient of decay rate of pollutants; – diffuse flow module polluted water; – pollutant flow through the initial target of the channel section.

When calculating the masses of BOD and pollutants in the closing section of each site, both their entry to the site from various sources and their transfer from overlying sites were taken into account. For a more accurate description of the process of pollutant intake from point sources, the concept of "aggregated pollutant drain collector" was introduced.

The choice of wastewater treatment methods and the allocation of the corresponding capital costs between the administrative units of the basin can be made on the basis of the model under consideration.

Wastewater in the basin is controlled by six indicators: BOD, petroleum products, suspended solids, total phosphorus and nitrogen, as well as iron. Four cleaning methods are considered: mechanical, chemical, biological and biochemical. In the calculation process, each of these methods of wastewater treatment can be compared with the rest.

Conclusion

Classical is effectively used for rapid assessment of water quality and at usual (fairly low) concentrations gives quite satisfactory results not only for BOD, but also for other types of pollutants. The quality of river water is determined by the interaction of simultaneously occurring processes of pollution, dilution and self-purification of water. On this issue depends on various factors, as appropriate costs (rivers, side tributaries, low-level and other polluted water). The choice of wastewater treatment methods and the allocation of the corresponding capital costs between the administrative units of the basin can be made on the basis of the model under consideration.

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