Methodology of development limits and quotas of water use for program of multipurpose utilization of water resources

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Abstract. A methodology has been proposed to substantiate the effectiveness of measures in the development of limits and quotas for water consumption and wastewater disposal for all subjects of the territorial natural production complex, which ensures the distribution of the technogenic load on water bodies from all water users and guarantees the quality of water at the level of permissible discharges and permissible impact standards.

Restrictions (limits) on the use of water resources of surface objects are calculated on the basis of the developed water management balances and standards of permissible impacts for the calculated water management areas of the hydrographic unit, taking into account the current level of water use according to the reporting data of 2TP-water management enterprises of water users at the current time, forecasts for future water use [1, 2].

The share (quota) of use (withdrawal) of water resources is established for each constituent entity of the Russian Federation, which are located within one hydrographic unit. At the same time, the total share of water use that is given to a separate constituent entity of the Russian Federation should not be higher than the corresponding restrictions (limits) within the considered hydrographic unit [3].

The use of water resources is a significant environmental aspect, according to which standards are established for each water body.

Calculation of standards for the withdrawal of water resources for rivers with unregulated flow includes an assessment of the amount of ecological flow, the size and mode of which is due to the need to ensure a dynamic equilibrium of the geoecosystems of water bodies of territorial natural production complexes, while the value of the permissible withdrawal of water resources is equal to the difference between the volume of natural flow and environmental flow water body [3]:

\[
PES_{WWR} = W_{W} - W_{ER}
\]

where \(W_{W}\) – natural runoff in years of different water levels.

At the first stage of establishing water intake limits for water users of the territorial natural production complex from surface water bodies, intermediate values of the limits are calculated, equal to the sum of the excess water balance for the calculated water management areas for 95% of years \(W_{PROFEWMA}\) and requirements of water users for the intake of water from surface water bodies to the calculated water management areas \(W_{SW.EWMA}\):

\[
W_{PROFEWMA} = \frac{W_{PRO}W_{MA}}{0.95}
\]

where \(W_{PRO}\) – the total water use of water users of the territorial natural production complex from surface water bodies for the considered field of water use, \(W_{MA}\) – the total water use of water users of the territorial natural production complex from surface water bodies for the considered field of water use.
\[ L_{FWWR}^{EWMA} = W_{PROF}^{EWMA} + W_{SW}^{EWMA} \]  

(2)

where \( L_{FWWR}^{EWMA} \) - intermediate values of limits.

At the second stage, the intermediate values of the limits are compared with the values of the standards of permissible withdrawal for the calculated water management areas for a runoff of 95% supply. The total water intake limit must be equal to the lower of the indicated values:

\[ L_{FWWR}^{EWMA} = \min\left( L_{FWWR}^{EWMA}; PES_{WWR}^{L} \right). \]

The disadvantage of this approach is that the limits established in this way are practically equal for all settlement years and do not reflect the development of water use within the studied territorial natural production complex. The limits of water intake established in this way can exceed the requirements of water users by more than 100 times [4].

The results of calculating the limits of water consumption from fresh surface water bodies and the limits of wastewater discharge by water management areas and by calculated water management areas of one hydrographic unit of the northern part of the Gulf of Finland for 5 estimated water management subsections are presented in tables 1 and 3.

**Table 1.** Water use limits (water consumption quotas) within the boundaries of the territorial natural production complex of the Gulf of Finland basin.

| Water area code | № Estimated water management sub-section | Name of water bodies | Water intake (withdrawal) limit, mln.m³/year |
|-----------------|----------------------------------------|----------------------|---------------------------------------------|
| 01.04.03.005    | -                                      | Rivers and lakes of the Gulf of Finland basin from the border of the Russian Federation with Finland to the northern border of the Neva | 132                                          |
| 01.04.03.005    | 1                                      | Rivers and lakes of the western shore of the Vyborg Bay | 19.3                                         |
| frequent pool   | -                                      | r. Selezneva         | 11.0                                         |
| 01.04.03.005    | 2                                      | Rivers and lakes of the Gulf of Finland basin from Vyborg to the mouth of the river Chernaya (Gladyshevka) | 58.9                                         |
| frequent pool   | -                                      | r. Perovka           | 17.2                                         |
| frequent pool   | -                                      | oz. Krasnokholmsoye | 11.4                                         |
| frequent pool   | -                                      | r. Gorokhovka        | 19.2                                         |
| 01.04.03.005    | 3                                      | r. Chernaya (Gladyshevka) | 21.2                                         |
| frequent pool   | -                                      | r. Chernaya (Gladyshevka) | 19.2                                         |
| frequent pool   | 4                                      | r. Sestra            | 10.0                                         |
| frequent pool   | 5                                      | oz. Sestroretsksy Razlyv | 0.225                                         |
| frequent pool   | -                                      | r. Chernaya          | 3.08                                         |

Calculations showed that for the territorial natural production complex of the Gulf of Finland basin, the total allowable volume of water consumption for all subjects is 132 million m³/year. [5].

The limits of anthropogenic load (the maximum volume of wastewater discharge, the corresponding standards of permissible discharges, from all subjects of the territorial natural production complex) are established on the basis of the calculated water balances within the basin (region) under consideration,
taking into account the water conditions and the developed standards of the permissible impact for water users of the territorial natural production complex.

The limit (standard) of anthropogenic load is calculated as the ratio of the needs of water users of a territorial natural production complex in water consumption and disposal:

\[ L_{DS} = \left( \frac{W_{RW}}{W_{WU}} \right) * L_{FWWR} \]  

(3)

where \( W_{RW} \) - return water (surface runoff (discharge) and underground runoff (drainage water) within the water management area of the basin territorial nature-production complex;

\( W_{WU} \) - the need for water resources of all subjects of the basin territorial natural-production complex;

\( L_{FWWR} \) - established limits (standards) of water consumption for all subjects of the territorial nature-production complex.

When calculating the limits of anthropogenic load, the application of formula (3) is possible if the volume of water use does not exceed the volume of water disposal and the volume of wastewater discharge does not exceed the need for water resources.

For individual water users of a territorial natural production complex, the limits of anthropogenic load are set as follows:

\[ L_{i,ds} = \varepsilon_i * L_{i,ds} \]  

(4)

where \( L_{i,ds} \) – limit of load on water bodies of a territorial natural production complex from the i-th water user, \( \text{m}^3/\text{year} \);

\( \varepsilon_i \) – the share of the load from the i-th water user from the total load of all subjects of the territorial natural production complex.

Table 2 shows the results of calculating the limits of the total load of the subjects of the territorial natural production complex for the calculated water management subsections, taking into account the standards of the permissible impact of water intake.

**Table 2.** Limits of the total load of the subjects of the territorial natural-industrial complex for the calculated water management subsections, taking into account the standard of permissible impact of water intake.

| Water area code  | № Estimated water management sub-section | Name of water bodies                                                                 | Total load limit (waste water discharge), mln.m³/year |
|------------------|------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------|
| 01.04.03.005     | -                                        | Rivers and lakes of the Gulf of Finland basin from the border of the Russian Federation with Finland to the northern border of the Neva | 142                                                  |
| 01.04.03.005     | 1                                        | Rivers and lakes of the western shore of the Vyborg Bay                             | 42.1                                                 |
| frequent pool    | -                                        | r.Seleznevka                                                                       | 23.5                                                 |
| 01.04.03.005     | 2                                        | Rivers and lakes of the Gulf of Finland basin from Vyborg to the                    | 58.9                                                 |
For the purpose of sustainable integrated water resources management, quotas for the distribution and use of water resources are established at the regional (basin) level within the limits of water withdrawal.

Quotas for the use (intake) of water resources are determined as follows:

\[ K_{FWWR} = \varepsilon_{FWWR} \times L_{FWWR} \]  

(5)

where \( L_{FWWR} \) – water intake limit, m\(^3\)/year;

\( \varepsilon_{FWWR} \) – the share of the corresponding quota in the total water consumption is determined depending on the distribution of water consumption needs of the subjects of the territorial natural production complex.

The results of calculating quotas for the use of water resources within the territorial natural production complex of the Gulf of Finland basin on the basis of statistical reporting data 2-TP (vodkhoz) of water users of the territorial natural production complex are presented in Table 3. There are no water consumers within the boundaries of the calculated water management sub-section-3. There are also no water consumers for the calculated water management sub-site-4 and the calculated water-use sub-site-5 within the Leningrad Region, the entire intake is carried out within St. Petersburg.

Quotas for load distribution (wastewater discharge) for the subjects of the basin territorial natural production complex are established based on the limits of anthropogenic load and are calculated as follows:

\[ K_{DS} = \varepsilon_{DS} \times L_{DS} \]  

(6)

where \( L_{DS} \) – the size of the wastewater discharge limit, m\(^3\)/year;

\( \varepsilon_{DS} \) – the share of the corresponding quota in the total load on the water body is calculated in proportion to the total amount of wastewater disposal of the subjects of the territorial natural production complex.

**Table 3. Quotas for the use and distribution of water resources within the territorial natural production complex of the Gulf of Finland basin.**

| Water area code | № Estimated water management sub-section | Name of water bodies | Established quotas for the intake (withdrawal) of water resources, million m\(^3\)/year |
|-----------------|-----------------------------------------|---------------------|--------------------------------------------------------------------------------------|
| 01.04.03.005    | 3                                       | r. Chernaya (Gladyshevka) | 0                                                                                     |
| 01.04.03.005    | 4                                       | r. Sestra             | 0                                                                                     |
The results of calculating quotas for the distribution of the load on water bodies of the territorial natural production complex of the Gulf of Finland basin, the corresponding standards for permissible discharge and standards for permissible impact are presented in Table 5, while the total load within one water management area of the territorial natural production complex does not exceed the anthropogenic load limit in boundaries of this water management area.

Analysis of the data presented in tables 1, 2, 3 and 4 showed that within the boundaries of the territorial natural production complex of the Gulf of Finland basin (northern part), only 25% of water resources from the total volume of water withdrawal limits / quotas are actually used.

**Table 4.** Quotas for the distribution of the load on water bodies of the territorial natural production complex of the Gulf of Finland basin, corresponding to the standards of permissible discharge and standards of permissible impact.

| Water area code | № Estimated water management sub-section | Name of water bodies | Quotas of load distribution (waste water discharge), mln.m³/year |
|-----------------|------------------------------------------|---------------------|---------------------------------------------------------------|
| 01.04.03.005    | 3                                        | r. Chernaya (Gladyshevka) | 20.0                                                          |
| 01.04.03.005    | 4                                        | r. Sestra             | 2.59                                                          |
| 01.04.03.005    | 5                                        | Rivers and lakes of the Gulf of Finland basin from the mouth of the Sestra river to the northern border of the Neva river delta | 0                                                             |
| St. Petersburg  |                                          |                      |                                                                |
| 01.04.03.005    | 3                                        | r. Chernaya (Gladyshevka) | 1.15                                                          |
| 01.04.03.005    | 4                                        | r. Sestra             | 13.0                                                          |
| 01.04.03.005    | 5                                        | Rivers and lakes of the Gulf of Finland basin from the mouth of the Sestra river to the northern border of the Neva river delta | 4.65                                                          |

The calculation of the limits and quotas for the use of water resources and the distribution of the load on water bodies of the territorial natural production complex of the northern part of the Gulf of Finland by water management areas and by design water management areas in accordance with the considered methodology using the example of one hydrographic unit for 5 design water management subsections showed that:

a) the limits (standards) of water use for the subjects of the territorial natural production complex of the basin of the northern part of the Gulf of Finland, calculated on the basis of the standards of
permissible withdrawal, and the limits of anthropogenic load corresponding to the standards of permissible discharge are many times greater than the limits of water intake and disposal allocated for territorially natural -production complex located in the Leningrad region and St. Petersburg in 2019-2020;

b) the total use of water resources in the northern part of the Gulf of Finland is only 1.2% of the surface runoff, calculated according to long-term data. Therefore, in the period up to 2030, no increase in the established water withdrawal limits and anthropogenic load limits is expected.

The proposed methodology for the development of limits and quotas for water consumption and wastewater disposal in territorial natural production complexes makes it possible to distribute the anthropogenic load on water bodies from all water users, to ensure water quality at the level of established environmental standards and to substantiate the effectiveness of environmental measures for all subjects of the territorial natural production complex of the basin.

References
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