Efficient land usage of watered quarries in the Ural mining industrial region

V E Konovalov¹, V A Pochechun¹ and A I Semyachkov¹,²

¹Ural State Mining University, Yekaterinburg, Russia
²Institute of Economics, Ural Branch of the Russian Academy of Sciences, Yekaterinburg, Russia

viktoriypochechun@mail.ru

Abstract. The paper deals with the problems arising from the impact of technogenic water on the components of the environment. Such waters are formed in the formation of mining facilities, as well as in the process of mining and processing of minerals. The authors provide a classification of watered open-pit mines, analyse the usage of land sites, formed on watered open-pit mines territories. The actions that allow improving efficiency of such land usage are suggested.

1. Introduction
The development of mineral deposits (MDD) and primary processing of the extracted minerals are accompanied by the negative impact of mining on the environment. In the aggregate among factors of harmful environmental impact, not the last place is occupied by man-made water formed after the development of mineral deposits (MDD) [1-3], in particular, accumulating in depleted pits - watered quarries.

Mineral deposits (MD) on the territory of the Urals began to be actively developed in the 18th century, and from the mid of the 19th century, an open method for the development of MD was on the rise. For more than 300 years of mining and smelting business, a large number of quarries have been in operation in the Urals, and after the development of MD, many of them have been watered. The use of depleted pits, including those filled with water, is a problem for the national economy and life-sustaining activity of the population.

2. Materials and methods
The authors of this paper in their research used methods of ecological monitoring, cartography, interpretation of aerial photographs, and graphic modelling. The research is based on a large amount of bibliographic data, remote sensing technique, geochemical surveys.

3. Analysis and discussion
The extraction of minerals during the development of solid MD and peat is carried out by the open method resulting in excavations in the earth surface – quarries and pits. In the process of mining or on completing MDD, they can be artificially or naturally filled with surface or groundwater. Moreover, small quarries can be formed as ancillary structures in the production of oil and gas in wetlands. These
quarries are used to extract sand and move into the substrate of construction sites to accommodate well clusters.

Watered quarries can be considered in the following directions.

First, quarries (pits) are filled with water in order to place processing equipment in them for the extraction of minerals, as a rule, sand, (dredgers, etc.), i.e. watered quarries are used in the process of MDD. On the other hand, in the depleted parts of the MD, open pits are used either to dispose clarified water in the process of drainage from an operating open pit (figure 1), or to dispose liquid waste generated during the processing of mined minerals (figure 2).

![Figure 1. The artificial reservoir of the clarified water in the territory of the depleted quarry 1-2 by “Uralasbest” (JSC) (Asbest, Sverdlovsk region).](image1)

![Figure 2. The primary VGOK quarry filled with waste water by a washing house (Nizhny Tagil, Sverdlovsk region).](image2)

On completing MDD, the remaining open pits are filled with groundwater and surface water to the level of the groundwater horizon, and after the completion of the development of alluvial mineral resources in the river valleys, pits filled with river water will remain. In this regard, it is possible to subdivide the watered quarries into closed (secluded) ones, which are formed upon MDD by the classical open method, and flowing ones, which are formed upon MDD in the river valleys. The areas filled with water remained after the development of peat deposits, small in depth, but with sizeable area of flooding can be considered as a specific type of watered quarries. For example, the area of the depleted Bas'yanovsky peat deposit filled with water is 750 ha.

The size of closed (secluded) watered quarries can vary within wide limits depending on the size of the mined MD and range from 0.7 ha (Talkov Kamen quarry, Sysert, Sverdlovsk Region) to 930 ha (Bogoslovsky quarry, Karpinsk, Sverdlovsk Region). As for the flowing watered quarries, their width can reach up to 1 km, and the length along the river flow - up to 50-80 km (the Is River, Sverdlovsk Region). The depth of surface water in watered worked-out quarries is also uneven and depends on the level of groundwater, sometimes reaching almost the upper edge of the quarry, i.e. in fact, the actual depth of the quarry (the Bogoslovsky quarry, Karpinsk, Sverdlovsk Region).

Watered quarries are located both directly in the territory of settlements or in their outskirts, and in inter-settlement areas at a certain distance from settlements, which affects the possibility of their use in the life of the population, as well as the possibility of their impact on the environment. The use of watered quarries is possible both for production purposes, for example, for the purpose of water intake for municipal or technological needs, and for recreational purposes for the repose and sports activities of the population. The use of watered quarries depends on the quality of the water remaining in them upon MDD. Table 1 shows data on the watered quarries located in the Ural mining industrial region with solid types of mineral resources.
Table 1. Data on the watered quarries located in the Ural mining industrial region.

| № | RF constituent entity | Number total | w/o establishing a plot of land | Area, ha occupied by quarries | plots of land beneath quarries | for mining mineral resources | for other objects | for fish farming | for recreation | w/o a kind of permitted use |
|---|-----------------------|--------------|---------------------------------|-------------------------------|-------------------------------|-----------------------------|----------------|----------------|---------------|---------------------------|
| 1. | Bashkortostan Republic | 13           | 6                               | 1328                          | 1124                          | 3                           | 1              | 2              | -             | 7                        |
| 2. | Perm territory        | 6            | 4                               | 128                           | 75                            | 2                           | 1              | 1              | 1             | 1                        |
| 3. | Orenburg region       | 13           | 2                               | 457                           | 527                           | 3                           | 3              | 2              | 4             | 1                        |
| 4. | Sverdlovsk region     | 54           | 20                              | 3785                          | 3067                          | 17                          | 3              | 4              | 6             | 24                       |
| 5. | Chelyabinsk region    | 40           | 16                              | 2665                          | 990                           | 13                          | 7              | 1              | 1             | 18                       |
| Total: |                        | 126          | 48                              | 8363                          | 5783                          | 38                          | 15             | 10             | 12            | 51                       |

The analysis of the territories occupied by closed (secluded) watered quarries (Table) showed the following:

- land plots are not formed in all areas of mined MD, where watered quarries are located. On 38% of the watered quarries, land plots have not been formed, including those used for recreational purposes in a “wild” (unexplored) form;
- land plots are formed directly for the watered quarries (3 quarries) or their parts. In addition, the watered quarries are part of the formed land plot.

The categories of land where the watered quarries are located were distributed as follows: agricultural land - 7.1%, urban land - 22.2%, industrial and other land of special purpose - 24.6%, forest land - 6.3 %, reserve lands - 4.8%, lands of no specific category - 34.9%.

In the characteristics of land plots obtained from a public cadastral map, the type of permitted use of a land plot is indicated according to an approved classifier, or according to a document of a previously recorded land plot, sometimes it is not indicated at all (40.5%). Among the types of permitted use of land plots prevail those "for the extraction and development of minerals" (30.2%) or "for the location of industrial facilities" (11.9%), less often - "for agricultural purposes", for example, "for fish farming" (7.9%), or "for recreational purposes" (8.2%).

According to the content of harmful substances in water, all quarries can be divided into toxic (polymetals), slightly toxic (coal, etc.) and neutral (sand, clay, etc.). The use of man-made water bodies is primarily determined by their composition and content of chemical elements. In the case of the presence of dissolved metals or other minerals in them, it is possible to use the waters to extract useful components from them, and after clarification, mine waters can be reused for technical purposes in the State Industrial Complex [4-10].

In the absence of harmful components, man-made water bodies can be used in agriculture, for example, as reservoirs for irrigation, flooded areas of peat extraction as hunting grounds, in aquaculture - for fish farming [11, 12], as well as for recreational and sports purposes - for organizing recreation of the population.

By legislation, the watered quarries are classified as surface water bodies - reservoirs. The conditions under which a watered quarry can be in one or another form of ownership are set out in Article 7 Federal Law "On the introduction of the Water Code of the Russian Federation".

To increase the efficiency of using the watered quarries, the following measures can be proposed:
- given that the watered quarries belong to the category of water bodies, information about them shall be entered in the form of the State Water Register;
- to provide for an additional section in the State Information System for the Support of Urban Planning Activities, as follows - "Subsoil Use Objects", where to include information on the watered quarries and their use;
- to include the territories occupied by watered quarries in the State Register of Objects with Accumulated Harm to the Environment;
- to classify quarries, the waters of which are toxic, to objects that have a harmful effect on the environment with their entry into the State Register of Objects with a Negative Impact on the Environment.

4. Conclusions
As a result of the development of mineral deposits, secondary water technogenic objects are formed, the volumes and areas of which are commensurate with natural water bodies. The proposed typification of technogenic water bodies makes it possible to rationally organize monitoring of the state of such objects and to carry out effective environmental protection activities on the territory of operating mining complexes. In the territories remaining after the development of mineral deposits, it is proposed to carry out an inventory of objects of vulgar, accumulated in the places of deployment of liquidated mining enterprises, environmental damage with an assessment of their size and types for making appropriate decisions on the renovation of objects of mining landscapes or the rehabilitation of disturbed territories.

References
[1] Khokhryakov V S 2000 The contribution of the Urals to the mining industry in Russia for 300 years. Ural Mining Encyclopedia 1 ed. Prof. V.S. Khokhryakov (Yekaterinburg: UGGA publishing house) P 500
[2] Konovalov V E, Semyachkov A I, and Pochechun V A 2019 Methodical preconditions of liquidation of negative influence of technogenic waters of the mining territory on environment. IOP Conference Series: Earth and Environmental Science 321 p 012053
[3] V E Konovalov and M E Kolchina 2019 Use of man-made water bodies located on the lands of mining territories. Problems of improving the management of natural and socio-economic processes at the present stage. Environmental and Technosphere Safety of Industrial Regions: Proceedings of the IV International Congress Ed. Prof. TM Choduraev, Prof. A I Semyachkov (Bishkek: Cholpon-Ata) pp 116–122
[4] Golik V I, Komashenko V I, Leonov I V 2011 [Mining and Environment] (Moscow, Academy Project; Culture Publ.) P 210
[5] Elokhina S N 2013 [Hydroecological consequences of mining technogenesis on Urals] (Yekaterinburg, LLC “UNPC”) P 187
[6] Konovalov V E and Germanovich Iu G 2018 [Substance migration at mineral production and primary processing] Izvestiya vysshikh uchebnykh zavedenii. Gornyi zhurnal News of the Higher Institution. Mining Journal 2 pp 30–39
[7] Maximovitch N G 2012 [The basics of environmental monitoring during potassium salts deposit mining] Journal of engineering and environmental studies 8 pp 8–18
[8] Popov A N, Pochechun V A, Semyachkov A I 2009 [Innovate technologies of water objects protecting in mining industry regions] (Yekaterinburg, Institute of Economics of the Ural branch of the RAS) P 128
[9] Semyachkov A I 2009 [Economical and hydrogeological valuation of extraordinary conditions in mining industry regions] (Yekaterinburg, Institute of Economics of the Ural branch of the RAS) P 120
[10] Slavikovskaya J O 2012 [Ecological and economical aspects of mineral resources assimilation on urbanized territories] (Yekaterinburg, Institute of mining of the Ural branch of the RAS) P 208
[11] Salanki J and Salama H S 1987 Signalization, monitoring and evaluation of environmental
pollution using biological indicators *Acta biol. Hung.* 38 pp 5–11

[12] Fred A Otchere, Marcello M Veiga, Jennifer J. Hinton and Renato A. 2004 Farias and Robert Hamaguchi. Transforming open mining pits into fish farms: Moving towards sustainability *Natural Resources Forum* 28 pp 216–223