# KYIV SMALL RIVERS IN METROPOLIS WATER OBJECTS SYSTEM

P. Krelshteyn [1], M. Dubnytska [2]

[1] Taras Shevchenko National University of Kyiv, Institute of Geology, 03022, Kyiv, Vasylkivska Street, 90, kpdgeo@ukr.net
[2] Kyiv National University of Construction and Architecture, 03037, Kyiv, Povitroflotsky avenue, 31, dubnytskamv@gmail.com

**Commission V, WG V/7**

**KEY WORDS:** Small Rivers, Water Cadastre, Underground Channels, Rivers Urbanization, Ecological State.

**ABSTRACT:**

The article answers the question, what really are the small underground rivers with artificial watercourses: water bodies or city engineering infrastructure objects? The place of such rivers in metropolis water objects system is identified. The ecological state and the degree of urbanization of small rivers, as well as the dynamics of change in these indicators are analysed on the Kiev city example with the help of water objects cadastre. It was found that the registration of small rivers in Kyiv city is not conducted, and the summary information on such water objects is absent and is not taken into account when making managerial decisions at the urban level. To solve this problem, we propose to create some water bodies accounting system (water cadastre).

## 1. INTRODUCTION

### 1.1 Formulation of the problem

One of the consequences of urbanization and development of territories is the direction of small rivers and streams flow into collectors and concrete troughs and, consequently, the technological transformation of them into an integral part of urban rainwater drainage. At the same time, from the hydrological and ecological point of view, the watercourse remains a river that plays an appropriate role in the ecosystem, but its special status as a water object is being levelled. Uncertainty about the status of underground rivers, the lack of appropriate measures for their protection and control over their use leads to an extremely unsatisfactory ecological state of these objects.

### 1.2 Purpose of the article

The purpose of the article is to find the answer to the question what really are the small underground rivers with artificial watercourses: water bodies or city engineering infrastructure objects. One more task is determination the place of these rivers in metropolis water objects system, as well as an analysis of the ecological status and degree of urbanization of these rivers in Kyiv city.

## 2. CONTENT OF THE STUDY

### 2.1 Definition of the term "river". Coastal protective zones.

There is no definition of the term "river" in the Ukrainian legislation. At the same time, V.K. Khilchevsky and O.G. Obodovsky give the following interpretation: "The river is the water stream (watercourse), which flows in the natural course and is fed by the waters of the surface and underground drains of its basin. The rivers include only permanent and relatively large watercourses with the drainage basin area not less than 50 sq.km. Small rivers with drainage basin area up to 50 km$^2$ are called streams" (Khilchevsky et al., 2008).

Depending on the area of the drainage basin (parts of the earth's surface and thicker soils, from which water flows into the drainage or reservoir) (Water Code of Ukraine, Article 1, 1995), rivers in Ukraine are divided into large ones with an area of water catchment of more than 50,000 km$^2$, medium (from 2,000 to 50,000 km$^2$) and small (up to 2,000 km$^2$) (Water Code of Ukraine, Article 79, 1995). According to this classification, coastal protective zones are installed along the river banks on the basis of individual land management projects, respectively, 100, 50 and 25 m (Water Code of Ukraine, Article 88, 1995).
European Union Water Framework Directive, adopted on 23.10.2000, which is the main regulatory document of Ukraine-European relations in the field of water policy, defines the river as an array of inland water, which proceeds mainly on the earth`s surface, but some part of its way may flow underground. The last remark, in our opinion, is important due to the fact that the cases of directing underground rivers into concrete collectors and their actual transformation into a part of city sewage often take place in urban settlements. Recognition of such artificially modified rivers as water objects allows us to create a proper legal field for their protection. The Water Resources State Agency of Ukraine in the letter No. 4675/9/11-17 dated August 18, 2017 also notes that "the places of passage of small rivers and streams in closed collectors need the establishment of coastal protective zones in order to avoid the damage of them" (The Water Resources State Agency of Ukraine, 2017).
Consequently, a coastal protective zone, 25 m wide, with appropriate restrictions in land use, should be installed around a small river, regardless of the nature of its channel. Such restrictions include:
- the prohibition of land ploughing and gardening;
- storage and use of pesticides and fertilizers;
- arrangement of cattle summer camps;
- any structures construction (except hydrotechnical, navigational, hydrometric and linear structures), including recreation centres, cottages, garages and parking lots;
- washing and servicing of vehicles and machinery;
- arrangement of dumps, gnomes, cemeteries, bastards and fields of filtration;

- storage of liquid and solid wastes of production, etc. (Water Code of Ukraine, Article 89, 1995).

It should be noted that "in order to create a favorable regime on water objects, prevent their pollution, littering and exhaustion" (The Water Resources State Agency of Ukraine, 2017) the projects of water objects` coastal protective zones in Kyiv, in the context of the capital administrative districts, were developed by the state enterprise "Kyivgenplan Institute" in 2007-2008, but only six of ten projects were adopted at the sessions of the local self-government body. Later, these decisions were cancelled in court, so the borders of coastal protective zones in the capital today are not properly established.

**2.2 Kyiv city water fund.**

According to departmental data of the Department of the Water Resources State Agency of Ukraine in Kyiv city and Kyiv oblast, shown on the official site (2017, Department of the Water Resources State Agency of Ukraine in Kyiv city and Kyiv oblast), the hydrographic network of the city of Kyiv has 12 small rivers and 36 streams. These data are somewhat different from the List of Kyiv water bodies, approved by the Kyiv City State Administration on 04.02.2009, No. 111 (hereinafter - Order No. 11), according to which the capital of the water fund includes 11 small rivers and 32 streams, in general 43 watercourses (Kyiv City State Administration, 2009).

According to the communicated data of the municipal enterprise “Pleso”, which is assigned the tasks of Kyiv internal reservoirs protection, maintenance and operation, there are 17 small rivers and 37 streams in the capital. However, these figures represent an arithmetical sum of the number of watercourses in different administrative districts of the city, and one river can flow through the territory of several districts. This approach to water body registration is not entirely correct, and after the "manually" counting unique names of watercourses in the list it was found that the actual number of watercourses coincides with the data in the Order No. 11 – 11 small rivers and 32 streams.

The reason for this inconsistency is the lack of an automated geoinformation system for water objects in the Water Resources State Agency of Ukraine, which uses only public electronic maps in its work. A group of hydrologists headed by V.K. Khilchevsky distinguishes about 40 small rivers and streams in Kiev (Khilchevsky et al., 2014), while local ethnographer and researcher K.M. Stepanets counts 72 underground rivers and streams in Kyiv, as opposed to 43 watercourses, officially recognized by the authorities (Stepanets, 2015). The Specialized Department of Underground Works does not maintain a register of underground rivers and streams at all (2017, Fionic et al.). In general, all responses to our inquiries regarding the small underground rivers accounting and monitoring by those or other services were unprofessional and in no way related to cadastral accounting.

In this study, as the initial data, we received the departmental data of the Department of the Water Resources State Agency of Ukraine in Kyiv city and Kyiv oblast, which was given us in response to our appeal, and according to which through the territory of Kyiv flow 12 small rivers and 36 currents that belong to the Dnieper river basin and feed the main waterway of the country.

**2.3 Water fund management subjects.**

Since small rivers, flowing through the territory of the metropolis, obstruct the work of urban infrastructure, some of the rivers were passed through collectors or reinforced concrete beds. Within the boundaries of the Kyiv city, small rivers are used as part of the rainwater drainage system, which was established until the 70-s of the XX-th century, and has a total length of 2,700 km.

Although Order No. 111 defines the fact of "Kyiv inland water objects consolidation by the municipal enterprise "Pleso" on the right of economic management" according to the attached list, including all small rivers such as: Lybid, Nyvka, Vita, Konyk, Katurka, Syrets, Horenka, Lyubka, Darnitsa, Konoplyanka, Desenka (according to the Department of the Water Resources State Agency of Ukraine in Kyiv city and Kyiv oblast, plus Hlybochytsya), the municipal enterprise "Pleso" in the reply No. 2915 dated August 14, 2017, notes that it holds only Lybid and Syrets, and such rivers as Horenka, Nyvka, Vita and Katurka supposedly "relate to the rivers of the national significance and not recorded on enterprise`s balance" (Municipal enterprise "Pleso", 2017). Thus, the remaining 10 small rivers of the capital are actually "waif".

The Lybid river is at least partially recognized as the water object in the approved city planning documentation – the General Plan of Kyiv city and the project of its suburban zone planning for the period till 2020, adopted by the Kyiv City Council decision dated 28.03.2002 No. 370/1804 (Kyiv City Council, 2002), where the boundaries of the protected coastal strip of the river are determined on separate sections of the river. At the same time, the river Syrets is deliberately turned by planners into paper to a part of the rain sewer, without installing a coastal protective strip around it, avoiding writing the hydronym (the name of the river) to the topography plans scale 1:500, neglecting the river when developing a detailed plan on the territory (Fig. 1a, b).

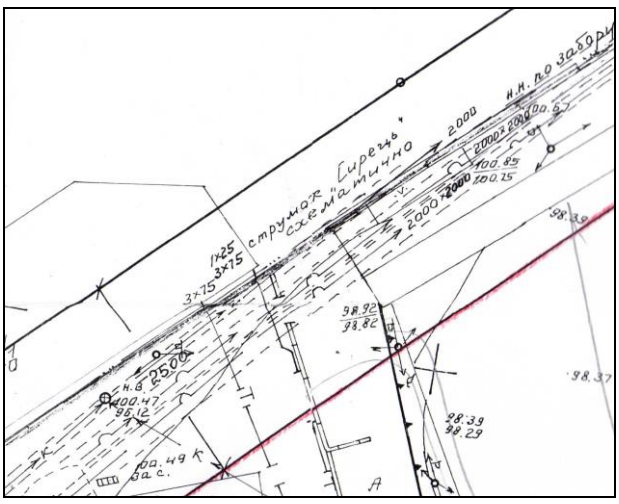


Figure 1a. A topographic plan fragment, scale 1: 500, drawn up in 2012, in which the hydronomic "Syrec stream" near the channel in the concrete collector is indicated.

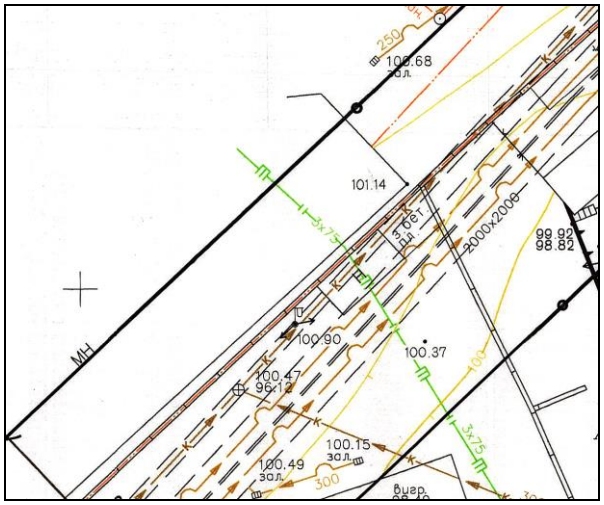


Figure 1b. A topographic plan fragment, scale 1: 500, drawn up in 2016, where the hydronym name is absent.

**2.4 Ecological status of underground rivers.**

In general, the ecological status of underground rivers largely depends on the state of their artificial channels. In the capital, in accordance with the decision Kyiv City Council dated January 24, 2008, No. 67/4539 "On approval of the Rules for the acceptance of surface runoff in the Kyiv city drainage system" (Kyiv City Council, 2008), the issue of the surface runoff drainage and the maintenance of rainwater drainage networks in an appropriate technical condition is carried out by the Service for receiving the surface runoff in the rainwater drainage system, which was created as part of the municipal enterprise “Pleso”. Accordingly, all rainwater drainage objects must be accounted on the balance sheet of the enterprise.

Instead, a significant proportion of rainwater collectors, 790 km from 2700 km, as the object of engineering infrastructure – is located on the balance of municipal enterprises – district departments for the repair and maintenance of roads, subordinate to the municipal enterprise "Kyivavtodor", which and are not profile organizations for the maintenance of water fund objects.

In this interpretation, artificial river beds are equated to sewage systems that do not require environmental protection, regular monitoring and the presence of which does not prevent the use of surrounding lands in any way, even if it can lead to water pollution.

Due to the legislative uncertainty of underground rivers with artificial channels status, none of the executive bodies monitor water in them. So, the State Service of Geology and Subsoil of Ukraine refers such water streams to surface waters, which is monitored by the State Service of Ukraine for Emergencies, and the latter notes that such rivers do not flow on the earth's surface, therefore, they are not within their competence. On the Water Resources State Agency of Ukraine balance sheet there is also no monitoring point on the underground rivers of the capital.

Many scientists note the critical ecological state of small rivers in Kyiv. Thus, the local ethnographer Stepanets K. points out numerous illegal loggings of faecal sewerage, drains from automobile sinks and industrial enterprises, household wastes, etc. (Stepanets, 2015). Prof. V. Vishnevsky observes that the litteriness of Kyiv small rivers disgust him "as a man and a scientist", and emphasizes the need to develop and implement a city program to streamline the small rivers of the capital (2014, Nikolaichyk, I.)

In fact, the registration of small rivers in Kyiv city is not conducted, and the summary information on such water objects is absent and is not taken into account when making managerial decisions in city, which to a large extent is likely to lead to emergency situations. The impact of small underground rivers on buildings and structures, and on the development of the city as a whole, is unexplored and unpredictable. To date, neither state bodies of executive power on urban planning and architecture, nor building enterprises, nor even balance-holders of water objects do not know exactly where the underground rivers flow and the boundaries of their catchment basins are and how these watercourses affect the bearing capacity of soils. The consequence of the lack of such information is the non-rational spending of budget and investor funds during the implementation of construction projects.

Instead, information on small underground rivers and their protected areas must be taken into account when developing urban planning, land management and construction documentation, civil defence measures and emergency management.

**2.5 Water bodies cadastre prototype.**

In order to solve the problem of Kyiv small underground rivers accounting and analysis of their channels and coastal protective zones status, in our study, a prototype of water objects cadastre was developed. According to the departmental data of the Department of the Water Resources State Agency of Ukraine in Kyiv city and Kyiv oblast in the software ArcMap small rivers and streams were mapped along the whole length of their channels, including their underground parts. The surface part of the rivers was plotted according space shots, dated 2017, from the Bing resource (Bing, 2017), and for precise localization of the underground part of the riverbeds topographic plates with scale 1:500, on which the accounting of engineering communications is conducted, were used. To designate the coastal protective zones of rivers, buffer polygons with a width of 25 m in each direction from the channel were created.

It should be mentioned that some alternative solutions for mapping river bodies in the urban environment may be used. For the purpose of water objects cadastre, high-resolution airborne images are more acceptable than space shot due to the higher surface water bodies localization accuracy. But even these images cannot solve the problem of underground rivers localization.

It was found that from the total length of the Syrets river, which is 8128 m, 1971 m of stream flows under the railways, and 3631 m through communal warehouses and industrial areas, without establishing any coastal protective zones, that is almost 70% of its path the river overcomes through environmentally unfavourable areas. Urbanization (i.e., the degree of urban development) of the river bed is 85% (Fig. 2).

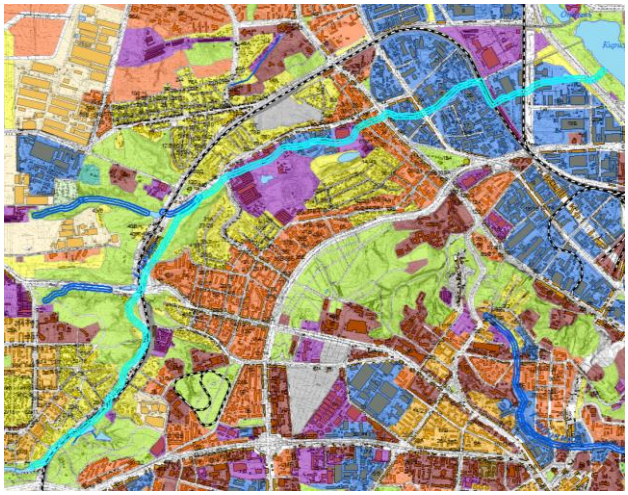

Figure 2. The Sirets river (marked by blue colour) is compared with the functional use types of the city territory (according to the General Plan till 2020). The purple colour indicates the communal and warehouse territories, blue – industrial, green – green areas of general use.

Similarly, the railway passing in the valley of the Lybid river duplicates the channel almost in its entire length, and the urbanization of the river is 100% (Fig. 3).

Figure 3. The Lybid river is compared with the functional use types of the city territory (according to the General Plan till 2020). The notation is identical to Fig. 2.

On the other hand, the passage of the railway saves the rivers from the construction and overlap of their channels with the buildings foundations. Thus, the channel and the coastal protective zone of the Hlybochytsya river in the upper reaches are built up (Fig. 4).

Figure 4. The channel and the coastal protective zone of the Hlybochytsya river (marked with blue), and the buildings within them (marked with orange).

In general, the analysis of the construction dynamics according to different time space shots and the functional use of territories according to the General Plan in coastal protective zones showed that the degree of urbanization of underground rivers increases uncontrollably every year, and the regime of economic activity within their coastal protective zones is not regulated in any way, which negatively affects the ecological state of the capital water objects and the quality of water in it as a whole.

## 3. CONCLUSIONS

In the course of the study, we received the answer to the question what really are the small underground rivers with artificial watercourses: water bodies or city engineering infrastructure objects? Although the high land cost in the metropolis leads to the fact that unscrupulous planners neglect underground small rivers, these watercourses remain water objects and require proper protection.

The vast part of Kyiv small rivers is hidden in the collectors and concrete troughs, thus transformed into rain water receivers, which is the main source of their nutrition. Cleaning and rehabilitation of such collectors is extremely rare; in addition, their ecological status deteriorates as a result of uncontrolled discharges of waste products and the construction of illegitimate seams of faecal sewage system. The waters of any of the Kyiv underground rivers are not properly cleaned before entering the Dnieper, which is the main waterway in Ukraine. Therefore, we consider it advisable to recommend the installation of sewage treatment facilities in the underground rivers channels confluence in the Dnieper River, as well as to provide posts for regular water monitoring in them.

It is also necessary to introduce alternative measures for the protection of rivers flowing through existing industrial and communal-warehousing areas by partially limiting environmentally harmful activities within the coastal protective zones, as well as the introduction of water resources utilization closed cycles at these enterprises.

It is worth to differentiate the balance value of rain collectors and the responsibility for their operation between the district departments for the repair and maintenance of roads and the municipal enterprise “Pleso” in order to avoid duplication of powers between these organizations and save budget funds.

Due to the lack of small underground rivers, that affect the metropolis, accounting, information about them is not taken

into account during the development of urban planning, land management and construction documentation, as well as during the forecasting and prevention of emergency situations, which necessitates the development of the water cadastre system architecture in further research.

The introduction of an open small underground rivers accounting and monitoring system at the state level will fulfil the function of public control over their state. In addition, it will be possible to test and reproduce projects on the small rivers revitalization and to predict the results from their implementation on such a platform.

Finally, the research may be useful to build up an international network on the topic of urban water management, or to set up projects for helping Ukraine to this aim.

## REFERENCES

ArcGIS, 2017. https://www.arcgis.com/features/index.html (21 Oct. 2017)

Bing, 2017. https://www.bing.com/maps/ (21 Oct. 2017)

Department of the Water Resources State Agency of Ukraine in Kyiv city and Kyiv oblast, 2017. Hydrographic network. http://www.kyivvodresursiv.kiev.ua/menus/view/67 (21 Oct. 2017)

Fionic, D., Kelm, N., Oksymets, O., 2017. Labyrinths of Kiev waters. https://tsn.ua/special-projects/kyiv-rivers/ (21 Oct. 2017)

Kaika, M., 2010. The Water Framework Directive: A New Directive for a Changing Social, Political and Economic European Framework. http://www.tandfonline.com/doi/abs/10.1080/09654310303640 (21 Oct. 2017)

Khilchevsky, V.K., Hrebin, V.V., et al., 2014. Water Fund of Ukraine: Artificial water bodies – reservoirs and ponds: Handbook. Kyiv, Interpress LTD.

Khilchevsky, V.K., Obodovsky, O.G., Hrebin, V.V., et al., 2008. General Hydrology: Textbook. Kyiv, Taras Shevchenko National University of Kyiv.

Kyiv city council, 2002. On Approval of the General Plan of Kyiv city and the project of its suburban zone planning for the period till 2020. Decision No. 370/1804, 28.03.2002.

Kyiv City Council, 2008. On approval of the Rules for the acceptance of surface runoff in the Kyiv city drainage system. Decision No. 67/4539, 24.01.2008.

Kyiv City State Administration, 2009. About the transfer to the balance and consolidation for KP "Pleso" water objects and registration of Kyiv water fund lands. Order No. 11 from 04.02.2009.

Municipal enterprise "Pleso", letter No. 2915, August 14, 2017.

Nikolaichyk, I., 2014. Victor Vishnevsky: "The rivers that are named in Kiev are about 50, without the name – more than 100". https://ukurier.gov.ua/uk/articles/viktor-vishnevskij-richok-yaki-mayut-nazvu-v-kiyev/ (21 Oct. 2017).

Stepanets, K.M. Encyclopedia of the Kyiv rivers, 2015. Kyiv.

The Water Resources State Agency of Ukraine, letter No. 4675/9/11-17, August 18, 2017.

Water Code of Ukraine, 1995. The Code of Ukraine, the law. Kyiv.

Water Framework Directive, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.