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Strengthening the role of hydrogeological research in the system of engineering investigations for construction

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ABSTRACT

Problem Statement. The necessity to review, revise, and supplement existing building regulations in the field of engineering surveys and design is driven by the increasing significance of hydrogeological research. This is in response to the growing trend of urban development on territories (mainly within urban agglomerations) that were previously considered unsuitable for construction due to adverse engineering-geological conditions. The issue becomes particularly relevant against the backdrop of Russia's armed military aggression against Ukraine, which necessitates deeper underground space utilization to construct reliable shelters for protecting civilians from missile and bomb attacks. Under these conditions, new and stricter requirements arise for the content and quality of engineering surveys, design solutions, as well as for measures related to the engineering preparation and protection of territories and individual objects from hazardous geological processes.

The aim of this study is to highlight the significance and objectives of engineering-hydrogeological surveys in construction and to propose recommendations for improving the state of survey and design activities in the context of large-scale reconstruction in Ukraine.

Research Methodology. The research involves the systematization and generalization of both domestic and international experience in conducting engineering-geological surveys for construction. Special attention is paid to identifying areas where hydrogeological studies should be prioritized. To formulate requirements and suggestions for improving the regulatory framework in the field of engineering surveys and design, the study analyzes various manifestations of flooding processes. Additionally, the impact of groundwater in various physical states on the strength and deformation properties of soils, as well as the initiation and intensification of hazardous engineering-geological processes, is investigated.

Results. The study presents the scientific foundations for improving the regulatory framework in the field of engineering surveys for construction, according to modern requirements. Special emphasis is placed on enhancing the role of hydrogeological research in deepening underground space utilization within urban agglomerations. It is noted that with the expansion of the interaction sphere between projected structures and the geological environment, the influence of groundwater on engineering-geological conditions intensifies, leading to a deterioration in the properties of specific soils and the activation of engineering-geological processes.

Scientific Novelty. For the first time, a theoretical justification is provided for the concept of mandatory inclusion of hydrogeological studies in the scope of engineering-geological surveys, even in cases where groundwater is absent within the interaction sphere of the designed structure and the geological environment. Based on the study and systematization of flooding processes, the stages of predicting changes in engineering-hydrogeological conditions have been improved.

Practical Significance. The theoretical findings can be used to enhance the regulatory framework in the field of engineering surveys, particularly for developing requirements regarding the content and quality of hydrogeological research. This will improve the reliability of designed buildings and structures while also reducing the risks of hazardous engineering-geological processes emerging or intensifying.

Keywords*: engineering-hydrogeological surveys, hazardous geological processes, building regulations, engineering protection of territories, flooding, physic-mechanical properties of soils, harmful effects of groundwater, complex engineering-geological conditions.*

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Statement of the problem. The need to review, edit and supplement the current building regulations, in particular the currently valid normative document DBN A.2.1-1-2008 "Search, design and territorial activity. search Engineering searches for construction" [2] regarding hydrogeological studies, caused by the trend towards engineering development of territories (mainly within urban agglomerations), which were previously considered unsuitable for construction due to unfavorable engineering-geological conditions [6-8].

On the example of the city of Kharkiv, the expansion of built-up areas is observed due to floodplains and steep slopes of river valleys, bottoms and slopes of streams and other territories characterized by unfavorable soil conditions and the development of dangerous engineering-geological processes [8, 14].

This problem has become particularly relevant against the background of the armed military aggression deployed by the Russian Federation against our country, in the conditions of which there is an urgent need for in-depth development of the underground space, with the aim of building reliable protective structures to ensure the lives of the civilian population during missile and bomb attacks.

The specified circumstances require significant deepening of the newly designed engineering structures, expansion of the scope of their interaction with the geological environment, therefore, an increase in the depth of the study of engineering-geological and hydrogeological conditions at the construction sites. At the same time, there are new, stricter requirements for technical solutions during the design of buildings and structures under construction and reconstruction, as well as measures for engineering preparation and protection of territories and individual objects from dangerous geological processes [1, 10, 13, 16].

Analysis of recent research and publications. The question of strengthening the role of hydrogeological research in the system of engineering-geological investigations has always been relevant during the formation of engineering geology as a science. Numerous scientific works were devoted to the peculiarities of engineering-hydrogeological investigations in the territories of urban agglomerations and to the study of dangerous engineering-geological processes, problems of forecasting changes in natural and man-made geological conditions, and the impact of planned construction on the environment [1, 9, 12]. The corresponding work was carried out by specialized research and production institutes and specialists of leading investigative organizations.

In Ukraine, articles by leading scientists E.F. Shestopalov, E.O. Yakovlev, A.V. Luschyk, V.O. Bokov, H.G. Stryzhelchyk were devoted to the problems of improving the quality of engineering investigations for construction, in particular, by increasing the importance of hydrogeological research, as well as the heads of large investigative organizations V. I. Bogdanov, V. I. Polevetskyi, P. M. Varyvoda, V. A. Sokolova, etc. [1, 7, 10, 14].

The influence of groundwater on the condition and physical and mechanical properties of soils, as well as on the activation of dangerous geological processes, is widely covered in numerous works by foreign researchers [11, 18, 21, 23, 25].

An important and still unresolved issue for our country, in today's conditions, is the generalization and systematization of the results of separate engineering-hydrogeological studies for the improvement of the regulatory framework in the field of engineering construction and design. At the same time, new requirements for the composition and quality of engineering investigations should appear, which would strengthen the role of hydrogeological research.

The purpose of the work is to draw attention to the importance and tasks of engineering-hydrogeological investigations for construction, formulation of proposals for improving the state of project and investigation activities in the field of large-scale restoration of our country.

Presentation of the main research material. According to the currently valid regulatory document DBN A.2.1-1-2008 [2], engineering-hydrogeological research (surveys) is carried out in four directions (Fig. 1):

- engineering-hydrogeological surveys for construction, which can be performed both independently and as part of complex engineering-hydrogeological surveys;
- search and exploration of underground water;
- designing and drilling wells for water supply;
- research of groundwater pollution.

The last three directions belong to specialized surveys, which are regulated by separate normative documents and must be performed in accordance with these documents, therefore, in this work, we will pay the main attention to the hydrogeological part as part of complex engineering-geological surveys for construction.

Due to the dynamism and significant variability of the underground hydrosphere, engineering-hydrogeological surveys have a number of features that distinguish them from standard engineering-geological surveys. Such features are the following [6, 13]:

1) performing a significant amount of research outside the site of the designed object;

2) conducting stationary regime observations without connection to specific construction;

3) taking into account the fact that the absence of underground water in the active zone of the foundation of the planned building at the time of investi-

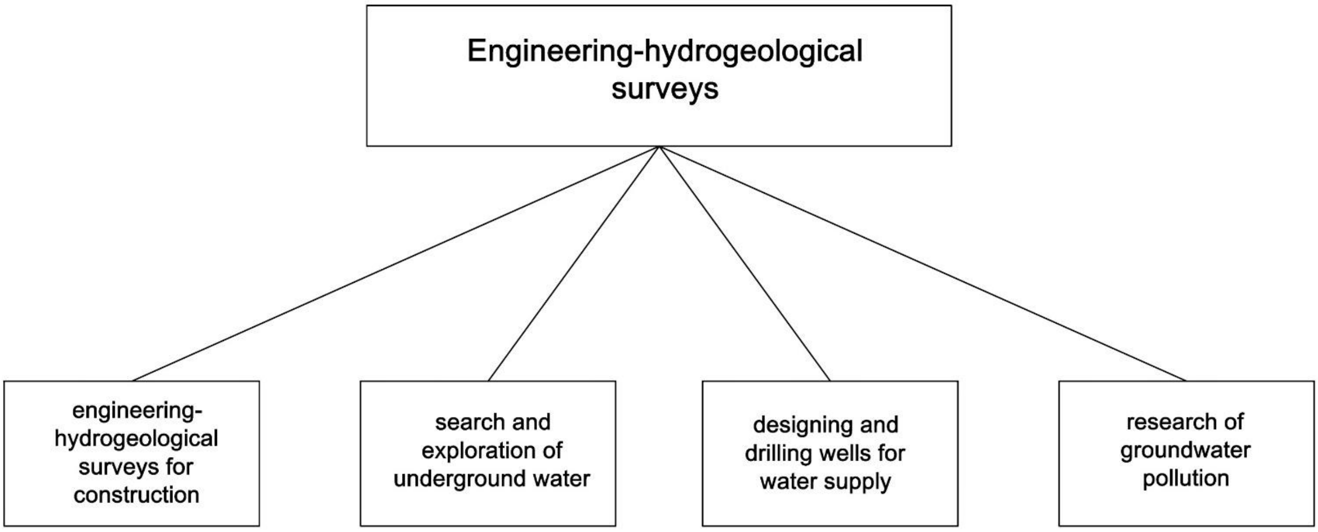

Fig. 1. Directions of engineering and hydrogeological investigations (according to DBN A.2.1-1-2008) [2]

gations does not cancel the need to perform hydrogeological studies, in particular, determining the permeability of soils.

The main regulatory document regulating engineering surveys for construction determines the place of hydrogeological research, firstly, as a separate type of research, with the aim of obtaining information about the engineering-hydrogeological conditions of the territories, and secondly, as hydrogeological works as part of complex engineering-geological research.

In the first case, we mean the study of problems caused by the process of flooding, as a manifestation and consequence of the negative impact of groundwater on the engineering-geological conditions of territories and construction sites, which is the main subject of applied engineering hydrogeology.

Among dangerous geological processes, flooding, along with erosion, currently occupies a leading place. According to Appendix E to DBN V.1.1-24:2009 "Protection from dangerous geological processes. The main provisions of the design" [3], manifestations of flooding on the territory of Ukraine are noted everywhere and recorded in all administrative regions of the country without exception (Table 1).

However, in this case, this process is usually associated with a direct, immediate negative impact of groundwater on the projected structures and individual territories, that is, with the consequences of raising their levels.

In a more complete view, the concept of "flooding" recently takes into account not only the rise in the level of groundwater, but also the increase in soil moisture (the definition of the term in DBN V.1.1-25-2009 [4]), which corresponds to the generally accepted, broader definition of groundwater, not only, as a free (gravitational) liquid, but as water vapor, ice, capillary, film water [5].

If we consider the causes of the emergence and development of dangerous geological processes and phenomena from this point of view, we will come to the conclusion that most of them are to one degree or another caused by the action of underground water [3, 8, 15].

Exceptions are processes caused by the action of surface waters, air masses (eolian phenomena), as well as slope processes caused by gravitational forces in their pure form (landslides, screes).

Therefore, the object of engineering-hydrogeological investigations for construction should be underground water in all possible states (gravitational, capillary, film, etc.), which affect the conditions of engineering activity in the geological environment [5]. Therefore, it is necessary to systematize the negative processes and phenomena associated with the action of underground water in the broad definition of this concept.

According to the nature of the influence of groundwater on the engineering and geological conditions for the creation of construction objects, two groups are distinguished: direct and indirect (indirect) action (Fig. 2).

The types of influence of a direct nature include manifestations of the direct action of groundwater on the conditions of construction and operation of buildings and structures, namely:

- flooding of buried parts of structures, communications, construction pits;
- corrosion of materials of underground structures;
- deterioration of general ecological and sanitary conditions of territories and plots;
- soil salinization;
- phenomena related to hydrostatic and hydrodynamic pressure of underground waters.

The first group of processes, consisting of mani-

Table 1

Registered manifestations of dangerous geological processes on the territory of Ukraine (according to DBN V.1.1-24:2009) [3]

Territory	Registered manifestations of dangerous geological processes								
	Landslides	Erosion	Attrition	Landslip	Sel	Avalanches	Karst	Flooding	Processing of banks
ARC	+	+	+	+	+	+	+	+	+
Vinnytsia region	+	+						+	
Volyn region		+						+	
Dnipropetrovsk region	+	+	+					+	+
Donetsk region	+	+	+				+	+	
Zhytomyr region		+						+	
Transcarpathian region	+	+		+	+	+		+	
Zaporizhzhia region	+	+	+	+			+	+	+
Ivano-Frankivsk region	+	+		+	+	+		+	
Kyiv region	+	+	+					+	+
Kirovohrad region	+	+		+				+	
Luhansk region	+	+						+	
Lviv region	+	+		+	+			+	
Mykolayiv region	+	+						+	
Odesa region	+	+		+			+	+	
Rivne region	+	+						+	
Poltava region	+	+	+						+
Sumy region	+	+							
Ternopil region	+	+		+				+	
Kharkiv region	+	+						+	
Kherson region	+	+	+					+	+
Khmelnytskyi region	+	+						+	
Chernihiv region	+	+		+				+	
Cherkasy region	+	+						+	
Chernivtsi region	+	+			+	+		+	
Note. A seismic effects on the territory of Ukraine are considered in DBN V.1.1-12									

festations of actual flooding in the general sense, is the subject of separate hydrogeological studies.

The effects of an indirect nature are manifested in the form of changes in the strength and deformation properties of soils under the action of groundwater, as well as the initiation and activation of engineering-geological processes, which include [11, 19, 22, 24]:

- karst;
- suffusion;
- shear processes;
- collapse phenomena;
- clay soil expansion;
- frosty swelling;
- floating phenomena;
- improvement of seismic properties of soils.

This group of processes is the subject of hydrogeological studies as part of complex engineering-geological studies, the study of most of which, at first glance, is a task of purely geotechnical investigations. Accordingly, one of the clauses of DBN A.2.1-1-2008 [2], which regulates geotechnical studies, includes the forecast of changes in the condition and properties of soils under the influence of various factors, including moistening, irrigation and drainage, that is, a purely hydrogeological task.

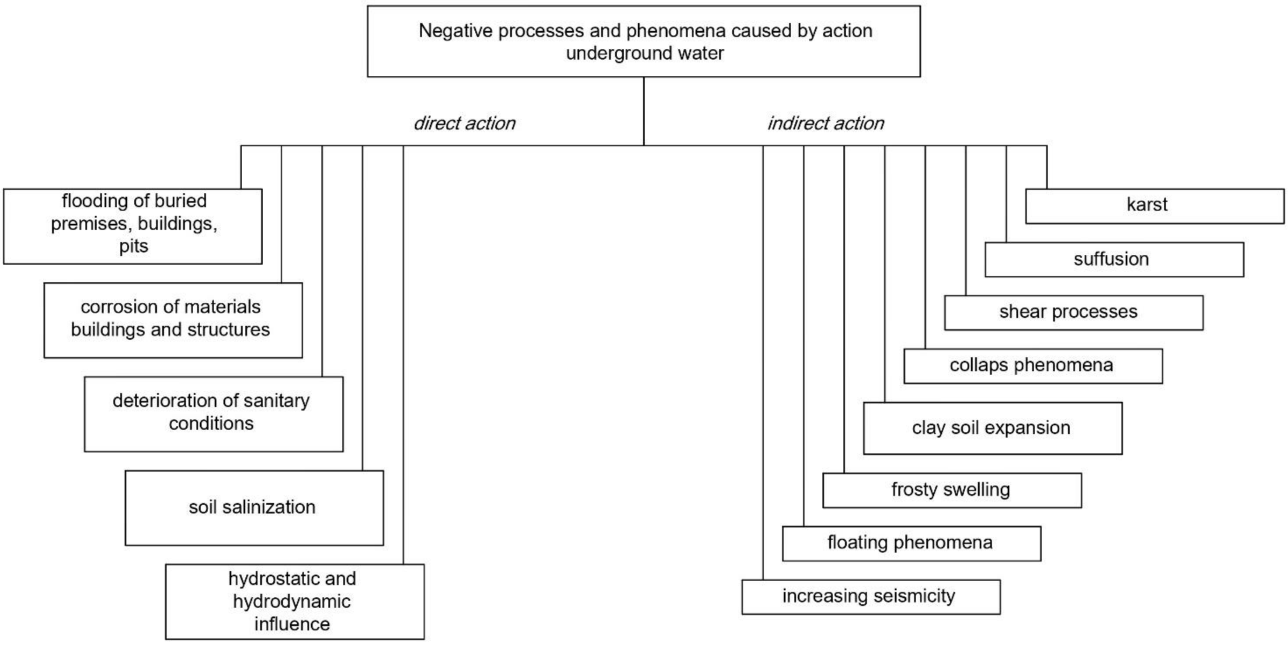

Fig. 2. Systematization of manifestations of the negative impact of groundwater on engineering-geological conditions, conditions of construction and operation of buildings and structures, the state of individual territories

It should be noted that forecasting changes in natural and man-made conditions is a mandatory requirement of regulatory documents during engineering investigations. Taking into account the mentioned influence of groundwater on the state and properties of soils, it becomes obvious that the most important component of forecasting in geotechnical research is forecasting changes in the moisture regime of soils and the level of groundwater, that is, changes in hydrogeological conditions.

This is especially important for research within the areas of soil development with special properties (clause 3.2.6.6 DBN A.2.1-1-2008 [2], regarding geotechnical investigations): collapsible, expansive, weak, saline, eluvial, man-made (it is necessary to add soils, that have flowing properties), as well as areas of development of dangerous geological processes (clause 3.2.9 DBN A.2.1-1-2008, regarding the study of engineering-geological processes and phenomena): karst, sufosis, landslides, etc.

From this follows the conclusion about the expediency of introducing additional requirements to the relevant subdivisions of the state building regulations about the need to implement the forecast of changes in hydrogeological conditions.

Since the ability of forecasts (their probability and completeness) depends on the composition and quality of the initial data, which in the case of hydrogeological studies are determined by the number of points and the depth of the test, it is necessary to supplement the points of DBN A.2.1-1-2008 regarding the depth and number of exploratory wells in the areas of soil availability with special properties and in places of development of dangerous geological processes [3, 6].

Addendums must contain requirements for hydrogeological research, with a mandatory definition of all characteristics and parameters necessary for exploratory and regulatory forecasting of changes in hydrogeological conditions. To do this, the requirements for the number and depth of the exploratory wells, which is currently limited by the capacity of the compressible layer, should be revised [2].

In order to fully characterize the hydrogeological conditions and obtain all the initial data for forecasting, it is suggested to set the depth of rock formations at least the depth of the first aquitard from the surface. It is advisable to establish the minimum number of hydrogeological wells, taking into account the scale of the planned activity:

- for small individual buildings – 1;
- for large buildings, groups of buildings, individual territories – at least 3.

It should also be emphasized the need to carry out a complex of exploratory hydrogeological works (pumping tests, regime observations, etc.), which ensure obtaining the necessary calculation characteristics (initial and boundary conditions; coefficient of water permeability; coefficient of head-conductivity (piezoconductivity); module of underground flow (infiltration supply); amplitude of seasonal and multi-year groundwater level fluctuations; capillary rise height) [4, 17, 20].

Since the issue of developing forecasts is a mandatory component of engineering research materials for construction, the meaning of this concept should be revealed in relation to engineering and hydrogeological research. The concepts of exploratory and normative forecast are borrowed from scientific forecasting, one of the methods of which is the problem-targeted approach of future research, which is the study of emerging trends and problems and the search for ways to solve them.

Exploratory and regulatory forecasts are widely used in various fields of science, in particular, economics, where the course of the development of phenomena is determined by the action of a large number of factors of different nature and direction. The action of these factors in various combinations, which in some cases leads to mutual reinforcement, in others - to mutual exclusion, and is the driving force of processes, the patterns of development of which are probabilistic in nature and do not lend themselves to purely analytical evaluation.

The same is observed during hydrogeological research: it is obvious that it is impossible to take into account the effect of all the causes and factors of flooding with the help of analytical calculations, therefore, one has to resort to probabilistic problem solving by performing exploratory and regulatory forecasts (Fig. 3).

Search forecast (genetic, exploratory) – a forecast that shows what states the forecasted object will reach at a given time under certain initial conditions [14]. Exploratory forecasting determines the possible or expected state of the phenomenon or object of forecasting in the future, answers the question: "what is most likely to happen if existing trends are maintained?"

In contrast to the exploratory forecast, the regulatory forecast shows the possible ways and terms of achieving the given, desired final state of the forecasted object (i.e., the goal). The regulatory forecast determines the ways and terms of achieving the possible state of the phenomenon, which is accepted as a goal and answers the question: "what are the ways to achieve the desired?" [13].

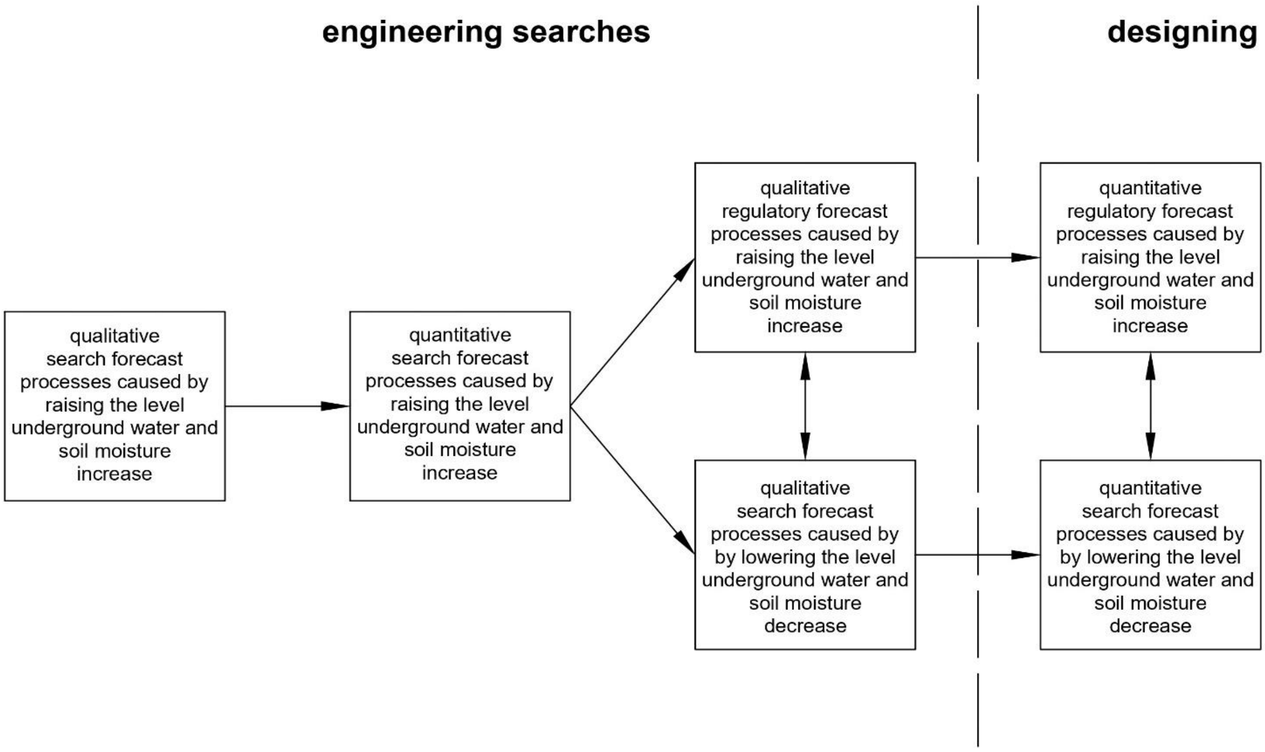

Fig. 3. Gradual forecasting of changes in engineering-hydrogeological conditions

Hydrogeological studies as part of complex engineering-geological investigations must take into account the presence of soils with special properties within the site (territory) that can change under the influence of groundwater, as well as the possibility of the occurrence and intensification of engineering-geological processes caused by changes in hydrogeological conditions [18, 21, 25].

The types and volumes of hydrogeological studies as part of complex engineering-geological surveys should ensure the acquisition of initial data sufficient for forecasting possible changes in hydrogeological conditions and their impact on the engineering-geological conditions of the territory (site), as well as for making design and technical decisions on the protection of territories and buildings.

Independent hydrogeological investigations are carried out to solve problems related to the direct negative impact of groundwater on engineering-geological conditions and are mainly aimed at solving the problem of flooding of territories, individual sites and structures [4, 10, 17].

According to the nature (state) of flooding conditions, one should distinguish between flooded territories (naturally and man-made, permanent and temporary) and non-flooded ones, among which potentially flooded and potentially non-flooded territories are distinguished.

When conducting hydrogeological investigations, first of all, it is necessary to determine the state of a specific territory in relation to the conditions of submergence. For this, the effect of all mode-forming factors (flooding factors) that determine the regime of groundwater in the studied territory should be taken into account [4, 12].

Given the complexity and multifactorial nature of geohydrodynamic processes, the formation of the underground water regime of a specific local area usually occurs at the expense of factors that operate far beyond its boundaries. Therefore, territorial engineering-hydrogeological studies should not be limited to the site of the planned construction.

The state of the territory (structure) in terms of flooding conditions is determined at the initial stages of searches, which makes it possible to adjust the composition and scope of further work. The main criterion is the maximum depth of the underground water level [4], the decrease of which, depending on the functional use and the character of the development of a specific territory, allows it to be classified as flooded.

Potential submergence is determined based on the analysis of a set of data on the natural and man-made conditions of territories (sites), with the determination of the main factors and reasons for the development of the submergence process at the regional and local levels. It is important to take into account all components of the groundwater balance, as the main prerequisite for the development of the process of flooding the territory.

The following are the geomorphological factors of flooding:

- insufficient natural drainage of the territory due to the weak vertical dismemberment of the terrain;
- the low location of the territory relative to the natural basis of drainage, which is the hydrographic network;
- the presence of negative forms of relief, due to which the accumulation of surface runoff and its transformation into underground occurs.

Geological and lithological factors of flooding include:

- shallow occurrence of the regional aquitard;
- the development of poorly permeable rocks with low water yield in the aeration zone, which causes the formation of zones of excessive moisture and complete water saturation;
- the presence in the vertical section of layers of weakly permeable rocks, which play the role of local water-resistant strata;
- litho-facies variability of the rocks of the water-saturated stratum, which creates conditions for groundwater support due to changes in filtration resistance along the path of underground flow;
- the presence of zones of tectonic disturbances, through which pressure aquifers are unloaded;
- the presence of zones of erosion of rocks of the regional water-resistant layer, which determines the connection with the underlying pressure aquifers;
- the presence of poorly permeable channel sediments in the zones of natural discharge of groundwater.

It was the combination of the first two groups of factors that formed the basis of the zoning scheme for the territory of the city of Kharkiv under the conditions of flooding, developed by specialists of the "UkrNDIINTV" institute.

Hydrometeorological factors of flooding are:

- a large amount of atmospheric precipitation, which prevails over evaporation from the free surface, and their unevenness in the annual cycle;
- natural seasonal fluctuations of the water level in reservoirs and watercourses.

Man-made factors of flooding include:

- additional infiltration feeding of groundwater due to leaks from water-bearing networks, which is a function of water consumption of the object (territory);
- changing the natural topography of territories with violation of surface runoff conditions;
- shielding of the earth's surface with engineering structures and artificial covering, which prevents evaporation from the free surface of groundwater;
- creation of a barrage effect as a result of supporting the underground flow by pile foundations and other underground structures;
- support of soil flow during the construction of reservoirs and ponds;
- decommissioning of underground water intakes;
- creation of conditions for the development of man-made aquifers in massifs of bulk or alluvial soils;
- man-made pollution of the geological environment, as a result of which rocks are cemented by mineral growths and the water-physical properties of rocks change under the influence of chemical and organic substances (for example, in the case of petrochemical pollution); chemical pollution can also cause the appearance of aggressive properties of underground water and soil in relation to the materials of buried structures.

The assessment of potential submergence is performed on the basis of qualitative forecasting of natural and man-made changes in the hydrogeological conditions of the territory, as a result of which the following phenomena may occur:

- increasing soil moisture in the aeration zone;
- formation of local aquifers ("headwaters");

- natural seasonal and multi-year fluctuations of the underground water level;

- man-made changes in the groundwater head;

- change in the chemical composition of underground waters, which can cause an increase in their aggressiveness towards the materials of underground structures.

The main task of engineering-hydrogeological investigations in flooded areas is to obtain initial data for the development of measures for the engineering protection of areas (structures) from flooding. The list of data required for this is agreed with the project organization and is included in the technical task.

According to special requirements, the technical task should indicate the maximum depth of the underground water level for the construction being designed [4].

The characteristics of the hydrogeological conditions of territories and areas, the determination of which is mandatory in the process of investigations, include the following:

- spatial arrangement (in section and in plan) of the boundaries of aquifers that fall into the zone of interaction of the projected structure with the geological environment;

- household and predicted position of the ground water level and the piezometric level of pressurized water;

- conditions on the borders of aquifers;

- hydrogeological parameters of aquifers (coefficients of water conductivity and head- or piezoconductivity);

- conditions of feeding and discharge of aquifers;

- chemical composition and corrosive activity of underground water in relation to building construction materials.

For special requirements, with proper justification, the following characteristics should be determined:

- permeable properties of the rocks of the aeration zone and the aquitard;

- the height of capillary rise of moisture in the soils of the aeration zone;

- amount of main and additional infiltration power;

- active porosity of aquifer rocks;

- the coefficient of water yield of rocks of the aquifer and aeration zone;

- the amplitude of seasonal and multi-year fluctuations of the groundwater level;

- coefficient of lack of water saturation of rocks in the aeration zone;

- hydraulic (permeable) resistance of reservoir bottoms;

- coefficient of flow through aquitard.

The types and volumes of searches are assigned depending on the complexity of the engineering-hydrogeological conditions and the degree of exploration of the territory. In general, engineering and hydrogeological surveys are performed in a certain sequence and include the following types of work [2]:

- collection of literary and stock materials: information on regional peculiarities of the hydrogeological conditions of the territory, results of scientific research, stationary regime observations, balance calculations, searches of past years;

- reconnaissance survey of territories, with the identification and assessment of active natural and man-made factors of flooding;

- exploratory hydrogeological drilling, which is performed in order to determine the lithological composition of the rocks of the aeration zone and the water-saturated stratum, the position of the groundwater level and the aquitard;

- field pumping tests are carried out to determine the permeable properties of the rocks of the aeration zone, water-saturated and water-resistant strata, hydrogeological parameters and boundary conditions of the aquifer;

- laboratory works include determining the chemical composition of groundwater; separate laboratory determinations of the granulometric composition, moisture and permeable properties of soils, i.e. natural geological features, on the basis of which the potential flooding of the territory is assessed;

- stationary monitoring of the groundwater regime is carried out under special conditions, as part of investigations for the construction of structures of a high category of responsibility, as well as for the engineering development of large territories; the need for conducting this type of research is substantiated in the work execution program;

- geophysical works, as a rule, are auxiliary methods of research, the necessity of which also requires justification;

- simulation of hydrodynamic processes using both physical models and special computer software is performed for complex hydrogeological conditions, in which the analytical solution of geofiltration problems using typical calculation schemes is impossible or involves significant errors;

- analytical and in-house processing of actual data obtained during searches, development of search and regulatory forecasts, formulation and justification of conclusions and recommendations for further project development.

The depth of mining (wells) during hydrogeological investigations should be determined taking into account the zone of possible mutual influence of the design object and the underground hydrosphere, but in any case it should not be less than the depth of the regional aquitard, with a depth of 2-3 meters.

When performing engineering-hydrogeological investigations on flooded and potentially flooded territories, as well as when developing recommendations for designing measures to protect against flooding, it is necessary to take into account the possibility of negative engineering-geological processes and phenomena caused by a decrease in soil moisture and a decrease in the level of groundwater (Fig. 4) [18, 20].

Such phenomena include the following:

- subsidence and dismemberment of massifs composed of expansive soils;
- dehydration-gravitational subsidence of soils, caused by a decrease in the effect of hydrostatic weighing;
- mechanical suffusion and erosion of soils;
- activation of karst and chemical suffusion;
- processes related to filtration pressure (soil displacement, pressure on supporting structures, etc.).

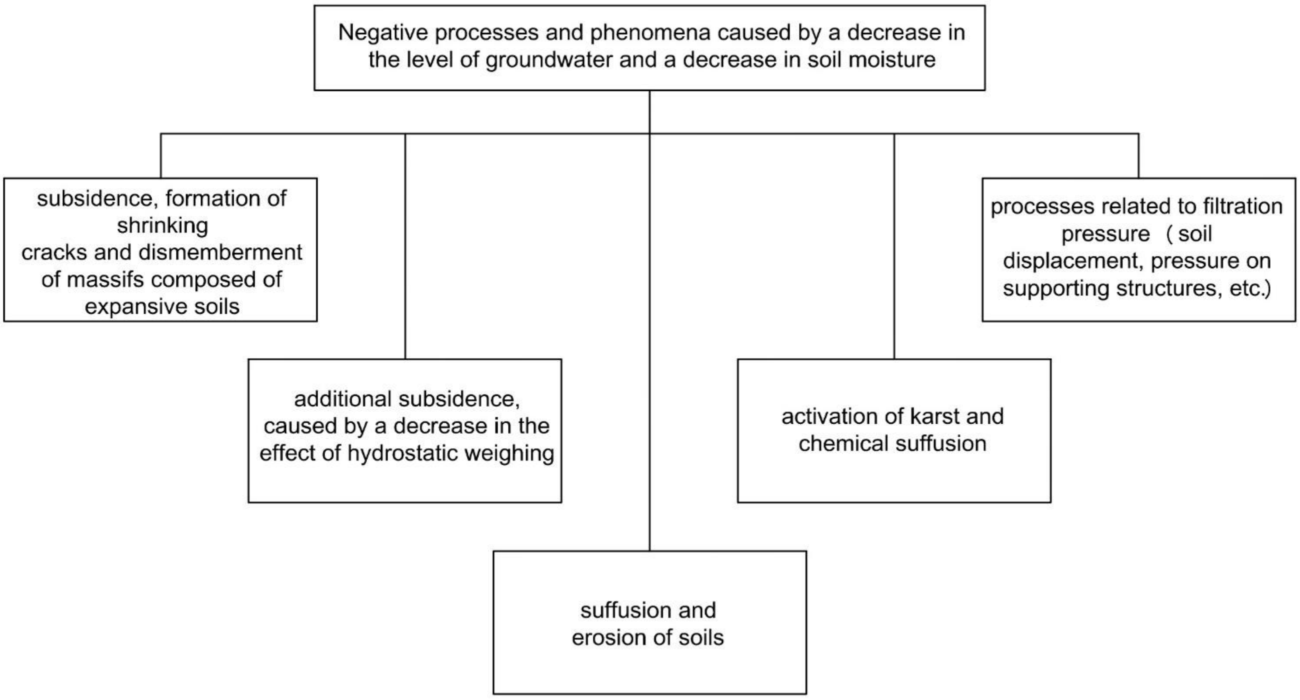

Fig. 4. Negative processes and phenomena caused by a decrease in the level of groundwater and a decrease in soil moisture

The action of the specified processes can spread to adjacent areas, which should be especially taken into account in areas of existing tight building within urban areas. The development of recommendations for the prevention or elimination of these processes is part of the regulatory forecasting of changes in engineering-geological conditions under the influence of the planned activity [10, 14].

Conclusions. 1. Currently, the need for a complete and reliable study of the hydrogeological conditions of construction sites has grown significantly in Ukraine. This is due to the mass development of territories with difficult engineering-geological conditions, as well as the use of underground space during the construction of objects for the protection of the civilian population.

2. Usually, a change in the groundwater regime is the main factor in the activation of dangerous engineering-geological processes (flooding, landslides, karst, suffusion, etc.).

3. The performance of hydrogeological surveys has a number of specific features that distinguish them from standard engineering-geological surveys. These features must be taken into account during the development of new state regulatory documents for the implementation of engineering-technical investigations.

4. In order to create safe construction conditions and comfortable living of the population, it is necessary to restore territorial activities aimed at monitoring dangerous engineering-geological processes, as well as at collecting, preserving and systematizing data about the natural and man-made geological environment. In the existing socio-economic conditions, the municipal government can entrust this activity to scientific and educational institutions.

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Посилення ролі гідрогеологічних досліджень в системі інженерних вишукувань для будівництва

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Необхідність перегляду, редагування та доповнення діючих будівельних норм у сфері інженерних вишукувань і проєктування, з метою підвищення значущості гідрогеологічних досліджень, викликана тенденцією до інженерного освоєння територій (головним чином, в межах міських агломерацій), які раніше вважалися непридатними для будівництва через несприятливі інженерно-геологічні умови. Проблема набуває особливої актуальності на тлі збройної військової агресії, розгорнутої Російською Федерацією проти України, в результаті якої виникає необхідність значного збільшення глибини освоювання підземного простору, для зведення надійних споруд із захисту цивільного населення від ракетно-бомбових атак. За таких умов виникають нові, більш жорсткі вимоги до складу і якості матеріалів інженерних вишукувань, проєктно-технічних рішень, а також заходів з інженерної підготовки та захисту територій та окремих об'єктів від небезпечних геологічних процесів. У роботі викладено наукові засади удосконалення нормативної бази у сфері виконання інженерних вишукувань для будівництва, відповідно до вимог, що виникають у сучасних умовах. Особливу увагу привернуто до підвищення ролі гідрогеологічних досліджень під час збільшення глибини освоєння підземного простору міських агломерацій. Підкреслено, що із розширенням сфери взаємодії проєктованих будівель і споруд з геологічним середовищем, значно підсилюється вплив підземних вод на інженерно-геологічні умови, що виражається у погіршенні властивостей специфічних ґрунтів, активізації інженерно-геологічних процесів. Вперше теоретично обґрунтована концепція щодо обов’язкового включення гідрогеологічних досліджень до складу інженерно-геологічних вишукувань навіть для випадків, коли підземні води є відсутніми у сфері взаємодії проєктованої споруди з геологічним середовищем. На основі вивчення і систематизації проявів процесу підтоплення удосконалено стадійність прогнозування змін інженерно-гідрогеологічних умов. Отримані теоретичні положення можуть бути використані для удосконалення нормативної бази у сфері інженерних вишукувань, а саме, для розробки вимог до складу і якості гідрогеологічних досліджень. Це дозволить підвищити надійність будівель і споруд, що проєктуються, а також знизити ризики виникнення і активізації небезпечних інженерно-геологічних процесів.

Ключові слова*: інженерно-гідрогеологічні вишукування; небезпечні геологічні процеси; нормативна документація у сфері будівництва; інженерний захист територій; підтоплення; фізико-механічні властивості ґрунтів; шкідливий вплив підземних вод; складність інженерно-геологічних умов.*

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