

## ANNOTATION

dissertation work of Borash Bokenbai Rabbimuly on the topic:  
**«Development of an effective technology for the construction of large-diameter water wells (on the example of the Mangistau region)»**,  
submitted for the degree of Doctor of Philosophy (PhD) in the specialty  
8D07208-Geology and exploration of mineral deposits

### **The relevance of research:**

There is a noticeable shortage of water resources in the Republic of Kazakhstan, which is a consequence of the natural features of the territory and climate. The Earth's surface, including the south and west, is often covered with salt marshes and salt flats, and permeable horizons close to the surface contain water with high mineralization and cannot be used for household needs.

Since 2002, several programs have been consistently implemented in the country (“Drinking Water”, “Ak-Bulak”, the State Program for the Development of Regions), the purpose of which was to provide the rural and urban population with high-quality drinking water from centralized sources of water supply systems. For this purpose, it is planned to finance 1.3 trillion. tenge, 2015 projects were implemented. Unfortunately, for a number of reasons, the implementation of these programs did not allow solving the problems of water supply in certain regions.

The Mangistau region is an industrial region, the basis of the economy of which is the oil and gas sector, which produces about 10% of the country's industrial output.

The region is supplied with water from the Astrakhan-Mangistau conduit of desalinated sea water, as well as from sources of natural groundwater, but there is still a shortage of water. The need for drinking water is 149 thousand m<sup>3</sup> per day, and there is a deficit of 51 thousand m<sup>3</sup>, with an increase in the future.

On the territory of the Mangistau peninsula, as a result of prospecting and exploration, a number of underground water deposits suitable for development were discovered. The explored Samskoye deposit is typical. It has an area of 1500 km<sup>2</sup>. Water-bearing formations have the shape of lenses and are represented by fine-grained sands with small admixtures of medium and fine-grained sands. The field has been in operation since 1970. A number of wells have been drilled with a low flow rate, their depth does not exceed 50 m and a small diameter of -150 mm. According to the reports, the total water withdrawal does not exceed 18% of the explored resources, and the problem of water supply for settlements is still acute.

In this regard, studies aimed at the use of technological drilling tools that can significantly increase well flow rates and improve the quality of produced water are very relevant.

### **Rationale for the need for this research work:**

The problem of a sharp increase in the use of groundwater from the Samskoye field can be solved by drilling wells with an increased diameter up to (500-1500 mm). This will make it possible to repeatedly increase the flow rate of water wells. It becomes possible to create a powerful layer of gravel packing, which improves the quality of produced water and increases the life of wells. Drilling wells with reverse flushing contributes to a multiple increase in the speed of the upward flow and the quality of bottomhole cleaning, and, consequently, the speed of deepening. Such wells are drilled with technical water flushing, which eliminates clogging in the well zone, contributes to a significant increase in water

inflow from the formation into the well, and the low downflow velocity practically eliminates the risk of well wall collapse.

There are two ways to create a backwash: back-suction using centrifugal or vacuum pumps and the second - using an airlift. Drilling with reverse airlift flushing is preferred for use in the development of the Samskoye field, taking into account the following qualities inherent in the method: simplicity of the device, the ability to pump out contaminated water and a large depth of the well (up to 500 m, depending on the characteristics of the compressor). At the same time, the widespread use of the airlift method when drilling water wells of large diameter is hindered by the need to use special three-channel (including compressed air supply channels) expensive drill strings, which dramatically increase labor costs and tripping time. Thus, solving the problem of abandoning special drill pipes in the airlift flushing method and replacing them with commercially available columns opens the way for the widespread introduction of large-diameter well drilling at Samskoye and many other groundwater deposits.

**The purpose of the dissertation:** The purpose of the work is to increase the flow rate of water wells constructed in geological conditions similar to the Samskoye field by using high-performance large-diameter rotary drilling with airlift flushing.

**Research objectives:**

- analysis of existing well drilling methods and justification for conducting studies of rotary drilling with airlift flushing;
- study of the geological features of the Samskoye field and justification of the feasibility of constructing large-diameter water wells with airlift washing;
- drawing up the design of a typical large-diameter water well during development at the Samskoye groundwater deposit;
- compiling a computer model for the construction of a typical water well at the Samskoye field;
- development of a mathematical algorithm for the operation of an airlift when drilling a typical water well;
- development of a technological scheme for the construction of a water well;
- calculation of the expected efficiency of the construction of water wells with airlift flushing according to the proposed technology.

**Object of study** - aquifer at the Sam field.

**Subject of study** - water well drilling technology at the Samskoye groundwater field.

**Research methods:**

- analysis of scientific and technical literature on the topic of research;
- patent research and filing an application for an invention;
- mathematical modeling of the construction process of a typical large-diameter water well with airlift flushing, taking into account the idea embodied in the RK patent;
- a detailed assessment of the design parameters of the functional circuit developed in the RK patent for an invention.

**Basic provisions for defense:**

1. The analysis of the pressure balance in the annulus and in the drill string during drilling of water wells with reverse airlift flushing makes it possible to establish, with a given accuracy, the average effective values of the output parameters: water flow as it approaches the mixer.

2. During rotary drilling of wells with reverse airlift flushing, with an increase in the depth of the well and the immersion of the mixer, the average effective value of the density

of the slurry-water-air mixture increases according to a logarithmic dependence, and its ascent rate and volumetric air flow decrease according to a power-law dependence.

3. During rotary drilling of wells with reverse airlift flushing, the average effective value of the density of the slurry-water-air mixture is inversely proportional to the mechanical drilling speed, and the speed of its ascent and the volumetric air flow are directly proportional.

The completed dissertation work has a connection with other studies on large-diameter well drilling.

**Scientific novelty of the work:** It is shown for the first time that the analysis of the pressure balance in the annular space and in the drill string makes it possible to set the average effective values of the output parameters with a given accuracy: the density of the sludge-water-air mixture, the drilling speed, the speed of its upward flow and the air flow at a given speed of the upward flow of water when it approaches the mixer. For the first time, a technique has been developed for the transition from the average-effective values of the output parameters of airlift washing to their average-interval values for a given depth. This makes it possible to establish the dependence of the values of the output parameters on the depth of the well, as well as the required compressor performance to ensure a given speed of flushing with drilling mud.

**Substantiation of the novelty and importance of the results obtained:**

The novelty and importance of the results obtained is confirmed by the issuance of a patent of the Republic of Kazakhstan for the proposed device, which greatly simplifies and reduces the cost of the technological scheme of the drill string for supplying components.

**The practical significance of the work:** as a result of research and analysis of existing technologies for drilling water wells, it was found that for the operation of the Samskoye field, drilling with reverse airlift flushing will provide a significant increase in the flow rate and quality of produced water. Modernization of the drill string in accordance with the patent of the Republic of Kazakhstan significantly reduces the time of tripping operations, which, when using previously used special strings, significantly exceeds the time of pure drilling. A significant reduction in the cost of the drill string opens the way to solving the problem of water scarcity through the widespread use of the method of drilling large diameter water wells. The created computer model will contribute to optimal planning and implementation of large-diameter well drilling technology.

**Compliance with the directions of scientific development or state programs:**

The dissertation solves the problem of increasing the utilization rate of groundwater reserves at the Samskoye field. Its content is in line with the State Programs "Drinking Water" (2003-2010) and "Ak-Bulak" (2011-2020), as well as the State Program for the Development of Regions (2020-2025).

**The personal contribution of the author** lies in the fact that the main calculations and the creation of a model of the airlift washing process compressor and the idea embodied in the received patent for the invention were obtained and developed personally by the applicant. The formulation of the problem and discussion of the results were carried out jointly with scientific consultants.

**Reliability of results:** The reliability of theoretical scientific provisions, conclusions and recommendations is confirmed by the fact that they are based on the known laws of hydraulics and computational mathematics and are confirmed by the practice of airlift drilling.

**Description of the main research results:** Based on the results of the research, the following main conclusions can be drawn:

1. An analysis of the geological and hydrogeological characteristics of the Samskoye field was carried out in terms of ensuring the maximum flow rate of boreholes. The analysis showed that aquifers are composed of sands with a filtration coefficient of 5-7 m/day, and the thickness of the layers is on average 10-20 m, and the depth of occurrence reaches 200 m. Aquicludes are represented by clayey rocks. The drillability of the rocks of the deposit does not exceed the fourth category according to uniform production rates.

2. An analysis of the effectiveness of methods for drilling large-diameter wells in the conditions of the Samskoye field was carried out. The construction of water wells is carried out by a rotary method with direct flushing or by a shock-rope method. The first of these methods usually creates wells of small final diameter, there are difficulties with the creation of a gravel pack and a reduced flow rate due to clogging of the near-wellbore zone of the aquifer. The second method is characterized by low labor productivity, high casing consumption and limited well depth.

Therefore, previously used methods for the construction of water wells do not allow for the water withdrawal necessary to meet the needs of the region..

3. As a result of a comparative analysis of existing advanced well drilling technologies, it was found that for the conditions of the Samskoye field, the most effective is the use of rotary drilling with reverse airlift flushing.

At the same time, the use of special flanged connections of drill pipes leads to high time spent on round-trip operations and build-up of the drill string. To further improve the efficiency of airlift drilling, it is necessary to develop a tripping technology that will ensure the use of commercially available oil-standard drill pipes.

4. To establish rational parameters of the airlift during drilling, it is necessary to develop a methodology taking into account the changing depth of the well, pressures in the annulus and drill string, the depth of the mixer.

5. Based on the analysis of the geological and geographical conditions for the construction of water wells in the Mangistau region, a typical model for drilling a water well was developed.

6. A mathematical algorithm has been developed for studying the airlift circulation method in rotary drilling with backwash, based on the analysis of the pressure balance in the annulus and drill string that occurs during drilling. Computer models have been created that make it possible to investigate the main dependences of the required values of output parameters (washing water and compressed air supply, mixture density, etc.) on the following parameters: drilling depth, actual well diameter, drill pipe diameter, deepening speed, upflow speed and etc. Calculations were made in relation to a typical well, some parameters of which were changed to obtain the corresponding dependencies.

7. It is shown that the reverse suction method using a centrifugal or vacuum pump is limited by the maximum depth of the well, since its use cannot exceed a certain fraction of atmospheric pressure. Most often these are wells up to 50-100m deep.

The depth of the airlift well depends on the power of the compressors used and can reach up to 300 and even 500 m. At any depth, the airlift method requires a higher travel speed than the reverse suction.

Further improvement of the airlift method can be implemented with the introduction of the proposed device and the creation of a drill string, for which a patent of the Republic of Kazakhstan has been received.

The essence of the invention lies in the fact that ordinary standard drill pipes are used, along the axis of which there are hoses for supplying air with connections, and the lower end of the air line is equipped with a mixer and connected to the drill collar, and the

drill pipe located above the drill collar is perforated. The necessary calculations have been made and the required characteristics of the components of the proposed device (hoses, weighting agent, guide pipe, winch, rollers) have been obtained, which serve as the basis for the development of technical documentation.

8. The developed technology for the construction of large-diameter water wells with airlift flushing and an improved version of the circulation system are prepared for implementation for drilling at the Samskoye field.

9. Evaluation of the expected technical and economic efficiency of implementation: the abandonment of special multi-channel drill strings with flanged connections in favor of commercially available drill strings will reduce the cost of building a typical 200-meter large-diameter well by 3419000 tenge, namely, to reduce it by 69.0% compared to the option using special columns. Rejection of special drill strings will reduce the cost of equipment by 2001000 tons.

10. Evaluation of the scientific level of the work performed in comparison with the best achievements in this field.

The performed studies and the results obtained correspond to the best achievements in the field of drilling large-diameter water wells.

#### **Publications and approbation of work:**

Based on the results of scientific research, 8 articles and reports were published, including 2 works in an international scientific publication included in the Scopus and Clarivate Analytics database and having a non-zero impact factor, and 2 articles in scientific publications recommended by the Ministry of Science and Higher Education of the Republic of Kazakhstan. As part of the tasks of the dissertation work, a patent of the Republic of Kazakhstan “Air supply device for drilling wells with backwash using an airlift” was obtained.

#### **Description of the contribution of the doctoral student to the preparation of each publication:**

All mentioned publications are based on the dissertation work of a doctoral student and reflect all its sections. The results presented in the sections are obtained personally by the applicant and discussed by scientific consultants.

Based on the materials of the dissertation, 8 scientific papers have been published. The scientific results of the research work were discussed in published scientific dissertation articles, at international scientific and practical conferences:

1. Muzapparova A. B., Borash B. R. On the results of preliminary exploration of groundwater in the Mangystau region / Collection of scientific papers of the II International Scientific and Practical Conference “Modern trends in geological exploration and petroleum engineering. EE "Caspian Public University" April 16, 2021, Almaty) C.99-103, ISBN 978-601-7940-24-9.

2. Borash B. R., Kozhakhmet K. A., Khomenko V.L. Selection of the optimal method for drilling water supply wells in relation to the conditions of the Mangystau Peninsula / Collection of scientific papers of the III International scientific-practical conference “Modern trends in geological exploration and petroleum engineering. EE "Caspian Public University" April 14-15, 2022, Almaty) C.3-7, ISBN 978-601-7940-24-9.