Positioning underground reservoir by underground dams by using geoelectric method

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Abstract

Today, saving and storing water are among the most critical and important issues which have attracted the world's attention. History of storing water in the form of ghanat and water reservoir by Iranians goes back to ancient times. Studies on this field show that benefiting from underground dams was one of the methods employed for exploiting water in past times. In countries like Iran, due to experiencing noticeable variations in groundwater levels during dry and wet seasons, this method has been considered beneficial for refining and storing water in dry seasons throughout the year. Following field studies and investigation of geological and geoelectrical properties of the region, this article presented the method of positioning the best site for constructing an underground dam and making an underground reservoir. In this paper, Watershed Koohzar Underground dam has been studied.

Keywords: Underground Dam, Water Storage, Groundwater, Geoelectric, Water Reservoir, Koohzar.

1– Introduction

Reduction of surface water resources due to less rainfall and climatic changes, increased water consumption due to population increase and drastic loss of groundwater tables in dry seasons and dry years as a result of drought is among essential and critical challenges of the countries in dry and semi–dry regions (Merati *et al.*, 2011).

Dry and semi–dry climates, which constitute a wide section of Iran, play a deep and fundamental role in emerging various architectural phenomena in this land. Therefore, since ancient times, in most wide plains of Iran, noticeable attempts have been made to access water. Relying on their whole capabilities, Iranians have excavated tens of kilometers of ghanat. In addition to making ghanat and dams, they have paid attention to storing a great deal of winter water to be consumed during dry seasons. To this end, they have innovated water reservoir.

The method and technique of making a water reservoir have a specific genuineness because, relying on their accuracy and perspicacity, makers of the units have considered principle rules like magnitude of pressure applied by water to reservoir bed, method of coating reservoirs' internal surfaces, ventilation of reservoirs, water refinery and avoiding its pollution. Reduction of vaporization rate, avoidance of water heat and decomposition (owing to the reservoirs' construction technique) and similar effects related to the performance of underground dam make it possible to integrate construction method and quality of storing and exploiting water in dry and semi–dry regions and take more effective steps towards eliminating the problems generated due to limited water resources in the regions.

On this ground, correct management of available water resources, saving and storing groundwater resources and making water available all over the year in some specific regions through making underground alluvial tanks and reservoirs by underground dams are among beneficial methods for solving the problem (Majidi *et al*., 2007).

Regarding the important and essential role of geology parameters like permeability rate, discharge coefficient and water quality as well as bedrock's steep and shape in the volume of stored water, this article accurately studied quality of investigation and determination of the proposed axis for making dams and underground reservoirs. The reservoir's site and depth were estimated based on geoelectrical, geological and local studies. Then, the exact location for constructing reservoirs using an underground dam was determined by field measurements and supplementary studies.

2– Geographical conditions

The Koohzar watershed was located in the south Semnan between 35˚, 20′, 17″ and 35˚, 30′ N (latitude) and 54, 22′, 30″ and 54˚, 45′, 08″ E (longitude). Outlet of surface and subsurface flows of the region ended to Kavir desert, which was out of access.

Average precipitation was 202.7 mm with mean annual temperature of 16.82 .˚ Average vaporization rate was estimated as 1175 mm. Flows were seasonal and discharged to the desert within a short time. According to De Martonne (Tabatabaei Yazdi *et al*., 2006), classification, the studied region was located in the dry to semi–dry climate.

According to the obtained relations between the area and monthly and annual discharge of the studied stations, overall annual discharge of the region was 5676480 m^3. Magnitude of hydrodynamic coefficient in the test pits was measured by in situ test (Lovran test- (Tabatabaei Yazdi *et al*., 2006) and reservoir alluvium was considered 0.003 cm/s.

The results of different hydro–chemical analyses of subsurface water were mostly within allowable tolerance or below maximum allowable rate for different consumptions. Its chemical quality was in good to relatively good range (PRWSC, 2001).

3– Geological setting

The studied region was placed inside northern regions of Central Iran Zone. According to Nogol-e-Sadat and Almasian classification (1993) (Ghorbani, 2013) which was proposed to Iran based on geological status and tectono–sedimentary units, the studied region was inside central magmatic subzone of Iran with many magmatic activities experienced in past times (Tabatabaei Yazdi *et al*., 2006).

Lithology of heights of the studied zone was a mixture of igneous, metamorphic and sedimentary rocks. A vast majority of surface was composed of extrusive igneous rocks as well as metamorphic rocks, most of which were primary igneous rocks. The studied axis for constructing a water reservoir was covered with disjointed sediments, some of which were accumulated in cement form and, some others were sediments of stream channel and dried river beds.

4– Geoelectric Studies

Geoelectric specific resistance is one of the best methods for evaluating aquifers and exploring groundwater resources as well as determining specifications of ground layers and shape of bedrocks (Memariyan *et al*., 2006; Afkar *et al*., 2010). Accordingly, geolecetric studies were conducted in the region in two stages in order to determine bedrock's depth and shape as well as alluvium thickness. In the first stage, 7 electrical soundings were applied to the region. In the surveys, the maximum distance between flow electrodes was 200 m, which provided penetration depth of 50 m. After analyzing results of the first stage surveys and defining selection of the studied region, in the second stage, 8 electrical soundings with similar specifications to the first one were conducted to finalize data collection and completely cover reservoir and axis areas. Data analyses, graph of geoelectrical cross sections and map of bedrock's isodepth were done and drawn using the results derived from the applied soundings as well as a few exploration boreholes. Figure 1 shows the location of harvest levels electrical catheterization.

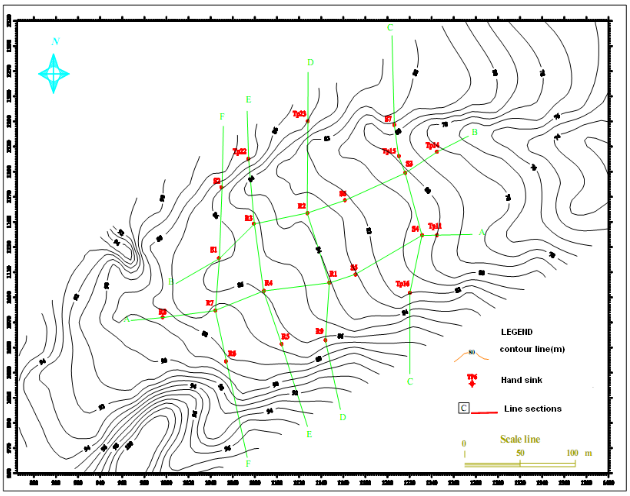

Figure 1) Location sections harvesting electrical cauterizations.

5– Volume of Reservoir Tank

Variation of the reservoir live storage to underground dam level was determined in the proposed axis using bedrock's topography as well as alluvium hydrodynamic specifications. On this ground, if underground dam was raised by 8 m up to the ground level in river bed, volume of the water stored in the made reservoir would be 6230 m^3.

6– Discussion

6–1. Specific Resistance of the Layer

Investigating results of the electrical sounding indicated a bi–layered model at the studied depth. The bi–layer consisted of alluvial layer and the beneath bedrock. Table 1 shows specific electric resistance obtained from comparing the layers' specific electric resistance in different soundings (Tabatabaei Yazdi *et al*., 2006).

Table 1) Comparing layers' specific resistance.

Layer type	Electrical range of specific resistance (ohm–m)
Alluvial layer	54–319
Bedrock	14–90

6–2. Describing Geoelectric Cross Section

Sounding results made it possible to draw two longitudinal sections A and B along stream channel and four lateral sections C, D, E and F parallel to the axis. The sections showed axis boundaries, reservoir tank and axis location (Tabatabaei Yazdi *et al*., 2006).

6–3. Longitudinal Geoelectric Cross Section A

The section showed alluvium thickness variations from the axis location up to 250 m off its upstream. It also demonstrated a bi–layered model. Bedrock steep was not the same in this section.

6–4. Longitudinal Geoelectric Cross Section B

This section again showed a bi–layered model. Alluvium layer of this section was larger than that of section A and its bedrock variations were less than those of section A.

6–5. Longitudinal Geoelectric Cross Section C

This section was located almost within the proposed axis for constructing water reservoir. Among the lateral sections, maximum alluvium thickness was in this section. Increasing electrical resistance towards the left support implied the existence of coarse–grained alluviums in this part of the section. Figure 2 shows geoelectric cross section C.

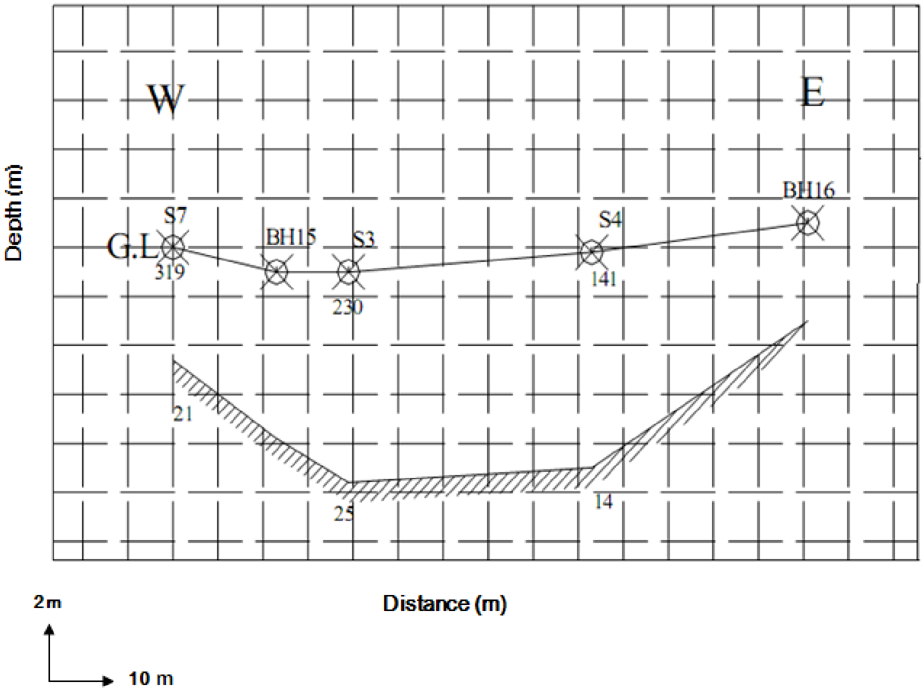

Figure 2) Geoelectric cross–section C.

6–6. Longitudinal Geoelectric Cross Section C

Bedrock variations of this section indicated that bedrock was located higher than its downstream and upstream levels throughout the section (Fig. 3).

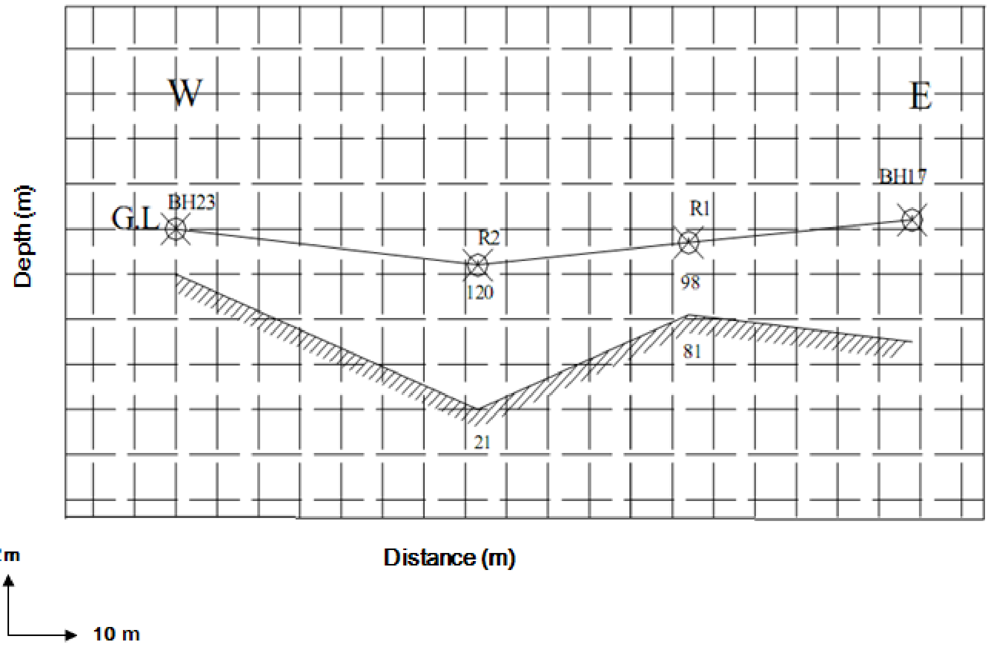

Figure 3) Geoelectric cross– section D.

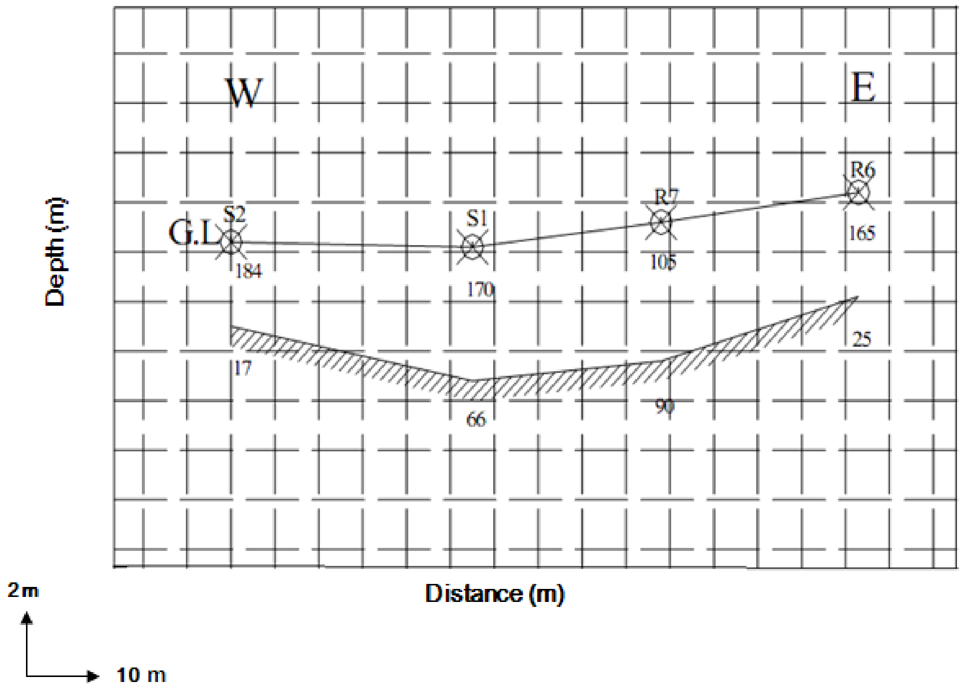

Figure 4) Geoelectric cross– section E.

6–7. Longitudinal Geoelectric Cross Section E

As shown in the Figure 4, the geoelectric cross section E was considered at the end points of water reservoir's tank.Table 2 shows electrical resistance in different layers of the studied sections.

Table 2) Layer's electrical resistance in different sections.

Section	Alluvial layer's electrical resistance (ohm–m)	Bedrock's electrical resistance (ohm–m)
A	161–89	–
B	241–129	66–18
C	319–141	25–14
D	120–98	81–21
E	184–105	90–17

7– Conclusions and Suggestions

Studying all electrical sounding results as well as drilled boreholes in the boundaries of the axis, water reservoir's tank and geoelectrical cross sections and the drilled exploration boreholes log resulted in the following conclusions:

1- Maximum and minimum thickness of the alluvium in the boundaries of the axis, underground dam tank or reservoir were 2m and 7.8m, respectively, and there was agglomerate conductive bedrock beneath the alluvium.
2- Considering that water was observed in some boreholes, a subsurface water flow was confirmed in specific routes. However, the existence of an aquifer on the bedrock was not confirmed.
3- Regarding alluvium thickness in the boundaries and around lateral section C, results of electric soundings and considerable volume of reservoir, the proposed axis was considered a proper location for constructing an underground reservoir. The higher electrical resistance, which indicates implied the existence of coarse–grained alluviums in this part of the section

To supply drinking and agricultural water in far desert regions, optimal management of subsurface water resources and constructing underground reservoirs using underground dams are recommended. To this end, the integrated plan for constructing and exploiting reservoir and underground dams by observing all engineering and technical issues is proposed as follows (Fig. 5):

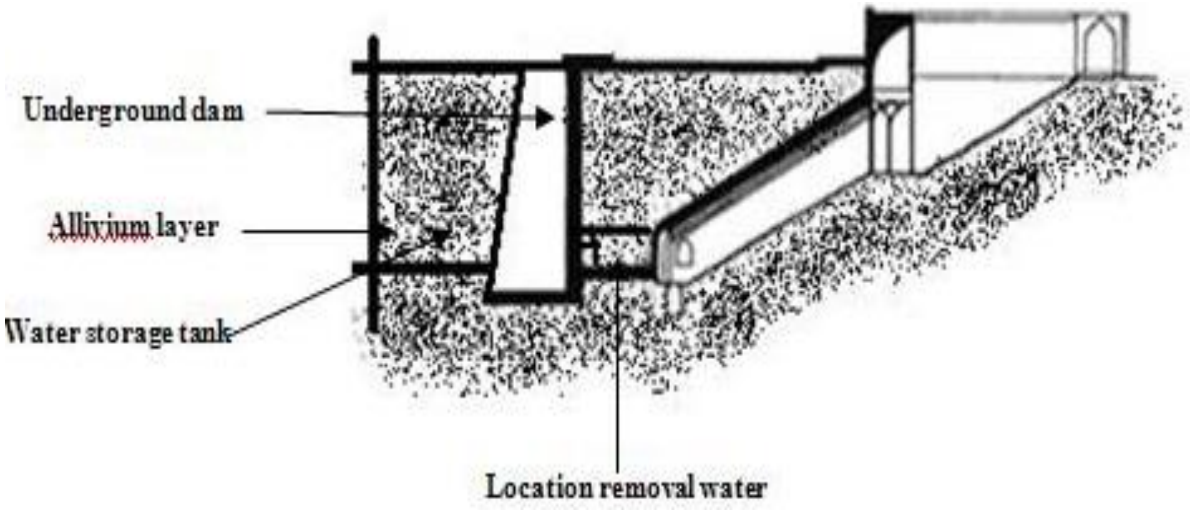

Figure 5) Integrated design, construction and operation of water storage and underground dam.

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