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DRAFT REPORT ON HYDROGEOLOGICAL SURVEY REPORT OF A NEW EXPLORED AQUIFER (LIGLE & LAAN ALI FIRIN), SOUTH WEST OF GAROWE CITY, PUNTLAND STATE OF SOMALIA

GRDSC Techniques and tools

Integration of Remote sensing, GIS and geophysical techniques to delineate groundwater aquifers.

Client: Puntland Water Development Agency

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Executive summary

This report summarizes the results of the Hydrogeological survey carried out by GeoResource Consultant to investigate the groundwater potential aquifer of south west Garowe area in Nugal Region.

The purpose of the water investigation of this site is to identify the aquifer parameters. The investigated area is covered by Gypsiferous sand and marls which overlay the Taleex Formation.

During the survey, five drilled boreholes were visited and gathered the hydrogeological information as well as geophysical investigation that was conducted before the drilling the boreholes.

The study found that this this aquifer is the most strategic and potential to cover the demand of water supply to the Garowe city, it has the highest yield that was recorded in more than one borehole with several km² area. Also the quality of water is more promising than the any other aquifer according to the others such as Jibagalle and Sallaley.

The study recommends that the stakeholders should focus and invest to that new aquifer area, however it important to plan conduct a detailed study since the location lies the upstream of the town where the pollution risk is absent.

1 INTRODUCTION

1.1 Project objectives

The main objective of this study was to identify a new promising aquifer characteristics in order to supply safe and sufficient water to residences and nomadic community as well as address hygiene and sanitation issues.

The specific objectives of this survey include:

- ☐ To investigate subsurface geology and hydrogeology of the area, in order to establish the depth, thickness and the pattern of any potential aquifer/s.
- ☐ To observe surface geology, local topography and drainage system to determine potential recharge, water distributing structures and suitable site for storage tank.
- ☐ To record subsurface geological units likely to be encountered during drilling.
- ☐ To identify suitable sites for borehole drilling and state their depth as well as drilling method.
- ☐ To respond to the water shortage in the Garowe city.

1.2 Location and Accessibility

Garowe is the capital of Nugal region and administrative capital of Puntland state in northeastern Somalia. The geographical coordinates of the town are 48.483056 ° East Longitude and 8.406389 ° North Latitude with an average elevation of 465 m. Garowe is traversed by a 750 km north-south highway. It connects major cities in the northern part of the country, such as Bosaso and Galkayo with towns in the south.

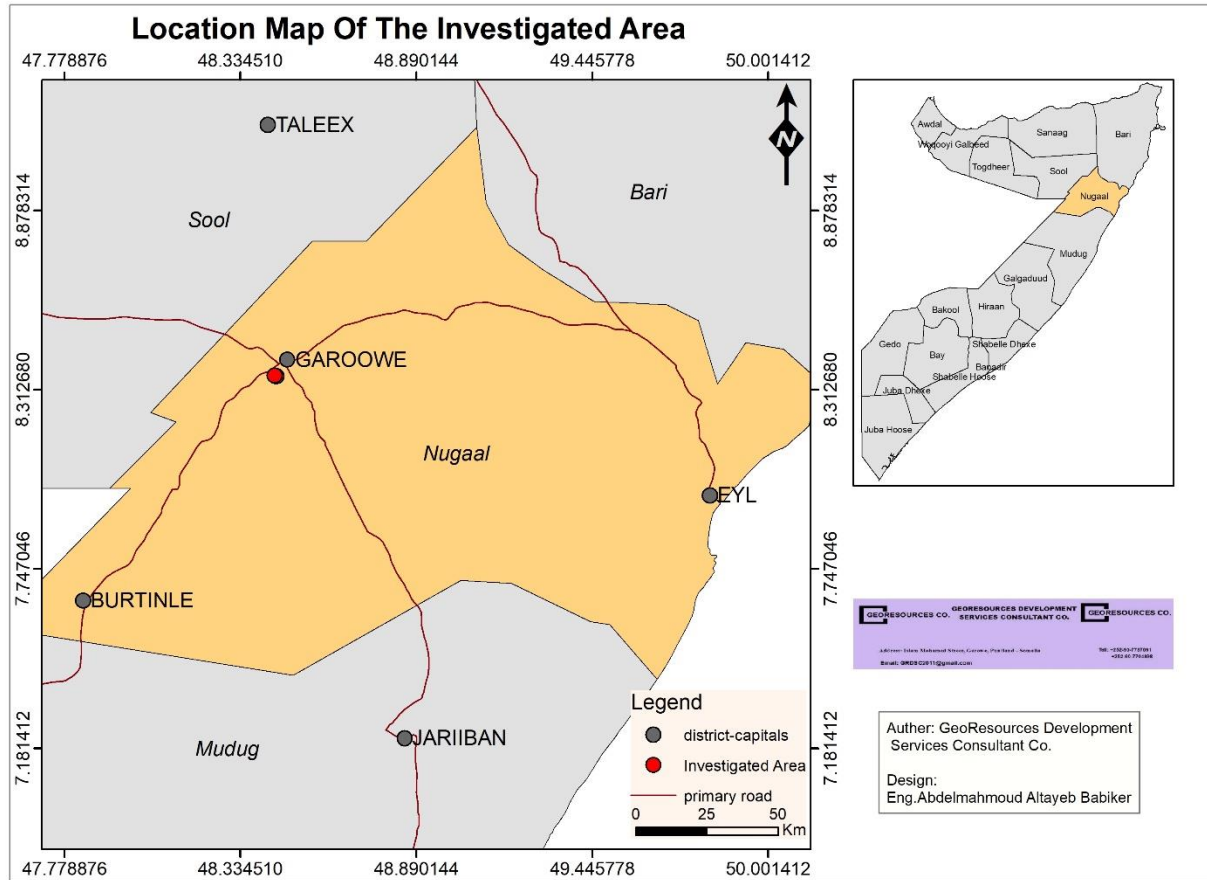


Figure 2: Location map of study area.

1.3 Climate

The general climate of northern Somalia ranges from very arid to semi-arid to temperate. Garowe has a desert climate. There is virtually no rainfall during the year in Garowe. The Köppen-Geiger climate classification is BWh. The average annual temperature is 25.7 °C in Garowe precipitation here averages 123 mm. The driest month is July, with 0 mm of rainfall. Most of the precipitation here falls in May, averaging 47 mm. The warmest month of the year is May, with an average temperature of 27.8 °C. January is the coldest month, with temperatures

averaging 22.5 °C. The difference in precipitation between the driest month and the wettest month is 47 mm. throughout the year; temperatures vary by 5.3 °C.

1.4 Physiography

Geomorphological, the investigated area is part of the Nugal valley, where slope increase gradually to the center of the valley (figure 3). The main drainage system is Garowe valley which runs from southwest of the town towards the main Nugal valley. The Garowe valley is part of a parallel drainage system from Haud plateau to Nugal basin which indicates the structural control nature.

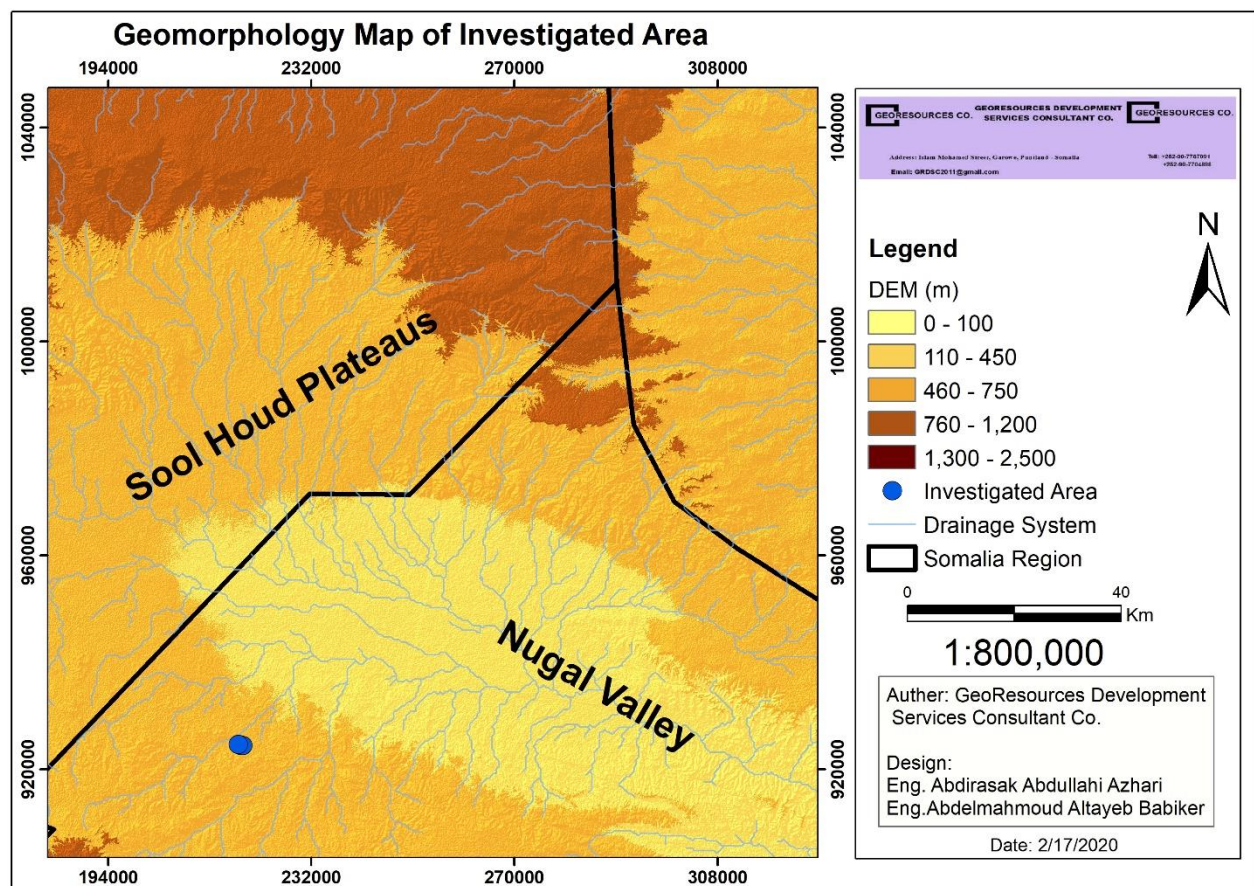


Figure 3: Geomorphological Map of the Investigated Area.

2 METHODOLOGY AND APPROACH

The feasibility of water supply source, identification and design activities have been made through the application of standard geological, hydrological, geophysical and engineering techniques. Basic data required for the design of the water supply were acquired from different sources as shown below.

The survey involved office and field works. The office work depended on collection of previous data, analysis of satellite images such as Landsat 8 and ASTER Digital Elevation Model (DEM) as well as employment of software such as Arc GIS 10.4.1, ERDAS 2014, PCI Geomatica-2018 and IX1D. In this stage, remote sensing and GIS techniques were applied to identify suitable sites to conduct the geophysical survey addition to hydrogeological setting and structural geology that affect the groundwater occurrence.

Instruments that used in the field measurement include SAAS1000 instrument, cables, electrodes, hummers, GPS and Camera.

2.1 Existing Data and Collected Materials

A) Digital Topographic, Hydro-SHEDS Database and Geological Maps

- ❖ Drainage networks covered by the study area
- ❖ ASTER Digital Elevation Model (DEM) at 30 m resolution covering the entire Puntland and Somali Land were obtained and used to model the topography, local physiographic and drainage systems addition to the determination of the Lineaments, fractures and faults zones in the investigated area.
- ❖ Landsat 8 satellite image which covering large areas of Puntland and Somali Land including the investigated sites were collected and analyzed to delineate the lithology and the structural geology of the investigated area.
- ❖ Geological Map of Puntland and Somali Land at prepared which obtained from SWALIM, Somalia in 2012.

B) Reports Reviewed

- Water quality data book of Somalia – Hydrogeology and water quality of Northern Somalia 1986 by Faillace and Faillace.
- Hydrogeological Survey and Assessment of Selected Areas in Somaliland and Puntland, Somalia Water and Land Information Management (SWLIM), December 2012.

- Geological – Hydrogeological – Geophysical Study, technical report by Terre Solidali in Garowe July 2014
- 12 Sites Hydrogeological site investigations in Puntland including Carmo BH by SHAAC Consulting Company, May 2016
- 16 sites Hydrogeological and Geophysical Survey in Garowe District by GeoResource Development Service Consulting Company, FEB 2018 – Sep 2020.



Figure 4: Geophysical Equipment used during the field work

3. Geology of the investigated area

Two Eocene formations and Alluvial deposits dominate the geology and hydrogeology in Garowe city area. These formations play a major role in the geology/hydrogeology of the study area and its surroundings. These formations are from top to bottom:

- **Alluvial Deposits** (Recent)
- **Karkar Formation** (Upper Eocene)
- **Taleex Formation** (Lower Eocene)

The name of the formation was derived from the first or geological section place that was described and it is not represents only this area but all rocks which have the similar facies and geological environments.

1. **Alluvial Deposits:**

Overlying deeper major Taleex and Karkar formation aquifers.

2. **Karkar formation:**

The Karkar formation is constituted by fossiliferous bedded, whitish and light grey chalky limestone, Marly limestone and white marls. Limestone is often cavernous; its color varies from white to yellow to brown. This sequence is generally conformable on the Taleex formation, and its thickness varies between 200 and 400 meters. Fissured-karstic aquifer moderate to good permeability.

3. **Taleex formation:**

This formation is named after the town of Taleex in Sool region, where it outcrops for a section of about 250 meters. It overlies the Auradu formation and consists of a sequence of massive and dense anhydrite beds with intercalations of limestone and gypsum. Clay, sand and layers of gravel deposited by rivers in shallow agonal evaporitic environments are also locally present in this sequence. Taleex formation changes from an evaporitic nature on the upper part to dolomitic and dolomitic limestone with much intercalation of marls and shales, due to the presence of karstification the aquifer has moderate to good secondary permeability often with various degree of salinity.

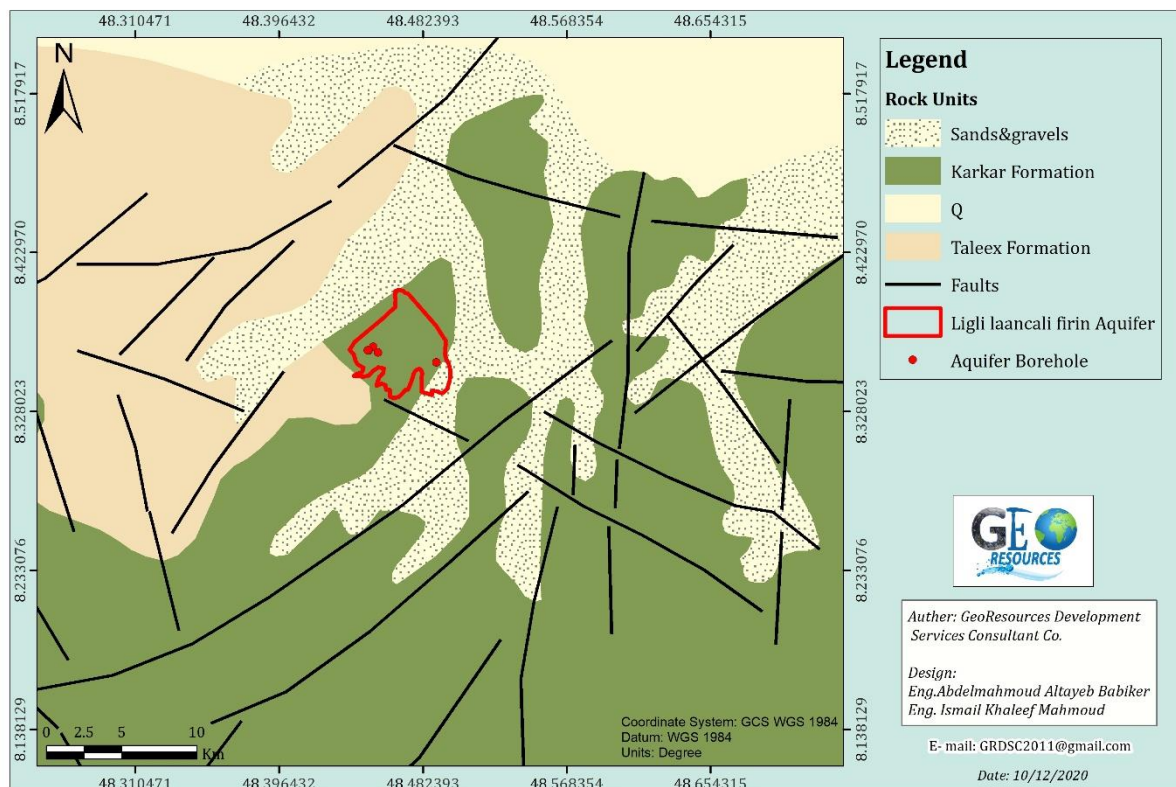


Figure 5: Geological map of the study area (Adapted from E. ABBATE, et al., 1993, Scale: 1: 1,500,000).

4. Hydrogeology of the study area

The groundwater system in the investigated area is controlled by structure geology, which affected by fractures/cracks (karstic landform) and drainage system in the area; however, the highest yield was recorded in the alluvial plain area and the lowest yield in badland and Escarpments areas.

In these areas infiltration occurs mainly in the sandy alluvial deposits of the stream beds and floodable depressions, and in the underlying rocks, if they are permeable. Rains of short duration generally do not generate recharge due to the high temperature and hot dry winds which accentuate the evaporation, estimated between 2000 and 3000 mm/year.

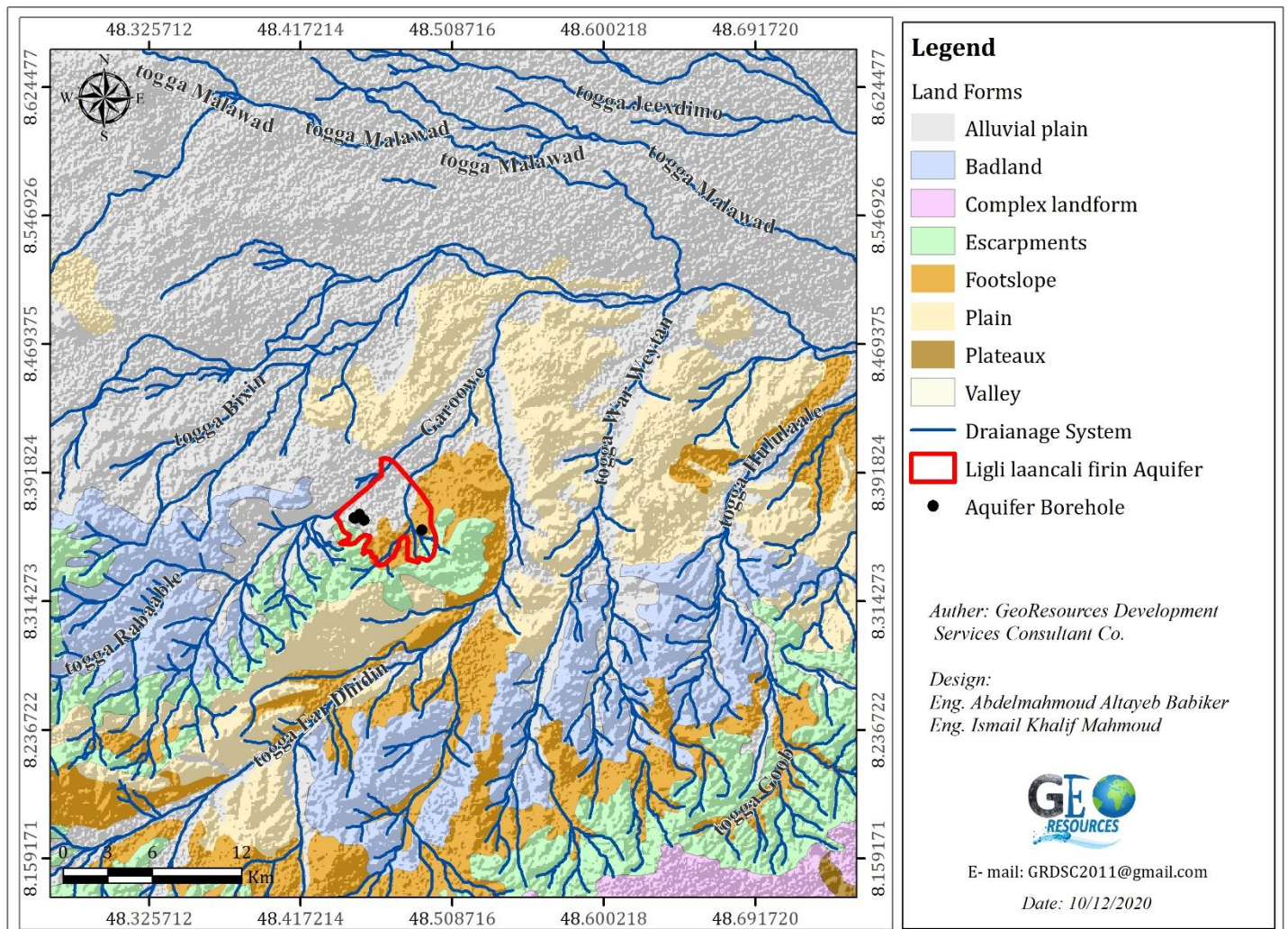
Recharge:

Recharge occurs mainly during April and May, when medium to heavy showers account for 40-60% of the annual rainfall.

Recharge of Karkar and Taleex formations, which cover most of the study area, occurs through fissures, joints and karstic/sinkholes depressions. These formations have been deeply incised by streams and dissected by several faults (fig 4).

Landforms:

Generally, the landforms of the study area consist of Complex landform, Alluvial plain, Badland, Escarpments, Foot slope, Plain, Plateau and Valley, drained by several streams running southeast towards Indian Ocean (Fig.5). the new explored Ligte and Laan Ali firin aquifer lies on the alluvial plain, this



Aquifer Parameters:

The result of boreholes drilled in this aquifer have been the key of the good indicator and also good news for water shortage of the city. The water table is generally shallow and less than 70 m. the recorded yield is the highest peak that was encountered since the first well was drilled by GIZ, in the other hand the depth also moderate and it is in the range between 80 m to 160 m.

In this aquifer the most interesting parameter is the water quality which has A TDS about 1600 ppm.

Borehole Name	Lat	Long	Depth (m)	Yield (m³/h)	TDS ppm	S.W.L (m)	D.W.L (m)
Amal	8.35727 °	48.49041 °	110	40	1550		
Ali Diiriye	8.36664°	48.45275°	90	57	1650	10.4	17.6
Ligle 1	8.364374	48.44995	165	40	1580		
Ligle 2	8.364607	48.44958	70	40	1620		
Kadleeye	8.36328	48.45555	105	60	1685		

Table 1: Some hydrogeological parameters of five Drilled boreholes within Ligle and Laan Ali Firin aquifer

Conclusions

The investigated area is promising groundwater of the unexploited aquifer, where both hydrogeological and scattered geophysical investigations that are not presented in this report show good anomaly of groundwater occurrence highly permeable aquifer. The recorded aquifer parameters indicate that high yield and the best quality that was not met from the other aquifers are present in Ligle and Laan Ali Firin aquifer

5. CONCLUSIONS AND RECOMMENDATION

1. The nature of this study is preliminary investigation based on scattered data collected through local hydrogeological and geophysical company called GeoResource Development Service consultant with collaboration with Puntland Water Development Agency
2. The geology of the investigated area is predominated by, Taleex Anhydrites covered by Marl and Gypsiferous sandy clay of recent alluvial deposit.
3. The water bearing layer in the investigated area is highly weathered and permeable limestone interbedded with anhydrite of different degree of weathering.
4. From hydrogeological data that was gathered from several boreholes within the aquifer highlights that the Lige and Laan Ali Firin area has a high potential aquifer.
5. **So our recommendation is to conduct more and detail hydrogeological and geophysical investigation for drilled borehole**