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IDENTIFYING AND MAPPING POTENTIAL GROUNDWATER USING THE 1-D GEOELECTRIC RESISTIVITY METHOD AT BOA VILLAGE, ROTE NDAO REGENCY,EAST NUSA TENGGARA

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Abstract — *Water is a basic human need. Population in Rote Regenscy growth up very fast led to increased water demand, but water management does not meet the required quantity. Therefore, research is needed to map groundwater potential for clean water supply for the community. This research was conducted in Boa Village, Rote Barat Distric, Rote Ndao Regency, East Nusa Tenggara. The purpose of this study was to determine the groundwater potential in the aquifer and the lithology type, depth, and thickness of the groundwater aquifer based on the resistivity of the rock types. Data acquisition in this study was conducted using the Schlumberger 1-D geoelectric method. Measurements were taken at three sounding points with a span of 40–50 meters. Based on the results of the 1D Ip2Win data processing, it was determined that the subsurface lithology of the study area consists of top soil, overburden, coral reff, rock , limestone, and sand.*

Keywords — *Schlumberger , 1-D Geoelectric, Underground, 1D Ip2Win data processing*

I. INTRODUCTION

Groundwater is water that fills water saturated pathways, including springs that surface naturally. Groundwater is a vital source of water, especially in areas with no drains, streams and rain, and provides an indication of groundwater to the potential for community formation to the extent permitted by their validity in terms of quality and quantity. The geoelectric resistivity method is considered to be the most suitable and efficient method for groundwater exploration. It is based on the concept of subsurface determination, which can yield useful information on the structure, composition and water content of the soil. Geoelectric can also be used to determine the aquifer depth, stratigraphy and water quality of the aquifer [6]. It is one of the geophysical methods that study the nature of electrical current in the earth and to know the change of resistance of rock layers beneath the soil surface by passing a DC current (direct current) that has high voltage into the ground. This method is more effective for superficial exploration, such as determination of depth of bedrock, water reservoir search, and also for geothermal exploration. One of the physical properties of rock is its capacity carrying an electric current or commonly referred to as a type of resistance [7]. This capacity is used by humans to distinguish the type of rock without having to make physical contact or drilling that takes a long time and high cost, yet the accuracy level of data is reliable because the pumping test can provide important information on transmissivity and storativity of groundwater aquifers [8]

II. GEOELECTRIC BASIC PRINCIPLES

Basic Principles of Geoelectricity The workings of geoelectricity are based on simple physical principles, namely Ohm's law and the law of electric current distribution in a homogeneous medium. Essentially, this method relies on measuring the electrical resistivity of rocks beneath the ground's surface. Resistivity is a measure of a material's ability to withstand an electric current; the higher the resistivity, the more difficult it is for electric current to flow through the material.

Geoelectric is a tool for measuring the electrical resistance of rocks below the surface that is detected from above ground level. This tool can also be used to study the freshwater lens in coast aquifer. Investigation of the type of

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resistance can be carried out over long distances and long periods, from unsaturated layers to saturated seawater and freshwater zones. Large resistivity values often leading to quite complex interpretations, for example, are extreme resistivity values in freshwater saturated zones, which are hardly recognized by pressure [10]. Another problem of nonunqueness arises in the correlation of the resistivity layer with the hydraulic parameters. The working principle of geoelectric is to inject electrical current into the earth. The electrode consists of two current electrodes (C1 and C2, see figure 1) that deliver the electric current, and two potential electrodes reading the potential difference value after the current through the rocks (P1 and P2). The four electrodes are plugged into the ground at a certain distance. The longer the distance of the current electrode will cause the flow of electric current can penetrate deeper rock layers. With the flow of electric current, it will cause electrical voltage in the ground.
Electrical voltage occurring at the ground surface is measured using a multimeter connected via 2 voltage electrode P1 and P2, which is shorter than the distance of C1-C2 electrode. When the position of the electrode distance of the current is changed to be greater than the electric voltage, potential electrode also changes according to the information of the type of rock that participates in the injection of electric currents at a greater depth. See Fig. 1.

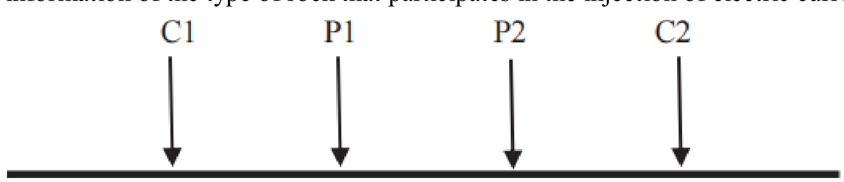

Figure 1. Simple Electrodes Array In Conventional Geoelectric Survey [11]
C1 = Current Electrode 1
C2 = Current Electrode 2
P1 = Potential Electrode 1
P2 = Potential Electrode 2

Resistivity can be done by configuration of Wenner, Schlumberger and dipole-dipole. However, the system of these four electrodes can be made effective for only three electrodes by keeping one of the far current electrodes from the rest of the electrode that it will have a negligible effect on the potential measurement. Hoel (1954) described a pole-dipole electrode system resembling the Schlumberger array, except that it uses only one current electrode. Eve and Keys (1956) and Coggon (1973) used three electrodes system, but only for profiling by keeping all three lines. The application of pole-dipole resistivity techniques for detecting cavity solutions under the highway was delivered by Smith (1986). A similar configuration has been proposed for resistivity where the position of the potential electrode is fixed and only one current electrode is used as the electrode moves along the line [12].

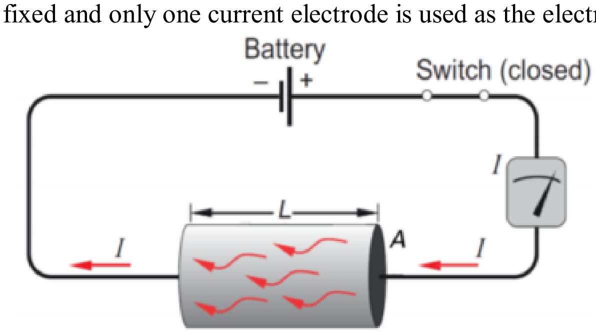

Figure 2. Fix Potential electrode one current electrode use as electrode move along the line.

Measurements for resistivity surveys are made by the streaming current into the ground through two electrodes type (potential electrode and current electrode), and measuring the resulting voltage difference across two potential electrodes. In its most basic form, the resistivity meter has a current source and voltage measurement circuit connected by cable to a minimum of four electrodes. The basic data obtained from the resistivity survey is the position of the current and potential electrode, current (I) injected into the ground and the resulting voltage difference (ΔV) between the potential electrode (Figure 1). Current and voltage measurements are then converted into a type resistance (ρa) of clear values using the following formula

$$\rho a = k\frac{\Delta V}{I} \quad (1)$$

where k is a geometric factor that depends on the configuration of current and potential electrodes [13]. Equation (1) is the simplest form and assumes that the earth is homogeneous for any combination of current measurements. Different settings of current and potential electrodes (or arrays) have been designed for years. The most commonly used arrays are shown in Fig. 3, accompanied by related geometric factors. where k is a geometric factor that depends on the configuration of current and potential electrodes [13]. Equation (1) is the simplest form and assumes that the earth is homogeneous for any combination of current measurements. Different settings of current and potential electrodes (or arrays) have been designed for years. The most commonly used arrays are shown in Fig. 3, accompanied by related geometric factors.

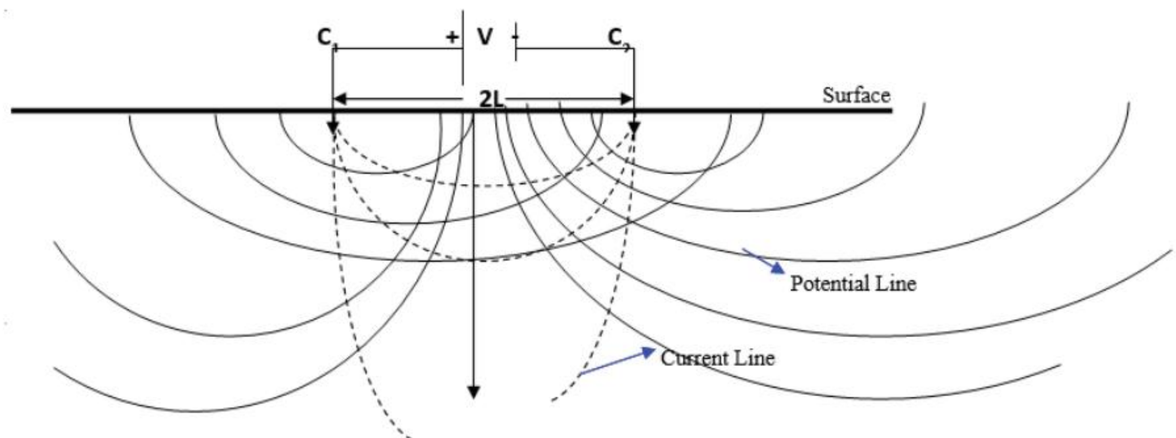

Figure 3. The gradient Array (13)

Argued that electrical gradients can produce water flow from high to low voltage when electric current is flowing into the ground [14]. When an electric current is poured into the ground, it will produce a resistance value.
The resistance equation is

$$R = \frac{A}{L}\frac{\Delta V}{I} \quad (2)$$

Where:
A = Area of current flow (m2)
L = The flow length (m)
ΔV = Voltage Difference / Voltage (V)
I = Current (A)
R = Resistivity (ohm-meter)
Vertical Electrical Sounding (VES) is commonly used in electrical resistivity surveys to determine the vertical variation between the earth's bottom of the electrical resistance and the potential field generated by the current. This technique involves the electric current induced into the ground through two implanted electrodes and measures the potential difference between the two other electrodes, referred to as the potential electrode. The current electricity used is the direct current provided by the dry cell. Therefore, the analysis and interpretation of geoelectric data is on the basis of resistivity value. The resistivity is calculated from the measurement of induced currents and the potential difference is referred to as "apparent resistivity". This measurement is based on the assumption that the soil isuniform. However, in reality, the Earth's resistivity is determined by homogeneous lithology and geological structure. Therefore, the graph of the apparent resistivity to the current electrode distance is used to determine the vertical variation in the resistance formation. Interpretation of this graph provides true resistivity and depth of sand, which is also used to ensure the presence of aquifers or groundwater in the area. Parameters known to influence the

estimation of groundwater resources include aquifer thickness and size and interconnection rates of pore space in aquifer materials.

Similar systems for soil surveys have also been developed. Some systems use cylindrical steel electrodes based on in-line geometry arrays, while others use spiked wheels to achieve continuous galvanic contact with the ground. The combined capacitive systems are used in areas with highly resistive surface materials (e.g. dry or frozen soil) or paved surfaces. This instrument uses an oscillating, electric dipole to produce a current flow in the ground and a second similar dipole to measure the distribution potential produced at ground level [15]

The geometric factors of the Schlumberger configuration are presented in equation 3 (Reynolds, 2011). where a is half the distance between the current electrodes, while b is the distance between the potential electrodes.

$$K = \frac{\pi a^2}{b}\left[1 - \frac{b^2}{4a^2}\right]$$

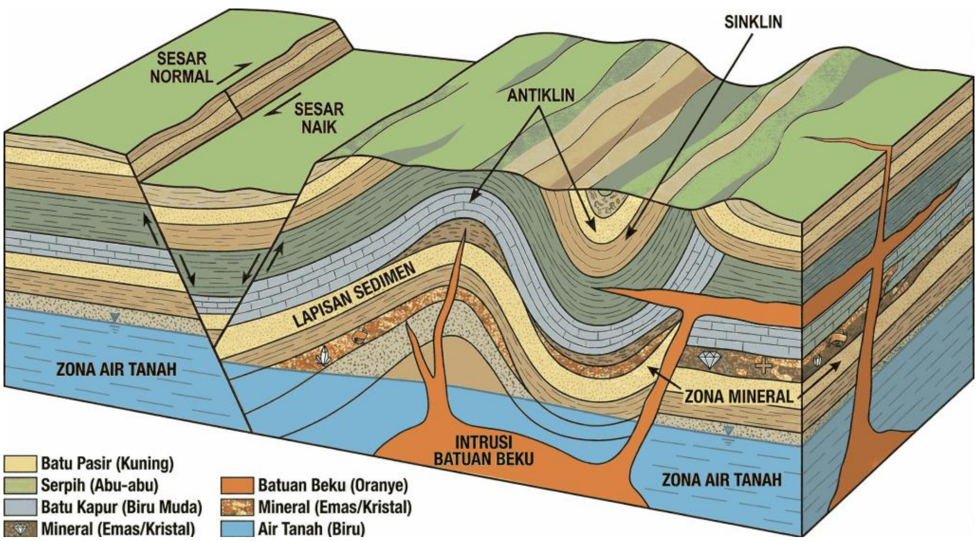

Figure 4. Schematic of the existence of groundwater in unconfined aquifers and confined aquifers[5]

Tabel 1. Rock resistivity value (Teleford, et, al 1990)

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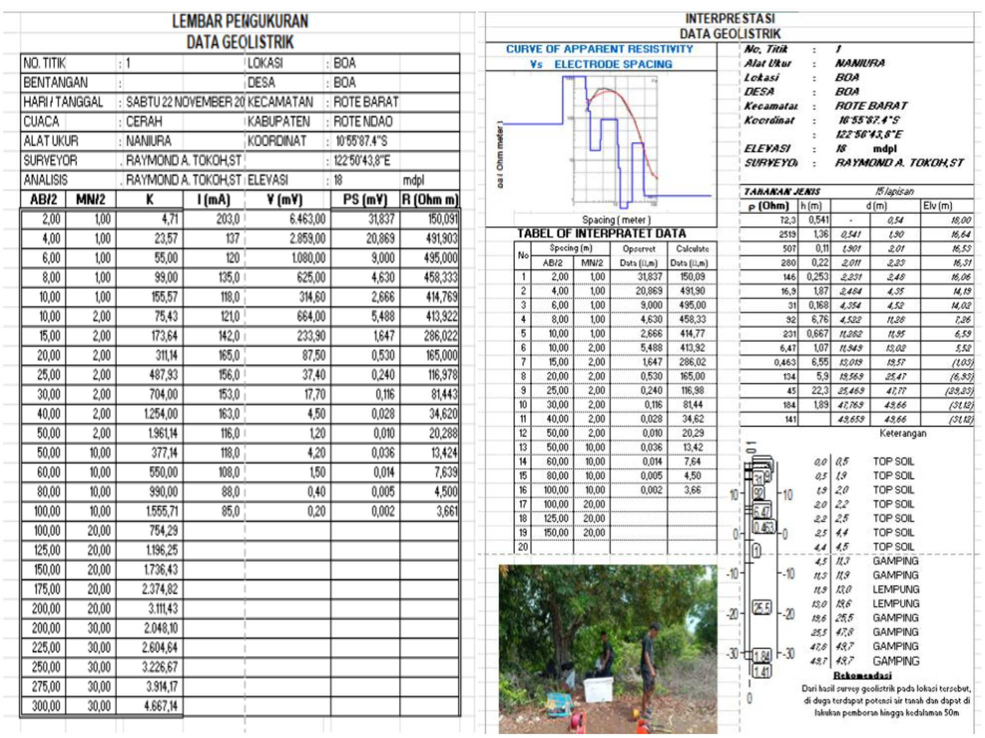
No.	Material	Resistivitas (Ωm)
1.	Udara (*Air*)	~
2.	Pirit (*Pyrite*)	0,01 – 100
3.	Kuarsa (*Quartz*)	$500 – 8\times10^{5}$
4.	Kalsit (*Calcite*)	$1\times10^{12} – 1\times10^{13}$
5.	Garam Batu (*Rock Salt*)	$30 – 1\times10^{13}$
6.	Granit (*Granite*)	$200 – \times10^{4}$
7.	Andesit (*Andesite*)	$1{,}7\times10^{2} – 4{,}5x10^{4}$
8.	Basal (*Basalt*)	$200 – 1\times10^{5}$
9.	Gamping (*Limestone*)	$500 – 1\times10^{4}$
10.	Batu Pasir (*Sandstone*)	200 – 8.000
11.	Batu tulis (*Shales*)	20 – 2.000
12.	Pasir (*Sand*)	1 – 1.000
13.	Lempung (*Clay*)	1 – 100
14.	Air tanah (*Groungwater*)	0,5 – 300
15.	Air laut (*Sea water*)	0,2
16.	Magnetit (*Magnetite*)	$0{,}01 – 1\times10^{3}$
17.	Kerikil kering (*Dry gravel*)	$600 – 1\times10^{4}$
18.	Aluvium (*Alluvium*)	10 – 800
19.	Kerikil (*Gravel*)	100 – 600

Data we get from Location No 1

Tabel 2. Data measurment geoelectric Location 1



LEMBAR PENGUKURAN
DATA GEOLISTRIK

NO. TITIK	: 1	LOKASI	: BOA
BENTANGAN	:	DESA	: BOA
HARI / TANGGAL	: SABTU 22 NOVEMBER 20	KECAMATAN	: ROTE BARAT
CUACA	: CERAH	KABUPATEN	: ROTE NDAO
ALAT UKUR	: NANIURA	KOORDINAT	: 10'55'87.4"S
SURVEYOR	. RAYMOND A. TOKOH,ST		: 122'50'43,8"E
ANALISIS	. RAYMOND A. TOKOH,ST	ELEVASI	: 18 mdpl

AB/2	MN/2	K	I (mA)	V (mV)	PS (mV)	R (Ohm m)
2,00	1,00	4,71	203,0	6.463,00	31,837	150,091
4,00	1,00	23,57	137	2.859,00	20,869	491,903
6,00	1,00	55,00	120	1.080,00	9,000	495,000
8,00	1,00	99,00	135,0	625,00	4,630	458,333
10,00	1,00	155,57	118,0	314,60	2,666	414,769
10,00	2,00	75,43	121,0	664,00	5,488	413,922
15,00	2,00	173,64	142,0	233,90	1,647	286,022
20,00	2,00	311,14	165,0	87,50	0,530	165,000
25,00	2,00	487,93	156,0	37,40	0,240	116,978
30,00	2,00	704,00	153,0	17,70	0,116	81,443
40,00	2,00	1.254,00	163,0	4,50	0,028	34,620
50,00	2,00	1.961,14	116,0	1,20	0,010	20,288
50,00	10,00	377,14	118,0	4,20	0,036	13,424
60,00	10,00	550,00	108,0	1,50	0,014	7,639
80,00	10,00	990,00	88,0	0,40	0,005	4,500
100,00	10,00	1.555,71	85,0	0,20	0,002	3,661
100,00	20,00	754,29				
125,00	20,00	1.196,25				
150,00	20,00	1.736,43				
175,00	20,00	2.374,82				
200,00	20,00	3.111,43				
200,00	30,00	2.048,10				
225,00	30,00	2.604,64				
250,00	30,00	3.226,67				
275,00	30,00	3.914,17				
300,00	30,00	4.667,14				

INTERPRESTASI
DATA GEOLISTRIK

CURVE OF APPARENT RESISTIVITY
Vs ELECTRODE SPACING

Spacing (meter)

No. Titik	:	1
Alat Ukur	:	NANIURA
Lokasi	:	BOA
DESA	:	BOA
Kecamatan	:	ROTE BARAT
Koordinat	:	16'55'87.4"S
	:	122'56'43,8"E
ELEVASI	:	18 mdpl
SURVEYOR	:	RAYMOND A. TOKOH,ST

TABEL OF INTERPRATET DATA

No	Spacing (m) AB/2	Spacing (m) MN/2	Opservet Data (Ω.m)	Calculate Data (Ω.m)
1	2,00	1,00	31,837	150,09
2	4,00	1,00	20,869	491,90
3	6,00	1,00	9,000	495,00
4	8,00	1,00	4,630	458,33
5	10,00	1,00	2,666	414,77
6	10,00	2,00	5,488	413,92
7	15,00	2,00	1,647	286,02
8	20,00	2,00	0,530	165,00
9	25,00	2,00	0,240	116,98
10	30,00	2,00	0,116	81,44
11	40,00	2,00	0,028	34,62
12	50,00	2,00	0,010	20,29
13	50,00	10,00	0,036	13,42
14	60,00	10,00	0,014	7,64
15	80,00	10,00	0,005	4,50
16	100,00	10,00	0,002	3,66
17	100,00	20,00		
18	125,00	20,00		
19	150,00	20,00		
20				

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ρ (Ohm)	h (m)	d (m)		Elv (m)
72,3	0,541	-	0,54	18,00
2519	1,36	0,541	1,90	16,64
507	0,11	1,901	2,01	16,53
280	0,22	2,011	2,23	16,31
146	0,253	2,231	2,48	16,06
16,9	1,87	2,484	4,35	14,19
31	0,168	4,354	4,52	14,02
92	6,76	4,522	11,28	7,26
231	0,667	11,282	11,95	6,59
6,47	1,07	11,949	13,02	5,52
0,463	6,55	13,019	19,57	(1,03)
134	5,9	19,569	25,47	(6,93)
45	22,3	25,469	47,77	(29,23)
184	1,89	47,769	49,66	(31,12)
141		49,659	49,66	(31,12)

Keterangan

0,0	0,5	TOP SOIL
0,5	1,9	TOP SOIL
1,9	2,0	TOP SOIL
2,0	2,2	TOP SOIL
2,2	2,5	TOP SOIL
2,5	4,4	TOP SOIL
4,4	4,5	TOP SOIL
4,5	11,3	GAMPING
11,3	11,9	GAMPING
11,9	13,0	LEMPUNG
13,0	19,6	LEMPUNG
19,6	25,5	GAMPING
25,5	47,8	GAMPING
47,8	49,7	GAMPING
49,7	49,7	GAMPING

Rekomendasi
Dari hasil survey geolistrik pada lokasi tersebut, di duga terdapat potensi air tanah dan dapat di lakukan pemboran hingga kedalaman 50m

Data we get from Location No 2

Tabel 3. Data measurment geoelectric Location 2

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DATA GEOLISTRIK

NO. TITIK	: 1	LOKASI	: BOA
BENTANGAN	:	DESA	: BOA
HARI / TANGGAL	: SABTU 22 NOVEMBER 20	KECAMATAN	: ROTE BARAT
CUACA	: CERAH	KABUPATEN	: ROTE NDAO
ALAT UKUR	: NANIURA	KOORDINAT	: 10°55'87.4"S
SURVEYOR	. RAYMOND A. TOKOH,ST		: 122°50'43,8"E
ANALISIS	. RAYMOND A. TOKOH,ST	ELEVASI	: 18 mdpl

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300,00	30,00	4.667,14				

INTERPRESTASI
DATA GEOLISTRIK

CURVE OF APPARENT RESISTIVITY Vs ELECTRODE SPACING

No. Titik	:	1
Alat Ukur	:	NANIURA
Lokasi	:	BOA
DESA	:	BOA
Kecamatan	:	ROTE BARAT
Koordinat	:	10°55'87.4"S
	:	122°50'43,8"E
ELEVASI	:	18 mdpl
SURVEYOR	:	RAYMOND A. TOKOH,ST

TABEL OF INTERPRATET DATA

No	Specing (m) AB/2	Specing (m) MN/2	Opservet Data (Ω,m)	Calculate Data (Ω,m)
1	2,00	1,00	31,837	150,09
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18	125,00	20,00		
19	150,00	20,00		
20				

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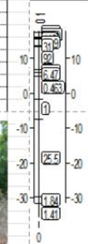
45	22,3	25,469	47,77	(29,23)
184	1,89	47,769	49,66	(31,12)
141		49,659	49,66	(31,12)

Keterangan



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19,6	25,5	GAMPING
25,5	47,8	GAMPING
47,8	49,7	GAMPING
49,7	49,7	GAMPING

Rekomendasi

Dari hasil survey geolistrik pada lokasi tersebut, di duga terdapat potensi air tanah dan dapat di lakukan pemboran hingga kedalaman 50m

III. DATA ANALYSYS

The groundwater needed for resort operation needs per day is 14210 liters (14.21 m³) with details of the estimated number of guests being 108 people and the number of employees being 25 people, requiring 108 x 120 = 12960 liters of water and 25 x 50 liters = 1250 liters.

Since the groundwater source is located 5 km from the resort, so truck tanker with capacity 6 m³ transportation is required to supply the groundwater. Therefore, the truck must bring water to the resort three times a day.

Based on the results of geoelectric resistivity tests at the two locations, it is strongly suspected that a very large freshwater source exists at a depth of 40-50 m. Plans are now underway to drill .

And insttall deepwell pump. Specification of deepwhell pump as below :

Specification of deepwell pump with Capacity : 10.8 m³ /h , or 180 liter/menit or 3 liter/s, head 60 m. The curve performance of deepwell see figure 3.1

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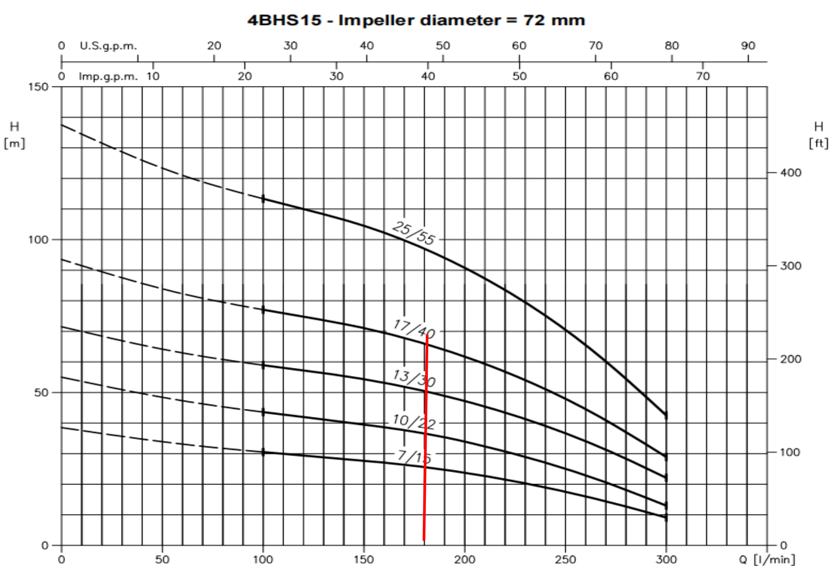

Figure 5. Curve performance of deepwell

IV. CONCLUSION

1. Based on the results of geoelectric resistivity tests at the two locations, it is strongly suspected that a very large freshwater source exists at a depth of 40-50 m
2. To meet the water needs of the resort 14.21 m³/day, deepwell with a capacity of 3 liter/s is required
3. Truck tanker with 6 m³ capacity 3 times transport a day.
4. Geoelectic metode stongly helpful for identify sourse of ground water.

REFERENCES

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