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CRITICAL STUDY OF SUB-SURFACE AQUIFER LAYER FOR GROUNDWATER AVAILABILITY BASED ON ELECTRICAL RESISTIVITY SURVEY: A PART OF DHALAI TRIPURA, INDIA

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ABSTRACT

In Tripura, there are many rivers and most of the rivers are almost dry due to high amount of silt carries from higher altitude and deposits as well at river bed. Thus quantitative as well qualitative results of surface water is not the sustainable resource for supplying for the different stakeholder and thus groundwater has the alternative source to meet the demand for the high density population in the state like Tripura. Dhalai Tripura located in the north east state of India has a good amount of coarse sand for groundwater development dependent. A critical study is undertaken to assess the groundwater availability in the sub-surface aquifer using vertical electrical sounding (VES) survey at nineteen locations with a total of thirty eight points spread over the area. The study results depict resistivity values ranging between 30 ohm and 150 ohm are found to be good aquifer zone with the thickness varied between 36 m and 44 m. Thus it concludes VES survey could be an alternative method to assess the groundwater potential at present and future scenario by reducing the overall project cost and also to reduce the chances of failure for making borewell in the same or nearby critical areas for all stakeholders.

Keywords: aquifer, litholog strata, resistivity value, groundwater, Agartala.

INTRODUCTION

Agartala is a developing and growing city which has the capacity to become the gateway of North-East to South East Asia through an international link. However it is already facing some scarcity of water in the area during non-monsoon seasons. Soils of these catchment areas have low retention capacity. These areas have the maximum density of urban population in the whole state (Debbarma*et al*., 2013). Hydrogeological, geophysical and hydrochemical studies were carried out by Mondal*et al*., (2005) in order to assess the extent of groundwater deterioration due to 80 functioning tanneries in the upper Kodaganar river basin region, India. The data of 37 Schlumberger VES were collected and interpreted using computer software RESIST-88. It was observed that the VES results at each station of the study area were entirely different due to in homogeneity of the subsurface layers and the presence of ion concentration. It was revealed that the resistivity values for spacing AB/2 between 10 m and 25 m were less than of 75 Ω-m. Rai *et al*., (2005) stated that the combined study conducted using remote sensing and geoelectrical methods of water-bearing weathered / fractured rocks varied from 120 Ω-m to 150 Ω-m and the better zones, which were most promising for groundwater exploration could be dug well up to depths of (30 ± 5) m and the study were carried out by VES surveys for 26 points conducted using Schlumberger electrode configuration in the Dhanbad district in Jharkhand, India.

Resistivity could be measured to delineate the depth of the basement rocks (bedrock) and the lithology of the overlying sediments for the purpose of bridges construction route.VES data was collected and interpolated using IX1D software (Mohammed, 2014). The final results of the modeled and interpreted resistivity data were depicted that a close agreement with the geological and hydrogeological conditions of the area was found. The geoelectrical resistivity profiling and VES data were acquired by Asare and Menyeh, (2013) from some small communities areas within the Gushiegu and Karaga Districts of Northern Ghana, in order to study the aquifer characteristics and recommend hydro-geologically suitable sites to construct water supply boreholes for the communities. The geoelectric sequence revealed predominantly a three subsurface layer which is largely congruous to the weathering profile above the fresh bedrock with thick top soil, the weathered and the variably weathered and fractured bedrock respectively were recommended on the basis of the perceived aquifer properties, sites for drilling water supply boreholes for the communities.

Vertical Electrical Sounding (VES) was tested by Sikandar and Christen, (2012) to estimate aquifer hydraulic conductivity at Chaj Doab and Rachna Doab, Punjab, Pakistan. The field data were interpreted using the Interpex IX1D computer software and the aquifer resistivity (ρ) vs depth models for each location were estimated. The VES survey has the potential to provide reasonable accurate results that can be used to understand the subsurface layers in groundwater exploration. The results of the VES must be verified with secondary hydro-

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
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geological data available in the study area referred by Debbarma*et al* (2016b).Atzemoglou and Tsourlos (2012) stated that 2D interpretation of 1D VES measurements can produce improved subsurface geophysical images and presents a potential useful tool for larger scale geological investigations especially in the case of reprocessing existing VES data sets.

It should be noted that the fact that the correlation coefficient is not equal to one signifies that the sub-soil litholog as interpreted from the VES study reported by Debbarma*et al*., (2017) is not the same as the litholog obtained from borehole and should not be treated as same. However, there exists a relation between the sub-soil layer as interpreted from the VES study and the borehole lithologic layer. The regression equation can be used to convert the results obtained from VES study to borehole log with great accuracy. Thus with the use of VES studies in the region in near future sub-soil lithologs can be prepared without doing borehole thus saving money and manpower moreover quicker results could be obtained (Felix *et al*., 2013).

Since as we know presently Agartala Municipality area has a higher water demand than any other parts in the state due to its higher density of population stated by Debbarma*et al*., (2016a) so detail information is needed related to sub-surface aquifers with the help of VES survey. Also the objective of this paper is to give a plan for estimating present as well as future water groundwater availability particularly for sub-surface aquifer only by knowing resistivity results with minim investment and also the study results will become user friendly manual for all kinds of stakeholders and to be reliable and sustainable resource without any lithological strata.

MATERIALS AND METHODS

Methodology

Total 19 nos. of location has been considered for the proposed study. Two nos. of point has been surveyed for each location with a total number of 38 points for the resistivity survey. A map is prepared referred in Figure-1 from google map mentioned all VES locations and accordingly resist survey is carried out with the help of VES instrument. The lithological strata for all locations are prepared for all sampling points with effective sand media even 250 m bgl from ground level. Finally after studying the geological and geophysical properties of the area and all field data are interpolated through hydrogeological software and also it is been inferred here.

Study area

After studying and interpreting the satellite imagery the area seems to fall under mountainous and elevated portion of Dhalai district. The soil of the region is somewhat alluvial in nature, with occasional Hills of alluviums. The soil has a thick cover of clay at top and lateritic formation with slate in abundance. The rivers are here in their mature stage and forms meanders. The main river is Gomati and distributaries of its crisscrossed the region.The region is well fertile and practiced with agricultural land by the local farmers. Natural vegetation is also seemed to be in good proportion.

Geological and physiographical settings

The proposed site falls on the east side of Dhalai district. The geological formation is of tertiary sediment sand of pliestocene-lower age. The lithostratigraphic units of alluvial formation consisting of Residual soil and is composed of sand, silt, clay (soft sediments) with rock fragments and laterite out crops and slate stone (hard formation).

Geomorphologically the area is a mountainous and hillock area. During rainy season the shallow river beds frequently over flow. The soil of the region is somewhat alluvial in nature. The area has been subjected to earthquakes in the past and land has formed hills of alluviums. Their folded structure is a synclinorium consisting of broad synclines and tight-faulted anticlines.

Hydro-geologically the area is a moderate to good zone for groundwater development. The water table lies between 15 m and 20 m below ground level in the unconsolidated sandy sediments of recent alluvium. Here the groundwater yield is good and can be developed with the use of deep tube wells.

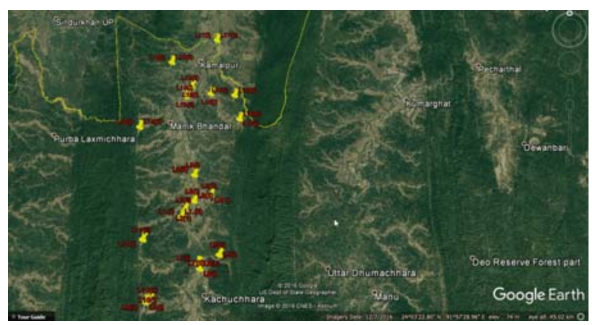

Figure-1.VES location points of the study area.

Hydro geological and hydrology

The area and blocks water supply is augmented with dug wells, shallow hand pumps and mini deeptubewells. Drinking water supply division, resource water division has taken initiatives and has installed numberoftubewellsin the area, which are in operation mode.

The tube wells are installed with water jet method and rotary rig method (direct/reverse).Static water level is in the range of 10-15m below ground level (bgl).Numbers of water ponds are also there which augments village water supply. Rainfall is high in the range of 1800-2000 mm annually. The study area is mostly dominated by dense vegetation. Paddy cultivation is practiced based on the rainfall.

RESULTS AND DISCUSSIONS

The area under study is a part of the eastern margin of Dhalai district. The water prospects hereareby the saturated water present in the sand aquifers below. The

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ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

tract is alluvial and composition of layers of the different sites (locations) investigated are almost identical, as such the tube wells may be installed at any of the points surveyed as per suitability. VES survey is carried out for two sampling location for each site with a total number of 38 VES points mentioned even block also. The resistivity results depicted that the aquifer depth are varied between 90 m and 180 m whereas the expected yields are calculated ranged between 27.27 and 45.46 m^3/h as highlighted in Table-1. The interpreted results depicted that the expected yield is found to be higher where resistivity values are varied between lower and higher reflected in Tables 2 (a), (b), (c), (d) and (e). Due to paucity of space and reducing the paper length, Figure-2 and Figure-3 represents the typical resistivity and thickness of different sub-surface layer considered as sample figure for one location. It is observed that the resistance values are found at different distance shown in Figure-2 whereas the aquifer formation at the same points is highlighted in Figure-3.

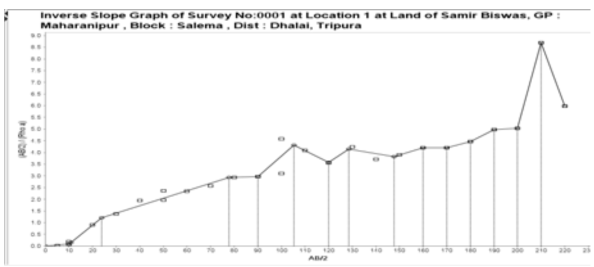

Figure-2. Distance vs. resistivity for L1(I).

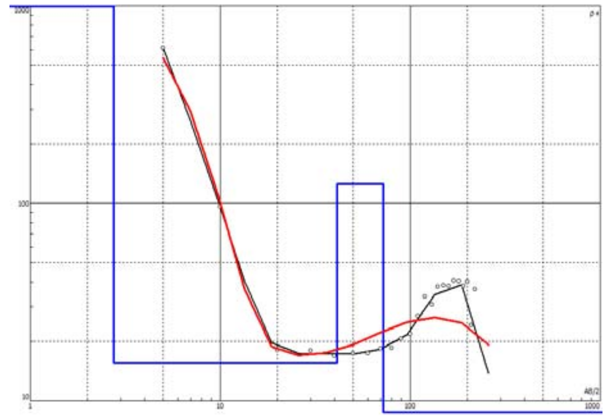

Figure-3. Depth vs. resistivity for L1(I).

CONCLUSIONS

Resistivity sounding data (VES) of 38 points with 19 locations, where data collections were good, spreads over Kamalpur valley in both sides of Dhalairiver under Dhalai district indicate that the subsurface formations in the areas of investigation are found to be distinct in terms of resistivity values. Resistivity values ranged between 30 ohm and 150 ohm are depicted with good aquifer zone varied between 110 m and 146 m and it has also been validated by Debbarma*et al* (2016c) in case of same terrain condition. However the discharge of well is observed to be limited even available of water is obtained at a greater extent. Thus it can be concluded that resistivity survey could be a good exercise not only to select the exact location of borewell but also in terms of cost and also to reduce the chances of failure of making a new bore well with a higher cost involvement. It also helps to prepare a contingency plan for estimation of availability of water for both irrigation as well as domestic purposes in the short as well as in the long run.

ARPN Journal of Engineering and Applied Sciences

Table-1. Aquifer information with expected yield in different blocks of Dhalai district.

S. No	District	Block	G.P./VC*	Location-1			Location-2			Aquifer zones depth (m)	Expected yield (m^3/h)
				Latitude	Longitude	Map Location	Latitude	Longitude	Map location		
1	Dhalai	Salema	Maharanipur VC	24.05374° N	91.82157° E	L-1(1)	24.05374° N	91.82138° E	L-1(2)	110-140	36.38-45.46
2	Dhalai	Salema	MaharanipurVC	24.05987° N	91.82454° E	L-2(1)	24.05982° N	91.82448° E	L-2(2)	120-150	36.38-45.46
3	Dhalai	Durgachowmuhani	Debichara	24.08876° N	91.83137° E	L-3(1)	24.08882° N	91.83136° E	L-3(2)	90-130	36.38-45.46
4	Dhalai	Durgachowmuhani	Chankap	24.07136° N	91.84688° E	L-4(1)	24.07129° N	91.84681° E	L-4(2)	110 -140	36.38-45.46
5	Dhalai	Salema	South Kachuchara	24.02309° N	91.85622° E	L-5(1)	24.02308° N	91.85642° E	L-5(2)	90 -130	31.82-36.38
6	Dhalai	Salema	Singinala	24.01234° N	91.84012° E	L-6(1)	24.01223° N	91.84005° E	L-6(2)	100-130	31.82-36.38
7	Dhalai	Salema	Avanga	24.01652° N	91.83810° E	L-7(1)	24.01662° N	91.83815° E	L-7(2)	150 -180	36.38-45.46
8	Dhalai	Salema	Dabbari	24.06684° N	91.83202° E	L-8(1)	24.06682° N	91.83223° E	L-8(2)	110-140	36.38-45.46
9	Dhalai	Salema	PaschimDaluchara	23.98741° N	91.79570° E	L-9(1)	23.98742° N	91.79552° E	L-9(2)	110-130	31.82-36.38
10	Dhalai	Salema	AshapurnaRoaza Para	23.98878° N	91.79886° E	L-10(1)	23.98877° N	91.79860° E	L-10(2)	105-125	36.38-45.46
11	Dhalai	Salema	Mendhi	24.03603° N	91.78931° E	L-11(1)	24.03558° N	91.78925° E	L-11(2)	105-125	27.27-36.38
12	Dhalai	Durgachowmuhani	WestKuchainala	24.16816° N	91.82442° E	L-12(1)	24.16794° N	91.82425° E	L-12(2)	100-130	36.38-45.46
13	Dhalai	Durgachowmuhani	West Kuchainala	24.15864° N	91.81969° E	L-13(1)	24.15884° N	91.82020° E	L-13(2)	100-130	36.38-45.46
14	Dhalai	Durgachowmuhani	Kuchainala	24.16117° N	91.84283° E	L-14(1)	24.16143° N	91.84279° E	L-14(2)	90-110	27.27-36.38
15	Dhalai	Durgachowmuhani	Marachara	24.15960° N	91.86553° E	L-15(1)	24.15944° N	91.86561° E	L-15(2)	120-140	31.82-36.38
16	Dhalai	Durgachowmuhani	Shibbari	24.13744° N	91.87054° E	L-16(1)	24.13735° N	91.87082° E	L-16(2)	120-150	36.38-45.46
17	Dhalai	Durgachowmuhani	Mohanpur	24.21344° N	91.84650° E	L-17(1)	24.21352° N	91.84650° E	L-17(2)	110-140	36.38-45.46
18	Dhalai	Durgachowmuhani	Noagaon	24.19168° N	91.80380° E	L-18(1)	24.19205° N	91.80382° E	L-18(2)	110-140	27.27-31.82
19	Dhalai	Durgachowmuhani	Srirampur	24.13080° N	91.77812° E	L-19(1)	24.13104° N	91.77832° E	L-19(2)	120-150	27.27-36.38

*VC-Village Council

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Table-2(a). Resistivity survey with interpreted results for four locations (LS-1 to LS-4).

S. No.	Location-1	Location-2	Probable strata section as interpreted from Inverse slope & VES curve			Resistivity nature
	Map location	Map location				
1	L-1(1)	L-1(2)	1stlayer	0-30 m	Shallow Depth Soil and Sand-Dry	Very High to High Resistance
			2ndlayer	30-40 m	Fine Sand	High Resistance
			3rdlayer	40-110 m	Clay Beds	Moderate High to Low Resistance
			4thlayer	110-140m	Finesand (Aquifer Zone for strainer)	Low to High Resistance
			5thlayer	140-250 m	Clay Beds	Low Resistance
2	L-2(1)	L-2(2)	1stlayer	0-30 m	ShallowDepthSoilandSand-Dry	Very High to High Resistance (Topsoil& Dry Sand)
			2ndlayer	30-45 m	Fine Sand	High Resistance (1stAquifer Fine Sand)
			3rdlayer	45-120 m	Clay Beds	Moderate High to Low Resistance
			4thlayer	120-150 m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	140-220 m	Clay Beds	Low Resistance
3	L-3(1)	L-3(2)	1stlayer	0-20m	Shallow Depth Soil and Sand-Dry	Very High to High Resistance (Top soil & Dry Sand)
			2nd layer	20-40 m	FineSand	High Resistance
			3rdlayer	40-90 m	Sandy Clay	Moderate Highto Low Resistance
			4thlayer	90-120m	Fine sand(Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	120-240 m	Clay Beds	Low Resistance
4	L-4(1)	L-4(2)	1stlayer	0-20m	Shallow Depth Soil and Sand-Dry	Very High to High Resistance (Topsoil & Dry Sand)
			2ndlayer	20-30 m	Fine Sand	High Resistance (1stAquifer Fine Sand)
			3rdlayer	30-110 m	Clay Beds	Moderate Highto Low Resistance
			4thlayer	110-150 m	Fine to Medium sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	150- 230 m	Clay Beds	Low Resistance

ARPN Journal of Engineering and Applied Sciences

Table-2(b). Resistivity survey with interpreted results for four locations (LS-5 to LS-8).

S. No.	Location-1	Location-2	Probable strata section as interpreted from inverse slope & VES curve			Resistivity nature
	Map location	Map location				
5	L-5(1)	L-5(2)	1stlayer	0-70 m	Clay	Low Resistance (Topsoil & Clay
			2ndlayer	70-90 m	Sandy Clay	Low to High Resistance (1st Aquifer Fine Sand)
			3rdlayer	90-130 m	Fine Sand	High Resistance
			4thlayer	130-150 m	Fine to Very Fine sand	High to Low Resistance
			5thlayer	150-210 m	Clay Beds	Low Resistance
6	L-6(1)	L-6(2)	1stlayer	0-40 m	Clay	Low Resistance
			2ndlayer	40-70 m	Sandy Clay	Low to Moderate High Resistance
			3rdlayer	70-100 m	Sandy Clay & Fine sand	Moderate High to High Resistance
			4thlayer	100-130 m	Fine to Medium sand (Aquifer Zone for Strainer)	High Resistance
			5thlayer	130-220 m	Clay Beds	High to Low Resistance
7	L-7(1)	L-7(2)	1stlayer	0-30 m	Clay	Low Resistance
			2ndlayer	30-40 m	Fine Sand	Low to Moderate High Resistance
			3rdlayer	40-110 m	sandy Clay	Moderate High to High Resistance
			4thlayer	150-170 m	Fine sand (Aquifer Zone for Strainer)	High Resistance
			5thlayer	170-220 m	Clay Beds	Constant Resistance
8	L-8(1)	L-8(2)	1stlayer	0-70	Shallow Depth Soil and Sand-Dry	Very High to High Resistance
			2ndlayer	70-90 m	Fine Sand	High Resistance
			3rdlayer	90-110 m	Sandy Clay	Moderate High to Low Resistance
			4thlayer	110-140 m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	140-250 m	Clay Beds	Low Resistance

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Table-2(c). Resistivity survey with interpreted results for four locations (LS-9 to LS-12).

S. No.	Location-1	Location-2	Probable Strata section as interpreted from inverse slope & VES curve			Resistivity nature
	Map location	Map location				
9	L-9(1)	L-9(2)	1stlayer	0-30 m	Clay	Low Resistance
			2ndlayer	30-40 m	Fine Sand	High Resistance
			3rdlayer	40-110 m	Clay Beds	Moderate High to Low Resistance
			4thlayer	110-130m	Fine to Medium sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	130-240 m	Clay Beds	Low Resistance
10	L-10(1)	L-10(2)	1stlayer	0-60 m	Clay	Low Resistance
			2ndlayer	60-70 m	Fine Sand	Low to High Resistance
			3rdlayer	70-105 m	Sandy Clay	Moderate High to High Resistance
			4thlayer	105-125m	Fine sand (Aquifer Zone for Strainer)	High Resistance
			5thlayer	125-220 m	Clay Beds	Very High Resistance
11	L-11(1)	L-11(2)	1stlayer	0-20 m	Shallow Depth Soil and Sand-Dry	Very High to High Resistance
			2ndlayer	20-50 m	Fine Sand	High & Low Resistance
			3rdlayer	50-105 m	Clay Beds with slate formations	Moderate High to Low Resistance
			4thlayer	105-125m	Fine sand (Aquifer Zone for Strainer)	Fluctuating Low to High Resistance
			5thlayer	125-220 m	Clay Beds	Low Resistance
12	L-12(1)	L-12(2)	1stlayer	0-30 m	Sandy Clay	High Resistance
			2ndlayer	30-40 m	Fine Sand	High & Low Resistance
			3rdlayer	40-100 m	Fins Sand & Clay Beds	Moderate High to Low Resistance
			4thlayer	100-130m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	130-240 m	Clay Beds	Low Resistance

VOL. 12, NO. 21, NOVEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Table-2(d). Resistivity survey with interpreted results for four locations (LS-13 to LS-16).

S. No.	Location-1 Map location	Location-2 Map location	Probable Strata section as interpreted from inverse slope & VES curve			Resistivity nature
13	L-13(1)	L-13(2)	1stlayer	0-30m	Shallow Depth Soil and Sand-Dry	Very High to High Resistance
			2ndlayer	30–40 m	Fine Sand	High Resistance
			3rdlayer	40-100 m	Clay Beds	Moderate High to Low Resistance
			4thlayer	100-130 m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	130-220 m	Clay Beds	Low Resistance
14	L-14(1)	L-14(2)	1stlayer	0-30 m	Sandy Clay	Very High to High Resistance
			2ndlayer	30-40 m	Fine Sand & Sandy Clay	High Resistance
			3rdlayer	40-90 m	Fine Sand	Moderate High to Low Resistance
			4thlayer	90-110m	Fine to Very Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	110-200m	Clay Beds	Low Resistance
15	L-15(1)	L-15(2)	1stlayer	0-30m	Clay zones	Low Resistance
			2ndlayer	30-40m	Fine Sand	Low to High Resistance
			3rdlayer	40-120 m	Sandy Clay	Moderate High to Low Resistance
			4thlayer	120-140m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	140-200m	Sandy Clay	High Resistance
16	L-16(1)	L-16(2)	1stlayer	0-30m	Sandy Clay	Very High to High Resistance
			2ndlayer	30-60 m	Fine Sand	High Resistance
			3rdlayer	40-120 m	Clay Beds	Moderate High to Low Resistance
			4thlayer	120-150m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	150-200 m	Clay Beds	Low Resistance

ARPN Journal of Engineering and Applied Sciences

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Table-2(e). Resistivity survey with interpreted results for three locations (LS-17 to LS-19).

S. No.	Location-1 Map location	Location-2 Map location	Probable Strata section as interpreted from inverse slope & VES curve			Resistivity nature
17	L-17(1)	L-17(2)	1stlayer	0-30 m	Clay	Low Resistance
			2ndlayer	30-40 m	Sandy Clay	Low Resistance
			3rdlayer	40-110 m	Very Fine sand & Clay	Moderate High to Low Resistance
			4thlayer	110-140 m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	140-210 m	Fine Sand & Sandy Clay	High Resistance
18	L-18(1)	L-18(2)	1stlayer	0-30m	Sandy Clay	Very High to High Resistance
			2ndlayer	30-40 m	Fine Sand	High Resistance
			3rdlayer	40-110 m	Sandy Clay	Moderate High to Low Resistance
			4thlayer	110-140m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	140-250 m	Clay Beds	High to Low Resistance
19	L-19(1)	L-19(2)	1stlayer	0-30m	Surface sand & Sandy Clay	Very High to High Resistance
			2ndlayer	30-50 m	Sandy Clay	High Resistance
			3rdlayer	50-120 m	Clay Beds	Moderate High to Low Resistance
			4thlayer	120-150m	Fine sand (Aquifer Zone for Strainer)	Low to High Resistance
			5thlayer	150-220 m	Clay Beds	Low Resistance

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