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Systematic Groundwater Investigations for Constructing a Tube Well in Coastal Plains of Nellore, Seemandra State, India

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Abstract:- To exploit the groundwater resources for water supply projects in any area needs proper systematic groundwater exploration techniques. This study pertains to providing water supply to an aquaculture project for which systematic groundwater investigations have been taken up in a coastal plain of Nellore district. The research area falls in Venkannapalem of Thottapalli mandal in Nellore district of Seemandra state, India. It is a coastal sedimentary area, about 2 to 3 kms from sea coast. Geological, hydrogeological, geoelectrical investigations and pumping test have been conducted to prospect the groundwater resources. Among the surface geophysical methods, electrical resistivity technique [ERT] is widely used, which is non- invasive and cost effective. 1D VES was carried out to explore the potential phreatic aquifers. A pilot borehole was drilled and electrically logged to delineate the granular and fresh water zones. A tube well has been constructed to a depth of 51m, developed and completed. The yield was reported as 4'' [276 lpm]. A constant discharge pumping test was done to evaluate the aquifer parameters, transmissivity [T], Storativity [S], hydraulic conductivity [K] by both Jacob's straight line graphical method and by software program . The values computed by both methods are nearly the same. The T, & K values are 97/90 & 6.4/6.01 respectively. The specific capacity of the aquifer is 683 lpm/ 1.3m dd/ 8 hrs of pumping. Thus the systematic groundwater investigations in coastal plains proved to be successful and fruitful.

Keywords:- *Phreatic aquifers;1D VES;Electrical well logging; Aquifer parameters.*

I. INTRODUCTION

Electrical Resistivity Techniques [ERT] have been widely used to study the ground water contamination and sub surface lithology. The decrease in resistivity caused by salination of ground water help to identify the contaminant zones.The coastal aquifers that are prone to saline water intrusion are delineated by relatively low resistivity values, indicating salt water intrusion.Electrical well logging facilitates continuous recording of electrical response verses depth by a sensor when it moves inside the bore hole [3]. Among the several methods of well logging the common method used for subsurface ground water exploration is electrical well logging which includes SP log and resistivity logs [3]. Success of well depends on the well design and construction. The tube well design shall ensure an efficient and economical well with a service life of more than a decade.Hydrogeologist determine the hydraulic characteristics of water-bearing formations, by conducting pumping tests which is also called as aquifer tests for aquifer parameter evaluation. A pumping test consists of pumping groundwater from a well, usually at a constant rate, and measuring water levels in the pumped well [4].

II. AREA OF INVESTIGATION

The area Venkannapalem [Gachodipalem] belongs to Thottapalli mandal in Nellore district of Seemandra state, India The area falls on N lat 14°09'39.37'' & E long 79°58'05.26''. It is a coastal sedimentary area [Figs 1 & 2], about 2 to 3 kms from sea coast. The investigation is for an aquaculture project to construct a tube well.

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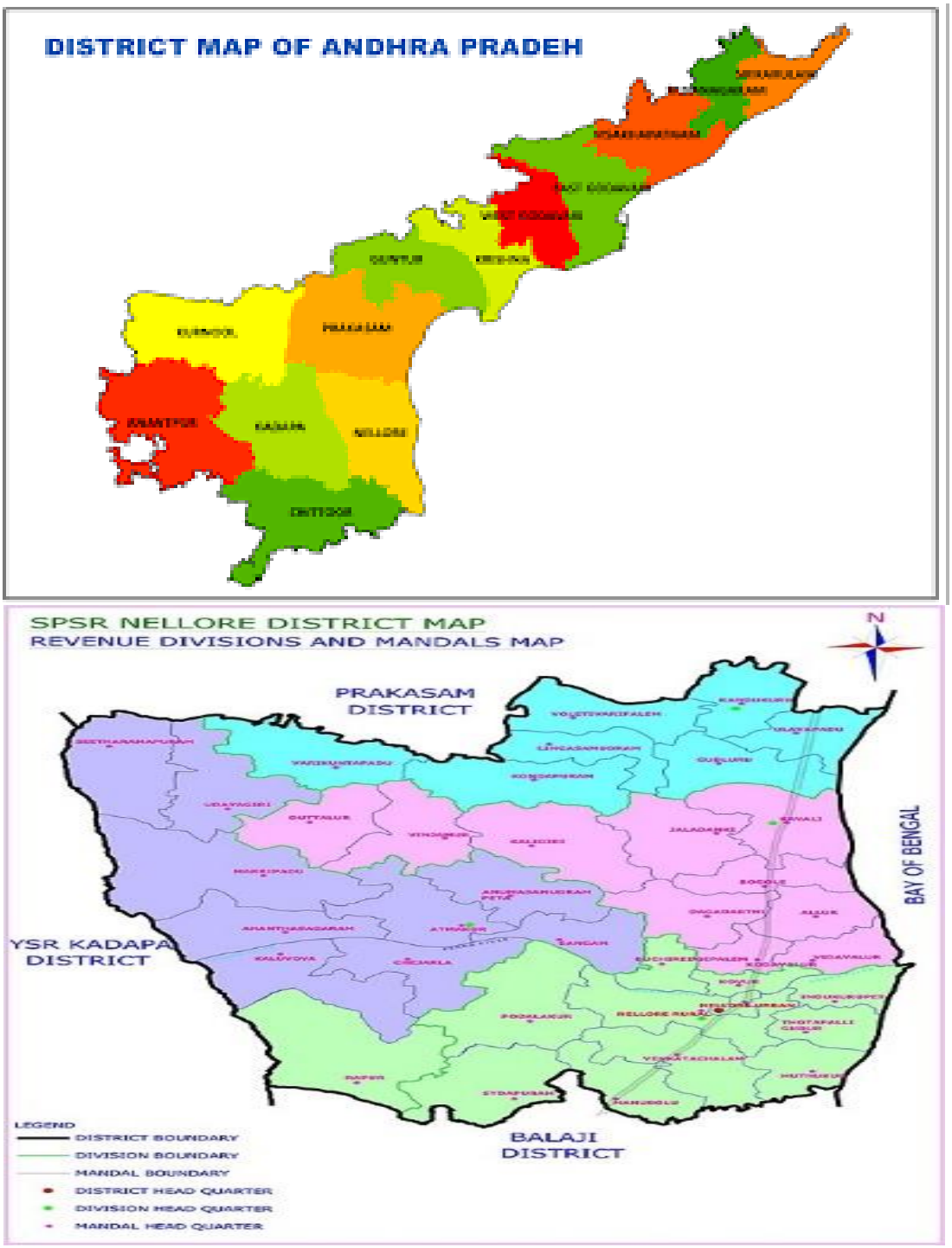

Fig. 1: Seemandra [AP] state & Nellore district map+ mandals

A. Geological and hydrogeological setup of the area

Geomorphologically the district can be broadly divided into 3 distinct units, viz., western hills, central pediplain and eastern deltaic & coastal plains. The deltaic and coastal plain extends from north to south along the eastern margin of the district all along the coast. The district is underlain by variety of geological formations comprising from the oldest Archaeans to Recent Alluvium. Pennar and Swarnamukhi rivers drain the area. The river alluvium occurs all along the banks of major rivers and the deltaic areas formed by Pennar and Swarnamukhi rivers. The coastal alluvium covers an area of 900 Km2 lie along the coast [1]. Ground water occurs in all most all geological formations. Among the un-consolidated formations river alluvium i.e., in deltaic area form potential aquifers. Ground water occurs under phreatic to confined conditions and is developed through shallow dug wells, filter point wells and tube wells. The annual normal rainfall of the district is 1084 mm [1].

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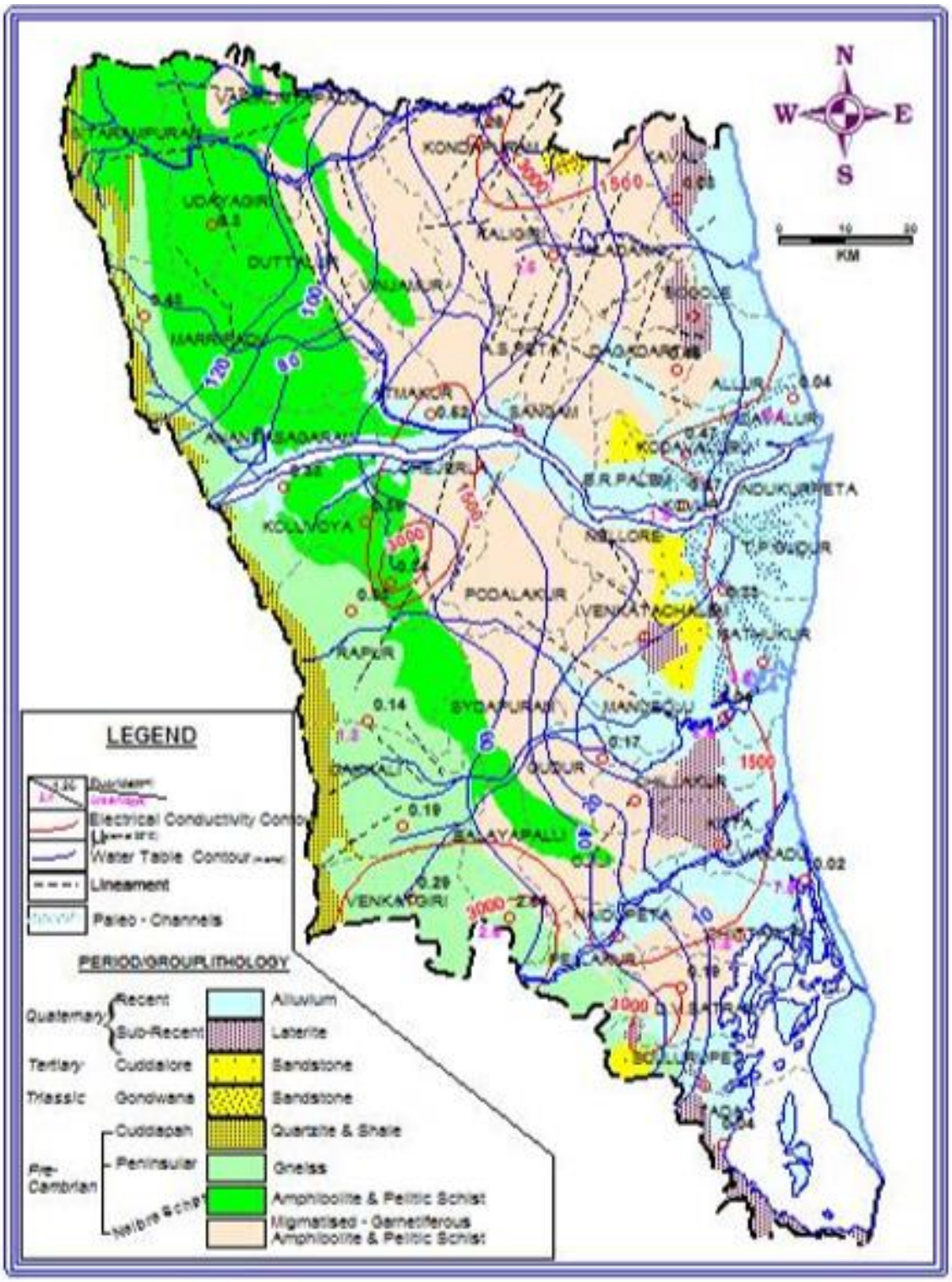

Fig. 2: Hydrogeology map of Nellore district

III. GROUNDWATER PROSPECTION BY SURFACE GEOELECTRIC METHOD

A. 1D Vertical electrical sounding [VES]

Ground Water Exploration comprises a number of stages, namely the first stage, identification of suitable well site by integrated hydro geological and geophysical methods.

The next stage is drilling and the last stage is development [3]. After a detailed geological and hydrogeological investigations, 1D VES has been carried out @ Gachodipalem using IGIS make DC resistivity meter employing Schlumberger array. Four VES have been done with AB/2 separation of 120 m. The VES curves were interpreted by Rinvert software.

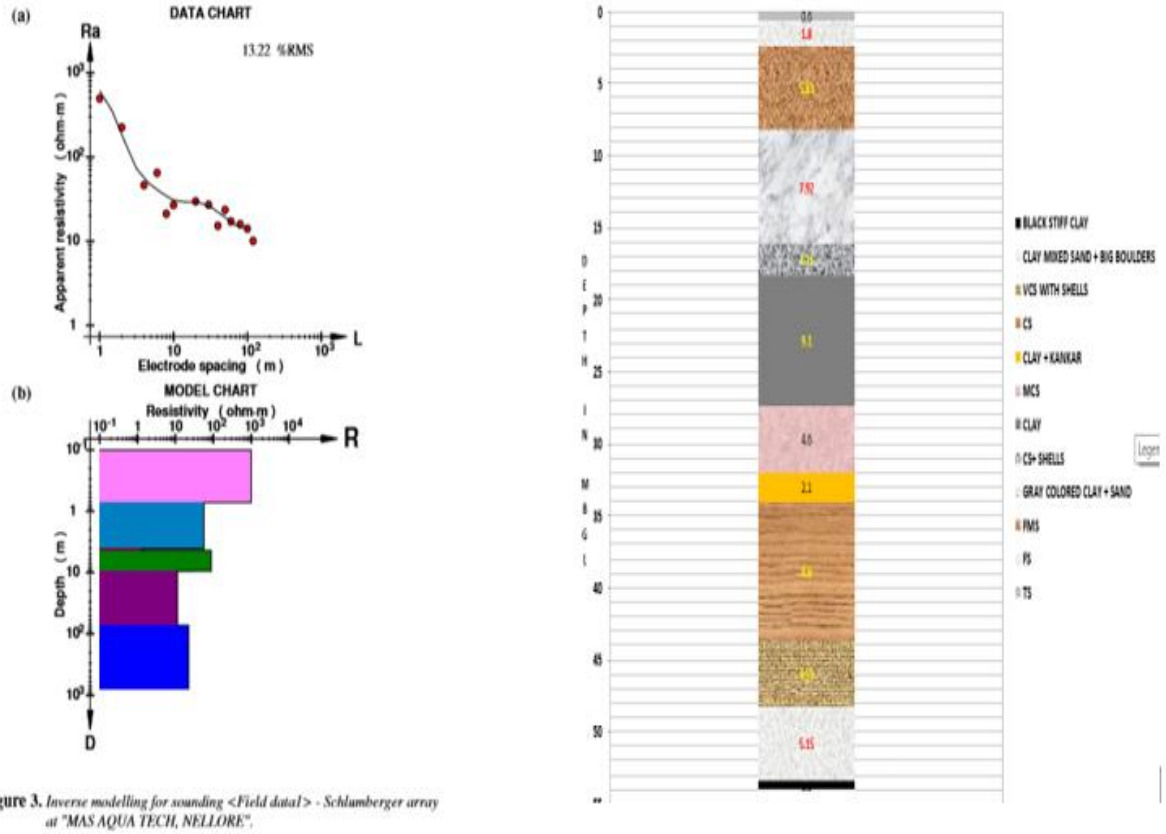

Figure 3. *Inverse modelling for sounding <Field data1> - Schlumberger array at "MAS AQUA TECH, NELLORE".*

Fig. 3: VES curve + geoelec section & Lithology

Drilling of pilot borehole: Based on VES results the pilot borehole was drilled @ VES-01 to a depth of 55m by rotary rig.

B. Electrical well logging

Electrical well logging has been done using IGIS-portable logger with the same DC resistivity meter. SP log, normal resistivity logs- short normal [SN-16''] and long normal [LN-64''] modes were conducted and the data have been recorded for every 2m [Figs-6 & 7]. The electrologs have been prepared by Excel software. The electrologs have been correlated with lithology and delineated the fresh, saline water zones and the productive potential aquifers. Three potential aquifer zones with a total thickness of about 19m have been identified. Based on the well logging findings, a tube well of 200mm dia was constructed to a depth of 51m [Fig-8] .The well was developed and finally completed. The reported yield was 4'' [276 lpm].

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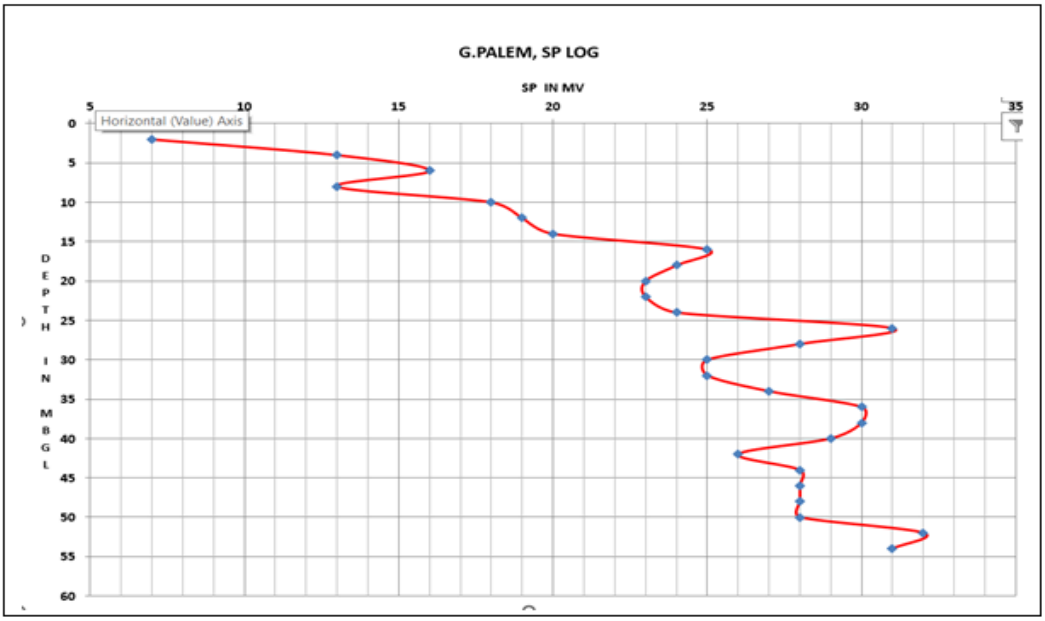

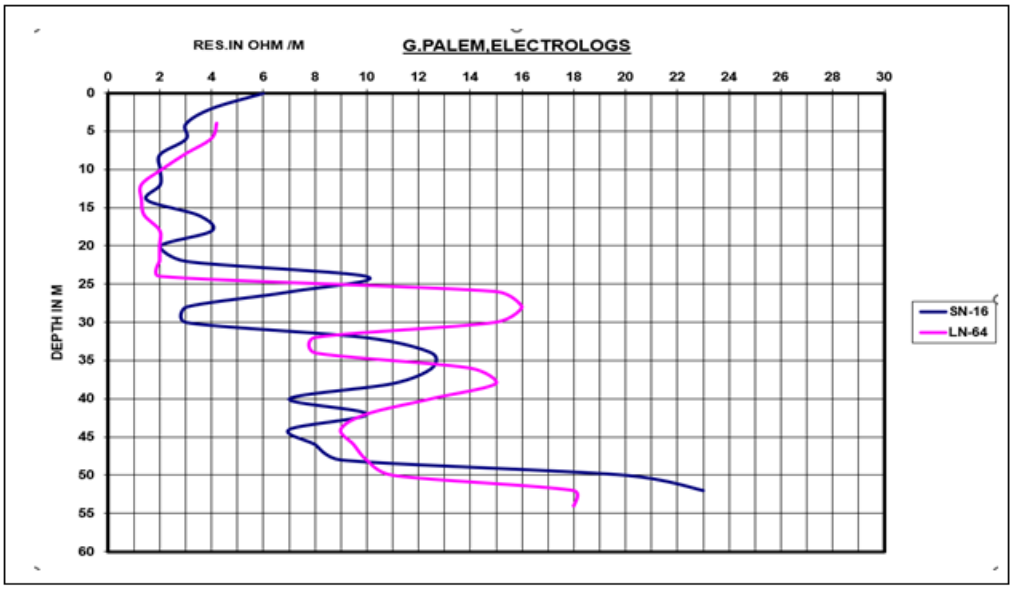

Fig. 4: SP, SN-16'' & LN-64'' logs.

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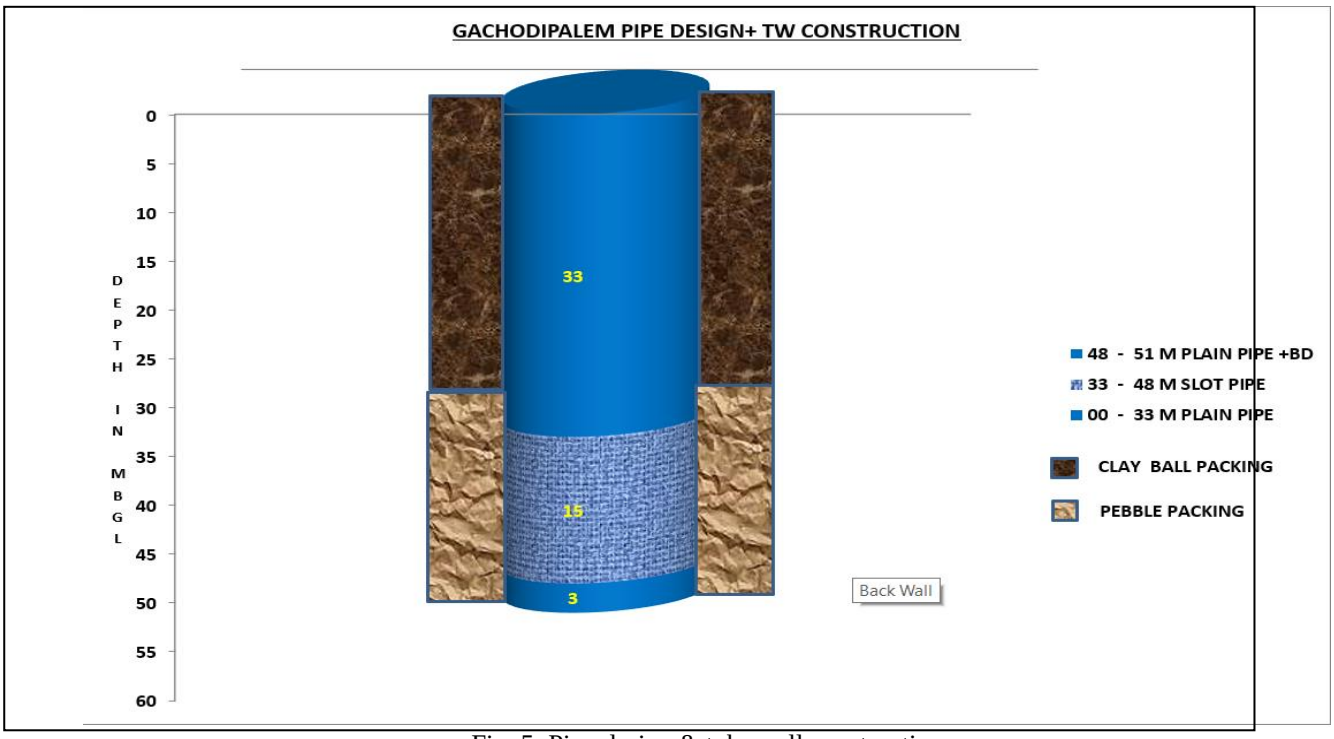

Fig. 5: Pipe design & tube well construction

C. Pumping test

A pumping test consists of pumping groundwater from a well, usually at a constant rate, and measuring water levels in the pumped well [4]. Pumping test is the most accurate reliable and commonly used method to evaluate the hydraulic parameters of an aquifer, efficiency of well, safer operational rates of pumping and selection of suitable pump. The objective of pumping test is to determine the aquifer parameters such as transmissivity [T], storage coefficient [S], hydraulic conductivity [K] and well performance and safe yield [6]. The common types of pumping tests conducted are, constant discharge test [CDT], step drawdown test [SDT] and recovery or recuperation test [RT] [5].

Well used for pumping is called as pumping well or exploratory well. The water level of the same well may be used. Otherwise, some nearby well may be used as an observation well. The water level observed in a well is called as hydraulic head [4]. A well yield test is a short flow test, usually done once the well is completed to provide a rough estimate of the well's yield. Well yield tests are done using by bailing or air lifting methods. Well yield is a measure how much water can be withdrawn from the well over a period of time and measured in m3/hr or m3/day. Specific capacity is referring to whether the well will provide an adequate water supply. Specific capacity is calculated by dividing pumping rate over drawdown (Q/S). The Static water level is the level of water in the well when no water is being taken out. Dynamic Water level is the level when water is being drawn from the well [4]. The term Drawdown refers [fig-11] to the declining water level in a well due to pumping.

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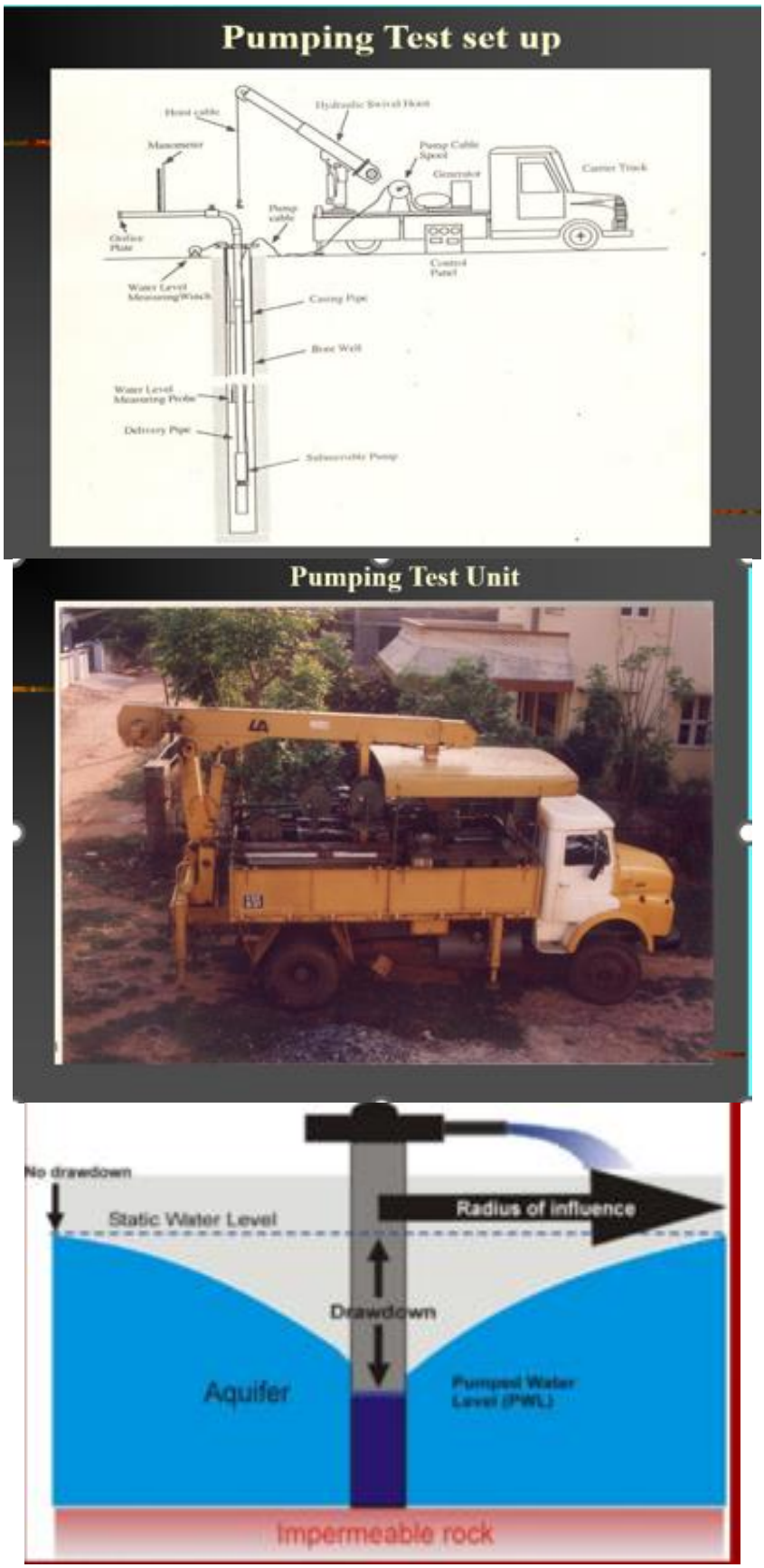

Fig. 6: PT setup & unit, Draw down [DD]

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IV. PUMPING TEST IN THE AREA OF INVESTIGATION

The details of tube well: depth-51m, dia-200mm, static water level [SWL]-16.59m, screen [slotted pipe]- 15m, discharge-683 lpm- 0.0113833 m3 /sec. Constant discharge test [CDT] with pumping duration of 530 minutes [8.83 hrs] was carried out by 5 HP submersible pump.No observation well is available for this work. Draw down for every minutes up to 125 minutes, then for every 15 mts up to 260 mts, for every ½ an hour up to 410 mts and for every 1 hr up to 530 mts.

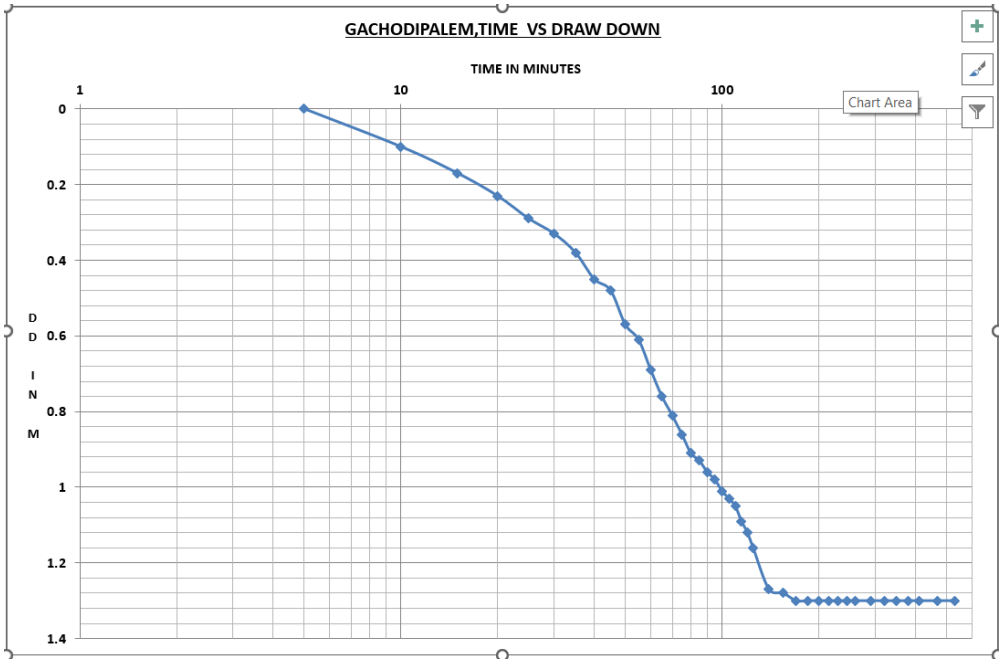
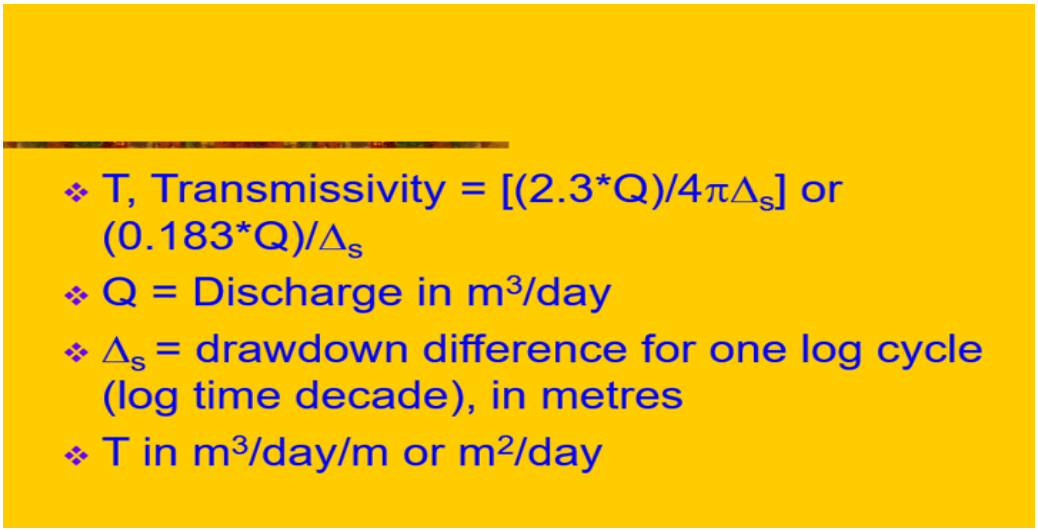


Fig. 7: Chart-1, Time Vs draw down graph

The total draw down is 1.3m and the equilibrium stage has reached after 170 minutes of pumping and the same 1.3 m DD was continuing up to 530 minutes.



As per Jacob's straight line graphical method, T is computed as follows,

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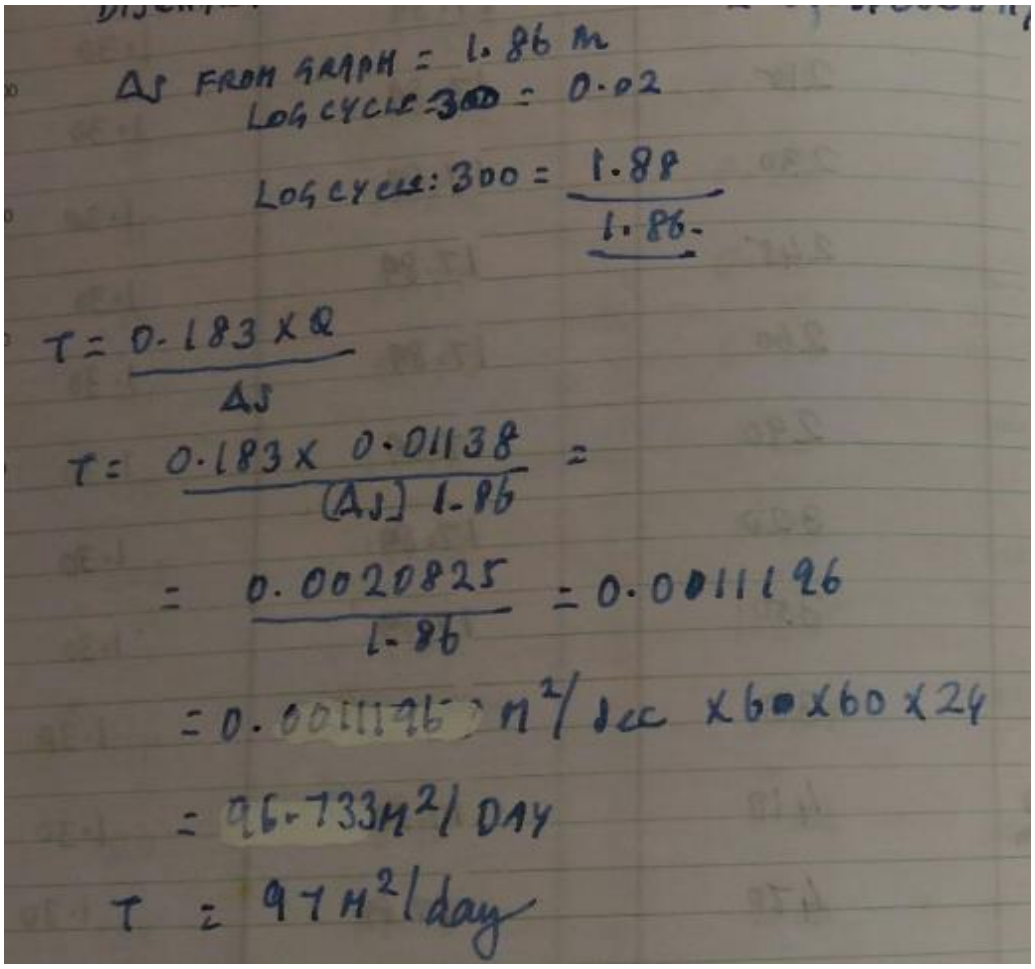

T= K x b
T- Transmissivity
K- Hydraulic Conductivity
b- Aquifer Thickness
K= T/b
T= 97m2/day, b = 15m. Therefore K= 97 / 15 = 6.47 m /day.

D. Computation of aquifer parameters by Aquifer test pro software by Theis method

The aquifer parameters have been computed by Aquifer test pro v 4.2, software package, which is a demo version used here, developed by Schlumberger water services of waterloo hydrologic software, designed for graphical analysis of pumping and slug test data. It offers necessary tools to calculate aquifer hydraulic properties. It is versatile enough to consider confined, unconfined, leaky and fractured rock aquifers [6].The result is as follows.

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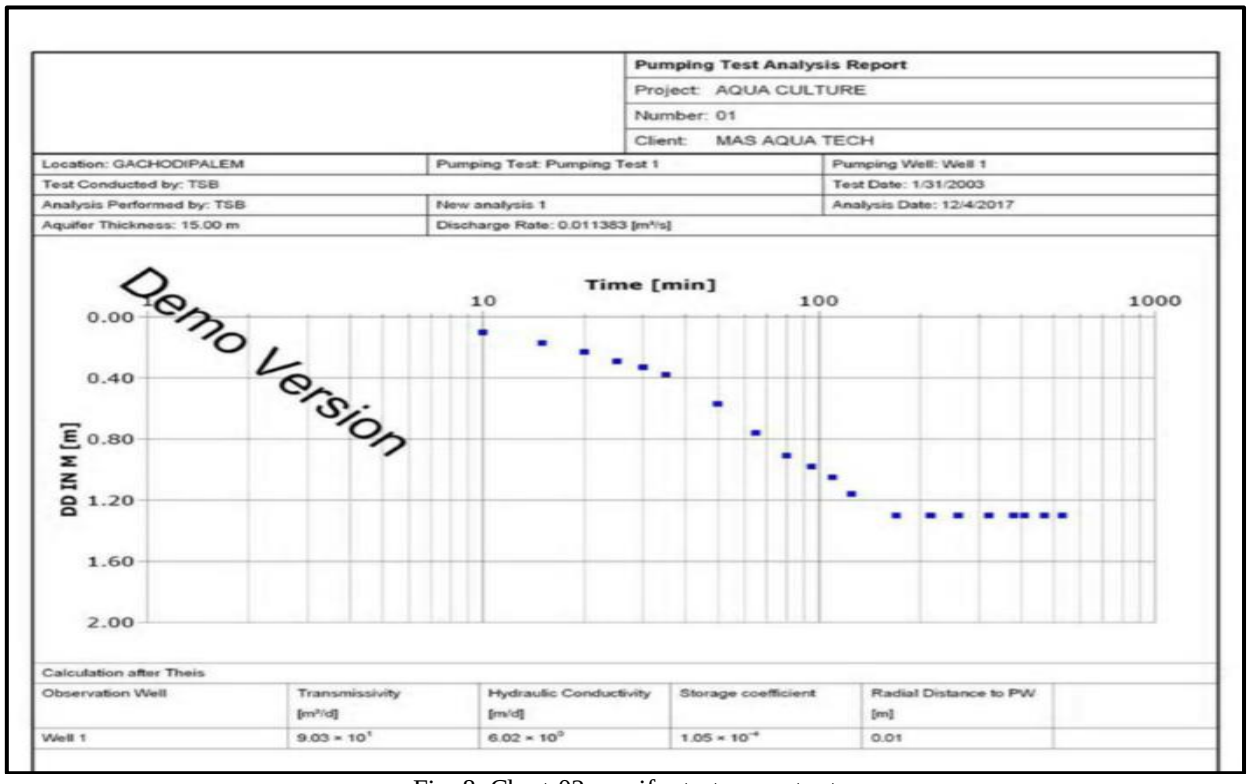

Fig. 8: Chart-02- aquifer test pro output

As per software computations, the aquifer parameters T, K&S are:

9.03×10^{1}	6.02×10^{0}	1.05×10^{-4}

The aquifer parameters T, K arrived by Jacob's straight line graphical method are $97 m^2$/day, 6.47 m /day.

V. RESULTS AND DISCUSSION

From the fig-4, it may be observed that the VES curve is multi layered [6 layered] curve with a minimum & maximum resistivities being 1.3 & 960 ohm.m indicating dry sand and clayey formations. From the fig-7 it can be noticed the brackish /saline water zone extends up to a depth of 24m as both resistivity logs show a low resistivity range of 2-4 ohm.m and below 25m depth only the resistivity logs display a increasing trend indicating fresh water zones. Below 35m showing a fluctuating trend of 8 to 15 ohm.m. below 45m depth both logs exhibit a same increasing trend reaching to a maximum of 23 ohm.m cleary indicating good fresh water sands. In fig: 8 it is evident that dry clay ball packing is recommended up to 28m to arrest the infiltration of top zone brackish / saline aquifers. Below 30m only pebble packing is given for free entry of fresh waters. The slotted pipes of 15m length is provided which being the correct fresh water aquifer thickness.From the chart-1 it could be seen still 155 minutes of pumping there is a steady draw down of 1.28m and from 17 mts onwards there is no draw down indicating the equilibrium stage. Till the last i.e. 530 minutes of pumping no draw down is there. From the chart-2 and Jacob's graphical method both T & K values are nearly the same.

VI. SUMMARY AND CONCLUSION

The study area Venkannapalem of Thottapalli mandal in Nellore district of Seemandra state, India is a sedimentary coastal plain where systematic geological, Hydrogeological, geoelectrical- 1D VES investigations followed by electrical well logging and pumping test have been conducted to prospect the groundwater resources for successful exploitation. The aquifer parameters by both Jacob's straight line graphical and as well as software program have been evaluated which are found to be nearly the same. The specific capacity of the aquifer is 683 lpm/ 1.3m dd/ 8 hrs of pumping.

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