

ELECTRICAL WELL LOGGING TECHNIQUES FOR GROUND WATER EXPLORATION



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PREFACE.

- Ground water is the most important component in our life support system. Ground water is a natural resource that occurs in the subsurface within the sediments & rocks.
- To exploit ground water resources, the disposition of the aquifers & ground water potential has to be studied.
- Ground water is replenished through precipitation. Over with drawl & scanty rainfall results in depletion of ground water & hence water scarcity occurs.
- Ground water does not occur every where & as its occurrence & distribution are confined to certain favorable geological formations & structures, the exploration poses problems.
- Ground water @ all locations is not directly useable if the quality of water is poor. These problems can be solved using proper exploration techniques.
- Thus numerous problems of Ground water exploration & exploitation requires systematic use of scientific techniques.

GROUND WATER EXPLORATION METHODS & TECHNIQUES.

- **Ground water exploration consists of several methods involving many disciplines. The four primary methods are Aerial, Surface, Subsurface & Esoteric.**
- **All ground water investigation requires the service of Geophysical method as it aids in determining the subsurface structure.**
- **Exploring the ground water by geophysical method is termed Ground water geophysics.**

WHAT IS GEOPHYSICS ?.

- The study of the earth using quantitative physical methods, remote insight into the earth.
- We designate the study of the earth using physical measurements at the surface as geophysics.
- In a broader sense, geophysics provides the tools for studying the structure and composition of the earth's interior

GEOPHYSICAL INVESTIGATION

- **Geophysical methods comprise of measurement of signals from natural or induced phenomena of physical properties of sub surface formation.**
- **Various physical properties that are made use of in different geophysical techniques are electrical conductivity, magnetic susceptibility, density, elasticity & radioactivity.**

GROUND WATER GEOPHYSICS.

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graph TD; A([GROUND WATER GEOPHYSICS.]) --> B([SURFACE GEOPHYSICS.]); A --> C([SUBSURFACE OR BORE HOLE GEOPHYSICS.]);
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SURFACE GEOPHYSICS.

**SUBSURFACE OR
BORE HOLE GEOPHYSICS.**

SURFACE GEOPHYSICAL METHODS OF EXPLORATION.

SURFACE GEOPHYSICS –

- Geophysical investigations conducted on the surface of the earth to explore the ground water resources by observing some physical Parameters – density, velocity, conductivity, resistivity, magnetic, electromagnetic & radioactive phenomena etc.
- Purpose of exploring – to assess & quantify the potentials for exploitation.

STAGES OF GW EXPLORATION IN SEDIMENTARY TERRAIN.

SURFACE METHODS.
WELL SITE
SELECTON BY
INTEGRATED
HYDROGEOLOGICAL
& GEOPHYSICAL
METHODS.

SUB SURFACE METHODS.
DRILLING PILOT
BORE HOLE,
LITHOLOG,
ELECTRICAL WELL
LOGGING.

WELL DEVELOPMENT
BY AIR COMPRESSOR,
YIELD ASSESSMENT,
WELL COMPLETION,
PUMPING TEST-
HYDROGEO CHEMICAL
ANALYSIS OF
WATER SAMPLE..

STAGES & PROBLEMS IN GROUND WATER EXPLORATION.

- Ground water exploration programme comprises number of stages- the first stage is identification of suitable well site by integrated hydrogeological & geophysical methods-second stage is drilling & last stage is development of well.
- In some sedimentary coastal region & saline water infested area, the saline water mixes with fresh water & the well become useless.
- Such undesirable zone has to be sealed by constructing the well through well assembly consisting of plain & slotted pipes.
- For this purpose, the identification of precise disposition of various lithological layers, various aquifer zones & water quality changes are essential.
- Bore hole geophysical logging techniques are the best suitable for this purpose & with their widespread success & excellent scope of application , these have become indispensable in the development of water wells.

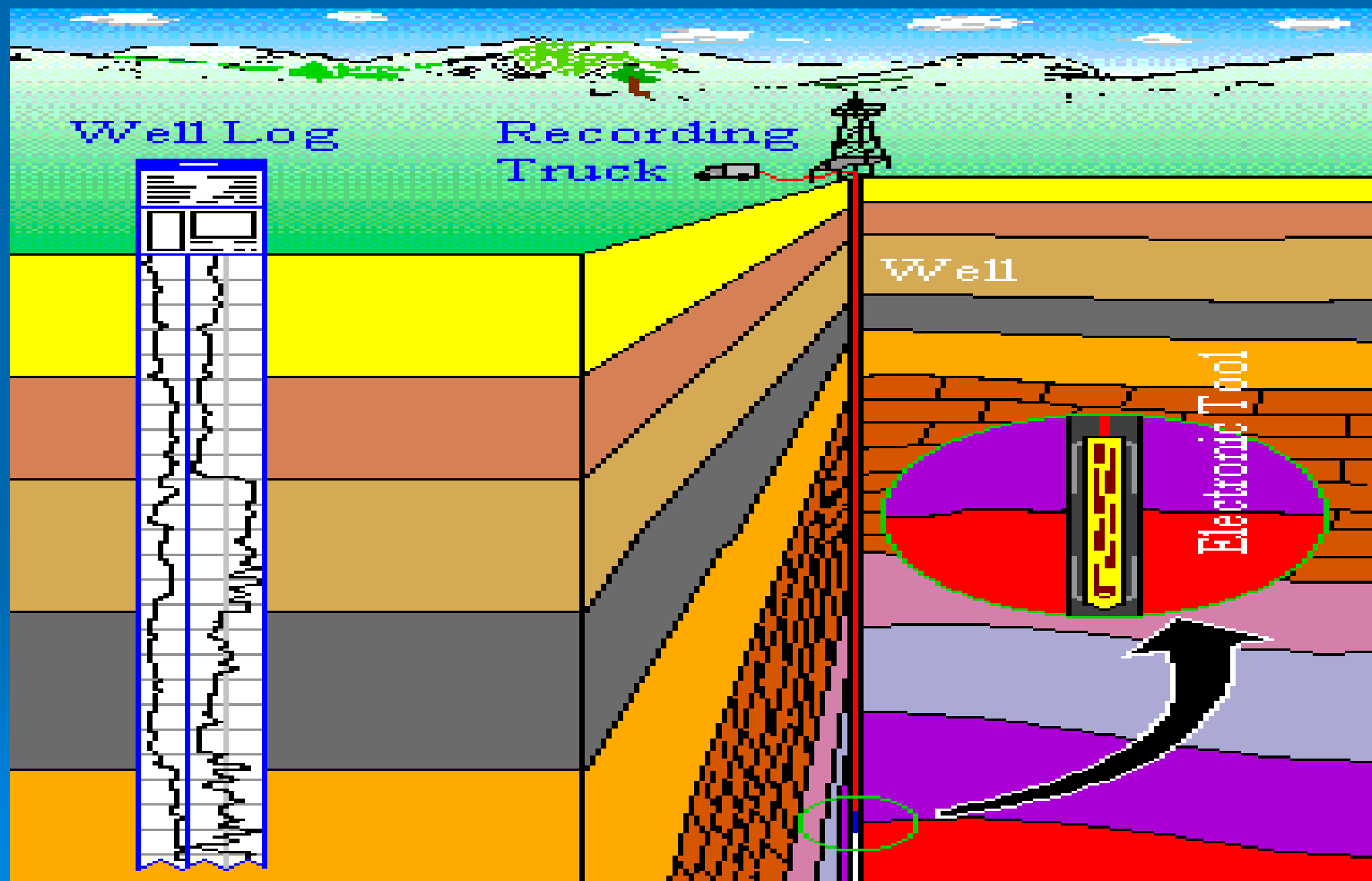
GEOPHYSICAL LOGGING TECHNIQUES OR BORE HOLE GEOPHYSICS- AN OUTLINE.

- Geophysical logging of boreholes came a long way since 1927, when Schlumberger brothers ran the first electric log.
- In India the geophysical logging of water well was carried out for the first time in 1953 by GSI, in Bihar.
- Basically there are two types of logging techniques- first utilizing the natural source & second utilizing stimulated controlled source.
- Geophysical logging technique utilizes the measurement of certain physical Parameters across different subsurface formations with the help of sensing probe inside the bore hole providing a continuous record of these parameters versus depth.
- These parameters are interpreted in terms of lithology, porosity, moisture content & quality of formation fluids.
- Different physical properties like electrical conductivity, magnetic susceptibility, radioactivity & velocity etc are utilized.

PURPOSE OF WELL LOGGING.

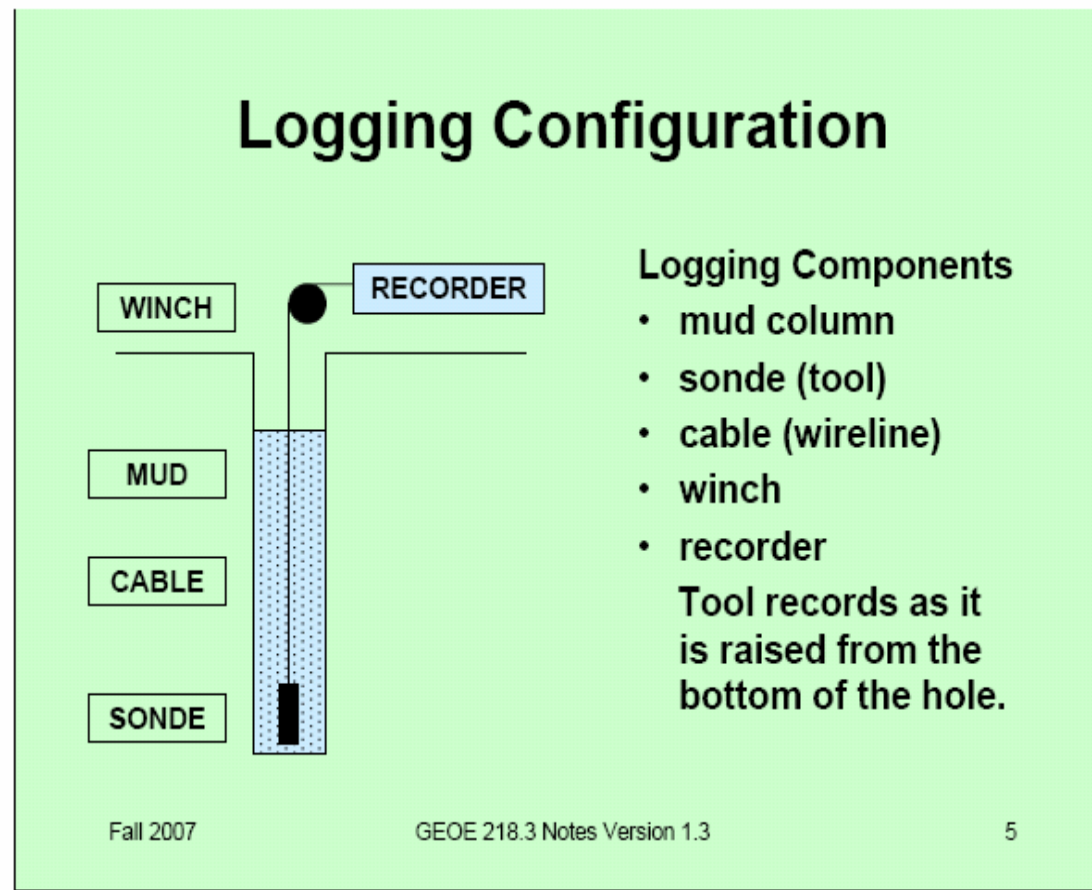
- It is a subsurface geophysical method of exploration, to get a clear picture about the under ground.
- The primary purpose of well logging is the identification of formations traversed by a bore hole & salinity of fluids.
- Used for stratigraphic correlation, detection of bed boundaries, porous & permeable zones.
- Used for the water well design & construction.
- Used for sea water intrusion studies of coastal aquifers.
- In hard rock bore wells the fracture systems can be studied for rejuvenation.
- Normally logging is carried out in pilot bore holes recommended, after thorough geological & surface geophysical surveys.

WELL LOGGING.




LOGGING CONFIGURATION.

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DIFFERENT TYPES OF LOGGING METHODS.

- **Electric logging – electrical resistivity & sp.**
 - **Radioactive logging – gamma ray & neutron logs.**
 - **Induction logging.**
 - **Sonic logging.**
 - **Fluid logging – temperature, fluid resistivity, flow meter & tracer logging.**
 - **Caliper logging.**
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ELECTRIC WELL LOGGING.

- The continuous recording of electrical resistance / resistivity & sp of the formations by a drill bore hole is electric logging.
- Point resistance & resistivity logs-the response of formations in form of resistance offered to the electric conduction is measured in 2 modes- resistance & resistivity.
- Sp log- the potential drop between bore hole electrode & a reference electrode @ the surface is recorded.
- Sp logs are highly useful in deciphering saline water & clay predominant zones.
- Resistivity logs- normal resistivity logs are 4 electrode system- used for ground water & mineral explorations.

SELF POTENTIAL LOGS

- The sp is recorded between the bore hole electrode & reference electrode @ the surface.
- The logging device for sp & point resistance is the same in most of the cases.
- Sp logs are highly useful to delineate clay dominant & saline water zones.
- Of much use in sulphide mineral explorations.
- Clay manifests as low sp & low resistance on electric log.
- The quality of formation water can be estimated from sp log.

SP LOGGING.

3. Spontaneous Potential (SP) Logging

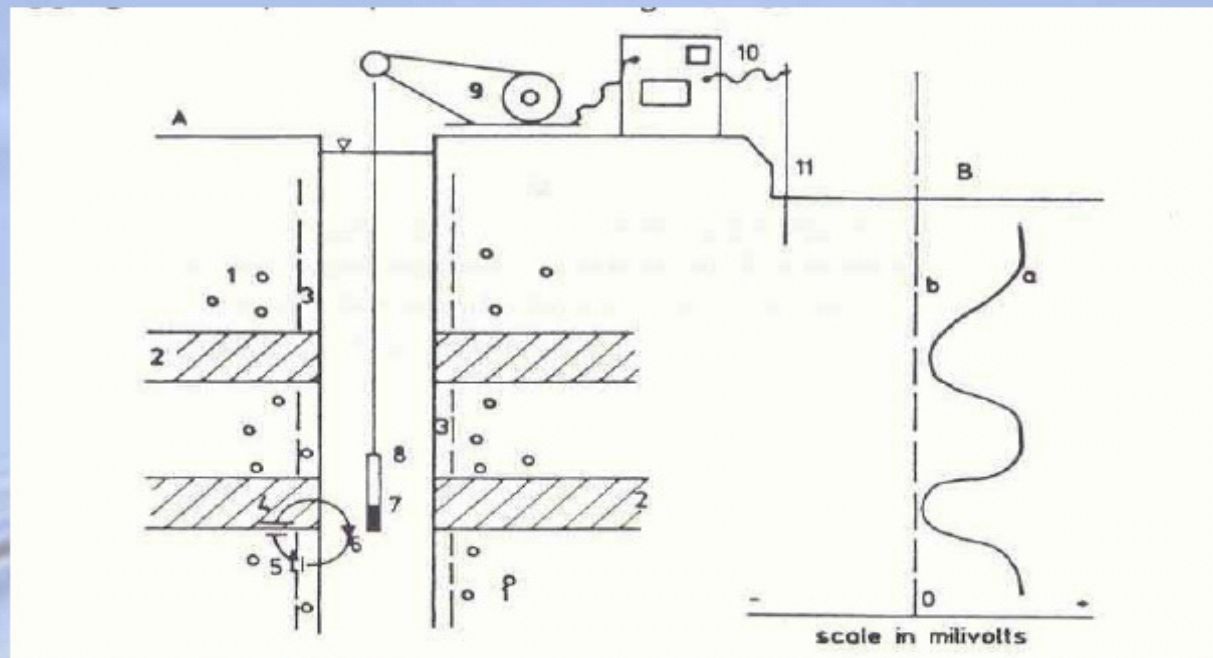
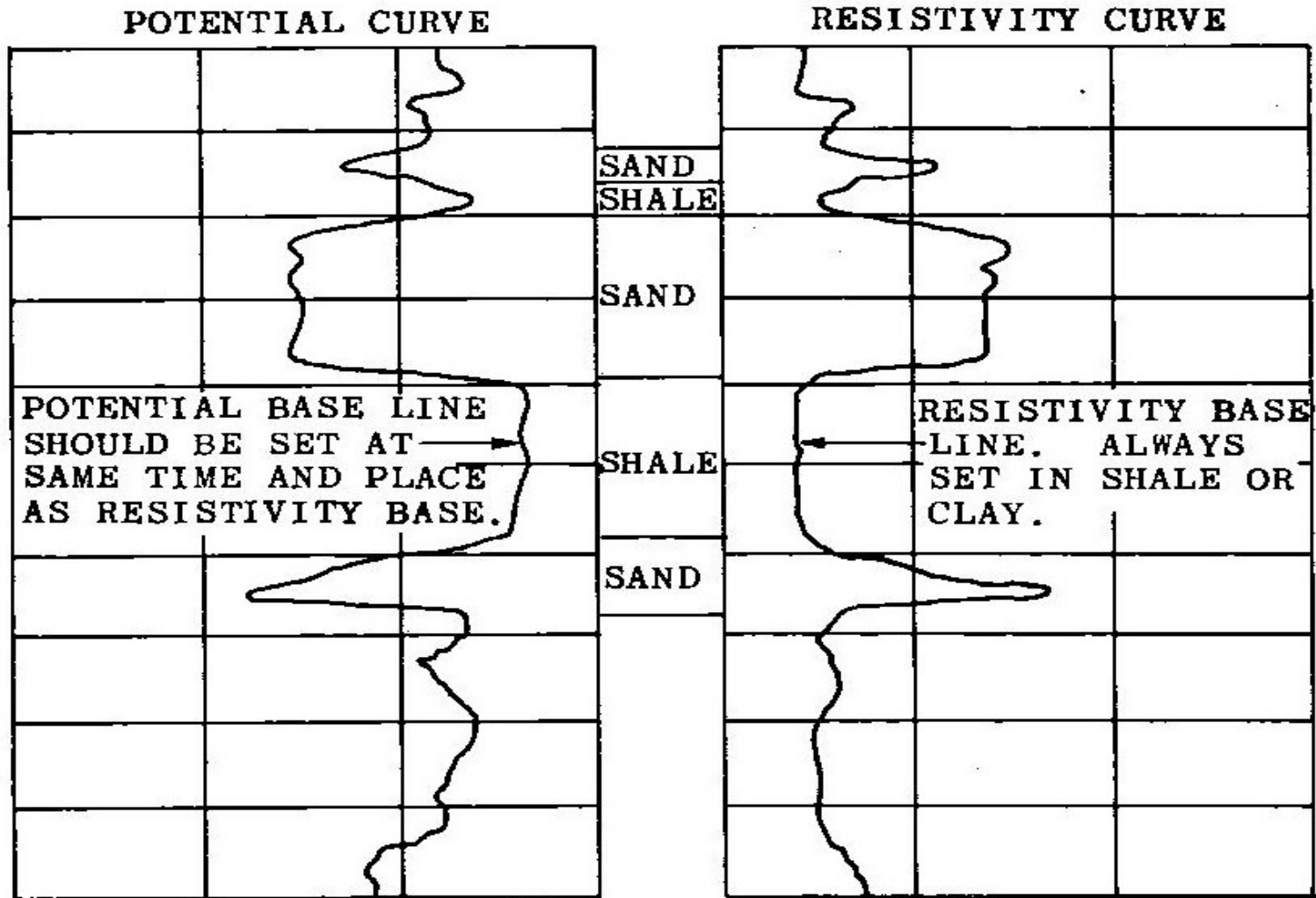


Figure 3.1 Layout (A) and associated log (B) for SP logging

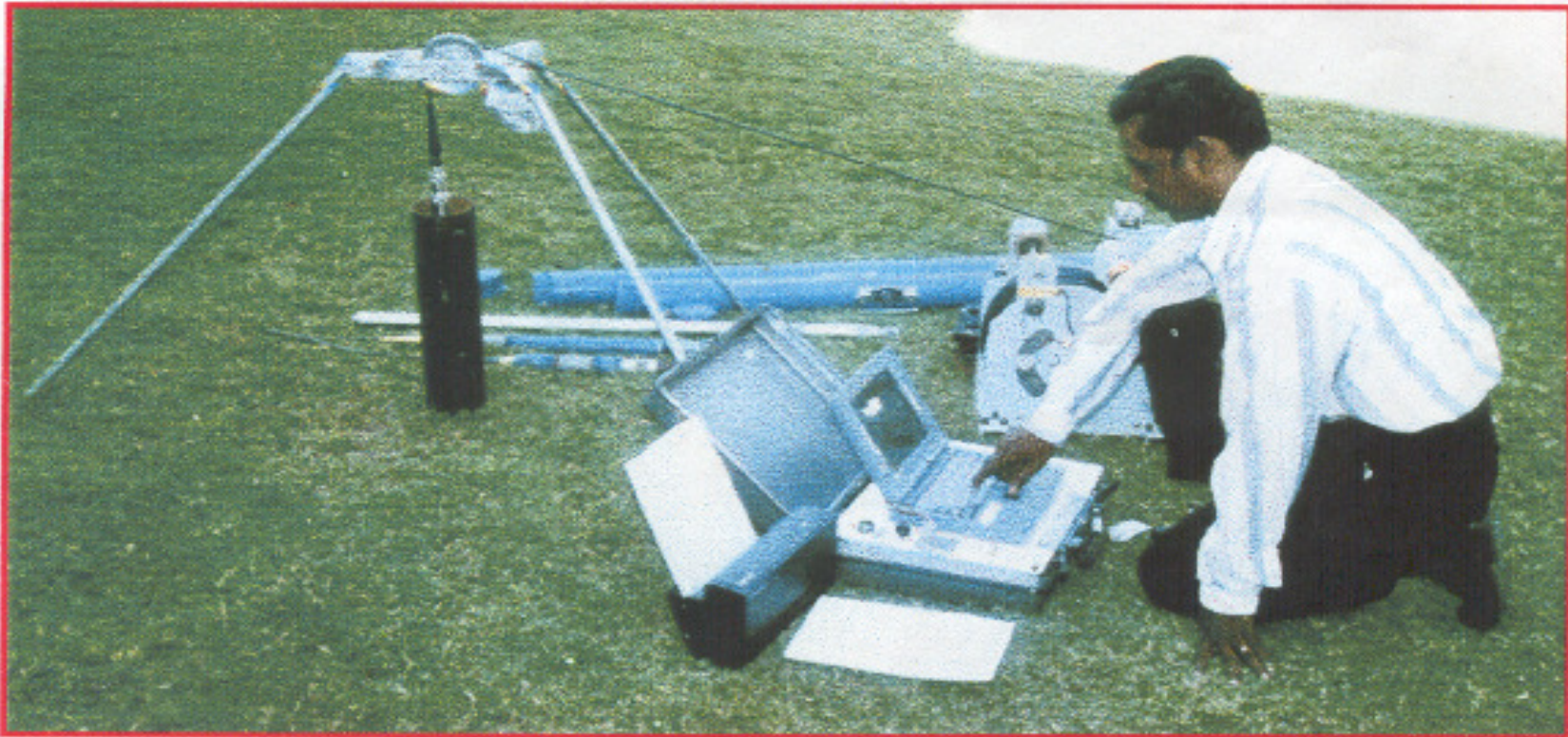
BASE LINE SETTING IN ELECTRICAL WELL LOGGING.



PORTABLE MINI SPOT ELECTRICAL WELL LOGGER.



MINI LOG – PMBL
PORTABLE MULTIPROBE BOREHOLE LOGGER
(D.S.T. TECHNOLOGY DEVELOPED AT N.G.R.I. HYDERABAD.)



ELECTRICAL WELL LOGGER.



LAYOUT FOR RESISTIVITY LOGGING.

4. Resistivity Logging

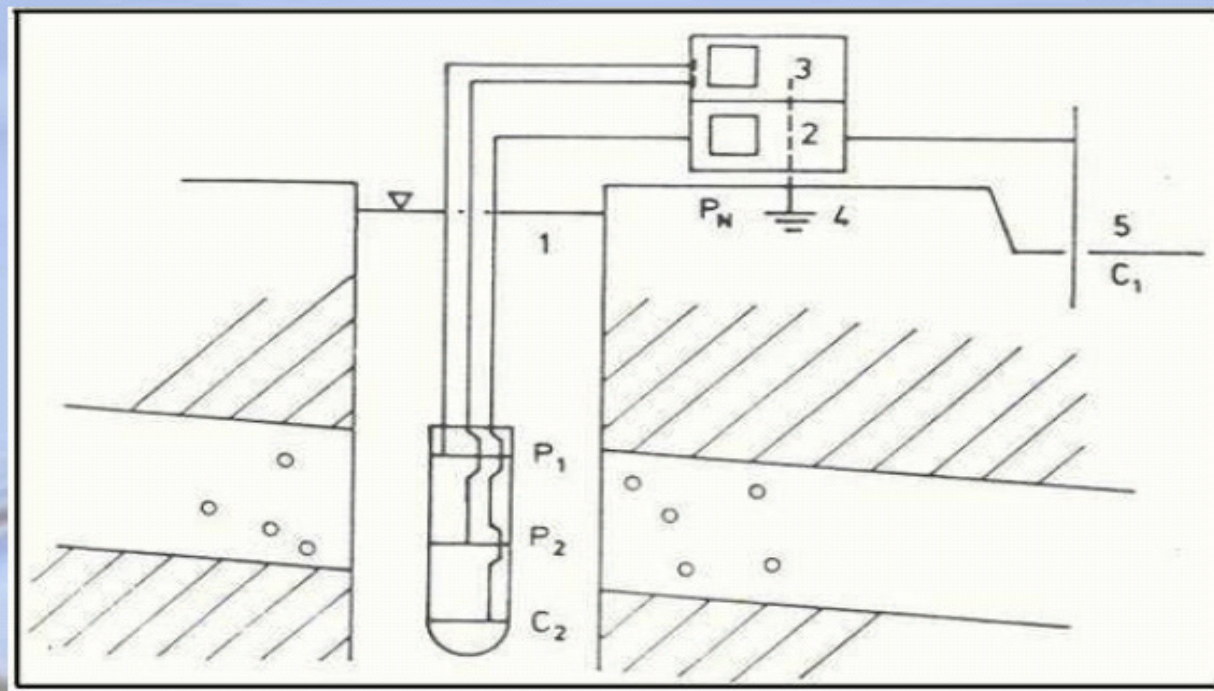


Figure 4.1 The layout for resistivity logging

SCHEMATIC CIRCUITS FOR MEASURING SP & POINT RESISTIVITY.

4. Resistivity Logging

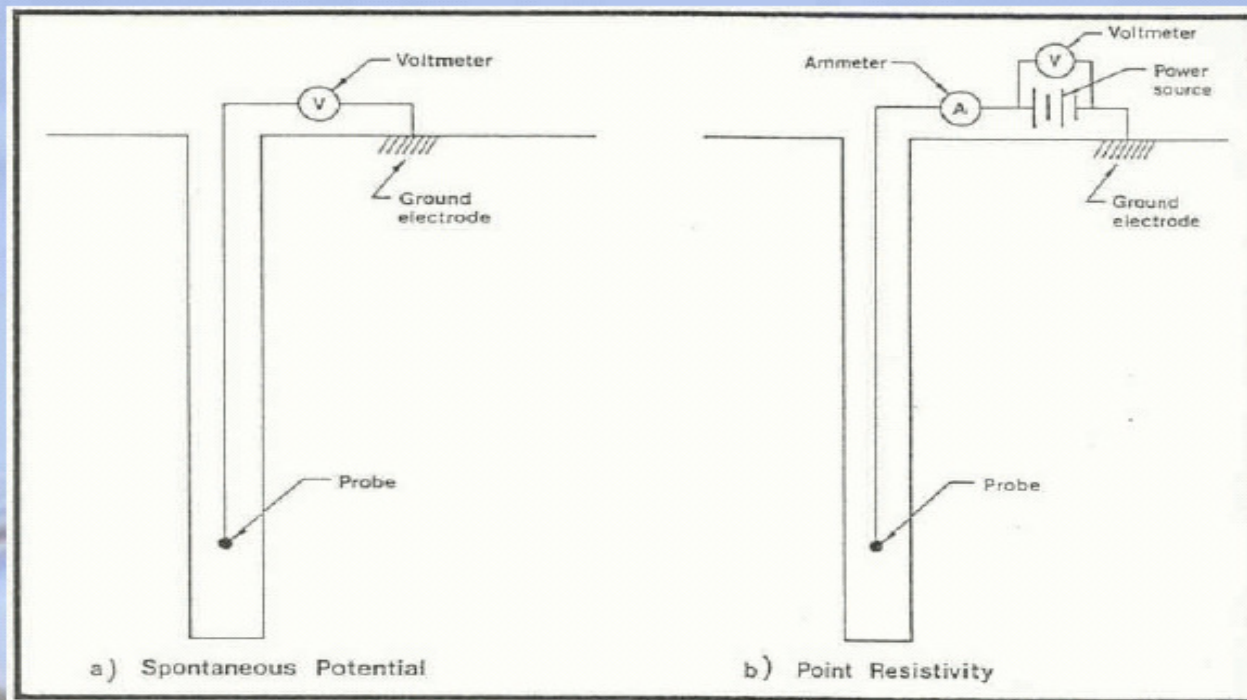
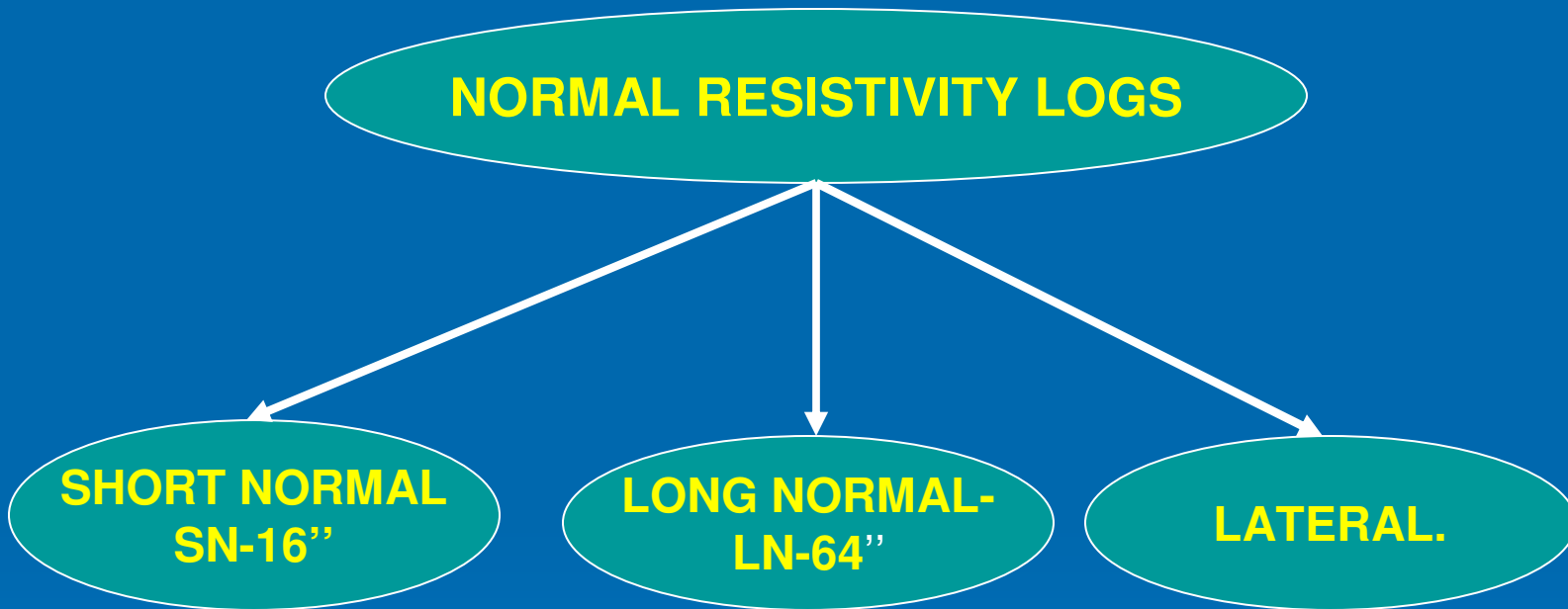


Figure 4.2: Schematic circuits for measuring Spontaneous Potential and Point Resistivity

NORMAL RESISTIVITY LOGS.



WELL LOG CHART

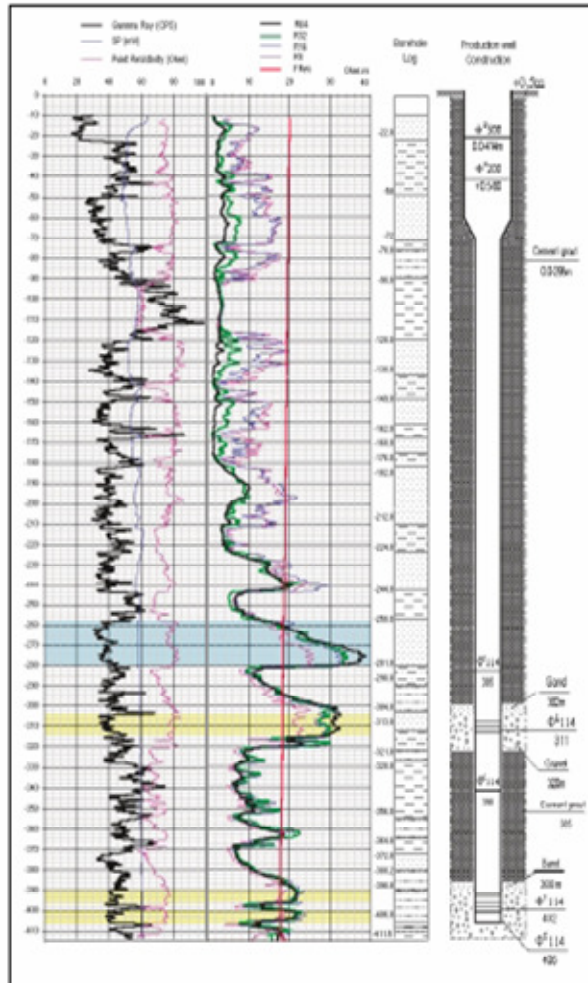


Figure 3 : Borehole Geophysical Data and Construction of Production Well SP3

CONSTRUCTION OF BORE WELL IN SEDIMENTARY TERRAIN

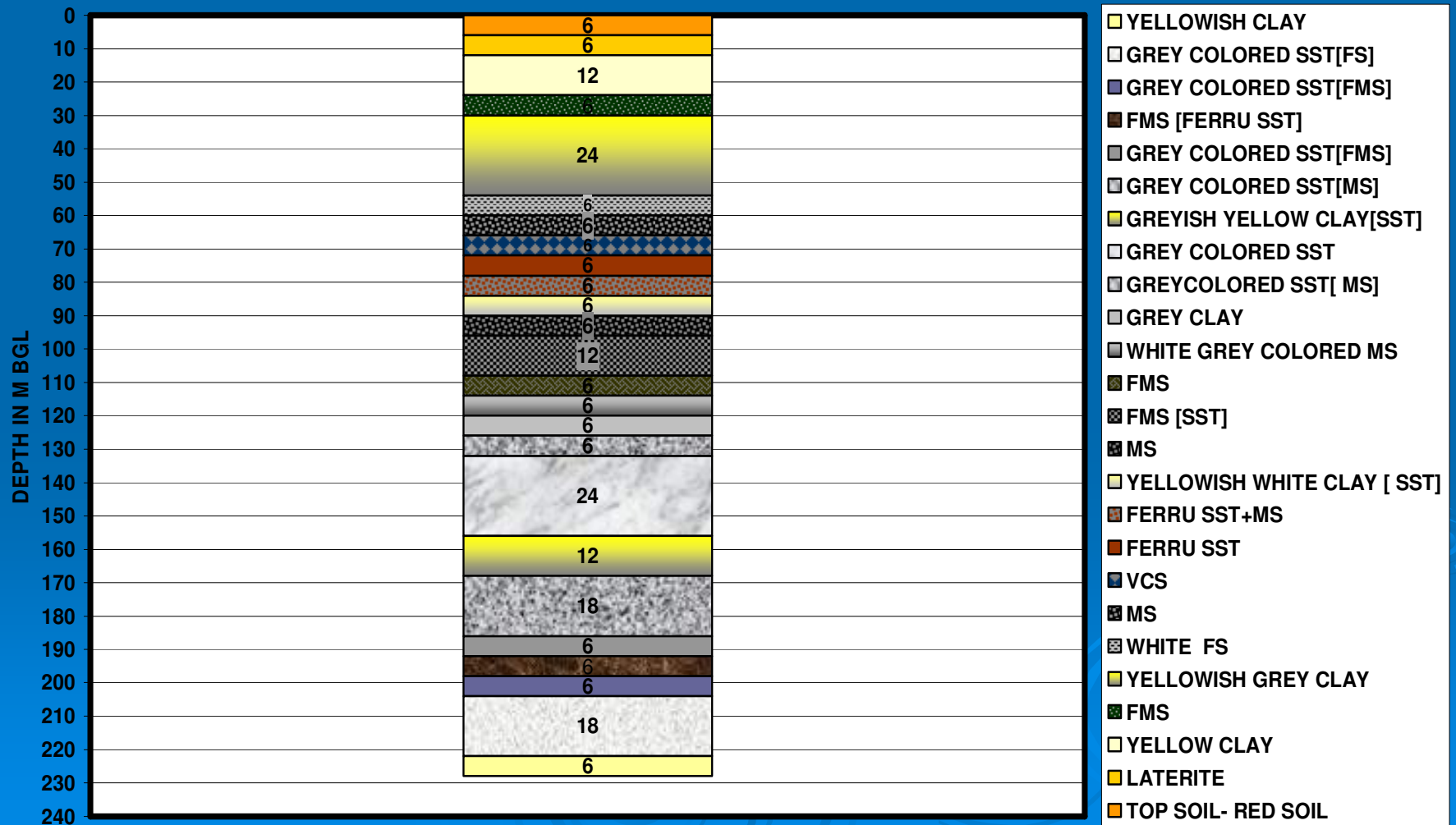


A CASE STUDY.

- **Area of investigation-** Srichakra Avenue, a coastal sedimentary area in Chidambaram taluk, Cuddalore district, Tamilnadu.
- **Problem-** Even shallow aquifer quality is very poor & saline- only deep confined aquifer below 130 metres is fresh- exploration & construction problematic.
- **Purpose-** For providing drinking water supply.
- **Methodology of exploration-** Integrated hydrogeological & hydro geoelectrical investigations for very deep bore well site selection-pilot bore drilled to a depth of 222 m- electrically well logged by portable spot logger.
- **Tube well construction-** Tube well of 150 mm dia constructed – depth- 219 m- saline water zone up to 130 m- 186 to 201 & 207 to 213 m slotted pipes provided- to arrest saline water dry clay balls packing up to 160 m & 160 to 219 m pebble packing.
- **Yield of tube well-** Tube well developed, completed- yield- 760 LPM- good drinkable fresh water.

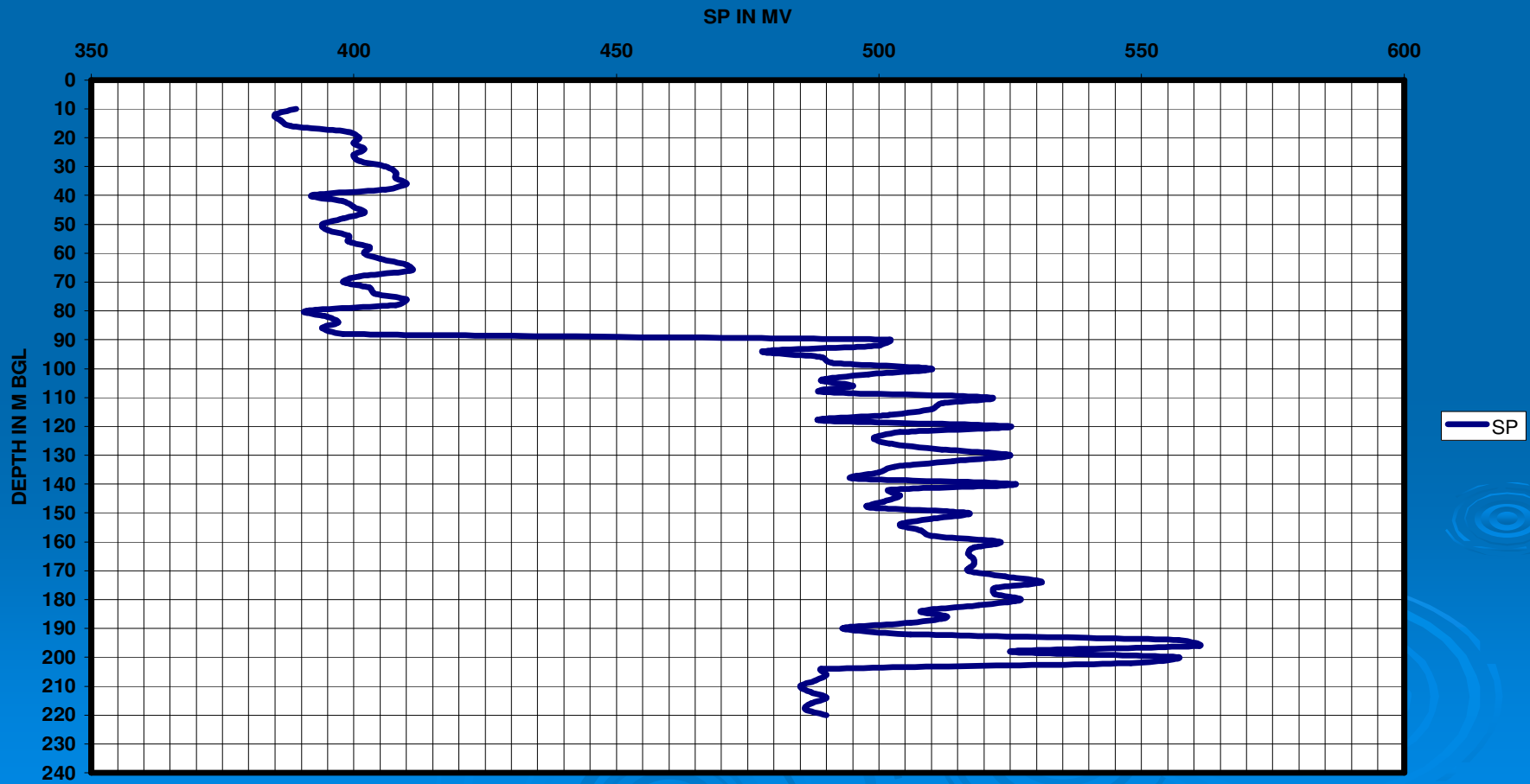
LITHOLOG.

SRI CHAKRA AVENUE LITHOLOG



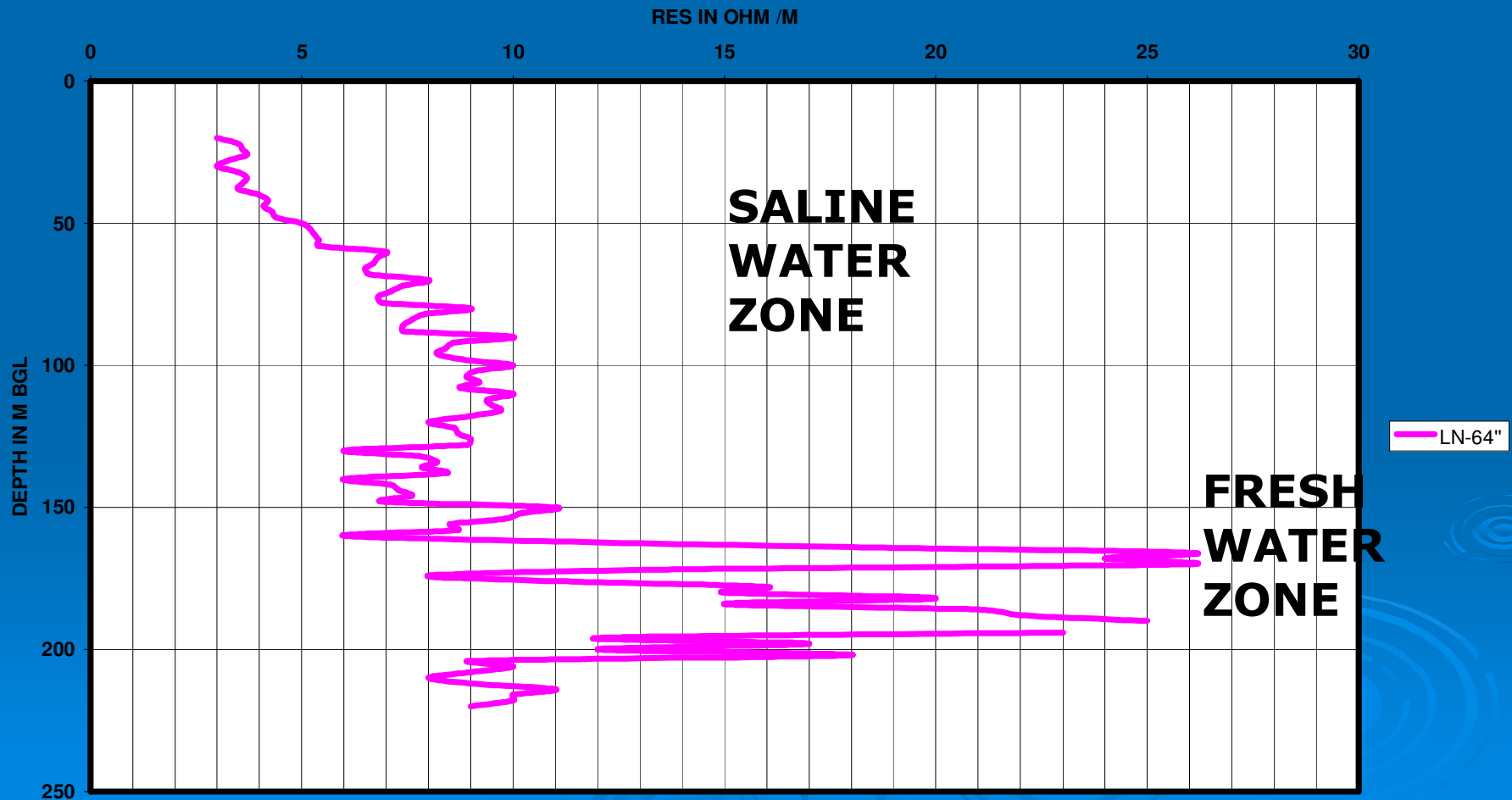
ELECTRICAL WELL LOGGING- SP LOG CURVE.

SRI CHAKRA AVENUE SP LOG



ELECTRICAL WELL LOGGING- RESISTIVITY LOG- LN-64" CURVE.

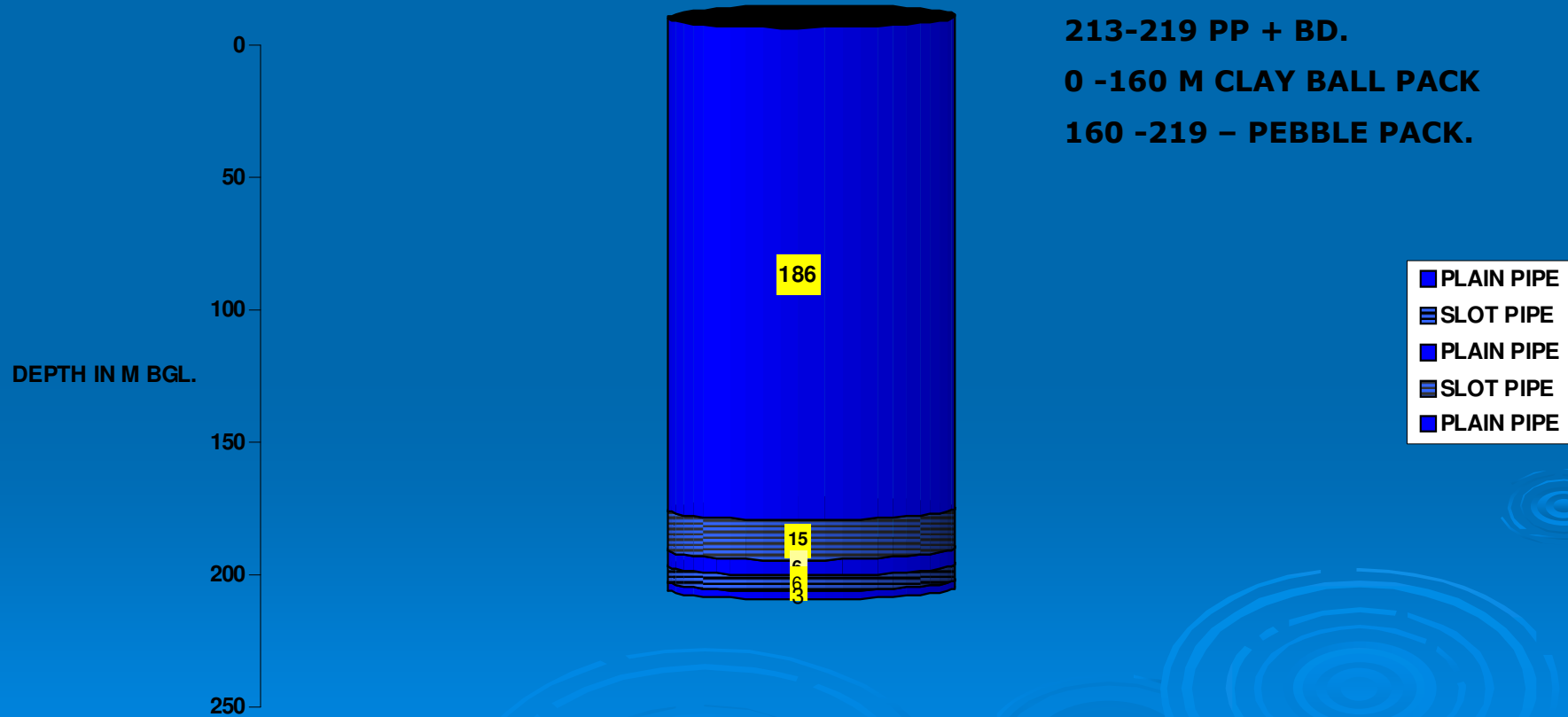
SRI CHAKRA AVENUE RES LOG- LN-64"



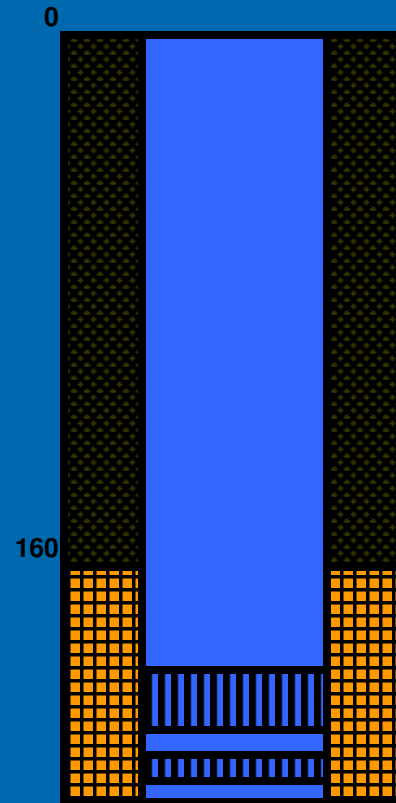
PIPE DESIGN.

SRI CHAKRA AVENUE PD

0- 186 M PP, 186 -201 SP,
201-207 PP, 207-213 SP,
213-219 PP + BD.
0 -160 M CLAY BALL PACK
160 -219 – PEBBLE PACK.



**SRI CHAKRA AVENUE TUBE WELL CONSTRUCTION.
NOT TO SCALE.**



LEGEND

 PLAIN PIPE

 SLOT PIPE

 CLAY BALL PACK.

 PEBBLE PACK.

CONCLUSION

Thus electrical well logging is a good tool for ground water exploration- only by this technique the saline aquifers & fresh water confined aquifers could be delineated.

This subsurface method is used for mineral prospecting. Hydro geological investigation & various geo scientific applications.

It is used to delineate the fracture systems in hard rock terrain for rejuvenation of failed & poor yielding bore wells.

It is cost effective, reliable & fool proof.

From this technique the quality of formation water can be very well ascertained- even parameters like EC & TDS can be determined.

If the quality of water is found to be saline after electrical logging, the bore hole may be abandoned & construction of tube well can be avoided which is the major expenditure incurred & thus unnecessary expenditure is curtailed.