

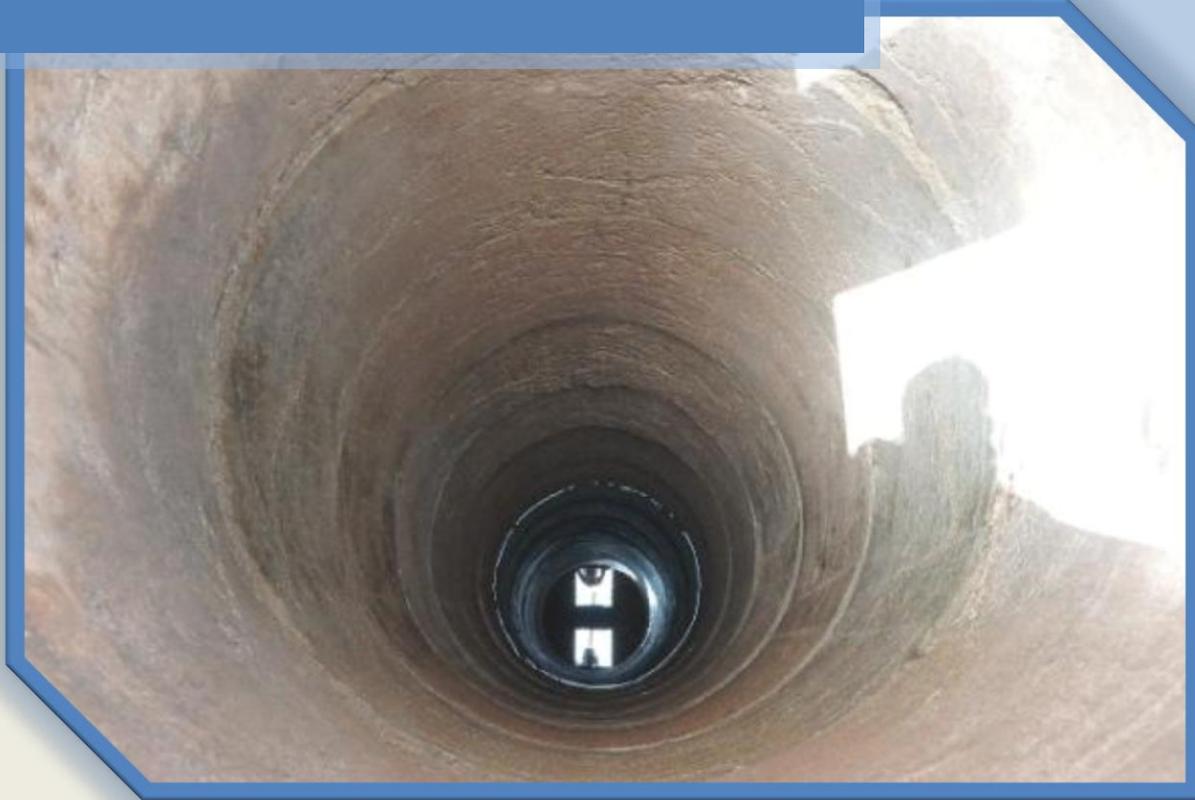


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2012

## Monitoring Ground Water Level and Piezometric Pressure



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January 2012



## APPLICATION NOTE

AN-120101

January 2012

### MONITORING GROUND WATER LEVEL AND PIEZOMETRIC PRESSURE

#### 1. Introduction

Groundwater is a critically important global resource. It requires careful monitoring, protection and management. Monitoring of ground water level (water table) and its recharge has become a mandatory requirement at several places all over the world. Encardio-rite manufactures a range of instruments for ground water monitoring ranging from the simple to the most sophisticated. Systems for monitoring ground water either manually or automatically are both available from Encardio-rite.

#### 2. Manual monitoring

##### 2.1 Model EPP-10SP standpipe for monitoring ground water level

Encardio-rite model EPP-10SP standpipe is basically an observation well used for measuring ground water level and its variation with time. It consists of a series of 3 m long PVC riser pipes around 50 mm in diameter with an inbuilt socket at one end for jointing. The intake point of the standpipe consists of a same diameter PVC slotted pipe, generally 1 m long fixed at the bottom of the pipe assembly. Slotted pipes up to 3 m long are also available. The slotted pipe is covered with geotextile to prevent any ingress of solid particles. The bottom end of the slotted pipe is plugged with a suitable PVC cap.

The standpipe is set in a 100 mm diameter borehole that is drilled into the soil/foundation to a depth beyond the maximum expected ground water level.

The space between the borehole and standpipe is filled with pea gravel or a clean sand and gravel mix. The top of the borehole is sealed with a cement bentonite plug. Ground water seeps into the riser pipe through the slotted end and attains a level equal to the ground water level at the location.

A plate hinged cover with locking arrangement is provided for mounting at top of the standpipe.

In figure 1 is illustrated a typical assembly and installation layout of Encardio-rite model EPP-10SP standpipe for monitoring ground water level.

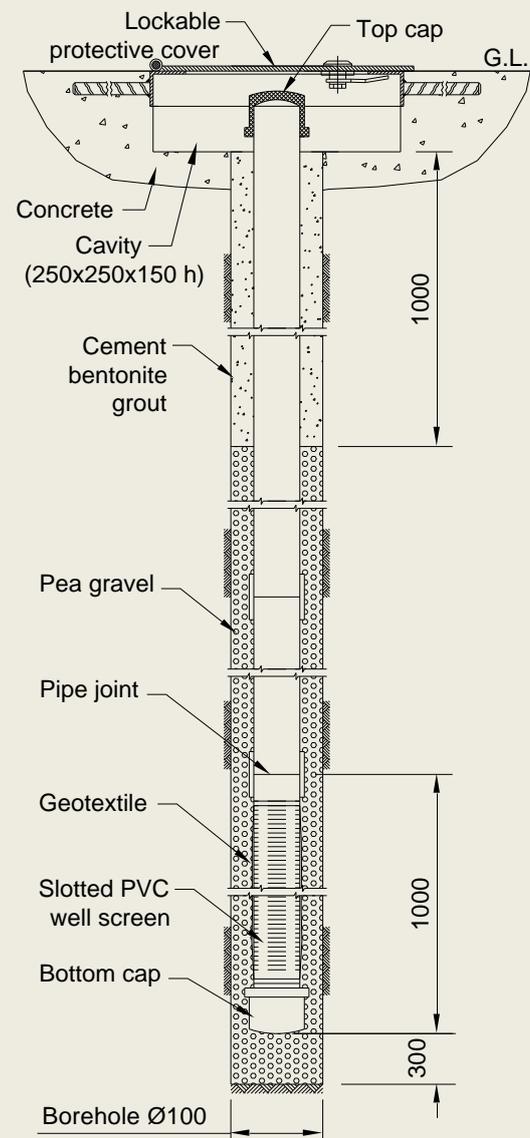


Figure 1 - standpipe to monitor water level

##### 2.2 Model EPP-10 Casagrande piezometer for monitoring piezometric pressure.

The pressure experienced by water contained in the pores of earth materials, concrete structures or rock is generally called pore water pressure. In instrumentation schemes for ground water monitoring,

measurement of pore water pressure (also known as piezometric pressure or level) generally plays an important role.

The main purpose of study of pore pressure is to determine the level and flow pattern of ground water.

Piezometric pressure at a point is generally equal to the ground water level around it but it is not necessarily so. In rock enclosed aquifers, the ground water pressure may be different from the surrounding ground water level. Take the example of a water spring. The water pressure in the aquifer connected to the spring makes water flow out to the ground; whereas one would have to dig a few meters away from the spring to find water.

The model EPP-10 Casagrande piezometer illustrated in the adjoining figure is used to measure piezometric pressure at any point below the ground surface.

The intake point of the piezometer consists of a porous tube of annular cross-section. The bottom end of the porous tube is plugged with a suitable rubber stopper. The porous tube is set in a borehole that reaches down to a depth where the pore pressure is to be monitored. The porous tube is connected to a 25 mm diameter plastic riser pipe extending to the surface.

The annular spacing between the riser pipe and the borehole is sealed with cement grout, thus ensuring that the piezometric pressure is monitored only at the depth at which the porous tip is installed. Please note that in section 2.1 (standpipe), this annular spacing is filled with pea gravel or a mixture of sand and gravel.

The pressure of the pore water surrounding the porous tube causes water to flow in through the piezometer tip and rise up in the riser pipe until the pore pressure is equalized by the head of water in the riser pipe.

Just as in the case of the Standpipe, a plate hinged cover plate with locking arrangement is available for mounting at top of the standpipe.

Please note that the standpipe measures the water table at any location; whereas the Casagrande piezometer measures the water pressure at the location of the installed piezometric tip.

### 2.3 Model EPP-10/6 water level indicator

The model EPP-10/6 water level sounder is designed to measure depth of water surface from ground level in a borehole, stand pipe, well or Casagrande piezometer installation.

The unit is robust, light weight and convenient to use. It is battery operated complete with an on-off switch, buzzer, LED, flat cable connected to a probe, winding reel and carrying handle.

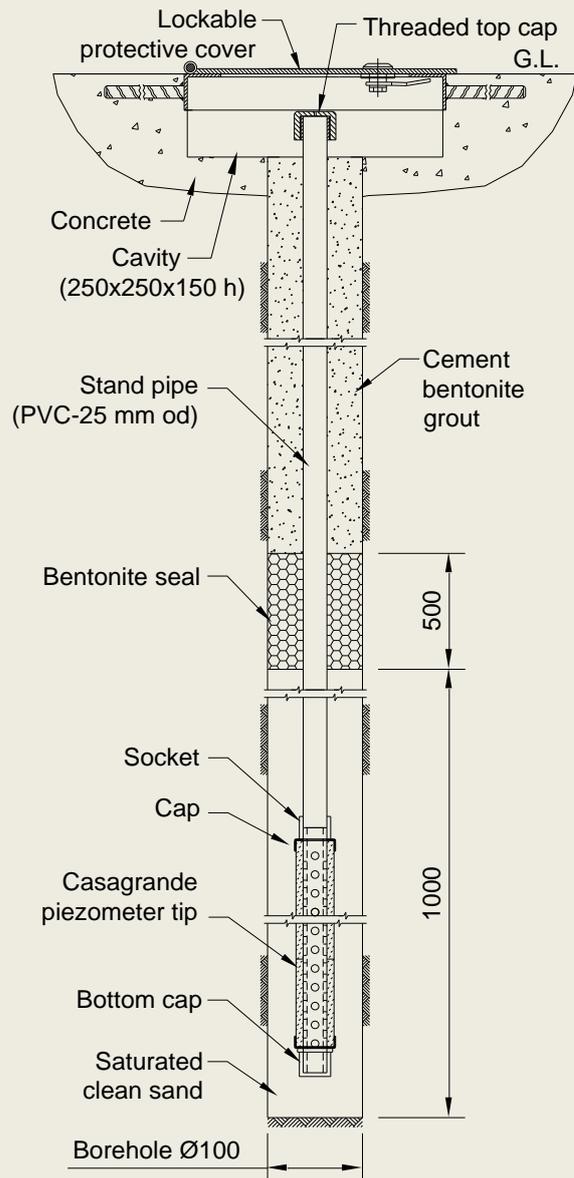


Figure 2 - Casagrande piezometer

The water level sounder probe is lowered from the surface with the help of the connecting twin conductor flat cable for taking observations. The cable contains a high tensile virtually non-stretch, insulated flat steel tape core and is 10 mm wide x 2 mm thick. The water level sounder gives an audible and visible signal when water in the borehole/well makes a contact with the tip of the probe. The depth of the probe from the riser tube top rim can be read off the graduated marks on the cable.

The moisture resistant electronics and standard 9 V PP-3 size battery are housed in the hub of the cable reel. The hub cover can be easily removed to replace the battery or check the electronics without disassembling the entire cable reel.

Model EPP-10/6 water level sounder is available in tape lengths of 30, 50, 100, 150, 200, 300 m with a 1 mm resolution.



Figure 3 – Water level sounder

### 3. Electronic Monitoring

#### 3.1 Model EPP-30V and EPP-60V for monitoring water level or piezometric pressure

Model EPP-30V and EPP-60V vibrating wire sensors are high accuracy devices specially designed to measure water level or pore pressure in a borehole depending upon how the sensor is installed. A thermistor is also provided in the pressure sensor for measurement of water temperature.

<b>Range EPP-60V</b>	3.5, 7 m wcl ( 0.035, 0.07 MPa)
<b>Accuracy</b>	± 0.2 % fs normal ± 0.1 % fs optional
<b>Dimension (Ø x L)</b>	30 mm x 160 mm
<b>Cable</b>	CS-1102 vented tube

Model EPP-60V is recommended for applications where maximum hydrostatic head (height of water level above piezometer location) over the sensor diaphragm is less than 7 m. The model EPP-30V is recommended for higher hydrostatic head or piezometric pressures.

<b>Range EPP-30V</b>	20, 35, 50, 70 m wcl (0.2, 0.35, 0.5, 0.7 MPa)
<b>Accuracy</b>	± 0.25 % fs normal ± 0.1 % fs optional
<b>Dimension (Ø x L)</b>	42 mm x 185 mm
<b>Cable</b>	CS-0502 or CS-0702 four conductor

The sensors incorporate the latest vibrating wire technology to provide remote digital readout or automatic data monitoring of water level or piezometric pressure in standpipes, boreholes, embankments, fully or partially saturated natural soils, compacted earth fills etc. Superiority of the Encardio-rite diaphragm type sensors for these applications is unquestionable.



Figure 4 EPP-60V low pressure sensor



Figure 5 – EPP-30V water level/pore pressure sensor

The sensor consists of a vibrating wire and a coil magnet assembly that is enclosed in a stainless steel housing which is electron beam welded to the pressure sensing diaphragm. This results in a vacuum of around 1/1000 Torr inside the model EPP-30V sensor thus making it almost immune to ingress of water or any other corrosive materials inside the sensor.

However, in case of model EPP-60V and those model EPP-30V sensors that are used for applications in which hydrostatic head is less than 15 m over the sensor diaphragm, two small openings are provided on the glass to metal seal. A special model CS-1102 vented tubes cable is used for these low capacity sensors.

This shielded cable has two vent tubes running through it which connect the inside of the sensor to the outside atmosphere, thus ensuring that sensor reading is unaffected by any change in barometric pressure. The open end of the vent tubes in the cable, terminate into a moisture trap assembly at the top of the borehole thus preventing any moisture from migrating into the vent tube or the sensor. The schematic is shown in the adjoining figure.

Outer body of these sensors is of stainless steel construction. It is therefore resistant to rusting or corrosion due to different kinds of dissolved impurities found in water under field conditions.

A low air entry value flat ceramic filter with a pore diameter of 40-60 microns is provided in front of the sensing diaphragm. The water oozing through internal pores or seams in rock formations, soil or reclaimed land etc. percolates through the filter to pressurize the diaphragm.

### 3.2 Installation of model EPP-60V

Installation of model EPP-60V in a borehole for water level monitoring is simple. Sensor with the vent tubes cable attached to it is lowered down in a 75 mm diameter borehole to the required depth. The cable is clamped at the top of the borehole as shown in the adjoining figure. As described earlier, the leads as well as the vent tubes in the cable are carefully routed and terminated in a terminal box and desiccant chamber mounted on a plate at the top of the borehole. Necessary protection of the installation at the top of the borehole must be suitably arranged by the user at site.

The desiccant in the moisture trap assembly needs to be changed when its colour changes from blue to white to prevent damage to the sensor.

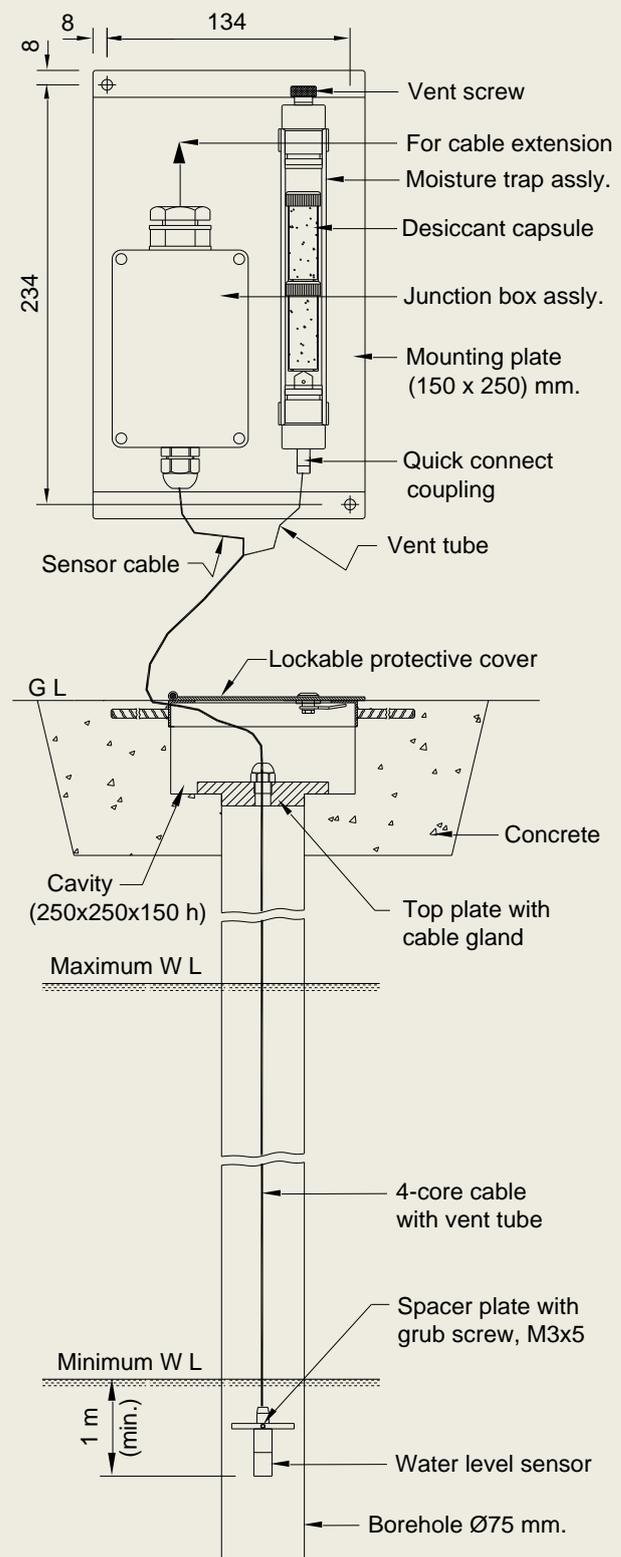


Figure 6 - installation for water level monitoring

### 3.3 Installation of model EPP-30V

Model EPP-30V sensor of 0.2 MPa capacity for applications in which hydrostatic head is less than 15 m over the sensor diaphragm is installed for water level monitoring in same manner as model EPP-60V. These sensors are provided with two small openings on the glass to metal seal. Other capacity model EPP-30V sensors are installed for water level monitoring in the same manner as illustrated in figure 6, excepting that there is no desiccant chamber and the cable used is not vented.

For monitoring piezometric pressure, a hole of 100 mm diameter is drilled to a depth of around 1 m below the elevation at which the sensor is to be installed using guargum as drilling mud (please do not use bentonite in place of guargum). Installation in the borehole is done by the fully grouted method. Multiple sensors at different levels can be installed in a borehole using the fully grouted method as shown in the adjacent figure 7. A single EPP-30V can also be installed in a borehole at the required level by the same method. The fully groutable method can be used for these sensors as these require very little volume of water to register a change in the water pressure, thus resulting in a fast response time. The fully grouted method cannot be used in the case of Casagrande type of piezometers or the standpipe.

The sensor/sensors are installed at the required depth. A grout mixture is made in the ratio of cement:bentonite:water of 50 kg:15 kg:125 liter. It is pumped into the borehole through the sacrificial grout pipe from the bottom as shown in figure 7.

### 3.4 Model EDI-51V read-out device

Model EDI-51V vibrating wire indicator is a microprocessor based readout unit for use with Encardio-rite's range of vibrating wire



Figure 7 - read-out logger

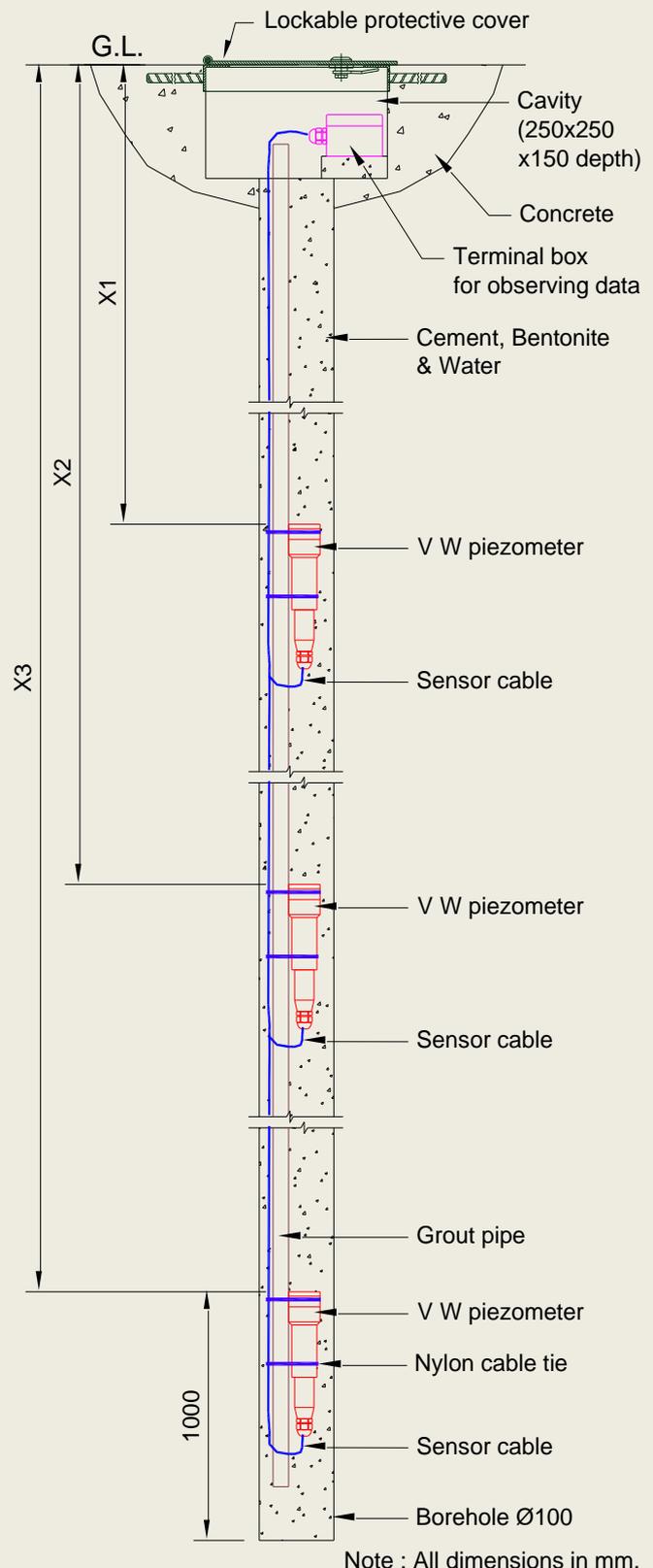


Figure 8 - installation for measurement of piezometric pressure

sensors. It can store calibration coefficients of up to 500 vibrating wire transducers so that the value of the measured parameter from these transducers can be shown directly in proper engineering units. It has an internal non-volatile memory with sufficient capacity to store about 4,500 readings with date and time of taking measurement. The model EDI-51V can also display and record the temperature of the sensor directly in degree Centigrade.

The stored readings can be uploaded to a host computer using the serial interface. The readout indicator is powered by an internal 6 V rechargeable sealed maintenance free battery. A fully charged new battery provides nearly 60 hours of operation on a single charge. A separate battery charger is provided with the EDI-51V indicator to charge the internal battery from 230 V AC mains.

EDI-51V indicator is housed in a splash proof plastic moulded enclosure with weatherproof connectors for making connections to vibrating wire transducer, computer for data transfer and the battery charger.

### 3.5 Model ESCL-10VT single channel VW datalogger

Model ESCL-10VT datalogger is designed to monitor and store data from the electronic sensor in engineering units. Sensor leads are connected to datalogger which is mounted on top of the borehole. The datalogger can store up to 14,500 data records which is sufficient for storing measurements taken every 10 minutes for 100 days.

<b>Sensor input</b>	<b>Vibrating wire sensor with thermistor for temperature measurement.</b>
<b>Sensor frequency range</b>	400 Hz to 5 kHz
<b>Resolution</b>	1 part in 160,000 at 5 kHz
<b>Frequency accuracy</b>	0.01% full scale
<b>Vibrating wire resolution</b>	1.35 ns
<b>Temperature measurement range</b>	- 40 to +60 °C
<b>Temperature measurement resolution</b>	0.1 °C
<b>Logging interval</b>	30 seconds to 168 hours
<b>Memory capacity</b>	14,500 date/time stamped data records.
<b>Data output format</b>	CSV text file. Can be easily imported in many third party applications like Microsoft® Excel
<b>Communication port</b>	One RS-232 serial port through MIL connector
<b>Bluetooth port</b>	Detachable Bluetooth dongle directly attaches to the serial port connector.
<b>Housing</b>	Aluminium die cast, IP-65
<b>Dimensions</b>	122 mm x 120 mm x 80 mm



Figure 9 datalogger

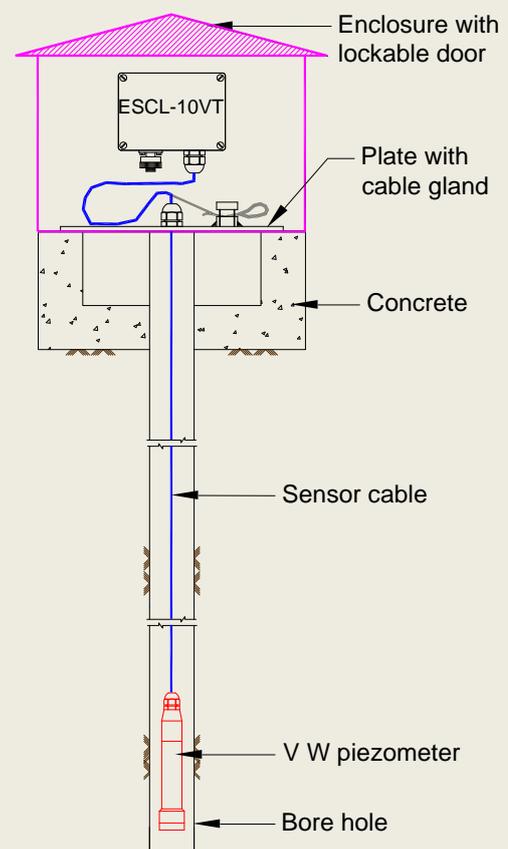


Figure 10 - schematic

The datalogger is supplied complete with batteries, mobile phone with datalogger manager software and operating manual.

The datalogger can be programmed to take a measurement from every 30 seconds to every 168 hours and to automatically store the water head or piezometric pressure. However, the number of measurements taken per day should be kept to the minimum required as higher frequency of measurements drains the power supply battery at a much faster rate.

<b>Display</b>	<b>Capacitive touch screen, 16M colors</b>
<b>Display type</b>	480 x 800 pixels
<b>Operating System</b>	Android OS, v2.2 (Froyo) or later
<b>Internal memory</b>	1 GB minimum
<b>Expandable memory</b>	microSD
<b>Bluetooth</b>	v2.1 with A2DP

### 3.5.1 Power supply option

**Standard option** D size 1.5 Volts zinc chloride (standard torch cells) or alkaline cells (recommended) which last much longer.

**AC mains** AC mains through an optionally available separate battery backed mains power supply module.

**Solar Panel** If bore-hole is at a remote location with difficult approach & user finds it sufficient to collect the logged data after a number of months, a solar panel backed power supply can be used for the datalogger instead of using primary cells.

Data can be collected by a mobile phone running on Android operating system and datalogger manager application software using the mobile phone's bluetooth interface. A removable bluetooth dongle needs to be attached to the datalogger for data transfer. The same bluetooth dongle can be used with different dataloggers for configuration or collecting data. The android datalogger manager application software is provided free with the system. The mobile phone also allows the data to be transmitted to a central ftp server of the user, if available, straight from the site itself.



Figure 11 – mobile phone for data retrieval