



Monitoring report Bhadra dam

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Authors: Cor verbruggen & Léon van Hamersveld
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Introduction

For the Damsafety project of the Bahdra Dam and reservoir data has to be collected to reach the target of the pilot project: to enhance dam safety and water management in India.

This data will be used:

- to forecast reservoir inflow and outflow, increasing reservoir performance and more controlled release of water in the environment.
- to demonstrate innovative tools for assessment of the dam condition resulting in optimization of Operation and Maintenance (O&M).

During the period from 5 to 14 September 2017 sensors were installed to collect data for the above mentioned target. The pore water pressure sensors under the masonry dam and the saddle dams 1 and 2 are installed in October 2017. Due to the construction of a seepage curtain under the dam the layout for the pore water pressure sensors is changed. In the monitoring plan at two places in the gallery two sensors should be installed (total 4); one straight and one in an angle of 10 degrees towards downstream side. Because of the construction of the seepage curtain 4 sensors are installed only in an angle of 10 degrees. The sensors will come outside the influence of the grouting material of the seepage curtain. For the location of these sensors see picture 21.

Monitoring locations

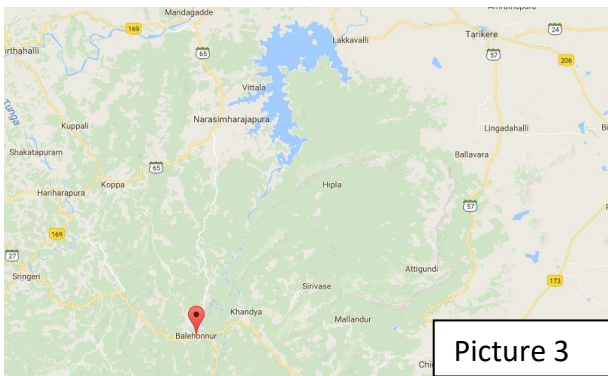
Meteo stations

At two locations meteo stations are installed (see also map)

Location 1

Balehonnur

Coordinates: 13.351157, 75.470665



Location 2

Narasimharajapura

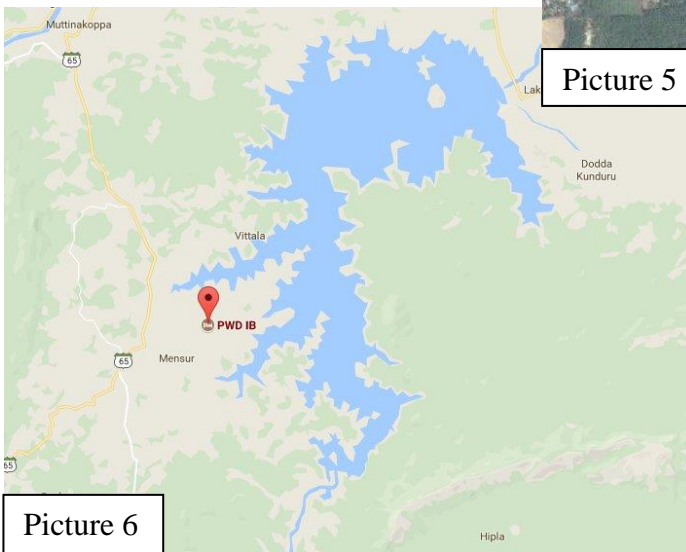
Coordinates: 13.610794, 75.519829



Picture 4



Picture 5



Picture 6

These meteo stations consists of the following items:

Lufft WS501-UMB Smart Weather Station

Lufft Rain Gauge WTB100

Eijkelkamp GDTm modem

Solar power system

Battery

Specifications

Specifications WS501-UMS weatherstation: See appendix 2

Specification WTB100 raingauge: see appendix 3

Specification Eijkelkamp GDTm modem: see appendix 5

Specification solar power system: 30 W – 12 V, size 45 x 38 cm with charge regulator.

Surface water level

Bhadra dam

Coordinates: 13.702322, 75.635834



Picture 7



Picture 8

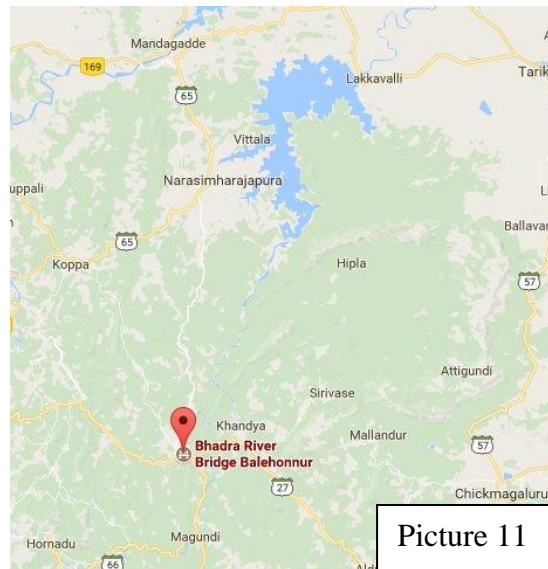
Sensor is installed inside white PE tubing in the stilling well of the dam.
The modem (blue tube) is installed inside the building of the stilling well.
Specifications of the diver: see appendix 1
Specification GDTs PRIME modem: see appendix 4

Bridge Balehonnur.

Coordinates: 13.352206, 75.470645



Picture 10



Sensor is installed in a white PE tube which is connected to the pillar of the bridge.

Purpose: using the known $Q-h$ relation the discharge is calculated.

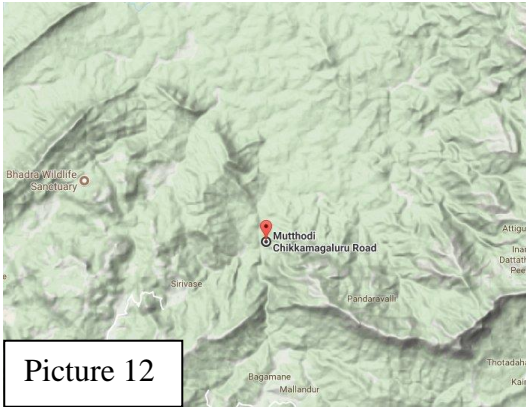
The modem is installed in a black PE casing with lock and is accessible from the top of the bridge.

Specifications of the diver: see appendix 1

Specification GDTs PRIME modem: see appendix 4

Bridge Tiger reserve

Coordinates: 13.419334, 75.643270



Picture 12



Picture 13



Picture 14

Pressure sensor (diver) is installed in a white PE tube which is connected to the pillar of the bridge.

Purpose: using the known $Q-h$ relation the discharge is calculated.

The sensor is connected to GDTs PRIME modem which is installed in a black PE casing with lock and is accessible from the top of the bridge.

Specifications of the diver: see appendix 1

Specification GDTs PRIME modem: see appendix 4

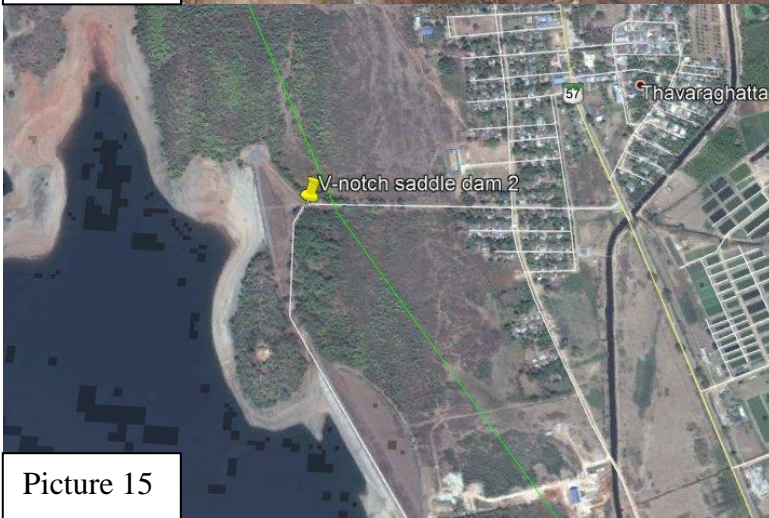
V-notch

Saddle dam 2

Coordinates: 13.714035, 75.630100



Picture 16



Picture 15



Picture 17

Pressure sensor (diver) is installed in a white pe tubing upstreams from the crest. The sensor is connected to GDTs PRIME modem which is installed at the roof on the nearby building.

Purpose: measuring and calculating the disharge of seepage water from Saddle Dam 2.

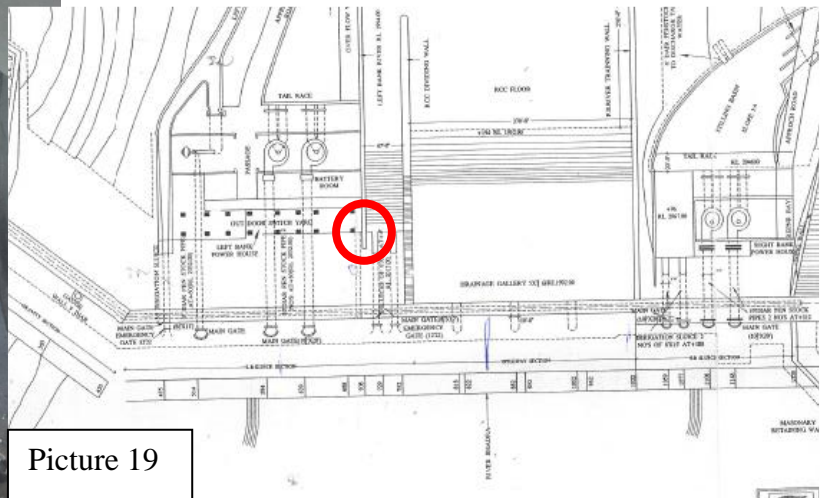
Specifications of the diver: see appendix 1

Specification GDTs PRIME modem: see appendix 4

V-notch

Gallery masonry dam

Location see pictures 18 and 19.



Pressure sensor (diver) is installed in a white pe tubing upstream from the crest. This sensor is connected to a GDTm modem which is installed outside the gallery.

Purpose: measuring and calculating the discharge of seepage water from the gallery in the masonry dam.

Specification of the diver: see appendix 1

Specification of GDTm SDI modem: see appendix 5

Pore water pressure

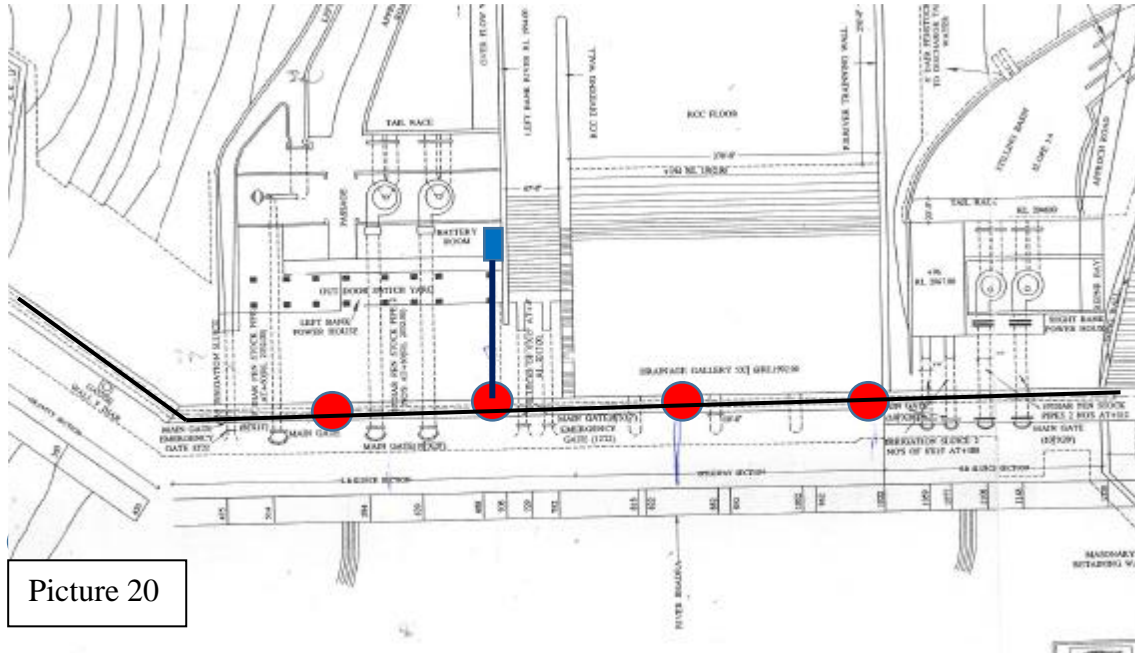
Gallery masonry dam

Location: see pictures

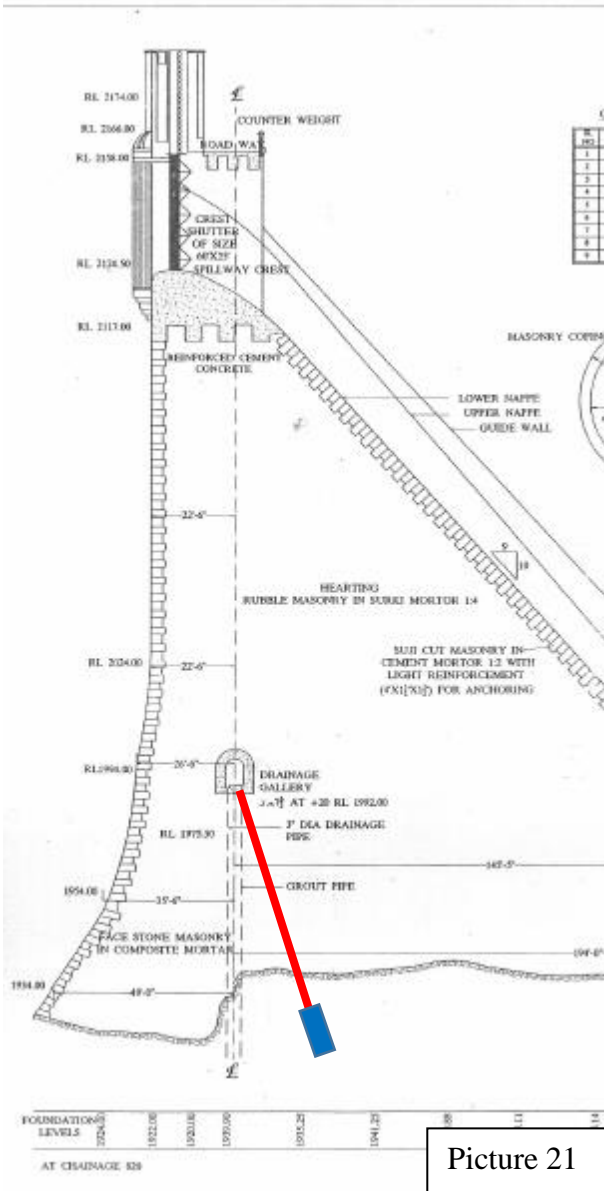
Four pore water pressure sensors are installed in the gallery at a distance of approximately 45 meters.

The boreholes for the pressure sensors are drilled in an angel of 10 degrees towards the downstream side of the dam at a depth of 1 to 2 meters below the dam into the natural foundation.

Specifications of pore water pressure sensors: see appendix 6



Picture 20



— Borehole diameter 47 mm,
 Angle 10 degrees

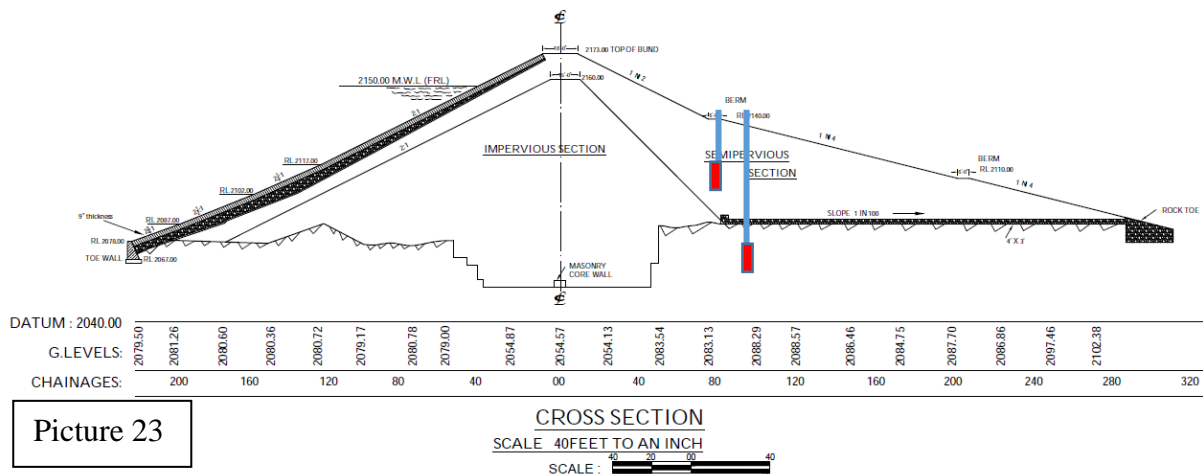
■ Pore water pressure sensor

Picture 21

Pore water Saddle Dam 1

Location: see pictures

Coordinates: XXXXXXXXXXXXXXXXXXXXXXXXX



Picture 23

Pore water pressure sensors are located above and underneath the drainage layer of the saddle dam. Sensors are connected to GDTs PRIME modems on top of the borehole and protected by a cover at surface level. Specifications of pore water pressure sensors: see appendix 6
 Specification of GDTs PLUS modem: see appendix 4

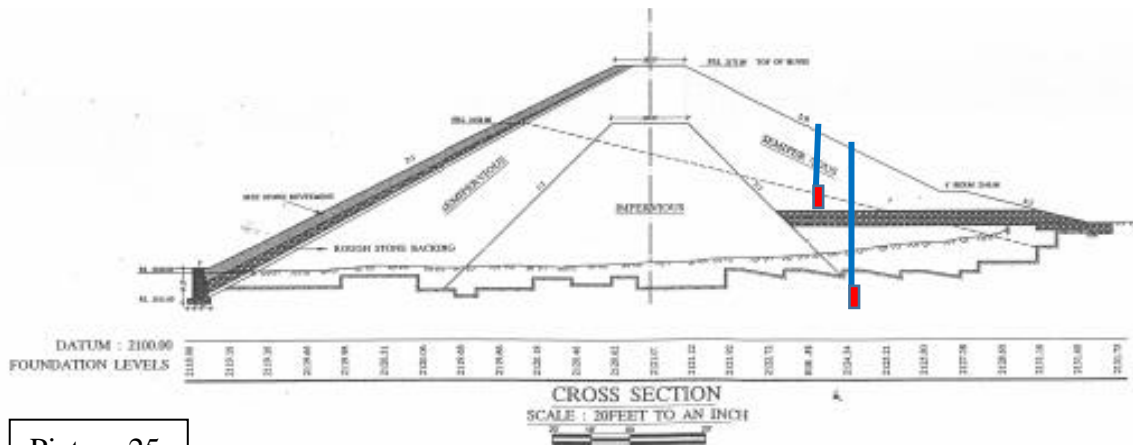
Pore water saddle dam 2

Location: see pictures

Coordinates: XXXXXXXXXXXXXXX



Picture 24



Picture 25

Porewater pressure sensors are located above and underneath the drainage layer of the saddle dam. Sensors are connected to GDTs PRIME modems on top of the boreholes and protected by a cover at surface level. Specification of GDTs PRIME modem: see appendix 5 Specifications of pore water pressure sensors: see appendix 6

Specification of all the sensors

APPENDIX 1

Diver

Length 110 mm

Diameter 22 mm

Weight 104 g

Memory 72.000 measurements (72.000 backup)

Battery lifetime maximum 10 years

Measuring interval ½ second to 99 hour

Housing stainless steel(316L) O-rings Viton[®] Pressure sensor ceramic (Al₂O₃) with thermal compensation

Product number 11110402, 11110404, 11110406, 11110408,

Pressure range 10, 20, 5,0 100, mH₂O

Accuracy* $\pm 0,5 \pm 1,0 \pm 2,5 \pm 5,0$ cmH₂O

Resolution 0,06 0,09 0,19 0,36 cmH₂O

Temperature range -20 - 80 °C

Calibrated 0 - 50 °C

Accuracy* $\pm 0,1$ °C

Resolution 0,01 °C

* = standard accuracy



Picture 26

APPENDIX 2

Weather station

Dimensions	Ø approx. 150 mm, height approx. 332 mm
Weight	Approx. 1.5 kg
Interface	RS485, 2 - wire, half - duplex
Power supply	4...32 VDC
Operating temperature	-50...60 °C
Operating rel. humidity	0...100 % RH
Heating	20 VA at 24 VDC
Cable length	10 m
Protection level housing	IP66
Mast mounting suitable for	Mast diameter 60 - 76 mm
Temperature	
Principle	NTC
Measuring range	-50 ... 60 °C
Unit	°C
Accuracy	±0.2 °C (-20...50 °C), otherwise ±0.5 °C (>-30 °C)
Relative humidity	
Principle	Capacitive
Measuring range	0 ... 100 % RH
Unit	% RH
Accuracy	±2 % RH
Air pressure	
Principle	MEMS capacitive
Measuring range	300 ... 1200 hPa
Unit	hPa
Accuracy	±0.5 hPa (0...40 °C)
Wind direction	
Principle	Ultrasonic
Measuring range	0 ... 359.9 °
Unit	°
Accuracy	< 3° RMSE > 1.0 m/s
Wind speed	
Principle	Ultrasonic

Measuring range	0 ... 75 m/s
Unit	m/s
Accuracy	± 0.3 m/s or ± 3 % (0...35 m/s) ± 5 % (>35 m/s) RMS
Resolution	0.1 m/s
Radiation	
Response time (95%)	< 18 s
Non-stability (change/year)	< 1 %
Non-linearity (0 to 1,000W/m ²)	< 1 %
Directional error (at 80° with 1,000W/m ²)	< 20 W/m ²
Temperature dependence of sensitivity	< 5 % (-10... +40 °C)
Tilt error (at 1000W/m ²)	< 1 %
Spectral range	300...2800 nm
Measuring range	2000 W/m ²
Altitude	0...60 °
Azimuth	-10 °...10 °



Picture 27

APPENDIX 3

Rainfall Gauge

Dimensions	Ø165mm, height 285mm
Connection type	Open cable ends
Collecting area	200cm ²
Weight	930g
Mounting type	On mast, Ø 60-76mm
Precipitation	
Accuracy	±2%
Resolution	0.2
Maximum intensity	144mm/h
Precipitation (with reduction ring)	
Accuracy	±2%
Resolution	0.5
Maximum intensity	360mm/h



Picture 28

APPENDIX 4

GDT-S Prime

Specification Dimensions

Enclosure enclosure 48 mm, top cap 60 mm, length 340 mm

Specification Weight

GDT-S prime (incl. alkaline batteries) approx. 890 g

Specification Materials

Enclosure Alu EN AW-6060, top cap POM (synthetic material), bottom cap POM (synthetic material)

Item Specification

Battery DD (internal) 3.6 V (Lithium metal)

Life time of the battery Based on Tadiran SL-2790 and ambient temperature of 10°C

10 years (at a 1 hour measurement interval and 24 hour wake-up interval)

Modem time accuracy better than 15 seconds/day

Antenna connector SMA connector

Sensor port 5-pin male M12 connector, A-coded

Barometer measuring range 10 ... 1200 mbar *

Resolution 0.01 mbar

Accuracy barometer ± 2 mbar (at 300 ... 1100 mbar, 0 ...50 °C

Temperature measuring range -40 ... +85 °C

Resolution 0.01 °C

Accuracy temperature ± 0.8 °C (at 25 °C)

± 2.0 °C (0 ... 50 °C)

Working Temperature -20 ... +60 °C

Ingression protection (enclosure) IP68 (50 hours@2mH2O)

Messaging Specification

Message mode web portal, e-mail, SMS alarm, other

GPRS Quad band type (850, 900, 1800, 1900 MHz)

UMTS (optional) Five band (800,850,900,1900,2100 MHz)

SIM card (nano SIM card socket)* Multi-network SIM M2M

Picture 29



APPENDIX 5

GDT-M SDI-12

Global Data Transmitter (incl. battery pack) approx. 1200 g

Specification Materials

Enclosure ABS

Mounting brackets Stainless steel

Item Specification

Battery pack (internal) 7.2 V

Power supply (external) DC 5.5 - 18 V

Life time of the battery pack > 3 years (at a 1 hour interval)

Maximum rated power usage 4.2 W (800 mA)

Modem time accuracy better than 1 minute/day

Messaging Specification

Message mode web portal, e-mail, SMS alarm, other

GSM Quad band type (850, 900, 1800, 1900 MHz)

UMTS (optional) 2100 MHz

SIM card Vodafone NL M2M *

Antenna connector SMB connector

Sensor port 4-pin male connector (with possibility to connect a 5-pole contra connector),

A-coded

External power connector 4-pin female connector, A-coded

USB port ** mini USB buccaneer type B receptacle

Barometer measuring range 10 ... 1200 mbar *

Resolution 0.01 mbar

Accuracy barometer ± 2 mbar (at 300 ... 1100 mbar, 0 ... 50 °C)

Temperature measuring range -40 ... +85 °C

Resolution 0.01 °C

Accuracy temperature ± 0.8 °C (at 25 °C)

± 2.0 °C (0 ... 50 °C)

* 1 mbar is approximately 1 cmH₂O

GSM Quad band type (850, 900, 1800, 1900 MHz)

UMTS (optional) 2100 MHz

Connector Bulgin buccaneer SMB (RG-174 coaxial cable)

Ingress Protection IP67 or better

* Other antenna types are available on request.

Number of sensor ports 6

Port 1 - 6 sensor (e+ logger or Diver) via sensor cable

In case of the GDT-M SDI-12 Port 1-4 SDI-12 sensors via sensor cable

Port 5-6 e+ and/or Diver via sensor cable



Picture 30

APPENDIX 6

Pore water pressure sensor (Piezometer)

The pore water pressure sensor consists of a diver with same specification as described and stainless steel point and housing.

Housing:

Material	stainless steel 316
Diameter housing	33 mm
Diameter point	35 mm
Total length	235 mm
Maximum pressure	500 kPa



Picture 31