**Borehole Drilling and Test Pumping TOR \_ Gedaref State, Sudan**

**CONTRACT #**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**DATE**  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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## BACKGROUND

Sudan hosts one of the largest refugee populations in Africa. South Sudanese make up the majority. Many others fled violence and persecution in neighbouring countries, including Eritrea, the Central African Republic, Ethiopia and Chad, but also the wars in Syria and Yemen pushed people to seek safety in Sudan. Most refugees live in out-of-camp settlements, host communities and urban areas, while others stay in camps, especially in East Sudan and White Nile State. Sudan continues to generously host and receive additional asylum-seekers. As at 31st October 2021, Sudan hosted 1,119,292 refugees and asylum seekers 70% living in out of camp while 30% is settled in camps.
Tigray emergency response

In early November 2020, military confrontations between federal and regional forces in Ethiopia’s Tigray region, which borders both Sudan and Eritrea, led the Government to declare a State of Emergency. Since then, and despite the announcement of an official end to military operations at the end of November, Ethiopia’s Tigray region has continued to be affected by armed clashes and insecurity.
UNHCR started recording an influx of Ethiopian refugees at the border entry points in East Sudan from northern Ethiopia, after the military confrontations in the Tigray region. UNHCR's teams on the ground in the eastern Sudanese states of Kassala and Gedaref continue working with the Sudanese Commissioner for Refugees (COR), local authorities and partners to continue monitor and respond to the situation, as well as mobilizing resources to provide life-saving assistance services to the new arrivals. Inter-agency coordination is well established. Similarly, Ethiopian asylum seekers have been crossing from Benishangul-Gumuz region into Sudan’s Blue Nile State. UNHCR, COR and partners are also on the ground to respond to their needs.

UNHCR is responsible for providing basic WASH services to the camps with its implementing and operational partners.

Currently the operation provides water supply to the 50,000 plus refugees through a mix of boreholes and water treatment plants. In Um Raquba camp, 11 boreholes are in operation fitted with submersible pumps to a reticulation system with 44 tapstands, Babikri camp has one borehole while Tunaybha camp, Village 8 Reception Center and Hamdayet Transit center are served from water treatment plants. Given the UNHCR standard of 20L/p/d for longer term supplies, the operation seeks to continually reduce the cost of providing potable water to refugees by exploring alternative sources, mainly ground water.

CARE (with funding from UNHCR) therefore would like to engage the services of a competent drilling company to drill exploration/production boreholes in Babikri (5) Tunaybha (1) and Doka (1).

CARE with UNHCR, UNICEF, WES and SWC with support from COR will also conduct a Hydrogeological Desk Study as part of the geophysical campaign with identification of priority sites for further investigation for the 7 exploration wells.

It is envisaged that the stakeholders will use the results of the drilling exploration to feed into the existing body of knowledge on groundwater potential in the selected sites and also recommend potential boreholes for installation of hand pumps.

## SCOPE OF WORK

The main objective of this scope of work is to increase as much as possible the access to safe water for all PoCs in Gedaref refugee camps to meet their daily needs as an immediate to midterm solution only.

It is recommended that the exploration programme be phased as:

* Phase 1 with the drilling of 7 exploration boreholes to approximately 30-70m depth or bit refusal with down the hole air hammer drilling techniques and 4” casing installed (nominal 6” drilled hole), gravel packed and developed with airlifting to determine indicative yield, as per figure 2 and Table 1 with nominal locations (subject to final ground truthing).
* Test pumping of the best yielding exploration boreholes if the airlift yield would indicate a borehole that can yield greater than 0.5L/s; followed by step test, constant rate test
* Phase 2: Construction of appropriate headworks to allow protection of the aquifer and borehole for installation of a hand pump on the completed production borehole(s).
* Phase 3 with drilling of more production bores completed with 6” casing (nominal 8” drilled hole), gravel packed, developed with airlifting, step tested and a constant rate test on each (shall be informed by the results from the explorative drilling phase).

Appendix 2a and b provides a sample design for the exploration borehole and production bores to be drilled.

Table 1. Nominal coordinates for Phase 1 exploration boreholes

|  |  |  |  |
| --- | --- | --- | --- |
| BH ID | Phase | Latitude | Longitude |
| 1 | Phase 1 Drilling Babikri |  |  |
| 2 | Phase 1 Drilling Babikri |  |  |
| 3 | Phase 1 Drilling Babikri |  |  |
| 4 | Phase 1 Drilling Babikri |  |  |
| 5 | Phase 1 Drilling Babikri |  |  |
| 6 | Phase 1 Drilling Tunaybha |  |  |
| 7 | Phase 1 Drilling Doka |  |  |

## GENERAL REQUIREMENTS

### GENERAL

Prior to the commencement of the work for all items, the CONTRACTOR shall submit a method statement to the EMPLOYER for approval. This shall include but is not limited to details of the arrangements and methods which the CONTRACTOR proposes to adopt for the execution of the works. No significant alteration to these arrangements and methods set forth in the Method Statement shall be made without this having previously been notified to and approved by the EMPLOYER in writing, which approval shall not be unreasonably denied.

### BASIS OF CONTRACT PRICE

The CONTRACTOR shall submit a Bill of Quantities and Rates against the guide provide in Appendix 1 by the EMPLOYER. The CONTRACTOR shall have priced for all activities necessary to complete the intended scope of works. The schedule will be referred to during interim measurements and assessment of work completed for such measurements. The CONTRACTOR will arrange for a visit to the sites to ascertain any particulars and access requirements concerning the sites and impact on operations.

The Bill of Quantities is to be priced as it is offered without any amendments, additions or alterations by the CONTRACTOR. Each individual item shall have an amount or rate entered against it or state ‘included’ where the item is covered elsewhere in the Bill of Quantities. Amounts shall be expressed in Sudanese pounds (SDG).

The amount entered in the schedule for each activity shall not be subject to escalation and will be exclusive of VAT. It shall represent the full inclusive cost, including allowance for preliminaries, ALL overheads, profit, risks, insurance and other expenditure for all work incidentals, contingent or considered necessary by the Contractor for the completing of the works in strict conformity with the specification.

Any additional works outside the Bill of Quantities must be agreed in writing with the EMPLOYER with sufficient advance notification, otherwise will not be paid.

### SITING OF BOREHOLES

The exact location of each borehole will be clearly marked in the field by the EMPLOYER in presence of the CONTRACTOR. The CONTRACTOR is responsible for accurately capturing the latitude and longitude using a GPS unit. The area of interest is Babikri, Tunaybha refugee camps and Doka.

**BOREHOLE IDENTIFICATION**

The borehole identification (ID) of each borehole has to be defined prior to drilling. The borehole identification stated on the drilling permit and/or a local borehole or Borehole ID must be clearly indicated on the borehole location in the field and systematically used in all documentation along with the GPS coordinates.

### GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS

The anticipated geological units and or hydro stratigraphy expected to be encountered include from the surface:

* Unconsolidated alluvium and or colluvium in or close to existing drainage lines which could vary up between less than a meter to 10 meters thick where minor water is expected to be encountered.
* In places a hard cap or laterite could also exist where the bedrock has been extremely weathered and leached which again could be less than 1 meter to several meters in depth where no water is expected to be encountered.
* Weathered crystalline basement (overburden) formed due to extreme insitu weathering of the crystalline basement which could be typically 15 to 30m thick and composed of variable clays and gravels. Sometimes referred to as saprolite. Most of the storage of groundwater is expected to found in this unit;
* Fractured crystalline bedrock which is also extremely weathered but has relatively higher permeability than the overburden or saprolite and can vary from being non existent to 10 meters thick; and
* Competent pre-Cambrian crystalline bedrock most commonly biotite or hornblende schists which when fractured and or faulted could also preferentially provide access to sources of water around 40m deep..

### BOREHOLE DESIGN

The complete borehole design is an integral part of the technical specification of this contract (Appendix 2a and b). The EMPLOYER is responsible for the borehole design and for approval by the relevant authorities (i.e. drilling permit). The CONTRACTOR may, upon request by CARE, offer an alternative borehole design based on its experience of ground conditions within the target area and or hydrogeological/geophysical surveys conducted by the Contractor or a third party independent expert. This alternative can only be implemented if approved in writing by the EMPLOYER and the relevant authorities.

### CONSTRUCTION PROGRAM

Within **7** days of the order to commence the CONTRACTOR shall provide the ENGINEER with:

* A scheme of the overall organization of the works and construction program and material specifications; and
* A schedule of proposed dates, from shipment and site delivery of all items required for the temporary works and permanent works.

Works will only proceed on signed approval by the ENGINEER following a kick off meeting to ensure through understanding of the scope outlined in this ToR and the schedule provided by the CONTRACTOR.

## MATERIAL REQUIREMENTS

### FIELD EQUIPMENT

The CONTRACTOR shall provide, deliver and maintain for use of the ENGINEER and for the duration of the works at an agreed location on the work site all the necessary equipment, apparatus, fittings, materials and supplies (e.g. sample bags, EC (Electrical Conductivity) and pH meters, turbidity tube, dip meter, marsh funnel, water sample bottles, boxes for sampling, etc.) to carry out the required tests as described in Section 7 under MONITORING, SAMPLING AND LOGGING REQUIREMENTS and allow the ENGINEER to witness any testing. All the equipment and tools shall be in good condition, calibrated and tested prior to onset of works.

### STORAGE OF MATERIALS

The CONTRACTOR shall store all materials shall be stored in a clean place, either in the open or under cover, especially any PVC material.

### TOXIC MATERIALS

The CONTRACTOR is prohibited to use any toxic or poisonous materials or sub-materials used in piping, its accessories, lining, coating, sealing etc., or in various kinds of concrete or in soil in any kind of usage.

## BOREHOLE CONSTRUCTION REQUIREMENTS

### DRILLING

The CONTRACTOR is to propose their preferred method of drilling, flushing techniques and bit selection to the ENGINEER, prior to commencing work. Sufficient drill collars and down-hole stabilisers will be required to ensure that good verticality is maintained throughout the drilling operation. All drill bits used throughout the works will be in good condition with minimal wear to bearings and cutting teeth. The CONTRACTOR will provide full details of the proposed drilling methods and equipment to be used including rig type, torque capacity and pullback capacity in their method statements.

The CONTRACTOR will provide sufficient temporary casing for a minimum of 20 metres length. The casing will be in good condition with workable threads and the lead length will be fitted with a cutting shoe capable of cutting through collapsed ground and bedrock where necessary. Spare casing shoes will be available on site. The casing will have a drive head in good working order to mechanically rotate the casing with the drilling rig. The rig will have the capability to handle the casing and to break the thread joints on recovery. Superficial deposits may be drilled using a mud or polymer flush to maintain stability of the borehole wall until temporary casing is installed.

Uncompleted boreholes must be made safe whilst unsupervised to prevent any debris or accidental or malicious objects being dropped into them.

During drilling, penetration rate, water strike information and other drilling observations shall be recorded and reported to the ENGINEER.

### ERECTION OF DRILLING RIG

The drilling rig must be erected at the borehole site in such a way that the hole will be drilled within 1 m of the mark which as shown to the CONTRACTOR by the ENGINEER.

### BOREHOLE DEPTH AND BOREHOLE DESIGN

All technical details on drilling and casing diameters are given in the borehole design, APPENDIX 2a and b.

The 7 exploration boreholes to be drilled will be required to nominally penetrate:

* Soil or poorly consolidated sediments which could vary up to 10m. It would be recommended then 3m of 8” surface casing be installed to allow further drilling of the main 6” diameter borehole.
* Weathered profile and crystalline basement should be drilled to final depth as a 6” diameter hole from 3 m to a nominal maximum depth of 70m; and
* Conditional on water strikes and yields established during drilling then 6 of the 12 holes will be cased and gravel packed with Class 10 PVC 4” slotted and blank casing

Phase 2 production boreholes to be sited and drilled based on the results of the exploratory drilling programme will be required to nominally penetrate:

* Soil or poorly consolidated sediments which could vary up to 10m. It would be recommended then 3m of 10” surface casing be installed to allow further drilling of the main 10” diameter borehole;
* Weathered profile and crystalline basement should be drilled to final depth as a 8” diameter hole from 3 m to a nominal maximum depth of 70m; and
* will be cased and gravel packed with Class 10 PVC 6” slotted and blank casing the design of which will be decided by the supervising ENGINEER.

### ASSEMBLING OF CASING

The assembling methodology for casing will be submitted to and approved by the ENGINEER before operation. A particular attention will be paid to the external diameter of casing and its compatibility with cementing and gravel pack insertion. The casing shall be coupled to each other either with threaded connectors. For threaded connections, the lubricating compound will not contain any heavy metal or hydrocarbons.

### CENTRALISERS

In order to achieve the required borehole linearity, all casing permanently installed in boreholes should be fitted with centralisers at 6-9 m intervals or as otherwise directed by the ENGINEER. The centralisers should be factory manufactured and shall not be installed within screened sections.

### FAILURE OF CASING STRING INSTALLATION

In the event that any string of casing will not enter the borehole, the casing will be removed, and the borehole will be reamed or re-drilled. If the string of casing still does not enter the borehole, the borehole will be declared lost.

### VERTICALITY AND ALIGNMENT OF BOREHOLES

The borehole(s) will be drilled and cased straight and vertical, and all casing will be set plumb and true to line. Upon completion of drilling or at any other time, the casing of the borehole shall be tested for verticality and straightness using a deviation-measuring device such as a dummy[[1]](#footnote-1) provided and operated by the CONTRACTOR. Should the borehole vary from the vertical preventing the borehole shall be corrected by the CONTRACTOR at its own expense.

Should the CONTRACTOR fail to correct such faulty alignment or verticality, the borehole may be deemed lost. The ENGINEER may waive the requirements of this paragraph for verticality if, in his judgment:

* The CONTRACTOR has exercised all possible care in constructing the borehole and the defect is due to circumstances beyond his control; or
* The usefulness of the completed borehole will not be materially affected.

In no event will the provisions of this paragraph with respect to alignment be waived.

### CHARACTERISTICS OF THE BOREHOLE CONSTRUCTION MATERIALS

Any equipment or material introduced into the ground, whether on a temporary or permanent basis has to fulfil the below requirements.

#### CHARACTERISTICS OF THE CASING AND SCREENS

The 8 and 10-inch surface casing can be standard steel casing.

The 4 and 6-inch casing characteristics should be:

* uPVC Casing shall be drinking water approved and without lead stabilising agent;
* Flush threaded joints or glued joints are acceptable;
* Slotted Screen - 1mm slots with a minimum of 9% open area; and
* Compressive Strength – 17 BAR (Class 10 minimum).

The technical specifications of all casings supplied by the CONTRACTOR which will be installed permanently in the boreholes must be new and must be provided and comply with international standards. The screen openings have to be appropriate (always smaller) than the grain size of the gravel pack (5.8.3). Examples of casing will be presented to the Supervising ENGINEER prior to commencing works.

#### CHARACTERISTICS OF CEMENT AND CONCRETE (\*if applicable)

Cement: Any cement, which is used, must comply with international standards and must not be older than three months. Unless otherwise instructed by the ENGINEER, a hardening agent such as calcium chloride should not be used to accelerate the cement setting process.

Cement slurry: The cement used for cement slurry will be PORTLAND type. No less than 800 kg of cement will be used per cubic meter of water.

Cement mortar: The cement used for cement mortar will be PORTLAND type. No less than 50 kg of cement will be used for 100 l of water. A minimum of 600 kg of cement shall be used per cubic meter of sand.

Concrete: Concrete will be a mixture of Portland cement and aggregates (with only small amount of fine material) of not less than 250 kilograms per cubic metre of finished concrete. Aggregates used will be sound, durable and well graded in sizes ranging from sands to boulders of four centimetres. Concrete mixtures will contain no more than 30 litres of water per 50 kilograms of cement. Concrete will be measured by the cubic metre, and will be mixed in approved mixers or in mixing boxes and not directly on the ground.

Water for cement and concrete: The water used shall be potable water or be of a suitable quality to allow mixing of good quality cement and concrete, avoiding any introduction of substances with health hazard into the subsurface.

#### GRAVEL PACKING, BENTONITE AND PARTIAL BACKFILLING OF BOREHOLES

All gravel pack material should be made of well-rounded and well-sorted grains of inert material. The gravel needs to be clean and washed. It should be uniformly placed in the annular space between the screen and the borehole wall. The volume of introduced material has to be monitored and cross-validated with the calculated annular space.

For the gravel pack used in the screened sections, the gravel pack grain size and gradation are determined by the CONTRACTOR after analysis of the drill cuttings and the drillers log (formation stability, penetration rate, fluid loss and returns) and must be approved by the ENGINEER. The grain sizes have to be larger than the slots of the screened casing (5.8.1). In plain casing sections, gravel pack is used as formation stabiliser.

If a lower aquifer is targeted, then a bentonite seal (expanding granules, minimum length 2 meters) is introduced in the annular space just above screened sections to prevent mixing of groundwater of different aquifers.

Bentonite granules or cement are used to fill the annular space of the unsaturated zone, or at least the uppermost 5 meters until 1 meter below surface.

The CONTRACTOR shall, upon request, backfill the existing borehole to a depth specified by the ENGINEER. The backfill material will consist of clean crushed or graded gravel. All such backfill material must be approved by the ENGINEER before being used in the borehole.

## BOREHOLE COMPLETION REQUIREMENTS

### BOREHOLE DEVELOPMENT

Borehole development will be conducted using a **airlift** system with an appropriate compressor.

Development shall continue until water is clean, but at least 6 hours. The development shall be monitored by measuring the discharge rate and the sand content at 15-30 minute intervals. Development shall not stop until the discharge water is clean and free of sand (i.e. less than 1 cm diameter with sand stain test in a 10 litre bucket, approximately 1ppm) and the discharge rate is stable for at least 2 hours or until the ENGINEER finds acceptable.

### PUMP TESTING REQUIREMENTS

The aquifer pumping test characterises the borehole performance and the water bearing formation in the vicinity of the borehole. The CONTRACTOR must correctly monitor test pumping operations to ensure that accurate data is obtained. For testing operations, the test pump will be installed in the pump housing defined in the borehole design (APPENDIX 2a and b).

For the purpose of calibration and pump testing, the CONTRACTOR provides a range of pumps and valves to regulate the flow to produce [**3.6 to 7.2** (m3/h)] against 60 meters of pressure head. The CONTRACTOR provides all accessories required to install, operate and uninstall these pumping units, such as electric cable, electric panel control and exhaust pipes.

The pumped water during calibration and pumping tests must be disposed by means of discharge pipes toward a nearby natural drain over a distance where infiltration in to the aquifer during testing is negligible (minimum 50 meters and discharging downstream). No pools shall be allowed to form in the vicinity of the borehole to avoid re-infiltration.

During the tests, the CONTRACTOR shall measure and record water levels with the recommended frequency defined in the standard sheet ( APPENDIX 3) in the pumped borehole by means of an installed PVC-airline (dip tube) with a well-defined datum for measurement within an accuracy of +/- 1 cm and recorded. For measurement of water levels, electric dip meters shall be used.

For discharge measurements, a flow meter shall be installed and calibrated/cross-validated with manual volumetric measurements and the measurements recorded with the recommended frequency defined in the standard sheet (APPENDIX 3). The discharge rate during the pumping shall be maintained within ten per cent (10%) of the design rates established with the calibration test (Section 6.2.1) and approved by the ENGINEER and the CONTRACTOR shall maintain uninterrupted pumping during the period of all tests.

Should the CONTRACTOR fail to provide accurate water level and flow measurements, then the ENGINEER may declare the test as interrupted. No payment will be made for the elapsed time of the test prior to the interruption. Unless otherwise directed by the ENGINEER, interrupted tests shall not be restarted until sufficient time has elapsed for at least ninety-five percent (95%) recovery of the water levels in the pump or observation borehole and shall not be considered to be a part of the pumping test for purposes of payment even though water level measurements shall be made during that period by the CONTRACTOR.

#### CALIBRATION TEST AND TEST DISCHARGE RATE DESIGN

Before beginning the pumping tests, a calibration test must be carried out to check that all equipment including the pump, generator, manometer, flow regulation valves and pipes are working satisfactorily. This test is also required to design the discharge rates for the step draw-down pumping test. The discharge pipeline shall be checked for leaks.

The calibration test must be carried out the day before the pumping test to allow the water levels to recover before the actual pump test operations begin.

A maximum stabilised dynamic water level (resulting in the maximum admissible draw-down smax of the borehole) is defined prior to the test as target. It is defined either by:

* The depth of the first screened section (in case the pump is installed below the screens); and
* Two meters above the pump position.

The maximum admissible draw-down smax is sought by trial and error during the equipment test, by slowly increasing the discharge rate and recording the water levels, resulting in the highest possible pumping rate Qmax.

Cases for which the calibration test has to be repeated at the expense of the CONTRACTOR are as follows:

1. If the maximum admissible draw-down smax is ‘over-shot’ with the maximum flow rate of the pump during the calibration test, then the pump is oversized and a new test has to be carried out with a smaller pump.
2. If the pump is not be capable of producing the required maximum admissible draw-down *s*max, then two options should be considered:
3. Restart the calibration test with a more powerful pump; or
4. If the maximum flow rate of the calibration test exceeds the design yield by 150%, the ENGINEER can approve the use of the maximum pump rate for the further tests.

Design of discharge rates for step draw-down pumping test is as follows:

* The maximum discharge rate (Qmax) obtained from the calibration test is used to design the pumping rates for the step draw-down test, by dividing Qmax by the number of steps and homogeneously distributing the discharge rates over the whole range; and
* During the calibration test, the gate valve shall be graduated and positions of the different discharge rates marked in preparation for the step draw down test.

#### STEP DRAW-DOWN TEST

The continuous step draw-down test shall ideally have six (6) steps, but a minimum of four (4), all the of same time duration of 60 minutes until water levels stabilise, without intermittent rest period. The test shall begin with the lowest discharge rate and increased consecutively until the maximum discharge rate is reached. Upon completion of the step draw-down test, the recovery shall be monitored for at least two (2) hours or until ninety-five percent (95%) of its pre-pumping level.

#### CONSTANT RATE PUMPING TEST

At the end of the step-draw-down test, the CONTRACTOR carries out a rapid interpretation of the field data to define the borehole constants and calculate the critical yield of the borehole, corresponding to a borehole-efficiency of fifty percent (50%).

The constant rate pumping rate is either defined by the critical yield. If one hundred and twenty percent (120%) of the design yield is lower than the critical yield, the CONTRACTOR can suggest carrying out the constant rate pumping test with this yield.

The ENGINEER must approve the pumping rate to be used for the constant rate pumping test, as obtained from Section 6.2.2.

Constant rate pumping tests will be carried as:

* up to 6 hours for the 6 4” cased and gravel packed exploration boreholes with a 2 hour recovery period; and
* 48 hours for the 4 6” cased production boreholes followed by up to a twelve (12) hours recovery period or reaching 95% of the initial static water level (pre-pumping measured water level).

The pump test shall be terminated only after approval by the ENGINEER.

The test pump cannot be removed from the borehole during the recovery periods.

### SANITARY SEAL

Once the surface casing is in place, the annular space between the drilled hole and wall of the surface casing shall be grouted for sanitary seal with cement slurry by a pour-in method from the top for a minimum of 1m below the borehole head.

### HEAD AND CAPPING

The head design is detailed in the drawings which are to be found in APPENDIX 2a and b for completed holes with gravel pack, bentonite seal and surface sanitary seal. Remaining exploration holes which were deemed not to have a high enough airlift yield during the drilling process will be cased with 4” uPVC and a cap only. The CONTRACTOR shall supply all materials and carry out the construction of the head according to the design drawings provided. The head shall be marked with the borehole number, in a manner approved by the ENGINEER; once pumping tests are completed, an external lockable steel cap shall be provided and fitted as shown in the drawings, allowing for permanent installation of a 1’ dip tube for water level monitoring. Care shall be taken to ensure that the cap is closely fitted and fully seated on the top of the casing, yet easily removable. The locking blade shall be fitted so that it can be easily inserted and removed.

### CLEAN-UP AND CONTAMINATION PREVENTION

The CONTRACTOR shall at all times take every precaution to ensure that the borehole is kept free of contamination.

### DISPOSAL OF WATER

The disposal of water during development and testing is the Contractor's responsibility. The Contactor is responsible for all liability, expenses and costs for any damages, losses or claims which might arise from the disposal of water, including without limitation due to flooding, loss of crops, contamination.

##  MONITORING, SAMPLING AND LOGGING REQUIREMENTS

### BOREHOLE LOGGING

Penetration rates, measured as minutes per meter drilled, must be recorded for every meter in the drillers log in regard with the pressure on the tool. The CONTRACTOR must report immediately to the ENGINEER on site any changes in the penetration rate. The penetration rate report must include the method of drilling used and if any changes in the drilling method have been undertaken its depth and time of change must be recorded. Drilling interruption for flushing without drilling, stoppage during installation of additional drill pipes, breakdowns, etc. must be properly recorded so that the drilling rates can be properly interpreted purely based on time taken for drilling.

The CONTRACTOR shall endeavour to operate in such a way as to detect water strikes by noting increases in flow rates. The CONTRACTOR submits the method with which increased flow rates are measured for approval to the ENGINEER.

### FORMATION SAMPLING

Representative samples of the strata penetrated will be collected every meter (or as otherwise directed and approved by the ENGINEER), by whatever method is standard for the drilling technique in use.

When requested by the ENGINEER, the samples will be displayed in a neat and organised manner so that the entire geologic section is clearly represented.

### PUMP TEST MONITORING

Results of all pump tests will be provided to the ENGINEER in raw format on sheets detailed as per APPENDIX 3, and in digital format. Full results and preliminary interpretation of the Step Pumping Test with suggested yield for constant rate pump test will be given to the ENGINEER on the day that the step test is completed. The ENGINEER has to approve the constant rate test yield. In the tested borehole, the measurement will be done through a temporary measurement dip tube which shall be deep enough to reach the top of the pump.

#### WATER LEVEL MONITORING

The water level measurements must be done in the borehole, which is tested and if possible, in up to 2 neighbouring boreholes designated by the ENGINEER.

For the tested borehole, the following indicative time intervals are recommended, as shown in Appendix 3:

Every 1 minute from 0 to 10 minutes of pumping;

Every 2 minutes from 10 to 30 minutes of pumping;

Every 5 minutes from 30 to 60 minutes of pumping;

Every 10 minutes from 60 to 360 minutes of pumping;

Every 15 minutes from 360 to 600 minutes of pumping;

Every 30 minutes from 10 to 24 hours of pumping; and

Every 60 minutes from 24 hours of pumping.

It is crucial that the exact time of a measurement be recorded, even in the event that the above indicative times could not be exactly met.

#### FLOW RATE MONITORING

The pumping rate from the new production boreholes shall be recorded at fifteen (15) minute intervals specified below within an accuracy of +/- 10% by means of a flow meter or a volumetric gauging device (weir tank) or graduated bucket for low flowing boreholes. The flow meter must be installed such that a full pipe flow exists at all times during pumping and be located in a straight pipe at the borehole site with at least ten (10) pipe diameters length on either side of the meter.

#### WATER QUALITY MONITORING AND WATER SAMPLING

During pumping operations, temperature, electrical conductivity and pH of pumped water will be recorded for any flow measurement. Water samples for water quality analysis for commissioning of the borehole must be collected during the pumping test as directed by the ENGINEER and in accordance with the legal regulations.

## REPORTING REQUIREMENTS

The Contractor shall submit to the Engineer’s Representative at the end of the works, a full report, including the borehole completion report, the photographic documentation and a detailed description of the following:

* Progress narrative of excavation, pipe laying, concrete placement, backfilling;
* Detailed lithological description with photo documentation of samples;
* Documentation from pumping tests including all details for the step draw-down and constant rate tests;
* Results of water quality analysis;
* Details of pipes and materials;
* Particulars of other materials, accessories and related materials delivered to the site and those available; in the stores at the end of the month used in the permanent works during the month;
* An as-built drawing of the finalised borehole, including the encountered lithological units; and
* All raw data of the calibration and pumping tests including interpretation of pump tests.

## APPENDIX 1: BoQ

## APPENDIX 2: TECHNICAL DRAWINGS: BOREHOLE DESIGN, HEAD AND CAPPING

## APPENDIX 3: STANDARD PUMP TEST FORM





## APPENDIX 4: STANDARD BOREHOLE LOG AND QUALITY CONTROL CHECK LIST



This checklist should be used to ensure that all the appropriate information is collected and documented during all phases of borehole construction including siting, drilling, pump testing, development and completion.

|  |  |
| --- | --- |
| **WELL CONSTRUCTION CHECK-LIST** |   |
|  |
| **1. BASIC WELL INFORMATION** | **Data availability (Y/N)** |   |
| **1.1** | **BH-ID (Official/Local)** |   |
| **1.2** | **Location/Country** |   |
| **1.3** | **Drilling contracted by** |   |
| **1.4** | **Longitude ° (degrees)**  |   |
| **Latitude ° (degrees)**  |   |
| **1.5** | **Well head elevation [masl]** |   |
| **1.6** |  **Well depth [m]** |   |
| **1.7** | **Drlling completion date** |   |
| **1.8** | **Contractor** |   |
| **1.9** | **Drilling method/Drilling fluid** |   |
| **1.10** | **Drilling equipment** |   |
|   |
| **2. WELL CONSTRUCTION** | **Data availability (Y/N)** |   |
| **2.1** | **Drilling diameters** |   |
| **2.2** | **Casing characteristics** |   |
| **2.3** | **Annular space filling** |   |
| **2.4** | **Lithology and hydrostratigraphy** |   |
| **2.5** | **Static water level (SWL)** |   |
| **2.6** | **Backfilling**  |   |
| **2.7** | **Concrete Apron (sanitary seal)** |   |
| **2.8** | **Bottom plug** |   |
| **2.9** | **BH Development type** |   |
| **2.10** | **Equipment type** |   |
| **2.11** | **Development duration (hours)** |   |
| **2.12** | **Well development Monitoring** |   |
| **2.13** | **Drillers yield (Expected production rate) [m3/hour]** |   |
| **2.14** | **Pump position** |   |

1. A dummy consists of an axially suspended cylinder (or cage-ring) of at least 7 m length with a minimum external diameter corresponding to the expected pump diameter. The dummy should freely be passed down the borehole without force [↑](#footnote-ref-1)