**UNHCR Sample Drilling Contract and Specification**

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

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

**TECHNICAL SPECIFICATIONS**

[1. SCOPE OF WORK 4](#_Toc476258716)

[2. GENERAL REQUIREMENTS 4](#_Toc476258717)

[2.1 GENERAL 4](#_Toc476258718)

[2.2 LOCALISATION OF BOREHOLES 5](#_Toc476258719)

[2.3 BOREHOLE IDENTIFICATION 5](#_Toc476258720)

[2.4 GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS 5](#_Toc476258721)

[2.5 WELL DESIGN 5](#_Toc476258722)

[2.6 CONSTRUCTION PROGRAM 6](#_Toc476258723)

[2.7 LIASON WITH STATUTORY AUTHORITIES 6](#_Toc476258724)

[3. PERSONNEL REQUIREMENTS 6](#_Toc476258725)

[3.1 EMPLOYER’S SUPERVISING ENGINEER 6](#_Toc476258726)

[3.2 CONTRACTOR’S EMPLOYEES 7](#_Toc476258727)

[4. INFRASTRUCTURAL REQUIREMENTS 7](#_Toc476258728)

[4.1 ACCESS TO SITE, MOBILISATION AND DEMOBILISATION 7](#_Toc476258729)

[4.2 EXISTING FACILITIES 7](#_Toc476258730)

[4.3 SUPPLY OF WATER AND ELECTRICAL POWER 7](#_Toc476258731)

[4.4 SITE LABORATORY 8](#_Toc476258732)

[5. MATERIAL REQUIREMENTS 8](#_Toc476258733)

[5.1 QUANTITIES 8](#_Toc476258734)

[5.2 ORIGIN 8](#_Toc476258735)

[5.3 STANDARDS 8](#_Toc476258736)

[5.4 TOXIC MATERIALS 9](#_Toc476258737)

[5.5 STORAGE OF MATERIALS 9](#_Toc476258738)

[6. BOREHOLE CONSTRUCTION REQUIREMENTS 10](#_Toc476258739)

[6.1 ERECTION OF DRILLING RIG 10](#_Toc476258740)

[6.2 BOREHOLE DEPTH AND BOREHOLE DESIGN 10](#_Toc476258741)

[6.3 DRILLING SEQUENCES 10](#_Toc476258742)

[6.4 REAMING OF WELLS 10](#_Toc476258743)

[6.5 ASSEMBLING OF CASING 10](#_Toc476258744)

[6.6 CENTRALISERS 11](#_Toc476258745)

[6.7 VERTICALITY AND ALIGNMENT OF BOREHOLES 11](#_Toc476258746)

[6.8 FAILURE OF CASING STRING INSTALLATION 12](#_Toc476258747)

[6.9 CHARACTERISTICS OF THE BOREHOLE CONSTRUCTION MATERIALS 12](#_Toc476258748)

[6.9.1 DRILLING FLUID AND ADDITIVES 12](#_Toc476258749)

[6.9.2 CHARACTERISTICS OF THE CASING AND SCREENS 12](#_Toc476258750)

[6.9.3 CHARACTERISTICS OF CEMENT 13](#_Toc476258751)

[6.9.4 PARTIAL BACKFILLING OF WELLS 13](#_Toc476258752)

[7. BOREHOLE COMPLETION REQUIREMENTS 13](#_Toc476258753)

[7.1 BOREHOLE DEVELOPMENT 13](#_Toc476258754)

[7.2 AQUIFER TESTING REQUIREMENTS 14](#_Toc476258755)

[7.2.1 CALIBRATION TEST AND TEST DESIGN 15](#_Toc476258756)

[7.2.2 STEP DRAW-DOWN TEST 16](#_Toc476258757)

[7.2.3 CONSTANT RATE PUMPING TEST 16](#_Toc476258758)

[7.3 SANITARY SEAL 16](#_Toc476258759)

[7.4 WELLHEAD AND CAPPING 16](#_Toc476258760)

[7.5 CLEAN-UP AND CONTAMINATION PREVENTION 17](#_Toc476258761)

[8. MONITORING, SAMPLING AND LOGGING REQUIREMENTS 17](#_Toc476258762)

[8.1 DRILLING FLUID MONITORING 17](#_Toc476258763)

[8.2 WELLHEAD LOGGING 17](#_Toc476258764)

[8.3 FORMATION SAMPLING 18](#_Toc476258765)

[8.3 PUMP TEST MONITORING 18](#_Toc476258766)

[8.4.1 WATER LEVEL MONITORING 18](#_Toc476258767)

[8.4.2 FLOW RATE MONITORING 19](#_Toc476258768)

[8.4.3 WATER QUALITY MONITORING AND WATER SAMPLING 19](#_Toc476258769)

[8.4 CAMERA INSPECTION [above XY COST threshold] 19](#_Toc476258770)

[9. REPORTING REQUIREMENTS 19](#_Toc476258771)

[9.1 REPORTING SCHEDULE 20](#_Toc476258772)

[9.2 DRILLING PROGRESS REPORT 20](#_Toc476258773)

[9.3 PHOTOGRAPHIC AND VIDEO DOCUMENTATION 20](#_Toc476258774)

[9.4 PUMPING TEST REPORT 21](#_Toc476258775)

[9.5 FINAL REPORT 21](#_Toc476258776)

[APPENDIX 1: WELL DESIGN AND TECHNICAL DRAWINGS 21](#_Toc476258777)

[APPENDIX 2: STANDARD WELL-ID FORM (WELL CONSTRUCTION, LITHOLOGIACL DESCRIPTION, DEVELOPMENT MONITORING, PUMP TEST FORMS) 21](#_Toc476258778)

## SCOPE OF WORK

The work required by this contract includes the construction of **[ENTER NUMBER OF BOREHOLES]** production well(s), according to the well design provided by the EMPLOYER and amended to this contract (**Appendix A**).

**[Exact description of the drilling works to be carried out, according to the well design (Appendix A]**

The construction work comprises the following tasks [**Description of main activities of the works**]:

1. Drill a [drilling diameter] hole to the depth of [XY] and install and cement [X meters] of [XY inch] surface casing
2. Drill a borehole to [X meters] of [diameters] and install [diameter and type] of casing
3. …Drill from X to Y [meters] with [diameter]

….

During drilling, EC and pH of the drilling-returned water will be measured at regular intervals, drilling penetration rates will be recorded and lithological samples will be bagged and described, according to 8.4.3.

The Test Pumping Operations will comprise a calibration test, a step-test, a constant rate test and a recovery period, to be carried out according to6.9.2.

## GENERAL REQUIREMENTS

### GENERAL

* Any Works whether or not shown on the Drawings and/or described in the Specifications but which can reasonably be inferred as necessary for the completion and proper operation of the works will also form part of the extent of the Contract.
* Materials and works not covered by these specifications will be specified either in the conditions, Drawings or in the Bill of Quantities (BoQ).
* The General and Special Specifications shall be read together in conjunction with the Bills of Quantities, Drawings and other Tender Documents, which shall be considered as mutually explanatory.
* Prior to the commencement of the work for all items, the CONTRACTOR shall submit a method statement to the EMPLOYER for approval. This should 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 shall be made without this having previously been notified in writing to the EMPLOYER.
* All Brands or commercial names mentioned in this tender document are a reference to the CONTRACTOR to consider the minimum required level of quality. In the construction phase, the EMPLOYER has the right to approve the brands or equal and /or to request for additional Brands.

### LOCALISATION OF BOREHOLES

The exact location of each borehole will be given and clearly marked in the field by the EMPLOYER in presence of the CONTRACTOR, with a minimum **XY** day’s notice before erection of the drilling rig.

### BOREHOLE IDENTIFICATION

The borehole identification of each borehole has to be defined prior to drilling. The borehole identification figuring on the drilling permit and/or a local borehole or Well ID has to be clearly indicated on the borehole location in the field and systematically used in all documentation.

### GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS

The geological units for Borehole XY are expected to be encountered are **[XX],** at the **[XX]** depths and the expected static water level is expected to be at **[XX]** meters depths.

The geological units for Borehole XZ are expected to be encountered are **[XX],** at the **[XX]** depths and the expected static water level is expected to be at **[XX]** meters depths.

### WELL DESIGN

The complete well design is an integral part of the technical specification of this contract (Appendix 1). The EMPLOYER is responsible for the well design and for approval by the relevant authorities (i.e. drilling permit).

### CONSTRUCTION PROGRAM

Within **[XX]** days of the order to commence the CONTRACTOR shall provide the EMPLOYER with:

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

### LIASON WITH STATUTORY AUTHORITIES

The CONTRACTOR is required to have the appropriate license to operate issued by the STATUTORY AUTHORITY or other professional body recognised by that authority. The CONTRACTOR shall be solely responsible for liaison with all the Statutory Authorities and other CONTRACTORS who are working in the same area having jurisdiction over any aspect of the CONTRACTOR’s activities under the Contract.

The CONTRACTOR shall also be fully responsible for the timely obtaining of any approvals, consents and the like which are required by such authorities especially for the location of the sewers and force mains within the right of way of the roads in the project area.

The CONTRACTOR has to make full coordination with other contractors who are implementing construction activities in the area at no extra cost.

The CONTRACTOR shall modify his program if and when necessary for the EMPLOYERS approval, during the course of carrying out the Works, as a result of any restrictions imposed by statutory authorities. The costs for complying with the provisions of this clause shall be deemed to be included in the Contract unit rates and no claims for additional costs arising from delays or any matters (whether foreseen or unforeseen) will be entertained. The CONTRACTOR is required to comply with all reporting requirements imposed by the STATUTORY AUTHORITY including but not limited to, the location, depth, technical design criteria, construction methods, equipment and materials used, etc..

## PERSONNEL REQUIREMENTS

### EMPLOYER’S SUPERVISING ENGINEER

In view of the specialised nature of the drilling works, drilling may only take place under the direct supervision of the ENGINEER, representing the EMPLOYER (hereafter referred to as ENGINEER) who will provide on-site supervision at all times. The ENGINEER, who needs to have extensive experience in well design and construction (e.g. hydrogeologist, geologist) will provide instructions regarding borehole depths and will supervise the borehole development and aquifer testing and water quality sampling.

The CONTRACTOR shall provide all material, such as ladders and lighting facilities and all things necessary required by the ENGINEER to inspect any part of the Works.

### 3.2 CONTRACTOR’S EMPLOYEES

The CONTRACTOR is required to have adequate managerial, technical and supervisory staff, skilled and unskilled labourers to enable him to meet the construction programmed targets.

The CONTRACTOR shall ensure that his managerial, technical and supervisory staff have the necessary experience, and shall supply the EMPLOYER with details of work experience and qualifications of all key personnel of his staff.

For skilled labour, the CONTRACTOR shall employ certified craftsmen who may be asked to produce their certificates on the request of the ENGINEER.

## INFRASTRUCTURAL REQUIREMENTS

### ACCESS TO SITE, MOBILISATION AND DEMOBILISATION

The EMPLOYER will obtain the necessary permission for access to the drilling site and ensure heavy drilling equipment can be brought to the drilling sites.

### EXISTING FACILITIES

The exact locations of existing utilities have to be checked on site and by coordination with the concerned authorities by the CONTRACTOR prior to undertaking any work in their proximity.

The CONTRACTOR shall take all precautions to avoid any damages whatsoever to existing facilities or utilities.

If by any chance the CONTRACTOR causes damage or disruption, he shall immediately notify the concerned authority and bear all costs of repair at his own expense.

### SUPPLY OF WATER AND ELECTRICAL POWER

The CONTRACTOR shall make his own arrangements for all electrical power supply and drilling water supply which will be needed for the execution of the works. The cost of providing electric power supply and drilling water supply for all purposes shall be uniformly spread over all items of the Bill of Quantities.

The EMPLOYER shall cooperate and deal with the camp authorities for getting permission to use drilling water by the CONTRACTOR from available sources in the surrounding areas of the works.

### SITE LABORATORY

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 and pH meters, dip meter, marsh funnel, boxes for sampling, etc.) to carry out the required tests as described in 8.4.3 and allow the ENGINEER to witness testing. All the equipment and tools shall be in good condition, calibrated and tested prior to onset of works.

## MATERIAL REQUIREMENTS

### 5.1 QUANTITIES

Before ordering the materials to be installed, the CONTRACTOR shall make a proper survey of all quantities and shall make sure of the necessary specifications of each type of equipment, material and pipe, numbers of any type of material necessary to complete the works.

Quantities given in the Bills of Quantities are approximate values only. The Quantities may be subject to modification by the CONTRACTOR during execution of works.

### 5.2 ORIGIN

The CONTRACTOR shall provide the EMPLOYER prior to confirmation of any import of any material required for the works, with information on the material to be imported such as country of origin, manufacturer, catalogues and technical specifications.

### STANDARDS

The CONTRACTOR shall submit prior to onset of the works to the ENGINEER one original and two copies of all the standards relevant to all items provided for or used in the works.

The CONTRACTOR is required to submit a list of suppliers that he intends to deal with together with his Tender bid in conformity with the manufacturer’s authorization forms.

The materials offered in the tender in the letter of submission, manufacturer’s authorization and particular material specification must match and are binding for the successful tenderer as well as the suppliers mentioned by the tenderer in his bid.

The CONTRACTOR shall submit for the approval of the ENGINEER, before ordering a Master List describing in detail:

a. Type of materials to be used, dimensions, thickness, lengths, shape, weight, class, tolerance limits and quality.

b. Standards to which the item is manufactured.

c. Details of specials, adaptors, fittings and joint design.

d. Coating and lining methods.

e. Country of Origin.

f. Supplier.

All pipe and coating materials must be certified for potable water use and shall contain no ingredients that may migrate into water in amounts that are considered to be toxic or otherwise dangerous for health.

All pipes shall be certified as safe for transporting potable water by an independent third party testing laboratory.

### TOXIC MATERIALS

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

Any import or usage of the above-mentioned materials by the CONTRACTOR is require to be licensed in writing by the EMPLOYER; otherwise, the CONTRACTOR shall be liable for any legal pursuance or other consequences resulting there from.

### STORAGE OF MATERIALS

The CONTRACTOR shall be responsible for the storage and well-being of all materials purchased under this Contract.

The CONTRACTOR shall manage and maintain stockyards that can accommodate all materials purchased and approved by the ENGINEER under this Contract. The materials shall be stored in a clean place, either in the open or under cover as required by the manufacturer/suppliers instructions, and shall be regularly inspected by the ENGINEER and maintained to the ENGINEER’s satisfaction.

## BOREHOLE CONSTRUCTION REQUIREMENTS

### 6.1 ERECTION OF DRILLING RIG

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

No payment will be made for a well not located at the designated site.

### BOREHOLE DEPTH AND BOREHOLE DESIGN

All technical details on drilling and casing diameters are given in the well design, APPENDIX A.

**[brief description of drilling sequence to be given hereafter]**

…The boreholes to be drilled will be required to penetrate thickness less than **XY** m of soil or poorly consolidated sediments. The surface casing should be installed up to **XY** m deep and not less than 5 m deep. The drilling diameter for surface casing should be at least **XY**’ diameter and the surface casing should be at least **XY**’ diam…The total depth of the borehole should be **XY** meters.

### DRILLING SEQUENCES

The expected drilling sequence is  [**detailed description of drilling sequence, including all drilling diameters, the sequence of installation of casings etc**]

### REAMING OF WELLS

All reaming will be carried out with hole openers which are designed specifically for reaming or with bits which have been modified for reaming in a manner approved by the ENGINEER. Care will be taken to ensure that reaming work results in wells which are properly aligned and straight and concentric to the original well.

### 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 may be coupled to each other either with welds or with threaded connectors. If welding is done and in order to secure mechanical and corrosion resistances, the CONTRACTOR shall submit the certificates and qualifications of the welding operator as well as the welding procedures to the ENGINEER and get his approval before starting operations. All welding electrodes must comply with the Standard Specifications standards. For threaded connections, the lubricating compound will not contain any heavy metal or hydrocarbon.

### CENTRALISERS

In order to achieve the required borehole linearity, all casing permanently installed in wells should be fitted with centralisers at 9 m intervals or as otherwise directed by the ENGINEER. The centralisers should be factory manufactured.

### VERTICALITY AND ALIGNMENT OF BOREHOLES

The well(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 to the depth of the pump housing using deviation-measuring instruments like inclinometer, draft indicator, etc. provided and operated by the CONTRACTOR at the CONTRACTOR’s own expenses. Readings of deviation and direction will be taken at three metre depth intervals. Deviation shall be no more than 10%.

After casing installation, verticality will be tested by means of a dummy. The dummy will consist of an axially suspended cylinder (or cage-ring) at least 7 m long with a minimum external diameter corresponding to the diameter of the pump expected to be installed. The dummy should freely be passed down the borehole without force and is provided and operated by the CONTRACTOR at the CONTRACTOR’s own expenses. Should the dummy fail to move freely throughout the length of the casing or hole to the bottom of the housing line or should the borehole vary from the vertical in excess of above specified value, or beyond limitations of this test, the plumbness and alignment of the borehole shall be corrected by the contractor at his own expense. Should the contractor fail to correct such faulty alignment or verticality, the well 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.
* The usefulness of the completed borehole will not be materially affected.
* The cost of necessary remedial measures will be excessive.

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

### FAILURE OF CASING STRING INSTALLATION

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

### 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.

#### DRILLING FLUID AND ADDITIVES

The choice of drilling mud has to be in accordance with the legal regulations and may either be anorganic (bentonite) or of biodegradable type and non-toxic and amenable to degradation by an appropriate chemical agent.

The CONTRACTOR must ensure he has the necessary equipment including mud pumps, viscosity-measuring apparatus, water tanks etc., to enable him to successfully complete the works. In case of use of drilling fluid, the mud pump should be able to ensure a 30 m/min ascending velocity of the fluid.

The CONTRACTOR shall specify the brand name and manufacturer of any mud or chemicals or additives proposed to be used and include technical specifications or any other relevant data.

#### 6.9.2 CHARACTERISTICS OF THE CASING AND SCREENS

The XY” surface casing can be standard steel casing.

The XY” casing characteristics should be:

* [**Brand and standard**]
* the minimum collapse Strength will be [**XY**] bars
* connections are [**type**]

All casing and tubes supplied by the CONTRACTOR and which will be installed permanently in the boreholes must be new and must comply with the ASTM standards. The appropriate manufacturer’s product information pamphlets with full details of the offered casing, including method of joining must be provided to the ENGINEER and accepted before installation in the hole. The following information should be engraved on equipment:

* Supplier name
* Material
* OD and nominal thickness for tubes, OD for connectors

#### 6.9.3 CHARACTERISTICS OF CEMENT

Cement: All cement, which is used, must comply with the Standard Specifications (e.g. DIN 1164, EN 197, DIN 18555) 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. The normal aggregate size for use with the cement may not exceed 19 mm unless otherwise stated.

Cement slurry: The cement used for cement slurry will be PORTLAND type. The water used shall be potable water. 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 API Class A cement and aggregates made up of not less than five sacks of fifty kilograms each per cubic metre of finished concrete. The mix will not contain large amounts of fine materials. Fresh, potable water will be used as mixing water. Aggregates used will be sound, durable and well graded in sizes ranging from sands to rock of four centimetre. No stones larger than eight centimetre will be allowed in concrete. Concrete mixtures will contain not more than thirty litres of water per fifty kilogram sack 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.

#### PARTIAL BACKFILLING OF WELLS

The CONTRACTOR might be required to backfill the existing well 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 well.

## BOREHOLE COMPLETION REQUIREMENTS

### BOREHOLE DEVELOPMENT

Well development will be conducted using a **[airlift]** system. All well development methods and chemicals must be described in the work plan (section 2.6) and approved by the EMPLOYER.

Development must begin from the bottom of the borehole, the apparatus being placed about 1 m above the base of the borehole. The air is turned on and off repeatedly to agitate the fine material within the gravel pack and the surrounding formation. This process continues every two meters upward within the borehole until the static water level is reached. Once this is completed the apparatus is lowered to the bottom of the borehole to remove sand and gravel and the borehole is then further airlifted until the water is totally clean to the satisfaction of the ENGINEER. Development shall continue for a minimum of 6 hours air-lift development and until the discharge water is clean and free of sand (i.e. no more than 1 cm diam. sand stain test) or until such time as the Engineer finds acceptable. The disposal of water during development and testing is the Contractor's responsibility, including all costs for possible damages or claims which might arise due to flooding, loss of crops or other possible losses. Development of the well shall be carried out until the following conditions have been satisfied:

1. Complete removal of all products resulting from drilling i.e. drilling mud, smear, foam or additives.

2. Complete removal of small loose particles of the formations encountered by the borehole.

3. Attempts have been made to remove blockages or encrustation of joints or other openings in the formations.

### AQUIFER TESTING REQUIREMENTS

The aquifer pumping test is a thorough and precise test of the characteristics of the water bearing formation in the vicinity of the well and of the well performance. It is of prime importance that the CONTRACTOR correctly monitors test pumping operations to ensure that accurate data is obtained. Testing work will be carried out with the intent of maximising the chances of success in completing tests within the allocated period of time. For testing operations, the test pump will be installed at the bottom of the pump housing.

For the purpose of calibration and pump testing, the Contractor will provide one pump able to produce **XY** m3/h against **YZ** m head. The Contractor will provide electric cable, electric panel control, exhaust pipe and all accessories required to install, operate and uninstall these pumping unit.

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. No pools shall be allowed to form in the vicinity of the well to avoid re-infiltration.

During the period of the tests, the Contractor shall measure and record water levels in the pumped well by means of an installed PVC-airline with a well-defined datum for measurement. For measurement of water levels in wells, electric dip meters or pressure meters shall be used.

The pumping rate from the new production boreholes shall be recorded at the intervals specified in section 8.3 below within an accuracy of +/- 1 cm and recorded on standard sheets detailed in APPENDIX 2. The discharge rate during the pumping shall be maintained within five per cent of the rate established by the ENGINEER and the CONTRACTOR shall maintain uninterrupted pumping during the period of all tests.

Shall the Contractor fail to provide accurate water level and flow measurement with the recommended frequency, the Engineer may also declare the test 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 complete recovery of the water levels in the pump or observation well 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 DESIGN

Before beginning the actual tests on each well, a calibration test must be undertaken. This involves checking that all equipment including the pump, generator, manometer and pipes are working satisfactorily. The discharge pipeline shall be checked for leaks.

The calibration test is an important preparatory step for the pumping test procedure and must be carried out at least one day before the pumping test is carried out to allow the water level to recover before the actual pump test operations begin. The calibration test should be carried with the design discharge rate in the back of the mind but particularly to test the full capacity of the well in its ‘as built’ situation.

A calibration test implies testing of the dynamic water level behaviour in response to a highest possible pumping rate. The highest possible pumping rate (maximum discharge rate) is constrained by the maximum design draw-down, which in turn is defined the depth of the first screened section (in case the pump is installed at a lower level), or 2 meters above the pump position. If draw-down is insignificant, then the maximum discharge rate should be chosen as 150% of the design pumping rate. The maximum discharge rate (Qmax) obtained from the calibration test allows designing of the six pumping rates for the step draw-down test, starting with 1/6 of Qmax and ending with Qmax .The gate valve shall be graduated with respect to these discharge positions and marked in preparation for the step draw down test.

Cases for which calibration test needs to be repeated:

1. Should the pump not be capable of producing the required maximum design draw-down *s*D-max, then two options should be considered:

* Restart the calibration test with a higher-yielding pump
* If the maximum flow rate of the calibration test exceeds the design yield by a factor 1.5, this pumping rate may be taken as Qmax.

1. Should the maximum design draw-down be ‘over-shooted’ with the maximum flow rate during the calibration test pump, then the pump is oversized and a new test has to be carried out with a smaller pump.

#### 7.2.2 STEP DRAW-DOWN TEST

The continuous step drawdown test shall have six (6) steps of one (1) hour each, without rest period. The test shall begin with the lowest discharge rate (about 1/6 of the maximum discharge rate), as described in 6.9.2.1 and increased consecutively until the maximum discharge rate is reached. Upon completion of the step drawdown test, the recovery shall be monitored for at least two (2) hours.

#### 7.2.3 CONSTANT RATE PUMPING TEST

Constant rate pumping tests will be carried out during seventy two (72) hours in length followed by a twelve (12) hours recovery period. The pumping rate for the constant rate pumping test should be 120% of the design pumping rate unless the step drawdown test results show that the well efficiency for this discharge rate is below 0.5. If this is the case, then the ENGINEER will decide upon the discharge rate of the constant rate pumping test.

The ENGINEER or his representative during the test on the basis of the measurements made and his analysis may increase or reduce both periods thereof. The pump test shall be terminated only upon the written notice of the ENGINEER or his representative.

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

### SANITARY SEAL

Once the surface casing is in place, the annular space between the 24” drilled hole and wall of the surface casing shall be grouted for sanitary seal with mixture of cement and water slurry by a pour-in method from the top. Cement grouting shall be carried out in one continuous operation before initial setting of the cement occurs. Regardless of the method used, the grout shall be introduced at the bottom of the space to be grouted. In no circumstance will this be less than 1 m below the wellhead.

### WELLHEAD AND CAPPING

The wellhead design is detailed in the drawings which are to be found in APPENDIX 1. The CONTRACTOR shall supply all materials and carry out the construction of the wellhead according to the following instructions: the ends of the surface casing and well casing shall be cut off to the lengths required. These cuts must be square and neat in appearance and shall be smoothed by grinding; the annular space between the surface casing and well casing shall be filled with concrete as specified and neatly finished at the top; the well head block shall be cast around the surface casing in accordance with the drawings; if necessary, the wellhead must be modified to fit any size casing and these modifications must be approved by the ENGINEER; the well head shall be marked with the well number, in a manner approved by the ENGINEER; once pumping tests are completed, an external steel cap shall be provided and fitted as shown in the drawings, allowing for permanent installation of a 1’ airline 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.

## MONITORING, SAMPLING AND LOGGING REQUIREMENTS

### DRILLING FLUID MONITORING

During drilling, readings of the mud condition (pH, viscosity, density and sand content) will be collected and recorded as directed by the ENGINEER. Steps will be taken immediately to correct any variations of the preferred values. Where applicable and required, mud dispersing agents and other chemicals applicable to standard procedures may be used if in accordance with the legal regulations. If polyphosphates are used, it must be followed by well disinfection. It is recommended, however, to provide a polyphosphate product that already contains disinfecting agents.

### WELLHEAD 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 endeavor to operation in such a way as to detect water strikes by noting increases in flow rates. For this purpose marsh funnel and stopwatch must be available. In order to measure yield rates during drilling and so to obtain an indication of water strikes, the return water must be directed through a gauging weir consisting of a 90º weir plate (V – Notch) installed at a suitable point in the return water circulation system. The dimension of the V-Notch should be at least 800 mm wide across and 400 mm vertical depth.

### 8.3 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.

A sample of the formation cuttings will be removed from the drilling medium by collecting the sample in a screen, or by collecting a large sample of the drilling fluid and allowing the cuttings to settle out. Care will be taken to ensure that the sample is representative of the material being drilled and not contaminated by hole erosion or caving.

The samples will be placed in approved and appropriately marked heavy plastic sample bags and handed over in a sturdy box to the ENGINEER. The sample box will be a container fitted with individual compartments for the samples. A card will be inserted into each compartment along with the sample, indicating, in water-proof ink, the depth from which the sample was recovered.

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 2, and in digital format. Full results of the Step Discharge Test will be given to the ENGINEER on the day that the step discharge test is completed. The ENGINEER will use this data to outline the likely yield of each borehole and the rate at which the constant rate test should be undertaken. Results of the constant rate test will be forwarded to the ENGINEER within 2 working days of the completion of the test. If water level indicator is used, the CONTRACTOR shall have at least two water level indicators on each site. In the tested well, the measurement will be done through a temporary measurement pipe which shall be deep enough to reach the top of the pump.

#### 8.4.1 WATER LEVEL MONITORING

The water level measurements may also be done in up to 2 neighbouring wells designated by the Engineer.

For the tested borehole, the following time intervals are recommended:

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

Every 60 minutes from 24 hours of pumping

#### 8.4.2 FLOW RATE MONITORING

The pumping rate from the new production boreholes shall be recorded at 15 minute intervals specified below within an accuracy of +/- 10% by means of a flow meter or a volumetric gauging device (weir tank). 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 15 pipe diameters length upstream and 10 pipe diameters length downstream of the meter. Weir tanks must incorporate suitable baffles and/or stilling well. For volumetric flow measurements, flow measurements shall be made by means of a gauging weir consisting of a 90º weir plate (V – Notch) or any other method approved by the ENGINEER. The contractor is responsible with mobilising testing pump with sufficient capacity to meet the planned well yield.

#### 8.4.3 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 well must be collected during the pumping test as directed by the ENGINEER and in accordance with the legal regulations. Each sample consists of 2 containers as in a glass or suitable plastic container of 1-liter capacity each. Water samples should be clearly marked showing name and number of well, date of sampling, hour of sampling, temperature and conductivity of water during sampling and signature of person taking the sample. The water sample shall be given to the EMPLOYER as soon as collected.

### CAMERA INSPECTION [above XY COST threshold]

At camera inspection is to be carried out at the end of the pumping test and shall be recorded revealing the as-built state of the well along its entire length.

## REPORTING REQUIREMENTS

The main reporting requirement for the borehole construction documentation is the completion of the QC form in APPENDIX 2, which includes the full documentation in the required standard UNHCR format. The progress reporting involves the updating of the QC form during the process, while the final report consists of the finalised and completed form.

### REPORTING SCHEDULE

The progress report is submitted and counter-signed by the ENGINEER on a daily basis, including the information referred to in 9.2.

The final report is submitted with a cover letter to the EMPLOYER no later than 14 days after completion of the borehole, including the items of 9.2 to 9.4.

### DRILLING PROGRESS REPORT

The drilling progress report is submitted to the ENGINEER on a daily basis, using the QC form and filling in the QC form up to the stage of drilling progress, including all the relevant information on technical details of the progress as well as on the lithological and hydrogeological findings. The required data for documentation are described in detail in APPENDIX 2.

### PHOTOGRAPHIC AND VIDEO DOCUMENTATION

The CONTRACTOR shall be responsible for the production of photographic documentation of work in progress as provided herein. Photographs of the overall general site or pertinent features thereof and of each area of construction shall be taken before the commencement of work at the sites and promptly submitted to the Engineer. The same views shall be re-photographed upon completion of all construction activities and submitted with CONTRACTOR’s application for final payment. All photographs shall be coloured photographs of commercial quality. All digital copies shall be submitted as electronical supplement with the final report. Printed photos shall be individually mounted and identified with description of view and date. Included in each view shall be a board that clearly indicates the name and number of the Contract, name of CONTRACTOR, borehole identification, description and location of view, and date photographed.

The full video documentation of the video inspection includes full inspection of the whole length of the borehole with depth indication is delivered as soft copy.

All costs involved for delivery of the photographs as described above shall be borne by the Contractor and are included in the Contract unit rates.

### PUMPING TEST REPORT

The CONTRACTOR shall record test-pumping data using the standard format of the WELL-ID form (APPENDIX 2). The data sheet shall be filled in the English language. The data sheets shall be prepared and delivered as soft and hard copy and include all the information, as described in APPENDIX 2, including full documentation of the equipment test, the step draw-down test design procedure, the step-draw-down test with interpretation, the design of the constant rate pumping test and the constant rate pumping test and interpretation.

The pumping test will only be considered as completed and will only be paid as quoted in the BoQ upon full documentation of the entire test procedure.

### FINAL REPORT

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

* Progress narrative of excavation, pipe laying, concrete placement, backfilling, sampling;
* Hydraulic testing, water sampling and other important items of the works;
* Particulars of the staff employed on the Contract;
* 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

## APPENDIX 1: WELL DESIGN AND TECHNICAL DRAWINGS

## APPENDIX 2: STANDARD WELL-ID FORM (WELL CONSTRUCTION, LITHOLOGIACL DESCRIPTION, DEVELOPMENT MONITORING, PUMP TEST FORMS)

.