**appendix 4: technical specifications**

**1.0 Scope of works**

The scope of the works involves the drilling of 24 boreholes in Butaleja (8) and Kaabong (16) and these require that contractors furnish only successful boreholes to the client - GOAL. A successful borehole is defined as one conforming to all the requirements for the siting, drilling, test pumping, yield, and water quality. The well delivers more than 500l/hr with recovery of not less than 65% in one hour. The well must pass the minimum acceptable potable water quality standards (Government of Uganda acceptable water quality standards).

Wells whose yield is less than 500l/hr or whose water quality is not acceptable according to GOU standards will be replaced by the Contractor at no further cost to GOAL. The drilling records for all unsuccessful wells must be provided to GOAL including for poor quality wells the water quality test certificates.

All the wells successfully drilled and tested will be installed with U2 hand pumps with stainless steel (G316 steel) pipes and rods or depending on the depth of the well and water quality, Upvc pipes with stainless steel coupling and stainless-steel rods. As a rule, all wells with hand pumps deeper than 36 meters will be installed with Stainless steel pipes and rods (G316 steel) as described in the specification. All wells with hand pumps recommended to be installed at or shallower than 36m may be installed with Upvc pipes with stainless steel coupling and stainless-steel rods at GOAL’s discretion.

The depths of installation of hand pumps and type of pump must be recommended and approved by GOAL.

The works includes hydrogeological survey, drilling of 5” ND borehole, installation of plain and screen casings, provision of gravel packing; development of the boreholes, pumping test; obtaining rock/cuttings and water samples for physiochemical analysis, provision of sanitary seal, well platform casting and installation of boreholes, and site clearance as specified hereinafter and as directed by the client.

* 1. **Location of the works**

The works are in communities and institutions in Butaleja and Kaabong districts.

Where there are failures because of any issues, GOAL will furnish the contractor with a replacement location in the same geographical area.

* 1. **Borehole siting (See Appendix 4A for additional detailed specification for siting)**

The Contractor is to carry out detailed geophysical analysis in the communities and institutions in the named districts. A method of geophysical survey best suited to the geography/geology of the area is to be employed.

The geophysical analysis will include the desk study, the hydro census and the geophysical survey. The reports of the surveys will be included as part of the final reports submitted for the whole works.

The desk study will include a review of existing reports, borehole logs, topographical, geological, and hydro geological maps, previous geophysical surveys, and the evaluation of aerial photographs if any. The Contractor can always retrieve this data from the respective District Water Offices and/or archives in the Directorate of Water Resources Management– Ministry of Water and Environment.

The Contractor’s hydrogeologist should carry out a hydro census in the vicinity of the target areas. This will include a detailed inventory of all existing water supplies to ensure that the current site does not influence nearby wells and to be able to make decisions that could affect the success of the new boreholes.

The Contractor should ensure that the siting/Geophysics work is to be carried out by suitably qualified and experienced person(s). The nominated person(s) shall be available for the specified contract period. Proposed changes to the hydro-geologist should be agreed with the supervising engineer/GOAL.

During the siting, the hydrogeologist should ensure that representatives of the local community/institution shall be involved. GOAL will assist with community liaison activities.

**2.0 Drilling site and Borehole siting (see additional detailed specifications for borehole siting Appendix 4A)**

Borehole locations shall be identified in agreement with the local communities and in consultation with GOAL. Sites selected for the hand pump should preferably be within the communities and not further away than 0.5km from 80% of people of the village. Changes to locations and distances should be discussed and mutually agreed with the supervising engineer.

The hydrologist will use their experience to determine alternative suitable sites for borehole construction for each village in case the initial site is abandoned for any reasons including dry wells. Boreholes should not be sited in or near to places that get flooded during rains. Flood plains should be avoided. Additional measures should be taken to ensure that sites are located outside the minimum distances prescribed from sanitation installations, sources of pollution, landfills, graveyards, and animal kraals.

Ultimately, the location of the drilling site is the responsibility of the Contractor and their hydrogeologist with input from GOAL and the local community. The Contractor shall drill the well(s) at location(s) as determined by their hydrogeological surveys. Access to the site shall be the responsibility of the Contractor. Tracks required for access of drilling plant, gear, camp and accessories to the well site shall be made by the Contractor and shall minimize as much as possible interference with existing fences and cultivated land. GOAL and the communities will be of assistance.

**3.0 Hydrogeology**

While deep wells have been constructed in these areas before, there is inadequate information regarding success rates and soil profiles. The conditions of drilling cannot therefore be precisely described, and the precise or proximate locations of aquifer(s) cannot be described. The Contractor hydrogeologist should therefore determine the most probable point with the best hydrogeological properties. While drilling conditions are not expected to be difficult, the driller should be prepared to deal with dry wells and unsuitable water quality tests.

**4.0 Environmental protection of the site**

Care must be taken in the handling and storage of drilling fluids, oils, greases, and fuel to avoid introducing environmental contaminants and pollutants. The Contractor shall dispose of any toxic materials including drilling fluids, cuttings and discharged waters in a manner approved by GOAL and so as not to contaminate/pollute public and private property. The Contractor shall adhere to relevant National regulations and guidelines on Environmental protection that apply to drilling. The Contractor shall ensure that all their personnel are aware of Environmental protection requirements.

**5.0 Materials for the works and Workmanship**

Materials that will form part of the complete works must be supplied new and never used. Materials must comply with the minimum specifications in the relevant codes. Materials not specified here must comply with the minimum specifications in the relevant codes of practice. Where a national standard does not exist for the material, the relevant British Standard shall apply.

The Contractor is expected to carry out all works as specified and in a professional manner. The Contractor shall carry out operations in accordance with the terms of the contract and to the satisfaction of GOAL. The Contractor shall use suitable equipment and supply efficient and experienced staff.

a) The Contractor will provide an experienced project Coordinator to oversee the drilling and testing to be carried out under this Contract.

b) The Contractor will maintain a full crew on each drilling unit and test pump unit. If a member of crew quits for any reasons including illness or injury, the Contractor will replace him as soon as possible with a worker of similar experience.

c) If the supervising Engineer is dissatisfied with the performance of a member(s) of the crew, such members shall be informed of their shortcomings and warned by the Contractor. If no change results within a reasonable period, the Contractor will be notified and requested to take necessary measures on the unsatisfactory crewmember.

d) If GOAL wishes to operate drilling equipment more than one shift per day, the Contractor shall increase the size of the drilling crew as required. However, in the percussion drilling, the rig will be operated for a minimum of 20 hours a day.

e) Where one or more members of the drilling crew is absent for any reasons, the supervising engineer will notify the contractor and agree whether to proceed with drilling operations.

**6.0 Contractor to provide all equipment for the works**

All necessary machinery, equipment, and materials to carry out the works shall be provided by the Contractor. Test pumping equipment shall be independent from the drilling rig(s). Prior to mobilization, the supervising engineer shall verify the specifications and state of repair of all major items of plant and transport and shall have the right to order the removal and/or replacement of any items which in the supervising engineers’ opinion are insufficient or in unsatisfactory condition. Acceptance by GOAL of the Contractor’s proposed plant and transport does not relieve the Contractor of his obligations under this contract, where such transport or plant fails to successfully complete the required works.

**7.0 Drilling**

a) Drilling method

The Contractor may use any motorized drilling technique that will achieve the depth and diameter required of the well, provided that the techniques used are those specified in his proposal and approved by GOAL. The rig to be deployed must be capable of drilling to at least a depth of 25% beyond the minimum final depth at the required diameter. Temporary casing may be installed in the borehole to prevent formation heave or collapse.

The average borehole depths shall be 60m for Butaleja and 70m for Kaabong

During rotary drilling using air as the circulating fluid, approved surfactants and artificial foam stiffening additives may be used if ground conditions warrant their use. Fluid additives of bentonite will not be accepted. Cellulose based reconstitution powder, or liquid polymeric additives may be required for viscosity enhancement. The Contractor will be required to state the type of polymer to be used and describe how the selected fluid additive will be mixed.

(b) Air Lift Yield

The Contractor is required to provide accurate air lift yields to GOAL. The method of the airlift yield estimation will be approved by GOAL.

**8.0 Strata sampling and borehole geo data**

While the drilling operation progresses, representative samples (min. 100 grams) of strata penetrated shall be collected at every Two (2) meters intervals or according to standard requirements of the Ministry of Water and Environment (MWE) where applicable. Strata samples will also be taken at every change in the profile and where water or an aquifer is struck.

At completion of drilling, the Contractor will be required to complete the borehole geo-log with all information describing the properties of the samples, appearances of water and aquifers, rock types and sampling details.

The Contractor will then complete the borehole log reports forms and supply them together with the borehole completion records including water quality test certificates to GOAL. Incomplete records or un-obtained samples are a reasonable ground for rejection of a borehole **(conditions of contract Clause 11).**

**The Contractor will be required to hand to GOAL at the end of the drilling operation borehole logs and pumping test data including information from dry boreholes.**

**9.0 Borehole depth and diameter**

The Contractor shall drill to the total appropriate depth depending on the geological formation and to a diameter that shall allow minimum borehole nominal diameter bore of 5 inches at the completion of the borehole, including casing installation. The average depth of the borehole shall be 60m for Butaleja and 70m for Kaabong. The minimum acceptable stable yield at test pumping shall be 500 liters/hour at an aquifer recovery of not less than 65% in one hour.

**10. Temporary casing**

Installation and diameter of any temporary casing required for the successful construction of the boreholes will be at the discretion of the Contractor provided that the completed borehole meets the specifications and design required under this Contract and is approved by the Supervising engineer. The cost for supply, installation and removal of temporary casing shall be entirely borne by the Contractor.

**11. Casing and screens**

Aquifer zones shall be completed with *U*PVC screens supplied by the Contractor and shall have a minimum wall thickness of **3.3mm** for 5 inches **ND** casing. The supervising engineer however reserves the right to vary these specifications if deemed necessary. The collapse resistance of the casings shall normally be a minimum of 6.5kg/cm2, while that for screens shall be a minimum of 50% of that of the casing. The screen open area shall not be less than 4% and shall have a uniform slot size of between 0.3-1mm. Screen length should not be compromised to save cost as this can result in a dry borehole.

Sections of the screen shall be provided in maximum 3m lengths and joined watertight by either flush threaded connections, or by an appropriate method recommended by the screen manufacturer or an equivalent standard, so that the resulting joint shall be strong and have the same structural integrity as the casing and the screen themselves. In some cases, the lower end of the screen shall be completed with a sump of minimum 0.5m and maximum 2m length. The bottom end shall be sealed with a suitable bottom cap.

The casing and screens must be centralized in the well so that an annular space of at least 25mm exists between the well wall and the casing. Suitable centralizers shall be provided to allow the casing screen to be set correctly in the center of the well. A centralizer shall be used every 3m.

**12. Verticality and Alignment**

All wells shall be vertical, shall be drilled and cased straight, and all casings/screens shall be set round, plumb and true to line. If required, the Contractor shall make a verticality test during and after drilling and at his own expense to demonstrate that the departure from the vertical does not exceed 0.1% between ground level and the bottom of the well. If this departure is exceeded, the Contractor shall make the necessary corrections, without additional payment. If the error cannot be corrected, drilling shall stop, and a new well shall be drilled. The abandoned well shall be backfilled and /or capped. No payment shall be made for re-drilling, the sealing/backfilling of the abandoned well, or for moving to a new site. Any materials (i.e., casing, screens, gravel pack, cement, etc) lost in the abandoned well shall be at the Contractor’s cost.

**13. Loss of equipment**

Any equipment lost down a well must be removed by the Contractor or the well shall be considered a lost bore. A replacement well shall have to be constructed at the Contractor’s expense.

**14. Lost bore**

If completion of the well is prevented by any of incident to the plant, ground conditions, jamming of the tools, or casing or any other cause, the well shall be deemed to be lost and no payment shall be made for that bore or for any materials not recovered there from, nor for any time spent during drilling or while attempting to overcome problems.

In the event of a lost bore, the Contractor shall construct a new well. The option of declaring any bore lost shall rest with the Contractor, subject to the approval of the supervising engineer.

**A lost bore shall be treated as follows:**

1. The Contractor may salvage as much casing and screen from the lost well as possible and may use it if not damaged in a replacement well, with the approval of GOAL.
2. Any material supplied by the Employer and salvaged damaged shall become the property of the Contractor, and the Contractor shall compensate the Employer accordingly.
3. The lost bore shall be sealed by concrete or cement grout, which shall be placed from the bottom upward by methods approved by GOAL.
4. The upper 2 meters of the lost bore shall be backfilled with native topsoil. Sealing of such abandoned wells shall be done in such a manner as to avoid accidents or subsidence, and to prevent it from acting as a vertical conduit for transmitting contaminated surface or subsurface waters into the water bearing formations.

**15. Water supply for drilling**

The Contractor shall make his own arrangement for obtaining, transporting, and pumping of water required for drilling purposes and for use by the drilling crew at their camp site.

**16. Well design**

The closed hole (shallow well) design shall be used for all wells constructed in this contract. Any well designed as an open well shall therefore be rejected and GOAL shall not make payments for such works. ***Refer to typical design notes below and the drawings at the annex A.* Design Notes:** - Drilled with 10 5/8" bit to final depth where necessary finished with 8" bit to final depth. Cased with 5" ND uPVC Class D casing, 6mm wall thickness. Screened sections adjacent to aquifer zones and gravel packed.

**17. Gravel pack**

The Contractor shall supply suitable gravel pack. Prior to delivery, samples of the gravel pack shall be inspected and approved by GOAL.. Gravel pack shall consist of washed, well-rounded particles of a uniform grading of between 2.5 and 4.0mm, shall comprise at least 95% siliceous material and must contain no clay, shale, silt, fines, excessive amounts of calcareous material or crushed rock. The gravel pack needs to be installed slowly and carefully, preferably with a tremie pipe and a funnel.

**18. Sanitary seal**

To provide an effective seal to the entry of contaminants, the upper **3 meters** of the annular space between the casing and the well wall shall be grouted using suitable prepared cement slurry. Grout is to be injected into the annulus in a single operation so that a complete and continuous seal is achieved.

**19. Development and cleaning of wells**

Well development must be undertaken before the Contractor moves to the next site. Development and cleaning of the wells, to remove native silts, clay and drilling fluid residues deposited on the well wall during the drilling process, shall be carried out by the Contractor upon completion of the drilling and installation of casings. The borehole should be flushed until it is free of fine silts and turbidity. When the water clears, the borehole should be flushed for an additional period of not less than 45 minutes.

Whenever possible, natural well development must be used. If organic drilling fluids are used, they shall be broken down chemically according to manufacturer’s recommendations before or during development. Cleaning may be carried out by airlift pumping, surging, backwashing, or jetting, to the approval of GOAL. Clay de-segregation by means of Sodium Hexametaphosphate (“Calgon”) treatment may, in some cases, also be called for by GOAL.

The method proposed by the Contractor for development of wells shall be submitted to GOAL in writing for his approval. Development of wells shall be effective from the depth at which water is encountered to the bottom of each well. Development shall continue for such time as directed by GOAL and until GOAL is satisfied that the water is as free from fine particles as possible. Upon completion of development, any accumulation of material shall be removed from the bottom of the well by airlifting.

**20. Test Pumping (See Annex 4B detailed spec for test pumping and yield measurement)**

The Contractor shall perform test pumping to establish well efficiency and assess the aquifer properties, and shall provide a suitable, self-contained, mobile test-pumping unit. The method for varying the discharge rate of the pumps shall depend on the type of pump used. The Contractor shall ensure the provision of a suitable means of achieving the range of constant flow rates specified.

Test pumping shall be undertaken in each productive well. In the case of wells with **indicative yields of between 800 and 2500 litres/hour constant discharge test pumping shall be carried out for 3 hours or until the water level stabilizes**. If the draw down is considerably low due to underestimation of the uplift yield (Driller’s yield) i.e., draw down less than 6 m the pump test is repeated using a higher discharge value.

In case of wells with an indicative yield of greater than 2500 litters/hour the well shall be tested in the manner of **a step-test**, with the initial step being at 2500 litres/hour the duration of each step shall be 60 minutes, and a minimum of three steps of increasing discharge shall be undertaken. The discharge rates thereafter shall agree with GOALs representative onsite.

**21. Water level observation**

The Contractor shall apply appropriate electronic contact water level gauges for measuring water level in the wells. Measurements shall be made at predetermined intervals, depending on the nature of the test. Well head arrangement shall permit these gauges to be inserted.

Water level shall be measured to 5mm accuracy during test pumping by the Contractor by means of an electronic contact gauge (dipper). The frequency of measurement shall be as specified on the agreed test pumping data form, or one otherwise determined by GOAL.

Discharge shall be measured by volumetric methods or means of approved measuring device. During test pumping, discharged water shall be disposed-off sufficiently far from the well to prevent recharge.

**22. Water Quality Testing**

Water samples for testing the biological, physical, and chemical properties shall be taken at the end of the test pumping. The Contractor shall collect and store samples in approved containers. The Contractor shall be responsible for testing of the water quality in Government of Uganda approved water testing laboratories and as specified, furnish GOAL with the test certificate.

The following parameters should be tested on site using portable water quality testing meters. The results of these tests shall be included as part of the final borehole records for each well.

* **Electrical conductivity**
* **Temperature**
* **PH**
* **Turbidity**

After completion of test pumping the borehole, the Contractor will take one (01) liter samples in clean, properly sealable, sterilized plastic bottles for laboratory analysis. The samples will be used for physical and chemical analysis. The samples should reach the laboratory within 5 days from the time of collection. Specific parameters to be measured include

* **Physical Parameters – PH, Colour apparent (PtCo), Turbidity (NTU), Electrical Conductivity (µS/cm), TSS (mg/L)**
* **Chemical Parameters – Nitrate (mg/L NO3-), Total Hardness (mg/L), Fluoride (mg/L F), Chloride (mg/L Cl-), Sulphate (mg/LSO42-), Total Iron (mg/L Fe) Manganese (mg/L Mn), TDS (mg/L), Calcium (mg/L Ca2+), Magnesium (Mg/L Mg2+), Bicarbonate (mg/L CaCO3), Alkalinity (total mg/L CaCO3) and Total Phosphates (PO43- mg/L) and Nitrites mg/l, NO2-**

Before approval of water quality test results, GOAL shall verify with the management of the respective laboratories to own the test certificate issued. If the test results are denied/ disowned with adequate proof, GOAL shall discard such results and shall penalize the contractor in line with GOALs’ anti – fraud policy.

**23. Capping of well**

During well construction, installation, development and test pumping, the Contractor shall use industrial made well caps. The Contractor shall also use all reasonable measures to prevent entrance of foreign matter into the well. The Contractor shall be responsible for any objectionable materials that may fall into the well and any effect it may have on water quality or quantity until completion of the Works and acceptance by GOAL.

**24 Acceptance of well**

GOAL shall accept the well upon satisfactory completion of all drilling operations, installation of casings and screens, development works, pumping tests, presentation and approval of complete drilling reports and logs and provided the well yield is above minimum recommended values and water quality tests are suitable for potable water according to the GOU standards.

**25. Standby time**

In the event of delays occurring because of the action or inaction of GOAL, for which the Contractor would be entitled to claim Standby Time, the Contractor shall notify GOAL immediately in writing. A claim for Standby Time is only effective if all the Contractor’s plant, equipment, and personnel are on site, available for work and in a serviceable condition. Standby Time shall not exceed the standard working day as defined in the Contract Data, and any claim shall only be deemed to start at the date and time of a notice in writing to GOAL.

**26. Concrete apron/platform casting and hand pump installation**

Upon receipt of satisfactory water quality results and after being verified by GOAL, the Contractor shall cast a concrete slab on the wells according to these specifications

The Contractor shall construct concrete platform for each successful borehole carrying out the following activities in order:

Excavate square pit 760x760x400mm deep around casing pipe and remove all the topsoil all-round the square pit to a depth not exceeding 150mm and to a radius of 1 m from the pedestal and, level the ground to receive platform concrete. Also remove the topsoil to the depth not exceeding 200mm for all the area on which the well drainage channel will be constructed.

1. Place stand assembly (pedestal) over casing pipe, ensuring third leg (corresponding to the water tank spout pipe position) faces the proposed direction of the drain.
2. Making sure the pedestal is vertical, construct concrete in layers of 100mm up to top of legs.
3. Cover stand assembly with a cover plate and, level the ground around the pump pedestal.
4. Cast 50mm thick mass concrete bed, well compacted ready to receive well-aligned mild steel shuttering (Moulds). Place T10mm rebar eccentric to the channel thickness and A98 wire mesh fabric to the apron (refer to the drawings) and cast platform in mass concrete (mix 1:2:4/20mm agg.) conforming to the dimensions and other specifications shown in drawings.

Whenever very weak soils (subgrade) are encountered, this should be removed to a 75mm depth, a 50mm hardcore bed laid ready to receive 25mm thick r/f concrete bed (mix 1:2:4/20mm agg.) prior to placing of the steel mould.

1. Cure concrete for not less than 5 days and protect it from excessive sunshine and vandalism (using gunny bags, wet sand and thorny bushes, etc).
2. Plaster platform and drain in cement screed to a smooth finish, then engrave the borehole details provided by GOAL on the platform

**27. Hand pump equipment and installation**

The Contractor shall supply pipes and pump parts, to cast and install India Mark II Deep well Hand pump as per Bureau of Indian Standard Specifications IS-13056: 1991, Bureau of Indian Standard Specifications IS-13056: 1991 – Amendment 6, with 50mm dia. cast iron brass sleeved open top cylinder assembly with extractable plunger and foot valves assemblies or a similar specification according to Uganda standards. Where water is hard/salty the Contractor shall install the U2 modified hand pumps.

**28. Pump cylinders**

All wells with depths beyond 40m are to be installed with heavy duty extra deep well cylinders with 3 washer cups or valves. **GOAL must confirm the cylinder before installation.**

**29. Clearing the site**

Upon completion of works on a well site, the site must be left free from debris, hydrocarbons and waste, and all pits must be filled up. A site not delivered clean may render the well unacceptable.

**30. Records and reporting (See Appendix 4)**

The Contractor shall keep daily activity records for each borehole. The records shall contain the information as specified below. In addition, separate records should be supplied for each borehole upon completion.

**i) Daily Record**

\_ Site name

\_ Reference number of borehole

\_ GPS Co-ordinates of borehole (latitude / longitude)

\_ Date of reporting

\_ Names of foreman and drillers

\_ Method of drilling

\_ Make, model, type and size of drilling rig

\_ Diameter of hole, and depth of changes in diameter

\_ Depth of hole at start and end of shift or working day

\_ Depth and size of casing at start and end of shift or working day

\_ Description of strata drilled with depth of transitions encountered

\_ Depth at which water is struck

\_ Yield of air lifted water, when drilling or developing with air in litres per second.

\_ Time log showing rate of penetration in minutes per metre, type of bit, standby time due to breakdown.

\_ Depth intervals at which formation samples are taken

\_ Records of components and quantities used or added to the drilling fluid or air.

\_ Water level at the start of each working day

\_ Electrical conductivity measurements during test pumping

\_ Problems encountered during drilling

\_ Details of installations in the borehole (if any)

\_ Depth, size and description of well casing

\_ Depth, size and description of well screens

\_ Aquifer depth and SWL after completion of well

A copy of the Daily Record log shall be made available daily to the Supervisor, including any other pertinent data as may be requested by the Supervisor.

**ii) Borehole Completion Record**

\_ As per standard Borehole Completion Form.

\_ Detailed drillers geological log.

\_ Borehole design and installation details (as-built drawing)

**ii) Monthly Contract progress report**

The Contractor shall submit a monthly progress report detailing progress on the contract. The month report shall include the progress of projects successfully completed, problems encountered that are hindering progress and remedial recommendations to accelerate contract progress.

**iii) End of Contract Report.**

The Contractor shall prepare an end of Contract report, which should address at the minimum the following issues.

1. The selected sites

*(Suitability, accessibility)*

2. The drilling /test pumping methodologies

*(Type of drilling, designs used, test-pumping methods)*

3. Activity schedules and duration

*(Summarised diary of events and actual durations)*

4. Summary of results and analysis

*(Table showing locations, well numbers, depths, casing type and depths, drillers and test pumping yields, water quality and any other information necessary)*

5. Casing /screens received and used on the Contract (if any)

*(Table showing casings received, used, damaged and balances)*

6. Problems encountered

*(With accessibility, formations, equipment, and community, etc)*

7. Suggestion for improvement

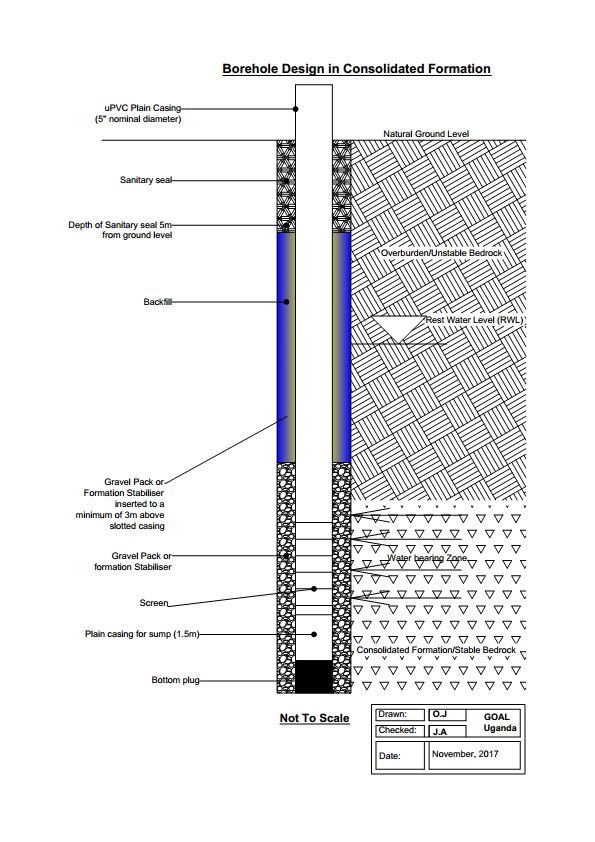
*(On supervision, documentation, durations, etc)*

8. Borehole Completion Records,

*(Original Drilling and test pumping logs bound separately from the report)*

9. Any other information that the Contractor may deem important or necessary. Two copies of the End of Contract Report (one without the Borehole Completion Records) shall be submitted to the Supervisor.

**31. Typical Schematic Drawing of Well Designs**

**Borehole design 1: Consolidated formations** 

**Schematic Drawing of Hand pump platform designs**

*(Refer to attachments at the appendix for drawings )*

**Appendix 4A: Technical specification - TOR for Geophysical Survey**

**1.0 Scope of Works**

The Contractor’s hydrogeologist will carry out a detailed geophysical analysis in the areas specified of assignment. These areas will be provided to the Contractor in batches of 10 villages depending on the assigned numbers. Please consult GOAL about the assigned villages.

A method of geophysical survey best suited to the geography/geology of the area is to be employed. The hydrogeologist should preferably discuss the methods they are to employ with GOAL before commencement of the works.

Representatives from the local community shall be involved in these activities and GOAL Uganda will assist with community liaison activities.

**The geophysical analysis will include four elements**

1. **Desk study**

The hydrogeologist should review existing reports, borehole logs, topographical, geological and hydro geological maps, previous geophysical surveys and the most current aerial photographs available. The consultant must state the sources of all this information and make them available in their reports.

1. **Hydro census**

The Contractor shall carry out a hydro census in the vicinity of the target areas. This includes a detailed inventory of all existing water supplies and data on well depths, yields, water quality, static water levels, etc. If the hydrogeologist requires any additional information that may be held by GOAL, they should request this this. The hydrogeologist will remain responsible for verifying and compiling all relevant information (both from GOAL and others) in order to compile a comprehensive study.

The following are additional features that can be compiled from the hydro census

* Identify details of water-related features (e.g. storm water channels, erosion gullies, weirs, diversion embankments), and disused or abandoned boreholes and wells.
* Identify features where water could collect in rainy periods (quarries, borrow pits, seasonal puddles, etc.).
* Identify potential sources of contamination (latrines, waste disposal sites, animal kraals, defecation sites, animal watering points, soak-away pits and drains, etc.).
* Identify visible features and symptoms (e.g. borehole casing rusted away at the surface, presence of algal blooms in stagnant water) that indicate the potential for water contamination.
* Identify water sources and, where possible, indicate the flow rate and the quality of each water source.

**It is important for the hydrogeologist to present to the GOAL technical team the results of their findings after the desk study and the hydro census but before commencement of the detailed geophysical surveys. Initial findings may inform the selection or inclusion of sites for more detailed studies.**

1. **Geophysical Survey and initial recommendations**

After the desk study and hydro census, the hydro geologist will use the findings to carry out the preliminary geophysical surveys and the detailed surveys.

1. **Final conclusions and Reports**

The hydrogeologist shall compile the final siting reports which will form part of the complete report for all the works.

**2.0 Inspection**

GOAL Uganda or their authorised representative has the right to witness the surveys and the Contractor or their hydrogeologist shall provide reasonable assistance to allow access as and when required by GOAL Uganda

**3.0 Clearance of Site after works**

Upon completion of the survey works, the Contractor’s hydrogeologist shall remove from the site all equipment, tools, surplus materials, rubbish and temporary works and shall leave the site clean and in a condition satisfactory to GOAL Uganda.

**4.0 Safety and Protection of Environment**

The Contractor or their hydrogeologist shall, through the contract period, be responsible for the safety of all persons entitled to be on the survey site and to keep the site in an orderly state to avoid any danger to such persons. The Contractor further undertakes to ensure that he will abide by safety procedures as set out by the government and regional authorities in conducting this work, and by implementing clean environmental procedures whilst conducting this work.

The number of locations given to the Contractor which will require the siting are included in the contract. At each location/geophysics survey site three possible borehole sites shall be indicated and rated/prioritised in order of preference, according to the survey results.

**5.0 Data Analysis**

Interpretation and evaluation of data arising from the desk study and hydro census is a critical early activity since preliminary conceptual models relating to the ground water systems within the project area will be based upon this information.

All data collected should be entered into a computer database and made available to GOAL during the survey period. It should form part of the appendices of the final report. The hydrogeologist should present their findings for each batch of complete preliminary surveys and final surveys.

**6.0 Geophysical methods**

Each geophysics survey should include (but not limited to) the following

* + - 3 x VES (Vertical Electrical Soundings)
    - 1km Resistivity Profiling
    - Interpretation of data
    - Verbal recommendations and marking of 3 sites

**7.0 Interpretation**

Results of the geophysical surveys should be recorded daily on completion of the field activities. Processing and interpretation of data should be carried out on site and the geophysicist will identify potential borehole sites. At each location (geophysics survey site) three possible borehole sites are to be indicated in the field with marking pegs cast in concrete and rated in order of preference according to the survey results. GPS coordinates for each of these sites will also be recorded.

**8.0 Reporting**

**The hydrogeologist should avoid the use of generic reports which do not have anything in common with the project. Technical reports should indicate a level of awareness and detailed study of the field areas. Copied or modified reports when encountered will be rejected together with the whole survey claimed.**

**Three stages of reporting shall be completed:**

* Inception reports summarising the findings of the desk study and the results of the hydro census. The report will provide 1:50,000 scale location maps which will show existing water points, aerial photographs, and topographical maps showing contours, drainage, and surface water bodies.
* Field reports which provide the results and interpretations of the geophysical surveys. Potential borehole sites shall be identified together with the target aquifer and recommendations for drilling, including method of drilling and borehole design. Sites will be ranked according to their respective groundwater potential. Three (3) sites shall be identified for each borehole location under investigation. A copy of the field report shall be provided for the community of each respective site. Field reports shall be submitted to GOAL Uganda field staff upon the completion of each survey to facilitate timely completion of drilling activities. Additionally, this information shall be presented in a briefing to the GOAL field staff.
* Final Report shall provide a detailed account of all project activities and include all of the archive, hydro census and geophysical survey results. Both soft and hard copies of the final report shall be handed to GOAL (GOAL Uganda).

**9.0 Equipment**

The Contractor shall provide all equipment (geophysical and otherwise) necessary to carry out geophysical surveys as described above in the technical specification. All equipment must be properly calibrated and in full working order. The suitability and appropriateness of the equipment shall be verified by GOAL Uganda prior to commencement of the work. **Appendix 4B: Technical specifications - TOR for Test Pumping**

**1. Introduction and Background**

GOAL is desirous that the Contractor performs Test Pumping of all wells in conformity with the procedures outlined here in the terms of reference. The output of the test pumping will form part of the drilling report presented at the end of the borehole drilling and construction works.

GOAL wants to know the actual yield of each well for future changes in pumping technology, if necessary, in order to serve bigger populations. Specifically, wells with higher yields may be motorised to bring water closer to distant communities. In this regard, we want to establish the actual yield of wells even greater than 2000lph.

**2. Scope of Works**

The Contractor, by accepting the terms of this contract with GOAL, accepts and understands that the primary purposes of conducting test pumping are as detailed below: -

1. To determine the reliable long-term yield (or ‘safe’ yield) of a borehole, and therefore whether the borehole can be regarded as a ‘success,’ and how many people it will be able to supply.
2. To assess the hydraulic performance of a borehole, usually in terms of its yield-drawdown characteristics thus how much drawdown it takes to yield a certain amount of water
3. To derive the hydraulic properties of the aquifer.
4. Pumping tests are the classic (and perhaps the only) way to derive *in situ* aquifer hydraulic properties, such as transmissivity and the storage coefficient, or to reveal the presence of any hydraulic boundaries.
5. To test the operation of the pumping and monitoring equipment, to make sure that everything is working safely and efficiently, and if applicable, to confirm that the Contractors have done their job properly.
6. To determine the effects of abstraction on neighboring abstractions (sometimes referred to as derogation).
7. To determine the environmental impact of the abstraction. All groundwater abstraction eventually has an impact; it is only a matter of where, when and whether the impact is acceptable.
8. To provide information on water quality. Is the water quality suitable for the intended use? Is it stable in the long term? Are there likely to be any problems such as drawing in saline or polluted water after extended periods of pumping?
9. To optimize operational pumping regimes (especially from multiple-borehole sources), including selecting the most suitable pumping plant for long-term use, and estimating probable pumping and/or treatment costs.
10. To help determine the correct depth at which the permanent pump should be installed in the borehole (the subjects of pump choice and installation are covered in other guidance documents).

**The Scope of the work will be to: -**

1. Carry out desk study on the drillers yields, borehole depths, well diameters and screen depths of the drilled boreholes
2. Perform Test pumping for all the drilled wells and the following tests will be conducted:

* A step test of at least 3 steps of a minimum duration of 1 hr for wells with a yield greater than 2.5m3/hr.
* Constant rate test for a minimum duration of 3 hrs.
* A recovery test of duration sufficient for water levels to return to the pre-constant rate test level.

1. Complete all forms related to test pumping as detailed by MWE guidelines.
2. Carry out interpretation of all the test pumping results according to the methodology described by MWE guidelines.
3. Present all findings in a comprehensive report, of which the contents must comply with the demands of this ToR. All field and raw data will also be made available to GOAL.

**3. Test Pumping Procedure and expected out put**

GOAL Uganda expects the Contractor to follow the laid down pump testing procedure in the TOR for coming up with the results that will form part of the Drilling report. The chart hereunder outlines the procedure and expected output of the test pumping.

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**4. Equipment for the Test Pumping**

The Contractor shall provide the following equipment to conduct the test pumping detailed in these Terms of Reference:

1. An appropriately sized pump fitted with a non-return valve (NRV) to be able to conduct the recovery test, as detailed in section 2,
2. A rising main fit for the purpose of conducting these tests, i.e., without any leaks,
3. Adequate pipework to ensure that discharge from the well achieves a minimum distance of 100m from the well and that the risk of recharge to the aquifer/well is minimised for the duration of the tests,
4. The power generating capacity and necessary fuel to run the pumping equipment,
5. Means to accurately control the yield of the pump by either inducing extra pumping head by valve or varying the frequency of electrical supply to the pump, should the pump be compatible with this technology,
6. An accurate and well calibrated means of measuring flow from the well. Note that any device such as a V-Notch weir used for measuring flow MUST be calibrated on site using the ‘stopwatch and container’ method,
7. An accurate means with which to measure water levels in the well throughout the duration of the test. Note that if a dipper meter is used then it should be of a type with sensitivity adjustment to avoid erroneous errors caused by ‘cascading fractures and any pumping induced turbulence in the well,
8. An accurate means to measure time, e.g. stopwatch,
9. A conductivity, temperature, and pH meter (combination or individual), calibrated prior to each of the tests that will be used for (step and constant rate test),
10. A means to measure turbidity, either manual or electronic,
11. A camera for taking pictures of the site, related installations and any observed water quality issues, e.g. high turbidity and/or sand content,
12. Copies of the field data forms provided in this document and additional note paper for unforeseen needs,
13. Sets of graph paper, both linear/logarithmic and linear/linear, for the plotting of field curves to verify data and make some field calculations for better conducting other tests.

**As stated in section 4, the consultant will provide details of all the above equipment in the final report.**

**5. Objectives**

**The Desk-based Study**

The desk-based study will include collecting the following information:

1. All drilling and construction details of the borehole(s)/wells(s) to be tested
2. Gathering of information on static water levels, water quality information, well depth, well diameter, height of measurement point above ground level.
3. Gathering of information related to the basic geology and hydrogeology of the area. If a previous geophysical survey is available from the site, then the consultant must mention these and, if possible, present the findings in the final report,
4. Ascertain if there are any surface water features in the study area which might reasonably be expected to have an interaction with the aquifer and could be affected by a pumping test,
5. Conduct a risk-based assessment of the validity of these tests in terms of seasonal factors that might affect the performance of the aquifer and/or the well at other times of the year from that during which the tests are conducted.

**6. The Step Test**

**Introduction**

The Contractor will understand that the purpose of conducting a step test is to establish the short-term relationship between yield and drawdown for the well/borehole being tested. This is achieved by measuring drawdown at a range of yields. The following can reasonably be expected to be determined from the test:

1. The performance of the well, i.e. the relationship between drawdown and yield for a range of flows even when that flow might not have been achieved during the test,
2. The linear well losses, or B factor, and non-linear well losses, or C factor, for the well according to the relationship[[1]](#footnote-1);

Where, sw is the drawdown in the well (m), Q has the dimensions [L3/T], B has the dimensions [T/L2] and C has the dimensions [T2/L5].

And the following equation relationship should yield a straight line[[2]](#footnote-2);

Where Q/sw is termed the specific drawdown and has dimensions [L/L3/T]

1. The maximum safe yield of the well, often taken to be the yield (and associated drawdown) where linear well losses (BQ) by themselves account for at least 50% of the drawdown
2. The safe yield of the well, often taken to be 80-90% of the maximum safe yield.

**Note: Information obtained from the step test will be critical in the proper design of the constant rate test. For example, yield can decline during a constant rate test as drawdown deepens and pumping head increases – data from the step test can help the hydro geologist to ensure that the correct adjustment are made at the appropriate time during the constant rate test.**

**A period of at least 24 hours must be given between the Test pumping and the completion of drilling.**

The Contractor will ensure the following:

1. The datum for all water level measurements must be chosen and adhered to for the duration of this test and all others conducted subsequently and this point must be reported,
2. The test shall comprise three steps with yields set using the following calculation.

**Q1 = Qdes/3, Q2 = Qdes/2, Q3 = Qdes**

Where, Qdes is the design yield, estimated from the constant test and allowing for a safety factor that will ensure that the last step is not beyond the capacity of the well and the depth of installation of the pump, i.e. that the PWL*[[3]](#footnote-3)* should not arrive at the level of the pump,

1. Each step will continue for a minimum duration of 60 minutes,
2. Multiple and accurate flow measurements shall be made throughout the duration of the test and especially immediately after the change in yield from one step to another,
3. The interval of measurement for the water level in the well (PWL) during each step adheres to the MWE recommendation set forth on the test pumping data recording sheets.

Every 30 seconds for the first 10 minutes,

Every minute up until 30 minutes, and then

Every 5 minutes up until 120 minutes.

1. Ideally the drawdown should stabilise - reach a ‘steady’ or ‘quasi-steady state’ - before the end of each step. If this is not the case, then the consultant understands that the method of interpretation of the data differs from that of a standard ‘steady-state’ analysis and must present this in the final report.

**7. Constant rate test**

**Introduction**

The Contractor shall carry out constant-rate test for all the drilled boreholes. Here the well is to be pumped at a constant rate for 3 hrs. The water levels and pumping rates are monitored simultaneously. The same equipment used for step test shall be used.

**Constant-rate test procedure**

Assuming that all the equipment is ready, and people have been assigned their tasks, the procedure for conducting a constant-rate test is as follows:

1. Choose a suitable local datum (such as the top of the casing) from which all water-level readings will be taken and measure the rest-water level. The water level must be at rest before the start of the test, so the test should not be conducted on a day when the borehole is being drilled or developed, or when the step test is taking place.
2. Open the valve to the appropriate setting and switch the pump on, starting the stopwatch at the same time. Do not keep changing the valve setting to achieve a particular pumping rate (a round number in liters per minute, for example). Rather, aim for an approximate rate and measure the actual rate.
3. Measure the water level in the borehole every 30 seconds for the first 10 minutes, then every minute until 30 minutes have elapsed, then every 5 minutes until 2 hours have elapsed. After 2 hours, observe how quickly the water level is still falling, and decide an appropriate frequency for water-level readings until the end of the test. If the water level is falling very slowly, then a reading every 30 minutes or even every hour may be sufficient. If the test is to continue for several days, review the measurement frequency depending on the behaviour of the water level. If you miss the planned time for a water-level reading, write down the actual time the reading was taken. Record all the readings on the standard form recommended by MWE.
4. Measure the pumping rate soon after the start of the test, and then at intervals during the test (every 15 minutes would be reasonable for the first few hours, then decide a suitable frequency for the remainder of the test). If there is a noticeable change in the rate of increase of drawdown, or if the pump sounds different, then measure the pumping rate at those times as well. If the pumping rate changes significantly (say by more than 10%), then adjust the valve setting to maintain as steady a pumping rate as possible throughout the test but be careful not to over-adjust and make the problem worse.
5. At the end of the test, switch the pump off, note the time (or restart the stopwatch), and immediately start measuring the water level recovery.

**8. The Recovery Test**

**Introduction**

The recovery test for the wells must be done and the results presented together with the test pump results. The purpose and benefits of conducting a recovery test is outlined below:

1. They provide a means to verify results from the constant rate test,
2. The absence of variations in pumping rate that might occur during the constant rate test led to smoother graphing of residual drawdown[[4]](#footnote-4) data,
3. They can help GOALs’ supervisor propose a future pumping regime.
4. Water levels in the well can be easier to measure during this type of test due to the absence of cascading fractures and/or pump induced turbulence in the well,

**The Recovery Test Procedure**

The following procedure shall be followed for the recovery test:

1. The pump shall be provided and installed by the Contractor and ensure that a non-return valve (NRV) has been fitted immediately above the pump to prevent backflow of Water in case of pump failure.
2. This test MUST be started immediately after the constant rate test described above and not after any other pumping event at the site,
3. Water level measurement intervals will be the same as for the constant rate test, detailed in MWE well recovery data monitoring tool.
4. Data will be recorded on the form developed or recommended by MWE

**9. Analysis and Interpretation and reporting**

The analysis and interpretation of the test pumping results will be done by analysing the time taken for the well water level to recover to its original level before test pumping. For wells that do not recover more than 50% of their original static water level in a period of one hour such wells will be deemed unsuccessful. The Contractor will be expected to produce accurately measured raw field data in the final report and this is the basis for consideration of successful execution of the contracted works.

The Contractor’s final report will indicate the actual yield of the well for all wells

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| --- | --- | --- | --- |
| Signed: |  | | |
| Print name: |  | Position: |  |
| Company Name: |  | Date: |  |
| Address: |  | | |

1. After Jacob (1946), note that some hydrogeologists consider that the quadratic relationship in this equation is too simplistic and that CQ2 should be replaced by CQn, where n is >1. However, the quadratic relationship often serves as a good enough relationship. [↑](#footnote-ref-1)
2. Often termed the Hantush-Bierschenk plot. [↑](#footnote-ref-2)
3. PWL = pumping water level [↑](#footnote-ref-3)
4. [↑](#footnote-ref-4)