

A. *General Technical Specifications*

1. General

1.1. Technical Definitions

The following definitions shall apply:

- a) Borehole – means any drilled section or boring before completion of a well as defined below.
- b) Casing – means unslotted or non-perforated lining tubes.
- c) Development equipment – means high velocity jetting tool, airlift equipment, surge plunger and all other equipment needed to restore the soil formation to its nearest natural condition that was damaged during the drilling process and improve the hydraulic properties of a well.
- d) Diameters – means nominal diameters unless otherwise stated.
- e) Drilling Rig – means the drilling equipment and the auxiliary equipment for its operation.
- f) Drilling Unit – as defined in Section A.2.2.
- g) Final Well Design – means the drawing and description prepared by the Engineer upon completion of drilling specifying the final well construction.
- h) Lining Materials – means any casing, screen, slotted lining or perforated lining tube whether permanently or temporarily installed in the borehole.
- i) Pumping Unit – as defined in Section A.8.7.
- j) Screens – means continuous wedge wire wound stainless steel screens, slotted or perforated lining tube.
- k) Preliminary/Tentative Well Design – means the Contract Drawing showing the estimated quantities of the work.
- l) Well – means any completed hole in which all lining material has been set, all grouting completed and all temporary lining removed.

1.2. Technical Standards

All materials or workmanship shall comply with the Specifications. Other standards equal or superior to those numerated in this Specifications, shall be acceptable, subject to the approval of the Engineer. The opinion of the Engineer must be obtained prior to utilizing such materials or workmanship on or off the site.

1.3. Water Supply and Illumination

- 1) In the absence of adequate quantities of water or illumination required for drilling at the drilling site, the Contractor shall make such arrangements including the provision for mobile tanks or fixed tanks as may be necessary to ensure a supply of water and illumination sufficient for drilling operations.
- 2) The contractor shall make such arrangements as may be necessary to illuminate all temporary working areas.

1.4. Electrical Power Supply

- 1) The Contractor will make arrangements as may be necessary for the connection of or supply of power to the site.

- 2) Payment for the provision of electrical power supplies as specified in Section A.1.4.1 shall be deemed to be included in the rates entered in the Bill of Quantities for setting up equipment at the site, drilling rates and rates entered for operation of pumping unit.

1.5. Storage of Inflammable Fuels

The Contractor shall comply with all local authority regulations applicable to the use and storage of diesel oils, gasoline, and other inflammable fuels they use on the site, and shall ensure that adequate precautions are taken against fire.

1.6. Boundaries of Work

The Procuring Entity shall provide land or rights-of-way for the work specified in this Contract and make suitable provisions for ingress and egress. The Contractor shall not enter or occupy with men, tools, equipment or material, any ground outside the property of the Procuring Entity without the written consent of the Procuring Entity. The Procuring Entity may, for all necessary purposes, enter upon the work premises used by the Contractor, and the Contractor shall conduct their work so as not to impede unnecessarily any work being done by others on or adjacent to the site.

1.7. Access Road

Construction or improvement of access roads to the well site shall, unless otherwise agreed, be done by the Contractor at their own cost, which is deemed to be included in the contract sum. The access road shall be kept in proper condition during the entire construction period.

1.8. Protection of Site

- 1) Except as otherwise provided herein, the Contractor shall protect all structures, walkways, pipelines, trees, shrubberies, lawns, etc., during the progress of their work, shall remove from the site all drill cuttings, debris, and unused materials, and shall upon the completion of the work restore the site as nearly as possible to its original condition, including removal of access tracks and the replacement, at the Contractor's sole expense, of any facility or landscaping which has been damaged beyond restoration to its original condition, all to the satisfaction of the Engineer.
- 2) Water pumped from the well shall be conducted to a place approved by the Engineer where it will be possible to dispose the water without damage to property or creation of a nuisance.

1.9. Site to be kept Tidy

The Contractor shall at all times keep the site and all working areas in a tidy and workmanship condition and free from rubbish and waste materials.

1.10. Temporary Buildings for Use by Contractor

The Contractor shall provide at the site the works such temporary buildings, tanks, workshops, etc. as may be necessary and proper for their general use in connection with the works, and for the use of persons employed by them. The nature of the buildings, tanks, etc. and the positioning of them shall be subject to the prior approval of the Engineer and the relevant authorities.

1.11. Shop Drawings

- 1) The Contractor shall if requested by the Engineer prior to start of each operation, produce for the Engineer's approval shop drawings showing details of technical

operations such as test of plumbness and alignment, the method of the slotted casing production, if so required, the methods of placement of formation stabilizer and/or cement grout, the arrangement for well testing, the method for well development and all other drawings pertinent to the well drilling, well construction operations and well development as requested by the Engineer.

- 2) Shop drawings shall be completed with respect to dimensions, design criteria, materials, methods of constructions and the like to enable the Engineer to review the information as required.

1.12. Well Head Protection

- 1) At all times the progress of the work, the Contractor shall protect the well in such manner as to effectively prevent either tampering with the well or the entrance of foreign matter into it, and upon its completion they shall provide and install a well head cap, satisfactory to the Engineer.
- 2) In the event that the well becomes contaminated or that water having undesirable physical or chemical characteristics has entered the well due to the negligence of the Contractor, they shall at their own expense perform such work or supply casings, seals, sterilizing agents or other materials as may be necessary to eliminate the contamination or to exclude any undesirable water in the well.

1.13. Transport of Personnel and Equipment

- 1) The Contractor shall supply and operate all transport required for transporting his/her employees, materials and equipment.
- 2) The cost of movement of personnel, materials and equipment shall be included in the rates given for drilling, development and pump operation.

1.14. Site Preparation and Reinstatement

- 1) The Contractor shall prepare the site, provide all necessary tanks and pits and make all necessary arrangements for erecting and dismantling the drilling unit and shall reinstate the site on completion of such phase of work to the satisfaction of the Engineer.
- 2) Payment shall be deemed to be included in the items entered in the Bill of Quantities for erection and dismantling of drilling rigs.

1.15. Standby Charge

Standby Charge will be paid only when drilling is suspended on the written instruction of the Engineer beyond ten (10) cumulative calendar days and for reasons not attributable to the Contractor.

2. Well Drilling

2.1. Scope

- 1) The Contractor shall provide and operate one (1) Rotary Drilling Rig required to complete the works within the contract period.
- 2) The Contractor shall provide all auxiliary equipment, lubricants, fuels and spares necessary to keep the Rotary Drilling Rig in continuous operation.

2.2. Equipment

- 1) The rotary drilling rig together with all auxiliary equipment and personnel shall be defined as the Drilling Unit.
- 2) The rotary drilling rig shall have sufficient capacity to drill the specified borehole in the diameter specified in the tentative well design to a depth which on the minimum is 25% higher than indicated in the Contract Drawings.
- 3) Payment for drilling will be by the linear meter of borehole as measured after removal of drill string. The rates set against drilling items in the Bill of Quantities shall be deemed to include all equipment, personnel, fuels and lubricants and the accessories required for operation of the Drilling Unit.
- 4) When the Rotary Drilling Unit is being used for a purpose other than drilling, then the rates for that purpose entered in the Bill of Quantities shall be deemed to include the running costs of the Drilling Unit.

2.3. Drilling Method

- 1) All drilling shall, unless otherwise specified in the Special Technical Conditions, be performed with the **Rotary Drilling Method**.
- 2) The Contractor shall drill the hole to such depth and with such a diameter which shall enable an easy installation of casing and screen and placement of gravel envelope with a uniform thickness as specified, if required. During drilling of the hole, the Contractor shall ensure that the natural permeability of the yielding strata near the well bore is not irreversibly reduced due to the drilling method employed.

2.4. Strata Sampling

- 1) Strata samples shall be taken at 1 meter intervals or more frequent if the formation penetrated changes. Samples shall be placed in plastic or other appropriate bags on which or in which the sampling depth and the date of sampling is written in such a manner that it is permanently readable.
- 2) The sampling procedure must provide that all the fractions of the penetrated strata are present in the sample.
- 3) Each sample shall be placed in a wooden box with space for storage of one sample and the sampling depth shall be written on the box.
- 4) A record of samples taken with the details described above shall be submitted to the Engineer every day.
- 5) Payment for sampling shall be deemed to be included in the rates entered for drilling in the Bill of Quantities...
- 6) The failure on the part of the Contractor to obtain, preserve and deliver samples or records, satisfactory to the Engineer, shall be considered as actual damage to the Procuring Entity. In the event that, in the opinion of the Engineer, the failure of the Contractor to take and preserve the samples may affect the proper design of the well, the Contractor may be required to perform such work as the Engineer deems necessary to remedy such failure at no cost to the Procuring Entity.

2.5. Drilling Mud

1. Bentonite shall be used and shall be the basis for the priced offer.
2. The bentonite shall be of premium quality in accordance with API Standard 13A (ISO Standard 13500:2009) with 150 kg/cum of make-up water yielding a mud

with a viscosity of between 35 and 40 seconds using a Marsh Funnel Viscosimeter and a mud weight of not less than 1.10 kg/l (9.2 lb/US gal).

3. Make-up water shall be treated with caustic soda (soda ash) to maintain the pH between 8.0 and 9.0 prior to mixing of mud.
4. During drilling with mud the Contractor shall perform hourly or per meter (as directed by the Engineer) measurements of the following mud characteristics:
 - pH value
 - Specific Gravity
 - Sand content
 - Filtration loss
 - Filter cake thickness
 - Funnel viscosity

The recorded mud characteristics shall not exceed the following values, without the prior approval of the Engineer:

- Specific Gravity	:	(1142 kg/m ³ (9.5 lb/gal)
- Sand content	:	4%
- Filtration loss	:	10 ml
- Filter cake	:	1.5 mm

2.6. Working Hours

All major drilling activities, such as pilot hole drilling, reaming of pilot, installation of casings, screens and gravel, and continuous constant discharge pumping test shall, be on a round the clock basis.

3. Geophysical Logging

3.1. Scope

The Contractor shall, if specified in the Special Technical Conditions, perform geophysical logging as specified in the Special Technical Conditions.

3.2. Equipment

- 1) The geophysical logs may be recorded either by automatic recording on a chart strip or by manual reading of recorded values. In case the logs are recorded by the manual method, readings shall be taken per meter of borehole length.
- 2) The recorded logs shall be submitted to the Engineer immediately upon completion of logging as plots of recorded characteristics versus depth for his/her approval. In case of disapproval by the Engineer, the logs shall be repeated immediately.

3.3. Logs

Geophysical logging shall, unless otherwise specified in the Special Technical Conditions, comprise the following logs:

Resistivity log (short normal and long normal)
Self-potential log (SP)

4. Well Casing

4.1. Scope

The Contractor shall provide and install the well casing specified in the Contract Drawings and any temporary casing required during the work, unless otherwise specified in the Special Technical Conditions.

4.2. Casing Material

- 1) The Contractor shall, before commencement of work, submit for the approval of the Engineer the following details of all casing:
 - a. Type of material
 - b. Internal and external diameters
 - c. Wall thickness
 - d. Method of jointing
 - e. Name of Manufacturer
 - f. Standard the pipe is manufactured to
- 2) All permanent casing material shall be spiral welded and of a new stock unless otherwise specified in these documents.
- 3) The Contractor shall assume responsibility for any casing failure and shall correct, as approved by the Engineer, any casing failure at no cost to the Procuring Entity. In the event that the Contractor cannot correct a casing failure the Contractor shall replace the casing with material complying with the Specifications, or if necessary, better casing as approved by the Engineer at no extra cost for the Procuring Entity.

4.3. Temporary Casing

The Contractor shall provide such temporary casing as may be necessary to well to be sunk to the specified depth and to allow the insertion of permanent lining material as required. The Contractor shall remove the temporary casing before completing the well, unless otherwise specified in these documents.

4.4. Lining Installation

- 1) Lining material shall be assembled and located in the well at the required depth in a continuous operation. The lining material shall be set concentric within the borehole by centralizing guides unless otherwise agreed with the Engineer.
- 2) If the lining jams or is lost before it is set to the specified depth, the Contractor shall endeavor to remove the lining material from the well or, if unable to effect removal, shall redrill the well and replace the lining material at their own expense.

4.5. Lining Material Accessories

- 1) The Contractor shall provide as necessary the following accessories to set the lining material to the required depth:
 - a. Centralizers to be affixed to the lining material, if necessary, at intervals specified by the Engineer, to locate the lining material in the center of the drill hole;
 - b. Supporting clamps, equipment and tools;
 - c. Reducing cones and connecting pieces;
 - d. Tuck-welded bottom plate at the end of the sump pipe;
 - e. Casing hangers; and
 - f. All other necessary equipment.

- 2) Except where expressly provided, all accessories shall be deemed to be included in the Bill of Quantities for the provision and insertion of lining material.

4.6. Testing for Plumbness and Alignment

- 1) All boreholes shall be constructed, plumb and true to line as defined herein. To demonstrate the compliance of their work with this requirement, the Contractor shall furnish all labor, tools and equipment and shall provide the detailed drawings and the description of the tests to the satisfaction of the Engineer.
- 2) Tests for plumbness and alignment must be made after the complete construction of the well and before its acceptance. Additional tests, however, may be made by the Contractor during the performance of the work. No specific payments shall be made for making these tests.
- 3) Should the results for plumbness and alignment show that the plumb bob or dummy fails to move freely throughout the length of the lining or borehole to a depth of the lowest anticipated pump setting and should the well vary from the vertical in excess of two-thirds of the smallest inside diameter of that part of the well being tested or beyond the limitations of this test, the plumbness and alignment of the well shall be corrected by the Contractor at their own expense. Should the Contractor fail to correct such faulty alignment or plumbness, the Engineer may refuse to accept the well and the Contractor shall drill a new well without charge to Procuring Entity.

5. Well Screens

5.1. Scope

The Contractor shall provide and install the well screens specified in the Contract Drawings, unless otherwise specified in the Special Technical Conditions.

5.2. Type of Screens

- 1) The type of screens shall be as specified in the tentative well design and the Special Technical Conditions.
- 2) Slotted screens, if specified for installation, shall be so fabricated as to ensure the maximum yield of the well and to prevent clogging and encrustation and shall be free from jagged edges and irregularities that may accelerate clogging or corrosion.

5.3. Responsibility for Malfunction

- 1) The Contractor shall assume full responsibility for any malfunction of the screen caused by inadequate installation procedure and shall undertake any correction as approved by the Engineer at no extra cost to the Procuring Entity.
- 2) The screen must have no change of alignment at any of its joints after installation. If requested by the Engineer, the Contractor shall submit for approval by the Engineer the design and method of construction and installation of the screen.
- 3) In the event that the Contractor cannot correct a screen failure, the Contractor shall replace the screen with material complying with the specifications of this Contract at no extra cost to the Procuring Entity.

5.4. Screen Strength

The screen shall have adequate strength to resist the external forces that may be applied during and after installation.

5.5. Screen Accessories

All fittings, packers, couplings, joints, plugs and seals used during installation of well screen together with the installation procedure, shall be to the approval of the Engineer.

6. Formation Stabilizer/Gravel Pack

6.1. Scope

The Contractor shall provide and install formation stabilizer, or gravel pack if specified in the Contract Drawings and the Special Technical Conditions.

6.2. Material

- 1) The formation stabilizer/gravel pack material shall consist of well rounded, water-worn siliceous grains. Angular chipping or road stone must under no circumstances be used as formation stabilizer/gravel pack material.
- 2) The Contractor shall, during the mobilization period, submit to the Engineer for his/her approval, samples of the formation stabilizer they propose to use, stating the source of the formation stabilizer, quantities available, rate of delivery and any other information requested by the Engineer.

6.3. Method of Installation

- 1) The method of placing the formation stabilizer/gravel pack in the annulus shall be such that separation of the gravel and bridging is avoided.
- 2) The formation stabilizer/gravel pack shall immediately upon completion of lining installation, be placed in the annulus between the borehole and the lining, in the screened section(s) of the lining, as specified in the Final Well Design.
- 3) If the borehole was drilled by the rotary method, installation of formation stabilizer/gravel pack shall be done by circulation of the drilling mud with fluid marsh funnel viscosity not exceeding 30 seconds. The rate of circulation should be slow enough to prevent the segregation of bigger particles from smaller particles.

a. Monitoring of Formation Stabilizer/Gravel Level

The level of the formation stabilizer/gravel pack shall be monitored and maintained during the progress of development activities as specified in Section A.7. Additional quantities of formation stabilizer/gravel pack shall be installed to maintain the level as specified in the Final Well Design. The cost of additional formation stabilizer/gravel pack shall be deemed included in the rates entered for the item, furnishing and installation of gravel pack materials, in the Bill of Quantities.

b. Gravel Fill-up Pipe

The gravel fill-up pipe shall be 50 mm diameter galvanized iron (GI) pipe fitted with a screw cap at one end and open at the other end. It shall be placed on top of the gravel pack and below the clay seal. It shall be installed after all the development activities are completed and before the clay seal is installed as specified in A.9.5. The cost of installing the gravel fill-up pipe shall be deemed included in the rates specified in the item installation of formation stabilizer/gravel pack in the Bill of Quantities.

7. Well Development

7.1. Scope

- 1) The Contractor shall furnish compressors, surge plungers, jetting tools, electric generators, chemicals and any other equipment required for satisfactory well development and shall undertake the development as directed by the Engineer.
- 2) Development shall, if the rotary method is applied, comprise of mud thinning/deflocculation, high velocity jetting along the continuous slot screens, surging with plunger in slotted screens and development by airlifting, unless otherwise specified in the Special Technical Conditions.

7.2. Expected Yield

The Contractor shall develop the well to its maximum expected yield, as specified in the Special Technical Conditions, by the methods specified in Section B.7.2.

7.3. Deflocculation

- 1) Upon completion of installation of lining or formation stabilizer/gravel pack, the drilling mud shall immediately be displaced from the well by pumping clean water into the sump pipe.
- 2) Mud displacement shall immediately be followed by injection and/or jetting through the screened sections with a mud thinner to deflocculate the mud cake on the borehole wall. The well shall then be left for 12-24 hours before developing is continued, to allow the mud thinner to react.

a. High Velocity Jetting

- 1) After the deflocculation material has been allowed to work for 12-24 hours all screened/slotted/perforated sections shall be developed by high velocity jetting.
- 2) The jetting tool shall be equipped with two or four nozzles. The nozzle design shall be such that it produces a concentrated jetting action. The tool shall be presented to the Engineer for approval before start of drilling operation.
- 3) The jetting tool shall be supplied with water through a high-pressure pump capable of producing a nozzle velocity of 50-70 m per second. The pump shall be equipped with a suitable pressure gauge on the discharge side to facilitate monitoring of nozzle velocity.
- 4) The development shall be carried out by slowly rotating the jetting tool and gradually lowering it in order to cover the entire surface of the screen.
- 5) At the same time as the high velocity jetting is performed, the well shall be discharged with a discharge rate slightly higher than the discharge rate from the jetting tool.
- 6) Each section of the screen shall be jetted until the return water is free from drilling mud, but no section shall be jetted less than 20 minutes per meter of screen.

b. Surging with Plunger

- 1) After development by high velocity jetting is completed, the Contractor shall develop the well by mechanical surging with surge plunger approved by the Engineer.
- 2) Before the start of surging the depth of the well bottom and the top of gravel pack shall be recorded.

- 3) Surging shall be done along the blank portions of the well, starting at the topmost section proceeding downward until the lowest blank casing before the sump pipe.
- 4) The length of time per surging interval shall be as directed by the Engineer.
- 5) The level of sediments deposited inside of the well at the end of every surging interval shall be measured and recorded before it is bailed out.
- 6) Surging shall be continued until accumulation of sediments in the sump pipe, during any surging operation, is negligible.
- 7) The length of development time is the total time consumed in the surging. Payment for the bailing out of sediments shall be deemed included in the rates entered for in the item development by surging including bailing out of sediments in the Bill of Quantities.

7.6 Development by Airlifting

- 1) The compressor used for development by airlifting shall be capable of developing a minimum pressure enough to counteract the hydrostatic head equal to depth of the well. The delivery shall be no less than 21.25 cum air per minute.
- 2) The quantity of water discharged from the well and the drawdown in the well at the commencement of the development shall be limited and shall be gradually increased only as the water clears. From time to time the air flow shall be stopped to facilitate loosening of trapped sand grains. The well may also be backwashed by pumping clean water in to the well.
- 3) During the airlifting operation, position of air pipe and conductor pipe, drawdown in well, approximate yield and time for each change in position shall be recorded by the Contractor.
- 4) The development shall be completed with a conductor pipe not more than 0.5 m above the bottom of the well to ensure that all sand has been cleaned out of the sump pipe.

7.7 Well Cleaning

Upon completion of the development operations, the Contractor shall demonstrate to the satisfaction of the Engineer that the bottom of the well is clear of all sand, mud and other foreign materials.

7.8. Freedom from Sand

- 1) The Contractor shall develop the well by the methods specified until the water pumped from the well is substantially free from sand and until the turbidity is less than 5 nephelometric turbidity units (NTU).
- 2) The water pumped from the well shall not contain fine material in excess of 1.0 mg per liter when the well is pumped at its maximum yield. The equipment for measurement of the sand content shall be furnished by the Contractor.

7.9. Acceptance of Development

- 1) The development by the specified methods shall be repeated and continued until the well is thoroughly developed in accordance with the criteria specified in Section A.7.8.
- 2) If the well yield after the well has been confirmed sand-free is still below the yield that is considered acceptable for the penetrated aquifer, then the Engineer may instruct the Contractor to perform further development.

8. Well Testing

8.1. Scope

The Contractor shall, unless otherwise specified in the Special Technical Conditions, provide and operate a Pumping Unit for the following purposes:

- 1) Step-drawdown pumping tests on the completed well
- 2) Continuous discharge pumping test on the completed well.

8.2. Equipment Capacity

- 1) The Contractor shall provide and operate pumping machinery capable of carrying out the specified pumping and shall provide adequate controls to allow discharge rates to be kept constant at varying pumping water levels and to permit pumping with a variation of not more than 5% of the designated discharge rate during any period of yield or aquifer testing.
- 2) The Pumping Unit set shall be able to deliver a discharge rate that is 50% higher than the expected yield of the well and a minimum discharge that is 15% of the expected yield of the well when suitably controlled by use of a gate valve.
- 3) Suitable pumping machinery will be deemed to be:
 - i. Submersible motor (electric) and pump unit together with generator and such accessories needed to run the pump.
 - ii. Line-shaft pump and internal combustion prime mover together with all accessories needed to run the pump.

8.3. Equipment Operation

- 1) The Contractor shall supply and operate all equipment and accessories necessary for installation and removal of pumps.
- 2) The Contractor shall maintain on site sufficient fuels, lubricants, spares and other accessories needed to run the Pumping unit for whatever period may be specified by the Engineer.
- 3) The Contractor shall provide sufficient competent personnel including a qualified fitter and electrician, as may be necessary to install and operate the Pumping Unit.

8.4. Control of Discharge Rate

The Contractor shall, during the pumping tests, provide a suitable gate valve on the discharge pipeline, to facilitate easy control of the discharge rate. Discharge shall be controlled with a valve. An additional measuring device (e.g. oil drum and stopwatch) shall be provided for back up and checking. Drawdown and recovery of the water level is to be monitored with a water level indicator at intervals specified by the Engineer on the site. The Engineer may demand water quality measurements. Monitoring forms shall be provided by the Engineer.

8.5. Water Level Sounding Pipe

- 1) The Contractor shall, if instructed by the Engineer, provide and install a temporary tube of at least 25 mm diameter from the top of the well to 2 meters above the pump bowl assembly to facilitate easy measurements of water level. The tube shall be open only at the bottom and top.
- 2) Payment for providing, installing and removing the tube shall be deemed to be included in the rates given for pumping tests.

8.6. Discharge Rate Monitoring

Discharge rates of up to 10 liters per second (36 cubic meters per hour) may be measured by drum filling (volumetric method). Discharge rates in excess of 10 liters per second shall be recorded with a production meter or by a V-notch (or rectangular) weir or discharge pipe fitted with orifice plate and piezometer tube. All items are subject to the Engineer's approval before start of drilling.

8.7. Definition of "Pumping Unit"

The equipment specified in Section A.8.2 – A.8.6 is referred to as the Pumping Unit.

8.8. Pumping Procedure

The Engineer will determine the pumping procedure necessary to obtain the objectives of this Contract.

8.9. Suspension of Pumping

If the Engineer finds the condition of any equipment, personnel, fuel, lubricants or accessories will prejudice the quality of data obtained from any pumping test, he may suspend the work in accordance with the provisions of the Conditions of the Contract.

8.10. Equipment Breakdown During Pumping

- 1) The pumping must be continuous and at a constant rate during the pumping tests. The Engineer will instruct the Contractor as to the expected maximum duration of each pumping test before start of each test.
- 2) If pumping is interrupted or the discharge rate fluctuates by more than 5% of the designated discharge rate, the test may be repeated after a period of recovery determined by the Engineer.
- 3) If any pumping test is interrupted because of equipment breakdown or inadequate supervision or discharge control, no payment will be made for any pumping period.

8.11. Duration of Tests

- 1) The step-drawdown pumping tests shall be performed on 5 steps with the duration of 1 hour each step.
- 2) The continuous constant discharge pumping test shall be performed for a period of 3-5 days, unless otherwise specified in the Special Technical Conditions or unless otherwise instructed by the Engineer.

8.12. Temporary Pipeline

- 1) The Contractor shall provide a temporary pipeline as directed by the Engineer for the discharge from pumping tests to a suitable watercourse or drain.
- 2) Under certain circumstances when re-infiltration cannot be avoided or it is costly to provide for this condition, the Engineer shall decide to what distance from the well, water may be discharged on the ground.

9. Cement Grouting

9.1. Scope

The Contractor shall, unless otherwise specified in the Special Technical Conditions, provide the cement and mixing equipment required for the mixing of the grouting indicated in the Tentative Well Design and shall place the cement grout, on top a clay seal, as specified.

9.2. Grouting Material

- 1) Cement grout shall consist of Portland cement and clean water, mixed in the proportion of 50 kg of Portland cement to maximum 30 liters of water.
- 2) All cement, unless otherwise specified in the Contract Documents, shall conform to the "Specifications for Portland Cement" (ASTM C150 – latest revision).

9.3. Clay Seal

Clay seal shall consist of bentonite made into mud balls and placed into the annulus between the final well casing and borehole wall. The consistency of the mud balls and its placement in the well shall be subject to the approval of the Engineer.

9.4. Method of Placing Grout Material

- 1) The method and equipment for placing the grout shall be to the approval of the Engineer. No method will be approved that does not provide for the forcing of grout from the bottom of the casing/hole/annulus to be grouted, to the surface. Flushing of the annular space with fluid to assure the space is open and to remove loose material will be required to the Contractor before grouting is commenced.
- 2) Any grouting operation shall be continuous and before starting, sufficient grout shall be mixed to complete the whole operation. During the grouting operation, the mixed grout shall be continuously stirred. The Contractor shall provide such tanks, hoppers and other equipment as may be necessary to meet these requirements.

9.5. Setting Time

No work will be allowed on the well within a period of 72 hours after completion of grouting unless a quick-setting cement is used. In such case, the idle period may be reduced to 24 hours subject to the Engineer's prior approval.

10. Well Disinfection and Cleaning

10.1. Scope

- 1) The Contractor shall upon completion of well construction and well testing thoroughly clean the well of all foreign substances including tools, timbers, rope, debris of any kind, cement, oil, grease and scum.
- 2) The casing pipe shall be thoroughly swabbed using alkalis, if necessary, to remove oil and grease of joint dope.

10.2. Chlorine Solution

- 1) The chlorine solution for disinfecting the well shall be such volume and strength that a concentration of at least 50 mg/liter of chlorine shall be obtained in all parts of the borehole.

- 2) The chlorine solution shall be prepared and applied in accordance with the directions of and to the satisfaction of the Engineer and shall remain in the well for a period of at least two hours.

10.3. Cleaning of Test Pump

In the event that the test pump is to be installed after the well has been disinfected, all exterior parts of the test pump coming in contact with the water shall be doused with a chlorine solution as directed by the Engineer.

10.4. Disinfection Procedure

- 1) Method A: Where practical, the chlorine solution of standard concentration used to disinfect the well shall be prepared on the surface in containers having a volume of water contained in the well. This prepared solution shall then be discharged rapidly into the well, care being taken to flush the walls of the well above the water level.
- 2) Method B: In lieu of using liquid chlorine solutions, a perforated pipe container capped at both ends containing a granular chlorine compound or HTH, may be moved up and down in the well by means of a weighted cable. The amount of compound applied should be such as to provide the standard concentration.

11. Well Completion

11.1. Scope

The Contractor shall provide and operate all equipment necessary to restore the site as near as possible to its condition before commencement of drilling and shall furnish and install a well head cap as specified in the Contract Drawings.

11.2. Site Restoration

The site shall be restored to a condition as nearly as possible to that which existed before the well drilling and testing activities commenced. This work shall include, but not limited to, restoration of fences and structures, removal of drill cuttings, leveling of the disturbed ground surfaces and replacement or compensation for the destroyed plants and landscaping.

11.3. Well Head Capping

The well head shall be completed with a well head assembly fully welded to the upper casing as well as water level sounding tube with screw cap in order to prevent any unauthorized tampering of the well.

12. Submittal of Reports and Borehole Data

12.1. Scope

- 1) The Contractor shall submit to the Engineer daily records in duplicate containing the following information:
 - Site:
 - Date:
 - Description of each stratum encountered:
 - Depth below ground of each change of stratum:

Depths and details of all disturbed samples:

- 2) The Contractor will be required to keep a record of penetration rate, mud losses and mud conditions.
- 3) At the end of the well construction and before final payment is made, the Contractor shall submit to the Engineer a narrative report and as built drawings containing the following information, but not limited to wit:
 - a. The total depth of the well.
 - b. Description of the strata encountered and penetration rate.
 - c. The sizes and the lengths/specifications of the casing installed.
 - d. The date of the start and the completion of the well construction.
 - e. The locations and the description of the casing perforations or the well screen placement.
 - f. The locations of the gravel, the size of the gravel, if applicable, and the amount of cement grout installed.
 - g. Records well development activities undertaken together with description of the methods of the development, amount of time consumed for each type of development method employed, amount of sediments taken out of the well per type of development method, and changes in the quality of water, if applicable.
 - h. The well yield (expressed as discharge rate and drawdown), the dates and the duration of the test(s).
 - i. The methods of measuring the discharge rate and the drawdown.
 - j. Pump test evaluation including drawdown graphs, other illustrations, calculation of hydraulic parameters (transmissivity, storage coefficient, well and aquifer efficiency, specific capacity, etc.).
- 4) The cost of records shall be deemed to be included in the contract rates.

B. Special Technical Conditions

1. General

1.1. Scope

The work includes the drilling of one (1) production well at Brgy. Malibong Matanda, Pandi, Bulacan.

1.2. Water Level Sounding

The Contractor shall provide a functioning and accurate water sounding instrument acceptable to the Engineer to measure the water level during all drilling, development and testing of the wells. Failure to provide such instrument will subject the Contractor to a penalty of P3, 000.00 per day.

2. Well Drilling

2.1. Equipment

The Contractor shall provide and operate **one (1) Rotary Drilling Rig** including all auxiliary equipment necessary to complete the work within the contract period.

2.2. Drilling Method

All drilling shall be performed with the **Rotary Drilling Method**.

3. Geophysical Logging

3.1. Scope

The work include geophysical logging (refer to Sec. A.3.3).

The Engineer and the operator of the logging device will decide jointly on the logging velocity. The logging direction shall generally be from bottom to top. Processing of the measurements and printout of graphs must take place on the site. The Contractor shall assign the borehole logging to a person familiar with the instrument and the data processing. "Learning-by-doing" will not be accepted.

4. Well Casing

4.1. Casing Material

All permanent casings to be installed shall be spiral welded steel casing with minimum wall thickness of 6 mm and should be of new stock, beveled ends, with outside paint coating.

5. Well Screen

5.1. General

The well screen should be of continuous and precise slot openings that can withstand high mechanical impacts, fabricated by circumferentially wrapping wedge wire around a circular array of internal rods. Wire should be designed to provide maximum inlet area consistent with strength requirements. For maximum collapse strength, each juncture between the horizontal wire and the vertical rods shall be pressure/fusion welded under water by the electrical resistance method. End fittings shall be welded by the MIG process to the screen body.

5.2. Material and Fittings

The well screen shall be fabricated from corrosion resistant type 304 Stainless Steel (or better) and strictly in accordance to A.I.S.I. standards. (Material certificates, mill's test certificates are to be supplied and shipped together with the goods.)

5.3. Slot Opening

Slot opening is selected with 1.50 mm. The maximum allowable tolerance is $\pm 10\%$.

5.4. Well Screen Dimensions

Well screens have to be designed to match with the casing supplied under this contract.

Well screen overall length – 3.0 m

5.5. Well Screen Construction

Detailed information of the profile wire, slot forming profiles and the support cross bars are to be provided with the Bid.

5.6. Open Area

The minimum open screen area shall be as follows:

Screen	200 mm Screen	250 mm dia. Screen
1.5 mm	33.3%	30%

5.7. End Fittings

Screen	200 mm dia. Weld ring each end	250 mm dia. Well ring each end
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Weld rings should be beveled ends to be welded to each other or the casings, supplied under this contract.

5.8. Hydrostatic Collapse Pressure

150 m depth or less – 10 bar

5.9. Quality

Manufacturer shall submit the proof that the manufacturing is done according to accredited international quality control system.

6. Formation Stabilizer/Gravel Pack

6.1. Scope

The Contractor shall provide and install graded gravel pack materials with grain size 5 to 7 mm. The final grain size of the gravel pack to be installed, if any, shall be determined based on the strata samples collected during drilling.

7. Well Development

7.1. Scope

Well development for the production well shall consist of deflocculation, high velocity water jetting, airlifting and surging with plunger including bailing out of sediments,

7.2. Expected Yield

The production well is expected to yield at least 10 lps.

8. Well Testing

Should it be proven by the Engineer that completing the 72-hour continuous constant discharge pumping tests is not necessary and/or not possible, Pandi Water District shall pay the Contractor a minimum amount corresponding to 24 hours of pumping.

9. Cement Grouting

No Special Provisions.

10. Well Disinfection and Cleaning

The work does not include disinfection with a chlorine solution.