

REPUBLIC OF LEBANON

MINISTRY OF ENERGY AND WATER

COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

UPGRADING OF WATER SUPPLY IN THE VILLAGES OF QARQAF, BERQAYEL AND BEIT EL HAOUCH (AKKAR CAZA)

VOLUME 4

PARTICULAR SPECIFICATIONS

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- Part 3 – Mechanical Works**
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- Part 5 – Instrumentation and Control**
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PART 1

GENERAL REQUIREMENTS

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PART 1

101. GENERAL REQUIREMENTS

101.1 APPLICATION OF PARTICULAR SPECIFICATION

This Particular Specification is to be read and construed together with the General Specification contained in Volume 3 of the Contract Documents for this Tender. In case of ambiguities or discrepancies between this Particular Specification and the General Specification, the Particular Specification shall prevail, except if and to the extent otherwise provided by the Contract or directed by the Engineer.

Whenever the term "Specification" without further qualification is used in the Contract Documents, it shall mean the General Specification together with the Particular Specification.

101.2 LOCATION OF WORKS

The work covers the drilling and equipping of 1 new borehole in El Qarqaf village, construction of control and chlorination rooms and the construction of the distribution network for el Qarqaf village. The works includes all necessary civil and electromechanical works to improve the water resources at the mentioned village due to the scarcity of rain in the last few years and consequently, the severe recession of all springs and wells.

101.3 THE SITE

For electromechanical works within El Qarqaf area, the limits of the Site (Conditions of Contract Sub-Clause 1.1) shall be the limits of land in public ownership which shall be taken to be any boundary fence or wall which is in our case the fence of El Qarqaf existing water tower.

The Contractor shall have inspected the Site (Conditions of Contract Sub-Clause 1.1) and shall have included for the provision of any additional working area that he may require outside the limits of the Site (Conditions of Contract Sub-Clause 58.2).

101.4 SCOPE OF WORK

The scope of work covered by this Contract includes the following:

- Drilling and Equipping of the borehole.
- Excavation and backfilling.
- Supply and installation of steel pipes.
- Supply and installation of one submersible pumps.
- Supply and installation of rising steel pipes.
- Supply and installation of an electrical control panel.
- Supply and installation of connecting pipes and hydraulic accessories (valves, air-release valves, check valves, etc...).
- Supply and installation of electromagnetic flow meters.
- Supply and installation of one liquid chlorinator units.
- Construction of new pumping station buildings.
- Construction of complete distribution network for el qarqaf village.
- Construction of a well head concrete structure.
- Conduction of semi industrial and industrial testing.
- Operation of the well for a couple of days prior to its commissioning.

101.5 CONDITIONS PREVAILING AT SITE OF WORKS

The Contractor's attention is drawn to his obligation to satisfy himself, before submitting his Tender, as to the conditions prevailing at the Site of Works and its surroundings (Clause 11 of Conditions of Contract) and relevant sections of the General Specification for Civil Engineering Works.

101.6 PRIVATE LANDS

The Contractor shall not enter upon or occupy with men, tools, or materials of any nature, any lands other than the working areas shown on the Drawings, except after consent shall have been received by him from the proper parties and a certified copy of such consent shall have been furnished to the Engineer. Any rentals or damages paid for occupying private lands shall be at the Contractor's expense.

101.7 EXISTING SERVICES

In the course of works, the Contractor will encounter within the limits of the working areas and in the vicinity, miscellaneous above ground and underground services such as drains, pipes, cables, telephone and electric poles and lines, water supply and similar existing services. The Contractor's attention is directed to the provisions of Clause 101.12.4 of the General Specification with regard to such existing services.

101.8 ACCESS ROADS

101.8.1 Temporary access roads

The necessity of construction of Access Roads and/or temporary roads may arise, in which case such temporary roads shall be subject to the provisions of Clause 101.12.3 of the General Specification for Civil Engineering Works, and shall be executed at the contractor's responsibility and expenses in coordination with the concerned Authorities and according to the Engineer's requirements.

101.9 PROGRAM AND MONITORING

It is a primary requirement of the Employer that a comprehensive knowledge of the status of progress to date, predicted progress, costs and cash flow forecasts is available at all times. The Contractor shall be responsible of the requisite information and shall be responsible for programming the Works, preparation of cash flow estimates and measuring and reporting the progress of the works in an approved format. In order that programming, progress measurements and reporting is executed in a timely and efficient manner, the Contractor shall program the Works, monitor progress and generate cost reports and cash flow projections by utilizing a recognized industry standard approved P.C. based Project Management software package.

The Contractor's master program and cash flow estimates and subsequent updates, submitted in accordance with Clause 14 of Conditions of Contract shall, as a minimum, detail the sequence of procurement, installing, testing and commissioning, and handing over for each of the works items including each item described in the Bill of Quantities.

At least 21 days prior to taking possession of any portion of the Site and starting of work, the Contractor shall submit a detailed construction program for that portion of the Site. The detailed construction program shall be to a level to adequately identify the intended sequence of working on each individual item of work. The minimum level of detail shall not be less than that needed to identify each individual payment item included in the Bill of Quantities.

The Engineer's obligation to measure the Works in accordance with Sub-Clause 56.1 of the Conditions of Contract shall be dependent on the Work being programmed and progress being monitored and reported in accordance with the requirements of the Contract.

101.10 LIST OF ABBREVIATIONS

In the Contract Documents, the following abbreviations have been employed :

uPVC	- Unplasticized Polyvinyl Chloride
D.I.	- Ductile Iron
R.C.	- Reinforced Concrete
C.I.	- Cast Iron
G.S.	- General Specification
C.O.C.	- Conditions of Contract
B.O.Q.	- Bill of Quantity
PN	- Nominal Pressure
DN	- Nominal Diameter
ID	- Inner Diameter
OD	- Outer Diameter

101.11 OR EQUAL CLAUSE

Wherever references to Standard Specifications, such as British Standards, are made, they shall not be construed to restrict materials to British products. Materials from other scheduled countries will be considered provided that the producer of the material certifies its conformity to the appropriate Standard Specification.

Similarly, whenever a required material or article is specified or shown in the plans by using the name of the proprietary product or of a particular manufacturer or vendor, any material or article which will perform adequately the duties imposed by the general design will be considered equal and satisfactory provided the material or article so proposed is of equal substance and function in the Engineer's opinion. It shall not be purchased or installed without his written approval.

101.12 GOVERNMENT REGULATIONS

The Contractor shall comply with all provisions of the rules, regulations and orders of Government and Municipal agencies, such as the Public Works Department, Electricity of Lebanon, and Telecommunications Authority.

The Contractor shall co-operate with the Employer in promptly furnishing any information that may be required by such governmental agencies. It shall be the obligation of the Contractor to keep himself informed of these governmental rules, regulations, and orders and the Contractor shall make the requirements of this article a part of any sub-contract he may enter into.

101.13 FACILITIES FOR THE ENGINEER'S REPRESENTATIVE

Refer to text of section 101.22 of Volume 3 - Technical Specifications - Part 1 - General Requirements

The Contractor shall provide any necessary protective clothing and safety equipment for the use of authorized visitors to the site including the Employer and his staff and Representatives and those of any relevant authority who have reason to visit the site.

101.14 ACCESS TO WORK

The Engineer and his duly appointed representatives and the Employer or his representatives or agents may at any time and for any purpose whatsoever enter into and upon the work and the premises used by the Contractor. The Contractor shall provide free, proper, and safe facilities therefore.

101.15 SURVEY AND SETTING OUT

All levels used for construction shall be referred to the National Height Datum. The Contractor shall be responsible for obtaining the location and values of the permanent bench Marks. In cases where such bench Marks do not exist, a site datum shall be agreed with the Engineer.

Prior to the commencement of the work the Engineer shall approve all plans showing benchmarks, limits of plot and auxiliary baselines. The Contractor, under the supervision of

the Engineer, shall set out on-site and erect appropriate permanent markers where instructed by the Engineer.

The Contractor shall employ an experienced licensed Surveyor for the duration of the Contract. He shall furnish the Engineer with a duly signed map showing the various centerlines, baselines, reference points permitting the renewal of markers and boundaries of parcels and blocks, if destroyed. Before starting and during earthwork on the site, the Contractor shall set out a net of square coordinates at distances not exceeding 10 m in each direction. A peg shall be driven at each intersection and at other relevant points and levels of peg tops and of ground at the same spot shall be measured.

The levels of the ground and the levels and dimensions of existing features shown on the Drawings are not guaranteed to be correct.

Wherever dimensions or levels are marked on the Drawings such dimensions or levels shall take precedence over dimensions scaled from the Drawings. Where no dimensions or levels are shown on the Drawings, instructions shall be obtained from the Engineer. Large scale drawings shall be taken in preference to drawings of smaller scale.

101.16 NOTICE BOARDS

The Contractor shall provide and erect sign boards at the sites (Nb. 5, & refer to Annex 1 of this volume) where works are being executed, giving information to the public on the Project and the Employer and further details as will be prescribed by the Employer. The location and number of the sign boards at the sites will be indicated by the Engineer. The Contractor shall maintain, alter, move and adapt the sign boards from time to time as instructed by the Engineer. The display of any named Subcontractors or any other information associated with the Works shall be to the approval of the Engineer.

101.17 MANUFACTURE'S CERTIFICATES

The Contractor shall furnish the Engineer with a manufacture's certificate confirming compliance to the specification in respect of all items of equipment.

The original and one copy of the manufacturer's certificate shall be delivered to the Engineer not later than 14 days prior to the intended date of delivery of the Item to site.

101.18 PRECAUTIONS AGAINST CONTAMINATION OF THE WORK

The Contractor shall at all times take every possible precaution against contamination of the works. The site and all permanent and temporary works shall be kept in a clean, tidy and sanitary condition. The Contractor shall at all times take measures to avoid contamination of the existing water courses and drains by petrol, oil or other harmful materials.

101.19 ACCESS TO PROPERTIES

The Contractor shall not disrupt any private or public access way without first providing alternative arrangements.

101.20 TOPOGRAPHIC SURVEY

Where the Contractor gets the approval of the Engineer to execute a topographical survey, mapping shall be at 1:200 with contour lines at an interval of 1 meter. A ground profile along the centerline of the pipe route shall be provided and shall be at the same scale of the construction drawings relative to the contract.

The extent of mapping shall be the width of roads or dual carriage ways up to the property lines on either side of the public land, or one meter from the edge of road which ever is nearer to the road centerline.

In open areas and along water courses the mapping corridor shall be 20 meters. The mapping shall be supplied on film plotted from digital data.

All control points, and heights shall be related to the National Height Datum in meters. Station Descriptions with distances to reference objects and a list of coordinates and heights shall be submitted to the Engineer.

Permanent bench marks shall be constructed from steel pins, road nails or painted marks on existing stable features. A minimum of two site bench marks shall be established on existing stable features.

All man-made hand detail features, road edges, curbs, existing manholes, inspection covers, culverts, and underground service pipeline shall be surveyed in their true position and shown by conventional symbols. The detection of the existing services will be paid separately and must be approved by the Engineer.

Any surveyor who will subcontract topographical works from the Contractor shall be approved of by the Engineer. However, the Contractor will still be held responsible for the accuracy of the survey until it gets approved by the Engineer.

101.21 DRAWINGS AND DOCUMENTS

All drawings and documents submitted by the Contractor shall have been checked and signed, shall be ready for issue and shall bear the title of the drawing, the scale, the date, the Contract number and name, the document number complying with an approved numbering system, the name and references of the Contractor, the name of the Employer and the Engineer, the date of approval by the Contractor and the signature of the person responsible for the approval.

Unless otherwise specified, the Contractor shall allow a minimum of 15 days for approval of drawings and documents by the Engineer.

101.22 MEASUREMENT AND PAYMENT

Unless otherwise provided for in the B.O.Q, all costs incurred in complying with the requirements of this Division 101 shall be deemed to be included by the Contractor in his unit rates in the Bill of Quantities and shall not be paid for separately.

PART 2
CIVIL WORKS

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201. CONCRETE WORKS

201.1 GENERAL

201.1.1 Life Span of Concrete Structure

New works are to be designed for a life of 60 years.

201.1.2 Codes and Standards

Complementary or new design shall as far as possible be carried out in compliance with relevant International Standards such as:

- BS Standards.
- ACI and Uniform Building code.
- BAEL 1992
- AFPS 90

or equivalent standards

201.2 SOIL PARAMETERS

The Contractor shall carry out soil investigations to satisfy himself with the prevailing soil conditions for all sites.

201.3 MATERIALS

201.3.1 Grades of Concrete

The minimum grades of concrete for the various structures are given as follows:

Grade	Component
C30	Reinforced concrete for Reservoirs (400 Kg cement/cu.m)
C30	Reinforced concrete for Buildings and Structures (350 Kg cement/cu.m)
C25	Reinforced concrete for thrust blocks (350 Kg cement/cu.m)
C20	Mass concrete and Blinding concrete (250 Kg cement/cu.m)

Reinforced and mass concrete must be vibrated.

Admixtures and mix design of the different Grades of concrete shall be submitted for approval prior to commencing the work.

201.3.2 Reinforcement

All reinforcing steels shall be Type 2 High Yield Bars and comply with the requirement of BS 8110 and shall have a specified characteristic strength of 420 N/mm².

Dowel bars and stirrups shall be Mild Steel grade 25, $f_y = 250 \text{ N/mm}^2$.

Lap lengths shall be 50 diameters. Mechanical bending for $\phi \geq 12 \text{ mm}$ is required.

201.3.3 Minimum Cover of Reinforcement

The concrete cover for all steel bars including stirrups shall not be less than 40 mm in structures where concrete surfaces are in contact with water.

Where concrete surfaces are in contact with soil, the cover of reinforcement shall not be less than 35 mm.

The cover of reinforcement in external surfaces of structures, and all elements of buildings shall not be less than 30 mm.

Formwork for all concrete surfaces in contact with water and/or soil and internal surface (walls and ceilings) of technical rooms shall be of form panels (marine plywood or metallic formwork) in order to obtain a regular and smooth finish.

201.3.4 Classes of Exposure and Crack Width

External and internal walls, columns and beams are to be considered as subject to severe exposure as defined in Sub-Clause 3.3.4 of BS 8110.

The faces of structures in contact with ground shall also be considered as subject to severe exposure.

Concrete surfaces in contact with water are designed for a maximum crack width of 0.2 mm.

201.3.5 Admixtures

Admixtures (retarders, mass waterproofing, silica fume...) are to be added to concrete in contact with liquid. Technical sheets and the mix design of concrete shall be submitted for approval.

202. COMMON REQUIREMENTS

All metal sheets shall be 3mm thick minimum. All metal works shall be epoxy painted over a primer. Openings for ventilation or other shall be taken into consideration.

All hardware shall be water resistant.

Buried walls shall receive a bituminous coating for protection.

203. PIPELINES AND PIPEWORK

203.1 TRENCH EXCAVATION

Excavation for pipelines shall be carried out in accordance with Sub-Section 201.3.2 of the General Specifications. During the pipelaying, jointing, testing of pipes and backfilling, the trench shall be completely dry.

The Contractor shall excavate the trenches without damaging existing pipes, cables and any other structure. In this respect, the Contractor shall excavate the necessary depth or change the route in order to avoid damaging the pipes, cables and culverts that cross the roads.

In case the modification of the pipe depth or route is impossible, the Contractor shall, after the approval of the Engineer, undertake all the necessary works including excavation, fill and concrete works, etc... to modify the culvert in a way to maintain the passing section of the culvert, the cost of these works, after getting the approval of the Engineer should be measured as a concrete works (according to concrete works item).

The Contractor shall clear away within the same day, all excavated material arising from trenches and headings on asphalted roads as the work proceeds, and shall keep these roads free from any accumulations and clear in a good condition, to the satisfaction of the Engineer.

In addition to Sub-Section 201.3.2 of the General Specifications, Earthwork shall not be classified in accordance with the hardness of the excavated material, all excavation should be classified as common excavation and the Contractor shall take the sole responsibility for his assessment of excavated material and conditions. He should also use all suitable materials in the permanent construction required under the contract.

203.2 BACKFILLING OF PIPE TRENCHES

Backfilling shall be carried out in accordance with the Ministry of Public Works decree No. 13495 dated 5/11/98 (Refer to Annex 1 of this volume) and in accordance with related general specifications of Volume 3.

In case of ambiguities or discrepancies between the content of the above mentioned decree and the general specifications, the decree shall prevail.

All pipes shall be placed in granular material (fine course) bedding and surround if the pipeline is above water table, and in gravel bedding and surround if the pipeline is below water table.

203.3 PIPELINES AND MATERIALS

As specified in the BOQ, ductile iron pipes shall be used.

Moreover, the materials used shall comply with the requirements of Section 101.9 of the General Specifications. Any unsuitable material not satisfying the specifications shall be rejected by the Engineer, removed from the Site and replaced by the Contractor at his own expense.

203.3.1 SPECIAL REQUIREMENTS

203.3.1.1 Manufacturer's Certificate

Materials shall be supplied with certificates, in respect of each delivery, stating that products comply with and have been factory tested in accordance with the specified Standards.

203.3.1.2 Special Tests

Whenever required by the Engineer, the Contractor shall supply and transport to an approved testing laboratory samples of materials selected by the Engineer. The number of samples shall not be less than 0.5% of total supplied, with at least one from each class, diameter and manufacturer. Failure of any sample shall be followed by a second and if necessary a third test from the same batch. A third test failure will result in all material from that manufacturer being rejected and replaced by material from a different manufacturer, subject to approval by the Engineer, after satisfactory testing. Laboratory test reports in an approved form shall be provided.

203.3.1.3 Manufacturer's Instructions

The Contractor shall observe the manufacturer's written instructions and recommendation in respect of handling, protection, stacking, storage, laying, fitting, cutting, repair of the products and materials as applicable.

203.3.1.4 Marking

Unless otherwise specified in the relevant Standard, products shall have legibly cast, stamped or indelibly painted on, the following marks, as appropriate:

- The manufacturer's name, initials and identification mark.
- Nominal diameter.
- Class designation.
- Initials and number of relevant Standard.
- Length of pipe if shorter than the standard length.
- Angle of bends in degrees.
- The date of manufacture.

203.3.1.5 Samples and storage of materials

Where required by the Engineer, the Contractor shall submit to the Engineer for approval samples of pipes, fittings and materials prior to procurement.

The Contractor shall store pipes, fittings and other materials only at places approved by the Engineer and shall at all times provide adequate supervision and watchmen to prevent theft or damage. Any loss or damage incurred will be the Contractor's responsibility.

Pipes shall not be stacked higher than recommended by the manufacturer. The area on which the pipes are to be stacked shall be free draining, the grass or other vegetation shall be kept cut and suitable timber or cradles shall be provided on which the pipes shall be laid. End stops to all stacks shall be provided.

Fittings and valves shall not be stacked more than one tier high and they shall be supported off the ground by suitable timbers.

Air valves, rubber joint rings, gaskets, bolts and similar fittings and materials shall be kept in approved locked premises and such fittings and materials shall not be distributed to the trench side until immediately prior to laying, fitting, jointing or assembly thereof. All rubber joint rings and gaskets must be stored in a cool damp location and all fittings and materials shall at all times be stored in the shade under cover and protected from the weather to the satisfaction of the Engineer.

203.3.1.6 Flanges

Unless otherwise specified, flanges shall be faced and drilled to conform to the dimensions specified in BS 4504. Flanges shall be compatible with the pressure rating of the adjacent pipework but not less than 16 bars. Bolts, nuts, and washers (two washers per bolt) shall be to BS 4504 Clause 5. No bolt shall project more than two full threads beyond its nut after tightening. In no circumstances shall be shortening of excessively long bolts but cutting be allowed.

Gaskets shall comply with BS 4865 and BS 2494 Type W.

Flanges shall be painted with two coats of epoxy resin paint.

203.3.1.7 Mechanical Couplings

Unless otherwise specified or shown on the Drawings pipes and fittings shall be supplied with flexible joints.

Mechanical couplings shall be of the Dresser, Viking Johnson type without a center register.

203.3.1.8 Materials for the assembly of flexible joints

Lubricant shall be of a kind not conducive to the growth of bacteria and shall have no deleterious effects on either the joint rings or pipes. Lubricants for water supply shall not impart to water taste, colour, or any effect known to be injurious to health.

203.3.2 WORKMANSHIP: OPERATIONS

- 1) Manufacturer's recommendations on handling, repairing, laying, jointing, anchoring, testing and other works for pipes and fittings shall be strictly followed.
- 2) The Contractor shall use cranes, hoists or forklifts as directed by the Engineer. The Contractor shall use hooks, spreader beams, ropes, band or wire slings etc. as recommended by the manufacturer for each type of pipe and as approved by the Engineer.

- 3) The Contractor shall stack pipes on a level surface. Pipes shall not rest on sockets or flanges and end pipes in the bottom row shall be securely chocked. Heights of stacks shall be in accordance with the manufacturer's instructions.
- 4) The Contractor shall handle material with care to avoid damage whenever moved by hand, forklifts or hoists.
- 5) The Contractor shall provide safe storage for all material. The interior of pipes, fittings etc. shall be kept free from dirt and foreign matter. The Contractor shall provide shade for materials as required by manufacturers' instructions and recommendations and to the Engineer's approval.
- 6) Pipe Cutting: The Contractor shall use hacksaws, manually operated wheel cutter or pipe cutting machine in accordance with manufacturers' instructions. If, in the opinion of the Engineer, special precautions are required to eliminate airborne particles, the Contractor shall use methods and equipment as directed by the Engineer. The Contractor shall prepare ends according to type of joint used and follow manufacturers' recommendations. The Contractor shall take care not to damage linings. The Contractor shall repair on site minor damage if so permitted by the Engineer.
- 7) The Contractor shall repair damaged coatings, sheathings or linings in accordance with the Specification and the manufacturer's instructions. The Contractor shall use material compatible with that originally used. Repairs shall be approved by the Engineer before incorporating the materials into the works.

203.3.3 SEQUENCE OF CONSTRUCTION

The Contractor shall adhere to the sequence of construction as set out below unless a justified request for modification is approved by the Engineer at least two weeks prior to commencement of work on the affected section of the network:

- 1) Stake out pipe alignments
- 2) Clear and grade the right of way (wherever required)
- 3) Carry out surveys, including trial pits if necessary, along the alignments to verify the location, depth, size and type of existing utilities.
- 4) Prepare and submit for approval composite Shop Drawings for all utilities showing alignment, ground elevation, trench invert elevation, pipe size, class and length, station and size of fittings, valves as applicable manholes, inlets, appurtenances and structures to be demolished and reinstated (kerbstone, rails, culverts, etc.). Cross sections showing location and inverts of existing pipes and those proposed shall be prepared. Pipes, structures and other utilities to be removed or relocated shall be indicated on the Shop Drawings.
- 5) Relocate, demolish and reinstate existing services and utilities interfering with pipeline alignments.
- 6) Remove pavement layers, excavate trenches and place bedding as required
- 7) Lay and join pipes, fittings, appurtenances, manholes, etc.
- 8) Place primary backfill material

- 9) Perform hydrostatic testing
- 10) Complete connections to existing services and curb/gutter inlets as required
- 11) Place final backfill
- 12) Restore or reinstate surfaces and structures as required
- 13) Carry out final surface works road surfacing curb stone, backing walls, sidewalk paving, etc.
- 14) Dispose of surplus materials.

203.3.4 DUCTILE IRON PIPES

203.3.4.1 General

- 1) Ductile iron pipes for raw and potable water pipelines shall be of Class C (preferred pressure class) pipes in conformance to BS EN 545-2010 or ISO2531-2009. Pipes shall be to pressure rating suitable for the condition of service as denoted on the drawings and not inferior to the preferred pressure class. All ductile iron pipes and fittings to be supplied under this Specification shall be obtained from an approved manufacturer having an ISO9001-2000 TOTAL QUALITY ASSURANCE system based on the latest version of the ISO9001 standard.
- 2) Spigot and socket ended pipe joints shall be used for straight runs and adjacent to elbows or fittings. These joints shall be provided with rubber gaskets, and external thrust blocks at elbows or fittings. Anchored joints shall be the push-in, self anchored type. Concrete thrust blocks are not required for anchored joints. The Contractor shall submit calculations verifying the number of restrained joints required noting that pipe pressure testing will be made when pipes are partially backfilled.
- 3) Prior to the ordering of pipe and fittings materials, the Contractor shall carry out his own calculations of the surge, the maximum allowable pressure and the Test Pressures, using approved parameters to ensure safety of the proposed system under worst working conditions, all to the approval of the Engineer. If the Contractor's approved calculations show that the resulting pipe classes needed are higher than the original Contract Documents, then the Engineer shall instruct the Contractor to adopt them; but if lower classes are needed, then the Contract classes shall prevail.
- 4) Flanges shall be provided in accordance with BS EN 1092-1:2002.
- 5) Factory protection for pipes shall be as follows:
 - Internally: cement lined to BS EN 545:2002 with ordinary Portland cement to BS EN 197-1:2000.
 - Externally: metallic zinc shall be applied in accordance with BS EN 545:2002 either hot applied coal tar material to BS 4164:2002 or bitumen to BS 3416:1991, minimum thickness 150 microns.
- 6) Factory protection for fittings shall be as follows:

Coated internally and externally by dipping, or other method, using hot applied coal tar based material to BS 4164:2002 or hot applied bitumen to BS 3416:1991, Type 1, grade D, minimum thickness 250 microns.

203.3.4.2 Joints

Joints of Ductile Iron Pipes and Fittings shall be of the Push in automatic standard type and any axial forces shall be taken by thrust and anchor blocks, where necessary and as shown on drawings.

203.3.4.3 Lubricant paste

The lubricant paste shall be a mixing of Vaseline, non soluble in accordance with French standard AFNOR T90 M DOC8. The quantities used in the assembly joints shall be as per manufacturer recommendation. The pipes and fittings manufacturer shall supply it.

203.3.4.4 Connecting pieces

All connecting pieces i.e. flexible coupling, flange adaptors, dismantling joint shall be made of ductile iron and shall be supplied from the same pipes and fittings manufacturer.

203.3.4.5 Pipes internal protection (including welded flanged pipes)

Pipes shall be internally lined with sulphate resisting blast furnace slag cement applied by a centrifugal process. The cement mortar lining shall be in accordance with the European Standard EN 545-2002 & with the International Standard ISO 4179-1985 with the thickness given in the following table:

	Thickness of mortar	
	Nominal mean value (mm)	Tolerance (mm)
80 – 300	3.5	-1.5
350 – 600	5	-2
700 – 1200	6	-2.5
1400 – 2000	9	-3

203.3.4.6 Pipes external protection (including welded flanged pipes)

Pipes shall be externally coated with:

- A metallic zinc coating in accordance with the European Standard EN545 – 2002 and the International Standard ISO 8179 Part 1-1995. The quantity of zinc shall not be less than 200 g/m².
- A bituminous varnish or equivalent anticorrosive paint which shall be applied over the zinc coating in accordance with the European Standard EN545-2002 and the International Standard ISO 8179 Part 1-1995, with a minimum thickness of 100 microns.

203.3.4.7 Connecting pieces internal and external protection

The connecting pieces (flexible couplings, flange adaptors, dismantling joint) shall be internally and externally protected with a powder epoxy coating having a minimum thickness of 150 microns or with a Rilsan nylon coating having a minimum thickness of 200 microns.

203.4 WARNING TAPES

Warning tapes shall be placed on well compacted Backfill at 450mm below the finished level and directly above the center-line of the pipeline.

Warning tapes shall be made of pigmented low density polyethylene and aluminium foil in a bright colour or other approved material not less than 250 mm wide and 0.15 mm thick. When laid, the tapes shall provide a continuous band detectable with a metal detector if the pipe itself is not detectable. The tapes shall be continuously and alternatively labeled in Arabic and English.

Where possible, tapes shall also be laid above ducts and concrete protection slabs as directed by the Engineer.

203.5 MANHOLES

Manholes shall be constructed as specified in Sub-Sections 202.11.2, 202.14.2 and 202.14.5 of the General Specifications and according to the dimensions specified in the BOQ and the related drawings.

Steel Ladders shall be manufactured in accordance with BS 4211:2005, mild steel, galvanized to BS EN ISO 1461:1999 with 200 grams of zinc per square metre.

All concrete faces in contact with the soil shall receive a waterproofing treatment consisting of two layers of brush-applied bituminous paint, in accordance with Sub-Section 213.2.1 of the General Specifications

203.6 CHAMBER COVERS AND SURFACE BOXES

Covers and frames shall be manufactured from ductile iron in accordance with BS EN 124:1994, non-rock, locking and solid tops. The wording on covers shall indicate the nature of the network (water supply). Grades of covers shall be Grade A, heavy duty test load 40 tons

Manhole covers shall be of a circular pattern unless otherwise indicated on the Drawings. Frames shall be provided with openings for fixing bolts for solid frame embedment into manhole concrete necks. Covers and frames shall be coated with a bitumen based compound to BS 3416:1991 with a minimum thickness of 200 microns.

203.7 IRONS STEP FOR VALVE CHAMBERS

Irons Step shall be manufactured in accordance with BS EN 13101: 2002.

203.8 TEMPORARY RESTORATION OF PAVED ROADS

In all paved roads, trenches shall be refilled and compacted to the underside of the original road surface.

A sub-base and base layers shall be laid and compacted as described in technical specifications.

The road surface shall be temporarily surfaced with finished thickness of 50mm bitumen.

203.9 PERMANENT RESTORATION OF PAVED ROADS

The permanent restoration shall comprise two layers of bitumen to a total compacted thickness of 100mm.

203.10 REMARKS

The Contractor shall lay pipes on one side of the streams and on one side of the roads (even if this is not shown on the drawings) and if possible outside the carriageway in order to avoid damaging the roads. The Contractor shall coordinate with the Administration and the Engineer and the relevant Authorities in order to obtain official authorization prior to any construction work.

204. HYDRAULIC ACCESSORIES

204.1 AIR RELEASE VALVES

For all transmission pipelines, air release valves should be exclusively double air release valves three functions, type anti shock type.

204.2 CHECK VALVES

For all transmission pipelines, check valves should be anti slam and in accordance with AWWA C508, iron body, bronze trim, 45 or 22 degree swing disc, renewable disc and seat, flanged ends.

204.3 PRESSURE GAGES

1. Description: ASME B40.1, Grade A phosphor bronze Bourdon tube pressure gage, with bottom connection.
2. Case: Drawn steel, brass, or aluminum with (115 mm) diameter glass lens. C. Connector: Brass, (DN 8).
3. Scale: White coated aluminum, with permanently etched markings. E. Accuracy: Plus or minus 1 percent of range span.
4. Range: Conform to the following:
 - Vacuum: 100 kPa of vacuum to 103 kPa of pressure.
 - Fluids Under Pressure: 2 times operating pressure.
5. G. Accessories:
 - Valves: (DN 8) brass or stainless steel needle type.
 - Siphons: (DN 8) straight coil of brass tubing with threads on each end.
 - Snubbers: ASME B40.5 (DN 8) brass bushing with corrosion resistant

204.4 NEEDLE VALVES

Needle valves shall be made of ductile iron material and shall include a cylindrical shutter that axially moves inside special hydrodynamic shaped valve body.

The water flows through the annular cavity between the body and the shutter; this cavity has a cross section continuously decreasing up to the valve seat, where reaches its minimum value. Downstream the valve seat the flow is oriented to the center of the valve.

By axially moving the shutter, the minimum flow area can be regulated until it became zero when the valve is completely closed.

The disk ring shall be made of a water seal material in order to guarantee the valve a tight closing and to reduce the service demand even if the valve operates under high pressure heads.

The valve shutter should be axially moved by a shaft – link-block - connecting rod operated by a gearbox (motor or manual operated), by a hydraulic cylinder, by a counterweight, by a floater or, by a combination of the above.

The valve shutter should be equipped with a stainless steel ring in order to symmetrically divide the flow in several radial jets colliding at the valve axis and to modulate the dissipation of the flow energy.

204.5 ELECTROMAGNETIC FLOW METER

1. Electro-magnetic flow meter shall comprise a detector head and converter. They shall be suitable for operation under the prevailing ambient temperature and site conditions. External weatherproofing paint of the equipment shall be executed by the application of epoxy resin.

2. The material used in the construction of the detection head shall comprise carbon steel for the flanges drilled to BS 4504 and suitable for the pressure rating of the pipework system. Flange adaptors shall be incorporated in the pipework adjacent to the flow meters to ensure ease of removal for maintenance or replacement. Specially double flanged pipe, insert pieces of ductile iron to the same specifications as the installed pipe shall be provided on each size of magnetic flow meter so that these can be inserted in the pipeline in the event of the removal of the unit. Face to face dimensions shall be in accordance with ISO or BS standards. Internal insulating lining shall be in accordance with manufacturer's recommendations. Electrodes in AISI 316 L or Nickel alloy C22.
3. The converter used shall have power supply, ON/OFF impulse/frequency, and load (in Ohm) suitable for the pipework system. A 24 Vdc alarm shall be incorporated. Digital inputs (reset totaliser, stop totaliser via internal or external, external calibration system, scale exchange, dosage, etc.) Grade of protection shall be IP 67.
4. The Contractor shall provide adequate portable testing equipment in order to demonstrate the proper performance of each element of the magnetic flow meter without dismantling its main parts and/or without interrupting the flow.

204.6 SURGE VESSEL

1. 1 unit of surge vessel, bladder type, it has to be installed at summit as shown on drawing 428W-P01.
2. Vertical or horizontal installation with minimum capacity of 1000 liters, the factory pressure test shall be performed at a minimum of 25 bar, the vessel has a single flanged connection in/out fitted with isolating valve PN16 DN 150 mm.
3. Particular requirements: adjust pre-charge pressure to 3.4 bar prior to opening to network.

205. SHOP DRAWINGS, AS-BUILT DRAWINGS

Shop Drawings and all necessary material technical specification shall be submitted to the Engineer for approval at least 21 days before starting of the work.

As-built drawings shall be prepared and submitted successively during the execution of works and shall be also submitted completely to the Engineer for approval one month maximum after the completion of the work.

It is the duty of the Contractor to undertake all the Engineer's recommendations, modifications and corrections at his own expense until complete satisfaction of the Engineer.

PART 3

MECHANICAL WORKS

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300. MECHANICAL WORKS: COMMON PARTICULAR SPECIFICATIONS - PUMPING STATIONS

300.1 PUMPING SYSTEM

300.1.1 Submersible Motopumpset (Deep Borehole)

- Pumps shall be semi-axial or radial multicellular.
- Motopumpsets shall have vertical axis, flooded, installed vertically in metallic casing (deep borehole).
- Pumps rotating speed shall be that of the electrical driving motor.

300.2 PIPING AND ACCESSORIES

- All pipes, valves, and hydraulic accessories shall have flanged and or mechanical joints.
- All piping of suction and discharge headers, and Motopumpsets inlet and outlet sections shall be internally and externally coated with epoxy (300 microns).
- All valves shall be coated internally and externally with epoxy (150 microns).
- The installation of piping and valves is deemed to include all the necessary miscellaneous hydraulic accessories required for the assembly of the complete system such as flanges, gaskets, coupling, adaptors, tees, bends, pipe supports, nuts and bolts, etc...
- All pressure reducing valves shall be supplied with a strainer installed before the valve.

300.3 DRAINAGE INSTALLATION

Drainage works for the pumping stations, reservoirs and valve chambers shall include but not limited to: drain outlets, floor drains, clean outs, gully traps, above and below ground pipeworks and fittings, drain, overflow, and rainwater installations from roofs, reservoirs, and surfaces inside and outside the pumping stations and reservoir sites as shown on the drawings, diagrams, and as per the specifications.

300.4 CHLORINATION SYSTEM

All water shall be chlorinated before going into public supply.

Chlorination facilities will normally be provided at sources of supply including boreholes and springs or at surface (booster) pumping stations. Where multiple sources feed into a reservoir the Chlorination facilities may be sited at the reservoir or a wet well. Care must be taken to allow maximum possible time/distance before any pump intakes.

Unless otherwise specified, the chlorine source will be bottled chlorine, with the pressure regulating valve mounted directly on chlorine cylinders, and where possible injection shall be by a vacuum chlorinator. In some cases direct injection of chlorine gas may be necessary and in other cases injection of hypochloride solution with dosing pump may be used.

Chlorine dosing shall always have manually adjustable pre-set rate facility, with a maximum dose rate of 5 mg/l.

In all cases chlorine control shall be by flow detection facilities, vacuum switch and where chlorine dosing is undertaken at a borehole or at a surface (booster) pumping station chlorine dosing shall be linked to pump operation, unless otherwise stated it shall be assumed that pump output is constant. At other locations, such as at a reservoir, Chlorination shall be controlled on flow and the Contractor shall include for the installation of the appropriate flow measurement and control facilities.

Unless otherwise specified, sufficient gas bottles or hypochloride solution shall be provided for two weeks usage at a dose rate of 5 mg/L. Above the two weeks usage, requirement for chlorinating substances for a duration of 2 days shall be provided.

The Contractor shall supply and install all necessary safety equipment. This shall include and not limited to, Chlorine leak detector, Gas masks, mechanical ventilation, alarm facilities and shower system with 1 m³ water tank as per chlorine schematic drawing. The chlorinator shall also be fitted with vacuum alarm switch to detect high and low vacuum for control and signalling purposes

The Contractor shall also provide training and detailed procedures for normal and emergency situations including literature and wall charts in English and Arabic.

301. QARQAF WELL PUMPING STATION

- Reference: Hydraulic Schematic drawing N° 562W -101-M01
Chlorination Schematic drawings N° 562W -101-M02
Mechanical drawing for wellhead N° 562W -101-M03

301.1 PUMPING SYSTEM

301.1.1 Electric Motor

Minimum Power Factor at 75% to 100% Output	Efficiency at 75% to 100% Output	No. of Starts/Hour	Quantity	Remarks
≥ 0.85	$\geq 85\%$	≥ 8	1	Submersible in borehole

301.1.2 Pump

Type: - Submersible Motopumpset (Deep Borehole).

Flow (l/s)	Head (m)	N.P.S.H. (m)	Efficiency at Duty Point	Quantity	Remarks
10	497	≤ 6	$\geq 73\%$	1	Pump in borehole

301.2 PIPING AND ACCESSORIES

301.2.1 Scope of Works

The hydraulic system of the well is composed of the following:

1. One (1) off submersible Motopumpsets with discharge check valve.
2. One (1) off rising column 100 mm diameters.
3. One (1) off wellhead and hydraulic accessories 100 mm diameter.
4. One (1) off well wash out pipe 80 mm diameter.
5. One (1) off reservoir inlet pipe 100 mm diameter.
6. Level, pressure, flow and temperature measurements as specified in “Instrumentation, Control Equipment and accessories” section.

301.2.2 Piping

Piping	Type	Material	DN (mm)	PN (bars)
Rising column	API 5CT, Wall thickness 6.4 mm or SCH80 for Steel grade B and 5.6 mm or SCH40 for steel grade X 42	Black Steel	100	Schedule 40
Well head piece, pipe and outlet	Seamless	Carbon Steel	100	16
Well wash out pipe	Seamless	Carbon Steel	80	16

301.2.3 Valves

Valves	Type	Material	DN (mm)	PN (bars)	Qty (No)
Well sampling Valve	Ball	Cast Iron	13	16	1
Well regulating valve	Globe	Cast Iron	100	16	1
Well isolating	Butterfly	Cast Iron	100	16	1
Well wash-out valve	Gate	Cast Iron	80	16	1
Well check valve	Anti-Slam	Cast Iron	100	16	1
Well air release valve	3 functions	Cast Iron	60	16	1

301.3 FIRE FIGHTING

301.3.1 Portable Fire Extinguishers

Location	"G" Type	"P" Type
Electrical room	2	-

301.4 PLUMBING AND DRAINAGE INSTALLATIONS

Refer to Common Particular Specifications.

301.5 LIQUID CHLORINATION SYSTEM

One manual liquid Chlorination system, serving the well water system, shall be supplied and installed on the discharge of the well as shown on the chlorine circuit schematic diagram and as described in the General Specifications. The operation of the Chlorination system circulation pump shall be interlocked with that of the submersible pump. A chlorine gas detection system shall also be supplied and installed. The minimum required distance between the intake and chlorine injection points should be not less than 60 cm.

- Capacity of chlorinator: 3 l/hr. (Qty=1)
- Injector back pressure: 2 bars
- Calcium Hypochlorite granules 250 Kg

PART 4
ELECTRICAL WORKS

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400. ELECTRICAL EQUIPMENT AND ACCESSORIES: COMMON PARTICULAR SPECIFICATIONS - PUMPING STATIONS

400.1 EDL TRANSFORMER (PROVISIONAL SUM)

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage pole mounted power transformer as follows:

- Dual primary voltage: 15/20 kV
- Secondary voltage: 400 V.
- Rated Power: as specified in the Contract's drawings and BOQ.

The transformer shall be supplied along with subscription to EDL and power meter and all necessary materials as per EDL requirements and recommendations. (Medium voltage power lines are not included).

400.2 GENERATOR SET

One standby diesel operated generated set with associated accessories, cooling air flow system, fuel water separator filter, start up, daily tank, fuel system, batteries & Charger, Instrumentation, protection and control equipment shall be installed to supply the pumping station equipment.

The primary distribution board shall include an incoming section with facilities for connection of a standby generator. An adequately sized opening with a hinged steel door shall be provided at low level in the external wall of the room of the building housing the primary distribution board. The incoming section shall incorporate an interlocked mains/standby supply, manually operated, change over switch. "Mains supply available" and "standby supply on" indicator lights shall be provided on the panel face.

400.3 MOTOPUMPSET SWITCHGEAR

Distribution board: A primary distribution board shall be provided at each installation. The board shall have, as applicable, feeds to:

1. Each motor starter/control panel.
2. Chlorination panel.
3. Instrumentation and control equipment.
4. Building services electrical distribution board.
5. Other as particularly specified.

The primary distribution panel shall be located in the control room. It may be either wall mounted or free standing as appropriate to its rating power factor meter and size. The board shall incorporate door mounted ammeters, voltmeter with a phase-phase and phase-neutral selector switch, frequency meter and power factor meter.

Where the EDL transformer is not in a building or where the incoming EDL supply to the site is at 380 V, an earth fault relay shall be incorporated in the main distribution board to trip out the incoming supply under earth fault conditions.

400.3.1 General Circuit Breakers (G.C.B.)

- G.C.B. shall be a moulded case circuit breaker of type “A” as described in the general specifications.
- G.C.B. shall be installed upstream the Automatic-Transfer Switch, one for network supply and another for emergency supply.

400.3.2 Circuit Breakers for Motopumpsets (C.B.P.)

- C.B.P. shall be a moulded case circuit breaker of type “B” as described in the general specifications.
- C.B.P. shall be installed upstream the starters that control the motopumpsets.

400.3.3 Auxiliaries Switchgear

- Shall include all outgoing feeders and corresponding protection for the auxiliaries of the site.
- The circuit breakers, shall be supplied and installed to supply all Auxiliary equipment of the site.
- The circuit breaker shall be a moulded case circuit breaker of type “B” as described in the general specifications.

400.3.4 Automatic Transfer Switch (A.T.S.) (Main/Standby Supply Changeover)

- A.T.S complete with mechanical inter-lock shall be installed for the pumping station.
- This Automatic Transfer Switch shall be supplied with auxiliary contacts for monitoring and control.

400.3.5 Starter

A combined starter/control panel shall generally be provided at each installation. The panel shall incorporate a suitably screened section for instrumentation and PLC. Panels shall be arranged for front and back access.

The panel shall be fed from the primary distribution board and shall incorporate a main incoming section with door interlocked isolator, “supply on” indicator lamp, voltmeter and ammeters on the panel face.

The panel shall incorporate phase failure, phase reversal and undervoltage protection. It shall not be possible for unauthorised personnel to adjust the voltage protection devices.

Starter/control panels shall be fully compartmentalised with each motor starter enclosed within its own cubicle with a door interlocked isolator. Unless instrumentation is specific to a particular motor separate instrumentation compartment(s) shall be provided, isolated as necessary to prevent pick up from the motor starters induced spurious signals.

All starters shall incorporate, mounted on the outside of the door, in addition to the features stated in the General Specification, the following:

1. Hand/off/auto selector switch.
2. Motor start and stop push buttons for use in hand control of the pump.

3. Emergency Stop push button, shall be of the mushroom headed push to stop/twist to reset type.
4. Motor “running”, “stopped”, “fault” indicator lights.
5. Cyclometer type running hour’s indicator.
6. PLC for control, monitoring and transmission purposes used to control:
 - The motopumpset operation.
 - The motopumpset protection and signalling.
 - The motopumpset discharge motorized valve with “local/remote/off” selector.

All panels shall have an audible alarm to sound under fault condition, together with a panel mounted mute push button to silence the alarm when acknowledged. This shall not clear the fault light which shall only be cleared when the fault is cleared.

Lamp test facilities with lamp test push button shall be provided.

In the event of multiple pump installations the panel face shall incorporate a duty selector.

Flow indication, integration and recording shall be provided at the station control panel.

N.B.: - A calculation sheet for design justification of all electrical switchgear shall be submitted.

400.4 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each, of adequate power output operating in redundancy shall be installed to supply the control, protection, measuring, signalling, valve actuators,... circuits of the pump station and suction reservoir.

Operation: One source is on duty, the other is on standby. Should the first source be out of service, the automatic change over to the second source occurs within the cycle at zero voltage.

400.5 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

- The Contractor shall supply and install a lightning protection system, covering all the pumping stations and reservoir or chlorination sites, and using early streamer emission type lightning conductors which number and type will be determined according to the site protection demand and in compliance with general specifications and latest standards.
- The lightning protection down conductors shall be flat conductors.
- The Contractor shall implement also an earthing circuit for the site, independent from the lightning ground network.
- The Contractor shall supply and install as well, a lightning current arrester at the point of entry of each power supply line into the stations and reservoir sites.
- The Contractor shall supply and install over-voltage protection systems for all power, data and communication networks in the station.
- The Contractor shall also connect to the grounding system all electromechanical equipment such as piping, electrical panels, H.V.A.C. system, switches, instruments, power outlets, luminaire chassis, etc...

400.6 PROTECTION OF MOTOPUMPSETS

The automatic shut off of the motopumpset shall occur in case of the following:

- Minimum water level in suction reservoir for motopumpsets fed from reservoirs.
- Minimum water level in borehole for well motopumpsets.
- High flow at the discharge of the motopumpset (with delay).
- Insufficient flow at the discharge of the motopumpset (with delay).
- High pressure at the discharge of the motopumpset (with delay).
- Low pressure at the discharge of the motopumpset (with delay).
- Unauthorized starting when main circuit-breakers are open.
- High water temperature at the suction of motopumpsets inside barrels (where applicable).
- High pressure at the suction of motopumpsets inside barrels.
- Low pressure at the suction of motopumpsets inside barrels.
- Minimum water level in barrels.

400.7 ALARMS & SIGNALLING

A visual indication and sound alarm shall be foreseen, in the electrical room with the switchgear, for the following faults (where applicable):

- Tripping of medium voltage circuit-breaker.
- Voltage fault.
- Minimum level in the suction and discharge reservoirs.
- Maximum level in the suction and discharge reservoirs.
- High pressure at the suction of motopumpsets.
- Low pressure at the suction of motopumpsets.
- Minimum water level in boreholes.
- Minimum water level in barrels.
- High pressure at the discharge of motopumpsets.
- Low pressure at the discharge of motopumpsets.
- Excessive flow at the discharge of motopumpsets.
- Insufficient flow at the discharge of motopumpsets.

- Motorized valve fault for each valve.
- Extreme levels in surge protection vessel (for each level).
- Emergency stop.
- Overheating of cooling air.
- Chlorine leakage.
- Fire alarm.

These defects shall be signalled on a luminous panel, constituted of labels of translucent material specific for each fault, and comprising two associated push-buttons: lamp test and reset (acknowledge).

A visual signalling (independent) of the state of each set shall be provided: RUN, STOP.

400.8 ELECTRICAL INSTALLATION FOR BUILDINGS

400.8.1 Electrical Panel Boards

Including signalling lamps, measuring instruments, selectors, bus bars, glands, cables, wiring, connections, to incoming and outgoing feeders, installations, connection, labelling, accessories, identification, etc...

These panels shall be installed where shown on drawings.

400.8.2 Circuit Breakers

The ratings and types of circuit breakers shall be as indicated on the respective panel drawings including installation, connections, labelling, accessories, etc...

400.8.3 Electrical Cables

Including conduits, cable trays, connections, supports, installation, accessories, identification, etc...

400.8.4 Conduits

Including clamps, flexible, fittings, connections, installation, accessories, etc...

400.8.5 Junction and Distribution Boxes

Including glands, installation, connections, labelling, accessories, covers, etc...

400.8.6 Switches

Including boxes, covers, installation, accessories, cables, conduits, wiring, connections to panel boards, etc...

400.8.7 Power Outlet Sockets and Plugs

Including plugs, boxes, covers, installation, cables, conduits, wiring, connections to panel boards, labelling, accessories, etc...

400.8.8 Lighting Fixtures

Including lamps, supports, poles, installation as and where shown on drawings, accessories, cables, conduits, wiring, connections to switches, etc...

400.8.9 Emergency Lighting System

Including luminaires where shown on drawings, lamps, conduits, installation, labelling, accessories, cables, wiring, connections to power supply, etc...

400.8.10 Testing and Commissioning

Including measuring of resistances of the grounding and the lightning protection systems, luminaires, power, continuity and insulation meggering of cables installation, etc...

N.B.:

- All conduits used for domestic electrical installation shall be imbedded in walls or in floor.
- All outlet sockets and switches shall be flush mounted.

401. QARQAF WELL PUMPING STATION

- Reference: Electrical schematic drawing No: 562W-101-E01
- Domestic electrical installation drawing No: 562W -101-E02
- Electrical installation drawing No: 562W -101-E03

401.1 EDL TRANSFORMER (PROVISIONAL SUM)

The Contractor shall coordinate with EDL after gathering all necessary information, supply, install test and commission a High Voltage/Low Voltage power transformer as follows:

- Dual primary voltage: 15/20 kV
- Secondary voltage: 400 V.
- Rated Power: 160 KVA.

The transformer shall be supplied along with switchgear panel and power meter and all necessary materials as per EDL requirements and recommendations.

(MEDIUM VOLTAGE POWER LINES ARE NOT INCLUDED).

401.2 GENERATOR SET

- A standby generator set with connecting cables and accessories shall be installed on a concrete pad, inside sound proof canopy, to supply the plant with the following main characteristics:
 - Rated Power (Continuous Rating): $P = 250$ kVA
 - Fuel Storage Tank : Volume: $V = 5,000$ liters, carbon steel sheets 4 mm minimum thickness, fabricated with level indication, filling pipe and washout valve.
 - Class of Protection : IP 23
 - Switch Gear: include monitoring, control protection and displays.

401.3 MOTOPUMPSET SWITCHGEAR

401.3.1 General Circuit Breakers (G.C.B.)

No. of Poles	Rating (A) at 380 V	Qty (No)
4	240	1
4	375	1

401.3.2 Circuit Breakers for Motopumpsets (C.B.P.)

No. of Poles	Rating (A) at 380 V	Qty (No)
3	220	1

401.3.3 Auxiliaries Switchgear

No. of Poles	Rating (A) at 380 V	Qty (No)
3	60	1

401.3.4 Automatic Transfer Switch (A.T.S.) (Main/Standby Supply Changeover)

No. of Poles	Rating (A) at 380 V	Qty (No)
4	375	1

401.3.5 Starter

Type	Rating (KW) at 380 V	Qty (No)
Variable Frequency Drive	≥ 101	1

Variable Frequency Drive control panel Should Have the following features:

- Open Loop.
- Proportional differential pressure.
- Constant Differential Pressure
- Constant level.
- Constant Flow Rate.
- Constant Temperature.
- Constant "Other Value".
- Duty/Standby Function to alternate between two pumps (each pump operated on separate Drive).
- Dry Running protection.
- 2 analog inputs, 1 analog output, 4 digital inputs, 2 signal relay.
- Availability of Output Filters from same brand "IF needed".
- Enclosure 200 x 80 x 40 cm.
- Filter

401.4 LOCAL ELECTRICAL INSTRUMENTATION

Local Electrical Instrumentation	Quantity (set)
Set of three digital Ammeters with current transformers	3
Set of digital voltmeters with selector switches	1
Digital hour meters	1
Digital frequency meters	1
Digital power factor measurement (Response time ≤ 1 s)	1
Signalling lamps (Set of three)	5

- Current, voltage, power factor and frequency measurements shall also be transmitted, via the relevant Programmable Logical Controller (PLC) and the main PLCs, to the supervisor program for calculation, remote display or any other application.

401.5 UNINTERRUPTIBLE POWER SUPPLY (U.P.S)

Set of two U.P.S. systems each.

401.6 GROUNDING SYSTEM - LIGHTNING & SURGE PROTECTIONS

Shall be as described in the Common Particular Specifications.

401.7 PROTECTION OF MOTOPUMPSETS

The automatic shut off, of the motopumpsets shall be as described in the Common Particular Specifications.

401.8 ALARMS & SIGNALLING

Shall be as described in the Common Particular Specifications.

401.9 ELECTRICAL INSTALLATION FOR BUILDING

Shall be as described in the Common Particular Specifications.

PART 5
INSTRUMENTATION AND CONTROL

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500. INSTRUMENTATION AND CONTROL: COMMON PARTICULAR SPECIFICATIONS - PUMPING STATIONS

500.1 PUMPING SYSTEM

The control system shall be designed and implemented on the following basis:

- All general circuit breakers (GCB), the corresponding MTS system, the circuit breaker for auxiliaries, the relevant signalling and electric parameters (voltage, current, frequency, power factor) shall be connected and/or controlled by one PLC unit adequately sized (PATs).
- For each motopumpset system, the circuit breaker (CBP), the starter, the suction and discharge motorized valves, where applicable, the discharge pressure, the discharge flow, the motor temperature measuring instruments, the relevant signalling and electric parameters (voltage, current, frequency, power factor) shall be all connected and/or controlled by one PLC unit adequately sized (PSC).
- One main P.L.C. unit (MPLC), shall be installed and connected to all PLC units through a communication bus, and shall be responsible for the automation and control of the pumping station/system according to the relevant parameters and variables.
- For each group of surface motopumpsets, and unless otherwise specified, the motopumpsets shall be operated cyclically and the maximum number of pumps simultaneously running is the total number of pumps less one pump.
- Where the pumping station consists of only one motopumpset system (borehole or surface), then this system and the electric ATS shall be controlled by the main PLC (MPLC) of the station.
- The Contractor shall supply one portable programming unit for the above PLC unit(s).
- The proposed equipment and add-in options shall offer and support cable redundancy on the network components.
- Where specified to lay down telemetry cables, they shall be drawn into ducts laid in the pipe trenches. Ducts shall be 63 mm Polyethylene (PE) pipe laid with 750 mm cover with draw pits at the ends and intermediately such that no length of continuous duct exceeds 100 m. Draw pits shall be installed at all changes of direction in excess of 22°.
- Cable route markers shall be installed at bends and along the cable length.
- Where the Contractor does not have a pipeline to install, he shall provide for the execution of all necessary civil works, trenches, etc... as described in the general specifications.
- In addition to the control and indication equipment (measurements display, alarms, push buttons, etc...) installed in the control room of the pumping station, this latter shall be designed to house a mimic panel representing the pumping system.

500.2 RESERVOIR / WATER TOWER

Each location of reservoir(s) / water tower shall be equipped with a remote terminal unit (RTU), adequately sized for the control of the water levels in the reservoir/ water tower, motorized valves and flow meter, etc. ...

500.3 CHLORINATION SYSTEM

Where a chlorination system is specified (at pumping station or reservoir/ water tower) then its controller shall be connected to the main PLC of the pumping station or the RTU of the reservoir / water tower for monitoring and supervision.

501. QARQAF WELL PUMPING STATION

- Reference: Control schematic No: 562W -101-I01
- Electrical schematic No: 562W -101-E01
- Hydraulic schematic No: 562W -101-M01
- Chlorination schematic No: 562W -101-M02

501.1 INSTRUMENTATION

The Contractor shall supply and install the following systems for the measurement of the operation parameters of the pumping installation, their local display and remote transmission.

501.1.1 Level Measurements

Location	Type	Qty (No)
Well (L1)	Piezoresistive	1
Well (LE)	Electrode	1 (set of 3 electrodes)
Reservoir (L2)	Piezoresistive	1

501.1.2 Pressure Measurements

Location	Type	Qty (No)
Well Motopumpset outlet	Manometer	2
Well Motopumpset outlet (P)	Piezoresistive	1

501.1.3 Flow Measurements

Location	Type	DN (mm)	PN (bars)	Qty (No)
Well Motopumpset outlet (F)	Electromagnetic	100	16	1
Well Drain (FS)	Flow Switch	13	16	1

501.1.4 Temperature Measurements

Location	Type	Qty (No)
Well Motopumpset electric motor	PT 100	1 (1 per motor)

501.2 CONTROL EQUIPMENT

- The main PLC shall have a provision for the connection to the RTU of reservoir / Water Tower.
- The control system of well pumping station shall use a cable link for the communication between the main PLC (MPLC) of well pumping station and the (RTU) of reservoir / Water Tower.
- The Contractor shall supply and install telemetry cables from well pumping station to the location of reservoir/ Water Tower.
- The Contractor shall supply and install a mimic panel showing the entire pumping system.
- The chlorine parameters (Vacuum switch, leakage detection, flow switch and or measurement, modulating valve...) shall be connected to the MPLC of well pumping station for control and protection.

PART 6

TRAINING, TESTING AND COMMISSIONING

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601. PUMPING STATIONS

601.1 TRAINING, TESTING AND COMMISSIONING

Refer to General Specifications, Volume 3, Part 6.

- 1) Testing and Commissioning of all Mechanical Equipment and installations.
- 2) Testing and Commissioning of all Electrical Equipment and installations.
- 3) Testing and Commissioning of all Controls/Instrumentation Equipment and installations.
- 4) Training of personnel.

601.2 WATER ANALYSIS

Reference : Pumping Station

Number of Analysis: 3 analysis

Type of Analysis : C3 + B2

PART 7

BOREHOLES

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TECHNICAL SPECIFICATIONS

3.2.1 GENERAL

3.2.1.1 PURPOSE AND SCOPE

The purpose of this document is to provide technical specifications for the construction, development, and testing of QARQAF well. The general location of the well is shown in Figure 1. The detailed plan of construction, completion and testing of the well has been prepared based on the results of the geological and hydrogeological survey performed in the study area. The aquifer targeted by Qarqaf well is the Miocene (mcg) which compromises conglomeratic deposits with alternation of clay and sand layers.

These specifications have been prepared based on the most recent information available regarding site conditions, drilling methods, and materials to be used. However, should the contractor have some reservation to any part of the specifications or well design, and is not prepared to follow the specifications as included herein, the contractor shall notify the consultant in writing before mobilizing to the project site.

The scope of work encompassed by these specifications consists of furnishing all plant, labor, equipment, and materials, in addition to performing all operations in connection with the drilling, sampling, constructing, developing and testing the well. The mandatory pre-bid meeting will allow potential bidders the opportunity to view the site and ask questions.

The well shall be drilled using a direct rotary drilling rig able to drill down to a total depth of 650 m in three phases specified below.

The Engineer will provide final well construction details to the contractor following review of mechanical grading analyses, isolated aquifer zone test results and geophysical borehole logs. All work is to be completed, and in strict accordance with these specifications and the attached drawings unless otherwise modified by the Engineer.

3.2.1.2 LOCATION, DEPTH, AND WELL DIMENSIONS

The planned well location will be in the center Qarqaf village near the water reservoir. The conceptual well completion diagram is shown in Figure 5. The contractor shall drill the well at the location indicated on the attached location maps (see Figure 1). The consultant will mark the exact field location of the well prior to mobilization. For the purpose of these specifications and bidding, the contractor may assume an approximate well completion depth of 650 mbgl based on current geologic cross sections. The contractor shall satisfy himself or herself by personal investigation of all local conditions affecting the work. Neither information contained in this section, nor that derived from maps or plans, or from the owner, the owner's representatives or

employees, shall relieve the contractor from any responsibility either specified herein, or from fulfilling any and all terms and requirements of the contractor's contract.

The borehole shall be drilled in three consecutive phases as shown below:

- From ground level to 20 mbgl using a 22" diameter bit,
- 20 to 200 mbgl using a 17,5" diameter bit,
- And from 200 to 650 mbgl using a 14.75" diameter bit.

The well dimensions and completion depth are as shown on the technical cross section (see Fig. 5) and shall be as specified herein. However, any of the various depths indicated herein may be increased or decreased by the Engineer in accordance with formations encountered during drilling and based on the results of geophysical borehole logging. In the event that drilling is authorized or ordered to a depth shallower or deeper than specified herein, a corresponding adjustment shall be made to the appropriate bid item cost within the contract.

3.2.1.3 LOCAL CONDITIONS - HYDROGEOLOGY

This well is proposed within the cadastral limits of Qarqaf area, near the existing water reservoir, at an approximate elevation of 230 masl. The well is expected to be situated entirely in the Miocene mcg aquifer which is more than 945 meters thick. Static water level is expected to be at 80 mbgl, as suggested by the hydrogeological survey conducted in the area.

Based on other production wells in the area of similar construction, the anticipated production capacity is approximately 10 l/s. The expected litholog of Qarqaf well according to the geological survey performed is shown in Fig. 2.

3.2.1.4 PERMITS, CERTIFICATION, LAWS, AND ORDINANCES

The contractor shall, at contractor expense, procure all necessary permits, certificates, and licenses required by law for the execution of his or her work. The contractor shall comply with all the Lebanese government laws, ordinances, or rules and regulations relating to the performance of the work.

3.2.1.5 PROTECTION OF THE SITE AND DISPOSAL OF WASTEWATER AND DRILLING MUD

Due to the proximity of the proposed well to agricultural lands, drilling activities shall be conducted in such a way as to prevent the introduction of pollutants to the ground surface during construction. Accordingly, any equipment or materials brought to the project area must be managed in accordance with the following procedures:

- Drip pans will be used to catch leaks and residual material in hoses and spigots under all stationary equipment. The drip pans will be checked daily and emptied as needed by reusing the substance or disposing of it properly at the contractor's expense.
- Hazardous materials spills will be contained immediately using sand, dirt or absorbent materials. Such spills will be cleaned up promptly along with the contaminant material and will be disposed of properly at the contractor's expense.

- Outdoor storage of all oils, solvents, cleaners, and other liquid materials shall be within secondary containment. The area should be covered, as necessary, to prevent storm water accumulation in the containment.
- Bentonite, cement, and any other powdered product shall be stored on pallets and away from any drainage path. The storage area should be covered and protected, if necessary, to prevent pollution runoff by wind or storm water.
- Chemicals, bagged material, or drums shall be stored on pallets within secondary containment.

Waste products generated during the drilling/construction work must be managed in accordance with the following procedures:

- Containerized waste will not be allowed to overflow. Any waste that requires storage in containers shall be removed from the project area on a regular basis and disposed of at an approved facility at the contractor's expense.
- Cleaning of the drilling rig, cement/bentonite mixtures, tremie pipe, and any other equipment shall be conducted within a fully contained area or outside the project area in a place approved by the consultant.
- Waste bentonite or cement must be removed from the project area prior to completion of the work.

The use and maintenance of drilling rigs and support vehicles shall be in accordance with the following procedures:

- Fueling of vehicles and equipment will be performed on site at designated areas. During fueling operations, drip pans will be used to catch leaks. "Topping off" of fuel tanks is not allowed.
- Maintenance of vehicles will be performed within designated areas to be approved by the consultant. Drip pans will be used during maintenance activities to catch any leaks.
- Daily inspections of drilling rigs and support vehicles and equipment will be made to check for leaks. Any leaks detected shall be fixed immediately.
- All contractor's employees shall be educated in the proper handling and storage of construction materials used during the project.
- Small spills shall be soaked up using absorbent materials and disposed of properly at the contractor's expense. Washing down or burial of spills is not allowed.

Except as otherwise provided herein, the contractor shall protect all pipelines, trees, and, as much as possible, shrubbery during the progress of the work. At completion of the work, the contractor shall restore the site to its original condition. The contractor shall use best industry practices for the protection of the well site during work activities and shall take whatever measures are necessary to ensure that work activities do not affect surrounding areas.

Disposal of drilling cuttings and excess drilling fluid shall be by spreading once the drilling rig has been demobilized. The contractor shall not allow fluids to flow either off the site, into nearby creek beds, or onto improved roadways.

3.2.1.6 SITE SECURITY

The contractor shall make adequate provision for the protection of the work area and the borehole, well against fire, theft and also for the protection of the public against exposure to injury.

3.2.1.7 SOURCE OF WATER

It shall be the contractor's responsibility to provide and maintain, at the contractor's own expensive, all water supply used for construction and domestic consumption. Before final acceptance of the well, all temporary connections and piping installed by the contractor shall be removed.

3.2.1.8 COMPETENT PERSONNEL

The contractor shall employ only sober, competent, and experienced workers for the execution of the work, and all such work shall be performed under the direct supervision of an experienced well driller satisfactory to the Engineer.

3.2.1.9 CLEARING UP AND CLEANING OF WORKSITE

Throughout the entire drilling, construction, development and testing process, the contractor shall maintain site cleanliness and shall not allow dirt, debris, waste or rubbish to accumulate. The contractor shall provide adequate trash receptacles at the job site to ensure proper housekeeping of the site is maintained on a daily basis. The contractor is responsible for disposal of all trash generated by workers or subcontractors at the site. A waste disposal bin of sufficient size, equipped with a locking cover, shall be located at the worksite at all times. The trash receptacle shall be emptied weekly, or as necessary, during the progress of work and the completion of the work. The cost of all disposal shall be borne by the contractor.

3.2.1.10 CONTRACTOR'S HEALTH AND SAFETY

The contractor shall provide all necessary materials and working in safe conditions for equipment and workers.

3.2.1.11 CONSTRUCTION INSPECTION

The contractor will be required to contact the Engineer at various stage of construction for the purpose of job inspection, including equipment, construction materials, mud products, cementing jobs.

3.2.2 DRILLING METHOD AND EQUIPMENT

3.2.2.1 SELECTED METHOD AND EQUIPMENT FOR DRILLING

The well shall be drilled by the reverse circulation drilling method using modern-day technology for drilling, construction, materials, and development. The contractor shall provide a direct circulation drilling unit, complete with all tools, accessories, power, lighting, water, and any other necessary equipment for the completion of the work. The contractor shall provide experienced onsite personnel necessary to conduct an efficient and safe drilling operation.

The contractor shall furnish, with the contractor's bid, a complete list of equipment that is proposed to be used in the performance of the work. After award of the contract, the work shall not proceed until the Engineer approves the proposed

construction method and is satisfied that the proposed equipment is adequate for the work and will be at the site when needed.

All equipment should be in good working condition and approved by the Engineer. The list of equipment includes the following:

- Working capacity of the mast (for powerhead rig, the pullback should be more than 70000 lbs. and the pulldown not less than 30000 lbs.
- Total available rig horse power.
- Compressor specifications (to be rated at 1070-1250 CFM at 350 psi minimum).
- The mud pump should have a pumping capacity of about 600 GPM, the minimum accepted is a duplex pump 7¼" x 12".
- Pump curves for the submersible pump to be used in the pumping test.
- Type and size of required shale shakers.

The contractor shall also submit a proposed drilling program and drill string components:

- Type or types of drill bits to be used for each phase (to mention the IADC code and the bit condition, used or new).
- Diameters, total length and number of stabilizers, drill collars...
- Size and type of drill pipes (OD, ID, length, weight of single, thread type).

In the drilling program, the contractor shall specify the drilling method that he/she redeems as the most efficient for the drilling operation. If air-based drilling fluids were used, the air compressors or boosters have to be able to lift the water column in the well. In this case, the contractor will be responsible for any technical problems which might result in the collapse of the borehole walls. In any case, any changes in the drilling program should be subject to the Engineer approval.

The following characteristics should be ensured for the well to be considered acceptable:

- The well should be vertically straight,
- the upper 200m should be completely isolated by cement,
- the casing should be safely set to total depth,
- the aquifer should not be contaminated by chemicals,
- the wall cake should be less than 1.6 mm;

The well has to be finished within reasonable time. No delays or work stoppages will be tolerated. The contractor shall be held responsible and payment may be withheld for damages done to the well due to any cause of negligence or faulty operation.

3.2.3 SAMPLING

Geological samples of 500 g (dry weight) shall be collected at 3m intervals, as well as on the principal geological boundaries. A smaller interval could be selected if deemed necessary by the Engineer.

For the collection of samples, a double decked shale shaker shall be installed that will help in sorting the cuttings and in obtaining a better representative sample of the encountered formations. Moreover, samples could be collected from the flow line directly to be diluted if deemed necessary by the consultant's representative.

Samples shall be first sun- or oven-dried, then packed in appropriate bags with clear labels indicating their time of collection and depth interval, to be stored in a safe place. These will be analyzed by the site engineer of the consultant.

The Contractor shall record the depth of any zone of lost circulation for which no sample was taken.

A log of the rate of penetration, in minutes per meter drilled, shall be kept. The depth of any voids, or of particularly rapid penetration, or significant changes in rig noise indicating changes in geological conditions, shall also be recorded.

3.2.4 WELL PROGRAMME

The well shall be constructed using the direct rotary drilling. Prior to the beginning of the drilling operation, all equipment supplied by the contractor shall be inspected by the Engineer to be suitable for the specified drilling operation. The replacement of any equipment later found to be unsuitable shall be at the contractor's expense.

The construction sequence of the well shall include but shall not be limited to the following:

- Drilling 22" hole from ground level to 20 m depth.
- Installing 18" ID x 6 mm conductor casing to 20 m, and cementing same to surface.
- Drilling 17½" inch hole from 20 m to 200 m.
- Geophysical logging.
- Installing 16" OD casing to 200 m depth and cementing same to surface.
- Drilling 14¾" hole from 200 m to total depth to 650m.
- Geophysical logging.
- Installing 12" nominal (12.75" OD) casing (350) with 300 m shutters louvre type (horizontal bridge slotted) screen 12.2% opening area, 1.5 – 2 mm slots.
- Verticality and alignment test.
- Development test.
- Step drawdown test.
- Constant rate test.
- Chemical and bacteriological analysis.
- Final well report.

3.2.5 SITE PREPARATION

In-the-ground pits are chosen for the fluid settlement. These shall be excavated on site in the specification shown in the schematic arrangements (**Fig. 3** and **Fig. 4**).

This arrangement is a subject to some modifications, depending on the functionality of the system. Any modifications shall be approved by the Engineer. Given that the site can accommodate the space needed for the mud pits, the metal mud tanks system is not necessary.

3.2.6 DRILLING FLUID PROPERTIES AND REQUIRED EQUIPMENT

The well shall be drilled using water-based drilling fluid based on bentonite. Other additives shall be used if approved by the Engineer. The requirements mentioned in the following sections are reduced to minimum (mud properties measurement and equipment).

If any drilling additives are used in the circulating medium, the time of day and depth of the borehole shall be recorded on the driller's daily report, and a strict accounting shall be kept of the materials used.

Drilling fluid additives, if approved for use, shall have such properties as to be adequate to form a thin but effective filter cake to coat the walls of the borehole to prevent water loss, to support the borehole wall to prevent caving, and to permit the recovery of representative samples of drill cuttings (formation materials). If there is a conflict between adjusting the drilling fluid properties for the ease of drilling or maintaining the proper drilling fluid properties for the protection of the aquifer, the protection of the aquifer shall prevail. The contractor shall make every effort to prevent the penetration of mud filtrate into the potential aquifers to be screened.

All contractors are required to make themselves aware of local drilling conditions and are required to be prepared with the proper drilling bits and necessary associated equipment.

3.2.6.1 DRILLING FLUID ADDITIVES

The yield of a bentonite is defined by the mud volume, at 15 CP viscosity, prepared using 1 ton of bentonite. A good yielding bentonite would yield 18 m³/ton and medium yield bentonite would give 8 m³/ton. It is advised to use 75-85 kg bentonite per 1 m³ of water.

In order to improve the bentonite yield, the used water should be treated before mixing the bentonite:

1. Water hardness:

If the total hardness of water (calcium + magnesium) is more than 100 mg/l, the water to be treated with Soda ash (Sodium carbonate Na₂CO₃). Usually needs 0.8 – 1.2 kg/m³ Na₂CO₃. As a rule, 4.53 kg of Na₂CO₃ will lower the Ca⁺⁺ cation by 100 mg/l in 16 m³ water.

2. PH value:

The pH of fresh water is in the range of 7. The water to prepare the mud (water base) should be in the range of 7.5 to 9. This is achieved by treating the water with caustic soda (NaOH), usually used 0.71-0.85 kg/m³ NaOH for

treatment. It is worth noting the water hardness should be treated before the pH.

3. CMC (optional): The carboxyl methyl cellulose is a polymer used as viscosifier and as a filtrate reducer. It is used in the range 6-8 kg/m³.
4. Optional used of:
 - Lignosulfonate as thinner (viscosity reducer).
 - Potassium chloride KCl as shale swelling inhibitor (at 3-5%).
- The expected total hole volume (to 650m) will be around 74 m³. But the mud chemicals should be calculated to higher values (calculated to 130 m³ mud) (Roscoe Moss Company, 1990):
 - Bentonite: 85 x 130 = 11050 kg.
 - NaOH: 90-110 kg (depending on water, PH).
 - Na₂CO₃: 104-156 kg (depending on water hardness).
 - CMC: 780-1040 kg.

Other acceptable drilling fluids include:

- A BENTONITE-PAC water base drilling fluid is also suggested to be used: The PAC (Polyanionic polymer) is a high purity sodium carboxy-methylethyl cellulose (98% pure). Comparing PAC to CMC, CMC is unpurified anionic polymer containing up to 40% salts (Sodium chloride and sodium glycolate).
- ANTISOL is the most common industrial PAC product. Some of Antisol benefits are:
 - Compatible with fluids of varying salt content.
 - Compatible with many additives as bentonite, barite and chalk.
 - Reduces foaming under shear.
 - Ensures effective dispersion of clay particles.
 - Forms thin and flexible filter cake at the interface.
 - Prevents swelling of shales formations.
 - Protects the drilling fluid against salt contamination.
 - Reduces loss of fluid.
 - Stabilize the borehole.
 - Stable at high temperature.
 - Efficient removal of cuttings, and keep cuttings in suspension when pumping stopped.
 - Easily adapts to different geological formations (gravel, sand, shale...).
 - Available at wide range of viscosity from high to low.
- To prepare a bentonite-Antisol mud, the bentonite at 20 kg/m³ should be blended and the Antisol will be added at 1-2 kg/m³ (depending of Antisol type), slowly as powder while mixing to the blended bentonite. The addition of Antisol should be only after at least 2-6 hours of bentonite blending.
- The Antisol may be used alone at about 1-5 kg/m³, without bentonite, resulting in a good polymer mud (effective viscosity and filtrate value...)

3.2.6.2 MUD PROPERTIES MEASUREMENTS

Whether or not drilling additives are used, the density, pH, and viscosity of the drilling fluid shall be measured and recorded a minimum of every 4 h during drilling or circulation of the borehole. The contractor shall provide the Engineer with an updated list of all products and the quantity of each product that is delivered to the site. The contractor shall record the type, time, and quantity of each product as it is used.

The drilling cuttings should be removed from the bottom and circulated out. For good drilling and good penetration rate (ROP), the circulating fluid shall not exceed the following parameters at any time:

- The Marsh funnel viscosity should be in the range 35-40 sec, this will give 13-17 cp effective viscosity.
- Density—1.02 to 1.08 kg/L, normal range. 1.14 kg/L, maximum
- pH, range 7.5 -9.

For this reason, the following equipment are required:

- Marsh funnel.
- Mud balance.
- Shale shaker, capacity 600 GPM.
- PH meter

3.2.6.3 EQUIPMENT HYDRAULIC PROPERTIES

The following characteristics are requested to improve the penetration rate and to ensure the effective removal of drilling cuttings:

- The annular velocity should be not less than 25 m/min. In the annulus 17.5” x 4.5” is required a flow rate about 3400 l/min (900 GPM), and about 2500 l/min in the 14.75” x 4.5”. For this well, it will be satisfactory to use a pump able to pump 2200 – 2500 l/min. The lifting capacity should be compensated by the mud rheological properties.
- 3 x 22 nozzles for the 17.5” bit (this will result in a pressure drop of about 16 bar at 2270 l/min flow rate, and the pressure drop in the system would reach 25 bar.
- 3 x 18 nozzles for the 14.75” bit. The pressure drop will be about 34 bar at 2270 l/min, and total circulating pressure will be around 50 bar (711 psi).
- Pump power:

The mud pump should deliver about 2270 l/min (600 GPM) at 50 bar (711 psi), the pump horse power will be equal to:

$$P = \frac{GPM \times psi}{1714 \times 0.85} (HP), \text{ where: } 0.85 \text{ is the pump efficiency.}$$

$$P = \frac{600 \times 711}{1714 \times 0.85} = 293 \text{ HP} = 222 \text{ KW.}$$

So, according to these data to choose the available pump type.
A 7.25" x 12" Duplex pump would be adequate.

3.2.7 WELL DRILLING, CASING AND CEMENTING

The well will be drilled, cased, screened and cemented according to what is shown in **Fig. 5**.

3.2.7.1 PHASE 22" HOLE

- 1- Drilling:
 - Drill 22" hole to 20m depth, using air or water or eventually percussion drilling.
- 2- Casing:
 - Install 18" ID steel casing, 6 mm thickness, to 20 m depth.
- 3- Cementing:
 - Cementing the annular 18" x 22" to surface at 1.9 kg/dm³ cement slurry, using water and dry cement at 26 sacs per 1 m³ water.

Theoretically, it will be needed, to fill the annular volume (1.61 m³), 2122 kg of dry cement mixed with 838 lit water using pouring method through 1.5" tremie pipe. But due to the hole enlargement, the quantities would be 150% in excess.

3.2.7.2 PHASE 17.5" HOLE

The drilling procedure of the well will be done as mentioned in **Fig. 6** alternative A or B.

- 1- Drilling:

The weight on bit (WOB) is essential on penetration improvement. One ton per inch of bit diameter is required (For 17.5" drilling, WOB should be about 17.5 tons). This weight should be equal to 80% of bottom hole assembly (drill collars) weight in the mud. As most available rigs have 30000 lbs (= 13.61 T) pull down in the air. For safe drilling, the WOB will be limited to about 5-6 Tons which will lead to lower penetration rate. Accordingly, the drilling string will be as follows:

- 17.5" bit (suggestion: Bit code 537 or 534 for insert bits, 437 or 434 for teeth bits), with 3 x 22 nozzles.
- 17.5" string stabilizer, 6-7m.
- 8.5" x 2 $\frac{13}{16}$ " drill collars, 255.5 kg/m, total length about 12m.
- 6.5" x 2 $\frac{12}{16}$ " drill collars, 155.5 kg/m, total length about 24m.
- 4.5" or 5" drill pipes.

The expected weight of the bottom hole assembly will be about 7.6 tons in air (16750 lbs), and the total string weight will be equal to 12 tons in air (26448 lbs).

2- 16" casing:

a- Specifications:

The casing is a grade B (35000 psi tensile strength), steel casing. The thickness is calculated to collapse resistance. As the expected outer diameter size to wall thickness ratio is more than 44.8 ($D/t > 44.8$), the collapse pressure is calculated to the elastic collapse equation (Eq 1) (Prirucnik Za Duboko Busenje, 1976).

$$P = \frac{2 \times E}{\left(\frac{D}{t}\right)^{3.045}} \cdot (\text{Eq. 1}), \text{ where:}$$

$E = 2.1 \times 10^6 \text{ kg/cm}^2$, steel elasticity modulus.

$D = \text{Casing outer diameter} = 16'' = 406.4 \text{ mm}$.

$t = \text{Wall casing thickness in mm}$.

$P = \text{The outer pressure in kg/cm}^2$.

Equation 1 is empirically derived from the theoretical equation for collapse (Timoshenko equation for a perfect cylinder):

$$P = \frac{2 \times E}{(1-\mu^2) \left(\frac{D}{t}\right)^{3.045}} \cdot \text{ , where } \mu \text{ is steel Poisson coefficient in the range of } 0.28 - 0.3 \text{ (Equation 2)}$$

The maximum external applied pressure on the casing is at the end of cementation is equal to:

$$P = \frac{(\gamma_c - \gamma_m) \times H}{1.0} \text{ (kg/cm}^2\text{)}, \text{ where:}$$

$\gamma_c = \text{the average specific gravity of cement slurry, } \gamma_c = \frac{1.86+1.5}{2} = 1.68 \text{ kg/dm}^3$

$\gamma_m = \text{the specific gravity of the mud in the hole, } \gamma_m = 1.05 \text{ kg/dm}^3$

$H = \text{the height of cement in the annulus.}$

$$\Rightarrow P = \frac{(1.68-1.05) \times 200}{1.0} = 12.6 \text{ kg/cm}^2.$$

$$\text{From equation (1): } P = 12.6 = \frac{2 \times 2.1 \times 10^6}{\left(\frac{406.4}{t}\right)^{3.045}}$$

Solving this equation, we get:

$$t = 6.24 \text{ mm}$$

as per API 5L standard, a 16" x 0.281" (=7.137 mm), grade B is chosen. So, this casing would have an internal diameter = 15.438 inch and 47.22 lb/ft weight = 70.294 kg/m. Its total weight in air will be = $200 \times 70.294 = 14058.8 \text{ kg} = 14.05 \text{ tons}$.

It is worth noting that the overburden pressure induced by high drawdown in the upper 200 meters in this well would be

accommodated by the cement and the casing thickness that is chosen with a safety factor of 1.14.

b- Running 16" csg x 0.281":

The first joint should be equipped with a float shoe with stinger for cementing the casing by pumping the cement through drill pipe having a male stinger at end. The float shoe should be equipped with a non-return valve (Fig. 7).

- The casing is lowered in the hole by means of:
 - o Spider and elevator: in this case a small plate to be welded on casing body which will be removed after welding each connection.
 - o Making holes in the casing body to hold the casing with adequate steel rounded axle. All opening should be rewelded back.
- An open hole centralizer 16" x 17.5" to be fixed at 5 and 10 m above the shoe.
- The casing should be filled up with mud while running to avoid floating.
- At top, the 16" csg should be centralized to 18" csg by adequate steel plates.
- Care should be taken to achieve the verticality and alignment of casing when welding.
- The welding should be performed by trained welders and by choosing the correct welding rods.
- When casing at bottom, pick up for about 0.3 m off bottom and land the casing on a rigid support at top.
- Break circulation through a circulating head if available, to check for flow and to clean the annulus from any debris.
- Run in hole with drill pipes with a stinger at bottom. A centralizer (38.5 cm diameter) to be fixed on drill pipe).
- Break circulation while slowly running the pipe, observe for the pressure, sting in into the shoe, the pressure should raise up, apply some weight on the pipe, and increase circulation to about 10 l/s and record the circulating pressure. Observe the return flow from the annulus 18" x 16" and if any return from the annulus pipe x 16" csg. Do not proceed for any cement job if there is return from the annulus pipe x 16" csg. A good practice is to hold the drill pipe with chains at top, to avoid sting out while cementing.

c- Cementing the 16" csg:

c.1- Cement slurry:

- The annular space around 16" casing will be cemented to surface

(200 m), using cement slurry (lead cmt) at 1.5 SG to cover the upper 100m, and followed by a cement at 1.86 SG to cover the lower 100m.

- The theoretical volume at SG = 1.5 is equal to 3.38 m³, and at 1.86 SG = 3.242 m³. Actually, there should be an excess 5 m³ of 1.5 SG cement (for any hole enlargement).
- To prepare 5 m³ slurry at 1.5 kg/dm³ SG, we need: 3.75 T (= 75 sacks) + 2000 lit water.
- Total cement = 157 sacks of 50 kg.
- Total water = 5850 lit.

c.2- Cementing procedure (**Fig. 7**):

The 16" casing to be cemented following a special procedure, using a stinger which is made up on drill pipe, and run to the 16" casing shoe. The success of the operation is related to many points which have to be guaranteed before, during and after performing the cementing job.

- Before the cementing job, the casing should be spaced out about 30 cm of bottom, and checked for any plugging at the shoe by circulation.
- The drilling mud to be conditioned by reducing the plastic viscosity and yield point, because the mud, in this case, is no longer used to carry cuttings. The surge effect is reduced and the risk of losses is minimized by decreasing the yield point of the mud.
- The cement pump should deliver a pumping rate equals or more than expected cementing flow rate. It has to be checked and tested before starting drilling the 17.5" hole.
- It is advised to run the last two casing joints (12 m) of 16" casing tubes with circulation to avoid plugging the casing shoe (in this case, a casing circulating head should be available).
- In order to make sure that the stinger do the job properly, the sealing adaptor and thread should be checked, also the stinger has to be tested into the stab-in shoe (**Fig. 7**).
- Make up and run in the hole with centralized stinger, pup joints should be prepared to use them, when spacing out. Establish circulation above stab-in shoe, then stab into the shoe and slack off. Establish circulation for 120% of the drill pipe string volume. Check and make sure that there is no flow between the drill pipe

string and the 16" casing. The mud should flow between the 18" casing and the 16" casing. If no losses are recorded and the mud is flowing normally, line up and switch to the cementing unit and start cementing as follows:

- a) Pump and circulate about 2 m³ water. This work as spacer mud and cement. In same time it will clean the annulus from any debris or heavy mud.
- b) Mix and pump the lead cement (4 m³ at 1.5 SG) (**Fig. 5**): when the lead cement gets at surface, divert the flow out of the settling pipe, to avoid mud contamination by cement, and stop mixing and pumping the lead cement without waiting to finish the total lead cement volume, because this volume is already overestimated.
- c) Immediately mix and pump the designed volume of tail cement (2.036 m³ at 1.86 SG) (**Fig. 5**).
- d) Displace the cement from the drill pipes by pumping the exact inner volume of the drill pipe to the shoe, using water or mud (the volume of 4.5" x 0.337" DP = 7.4135 l/m).
 - If available, a wiper plug could be dropped on top of tail cement in the drill pipes, and then perform displacement until the plug reaches the shoe.
 - From starting displacement until the end, the pressure will go up gradually and reaches its maximum at the end of displacement, when the annulus is full with cement, while the drill pipes are filled with water (it will be in the range of 7-8 bars for every 100 m cement in the annulus).
- e) Immediately mix and pump the designed volume of tail cement (2.036 m³ at 1.86 SG).
 - If any back flow is noticed, that means the non-return valve failed, hold back the pressure reached at the end of displacement for about 15 minutes or more according to the cement surface.
 - If no back flow, pull out one joint drill pipe and circulate through drill pipe using fresh water to clean the inner drill pipe string from cement, then start to pull out the stinger to surface.
 - Once the stinger at surface, hold the casing at its weight (no tension, and no slack down).

- Waiting on cement for about 48 hours depending on the cement samples setting time.
- The 16” casing will be welded to the 18” casing, as the final 12.75” casing will be landed and supported by both 16” and 18” casings.

c.3- Cement pump unit:

After waiting the cement for 48 HR, casing is held at its weight to CP18”.

The cement unit should be able to pump the cement slurry at a rate of 5-8 lit/sec. The pressure needed is about 34 bar.

3.2.7.3 PHASE 14.75” HOLE

- Drilling string: The bottom hole assembly will be the same as for the 17.5” hole, the bit will be 14.75” with some code as 17.5” bit, equipped with 3 x 18 nozzles.

The drilling of this section will be achieved using the hydraulic parameters and weight on bit mentioned here before.

At total depth, circulate one cycle (the hole volume) and pull out of hole.

- 12” Nominal csg:

A 12” nominal (12.75” OD), steel casing grade B, beveled end, will be used. The wall thickness is calculated to elastic collapse equation. The maximum external pressure is happened when the casing is empty and the external pressure is due to the hydrostatic pressure of a water column from surface to total depth, thus is $P = \frac{650 \times 1}{10} = 65 \text{ kg/cm}^2$. So, the collapse pressure will be as per equation:

$$P = \left(\frac{2 \times E}{D^3 \times 0.048} \right) (t) (\text{kg/cm}^2), \text{ where,}$$

$$E = 2.1 \times 10^6 \text{ kg/cm}^2$$

$$D = 12.75'' = 323.85 \text{ mm}$$

t = wall thickness in [mm]

$$\Rightarrow 65 = \frac{2 \times 2.1 \times 10^6}{\left(\frac{323.85}{t} \right)^3 \times 0.048}$$

Solving this equation, we get t = 8.52 mm

As per standard for line pipe, a 12” nominal x 0.344” (=8.737mm) wall thickness is chosen:

$$\text{OD} = 12.75'' = 323.9 \text{ mm}$$

$$T = 8.737 \text{ mm}$$

$$\text{ID} = 306.37 \text{ mm} = 12.062''$$

Weight = 67.91 kg/m.

As chosen the thickness $t = 8.737$ mm, the casing will be also safe for any formation collapse around the casing.

Screening:

The well will be screened using shutter or louver type screens. These screens should be manufactured from casing by perforating openings in such a way that no material is removed. As the name implies, the slots form horizontal louvers. In effect, these louvers represent small arches around the circumference of the screen. The slots are dense enough in the vertical direction that the arches are able to add to the collapse strength despite the openings in the horizontal direction. Thus, shutter screen is stronger in collapse strength than the casing from which it is made. It can be up to 60% stronger in configurations providing a higher number of openings per unit surface area. This is due to the corrugating effect of the louver-shaped openings.

Hydrodynamic collapse test data indicate that a 50% increase in strength over the theoretical value for blank casing is common if the standard eccentricity of 0.01 (1%) is used. These data also indicate that shutter screen is about 20% stronger than the theoretical value for blank casing, using the measured eccentricity of the specimen. Because the screen shape is complicated, a collapse pressure relationship based on theoretical considerations would be difficult to formulate. Manufacturer's test data should be consulted for actual values (typical values obtained from hydrostatic tests and three-edge bearing tests). To be conservative, a collapse strength for shutter screen can be assumed to be the same as for equal thickness blank casing.

Another characteristic of the shutter screen is that tight fitting swabs can be safely used to develop and redevelop wells. This is due to its high mechanical strength and full circular cylinder interior. For the same reason, wells can be repaired and deepened more easily.

Use of down-the hole cameras, model studies, and years of experience confirm that the Louver-shaped aperture resists clogging as well as, or better than, any other type of screen. Its shape is the same for any wall thickness. Better gravel control during installation, development, and operation is characteristic of shutter screen because of the hood-shaped, downward-facing orifice. Tolerance of the filter pack range is enhanced. Many wells have been successfully completed with greater than 80% of the pack capable of passing through the apertures. This latitude provides protection against variations in the gravel envelope gradation due to segregation or other reasons.

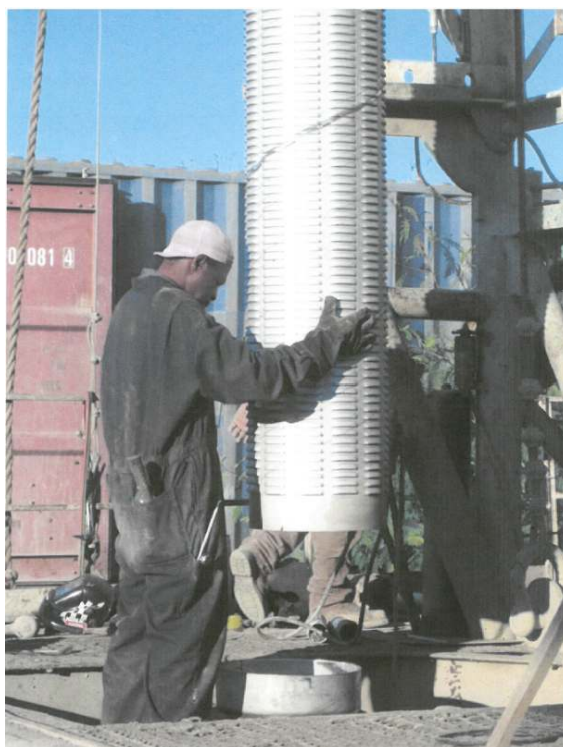


Fig. 1 – Shutter type screen

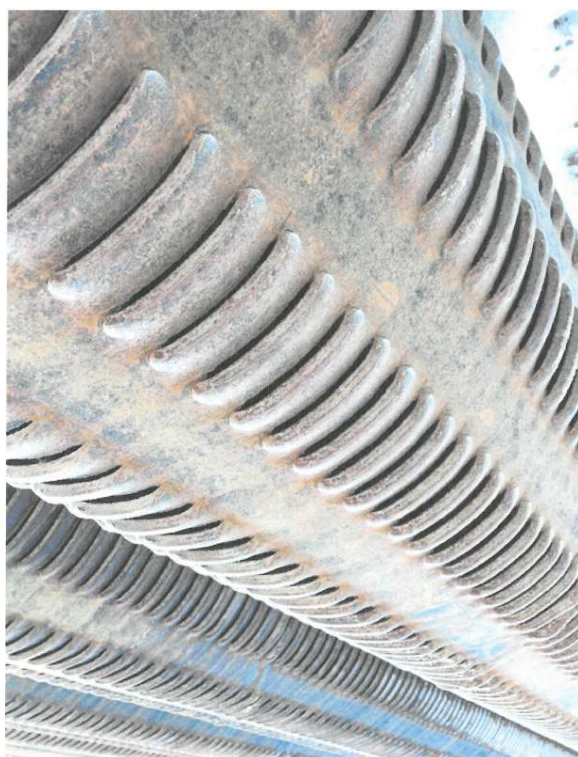


Fig. 2 – Shutter type screen

- Installation of the 12.75" casing and screens:

The casing will be run as follows:

- From surface 0 to 200m depth blank casing.

- From 200m to total depth 650m (=450m, 300m of which should be screened) the screens will be distributed in this interval depending on the formations and water bearing sections encountered during drilling.

Total screen = **300m**.

- The casing total weight in air will be around 44 tons.
- Total casing = **350m**.
- The casing should be landed at surface and supported without any slack down or tension up (to support only its normal weight) while holding the casing with crane, the casing should be centralized inside the 16" csg and welded together by means of thick plates.

3.2.8 VERTICALITY AND ALIGNMENT OF THE BOREHOLE:

All wells shall meet the two conditions of plumbness and alignment. In fact, it is not possible to align rigid pipes in a crooked well bore. In the event the bore is straight but considerably inclined from the vertical, pumps may not operate satisfactorily.

It is considered that:

- A deviation of 0.25% (25 cm per 100 m) is minor and seldom causes serious problems.
- Between 0.25% and 0.50%, the deviation becomes serious but not critical if the alignment is maintained.
- Beyond 0.50%, the deviation may cause severe wear on the pump.

Each well bore having a deviation equal or more than 0.50% shall not be automatically commissioned. The Contractor shall correct the straightness in regard with the required conditions.

Method of testing

There are many methods to measure well inclination and deviation such as, Totco, single and multi-shot, dummy method and plumb line method etc... The contractor shall specify in his bid the cost of the method he intended to use.

a) Alignment: Dummy method

- The Contractor shall lower into the well a section of metallic pipe 12 m long.
- The outer diameter of the pipe shall not be more than 1.3 cm smaller than the inside diameter of that part of the casing or hole being tested, when the nominal diameter of the casing is 25 cm or less.

When the nominal diameter of the casing or the well being tested is 30 cm or more, the outer diameter of the dummy shall not be smaller by more than 2.5 cm than the inside diameter of the casing or hole being tested.

Therefore:

for D (nominal diameter of the casing) ≤ 25 cm \Rightarrow hole diameter - d
(DUMMY) ≤ 1.3
for $D \leq 30$ cm \Rightarrow hole diameter - d (DUMMY) ≤ 2.5 cm.

b) Plumbness: Plumb line method

The test for plumbness shall be made with a plumb ring 5 to 6 mm smaller in diameter than the inside diameter of the well or the casing. The hub of the ring must not be solid, the water must pass through it as it is lowered in the well. It must be heavy enough to keep the plumb line taut (ϕ cable = 2 to 3 mm).

The cable shall pass through a guide pulley mounted on a tripod. The center of the pulley shall be exactly 3 meters above the top of the well and it shall be located in a way that the plumb line will come over the center of the well casing.

First the wire line is reeled out until the plumb is lowered 3 meters. The Contractor shall write down the new position of the cable according to 2 perpendicular diameter axes, marked with 4 reference points on the pipe's edge. The four reference points may constitute the four cardinal points set by a compass.

To facilitate the measurements of the cable position, the Contractor shall use a device like that shown in the enclosed figure. This device is a thick transparent plastic sheet on which a number of concentric circles are drawn. The larger circle corresponds to the outer diameter of the casing. The concentric circles shall have an equidistance of 20 mm.

As the plumb ring is lowered, the plastic sheet is rotated until the slot is oriented in the direction that the wire line tends to drift away from the center. Measurements along the edge of the slot can then be made every 3 meters, to determine the amount of drift as well as the displacement of the plumbing.

Example: Suppose that Pulley C is suspended 3 m above the ground and that plumb line E is in D at the center of the well (see figure 4).

If, after lowering plumb line E 3 meters into the well, cable A has drifted away 1.58 mm from the center ($1/16''$) of waterwell D, the deviation is thus equal to 3.175 mm.

If A is, for example, located at $1/16$ inch (1.58 mm) from the center D of the water well, when plumb line E is at a depth of 15 m, then the deviation is equal to $(1/16'' + 5/16'' = 3/8'')$ or 9.5 mm.

Generally, we shall multiply by $(n + 1)$ the cable's displacement value in order to obtain the extent of the deviation at 3 meters depth. It is noteworthy that the principle of the similar triangles allows to calculate the said deviation.

3.2.9 GEOPHYSICAL LOGGING

Geophysical logs shall be conducted by competent personnel provided by the contractor or by a commercial log service so as to compare the results with the existing lithological data, and to gather information about hydrodynamic characteristics of the aquifer formation, water-bearing zones, water quality (salinity), hole diameter, hole deviation.

- The required log in uncased borehole are the following:
 - Spontaneous potential log.
 - Resistivity log (short, normal, lateral)
 - Caliper log.
 - Gamma log.
 - Fluid resistivity.
- The required logs in cased borehole are the following:
 - Water temperature log.
 - Water conductivity log.
 - Deviation log.
- The contractor shall state clearly when submitting his bid:
 - The type and kind of equipment he intends to use as well as their characteristics.
 - The name of company which shall execute and analyze the measurements.

In all cases, the contractor shall specify clearly in driller's report all the results. Copies to be included in the final report. Two sets of logging to be performed during well execution (phase 17.5" hole and 14.75" hole) to get a full hole profile interpretation.

3.2.10 DEVELOPMENT AND PUMPING TEST

3.2.10.1 WELL DEVELOPMENT

General rules:

When mud is used as a drilling fluid, the well shall be washed with clear water through a direct injection at the base of the screen column. This operation shall last as long as water is muddy.

In some cases, washing shall be carried out under a high pressure (50 bars) with lateral jets that unclog the screen or clear out the filtering material from any plugging deposit. In this case, the Contractor must use a pump and jet tools, the technical specifications of which are submitted for approval. It is noteworthy, however, that the distance between the injector and the screen should not be less than 10 mm (**Fig. 8**).

This operation is essential before exploiting the drinking water well, it decreases to the maximum well and aquifer losses by eliminating fine particles of sand and clay detrimental to the operation of the well pump.

The development of the well will be done according to the following method:

- **Step 1: Injection of polyphosphate solution**

To remove the mud cake that is blocking the screens of the well, polyphosphates are used as dispersing agents. These chemicals disperse the clay particles in the drilling mud and break its gel properties which counteracts the tendency of the mud to stick to the sand grains. The polyphosphates that work effectively in helping mud removal are: tetra sodium pyrophosphate, sodium tripolyphosphate, sodium hexametaphosphate and sodium septa-phosphate (1966, Johnson).

About 2.3 kg are needed for each 100 gallons of water (1966, Johnson). Therefore, calculations should be made to decide on the amount needed for the well.

- The chosen solution (from the above-cited) should be injected through the pipe of the rotary machine, lowered to the bottom of the well.

- The pipe is removed progressively while the solution starts rising into the well.

- The chemical solution is kept in the well between 12 to 48 hours.

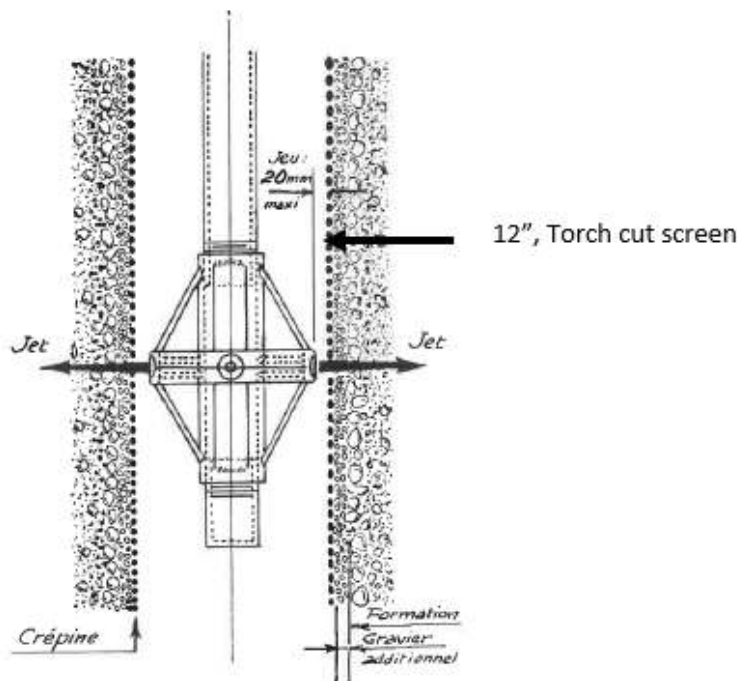
- The solution is finally pumped out.

The above procedure will allow the breaking of the mud from the walls of the borehole. The next step consists of developing the well through high-velocity jetting.

Step 2: High-Velocity Jetting

Jetting with polyphosphate solution (same as above) at high velocity is generally the most effective method of well development. It allows the removal of the mud cake from the borehole walls, that can be easily pumped out (1966, Johnson). The volume which will be injected in the well depends on the drilling machine pump capacity.

The jetting tool and its set-up are shown in the figure above.



The jetting procedure consists of the following:

- The jetting tool is mounted at the end of a pipe in which the polyphosphate solution is injected.
- The tool is lowered/raised gradually while rotating slowly and jetting water horizontally from its 4 nozzles, at high velocity, through the screen's slots (as shown in the figure). By proceeding gradually, the entire surface of the screen gets the vigorous action of the jet.
- The broken mud cake and residues are pumped out.

• Step 3: Progressive Over pumping

This process consists of increasing the discharge flow to exceed the projected yield. It shall only be applied to wells in alluvial or sandy soils.

The Contractor shall bear energy cost, installations and dismantling costs of the pump, discharge pipes, and electric cables...

The flows will start at 10 l/sec and will be progressively increased till 20 l/sec. The change of flow 10 to 15 and to 20 l/sec will be done once sand content of the water well will be less than 20 mg/l. Such procedure might last 1 to 5 or 6 days.

3.2.10.2 PUMPING TEST

The Contractor shall resort to a specialist Engineer to carry out a series of tests, and analyze the results according to the methods particular to each type of aquifer.

The parameters to be calculated are:

- Permeability (k)
- Transmissivity (T)
- Storage coefficient (S)
- Leakage coefficient.

Pumping tests require the measurement of several parameters:

- Time
- Water depth
- Flow

Pumping tests should allow the determination of the well losses (water well test) and the calculation of the hydrodynamic characteristics of the aquifer (aquifer test) so as to establish the yield of the water well.

3.2.10.2.1 Well test

The Contractor shall carry out a pumping test at different rates (step drawdown test) in order to determine minor losses in the water well and calculate the development efficiency regarding the flow. This is considered to be very critical. Pumps shall be of the electrical submersible type capable of supplying the flows mentioned below according to corresponding depths. The Contractor shall be responsible for the supply, installation and dismantling of the pumps at the end of testing.

The step drawdown test shall consist of up to four flow higher pumping steps of discharge. Each step shall be of approximately 4 hours duration and shall be followed by a period of recovery of not less than 2 hours. The maximal flow shall consist of several flow fractions (Q ; $2 Q$; $3 Q$; $4 Q = \text{maximal flow}$). During each step, the discharge rate shall be maintained constant.

3.2.10.2.2 Aquifer test

This test shall determine the hydrodynamic parameters such as transmissivity and storage coefficient. The use of at least one piezometer - when possible - near the tested well is recommended especially for the calculation of the storage coefficient, to establish the pumping production zone in the aquifer and the protection perimeter of the water well.

However, the installation of a water level measurement device during pumping is compulsory.

The constant rate discharge test shall be of seventy-two (72) hours duration or as directed by the Engineer. The lift flow must be as close as possible to the utilization rate of the water well, or slightly less than the critical flow previously determined in the step drawdown test.

The constant rate discharge test shall be followed by a recovery stage of a duration not less than twelve (12) hours. During the recovery stage care must be taken to avoid artificial disturbance to the water level in the test well and removal of the pumping unit must await completion of the recovery stage.

In the event of interruption of a stage or step during pump testing operations, for a maximum of 30 minutes per 24 hours, the Contractor shall repeat the test at a time to be decided by the Engineer. The Contractor shall bear the cost of any test that is interrupted where in the opinion of the Engineer the interruption is due to negligence by the Contractor or to failure, breakdown or inadequacy of any of the Contractor's equipment, or where the collection or recording of data or samples is unsatisfactory.

3.2.10.2.3 Discharge rate measurements

Water well discharges are measured either by calibrated volumetric flowmeters, or by the differential pressure method, orifice method or volumetric method. The Contractor should determine precisely and clearly in his bid the specifications of the equipment he intends to use as well as the accuracy of the measurements ($\pm 3\%$).

The static water level in each borehole shall be measured immediately before pumping. Throughout the duration of each test, the water levels and discharge rates shall be measured and recorded with the following frequency:

Elapsed time since beginning of	Minimal frequency of the flowrate measurement.
<ul style="list-style-type: none"> pumping process flow rate change 	
Between 0 - 2 minutes	every 30 seconds
Between 2 - 10 minutes	every minute
Between 10 - 20 minutes	every 2 minutes
Between 20 - 60 minutes	every 5 minutes
Between 60 - 120 minutes	every 10 minutes
Between 2 - 3 hours	every 15 minutes
Between 3 - 12 hours	every 30 minutes
Between 12 - 24 hours	every hour
More than 24 hours	every 2 hours

Measurements of water levels during pumping test shall also be made on observation wells (which may comprise existing boreholes, boreholes previously drilled under this

Contract and/or dug wells) not exceeding four in number and within a radius of 1 km from the pumped borehole. The frequency of measurement on such boreholes or wells within a radius of 200 m from the pumped boreholes shall be the same as that at the pumped borehole. Measurements of water levels in boreholes or wells at a distance greater than 200 m from the pumped boreholes shall be at one (1) hourly time intervals, the first measurements being immediately before and after pumping test has commenced.

3.2.10.2.4 Level measurements

Meters shall have a minimal precision in centimeters, and give a reading every 30 seconds.

The Contractor shall leave on site two meters to ensure the safety and the continuity of level measurements.

Levels shall be measured according to an easily identified mark kept unchanged. The probe used for water level measurements shall be brought down in the well inside an open and perforated pipe made of P.E. or galvanized steel, the lower part of which reaches the pump.

The Contractor shall clearly state in his bid the type of probes he intends to use and the pipes to be installed.

The Contractor shall abide by the following minimal frequency for water level measurements.

Elapsed time since beginning of the	Minimal frequency of the flowrate measurements
<ul style="list-style-type: none"> pumping process flowrate change pump stop (recovery) 	
Between 0 - 2 minutes	every 30 seconds
Between 2 - 10 minutes	every minute
Between 10 - 20 minutes	every 2 minutes
Between 20 - 60 minutes	every 5 minutes
Between 60 - 120 minutes	every 10 minutes
Between 2 - 3 hours	every 15 minutes
Between 3 - 12 hours	every 30 minutes
Between 12 - 24 hours	every hour
More than 24 hours	every 2 hours.

3.2.10.2.5 Time measurement

It is essential to connect closely flowrates and water level measurements with external phenomena that might affect the results, for example: operation or stopping of a nearby pumping station...

Flowrates and water level measurements shall be calculated in a relative time, in minutes and seconds, with respect to the starting of the pumping process, by means of a chronometer (tenth of a second). Incidents occurring during pumping (operation and stopping of pumping, flow variations, pump breakdown) shall be written down according to the absolute time, minutes and seconds given by a watch or a clock adjusted to the local hour. The Contractor will be responsible for supplying the equipment measuring relative and absolute periods of time.

3.2.10.2.6 Evacuation of pumped water

The pumped water shall be disposed of in an area far enough from the well undergoing pumping tests or located in a slightly pervious zone in order to avoid the return of the pumped water into the aquifer, which might alter pumping test results.

The Contractor shall evacuate at his own expense the water pumped during these tests towards the point of disposal determined by the Engineer.

3.2.10.2.7 Energy

The Contractor shall provide the site with an electrical generator supplying the pump with power during the entire period.

3.2.10.2.8 Pumping test

The well PUMPING TEST should be done when reaching the total depth. This test will be made after reaching the total depth of the borehole, and after installing the final casing and screens in their designated sections. This test shall be performed using a high capacity pump. It will be set at about 500m or higher, and should be able to insure a discharge rate of about 10l/s at 430m head. The pumping procedures (development, steps draw down, continuous pumping, recovery...) are the same as for the first test. All, flow and level, should be continuously recorded and later to be interpreted by an expert Engineer. A complete pumping test report should be presented completely in the final report.

3.2.10.2.8.1 Pumping tests

Pumping tests should be performed only in dry period of the year (between June and October).

A) Well Test (Step drawdown test)

The Contractor shall carry out a pumping test at different rates: 4, 6, 8 and 10 l/s.

Each step shall be run until reaching stabilization but not more than 24 hours duration and shall be of 4 hours duration and shall be followed by a similar time duration period of recovery.

B) Aquifer Test (Constant rate pumping test)

The constant rate discharge test shall be of 72 hours duration, and followed by a period of recovery not less than 24 hours. The lift flow shall be of maximum 10 l/s and shall be clearly defined upon the results of the step drawdown testing.

The submersible pump should be installed at a depth of 500 m, and should have a max head of 430 m and should be able to lift a max flow of 10 l/sec.

3.2.10.2.8.2 Pumping measurements and equipment

All measurements, such as Flow Measurements, Time Measurements and Water Level Measurements in the main well and the observation boreholes (piezometers), are recorded according to a preset plant. The details of which can be seen in the general specifications. All the details concerning the pumping and the accompanying measurements (during the development or all pumping tests) are recorded in the general specifications. The water recovery measurements are duly noted following the end of the pumping stage, as mentioned on the general specifications.

The Contractor shall provide all the necessary measuring devices that should be approved by the Consultant prior to the pump testing, in order to ensure the collection of accurate data by experienced number of technicians.

The Contractor shall also provide the necessary pump that would discharge the required amounts of water as well as a suitable electrical generator and fuel reservoir. A flexible polyethylene dip tube with a diameter of 1.5 inches shall be installed along with the pumps from 0.5m above ground level to the level of the pump assembly in order to measure the water levels inside the well. All the necessary maintenance of the generator should be done ahead of the pumping notably the Constant Rate Pumping Tests, which will be undertaken for 72 continuous hours without interruption.

3.2.11 WATER SAMPLES AND ANALYSES:

3.2.11.1 SAMPLING METHOD

Water samples shall be taken for the physico-chemical and bacteriological analysis. It is Sampling Method

Water samples shall be pumped water. It is advisable to take a minimum of 2 litres of water for the physico-chemical analyses and 250-500 ml of water for bacteriological analysis. Water will be sampled according to the indications of the laboratory or the Consultant.

The water samples for physico-chemical analyses will be collected in plastic or polyethylene bottles, whereas the bacteriological samples are collected in sterilized flasks by an approved laboratory.

The Contractor will install a regulating valve on the upper part of the pipe. The bottle in which water is sampled will be rinsed 3 times with pumped water before being filled. Each bottle will be hermetically sealed and carefully labeled indicating the name of the well, the date and time of the sample. The temperature of the flowing water is taken by a sensitive thermometer and it is also noted on the label so that the laboratory will include it in his results.

The regulating valve should be previously sterilized before samples are taken for bacteriological analyses. Each flask is filled once (without rinsing) and labeled again with the name of the borehole, the date and time. The samples are put in a cold box, stored under 4°C and not exposed to direct sunlight from the time of sampling to its final destination at the lab within a maximum time period of 24 hours.

Physico-chemical and bacteriological analyses should be carried out by a laboratory approved by the Consultant.

The samples should be taken during the constant rate pumping test after 24, 48 and 72 hours respectively from the beginning of the pumping tests.

3.2.11.2 REQUIRED ANALYSES

In order to determine the quality and suitability of the water several tests should be conducted that show the physico-chemical and bacteriological characteristics. These rules are laid down by the Lebanese Government and what the local laboratories are capable of. Most of these tests are quite known and inexpensive.

In order to study the physical characteristics of the water and the degree of contamination, the following analyses and measurements should be taken:

1-Bacteriological analysis:

- Thermotolerant coli forms
- Fecal streptococci coli forms
- Count of anaerobic bacteria revivable at 22° and 37° C
- Spores of sulfite-reducing anaerobic bacteria

2-Physico-chemical analysis: (C3)

a-organoleptic parameters:

- Appearance: odor, taste, color
- Turbidity

b-Physico-chemical parameters:

- Temperature
- PH-conductivity
- chlorides
- sulfates
- silica
- calcium
- magnesium
- sodium
- potassium
- aluminum

- DS
- Dissolved oxygen
- Free carbon dioxide (marble test or calculation of carbonate balance)
- carbonate

C-Parameters concerning undesirable substances:

- Nitrates
- Nitrates-Ammonium
- Permanganate value, hot, in acid medium
- Hydrogen sulfide
- Iron
- Copper
- Zinc
- Manganese
- Phosphorus
- Fluorine
- Residual Chlorine or any other parameter relating to the disinfection treatment

Interpretation of analysis(Potability):

The results will be compared to the values set by:

- EEC directives n.80/779/EEC-official Journal of the European communities, August 30, 1980. This directive groups together 62 admissible value parameters (guide level and maximum admissible concentration).
- WHO recommendations (Geneva 1986). Grouping parameters into five categories).
- French regulations (Decree N.89-3-official journal of January 3, 1989). This decree groups analysis type and tables of admissible physico-chemical and bacterio-logical parameters to the definition of water potability.

The approved laboratory should confirm, according to the total mineralization and PH, the action of water and temperature on the different metals.

3.2.12 WELL HEAD PROTECTION AND MANHOLE:

During the execution of the well, the contractor should provide a safety covering of the well.

Until the time of 12 inches casing installations, he shall provide a robust temporary cover which shall be securely fitted to be top of conductor pipe. The 12” casing top shall be secured with a threaded cover to the collar of the casing.

-Well head manhole:

The well head shall be equipped with a reinforced concrete inspection manhole impervious to water infiltration. The excess to the well head is ensured by a grooved galvanized steel placed on angle bars tightened to the inspection manhole. The cover shall be opened externally. A lock shall be placed in order to prevent access to the well head. The keys shall be manufactured according to the instruction of the engineer. Minimum size of the manhole= 1.5m x 1.5m inside clearance. The height from the bottom slab to the cover will be around 1.20m, depending on the expected final equipment. The well head designed is presented in appendix. Finally, all exposed metal parts on well head (casings, plates,

covers.....) shall be painted with 2 coats of black bituminous paint, and subsequent to fitting with a further coat.

3.2.13 NECESSARY DOCUMENTS:

3.2.13.1 DAILY DRILLING REPORT:

Throughout works executions, the contraction shall maintain a daily report recording all phases of works and references of used equipment, as well as the events shall be written down in a chorological order covering 24 hours daily. Two copies to be delivered to the engineer and the original copy shall be retained on site for inspection at any time during the contract. The contractor shall provide a format of that report when submitting his bid.

The daily report should contain the followings:

-Titles:

- company name
- date
- well name
- time since start
- midnight depth

-Bit record:

- size
- type
- nozzles
- depth in and out
- W.O.B
- RPM
- penetration rate

-pumps:

- SPM
- liner size
- pressure
- flow

-Drilling fluid:

- type
- chemicals used
- Density (specific gravity)
- funnel marsh viscosity
- Ph
- filtrate
- losses rate
- conductivity

-Drilling string:

- bottom hole assembly (drill collars sizes and numbers)
- Drill pipes
- reamer
- Drilling string weight (pick up and slack down weight)

- Deviation survey:
 - depth
 - deviation
- Time breakdown for 24 hours
- Formation samples:
 - Depth
 - Number
 - Description (Lithology)
- Remarks: To be used for special works or events:
 - losses (depth, rehabilitation.....)
 - casing running (size, grade, nominal weight, running operation.....)
 - cementing: slurry used, operation details
 - logging: type, depth....
 - Fishing jobs: description, tools.....
 - static level
 - development, pumping test (summary description)
 - accident
 - other events

The daily report should be signed by the contractor's driller and certified by the contractor's representative. A format of daily report is included in the annex.

3.2.13.2 FINAL WELL REPORT:

Before carrying out the operation prior to works commissioning, the contractor shall hand over to the owner a detailed final report of the works carried out giving a complete description of all the operations, and the measurements executed including the necessary interpretation and suggestions.

Presenting the final report in two copies, it should cover the followings:

- introduction
- location (x,y,z)
- work progress (operations time breakdown)
- geology of the well-lithology
- geophysical logging (results and interpretation)
- verticality and alignment (measurement data and interpretation)
- casing and screen report: specifications, installations
- cementing jobs: operation, cement slurries, displacement
- development and pumping test report: including all recorded data, used equipment, calculations, curves, interpretation
- water samples analysis (results and interpretation)
- conclusions and suggestions
- accident report
- annexes: -final well profile
 - final well head
 - photos or others.....

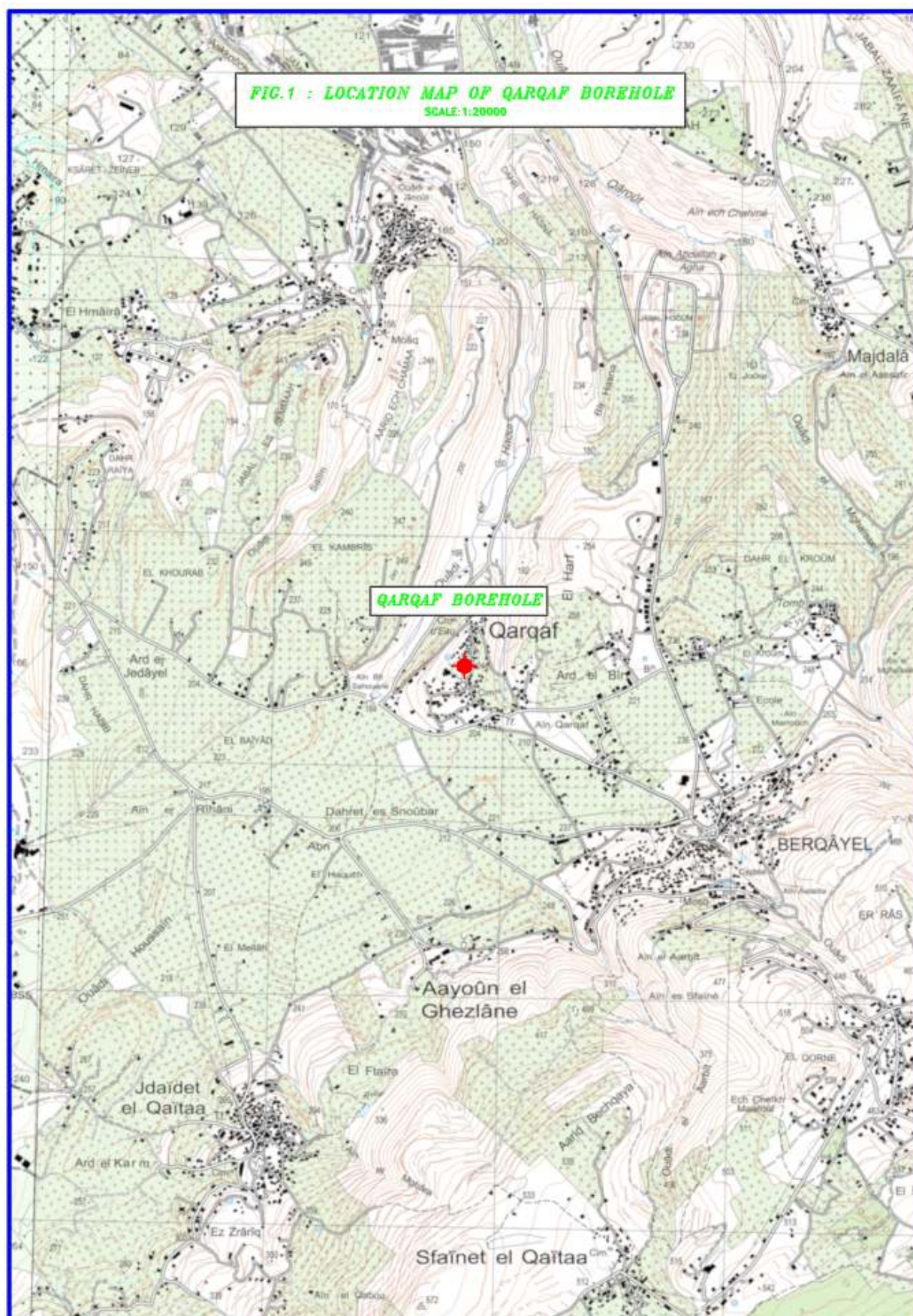
Within two weeks of the well completion, the contractor shall prepare and submit to the engineer for his approval a draft summary well report for his approval, and within two weeks of receipt of the engineer's approval, or amendments to the draft

summary report for the well, the contractor should provide to the engineer 5 copies of the final report

Control prior to works commissioning:

Before commissioning the well, the following shall be certified:

- the static water in the well
- the well depth
- control of well capping
- control of the site rehabilitation



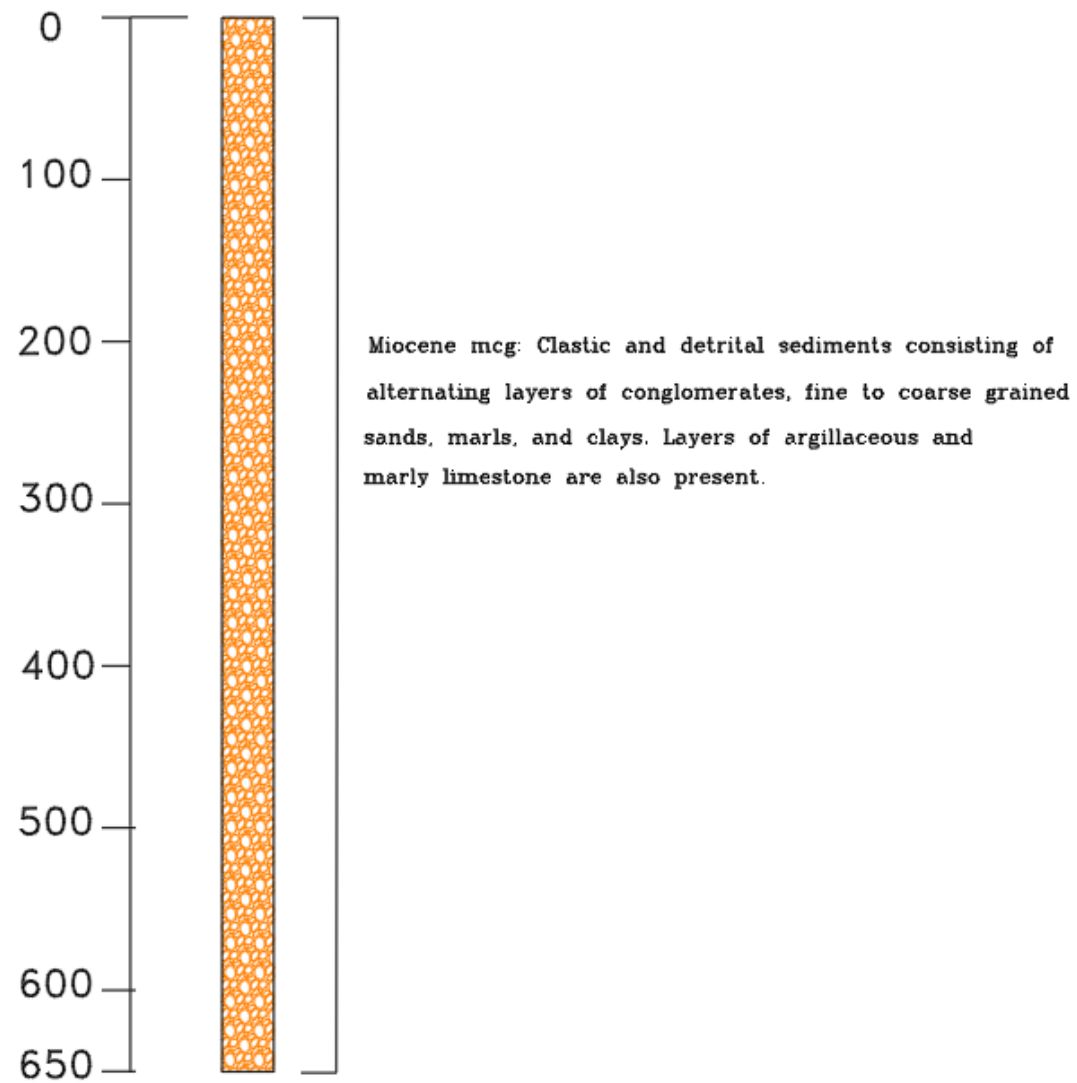
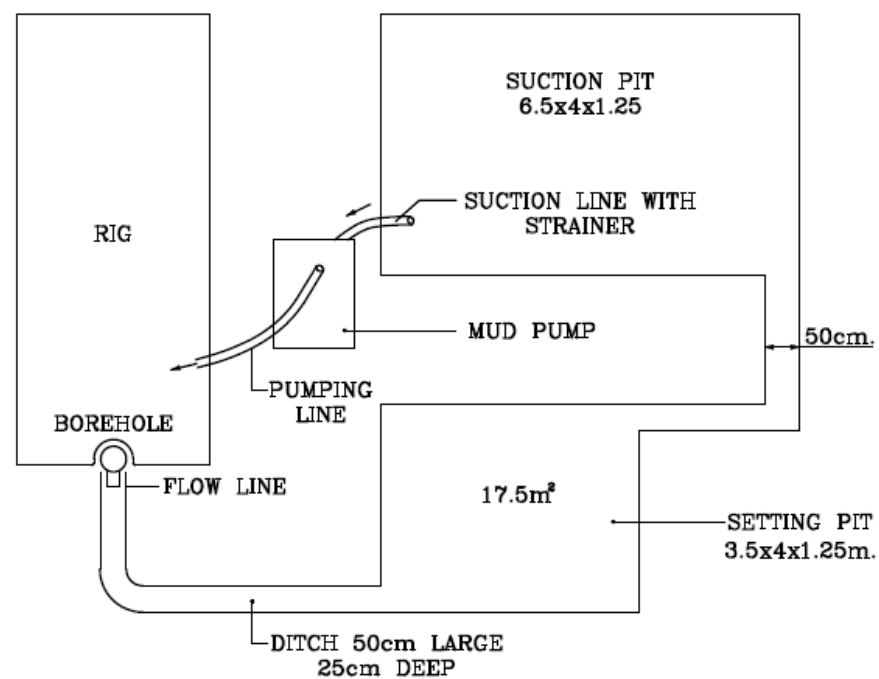


Fig.2 Qarqaf well LITHOLOG

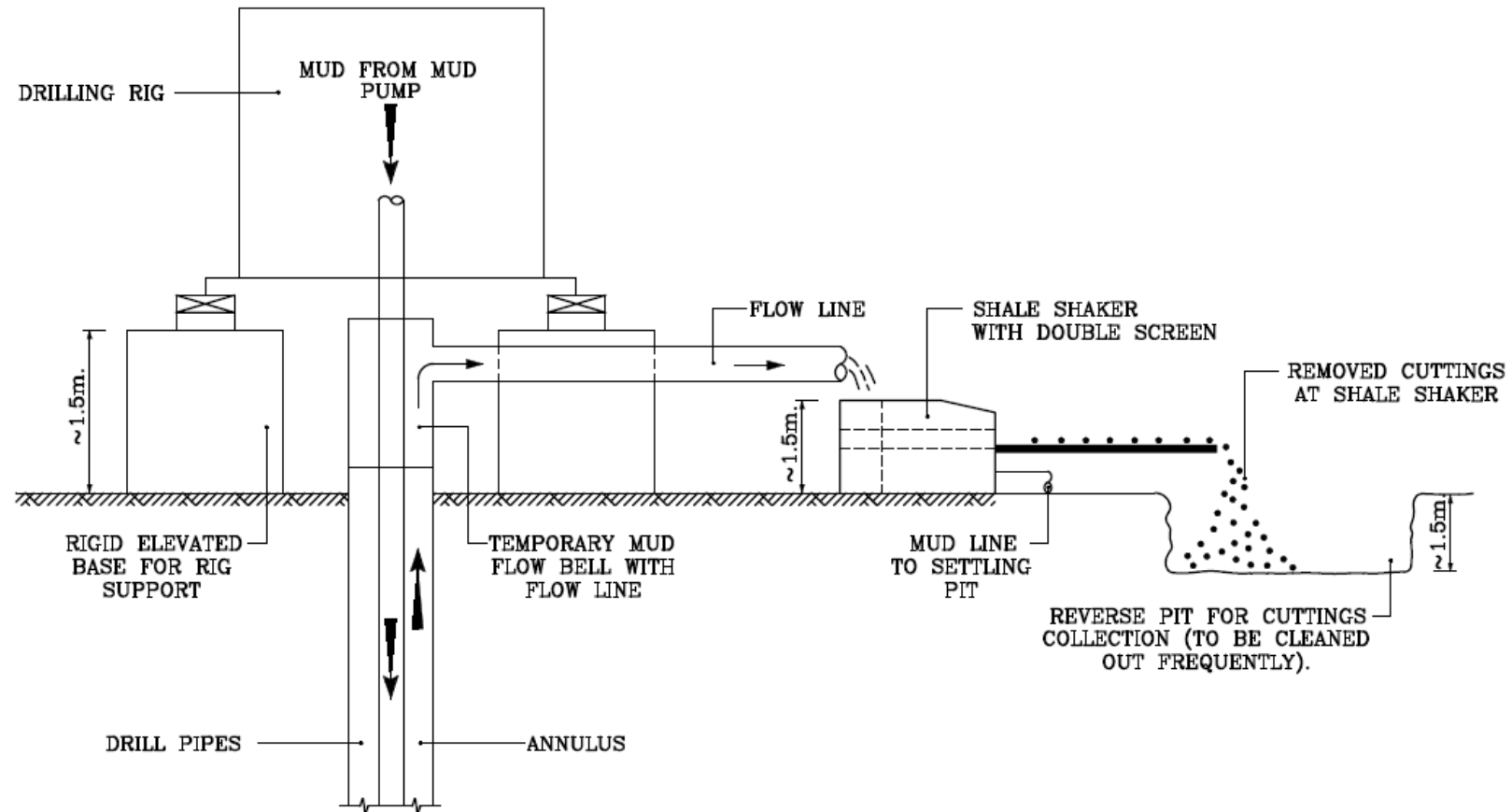
MUD PITS SCHEMATIC ARRANGEMENT

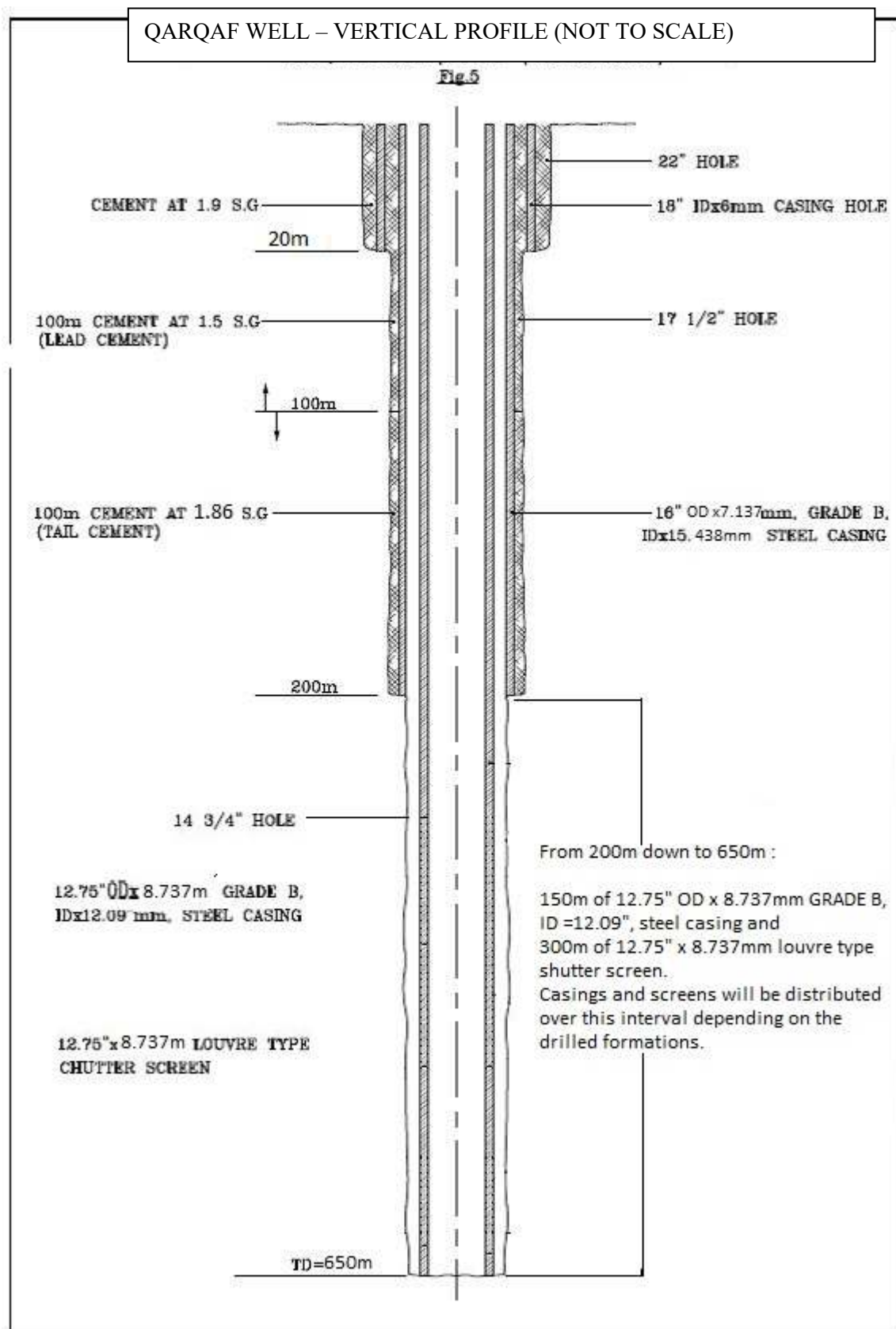
Fig.3



RIG POSITIONNING OF USING SHALE SHAKER

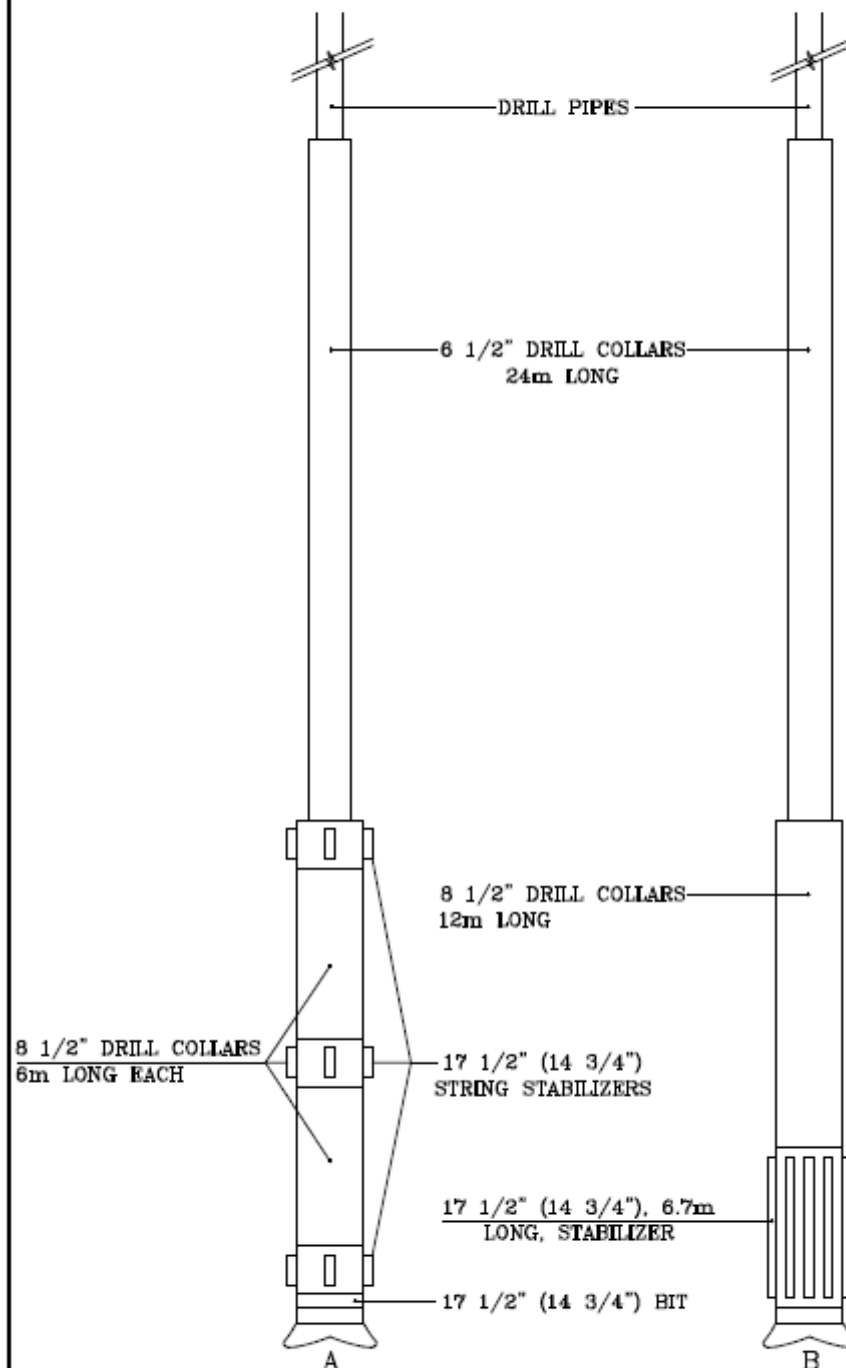
Fig.4





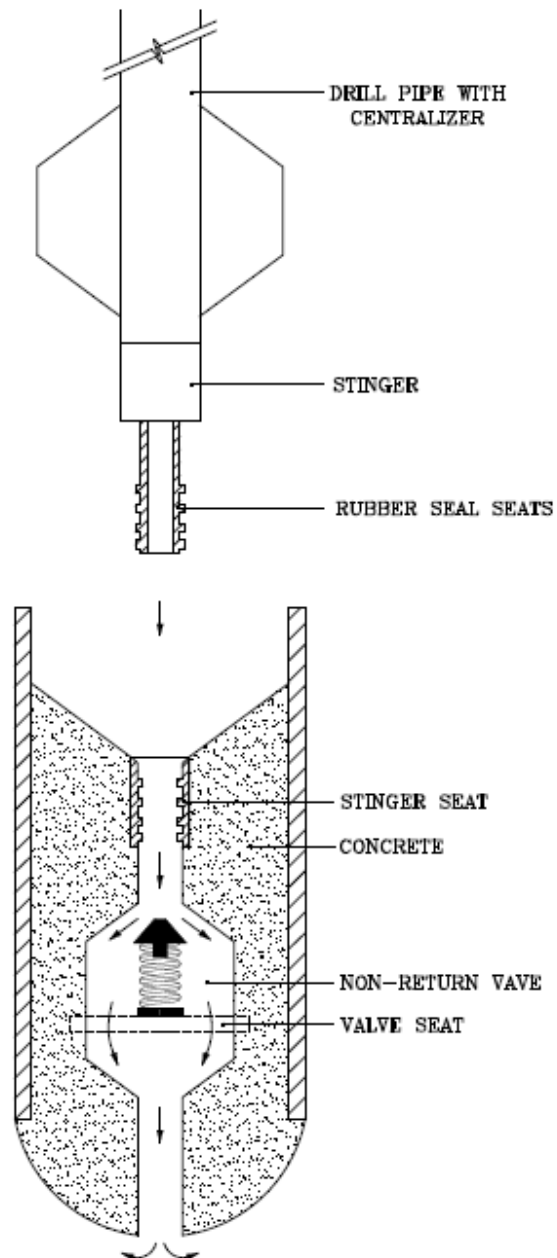
BOTTOM HOLE DRILLING ASSEMBLY ARRANGEMENT. A AND B ALTERNATIVES

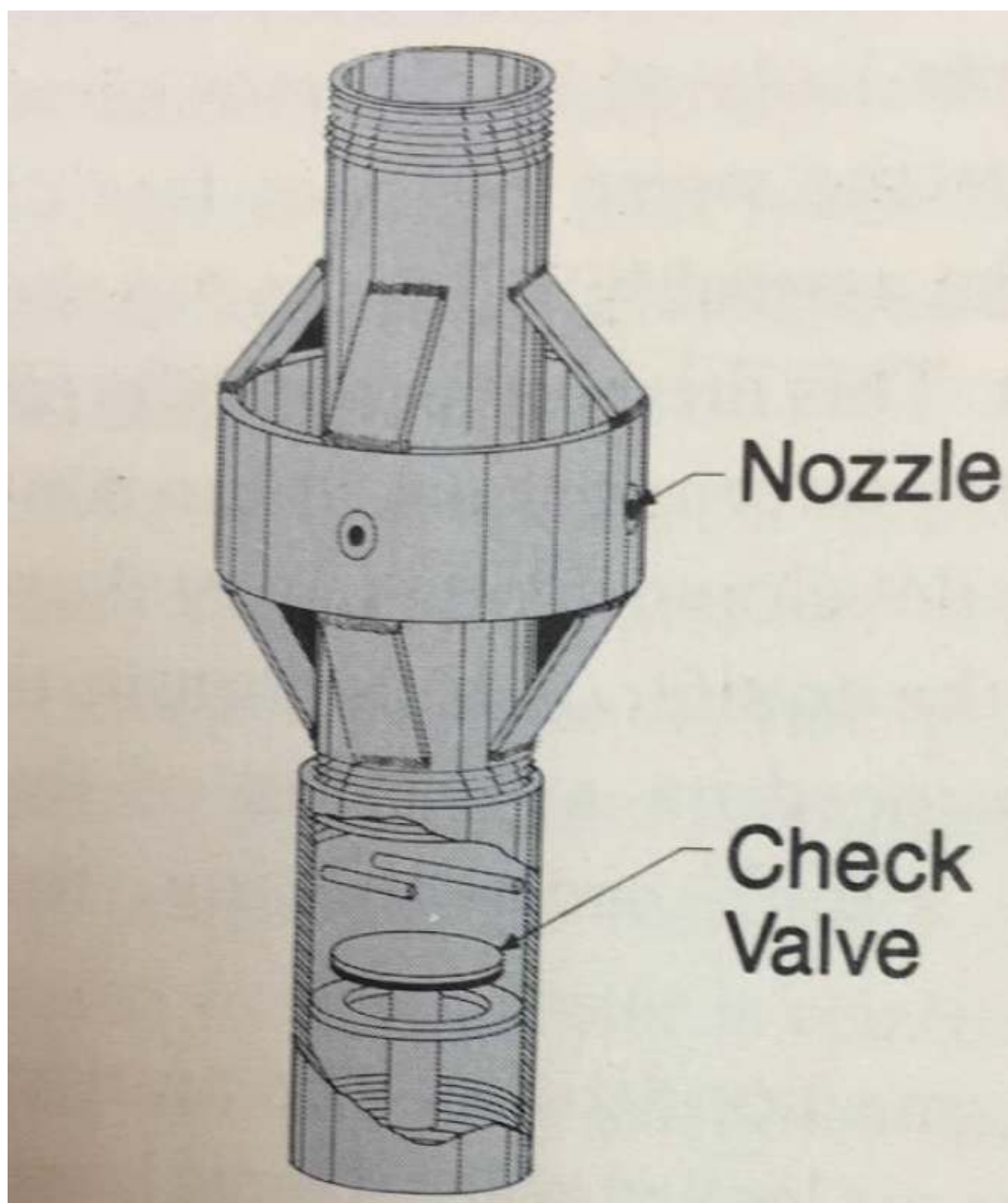
Fig.6




CEMENT FLOAT SHOE WITH STINGER

Fig.7





ANNEX 1

<div style="display: flex; align-items: center;"> <div style="width: 100%; border-left: 1px solid black; border-right: 1px solid black; height: 100%;"></div> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">50% of Width</div> </div>	<div style="display: flex; align-items: center; justify-content: space-between;"> <div style="width: 40%;"></div> <div style="width: 20%; text-align: center;"> <i>Width (2 meters min)</i> </div> <div style="width: 40%;"></div> </div>	
	REPUBLIC OF LEBANON MINISTRY OF ENERGY AND WATER	 <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="width: 45%;"></div> <div style="width: 50%; text-align: right;"> الجمهورية اللبنانية وزارة الطاقة والمياه </div> </div>
	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"><u>PROJECT NAME:</u></div> <div style="width: 50%; text-align: right;"><u>اسم المشروع:</u></div> </div>	
	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"><u>FINANCEMENT:</u></div> <div style="width: 50%; text-align: right;"><u>التمويل:</u></div> </div>	
	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"><u>CONSULTANT</u></div> <div style="width: 50%; text-align: right;"><u>الاستشاري:</u></div> </div>	
	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"><u>CONTRACTOR:</u></div> <div style="width: 50%; text-align: right;"><u>المتعهد:</u></div> </div>	
	<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <u>COMMENCEMENT OF WORKS:</u> <u>TIME FOR COMPLETION:</u> </div> <div style="width: 50%; text-align: right;"> <u>تاريخ المباشرة بالعمل:</u> <u>مدة التنفيذ:</u> </div> </div>	

Font: Helvetica, capitalized lower case, uniform size (3% of width)

Text layout: upper half in bold

Colors: background light yellow; CDR text in dark blue; all other text in black

Logos multicolor: maximum size: 10% of width

L.L = Max 40%
P.T = Max 10%

على ألا تحتوي على حجارة أو مواد صلبة يزيد حجمها عن 5 سم.

– تردم هذه المواد على طبقات بسماكة 20 سم وحتى عمق 60 سم ابتداء من طبقة الاساس وحتى الوصول الى كثافة 95% بروكتور معدل.

– من 60 سم وما دون ذلك تردم المواد الصالحة بسماكة 30 سم وحتى الوصول الى كثافة 90% بروكتور معدل.

ثالثا: فرش الطبقة الاسفلتية:

تفرش الطبقة الاسفلتية فوق طبقة الاساس على الشكل التالي:

نفس سماكة الزفت الموجود على الطرق على الا يقل عن سماكة 9 سم للطرق (الدولية والرئيسية والثانوية) وعلى ألا يقل عن سماكة 4.5 سم للطرق المحلية والداخلية.

رابعا: في حال عدم توفر الردميات المنصوص عنها في البند ثانيا يتم الردم بواسطة ردميات (sraoc esab bus) على ان يتضمن المواصفات التالية:

- معادل رملي لا يقل عن 40%
- التآكل (A.L) لا يقل عن 40%
- حد اللدونة (P.I) % 6 P.I xaM
- لا يزيد حجم الحجارة أو المواد الصلبة عن 5 سم.

– يتم الردم بسماكة 20 سم حتى عمق 60 سم ابتداء من طبقة الاساس حتى الوصول الى كثافة 95% بروكتور معدل.

– من مق 60 سم وما دون ذلك يتم الردم بسماكة 30 سم وحتى الوصول الى كثافة 30% بروكتور معدل.

– تدرج ضمن حدود المواصفات المطلوبة في دفتر الشروط.

مرسوم رقم 13495

تحديد دقائق تطبيق وتنفيذ المرسوم الاشتراعي رقم 68 تاريخ 83/9/9 (تنظيم أشغال الحفر لمد خطوط الخدمات العامة في الطرق وبراياتها)

ان رئيس الجمهورية،
بناء على الدستور،
بناء على أحكام المادة الثامنة من المرسوم الاشتراعي رقم 68 تاريخ 83/9/9 (تنظيم أشغال الحفر لمد خطوط الخدمات العامة في الطرق وبراياتها)،
بناء على اقتراح وزير الاشغال العامة ووزير الشؤون البلدية والقروية،
وبعد استشارة مجلس شورى الدولة (الرأي رقم 98/24-99 تاريخ 1998/10/22)،
وبعد موافقة مجلس الوزراء بتاريخ 1998/10/1،

يرسم ما يأتي:

المادة الأولى – مع مراعاة أحكام المادتين الرابعة والخامسة من المرسوم الاشتراعي رقم 68 تاريخ 83/9/9 (تنظيم أشغال الحفر لمد خط الخدمات العامة في الطرق وبراياتها) تطبق عند ردم اشغال الحفر المواصفات والشروط التالية:

أولا: في طبقة الاساس

- granular base coarse (T.V) :
- تردم بسماكة 30 سم على طبقتين تحت طبقة الاسفلت على أن تتكون كل طبقة من مواد صلبة مكسرة خالية من المواد الدلغانية (clay) وتتضمن المواصفات التالية:
- معادل رملي لا يقل عن 50%
- التآكل (A.L) لا يقل عن 40%
- تدرج ضمن حدود المواصفات المطلوبة في دفتر الشروط.

ثانيا: المواد الصالحة للردم:

تعتبر مواد صالحة للردم Suitable material المواد ذات المواصفات التالية:

المادة 2 - يبلغ هذا المرسوم من يلزم ويعمل به فور نشره في الجريدة الرسمية.

بعيدا في 5 تشرين الثاني 1998

الامضاء: الياس الهراوي

صدر عن رئيس الجمهورية

رئيس مجلس الوزراء

الامضاء: رفيق الحريري

وزير الاشغال العامة

الامضاء: علي حراجلي

وزير الشؤون البلدية والقروية بالوكالة

الامضاء: باسم السبع
