## TECHNICAL SPECIFICATIONS / DESCRIPTIVE MEMORIES

### SECTION 1 – CONTEXT AND INTRODUCTION

Before specifically addressing the works to be carried out, specifically the borehole, given the risk of occurrence of negative boreholes ***due to insufficient water and/or high salinity*** in the groundwater, Contractors must plan to carry out surveys to determine whether the sites are favorable for capturing groundwater through boreholes.

Research must be at least conduct the **geophysical survey and prospection**, and may be of another scope whenever necessary. The Contractor must include a specific item in the bill of quantities for the invoicing of geophysical surveys. It should be clear that the inclusion of geophysical prospecting in the list of quantities of the work situation implies carrying out the same and prior delivery of the respective report of the geophysical prospecting campaign to the client's representative (Inspector) and the client in writing and organize a moment for the evaluation and discussion of the findings and, in two days at the most, the data should be presented and the various options discussed in line with the results.

The contractor must present the instruments for the Survey, the drilling equipment and the respective materials necessary for drilling to be inspected at the shipyard located in the district where the works took place if applicable. All materials subject to submit manufacturing, inspection and certification certificates must be submitted. Unapproved materials will be removed from the work and if the inspection results in disapproval, the contractor will not be authorized to start work until the situation is rectified.

### PREFERRED LOCATION FOR DRILLING FOLLOWED BY A PREFERRED ALTERNATIVE LOCATION:

The contractor must only receive, through the Inspector, the list of locations confirmed by the District Government, where two preferred locations in the Community for the water point are indicated in order of priority. The geophysical study must prioritize the places indicated by the communities, however in the final communication of the place where the Contractor intends to carry out the drilling, or any other matter must communicate with the Inspector, who will facilitate, through the activists/volunteer team, access and contact with communities.

If the two locations indicated above by the community are not favorable for the construction of boreholes and the contractor intends to carry out drilling in a third location, he must first present the results of the two initial locations to the Inspector, justifying the reasons. If you intend to build on a third site, you must ask permission from the inspector who must coordinate with the activists/volunteer and with the knowledge of the SDPI and the community the indication or acceptance of an alternative third site.

Under no circumstances may the Contractor choose to start drilling without obtaining the BOREHOLE LOCATION CERTIFICATE duly signed by the Parties. Failure to display such a location certificate may mean the borehole is not recognized as a positive borehole and consequently non-payment.

The geophysical surveys to be carried out by the contractor must follow the following general methodology:

Methods to use:

i) Geo-electrical method (vertical electrical sounding – SEV and resistivity profiles)
ii) Electromagnetic method;

**METHODOLOGY TO BE APPLIED IN GEOPHYSICAL PROSPECTING:**

- Data base
- Cabinet Assessment/Recognition,
- Calibration using hydrogeological data from the zone
- **Fieldwork**: number of SEV's to be carried out per location, In rocky areas mandatory combination of resistivity profiles with SEV's.
- The use of electromagnetic profiles can be useful in rocky areas to locate faults/fractures (if the consultant has this type of equipment he can propose its use, although it is known that for deep aquifers the resistivity profiles are more conclusive).

The available equipment must be indicated in detail, presenting the basic data of its specifications (the Customer may request an inspection of the same).

Because data interpretation requires personnel expertise and equipment capability it is important that the Contractor has these resources available to reduce the risk of negative boreholes during the drilling campaign. The reports of the surveys carried out must be discussed with the Inspector, the Client's representative, aiming at greater coordination with the awareness that, the **Client assumes payment only for positive boreholes**.

### 1.1 Composition of Specifications

### A. Reference

These technical specifications concern the supply of water from groundwater abstraction, and include the following components:

- Drilling equipment (rig, compressor, mud pump...)
- Capture infrastructure (borehole)
- Pumping equipment, including pump attachment superstructure and discharge fittings.

### B. Topics

The design criteria presented in this document relate to the following stages of drilling a borehole:

- Shipyard inspection;
- Construction from the borehole;
- Equipment of a borehole, that is, the placement of the casing pipe (smooth and filter pipes), the filtering and sealing zone (cementation);
- Cleaning, development and testing of the flow rate of the borehole;
- Installation of Afridev manual pump;
- Construction of the platform and complementary works;
- Training of the maintenance group and delivery of the respective kits.

### Objectives

The design criteria were prepared in order to comply with the following parameters:

- The catchment scheme must be designed for a useful life of at least 20 years;

- The Positivos boreholes for groundwater abstraction must meet the expected water needs for 500 people in accordance with the SPHERE standard. Each borehole is sized considering that each beneficiary must have access to at least 20 liters/student(person)/day.
- The water quality must meet the requirements for water for human consumption, in accordance with the minimum standards established by MISAU/WHO.
- The use of the various available local water resources must be optimised.
- A well-designed groundwater abstraction project (borehole) may seem to take up additional time and make the work more expensive, but it turns out that, in general, it is worth it taking into account the capital costs, the recurrent operating costs , the social benefit and the period of life.

## SECTION 2 - GENERAL CONDITIONS

### 2.1 Borehole type

The finished borehole will be classified into the following types depending on lithology and geological formations:

**A - "Open" borehole – uncoated**

- Constructed in rock or consolidated formation, without filter tube but with smooth tube coating only in the layers from the top/soil to the contact with the consolidated or stable formation;

**B - Protected borehole in "at risk of collapsing or collapsible" formations**

- In fractured or fissured rocks, found in stable formations, lined with a filter tube to support the formation in the catchment area and lined with a smooth tube up to the mouth of the borehole;

**C - Borehole involved with uniform and granular gravel filter material**

- In unconsolidated formations (sediments), soft or very fissured rocks, with smooth tube and filter tube coatings, and placing a granular filtering material (uniform gravel selected by sieving) in the catchment zone and around the filter tube;
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NOTE:All boreholes to be constructed must be lined with piping indicated in the material specifications until otherwise decided by the Contracting Party.

### 2.2 Rocks and formations in Mozambique

**Stable formations are:**

a) Sound crystalline rock, such as: granite, gneiss, quartzite, basalts, rhyolites, etc.

b) Consolidated sedimentary rock, such as: compact sandstones, limestone and chalky formations, dolomites, etc.

c) Cemented laterites and ferrites.

**Unstable formations**

a) Fractured crystalline rock, such as: fractured gneiss, shales, fractured basalt, altered rhyolites, etc.

b) Fragile sedimentary rock: petrified sandstones, weakly cemented conglomerates, ferricretes, etc.

c) Unconsolidated formation such as: river sands, alluvium, transported sands, silts, loose laterites, etc.

### 2.3 Definitions of positive, negative, or abandoned borehole

A borehole is considered positive if it has potable water (suitable for human consumption) in accordance with MISAUOMS Water Potability standards and if it produces a minimum flow **of 1000 l/hour (17 l/min)** which is measured at the end of the borehole development process and confirmed during the flow test. If the borehole is not potable or insufficient

A borehole is considered negative or dry if it presents the following cases:

**a)** The minimum pumping flow of less than 1000 l/hour (17 l/min);
**b)** During the pumping test, the well does not sustain a minimum flow of 1000l/hr without draining within a time interval of at least 60 minutes;
**c)** The water quality is not acceptable, that is, if the minimum physical and chemical parameters to be tested are not within the ranges allowed for human consumption water by MISAU/WHO;

In such cases, a new drilling attempt can be **made by moving the probe to an alternative previously indicated location**. If the drilling proves negative again, the site may be abandoned, unless there is a special agreement between the parties. For all boreholes that result negative there will be no billing.

A borehole is considered abandoned if, due to technical problems, technology, conditions related to drilling, collapse of the borehole walls, breakdown of all or any machinery or equipment or any other reason, the borehole cannot be completed for reasons attributable to the contractor. In that case, a new attempt must be made, with no compensation or invoicing for the abandoned borehole.

### 2.4 excavation additives

Chemical foam and biodegradable (polymer) slurry are preferred over bentonite or other non-degradable slurries, primarily for environmental reasons. Using the latter, the necessary measures must be taken to avoid soil contamination.

### 2.5 Identification number

The borehole identification number must be provided by the Contracting entity (IOM with SDPI support), which must be physically engraved on the pump body and on the concrete platform, on a metal plate with minimum dimensions of 10 x 5 cm and with a thickness of 3mm. In the case of a solar electric pump, this number must be engraved in an alternative location, taking due care to ensure that it is inviolable. This number must appear in the reports that make up the borehole dossier to be delivered.

### 2.6 Reports

Contractors (drillers) must prepare drilling reports. It should contain information on: the geological formations traversed during drilling, the characteristics of the aquifers, the borehole yield, the water quality (physical, chemical and biological), the details of the borehole construction process and pump installation after the completion of the drilling.

After completing drilling in a given location (negative or positive borehole), the “driller” must systematically fill in the drilling dossier forms and submit them to the competent authorities for their approval (through the Inspection).

According to the Criteria for Construction of Wells in Mozambique, all drilling carried out for research or exploitation of groundwater must have a technical report, which must subsequently be shared with the authorities responsible for public works in the area (MOPH, DN Água, DPOPH, SDPI), so that the information is incorporated into the national database and also feeds the production sectors of hydrogeological information.

The Contractor shall complete the following forms during the construction process of the groundwater exploration source to be equipped with a hand pump:

- Form I Borehole location certificate,
- Form II Daily report of drilling activities,
- Form III Borehole completion report,
- Form IV Borehole development report,
- Form V Resulted from the flow test and water analysis,
- Sheet VI Pump installation report and sidewalk concreting,
- Form VII Provisional acceptance certificate,
- Sheet VIII Final acceptance certificate.

These documents must be the forms provided by the developer, completed in Portuguese, in the technical parameters indicated. Inspection is responsible for stamping all documents and submitting them to the project owner for approval.

Each constructed groundwater abstraction must have a process with all of the above forms. These documents must accompany the payment process and in the absence of any of them, invoices will not be accepted for payment.

## SECTION 3 - FINISHED BOREHOLE

### 3.1. final diameter

It is mandatory to maintain a minimum casing inside diameter of 102 mm (4") in the finished borehole, above and below the water table to allow the installation of a pump with a cylindrical diameter of 3”½ (89 mm).

### 3.2. Construction of Positive Boreholes

**Type B - Positive boreholes protected in formations at risk of collapse**

1) Percussion, air-cooled or mud-cooled rotation through the overlying layer (alluvium, laterite, very fragmented or soft rock), the final minimum diameter of the borehole must be 202 mm (8”);
2) Rotary percussion with down hammer on consolidated hard rock, the final minimum diameter must be 165 mm (6” ½);
3) Fractured rock – which contains the aquifer – is considered at risk of collapse and in need of protection using casing/filter tube (minimum internal diameter 102 mm (or 4”).
4) If necessary to prevent collapse of the overlying layer, a smooth pipe casing with a minimum diameter of 152 mm (6”) shall be installed,sealing the contact area of the coating with the rocky area with a thin mortar filling,backfilling with “tout-venant” landfill up to the top and cementing the final 5 meters at the top of the borehole.

**Type C - Borehole wrapped with uniform and granular gravel filter material**

1) Rotary percussion with air or mud cooling, through alluvium or unconsolidated rock, minimum final borehole diameter is 165 mm (6”).
2) A minimum annular space of 25 mm (1”) between the casing (outer wall of the casing pipe) and the walls of the borehole must be reserved for the installation of granular gravel filter material. A 2" or even 3" ring space is recommended;
3) Installation of the filter tube lining with a minimum internal diameter of 102 mm (or 4”);
4) Installation of gravel filter material up to at least 3 meters above the top of the first filter tube, followed by one meter of “clay material” to seal the contact with the upper part of the borehole,filling with “tout-venant” embankment up to the top and cementing the final 5 meters at the top of the borehole.

### 3.3. Borehole base (bag tube)

Positive boreholes must be drilled at least 3 meters below all aquifers or fracture zones in order to allow sufficient space for the sedimentation well. Whenever possible, Positive Boreholes should be drilled down to the rock underlying the aquifer zone, or if the rock depth is too deep, drilling may end up in an impermeable formation underlying the aquifer – for example, a clay layer.

The base of the borehole acts as a sedimentation well (bag tube) and support for the casing string, smooth tube and filter tube. The sedimentation well should be a smooth tube at least 1.5 meters long, with the same diameter as the filter tube, and with its lower end sealed with a “bottom plug” (wooden or PVC).

### 3.4. Preliminary design of the filter tube

The preliminary project for placing the filter tube must be determined in such a way as to avoid a lowering of the water level up to the lined section of the filter tube or below the first aquifer layer for water collection.

- The filter tube should normally be installed within the aquifer layer zone, as long as the lowering of the water level due to pumping does not reach the lower top of the filter tube or below the main aquifer.
- The groove for filter tubes is generally 1 millimeter, if the aquifer layer is made up of very fine sedimentary material (very fine sand or silt), the groove should be 0.5 millimeter.
- Notwithstanding the above, normally only the bottom 2/3 of the saturated layer is lined with filter tube.
- The length and position of the filter tube section affect the performance of the borehole. When the nature of the aquifer is well identified, the filter tube section must be designed in accordance with the nature and hydrostatic pressure of the aquifer.

The filtering area of the filter tube (open area) must have from 6 to 11% of the total area of the filter tube. The PVC material of smooth tubes and filter tubes must be of good quality (class 10). The thread must be trapezoidal with a length of 3", 3 threads per inch. The tube joints must be smooth without the “buchon” to allow the uniformity of the outer diameter of the tube column (see figure 1). Filters must be made in the factory mechanically with suitable equipment and techniques and not with hand-drilled slots. Filter slots must be uniform in width and length.

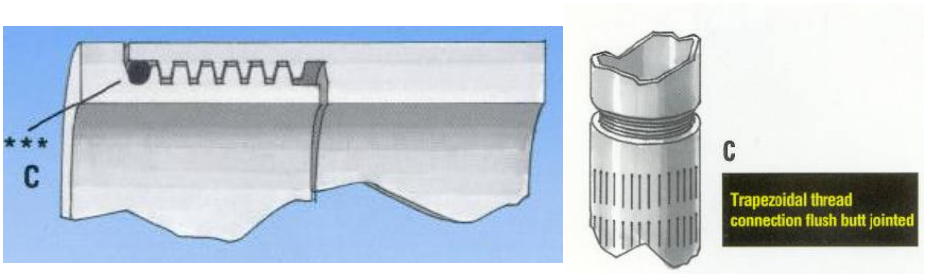


Figure 1: Type of connection between tubes and type of thread.
*** Rubber seal is optional

### 3.5. Filter material

It is necessary to place a filter material consisting of natural or artificial gravel around the filter tube to prevent fine particles from entering the boreborehole and to improve the hydraulic properties in and around the water intake section of the borehole.

Gravel filter material shall consist of siliceous material with rounded, smooth and uniform particles. Unstable minerals such as feldspars, calcite (limestone), laterite, among others, will be easily decomposed and will change the properties of the filter material in the short term, damaging the capture. Flaked particles such as shale and mica will clog the filter tube slots so will not be accepted.

Gravel filter material should be clean and well sorted, ie there should be no clay or silt particles adhering to the individual grains of sand or gravel. The filter material must be treated with care to avoid any kind of contamination.

The granulometry of the gravel filtering material will depend on the opening of the filter tube grooves. For slot openings of 1.0 mm, the granulometry of the filter material must be between a minimum of 1.5 millimeters and a maximum of 2.5 millimeters in diameter. For slot openings of 0.5 mm, the granulometry of the filter material must be between a minimum of 0.7 millimeters and a maximum of 1.5 millimeters in diameter.

The installation of the gravel filtering material must be in the annular space between the filter tube and the walls of the borehole, and must be placed from the bottom of the borehole up to 3 meters above the top of the first filter tube.

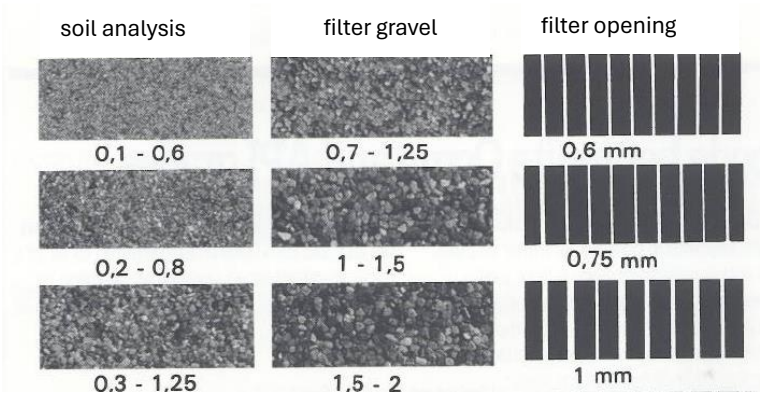


Figure1: Area selection and filter opening

Above the gravel filter material, a clay “seal” one meter thick should be placed. This clay “seal” is generally constituted by clayey granular material in pellets that swell in contact with water, constituting the desired clayey seal.

### 3.6. Filling with fine mortar or grouting – sanitary seal

Cementing or filling with thin mortar is standard practice for all public Positive Wells executed for water sources. Typically, Positive Boreholes must be filled with fine mortar from the surface downwards to a depth of at least 5 meters, in order to prevent the infiltration and percolation of surface contaminants, thus guaranteeing a sanitary seal, isolating contact with the surface and avoiding contamination of the aquifer.

**Sealing Materials**

- **Concrete**– A mixture of Portland cement, loose aggregate and water, in proportions of at least six bags of cement per cubic meter of concrete, for not more than thirty liters of water per bag of cement (50 kg), must be used.
- **Mortar**– A mixture of Portland cement, sand and water, in proportions of not more than two parts by weight of sand per part of cement, with not more than thirty liters of clean water per bag of cement, may be used.

The following practices must be taken into account and applied if deemed necessary by the Inspection:

- Positivo borehole drilled in the rock with a not very thick sedimentary layer, the cementation must be from the surface to the rock;
- Positivo borehole drilled in a sandy aquifer, with an impermeable overlay, cementation must occur from the surface to the aquifer;
- Formations where there are intersections of low quality aquifers and areas with high water quality, low quality aquifers should be closed with cement;
- The clay and backfill material must be properly compacted to avoid further cracks in the area between the slab and the concrete cover.

### 3.7 top of borehole

The upper end of the smooth pipe coating must protrude between 55 cm and 60 cm above ground level. It will be correctly cemented into the ground. If the hand pump (or other pump) is not immediately installed, then the top of the borehole must be properly sealed. (See the platform figure in the attachments)

### 3.8. borehole alignment

The installed piping must be cylindrical and straight (vertical). The alignment and quality of the piping (constant diameter and thickness) must be tested before and after installing the casing piping. The alignment is tested by inserting a cylinder 2.0 m long and with a diameter 4.00 mm smaller than the internal diameter of the casing to the bottom of the borehole without any resistance. This cylinder must be made available whenever required. For boreholes with depths above 40 meters this test is mandatory.

### 3.9 Cleaning Borehole development

The development improves the performance (yield) of the borehole as well as water quality. All Positive Boreholes will be developed after completion of the drilling, after installing the smooth tube coating and filter tube, cementingTheo and placement of the airto the.

The minimum required is the “air-lift” method of injecting compressed air until the groundwater comes out clear and free of turbidity, which must always be carried out for a minimum of 2 hours. If these conditions are not met after 2 hours, the compressed air injection method will continue to run until clear water comes out, up to a maximum of 12 hours.

The evaluation of the productivity of the borehole must be limited to the compressed air injection test, after the development of the same borehole.

3.9.1. CLEANING

Soon after the construction of the catchment, it must be cleaned. For this purpose, air under pressure is injected directly through the rods or galvanized pipe until the water coming out of the intake is free of oil, drilling fluids, clay, sand, etc...

In boreholes built with mud circulation, cleaning must be done effectively with the introduction of reverse water circulation in order to remove all mud from the borehole.

### 3.9.2. DEVELOPMENT

After cleaning the capture, the development begins as follows:

a) The total depth of the borehole and the static water level shall be measured.
b) The catchment must be developed using air under pressure or another effective method (eg pistoning) can be used to remove all the fine sand inside the casing of the borehole and also in the settlement and cleaning of the filter material. Water level recovery should be observed until the static water level is reached.

### 3.9.2.(a) DEVELOPMENT WITH AIR (air-lift)

The column to be used to carry out this operation must be capable of pumping air and bringing the water-air mixture to the surface. The compressor must be able to produce a pressure of not less than 8 bar. The air and water-air mixture tubes must have a diameter of 2 ½”(two")and ¾ “ respectively. This column must be able to move i.e. lift and lower within the catchment.

The water pumped during the development must be evacuated at a minimum distance of 12 m outside the catchment.

### 3.9.2.(b) WATER LEVEL AND DISCHARGE MEASURES

During development, the following indices will be observed:

a) Static water level in the borehole (in meters);
b) Flow rate during development at intervals shown on the development sheet (Q in m3/h.);
c) Electrical conductivity (EC in µS/cm);
c) Dynamic level (in meters);
d) Levels of recovery (in meters);
e) Turbidity and Color of water;
f) Presence of deposits (sand);

Minimum duration of development (6) hours, it should last until the water coming out of the borehole is clear and without any fine particles > 0.2mm (sand, clay). That is, with turbidity of less than 5 NTUs.

Level recovery should be observed until the uptake reaches the static level or in case the recovery is very slow for at least two hours.

To measure the discharge (flow) a container with a known volume (Liters) will be placed at the end of the discharge tube.

### 3.10 flow test

After the development of the borehole, wait until the complete recovery of the Static Level (NE) and then proceed with the Flow Test.

For the Positive Wells where AFRIDEV manual pumps are going to be installed, the flow test must be carried out with a submersible pump with a capacity of 1 to 1.5 $m^3$/hour.

The flow test must comply with three stages (3 levels) of pumping, where each one has a fixed flow (Level 1 - 0.6 $m^3$/h; Level 2 - 0.9 $m^3$/h; Level 3 - 1.2 $m^3$/h ). The pumping on each level must last for 60 minutes, with a record of the lowering of the water level at intervals shown on the test sheet. The change from one level to the other can be made as soon as the lowering stabilizes in at least 3 consecutive readings, even before the 60 minutes.

The flow test with the next step can only start after the dynamic levels of the previous step have stabilized. During the pumping test, drawdown and recovery, all water levels should be measured using an electrical contact meter that is at least 100 m long on tape and has graduations in meters and centimeters. There should be 2 gauges in perfect condition during development on site and 2 more clocks - backup chronometers. The contractor must carry out the pumping tests in the presence of the INSPECTOR.

The debit of the 1st stage will be 1/3 of the maximum or 33%, the second will be 2/3 of the maximum or 66%. During each step, the water level and flow will be measured at time intervals.

After completing the pumping on the last stage and turning off the pump, the observation of the recovery of the water level begins, with the records of the readings of the levels taken at the same time intervals of the pumping test. Recovery observation should be made until the initial hydrostatic level is reached. The flow test data must be presented in sheets indicated for the purpose and suitable for analysis and decision by the supervisor.

### 3.11 borehole disinfection

All Positive Boreholes must be disinfected after execution. Disinfection must be carried out by applying a chlorine solution inside the borehole so that a concentration of at least 50 mg/l (0.005%) of residual chlorine exists in all parts of the borehole under static conditions. All components of the borehole above the water level must be disinfected using the same solution. The solution should remain in the borehole for at least 24hours before cleaning it. Disinfection should proceed immediately after development and before the flow test.

### 3.12. soil sample

During drilling, soil samples should be taken at least at each drill rod depth. Whenever there is a change in the geology of the drilled material, this depth level must be noted and the respective sample collected, applying

## SECTION 4 - PUMPING EQUIPMENT AND PLATFORM

The hand pumps to be supplied must comply with international and national specifications. The Afridev type hand pump shall be SKAT specified and will also be inspected on site.

The pumps to be supplied must present the manufacturing certificate, pre-shipment inspection, LEM inspection certificate and the respective pump code fixed on the pump body. All pumps supplied to the shipyard will be verified through quality tests on their components together with the above-mentioned documents. All components without quality or that do not comply with the specifications will be rejected and removed from the construction site.

### 4.1 Pump installation depth

In an “open” borehole – uncoated (type A), the manual pump cylinder or the submersible electric pump must not be installed deeper than 1 meter above the water level.

In a protected borehole (type B) or a borehole with a filter tube surrounded by gravel material (type C), the cylinder of the hand pump or submersible electric pump must not be installed deeper than 1 meter above the top of the filter tube casing.

If the water table above the suction zone is too low to match the present specifications, then a pumping test must be carried out to accurately determine the borehole capacity (water intake depth, flow rate and duration of pumping ).

### 4.2. hand pump

#### 4.2.1. Installation

The AFRIDEV manual pump must be installed in accordance with the technical specifications and recommended technical procedures for manual pumps.

The immersion depth of the Afridev hand pump cylinder must not exceed 45 meters. All cases where the depth is greater than 45 meters must be informed to the owner of the work in writing for decision and authorization of the procedures to be followed.

#### 4.2.2. pump platform

The platform consists of a protection area, a support slab, a drain and infiltration pit. The quantities and details of size see in annexs.

When possible, the sand used for mortar should be clean, angular, unrolled and free of impurities. Sand with angular grains and rough surface improves adhesion. **Stones and aggregates for concrete must be free of impurities** and have an effective grain size between 10 and 20 mm.

The platform **must be hard and impermeable and the surface highly resistant**. The mortar for the protective area must be dense. The recommended proportions are as follows:

cement: sand: aggregate = 1:2:4, and cement: aggregate = 1:3 for foundation.

The respective drawingsare attached to the tender documents.

### 4.2.3. Drainage and arrangements

Excess water must run along the surface of the protection to the drain, without creating places of standing water. The drain must be 5 meters long minimum. The infiltration well must be opened if the excess water is not used for garden irrigation or other such as depositing in riverbeds, or natural drainage, so as not to create unhygienic surfaces. The infiltration well should have a diameter of 80 cm and a depth of 1 meter. It can be filled with granular material of uniform granulometry.

Reduced natural drainage can be improved by planting more trees and less moisture absorbing soils. Planting trees may be a better solution in these cases than building drains, which tend to clog up quickly, especially in clayey soils.

The platform must have a fence to prevent the penetration of animals to the pumping surface. Pillars made of wood, reeds, bamboo, etc., can be used to complete the platform fence.