Yemen Arab Republic
Ministry of Municipalities
and Housing
Ministry of Electricity
and Water
National Water and Sewerage
Authority

Kingdom of the Netherlands
Ministry of Foreign Affairs
Directorate General of
Development Cooperation

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RADA WATER SUPPLY AND SANITATION PROJECT

VISITOR'S REPORT

Dr W.K. Boehmer

4.08.052

CONTENTS

TIME SCHEDULE FOR THE PERIOD 8 NOVEMBER TO 3 DECEMBER 1988

Tuesday	8 November	Departure from Arnhem to Sana'a
Wednesday	9 November	Arrival Sana'a and en doorreis to Rada
Thursday	10 November	Meeting project personal RWSSP start with final site selection report
Friday	11 November	Day off
Saturday	12 November	Work on final site selection report
Sunday	13 November	Work on final site selection report (0.5 day) Discussion of groundwater model calibration with Mr H. Nieuwenhuis, RIRDP and collection of missing data by means of field trip (0.5 day)
Monday	14 November	Preparing data and answer on groundwatermodel study plus corrections of the base map of the Rada Basin for a telefax message to Arnhem.
Tuesday	15 November	Work on final site selection report
Wednesday	16 November	Work on final site selection report Lunch and Qat session 10 year celebration RIRDP
Thursday	17 November	Work on final site selection report
Friday	18 November	Day off
Saturday	19 November	Work on final site selection report
Sunday	20 November	Work on final site selection report
Monday	21 november	Work on final site selection report
Tuesday	22 November	Work on drilling contract documents
Wednesday	23 November	Finishing of final site selection report
Thursday	24 November	Description tasks supervision of drilling and conduct of pumpingtests; Set up of a programme for the backstopping of the RIRDP groundwater section (0.5 day)
Friday	25 November	Day off
Saturday	26 November	Meeting mr Ahmed A. Rijal, D. Smits and R. v. Schagen for approval of the flight for an aerial survey Explanation and discussion with H. Nieuwenhuis and R. Theunissen about tasks, instrumentation and work + reports to be produced in 1989.
Sunday	27 November	Discussion and explanation of the work with mr Ahmed Bakhid of socio-economic section, an the hydrogeologists Saleh and Jamil of the section;
Monday	28 November	Field trip to Agabah Riasha and the area of Dar Masab, sites for site selection for village water supply;
Tuesday	29 November	Discussion of the programme of the hydrgeological section for 1989 on site selection, monitoring, and groundwater modeling; Discussions about the programme of the geohydrological sections with mr Ahmed A. Rijal and mr Ali Hasan about progress of the work and programme for 1989.
wednesday	30 November	Discussion with Nwasa about the site selection and reservation of the wellfield area for the Rada drinking water supply; Discussions at TNO/WRAY project about availability and exchange of programmes on monitoring and geophysical interpretation with RIRDP;

Thursday 1 December Reporting;
Friday 2 December Day off and departure to Amsterdam;
Saturday 3 December Arrival Amsterdam, Arnhem

1 INTRODUCTION

During my stay at Rada the following tasks have been carried out for the RWSSP:

- Writing of a site-selection report
- adjustments of the drilling contract
- Writing of detailed instructions for the teamleader and a supervisor for supervision during drilling of boreholes and the and the conduct of pumping tests.

2 SITE SELECTION

From may to July 17 potential sites have been selected by Ir. P. Dukker in an area North of Rada. This area was reserved as drinking water supply area during a meeting of a project delegation, NWASA, the governor of Al Bayda, and representatives of Rada and the neighbouring villages. The sites have ben chosen on faults and intrusive dikes indicated by the electro-magnetic method. During my stay I prepared a report on the site selection for boreholes for the water supply of the Rada Urban Area. Approximately 10 of these sites are suitable for the drilling of wells because the distance between the boreholes should not be less than 500m.

3 ADDENDUM TO THE DRILLING CONTRACT

The drilling contract of Gitec-Dorsch is a very good base for a drilling contract of RWSSP. In order to adjust the contract to the circumstances in the Rada area the following changes are proposed:

Vol 3: Technical specifications

Chapter 1:

Drilling Method

Drilling should be carried out by means of the Rotary down the hole hammer method with foam installation. The foam should be of a desintegrating type and. The use of the straight rotary method with bentonite is not allowed in aquifer sections.

1.2.1 Drillings

2 The boreholes will be drilled in an area north of Rada Town and the depth of the borehole will be between 100 and 250m.

3 Well Design

a: drilling of a conductor hole 400mm (or 16 inch) diameter in loose material until the solid rock

b: installation of a surface casing of 350mm (14 inch) diameter

c: drilling of borehole of 300mm (12 inch) diameter to a depth indicated by the site engineer of RWSSP to a maximum depth of 250m.

d: Carefull collection of rock samples in plastic bags every 2m to be handed over to the engineer of RWSSP

e: Keeping of a record of the penetrated formations (drillers log) and the depths at which water is struck in the borehole with as good as possible estimates of the yield.

e: Allowance of time for running of an electric log (LN and SN) by the site engineer of RWSSP by timely (minimum of 24 hours) notice of reaching the wanted depth, cleaning of the hole and removal of drilling equipment out of the borehole.

f: Installation of screens at productive sections and casing of 200mm (8 inch) as deduced from the drilling and resistivity log and as directed by the site engineer of RWSSP.

g: Installation of a 25 mm(1 inch) diameter piezometer pipe of galvanised iron with screw cap for measuring water levels inside the well with a perforated section of 3m placed 10 m above the bottom of the borehole.

h: Construction of a reinforced concrete platform

i: Step-drawdown test pumping in four different stages with after a rest period of at least 12 hours followed by a constant rate test of appr. 50 hours concluded by a recovery test. All as indicated by the engineer of RWSSP.

j: The test pump should be a submersible pump driven by a generator and must have the following adjustable pumping ranges: 3 - 30 l/s up to a depth of 100m and 2-15 l/s fgrom 100 t0 200m depth.

k: The test pump must be adjustable by means of a valve in order to keep discharge rates constant during the tests and to adjust the pumping rate during the step-drawdown test.

1: Pipes must be available to lead the water at least 250m away from the tested well for the duration of the test.

m: Proper gravelpack specification for a Yemini contractor ???

4 SUPERVISION OF DRILLING AND THE CONDUCT OF PUMPING TESTS

During the drilling of boreholes supervision of the drilling operations is required. After completion of the borehole the borehole should be tested in order to determine its capacity and the type of pump plus its depth of installation. The tasks and activities of the team-leader and the drilling supervisor during drilling and pump testing of the borehole are described below.

Teamleader

The drilling supervisor works under the responsibility of the team-leader who remains responsible for all important decisions concerning:

- Exact indication of the site for drilling
- Solving any dispute with third parties about the site and the drilling activities;
- The depth of drilling;
- The final check on the depth of the borehole and the length of casing and screen applied at the proper depths;
- Interpretation of the drilling contract,
- Decision about depth of casing, screens, piezometer pipe and test pumping after examination of the borehole logs and information about depth and productivity of the aquifer from driller and supervisor;
  I recommend to do this in close cooperation with H.Nieuwenhuis geohydrologist of RIRDP.
- Timely warning (at least 24 hours in advance) of the geophysicist of the RIRDP for electric resistivity logging (Long Normal and Short Normal) of the uncased borehole, thus before the installation of screen and casing
- Work out an agreement with the driller about:
  . a proper communication between the RWSSP and the contractor on the drilling operations;
  . the time of drilling that the RWSSP supervisor can be on site to take samples and for consultance with the team-leader about drilling matters.
  (drillers often work in shifts which cannot be follwed by the supervisor resulting in unrealistically long working hours and standby duty).
  . warning of the RWSSP-office and the supervisor when he starts or stops drilling for more than 3 hours, for any reason in order to prevent many fruitless trips to the site.
- Agreement with RIRDP must be obtained about electric- resistivity logging of boreholes, Long Normal (LN) and Short Normal (SN) by the project geophysicist, in the open borehole prior to the installation of casing and screen. The agreement should include that the work must be carried out on the basis of a 24 hours notice by RWSSP to RIRDP. Inspection of the resistivity (LN and SN) logging equipment in advance is necessary.
- I recommend to use as much as possible to use existing forms of RIRDP for the recording of boreholdata and pumping test results. A copy of the results should be handed over for the files of RIRDP;

- Decision about use and number of observation wells. The decision about their distance and place can at best be made after completion of the production wells and after consultation with the hydrogeologist of the project in Arnhem.

Drilling supervisor

Drilling of boreholes

The following activities belong to the tasks of the supervisor for proper supervision of the drilling activities by the RWSSP.

- The exact positioning of the drill on the site indicated by the team-leader;
- Supervision of the carefull collection of drilling samples by the driller after every 2 metres of drilling;
- Collection of the samples in plastic bags;
- Marking of the plastic bags with the number of the borehole and the depth of the sample by means of a waterproof marker;
- With the project hydrogeologist of RWSSP make a preliminary lithological description of the samples to be drawn on a lithological log chart, availible with RIRDP.
- Stapling the plastic bags with samples in the right order to one long string;
- storage of the thus connected plastic bags at a safe place for final examination by the project hydrogeologist;
- collection of information in narrow cooperation with the driller about depth where water is struck in the borehole as well as an estimation of the increase in yield at any productive zone.
- collection of a water sample for analysis at any productive zone and measuring of its electric conductivity and temperature at the site;
- In case the sandstone proves to be very loose and sand is running into the borehole, a large sample of at least 2 kg is required for seeve analysis in order to determine slot openings for the screen and the type of gravelpack. Such zones of quick sand may be expected when drilling in major fractured zones in the sandstone. Clay is possible in the upper part of the borehole when drilling through weathered volcanic formations. Both conditions are considered to be rare but cannot be ruled out.
- Inform in time but at least with 24 hours notice the team-leader and the geophysicist of the RIRDP to carry out an electric resistivty log (LN and SN) of the borehole after drilling stopped and cleaning of the well but before the installation of screen and casing. The depth of screen and casing must be determined from above logs and information about the depths where water is struck in the borehole;
- Supervision of the proper installation of casing, filter and gravelpack, grouting operations, filling of the angular space between the wall of the borehole and the casing, proper installation of a 1 inch diamter piezometer tube of galvanized iron with screw cap over the entire depth of the borehole. The deepest 3 metre must be perforated. The purpose of this pipe is to carry out water level observations during the pumping tests and as permanent observation pipe.

- Check on the straightness of the borehole following the contract specifications. In case no special rules are described, use the following method: Lower 3 lengths of drilling pipe (18 m) on a cable over the total depth of the borehole. The borehole is straight in case the pipes do nowhere touch the side of the borehole.

The correct depths and contributions of the permeable zones to the total yield of the borehole must be recorded on a log.
The yield of the borehole can be estimated or measured by means of a weir available with RIRDP. Information about the depth of productive zones, their yield and electric conductivity is very important for the correct positioning of screens, casing and grouting operations in order to protect the well against brackish shallow groundwater and to determine the correct pump setting.

This information should therefore be collected with care and accuracy.

- Prepare the following borehole records
  . litholgical log in writing
  . log of well diameter, casing and screen depths and diameters, gravelpack concrete slab;
  . LN/SN- resistivity borehole log

PUMP TESTING

After a borehole is completed it should be tested.
The test pump specifications are more or less the same as in the contract of GITEC/DORSCH.
Pump equipment:
Electric submersible pump with the follwing pumping range:
Up to 100m: 3 - 30 l/s
From 100m up to 200m 2-15 l/s

Power generator
Four or Three inch valve for the proper adjustment of the discharge rate;
Four inch discharge pipe and flexible hose for the proper leading of water in the measuring tank

Diversion pipes to lead water 300m away from the test site

One open oil-drum, without sharp edges to prevent injuries, for measuring small pumping rates and adjustment of the discharge rate

Large tank of 1000 to 2000 liter for accurate measuring of the discharge rate. The tank must be equipped with a 3 inch or 4 inch valve at the bottom for a quick discharge of the water after filling the tank during the test.

Oil drum and large tank should be put on a flat horizontal plac e near the discharge pipe of the test pump in easy reach of the flexible hose. This site should be well drained;

The pump must be installed with care in order not to damage the observation pipe placed in the borehole. A somewhat excentric installation of the test pump in the hole is highly recommended in order to facilitate water level observations in the borehole during the tests.

After installation of the test pump the following should be checked:
- First, start with measuring of the water level and write it down with date and time in your note book;
- The proper working of the pump and generator set;
  the installation should be tested during a very brief test period of max 30 minutes;
- Find the max discharge rate of the pump or borehole (100%);
- Try-out of the different discharge rates during the step-drawdown test by adjusting the valve and remmeber or write down or mark the different adjustments of the valve during the step-drawdown test (25%, 50% 70% and 90% of max discharge rate of the pump or the borehole);
- The possibility for easy measuring of the water-levels through the piezometer pipe in the borehole with the electric probe (no water-level observations throughout the tests make testing useless);
- The set-up of the tanks for measuring the discharge rates;
- the lay-out and working of pipes and ditch to lead the water at least 300m away from the site;

- Adjust the valve to the correct discharge rate of the first step of the step-drawdown test (25% of the max discharge rate) and mark it on the tap of the valve;
- Stop the pump:
- Tell the operator not to start the pump until instructions from the supervisor;
- pumps on wells and boreholes within 300m from the test site and all pumps on boreholes on the same fault or dike within 2000m, should be stopped until at least 24 hours after the end of the constant discharge test;

After stopping of the pump a rest period of at least 12 hours is required before the start of the step-drawdown test.

STEP-DRAWDOWN TEST

The following activities are required for the proper conduct of the step-drawdown test.

- Check the following equipment properly;
  2 electric probes for measuring water levels, steel tape 5m with mm division, stopwatch, open empty oil drum without sharp edges to prevent injuries, approx.1000 liter tank with 3 inch valve at bottom for quick emptying of the tank during the tests;
- Measure the rest water level and check if the regulating valve is still in the correct position for the first step of approx. 25 % of the max discharge rate;
- Switch on the generator and pump and if necessry adjust the discharge rate as quick as possible to the required 25 % max borehole yield or 25% max yield of the pump;
- Measure the drawdown of the water level in the borehole by using the following timeschedule;
  observation time in minutes from the start of each step;
- 1,2,3,4,6,8,10,12,15,18,21,25,30,35,40,45,50,55, 60 minutes,
  (1,2,3,...,etc. after start next step step)
- Measure the discharge rate using the 200 l-oildrum as measuring container for small discharge rates and for quick adjustments of the discharge rate and the large container of 1000 litres for measuring the higher pumping rates);
- Measure the discharge rate frequently and accurately but at least 3 times during the last 30 minutes of each step with container and stopwatch (keep the rim of the drum horizontal);
- Adjust the discharge rate of the pump at the end of the last (4th) step of the step-drawdown test to the discharge rate for the constant rate test to be started the next day (this is the highest possible pumping rate that can be kept constant throughout the test period of 50 hours and is usually 70 to 80% of the max discharge rate).
- Mark the valve and stop the pump;
- Give instructions to the pump operator not to touch anything or start the pump again before told to do sdo the next morning;
- Start rest period of at least 12 hours;
- Measure the water levels in observation wells, and private wells within 100m from the site or on the same fault within 1000m distance;

CONSTANT DISCHARGE TEST

In order to take all the readings in time some assistance will be required by or two men during the first hour of the test.

- Measure the water-level
- Check test pump (fuel -full diesel tank-, water and generator)
- Check the valve of the pump and position of measuring tanks)
- Start generator;
- Start pumping test
- Measure water-levels in the pumped well and the observation wells if any according to the following time schedule in minutes after start pumping:
- 1/4, 1/2, 3/4, 1, 1-1/4,1-1/2,1-3/4, 2, 2-1/2, 3, 4, 5, 6, 8, 10, 12, 15, 18, 21, 25, 30, 35, 40, 50, 60, 75, 100, 125, 150, 175, 200, 250, 300, 350, 400, 500, 600, 750, 1000, 1250, 1500, 1750, 2000, 2500, 3000 minutes;
- Note the exact observation time in case measuring does not take place at the above indicated times (to the nearest second during the first 10 minutes, and to the nearest minute for the rest of the time)
- Measure the discharge rate 3 times during the first hour , after that every time after water level reading;
- In case that the discharge rate decreases during the test adjust it by carefull opening of the valve; (the discharge rate should be kept constant within approximately 3%, after adjustment measure the water-level again;
- The test pump should not be stopped at all during the first 24 hours of the test. In case this happens the test should be stopped. Wait until recovery of the water level to at least within 10 cm of the original static water level before starting again. After 24 hours a stop of max 5 minutes is possible for checking oil and water of the generator set;
- Check if the pumped out water is lead away from the test site;

RECOVERY TEST

Measuring the recovery of the water level after pumping stopped is an integrated and important part of a pumping test and should be carried out carefully. The following steps should be carried out:

- After the last water-level reading in the pumped well and all the observation wells stop the pump;
- Take water levels following exact the same time schedule as during the pumping period;
- During the night one water-level observation can be left out;
- Removal of the test pump from the well can be started one hour after pumping stopped but should not interfere with the observation schedule;
- Measuring can be stopped when the water level has recovered completely to a maximum of 50 hours after pumping stopped

All water level observations discharge rates and other data collected during the pumping test should carefully written down on appropriate forms for further interpretation. Forms available with RIRDP can be used to this purpose.

LIST OF EQUIPMENT REQUIRED

- Sample bags
- 2 water-level metres
- EC-meter
- thermometer
- tape 5m
- sample bottles
- set of seaves and balance