Well Construction Training Course Module

Water and Sanitation Programme
Human Resource Development Unit

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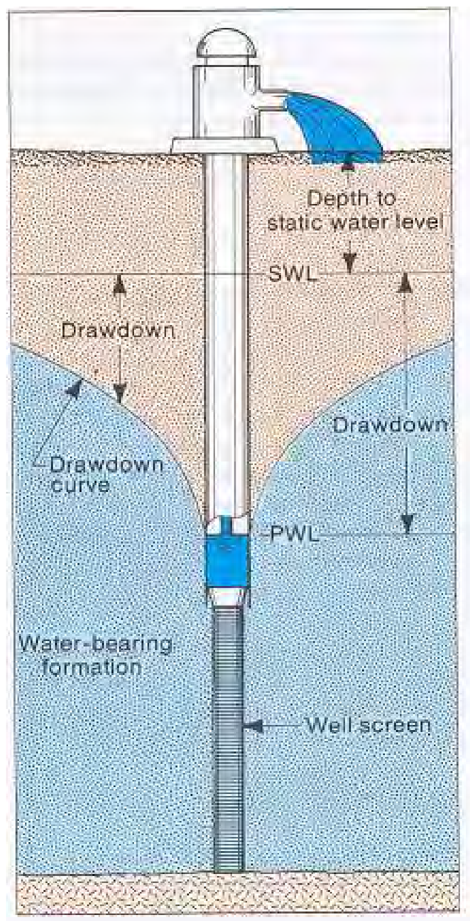
WELL CONSTRUCTION

Training Course



MRRD/DACAAR

Duration: 5 days

Contents Well Construction Training Module

Major Learning Unit Contents

Learning Unit

Goal of Course:

To broaden the participant's knowledge of the technical information necessary to construct a well that will meet technical specifications and supply sufficient good quality water for many years to come.

Course Objectives:

After completion of this course the participants will have gained:

0830-955	Introduction, knowing each other, fears and expectation, methodology and schedule	Trainer
0955-1015	The hydrological cycle	
1015-1030	Tea break	
1030-1140	The hydrological cycle	
1140-1230	Aquifers and ground water	
1230-0130	Lunch and prayers	
0130-0230	Aquifers and ground water	
0230-0300	Tea break	
0300-0350	Groundwater and wells	
0350-0400	Wrap up session	

- An awareness of The knowledge, expertise, and steps, necessary to construct a fully functional reliable well.
- Knowledge of the different well construction techniques, hand digging, percussion method, rotary drilling.
- A broader knowledge of the MRRD technical specifications.
- Knowledge of supervising well construction
- Knowledge of the drilling log and its value.

Day -One

Time	Topics	Resource Person
0830-955	Introduction, Knowing each other, Fears and Expectation, Methodology and schedule	Trainer
0955-1015	The hydrological cycle	
1015-1030	Tea break	
1030-1140	The hydrological cycle	
1140-1230	Aquifers and ground water	
1230-0130	Lunch and prayers	
0130-0230	Aquifers and ground water	
0230-0300	Tea break	
0300-0350	Groundwater and wells	
0350-0400	Wrap up session	

Tea breaks for 30 minutes at 10.15am. and 2.30 p.m. Lunch and prayers at 1230-0130

Day -Two

Time	Topics	Resource Person
0830-0915	Review of the previous session	Trainer
0915-0945	Filters	
0945-1015	Tea break	
1015-1045	Wells in Afghanistan	
1045-1145	A hand dug well	
1145-1205	Kareez	
1205-1230	Percussion drilling	
1230-0130	Lunch/prayers	
0130-0230	Percussion drilling	
0230-0245	Tea break	
0245-0315	Percussion drilling	
0315-03.50	Advantages and disadvantages of percussion drilling	
0350-0400	Wrap up session	

Tea breaks for 30-15 minutest 10.15am.2.30 p.m. Lunch and prayers 1230-0130.

Day Three

Time	Topics	Resource Person
0800-0900	Review	Trainer
0900-1000	Visit well ring fabrication site and hand dug well site	Site staff
1000-1030	Tea break	DACAAR staff support and
1030-0100	Visit DACAAR Water and Sanitation equipment storage yard. View all the equipment and parts that are used in well construction. Three hand pumps and their parts, demonstration of assembling and dismounting, Examine filters, casings and individual parts.	
0100-0200	Lunch and prayers	
0200-0230	Review mornings visits	
0230-0330	Tea break	
0330-0350	Review hand pump assembling	
0350-0400	Wrap up of session	

Tea breaks for 30 minutes at 10.15am. and 2.30 p.m. Lunch and prayers at 1230-1.30

Day -Four

Time	Topics	Resource Person
0830-0900	Review of the previous session	Trainer
0900-0940	Site selection	
0940-1020	Rotary drilling method	
1020-1050	Tea break	
1050-1120	Kareez and wells	
1120-1230	Cone of depression and draw down	
1230-0130	Lunch and prayers	
0130-0250	Pumping test	
0250-0305	Tea break	
0305-0350	Site management and supervision	
0350-0400	Wrap up session	

Tea breaks for 30 minutes at 10.15am. and 2.30 p.m. Lunch and prayers at 1230-1.30.

Day - Five

Time	Topics	Resource Person
0830-0900	Review of the previous session	Trainers
0900-1230	Visit two percussion-drilling sites and a rotary drilling site. Interview site workers and manager	Construction site managers and workers
	Visit the Kareez outlet at the suburb of Kareez	Trainers
1230-0130	Lunch/prayers	Trainers
0130-0230	Visit The suburb of Dasabz where a rotary drilled borehole supplies water to the district or Charasah where a rotary drilled bore hole supplies water to the suburb Dalamond	Trainer
0230-0300	Review the information collected during the field trip	
	Tea break	
0300-0400	Evaluation of the training Course and Distribution of certificates	

Tea breaks for 30 minutes at 10 am. and 0245 p.m. Lunch and prayers at 0100-0200.

Summary of Training Sessions

Day 1
Hydrological cycle Aquifers and ground water Groundwater and wells

Day 2
Wells in Afghanistan A hand dug well Percussion drilling Advantages and disadvantages of percussion drilling Site selection

Day 3
Visit well ring fabrication site Visit operating improved hand dug well Field visit to DACAAR Demonstration of mounting a pump and view three pumps Naming all the parts, casing, rising mains etc Viewing slush pump, apron moulds etc Trouble shooting equipment

Day 4
Rotary drilling Kareez Cone of depression and draw down Introduction to pumping tests Management and supervision of well construction

Day 5
Field visit drilling sites interview contractor Setting up the rig Safety precautions Drilling log Trouble shooting etc.

Day 1 Design and Timing

Training Events	**Time Needed**	**Training Methodology**	**Supporting Documentation**
Opening session Introduction, fears and expectations, methodology, schedule & objectives	1 hour 25 minutes	Brainstorming	Handout A & B
Hydrological cycle and development of water resources	1 hour 30 minutes	Brainstorming Presentation	Handout 1.1, 1.2 Annex P
Aquifers and ground water.	1 hour 20 minutes	Brainstorming Presentation Group Work	Handout 1.3, 1.4, 1.5, 1.6 Annex Q
Ground Water and wells	45 minutes	Brainstorming Presentation	Handout 2.1, 2.2 Annex Q
Wrap up session	10 minutes	Presentation Group Work.	
Total Time	5 hours 40minutes +1 hour for lunch and 30 minutes for tea breaks		

Title: Opening Session

Objectives: After completion of this session the participants have:

- Filled out the attendance registration list and profile.
- Be more familiar with the course objectives and the other participants.
- Become aware of the trainers and each other's needs.
- Become familiar with what everyone expects by setting rules.

Time: 1hour 25 Minutes

Method: Presentation plus brainstorming.
Materials: Handouts A, B, C color cards, stationary.
Physical setting: Participants sitting in U shape.
Process:

- Welcoming the participants
- Trainers introduce themselves and give some short information about the training.
- Distribute participants stationary (files, pens, notebook, color cards and profile list etc)
- Activity filling out color cards
- Game Fears and Expectations
- Setting ground rules using brain storming method.
- Brief explanation of course objectives and schedule.

Opening Session

A participant is invited to recite verses of the Holy Koran

Introduction: Game for everyone to get to know each other

Fears and Expectations

Participants briefly outline their expectations and fears on different coloured cards. Pin the cards on the board and reflect on the key fears and expectations highlighted by the participants and explain whether it will be possible to address them in the course of the training.

The trainer should say to the participants that he has a fear and some expectations. The trainer fears that participants will expect the trainer to be giving them knowledge. Training is not filling trainees with knowledge:

- Training is about introducing new ideas to participants and encouraging them to make use of them.

- Training is organising the knowledge that trainees already have in a way that they recognise their knowledge and make better use of it.

- Training is participants sharing ideas and experiences so that they enrich each other’s knowledge and skills.

Ground Rules

Ask the participants to state what is allowed and what is not. Get consensus and write them on a flip chart. The rules are to be followed by all.

Course Objectives

Show the Course Objectives. Discuss each point briefly to ensure clarity.

Schedule

Explain the Course Schedule Handout No. A, and discuss the topics to be covered. Be sure to emphasise the need to be on time for all sessions and to observe the ground rules

Title: Hydrological Cycle and Development of Water Resources

Session Summary

Objective: After completion of this session the participants will:

Understand the cycle of water, evaporation, transpiration, infiltration,
and run off and
Understand the different sources of ground water
Realize Afghanistan has major sources of water but most of the country

- suffers from water shortages or lack of safe water.

Time: 1 hour 30 minutes
Method: Brainstorming, presentation and group exercise
Material: Handout 1.1,1.2, 1.3, 1.4, Annex P.
Flip chart and markers.
Physical setting: U shape, group activity done on the floor

Process:
The topic is covered by asking questions and illustrating:
How does the ground water get into the water bearing strata?
The trainer explains the rainwater cycle by illustrating it on the flip chart and asking further questions**:**
Where does most of the water vapor in clouds come from?
What is transpiration?
Where would most of the transpiration occur in Afghanistan?
Where does most of the precipitation occur in Afghanistan?
Where does the infiltration occur?
If 70% of Afghanistan is mountainous why has Afghanistan such a big problem with lack of water in many places?
What were the traditional sources of water?
What can you observe about the picture of an open well?
What are the different problems Afghanistan faces with the water supply?
How can we overcome each of these problems?

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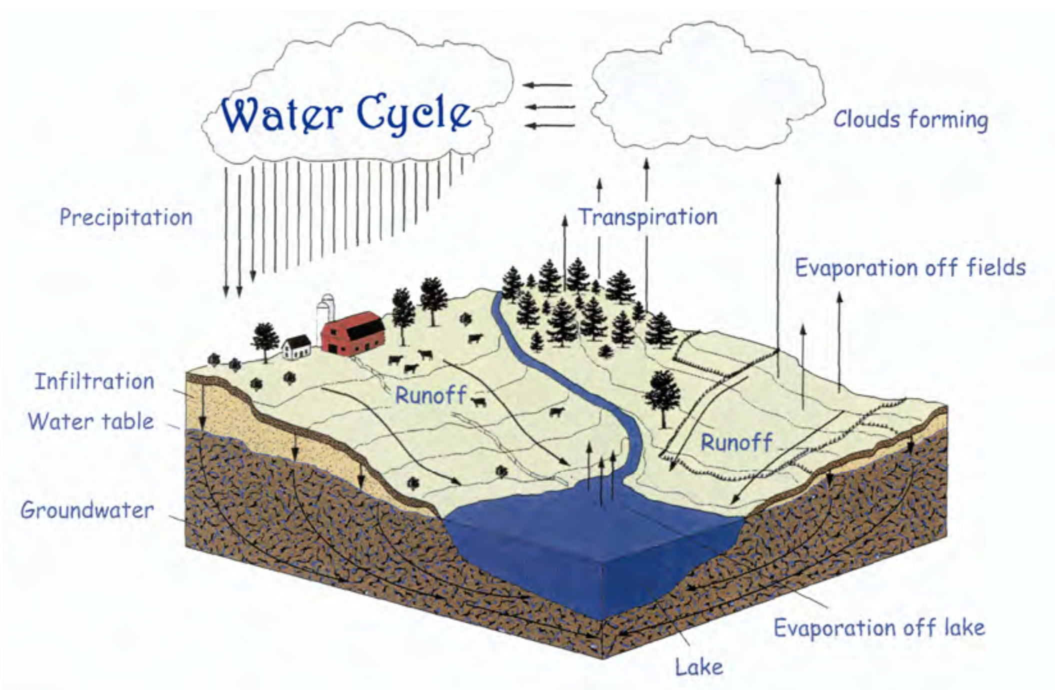
Hydrological Cycle and Development of Water Resources

Process:
Step1 See Handout 1.3
The trainer introduces the topic by saying
We are going to start at the very beginning with the rainwater cycle.
All of the water on earth comes from the condensation of water vapor.

How does the ground water get into the water bearing strata?

Would someone be prepared to explain?
Trainer writes down the responses See Annex R
Participants are encouraged to assist and ask questions
Step 2
The trainer explains the rainwater cycle by illustrating it on the flip chart and covering the following points, asking participants to contribute at each step.
Evaporation- from bodies of water
Condensation- when the clouds meet cool air
Precipitation- of rain and snow
Infiltration- ground water
Runoff- rivers, streams, lakes, reservoirs
Transpiration- especially from regions where trees are plentiful
Evaporation- by the radiation of the sun
The illustration below is shown and a participant revises the process



Step 2

Trainer asks question using a map of Afghanistan and world globe.

Where does most of the water vapor in clouds come from?

The sea, lakes

Trainer asks questions

What is transpiration? Where would most of the transpiration occur in Afghanistan?

Participants asked to indicate where the forests of Afghanistan are.

Trainer asks question -Condensation of clouds?

Where does most of the condensation occur in Afghanistan?

As the clouds rise when they meet the cold air of Afghanistan's mountain ranges

Trainer asks question –Precipitation? See Handout 1.4

Where does most of the precipitation occur in Afghanistan?

Afghanistan has a large mountain range that is 70% of the area of Afghanistan most of the precipitation occurs in the mountains.

Trainer asks question

Where does the infiltration occur?

Trainer asks

If 70% of Afghanistan is mountainous why has Afghanistan such a big problem with lack of water in many places?

See Handout 1.1.
Most of the water runs into the sea
Surface water is often polluted

Step 3

What were the traditional sources of water?

Trainer writes down the responses
Kareez
Open well
Rivers
Streams
The traditional well was large and open and often polluted

Trainer asks question

What can you observe about this picture of an open well?

Trainer records responses

The picture above is of an open well with a large diameter
The woman is carrying a baby on her back
Water is turbid.
Difficult to climb out of!

Step 4 See Handout 1.2
Divide participants into small groups and ask them to think of the different ways we can over come our water problems. They must list the problems first. Allow 30 minutes

What are the different problems Afghanistan faces with the water supply?
How can we overcome each of these problems?

Groups report back to the forum
Pipe schemes from springs and deep wells
Filtration of river water
Clean up the rivers
Educate people
Construct more dams and reservoirs
Complete the artificial recharge scheme the Chinese started on the Pancher River
Review and discuss each suggestion

Title: Aquifers and Ground Water

Session Summary

Objective: After completion of this session the participants will:

- Be aware of the types and properties of material that make up an aquifer
- Realize the importance this information is for a well constructor.

Time: 1 hour 20 minutes
Method: Presentation, group discussion.
Materials: Refer to Handouts 1.5, 1.6, Annex Q,
Large plastic bottles with the tops cut off containing materials you might find in an aquifer. Rock samples, flip chart and markers.

Process:
Information communicated by asking a series of questions and giving further information

- What materials do you think the strata where we find ground water is made of?
- We divide rocks into three different types sedimentary, metamorphic and igneous.
- Discuss and explain each type
- Trainer displays examples of each type.
- Knowledge and experience of water bearing materials will help you recognise the best
- materials and help you succeed in placing the pump in the best position.
- Porosity and permeability are terms we use to classify the material in an aquifer
- What does permeability means?
- What does having high porosity but low permeability mean?
- How long do you think it would take water to soak into a dry clay brick?
- Why is a dry brick so much lighter than a wet brick?

Aquifers and Ground Water

Process:
Step 1
Trainer draws the strata where the ground water is located.
Indicate the saturation and aeration zones.
This is where we find ground water.
This is where we must put the filter and foot valve.
This space is not an underground tunnel like a Kareez.

Trainer asks the participants

What materials do you think the strata where we find ground water is made of?

Trainer writes down the responses
Review each suggestion and discuss its qualities.
If any are missed the trainer can make additions by asking
Do you think limestone would be a good aquifer etc?[1]

Trainer says we divide the aquifer material into two types loose material and cemented material.
See Handout 2.1, 2.2.
Unconsolidated porous aquifer-loose material
Trainer explains when an aquifer is made up of sand or gravel or loose material we call the aquifer an unconsolidated aquifer.[2]
Consolidated aquifer – cemented material
When the aquifer is made of limestone, soft conglomerate sandstone or fractured rock we call it a consolidated aquifer[3]
Trainer displays unconsolidated material and consolidated material
Different materials, enables the water to move at different rates

Step 3 Handout 1.5

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[1] Unconsolidated sedimentary rocks: River sediments are unconsolidated sedimentary rocks. They are loose rocks and have good permeability and porosity.
Consolidated sedimentary rocks, soft conglomerates, soft sandstone, limestone and dolomite all make good aquifers.
Water dissolves limestone making caverns, tubes, caves, chimneys, and spaces underground through which the water can move.
Igneous and metamorphic rocks can be an aquifer when they have cracks' open joints, faults and fractured zones that water can infiltrate, percolate and move through. These rocks are hard and without fractures they are impervious

[2] River sediments are unconsolidated sedimentary rocks. They are loose rocks and have good permeability and porosity. These properties when well sorted make very good water bearing aquifers.

[3] Consolidated sedimentary rocks. Soft conglomerates, soft sandstone, limestone and dolomite Water dissolves limestone, making caverns, tubes, caves, chimneys, and spaces underground through which the water can move.
Igneous and metamorphic rocks can be an aquifer when they have cracks' open joints, faults and fractured zones that water can infiltrate, percolate and move through. These rocks are hard and without fractures they are impervious

Trainer says we can divide rocks into three different types.
Sedimentary, Metamorphic and Igneous.
Trainer asks

Does anyone know how any of these rocks were formed?

Participants contribute and trainer adds further information

Sedimentary rocks: Rock formed of sediment, and specifically:
(1) Sandstone and shale, formed of fragments of other rock, sand, stones or mud, transported from their sources and deposited by water;
(2) Rocks formed by or from secretions of organisms, such as most limestone.
Metamorphic rocks: Alteration of the minerals, textures and composition of a rock caused by exposure to heat, pressures and chemical actions.
Igneous rocks: Originate from molten rock below the earths surface. Igneous rocks are either from a volcano erupting or from magma cooling under the earth's crust Basalt and granite are two of the most common rocks on the earth's surface.
Trainer displays examples of each type of rock.

Step 3
Trainer asks the participants

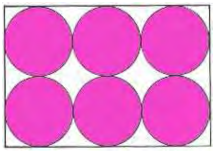
Why do you think it's an advantage to know the types of material in an Aquifer?

Trainer records answers
When drilling a well we keep a drilling log. Knowledge and experience of water bearing materials will help recognise the best materials for the filter and help to succeed in placing the pump in the best position.

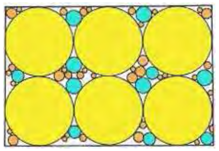
Step 4 Handout 1.6
Trainer explains
Porosity and permeability are terms we use to classify the material in an aquifer

- Porosity describes soil or rock with many spaces that the water can fill
- When there is a lot of space the material can hold a lot of water

Trainer illustrates material with high and low porosity and containers containing similar materials are displayed and passed around for close observation



High Porosity



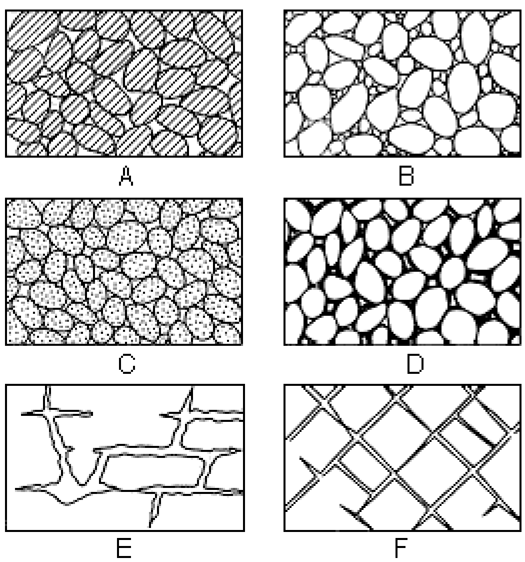
Low porosity

Trainer asks the participants

> Can you describe the first diagram?
> What do you think it represents?

Trainer repeats the question for the second diagram.
Why has the second illustration got low porosity?

Trainer then displays these diagrams and containers containing similar combinations



Trainer repeats the exercise with the diagrams above.[4]
Trainer refers to each diagram and chooses participants to describe what they see in the diagram.
Trainer assists using the information in the footnote

Step 5

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[4] (From Meinzer, 1923)

Diagram showing several types of rock intensities and the relationship between rock textures to porosity.

1. Well-sorted sedimentary deposit having high porosity;
2. Poorly sorted sedimentary deposit having low porosity;
3. Well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so that the deposit as a whole has a very high porosity;
4. Well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices;
5. Rock rendered porous by solution;
6. Rock rendered porous by fracturing

Trainer introduces permeability by asking

Can anyone tell me what permeability means?

Participants give their explanations then Trainer further explains
Permeability describes porous soil or rock where the air spaces are joined so that water can move easily through it.
Trainer demonstrates:
Trainer has a variety of different materials prepared in clear containers and pours water on them to observe the different times it takes water to pass through them.
The samples that the water passes through quickly are very permeable and the samples the water moves through slowly have low permeability.

Step 6
Trainer adds clay is an example of a material that has high porosity but low permeability then asks

What does having high porosity but low permeability mean? Can anyone explain?

After participants explain the Trainer explains
It means the material can absorb a lot of water because there are a lot of spaces in it but the water does not move through it. The spaces are not joined up to make passages for the water to move through.

Step 7
Trainer asks if we put a dry clay brick in a bucket of water

How long do you think it would take the water to soak into a clay brick?

Trainer accepts responses
The brick would eventually soak up the water but it would take a long time
Clay has a lot of spaces but low permeability.

Trainer asks

Why is a dry brick so much lighter than a wet brick?

Trainer records answers

Trainer asks

What does this tell us?

Trainer accepts answers and adds-

Unlike clay, sand and gravel are porous and permeable because they have many air many air spaces are joined and water can pass through gravel and sand easily.
The bottom of a river usually is sand and the water seeps away easily.

Step 8
Trainer asks question

Do you think clay[5] would make a good aquifer?

Trainer writes down the responses and adds:
Clay has many tiny air spaces but because the particles are so compact water cannot pass through clay because of this clay stores the water
When clay gets wet it gets sticky.

Step 9
Trainer leads discussion by asking

What are the many uses of clay?

Because of the special properties of clay-
We use clay to seal the bottom of a reservoir or dam to stop seepage.
Well diggers use clay to seal the sides of the borehole. See Annex F6.
Well diggers seal and back fill wells in front of salty or contaminated water.
Engineers when designing a dam wall in Afghanistan used clay and not concrete because if there is an earthquake concrete will crack where as clay will not.
Clay was used as cement or mortar to seal the rocks in the wall of Ghazi dam in Kabul.

Step 10
Trainer summarizes the session.

[5] **Clay:** A classic mineral particle of any composition that has a grain smaller than 1/256mm. Clay has high porosity and low permeability because pore spaces are not well connected. Clay often creates confining layers in the subsurface. **Mineral:** A naturally occurring inorganic solid with definite chemical composition and an ordered chemical structure. Minerals are not usually formed from animal or vegetable matter.
Example. gold and salt.
Lime: White substance obtained by heating limestone used in building materials Cement Grey powder made by burning clay and lime

Ground Water and Wells

Session Summary

Objective: Introduce participants to

Information about ground water and strata that results in artesian wells, and perched aquifers

Time: 45 minutes
Method: Illustrations, brainstorming and presentation.
Materials: Refer to Handout 2.1,
Prepare illustrations and diagrams to illustrate different wells and aquifers.
Physical setting: U shape seating arrangement.

Process:

- Trainer illustrates aeration zone and saturation zone

Uses two illustrations to explain

- Aeration and saturation zone
- Confined artesian aquifers
- Unconfined aquifers
- Artesian well-water under pressure
- Flowing artesian well illustrating water under pressure released
- Water table well in unconfined aquifer.
- Perched aquifer

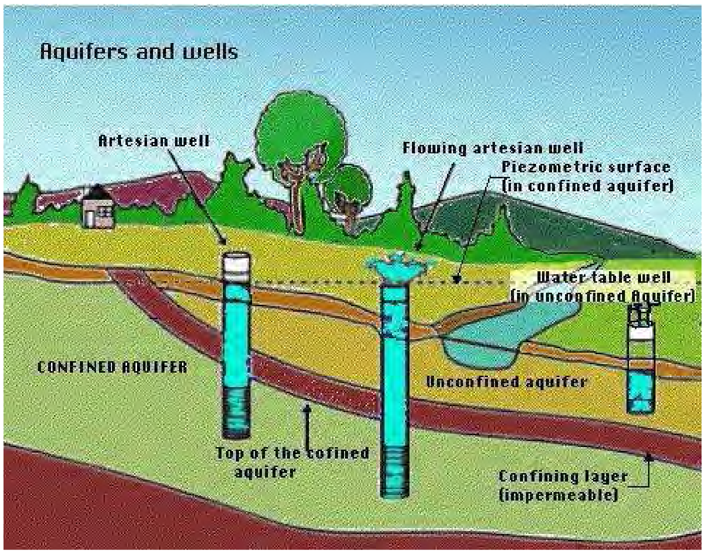
Ground Water and Wells

Process
Step 1
Trainer illustrates the saturation zone and the aeration zones on the flip chart covering the following points:

- Gravity compels water to soak into the ground and it sinks until it meets an impassable layer (aquifuge. An absolutely impermeable unit that will neither store nor transmit water, impervious solid rock without fractures through which water cannot pass).
- The area where the water accumulates and settles is called the saturation zone because the pores and cracks are filled with water.
- Above this area where it is not saturated although there is some moisture, is called the aeration zone.

Step 3 Artesian wells See Annex S
Trainer says sometimes the water enters the earth's surface and travels very deep. As the recharge area receives more water weighing down on the underground water it is unable to rise to the aeration zone because of a confining strata. The diagram below illustrates this.

Trainer displays the diagram below or if not possible illustrates it on the flip chart and says:



In the diagram we can see a confined aquifer and an unconfined aquifer
There are impervious strata that we call an aquifuge. An absolutely impermeable unit that will neither store nor transmit water, impervious solid rock without fractures through which water cannot pass that cause confined aquifers.

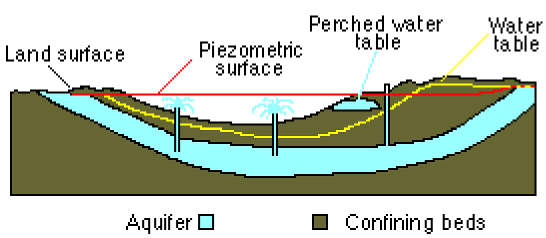
Trainer asks is there anyone who would like to explain this diagram?

Explain what this diagram represents?

Several people can explain what they observe.

- Confined artesian aquifers
- Unconfined aquifers
- Artesian well-water under pressure
- Flowing artesian well-water under pressure released
- Water table well in unconfined aquifer.
- Aquifuge. An absolutely impermeable unit that will neither store nor transmit water, impervious solid rock without fractures through which water cannot pass.

Trainer explains and summarizes what the diagrams represent and answers questions and uses the diagram below to explain what is a perched aquifer. See Annex S
If the diagrams are not available the trainer illustrates them before the session



Trainer asks is there anyone who would like to explain this diagram?

Explain what this diagram represents?

Several people can explain what they observe.
This acts as a revision of the points already covered and introduces perched aquifer.

Step 4

Trainer asks the participants

Why is it important for a hydrogeologist or experienced drill operator or engineer to be involved in selecting the site location and depth to drill when constructing a tube well?

Trainer writes down the responses

Review each suggestion and emphasize the importance of depth of drill

Knowledge of aquifers helps us to realize that constructing a fully functioning well needs experience knowledge and a drilling log.
Trainer briefly mentions a drilling log and if participants require more information see step 7 Percussion Method

Step 5 Trainer summarizes the session

Training Events	Time Needed	Training Methodology	Supporting Documentation
Opening session Review the previous day's session	30 minutes	Brainstorming	Handout A & B
Wells in Afghanistan	30 minutes	Brainstorming Presentation	Handout 3.2 Annex K, O, N.
Hand Dug Wells.	1 hour 20 minutes	Brainstorming Presentation Group Work	Handout 3.2 Annex D, O, N
Percussion method	1 hour 50 minutes	Brainstorming Presentation Group Work	Handout 4.1, Annex D, N
Advantages and disadvantages of the percussion method**.**	30 minutes	Brainstorming	Handout 4.1 Annex D, O, N
Wrap up session	10 minutes	Presentation Group Work	
Total Time	5 hours 40minutes +1 hour for lunch and 30 minutes for tea breaks		

Title: Wells in Afghanistan.

Session Summary

Objectives: After completion of this session the participants will:

- Be aware of the types of well most common in Afghanistan
- Be aware of the different construction methods
- Be aware of the suitability of each method

Time: 30 minutes
Method: Presentation, brainstorming
Materials: Refer to Handout 3.2 Annexes C, D, E, F, N and O
Flip chart and markers
Seating: U Shape
Process:

Presentation based on questions and brainstorming

- What type of water points do we find in Afghanistan?
- Give each type of well a percentage indicating the frequency of the type of water point in Afghanistan?
- What are the different methods used to construct hand dug and tube wells?

Wells in Afghanistan

Process:
Step 1 See Handout 3.2
Write the question on the flip chart-

What type of water points do we find in Afghanistan?

Trainer writes down the responses

- Hand dug well improved See Annex O
- Open hand dug well See Annex C
- Tube wells- See Annex C
- Tube well percussion method – See Annex D
- Tube well rotary drilling method See Annex E
- Deepened hand dug well-See Annex Q

Review each suggestion giving a description of each type

Step 2 See Annex M
Trainer says
Now I want you to divide into groups and decide what percentage of the total water point is attributed to each type.

Give each type of well a percentage indicating the frequency of the type of water point in Afghanistan?

Draw a pie graph to illustrate. Example Unimproved hand dug well 15%
Groups report back and compare the results

Step 3
Trainer says now return to your groups and discuss

What are the different methods used to construct hand dug and tube wells?

Each group records results and reports back

See Annex Q Hand dug wells
See Annex D Operating principles cable- tool/percussion method
See Annex E Rotary drilling

Step 4 Trainer summarizes the session

Title: Hand Dug Wells

Objective: After completion of this session the participants will:

- Have a better understanding of the construction of a hand dug well

Time: 60 minutes
Method: Presentation, group discussion and practical exercise.
Materials: Refer to Annex C, O, K and N
Physical setting: U shape
Process:
Presentation based on questions covering the following topics
How many hand dug wells do you think are in Afghanistan?
How many of these wells would have a hand pump and apron?
Why did so many wells go dry during the drought?
Does anyone know of any hand-dug wells that didn't go dry during the drought?
What is an improved dug well?
Lining rings
Placing rings in a well
Deepening a dug well
Back filling around the concrete rings
Finishing off a well

Note for Trainer A brief visit will be made to a ring fabrication site on day three

Hand Dug Wells

Process:
Step 1. Trainer asks the question

How many hand dug wells do you think are in Afghanistan?

Trainer writes down the responses

Trainer asks

How many of these wells would have a hand pump and apron?

Trainer accepts responses and settles on a percentage estimate. If there is disagreement do it only for the provinces people know about

Trainer asks

Why did so many wells go dry during the drought?

Trainer records all suggestions
Discuss the water column
Removing water while digging so that the well can be dug deeper to avoid it drying up.

Trainer asks

Does anyone know of any hand-dug wells that didn't go dry during the drought?

Where were these wells?
Why do you think they didn't go dry?
Note. DACAAR used two slush pumps running at the same time on a hand dug well so that they could dig deeper into the aquifer.

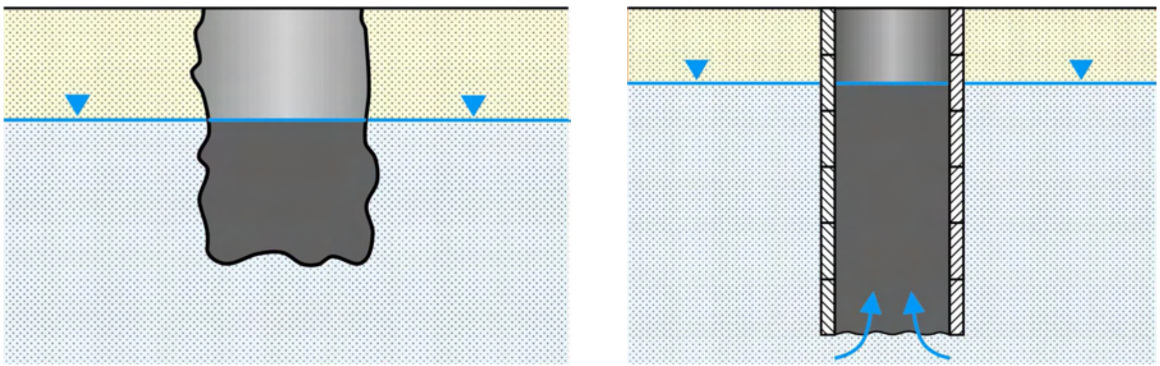
Step 2
An improved well
Trainer asks the question

What is an improved dug well?

Trainer writes responses
Is lined
Has a concrete platform or apron

Has a hand pump installed
The water enters the well from the bottom

Trainer displays the illustration of an unlined well and a well lined with concrete rings.



Step 3
Lining rings

See Annex D
The first field exercise includes 20minutes observing how a ring is made.
Trainer states if prefabricated lining rings are strong, uniformly made and care is taken when handling them they are much easier to mount in a well. Many of the Kabul ring fabricators do not put in the reinforcing wire that is recommended
In groups discuss this statement and list

What measures can be taken to ensure they are not damaged and chipped or cracked before lowering them into a well and why is it important that they be uniformly made?

Participants divide into groups and record their answers
Report back the information they recorded. See Annex Q

Step 4
Placing rings in a well

Trainer asks

Can anyone describe how the rings are placed in the well?

Choose someone to have a go at explaining and illustrating on the flip chart

Participants and trainers can assist. It is a job for a skilled person to place them so that they rise perfectly vertical. It's a similar skill to laying bricks. See Annex Q

Step 5

Deepening a dug well

Trainer asks

Has anyone had experience at deepening a dug well?

Choose someone to have a go at explaining and illustrating on the flip chart

Participants and trainers can assist

See Annex P and Annex Q

Step 6

Back filling around the concrete rings

Trainer asks

How do execute back filling around the concrete rings?

Participants describe the process

Backfilling

Careful backfilling of the concrete rings with fine gravel is necessary up to 2.0 meters above the highest level of the water column in the well. This keeps the waterway to the well open. Also fine gravel placed in the bottom of the well stops sand from entering the bucket. All other back filling can be done with ordinary soil.

Step 7

Finishing off dug wells

Trainer says there are many steps to be completed to finish a well, can you suggest some?

If we visit a finished well what things should we be able to observe?

Participant's answers recorded

- The projects donors name and the well number should be written on the post of the well
- Back filling the top concrete rings should be done properly sealing it from seepage with clay.
- The apron, the pedestal slab and the top ring should be joined and the pointing done properly. See Handout 3.2
- The community should be mobilized to fill the area surrounding the apron and level it.
- The waste- water should be diverted properly to prevent wastewater seepage around the well apron.

Step 8

Trainer summarizes the information discussed in the session.

Day 2 **Percussion Method**

Percussion Method

Objective:

To introduce participants to the percussion drilling method by covering the percussion procedures:

.

- Site selection for drilling a tube well.
- Setting up the drilling rig system
- Operation of well drilling.
- Logging (Sampling)
- Lowering of filter and casing pipes
- Gravel packing.
- Construction of well the apron.
- Installation of the hand pump.

Title: Percussion Method

Session Summary

Objective: After completion of this session the participants will:

- Have a basic understanding of the percussion method.

Time: 1 hour 55 minutes
Material: Refer Handouts 3.2, 4.1, 4.2, 4.3, 4.4, Annex D, a sample box.

Method: Presentation based on a series of questions.
Step 9 and 10 are group exercises that can be moved to different time slots to vary the day
Physical Setting: U shape and group activity

Process:
Well construction percussion drilling method is covered in this session.
Each step is based on a question. The trainer needs to refer to the Annex D and handouts 3.2, 4.1, 4.2, 4.3, and 4.4, to become familiar with the topics. Further reading is recommended if possible. It has been found the rig contractors provide valuable information.
Step 9 and 10 are group exercises that can be moved to different time slots to vary the day

Each step is based on a question.

Describe a tube well?
Who is familiar with the percussion method of drilling?
Where can we use percussion method and where can we use rotary drilling?
Has anyone had experience setting up a rig?
Has anyone had experience drilling different size diameters? (6" 8" 16")
Explain sampling and logging and why we do it!
Explain the lowering of the PVC pipe and filter!
Does anyone remember the process of gravel packing?
What does cleaning a well mean?
What materials do we use for back filling and the cement plug?
What should be included in a well apron design?
List safety procedures and equipment for a drilling rig operator!

Note to Trainer. Step 9 and 10 can be used at different time slots to vary the procedure

Percussion Method

Process:
Step 1 Trainer chooses several participants to

Describe a tube well?

Participants contribute their information
Trainer further adds
A tube well is a hole or a pipe in the ground that we can draw ground water from through a pump to the surface of the earth. Its design varies with the geological conditions of the formation and the purpose for which the ground water is to be used.

Percussion, air rotary, hand auger or mud rotary drilling systems can be used, according to the lithological condition encountered, with minimum drilling diameter of 8″ (203 mm).
In Afghanistan we use the two drilling methods rotary and percussion. Percussion is the one you will have more experience with
Step 2 See Hand out 3.1
Trainer asks the participants

Who is familiar with the percussion method of drilling?

Trainer invites participants to explain
Trainer further explains See Annex D 1.1

Trainer asks participants where can we use each of the methods?

Where can we use percussion method and where can we use rotary drilling?

Trainer accepts participants' responses
Trainer further explains
The rotary method is more expensive and is suitable for big water schemes when a deep borehole is necessary boring through hard strata.
Percussion is more suitable for rural water well work See Annex D 1.3.

Step 3 See illustration Handout 3.1
Trainer asks participants

Has anyone had experience setting up a rig?

Trainer asks participants to explain their experiences

Trainer further explains
The site has to be big enough to arrange the rig parts in readiness for hoisting, join the parts to form the tripod and hoist it using the pulley and chain then the drum. It area needs to be flat /horizontal. This is important to aid the vertical drilling of the borehole.
Trainer takes the opportunity to discuss mounting the Dando rig. This method is no longer common in Afghanistan. . See Annex F 1.1

Trainer note participants will visit a drilling rig and on day five of the course and view the drilling rig and ask the rig master to explain any further information they require.

Step 4 See Annex P
Trainer asks

What problems occur if the borehole is not drilled vertically?

Participants respond and trainer adds
During the drilling the bucket is more likely to fall inside the well
Casing is difficult to remove.
Repair work difficult in the future.
The rods will touch the PVC pipe and damage it.

Step 5 Refer to Handout 4.1
Trainer asks participants if they have experience drilling with different size diameters?

Has anyone had experience drilling different size diameters? (6" 8" 16")

Participants explain their experience. Trainer adds the diameter used in a borehole can be mixed. A small diameter ‘string’ of casing and screen can be telescoped into a well through set surface casing and below any anticipated pump setting depth. This could be used in a hard rock hole where there might be danger of rock crumbling into the hole. In an unconsolidated formation the screen section can be reduced in diameter-this will produce an annulus for gravel packing
See Handout 4.1 and Annex O. Tube wells percussion method

Step 6
Sealing a well
Trainer says if a tube well is being bored in a marshy area or through a stratum that contains salty water, to avoid mixing unpleasant or salty water with the fresh water the unwanted strata is blocked. We talked briefly about this process when we were discussing the properties of clay. This is a very interesting process
Trainer asks

Has anyone had experience with this process?

Participants' response is accepted and then the Trainer describes the process as is described in Annex F.

Step 7 The drilling log is an important aid to assist in deciding the right depth for the pump

What is a drilling log?

Trainer displays a drilling box and explains how samples of each change in strata are kept in the box with a label indicating the date and the depth of the strata.

Trainer asks for someone to explain why we take samples and record them

Explain sampling and logging and why we do it!

Participants describe the process
Trainer further adds information **See** Annex F 4 and Handout 3.1 Section illustration of well strata

Trainer asks

Would anyone like to have a go at transferring information from a drilling box record to a cross section illustration of a well?

Trainer also demonstrates how to draw a cross section of a well recording the well strata
See Hand out No 3.1 for an illustration of transferred log records to a cross section of a well.

Trainer relates an experience of when a well failed because of the lack of knowledge of the aquifer.
Trainer asks participants

Has anyone here had an experience when a well failed?

Trainer asks

Do you know why it failed?

In some areas of Kabul the well must go beneath a strata that holds salty water to reach the fresh water.
Kabul has three different geological zones each having different water bearing strata.
There are many stories of failed wells
The wrong filters fitted will either let the aquifer material into the well and fill up the blind pipe or block the straining holes so that water can't enter.
The wrong depth chosen for the pump with wells going dry two weeks after completion

Wells never providing sufficient water or pumps breaking down and no one repairs it

Step 8 Filter See Annex D, F and O, Handout 4.1
Trainer introduces the topic by asking the participants

What is a well filter for?[6]

Trainer writes down the responses
The filter is to stop unwanted material from entering the pump

Trainer asks for a participant to divide into groups and discuss the following points about a filter. Each group has a filter to examine. Trainer explains we have different size holes for different aquifer material

Describe a filter?

Describe a filter!
Where is the filter placed?
The diameter of the filter.
The length of a tube well filter.
Percentage of the area of a filter that is open?
Size of the filter holes See Handout 4.1 Annex D
Material the filter pipe is made of? Annex D
Trainer leads a review of each heading taking information from each group.
Trainer adds information. See Annex F
Note: Participants will view filters when they visit the DACAAR water and sanitation equipment storage yard. If possible devise an experiment to demonstrate different size filters in different containers of material.
Step 9
Lowering PVC pipe and filter
Trainer asks for someone to explain the lowering of the PVC pipe and filter.

Explain the lowering of the PVC pipe and filter!

[6] **Screen (filter pipe):** Wells that obtain water from sand and gravel aquifers – unconsolidated formations – require a filter pipe. A filter pipe is the most important component of a tube well. It is the medium through which water is drawn into the well. A filter pipe is installed adjacent to the aquifer stratum and should extend the full depth of the aquifer.
7.11 Important features of filter pipe are its: Diameter, length, slot size and open area, limit of inflow velocity, the material the filter pipe is made of.

After participants explain trainer adds further information See Handout 4.1

Gravel packing: See Annex F 8 and Annex P
Trainer says gravel packing is the step in well construction that makes the zone immediately surrounding the filter more permeable and prevents particles entering the pump.

Does anyone know the process of gravel packing?

Trainer accepts suggestions then further explains
Well-sorted gravel is a very good permeable porous material so we place some down at the level of the filter. The trained technician carefully drops gravel down the borehole. The borehole must be perfectly vertical.
When gravel packing the casing is raised 30 centimeters and the gravel pack should be 50 centimeters or more depending on the length of the filter..
See Annex F 8 and Annex P

Step 10
Cleaning/developing a well See Annex F
Trainer asks

What does cleaning a well mean?

Participants respond then trainer adds information covering removal of sand from the gravel pack.
See Annex F Cleaning of a tube well

Step 11
Back filling and cement plug. See Annex O
Trainer says back filling is the filling of the space down to the gravel pack and the cement plug is filling the upper1.5 meters. Can you describe it and say what materials we use

What materials do we use for back filling and the cement plug?

Participants respond then trainer adds information covering the process. See Annex O

Step 12
Constructing the well apron. See Handout 3.1Annex F, and Annex Q 6.6, 6,7.
Trainer asks the participants

What should be included in a well apron design?

Trainer lists suggestions
Stabilize and hold the pump pedestal.

Stop wastewater entering the well.
Drain wastewater away

Trainer says I want you to divide into small groups and draw and design the perfect well apron

Draw and design a well apron and describe the construction steps.

When the task is completed a group representative explains the drawing to participants
Was curing concrete included in the process?
Concrete
Trainer adds the DACAAR design uses a mould and will be in the handout.

Step 13
Safety equipment and procedures

Trainer says some of us know of accidents that have happened while drilling wells.
I can tell you one that I know of. Trainer relates the event.
Trainer gives participants an opportunity to relate situations they know of when accidents happen.
Trainer says we are going to divide into groups and decide a list of safety procedures and equipment for a drilling rig operator.

List safety procedures and equipment for a drilling rig operator!

Each group presents their list.
Children must keep away from the site.
Guard to watch equipment.

Helmets with chin strap.
Strong shoes
Gloves
Goggles
Medical Kit
Water purifying tablets
Trousers/overalls

Note to Trainer. Step 9 and 10 can be used at different time slots to vary the procedure

Step 14
Troubleshooting See Annex D and F See Handout 3.1

Trainer says problems often occur when drilling a well and many tools and methods have been designed to solve problems. An experienced operator will solve problems rapidly. This is often referred to as troubleshooting. Delays raise the cost of a well so it is best to avoid them.
Trainer asks

Has anyone had experience of a problem occurring and can tell us about it and how it was solved?

Trainer relates an experience of a problem and how it was solved.

Participants explain their experiences.

Trainer further adds, some of the common problems faced by drilling rig operators are:
The dropping of, the bucket, the casing, or the shoe cutter, onto the well bed.
Dropping into the well the bit and the bucket
Dropping into the well the casing and pipes
Each of these problems is discussed and Trainer explains the solutions provided in Annex F
And Handout 3.1 contains illustrations of some of the troubleshooting tools.

Step 14
Trainer reviews the topics of the day
Different tools used for trouble shooting will be shown at the DACAAR yard.

Title: Advantages and Disadvantages of the Percussion Method.

Session Summary

Objective: After completion of this session the participants will:

- Be aware of the advantages and disadvantages of the percussion drilling method

Time: 45 minutes
Materials: Refer Annex D
Flip chart and markers.
Method: Brainstorming and presentation.
Process:

- Trainer records contributions from participants on the flip chart
- If any have been overlooked trainer will add these to the list.
- Brief clarification and discussion on each method.

Advantages and Disadvantages of the Percussion Method

Process
Step 1 See Annex D
The percussion method is most commonly used method of constructing tube wells by DACAAR and MRRD. It is the method we will have more experience with. While there are advantages in using the percussion method there also disadvantages that we are going to look at.
There are advantages and disadvantages in using the percussion method

What are the advantages and disadvantages in using the percussion method?

Trainer writes down the suggestions as they are given including the following points. See Annex D
Advantages

- Low capital investment and cheap maintenance.
- Most reliable sampling technique that is particularly suitable for well construction
- Suited for working in remote areas as only small supplies of water, fuel and other materials are required

Disadvantages

- It often cannot penetrate hard rock
- Slow process
- Casing is hard to keep free when boring deep holes
- Heavy hammering can cause samples to mix

Step 2
Trainer summarizes the advantages and disadvantages

Training Events	Time Needed	Training Methodology	Supporting Documentation
Opening session Review the previous day's session	30 minutes	Brainstorming	
Visit well ring fabrication site in Kabul	30 minutes	Presentation Brainstorming	Annex O
View all the well construction tools Demonstration of troubleshooting examining tools. Demonstration of erecting pumps step by step	3hour 30 minutes	Presentation Brainstorming	Handout 3.1, 4.1, 4.2, 4.3, 4.4 Annex D, O
Review pump erection	1 hour 30 minutes	Presentation Brainstorming	Handout 3.1, 4.3 Annex D, O
Wrap up session	10 minutes	Presentation & group work.	
Total Time	6 hours 10minutes +1 hour for lunch and 30 minutes for tea breaks		

Title: Well Ring Fabrication and Assembling Hand Pumps

Session Summary

Objective: After completion of this session the participants will have viewed:

- Demonstration of well ring fabrication Refer Annex O
- Demonstration of pump construction Refer Annex D
- Individual pump parts Refer Annex N
- Pump stands
- Apron molds Refer Handout 4.2
- Casings and rising mains Refer Handout 4.1
- Filters
- Troubleshooting tools Refer Handout 4.1

Time: 3 hours 30minutes
Materials: Transport**,** notebooks pens, flip charts and markers.
Method: Brainstorming, group work and presentation.
Physical setting: If the weather is extremely hot do not keep participants standing in the sun for longer than 15 minutes. Plan beforehand where they can stand in the shade for demonstrations.
Preparations check off list:
Book transport in advance
Make lunch arrangements.
Find out where rigs are working.
Contact the contractors before hand.
Find a suitable well ring fabricator.
Advise DACAAR or other yard staff of your plan and requirements.
If there is not an appropriate yard visit a large hard ware shop thet specializes in hand pumps and spare parts
See if a DACAAR trained technician is available to assist.

Process:
Step 1 Visit well ring fabrication site
Learn about ratio of water, sand and cement
How it is mixed
Preparation of molds
Do the fabricators place reinforcing wire
Curing of concrete different methods for hot weather and cold weather

Step 2 Visit DACAAR yard or a similar water programme storage yard. If no yard is available visit a large hard ware shop selling pumps and spare parts.
View all the parts necessary to erect a pump
Demonstration of each step

Well Ring Fabrication and Assembling Hand Pumps

Process:
Step 1 Visit a well ring fabrication site

Interview skilled laborer

Participants and Trainers ask questions

- Learn about the cement mix ratio of water, sand and cement
- How it is mixed?
- Preparation of molds
- Do the fabricators place reinforcing wire inside the cement?
- Curing of concrete
- Do they have different methods of curing for hot weather and cold weather

Step 2 Visit DACAAR yard or a similar water programme storage yard.
View all the parts necessary to erect a pump
Demonstration of each step See Annex D installation of the hand pump

Step 3
Review fabricating a well ring

Assembling hand pumps

Process
Step 1

Revise assembling a hand pump.
Trainer says how much do you remember about assembling a hand pump?
Through a process of asking questions revise assembling a hand pump.
Trainer can use Annex D as a guideline.

How much do you remember about assembling a hand pump?

Step 2
Using Information in Annex D as a guide and summarise process.

Training Events	**Time Needed**	**Training Methodology**	**Supporting Documentation**
Opening session Review the previous day's session	30 minutes	Brainstorming	Handout A & B
Site selection	40 minutes	Brainstorming Presentation& group work	Annex A, N.
Rotary drilling method.	40 minutes	Group Work Presentation by power point	Annex C, E.
Kareez and wells	30 minutes	Presentation by power point Brainstorming	
Cone of depression and draw down	1 hour 10 minutes	Presentation Brainstorming	Annex I.
Pumping test	1 hour 20 minutes	Presentation Brainstorming	Handout 4.1 Annex I.
Site management and supervision	45 minutes	Presentation Brainstorming	Handout 6 Annex B
Wrap up session	10 minutes	Presentation & group work.	
Total Time	5 hours 35minutes +1 hour for lunch and 30-15 minutes for tea breaks		

Title: Site Selection

Session Summary

Objective: After completion of this session the participants will:

- Be aware of the processes of site selection
- Be familiar with the roles of the community and the Engineer

Time: 40minutes
Materials: Handout 2.4 flip charts and markers.
Method: Brainstorming, group work and presentation.
Physical setting: Sitting in U shape, group work on the floor.

Process:
Topic is covered by a series of questions:

Step 1 Who are the main people who are interested in the choice of the location for a well?

Step 2 Group activity answer: What are each persons requirements?

Step 3 Cover points included in Annexes A and P by posing questions
Do you think women should play a prime role in site selection?
What is the Engineers interest in site selection?

Note for Trainer:
Day 5 the participants are taken on a field trip. It is necessary to find locations that are suitable to visit before hand. If possible visits should be organized to a percussion drilling rig a rotary drilling rig and a well being dug by hand.

Check List

Lunch arrangements
Transport
Money if needed
Percussion Rig
Rotary Rig
Hand Dug well
Kareez

Site Selection

Process
Step 1 See Annex A, Annex P. and Handout 2.4
Trainer asks

Who are the main people who are interested in where a well is located?

Trainer records responses

Step 2 Group activity
After a list is made, divide the participants into small groups and ask them to answer the question

What are each persons requirements?

When the lists are completed each group's representative explains the groups findings

Step 3
Using the information in Annex A and P the Trainer covers any points that may have been left out and asks for example

Do you think women should play a prime role in site selection?

What is the Engineers interest in site selection?
Trainer records the extra points that are covered

Title: Rotary Drilling Method

Session Summary

Objective: After completion of this session the participants will:

- Be aware of the uses of rotary drilling
- Be familiar with the rotary drilling process

Time: 40 minutes
Materials: Refer Annex F
Flip chart and markers
Method: Brainstorming and presentation
Setting: U shape
Process:

Questions to guide brainstorming:
Do you know of boreholes in Kabul or anywhere else that have been drilled by a rotary drill?
Why is the rotary method not commonly used?
How does the rotary method differ from the percussion method?
Does anyone know the two types of rotary drilling systems?
Presentation:
Hydraulic Rotary Method and a Reverse rotary method
Using the notes in Annex D the trainer gives a brief explanation of the two types

.

Rotary Drilling Method

Step 1

The rotary drilling method is a very interesting. We will not be going into the details about its use during this course.
Trainer asks participants if they know of boreholes in Kabul that have been drilled by a rotary drill

Do you know of boreholes in Kabul or anywhere else that have been drilled by a rotary drill?

Participants respond and Trainer records responses
The suburb of Dasabz is supplied from a rotary drilled borehole supplies.
In the district of Charasah also has a rotary drilled bore hole supplying water to the suburb Dalamond

Step 2

Trainer adds this method is by far the quickest method but is not commonly used. Can anyone suggest some reasons why it might not be commonly used?

Why is the rotary method not commonly used?

Trainer accepts participants' responses
Because it is very expensive
Capital cost is three times as much as a percussion drill.
Parts are expensive

Step 3

Trainer asks

How does the rotary method differ from the percussion method?

Accepts participants responses then adds:
This is the fastest drilling method.
It is used for drilling large boreholes
Method is used in consolidated hard strata.
It has been used for wells up to 45 cm diameter and up to 150cm with a reamer.
It has been used for wells with a depth of up to 1600 meters.
Oil wells over 7000 meters deep have been drilled by this method.
Maintenance requires specialized mechanical expertise

Step 4
Trainer adds: There are two different types of rotary drills does anyone know the different types

Does anyone know the two types of rotary drilling systems?

Accepts participants responses then explains

Step 5
There is a Hydraulic Rotary Method and a Reverse rotary method.
Using the notes in Annex D the trainer gives a brief explanation of the two types.

Title: Kareez and Wells

Session Summary

Objective: After completion of this session the participants will:

- Have an increased knowledge of a Kareez and its historical origins in Afghanistan
- discussed the reasons why wells affect the water in a Kareez

Time: 30 minutes
Method: Trainer explanation and brainstorming
Materials: Hand out 2.5, Flip chart and markers
Physical setting: Sitting in U shape
Process:

Participants asked:

- What is a Kareez?
- How were Kareez built?
- How does a well constructed near a Kareez affect a Kareez?
- Trainer summarizes discussion and adds any further information needed

Kareez

Step 1 Trainer asks one of the participants to volunteer to explain and illustrate

What is a Kareez?

Participants are encouraged to contribute their knowledge.

A Kareez is an underground tunnel found in Afghanistan constructed in the past to channel water possibly dating back 3,000 years. Kareez although called by a different name are also found in Iran Iraq and Egypt. Some Kareez have been known to be as long as 30 kilometres. Kareez have well type entrances at regular intervals acting as air vents and used during construction and for maintenance.

Step 2

Trainer asks participants

How were Kareez built?

Participants explain

Trainer asks participants **See Handout 2.5**

Why does constructing a well near a Kareez affect the flow of water in a Kareez?

Participants explain

Trainer presents power point presentation that includes information about an existing Kareez that is being renovated on the out skirts of Kabul

Step 3.

As part of the field trip a Kareez outlet will be visited.

.

Title: Cone of Depression and Draw Down

Session Summary

Objective: After completion of this session the participants will:

- Be aware of the affect pumping has on the water in the Aquifer
- Be aware of the affect on the aquifer when wells that are constructed close together

Time: 1 hour 10 minutes
Materials: Flip chart and markers, illustration depicting what happens to the water level when a well is pumped- the cone of depression
Method: Brainstorming and presentation
Physical Setting: Sitting in U shape

Process:

Questions to guide brainstorming:
How do we know that wells that are dug close together influence each other?
What happens to the water in the aquifer after the people in the village have been using the pump all day?
Introduce cone of depression

Presentation:
Explanation and illustration how wells have different cones of depression and how the extent of the cones varies with the yield and the time of pumping, getting bigger (with an inverse logarithmic low) with time.

Cone of Depression and Draw Down

Cone of depression and draw down resulting from the pumping of water from a well

Step 1 Trainer asks participants

How do we know that wells that are dug close together influence each other?

Trainer accepts responses.[7]
Wells that were once reliable after having another well built near by have a reduced pumping capacity.
Experiments are done putting dye in one well to time if and how long it takes to reach the neighbouring well.

Step 2
Trainer asks participants

What happens to the water in the aquifer after the people in the village have been using the pump all day?

After responses are accepted trainer gives an explanation.
Trainer explains using diagrams illustrating the cone of depression
Explains the draw down that results from pumping water from the well
How given time the water level returns to pre-pumping levels 'the recovery'.[8]

Step 3

Why is it valuable to know the draw down of a well after pumping?

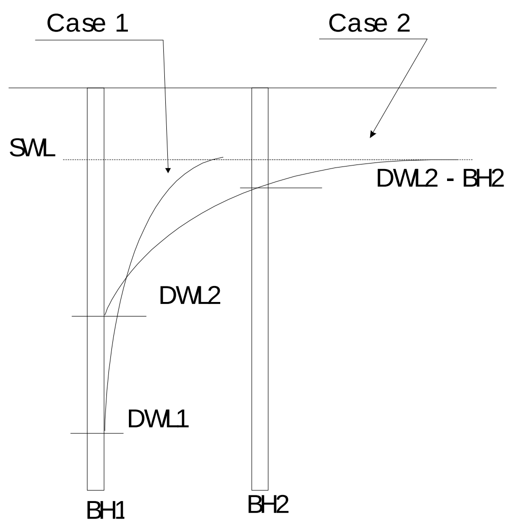
Trainer records responses
Trainer explains

[7] It could be interesting to make a parallel between the depression cone and the vulnerability of the aquifer (because of the flowing directions, if something dangerous rejoins the draw down cone, it would pollute the water well – that's why the larger the draw down is, the more protect the area.
[8] When a well is pumped for some time, it takes approximately the same time to come back to the original level after the pump is stopped.

If we know the pumping rate of the pump and we know the draw down level we will place the strainer below the dynamic water level to ensure the pump will never go dry

Step 4
Trainer explains
Depression cone
Every borehole, when pumped, creates a "depression cone" in the water table around it. The shape and dimension of this depression cone can be calculated with great precision having appropriate pump test data and the drilling log of the boreholes involved.

The drawing below illustrates what physically happens:
In this case we have 2 boreholes: BH1 and BH2. SWL is common to the two boreholes, as long as they are drilled in the same aquifer. BH1 is pumped, so that the water level will drop in the hole to the DWL (dynamic water level). The shape of the depression cone depends on the characteristics of the aquifer: in case 1 (deep DWL, narrow cone) we have a small permeable aquifer, in case two (shallow DWL, large cone) we have a very permeable aquifer. It is clear that in this case BH2 can be influenced, being the SWL disturbed (or in the so called influence area of BH1). The extent of the cones varies with the yield and the time of pumping, getting bigger (with an inverse logarithmic low) with time. When pumping stops, the cones reduce and after the recovery time the static water level returns and the cones disappear.



Step 5 Trainer asks participants

Why do some wells have quicker recovery rates than other wells?

Trainer records all responses

(Alternative exercise: group discussion to answer the question and return to forum to present report)

Trainer explains: all wells when pumped create a depression cone in the aquifer. The shape and dimension of this depression cone can be calculated with great precision having appropriate pump test data and the drilling log /sample box records, of the wells involved. See Annex K

An Introduction to Pumping Tests

Objective: After completion of this session the participants will:

- Have knowledge of the Multi Stage Pumping Test (to record the draw down and cone of depression).
- Realize the value of a pump test to assist us to choose the best location to place the cylinder and pump.
- Realize the value of a pump test to assist us avoid construction errors or assist us detect construction errors.

Title: An Introduction to Pumping Tests

Session Summary

Objective: After completion of this session the participants will:

- Have gained knowledge of the Multi Stage Pumping Test (to record the DWL) when pumping at different rates.
- value of a pumping test to assist us to choose the best location for the pump and to detect construction errors
- To understand the Dynamic Water Level and Static Water Level**.**

Time: 80 minutes
Method: Presentation, and brainstorming
Materials: Handout 3.2 includes pumping test graph See Annex I, J.
Process:
Why do we carry our pump tests on a well?[9]
For what kind of situation are these tests used? The Step, Test- Multi Stage Pumping Test, (MSPT).

Note for Trainer
If the trainer believes the participants will benefit from further information on pumping tests Annex I expands on the Step Test and includes an outline of the Duration Test and Annex J includes exercises for participants to complete.

[9] There are practical reasons why pump tests are performed, and there are practical reasons why every well should be pump tested.
When pumping commences, the level of water in the well drops, initially very fast and then slower and slower, with a logarithmic law. After constant pumping for some time the level of the water in the well stabilizes. If you increase the pumping rate the level drops again, with the same modalities. When you stop pumping, the water comes back to the Static Water Level (SWL) with the same modality: very fast at the beginning, than slower and slower, until the initial level is restored.

In practical terms, given the yield of the pump we install (i.e. hand pump) we want to know how much the level of water in the well will drop during pumping, and avoid the pump going dry by setting the pump lower than that depth. We also want to know how long the water table takes to come back to the original level when we stop pumping,.

An Introduction to Pumping Test

Process:
Step 1 Trainer asks participants

Why do we carry our pump tests on a well?

Trainer writes down all the suggestions then says
We want to learn how much the level of the water in the well will drop after constant pumping, when pumping at a regulated yield per second.
When we have enough information to estimate the level the water will drop after eight hours of constant pumping we will be able to place the pump well below this level when constructing a well.
Notes for Trainer
There are practical reasons why pump tests are performed, and there are practical reasons why every well should be pump tested.
When pumping commences, the level of water in the well drops, initially very fast and then slower and slower, with a logarithmic law. After constant pumping for some time the level of the water in the well stabilizes. If you increase the pumping rate the level drops again, with the same modalities. When you stop pumping, the water comes back to the Static Water Level (SWL) with the same modality: very fast at the beginning, than slower and slower, until the initial level is restored.

In practical terms, given the yield of the pump we install (i.e. hand pump) we want to know how much the level of water in the well will drop during pumping, and avoid the pump going dry by setting the pump lower than that depth. We also want to know how long the water table takes to come back to the original level when we stop pumping,.

Step 2 See Annex Q

- Trainer asks the participants if anyone has knowledge of Bailer Test, and Open Channel Method.

What is an open channel test?

Participants explain what they know and trainer adds further information
These simple methods are commonly used in Afghanistan

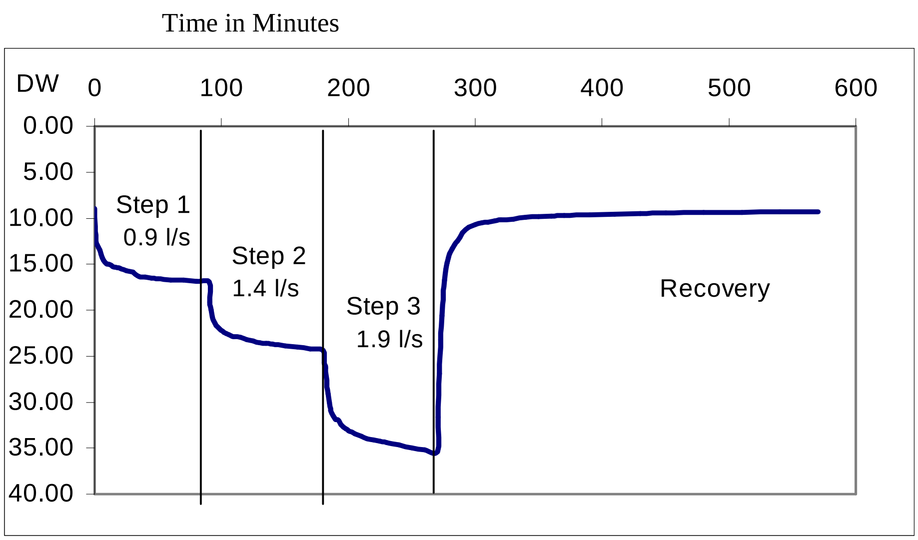
Open channel pump test: Used to measure the discharge of a spring, river or stream. If the section of the channel is uniform, straight, and rigid, it is ideal for the estimation of discharge. A small channel that is straight and uniform approximately 10 – 20 meters long is made. . A mean value of the area of the cross section of the length of the channel to be used for the study is determined. This area is multiplied

by the mean velocity of flow to give the discharge. The velocity of flow is determined by several methods. The simplest method is by a float. A small piece of wood or any floating body is thrown in the middle of the channel. The object is timed with a stopwatch to record how long it takes to travel the distance. The ratio of distance, S, in meters to time T in seconds, is the surface velocity
Discharge Q = Area X Velocity
Area = π x r^2 Velocity = Discharge/Area

Gallon test: is used to measure the discharge from a hand pump. How many liters per second (1 Gallon = 3.78541 liters) A stopwatch is used to measure the time it takes to fill the gallon bucket. A discharge of 220 liters per minute will take 60 seconds to fill the container

Bailer test: A bailer test is a simple test used to calculate the discharge of water from a pump. If the discharge is low, of the order of 150 liters to 600 liters per minute, it can easily be measured by an empty 220-liter drum. A stopwatch is used to measure the time it takes to fill the drum. A discharge of 220 liters per minute will take 60 seconds to fill the container.

Step 3 The Step Test- Multi Stage Pumping Test, (MSPT). Trainer says
The calculation of the exact specific draw down and well equation needs specific techniques. We are not going to attempt that in this course
We are going to look at an example of a pump test. This kind of test is called "Step Test". Each participant is given a hand out copy of the graph
You can use the Step Test to calculate the efficiency of the well.
If a well is badly constructed, it can be discovered!
The Step Test - Multi Stage Pumping Test, (MSPT).



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Trainer explains the graph to the participants pointing out that

Every 90 minutes the yield of the pump was raised
SWL is 8.97 m. The pump was started at 0.9 liters per second.
The level of water dropped very fast and then slower and slower, with a logarithmic law.
After 90 minutes the DWL stabilized at 16.95 m, with a draw down of 7.98 m (16.95-8.97).
After 90 minutes the yield of the pump was incremented to 1.4 l/s. What was the DWL after 180 m?
Then a last step was taken. Was the DWL stabilized? .
After 3 steps of 90 minutes, the pump was stopped and the residual DWL measured. It can be noticed that it took approximately more than 4.5 hours to come back to the original level.

Asks the participants what was the yield in the first 90 minutes

What was the dynamic water level after 90 minutes?

After the last step was the DWL stabilized?

When a well is pumped for some time, it takes approximately the same time to come
To come back to the original condition after the pump is stopped

This is only an approximate and general rule, with many exceptions:

In this example how long did it take the well to come back to the SWL?

Step 4
The trainer relates the DACAAR's experience

Every well should be pump tested. We have a practical problem though when we drill 100 wells in one area, we have to decide how deep those wells have to be to supply enough water for our hand pumps.

Each well has its own characteristics that can be summarized in a simple well equation. We don't have the well equation of each well; neither can we perform a pump test on each well.

But we know something we always install the same kind of pump, the AFRIDEV hand pump. The yield of this pump is always the same[10]: 600 liters per hour (0.16 l/s).

We can assume that in certain areas the conditions are similar, so we can estimate the average, approximate specific capacity of the wells. So we know that, to safely get our 0.16 l/s, we need the pump to be at least 10 m below the SWL.

DACAAR standard for silt terrains in Afghanistan is 10 m below the SWL.

Now, what happens when the users of a well complains that, after a while, the pump goes dry, and they have to wait some time to get water? It means that the specific capacity of the well is low, we haven't positioned the pump deep enough to supply the pump with 0.16 l/s, so the DWL reaches the pump, and we have to wait for recovery before pumping again.
It could be that the well is badly constructed filters, gravel pack etc, but may also be that the specific capacity of the area is lower than expected which depends on the formation i.e. Transmissivity and Storativity.

If all other wells in the area have water, the well must be badly constructed.

<u>Drill the next wells deeper,</u> even more than the 10 m in the strategy.

If you have a good drilling log, you should see if the conditions of this specific well are different less sand, more clay to justify the lower specific capacity.

If you encounter a good permeability layer i.e. gravel, the specific capacity of that point will also be very good. This is why it is so important to get a good drilling log, and put the filters just in front of good layers!

Step 4

Trainer summarises the content of the session
Note for Trainer
If the trainer believes the participants will benefit from further information on pumping tests Annex I expands on the Step Test and includes an outline of the Duration Test and Annex J includes exercises for participants to complete.

[10] In fact we know that it depends on how strong the user pumps the handle. 600 l/hour it is the maximum value.

Title: Site Management and Supervision

Session Summary

Objective:

Have a clearer understanding of the many aspects and responsibilities of site management and supervision

Time: 45 minutes
Method: Brainstorming and group work
Material: Handouts
Physical Setting: sitting in U shape and then groups working on the floor.
Process:

- Participants relate problems caused by a lack of management and supervision.
- Answer what are the different areas that need supervision or management
- Group activity based on expanding on individual areas of management and supervision.

Note for Trainer:
Day 5 the participants are taken on a field trip. It is necessary to find locations that are suitable to visit before hand. If possible visits should be organized to a percussion drilling rig a rotary drilling rig and a well being dug by hand. Contractors are to be advised and warned that they will be needed to answer questions

Check List

Lunch arrangements
Transport
Money if needed
Percussion Rig
Rotary Rig
Hand Dug well
Kareez

Site Management and Supervision

Step 1 See Annex B

Process
Trainer says many of you have had experience at management and supervision. What are the many aspects a site manager has to prepare for and manage? If management and supervision is neglected many things can go wrong. We often leave important jobs to junior people.

Trainer asks has anyone present had an experience where management neglected to take care of something?

> Has anyone present had an experience where management neglected to take care of something whether by neglect or mistake?

Several participants relate their experiences.
In each instance try and discuss the cause

Trainer asks

> What are five components of a well construction site that have to be managed and supervised?

Trainer accepts responses and then divides participants into small groups

Choose several of the areas that need management and list the more detailed aspects of each one that require management or supervision

Step 2
Participants return to the forum and report on their findings

Step 3
Trainer and participants add any points they feel are missed out.

Day 5 — Design and Timing

Training Events	Time Needed	Training Methodology	Supporting Documentation
Opening session Review the previous day's session	30 minutes	Brainstorming	
Visit two percussion-drilling sites and a rotary drilling site. Interview site workers and manager	2hours	Observation Presentation Brainstorming	Handout 4.1
Visit the Kareez outlet at the suburb of Kareez	30 minutes	Observation Presentation Brainstorming	Handout 2.5
Visit The suburb of Dasabz where a rotary-drilled borehole supplies water to the district or Charasah or Dalamond rotary drilled bore hole that supplies water to the suburb Dalamond.	1 hour	Observation Presentation Brainstorming	
Review Field Visits	30 minutes	Brainstorming	
Assessment Evaluation Certificate Presentation	1 hour	Written exercise	Handout C, and D
Total Time	5 hours 30minutes +1 hour for lunch and 30 minutes for tea breaks		

Visit Percussion Rig Rotary Rig and Hand Dug Well

Objective:
The participants have an opportunity to see well construction in progress and an opportunity to ask a rig operator or assistant's questions

Time: 3 hours

Locations that are suitable to visit are chosen before hand. If possible a percussion-drilling rig a rotary drilling rig and a well being dug by hand should be visited. If time permits a Kareez should also be visited.

Check List of Preparations

Lunch arrangements
Transport
Money if needed
Percussion Rig
Rotary Rig
Hand Dug well
Kareez

Course Evaluation and Assessment

Objective:

Through the completion of this questionnaire the trainers will be assisted

- To identify the strength and weaknesses of the course
- To assess the degree of information being assimilated by the participants.
- To get an idea about effectiveness of the facilitators

Time: 35 minutes
Method: Written exercise
Material: See Handouts
Physical Setting: Seated in U Shape
Process:

- Trainer explains the reason for the assessment
- Explains the questionnaires.
- Participants' complete questionnaires and trainer collects them.
- Trainer explains the reason for the evaluation
- Explains the evaluation questionnaire
- Participants' complete questionnaires and trainer collects them.

Note for trainer
Students should be given adequate time to complete the questionnaires.

Course Assessment, Evaluation and Certificate Presentation

Step 1
Trainer hand out the sheets for participants to complete
Participants complete assessment questionnaire

1. Which topic was of most interest to you?
2. What are the two methods of constructing tube wells?
3. How can you make a filter more effective?
4. Why are pumping tests carried out?
5. What do we call the water level when it drops after pumping?
6.What is an artesian well?

Step 2(See Handout C)

Evaluation of the training methods and the general arrangements

Participants rate the following on a scale of 1 to 5.Five being excellent.
1.Were the objectives of the course achieved?
2.Were the methods participatory?
3.Were the trainers friendly?
4.Was the material useful?
5.Was the venue conducive to learning?
6.Was the catering adequate?

Step 3
Presentation of Attendance Certificates

Step 4
Closure of the course

Annexes for Well Construction Training Course

Annex A Site Selection:

In collaboration with the user group the field engineer is responsible for the final site selection for each water point of the area. The user group is involved in site selection and should understand selection principles.

The selection of the improved water point should be based on the following criteria:

- The location of a well should be determined by a qualified hydro geologist or experienced water well contractor or engineer based on study of the location and a test drilling
- The technical person is responsible to provide technical information for the site selection. If the community has a clear understanding of the guidelines for choosing an appropriate site this will influence them to make a sound choice.
- Priority should be given to those villages without any access to safe drinking water.
- Villages where all or the majority of the families have private wells should be given a lower priority than those villages where the major drinking source is unimproved public water points and streams. This is because unimproved private wells are likely to give relatively safer water than unimproved public wells and streams. All families from the intended user-group must have access to the water point.
- The water-point should be located in a place where considerations of *Pardah* do not prevent women from using it. Wells should not be located along trafficked road because women will not have free access to the well. If there is no other possible location, roadside wells may be improved only if the community constructs a privacy wall.
- DACAAR has examples of site selections being made by only a select group in a village and later on the people who chose the site contacted DACAAR to have the site changed as women were unable to go there or it had been claimed by one family.
- The water point should be located so that access cannot be monopolised by anyone. This means that sites should preferably not be selected adjacent to the compound of powerful members of the community as it increases the risk of privatization.
- Consensus must be reached by user group on the site selected. The Field – Engineer will advise the user group on site selection.
- Where possible women should have the prime role in the selection of the site. The female Hygiene Educators should be used to ensure that women's opinions are collected during the site-selection process.
- The users must make a major contribution to site section. It is very important that from the beginning they feel the well belongs to them and not to the engineer or contractor. After completion the engineer and contractor will rarely get another chance to return.
- The site must not be open to contamination from latrines, washing areas, canals, ponds or other sources. There is no perfect rule governing the distance that is necessary for safety between latrine and well. Many factors such as slope and level of the ground water, and soil permeability influence the possibility of the bacteria in ground water.

- Where the sale, exchange or donation of land is required to construct or improve a water point then:
- The sale exchange or donation of land should be documented in a *waquf*. The site of the water point should not obstruct any future government plans.
- Test from other community wells will help the technical person understand the static water level, the quality of the water, and the direction of the ground water flow and the strata of existing wells.
- Perform chemical and microbiological analyses of the water to determine the characteristics of the water in the well /aquifer: this helps to predict the susceptibility of the well to encrustation or erosion, provide information on the water quality, and serve as a baseline record to detect any change in water quality or contamination.
- Elders in the community can advise the technical person about the rainfall over the past ten years.
- The Engineer will take all collected information into account when he advises at what depth to put the filter and estimating the recovery of the water table after pumping.
- Community members know their location and can advise on areas to avoid because of rocks and previous failed attempts to locate water.

Annex B Site Management and Supervision

Main points to be considered by the site engineer:

- Project plan and duration
- Work distribution among staff
- The involvement of community in all stages of the project
- Management follow up and supervision
- Management, administration work and reporting

- Staff should have clear understanding of

  What the management expects of them.
  Their own job description.
  The team's chain of responsibility.
  Work hours.
  Safety measures.
  Terms of employment etc.

Project plan and duration

- Project cost carefully calculated
- Draw up an implementation plan including estimated dates for completion of each stage
- Implementing agency should be well documented
- Beneficiaries- the people most in need of water identified.
- Expected output can be estimated for each week

We need to know the donor for the project and adapt our plan paying particular attention to the conditions attached to the budget and contract.

Daily work plan:

Planning also needs to be done on a daily basis. This plan should include

- Meeting with staff before work to discuss the days plan
- Distribution work among staff.
- Use of vehicle
- Efficient use of resources

An example of efficient use of resources is pre-paring for the sinking of rings.

  The user group is to be informed in advance to organize unskilled laborers.
  The well must have a sufficient water column.
  Mud must be cleaned from the well in readiness

Staff behavior:
The field engineer should ensure the good behavior of the staff
Staff should at all times respect the local culture “parda” system.
Staff should not expect the community to feed them and if there is no alternative they should not expect special food.
Staff should not walk around the area or in the village when they know it is not acceptable behavior

Community involvement in the project:
For the sustainability of the project it is very important to involve the user group in all stages of the project. The engineer should have meetings with the community from time to time to explain the project progress and importance of the project. The engineer should prove to the community he is working for their benefit and as if he is a member of the community. The site selection of several wells in one day would be completely inadequate.

Follow up and supervision.

Daily supervision of work is very important. Solutions should be found to solve problems. Problems occurring because of poor supply of materials or poor quality workmanship must be overcome.

Administration work and reporting:

A daily work record, stock book, vehicle and machinery logbook should be filled in daily.
The data base hand pump installation forms and other reports should be very accurate. The number of concrete rings, depth of wells, number of families etc should be precise, so that it can be entered into the data base survey.
Most of the donors require final financial and narrative reports at least one month after completion

Other points that should be considered by the field engineer during the implementation of the WS project

- The engineer should cooperate with all donor monitoring visits and provide them with the necessary information
- Prepare the camp rental contract if applicable
- Sign the project agreement with the local Shora and have it approved by the local authority.
- Obtain a letter from the authorities verifying the names of those chosen as project guards
- Prepare and install a project signboard indicating the donor’s name.
- Supply the site with a first aid kit.
- Staff should sign the attendance book each morning

- The daily work of the project should be recorded on a form prepared for this purpose.
- The curing of the concrete according to the weather in the area. If it is hot, water should be used to wet the concrete. If it is cold the concrete should be protected to prevent it from freezing.
- Curing concrete is difficult for user groups it needs technical attention.
- Water supply teams should try to obtain good quality sand and gravel for the project.
- The prepared concrete mix should be used within less than a half hour to prevent it from losing strength
- If one family is contributing all the unskilled labor this probably indicates they are claiming the stand post or well as their property.

Purchasing

- Proper bills or receipts are necessary
- Three quotations are necessary for items exceeding AFS 300 e.g. cement and iron bars etc
- When purchasing iron bars and cement a committee from a near by project is to be involved.
- A safe way for transporting materials should be found.

Production Site:

- A platform should be constructed for the manufacturing of pedestal slabs.
- A concrete mixer and vibrator should be used to manufacture concrete structures such as slabs, and concrete rings to ensure good quality
- The sand and gravel should be measured separately for each batch for the manufacturing of each structure and the well apron.
- The loop of the GI wire used to reinforce the concrete rings should be tied by winding wire.

Health education

- The engineer should reinforce the basic health education messages when addressing the community
- The community must understand why the surroundings of the well /water point should be kept clean at all times.
- The importance of storing and transporting water safely should be emphasized.
- Field staff should also keep their office, kitchen and sleeping beds clean.

Shallow wells and tube wells

- The projects donors name and the well number should be written on the post of the well

- The back filling of the concrete rings in the well should be done properly with small stones and gravel.
- The apron, the pedestal slab and the top ring should be joined and the pointing done properly.
- The community should be mobilized to fill the area surrounding the apron and level it.
- The waste- water should be diverted properly to prevent pollution around the well apron.
- The borehole should be straight
- A proper bill plug in the bottom is required.
- In areas where the aquifer strata has fine sand the filter slot size must be decreased
- A proper gravel pack is required around the filter
- For the sealing of the strata well-compacted clay is recommended.

Hand pump installation:

- Hand pumps should be installed in places where they are visible for people to see.
- Hand pumps must be installed vertical to the apron.
- The team should do the selection and training of the hand pump mechanic
- A skilled laborer should be instructed to install one clamp at each joint of the PVC rising main.
- The wages agreement for the hand pump mechanic should be signed with each user group before the installation of the hand pump.
- The rising main should be straight to avoid future problems
- The preparation of the necessary tools and bicycle for the hand pump mechanic in each project area is the responsibility of the water Supply team working in the area

Stocks

- The issue and receipt vouchers should be available at the project camp and should be filled in when any stock is received.
- The daily in and out of stock should be recorded properly on stock project cards.
- All construction material such as cement, iron and pipes should be stored properly.
- The sand and gravel used by the project should be recorded on the stock cards.
- Field Engineers should transfer construction material when a project is completed to the new project construction site as soon as possible. All vouchers should be sent to head quarters as soon as possible
- If materials are received from the supplier damaged this should be mentioned in the remarks column of the Receiving Voucher.

All material purchased has to be recorded in the stock book.

Annex C Wells

A well is a hole in the ground that fills with ground water. This water can be brought to the surface by a pump. Some wells, called artesian wells, do not need a pump because of natural pressure that forces the water up and out of the well. There are different types of wells. In Afghanistan there are two types of wells most common for drinking purposes: dug wells and tube wells.

1.1 Goals in water well construction

The purpose of water well construction is to provide a water supply well that will be hydraulically efficient and have a long service life. There may be some exceptions to these goals, such as temporary wells for military camps, but these are minor.

Wells providing potable water for human consumption should be designed and constructed to provide high-quality water meeting health standards such as those developed by the World Health Organization.

1.2 Well location, design, and construction for optimal performance

Depending on the application, a well location should be determined by qualified hydro geologist or experienced water well contractor based on a study of the location and test drilling, and in consultation with health authorities. Wells should be located to produce the maximum sustainable yield possible as well as to protect the water source from contamination.

A proper well design includes, determining the depth and diameter for the best yield, sanitary protection, procedures for well cleaning/development, testing, and disinfection, all of which are necessary to achieve the greatest efficiency and safety possible.

Designing for maximum efficiency minimizes encrustation effects. A good choice of materials enhances resistance to biofouling and corrosion. Good design includes provision for wellhead sampling, flow and water level monitoring.

High-capacity, high-cost wells such as those for municipal supply and irrigation should have blow off diversion for testing and treatment and wellhead flow meters.

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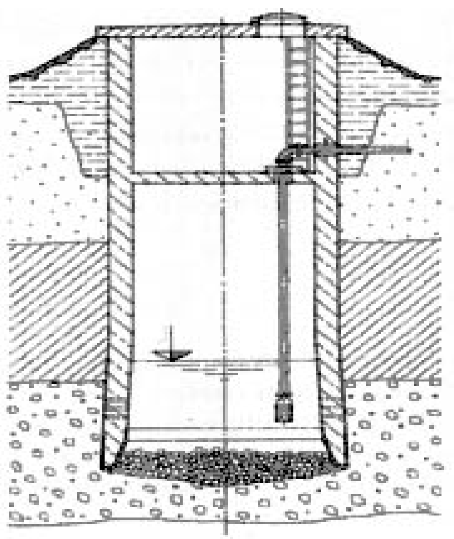
1.3 Summary of well design and placement guidelines

1. Well design should be done by a qualified groundwater professional (contractor, engineer or hydro geologist experienced with well hydraulics and construction).
2. Determine any fixed distance requirement from your state authorities: usually set as a ground radius from potential pollution sources (sewers, drains, streams, septic tanks).

3. Adjust these for site circumstances. For example, little filtering action (or absorption) will take place in limestone or fractured rocks formations. So a set 30m radiuses may provide little protection.
4. Perform chemical and microbiological analyses of the water to determine the characteristics of the water in the aquifer: this helps predict the susceptibility of the well to encrustation or erosion, provide information on the water quality, and serve as a baseline record to detect any change in water quality or contamination.
5. Choose materials that will provide a long service with the price being a secondary consideration.
6. Design and select screens and construction steps with the same priorities.

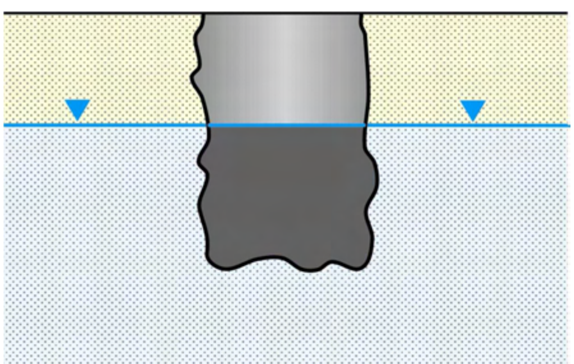
2. Hand dug wells

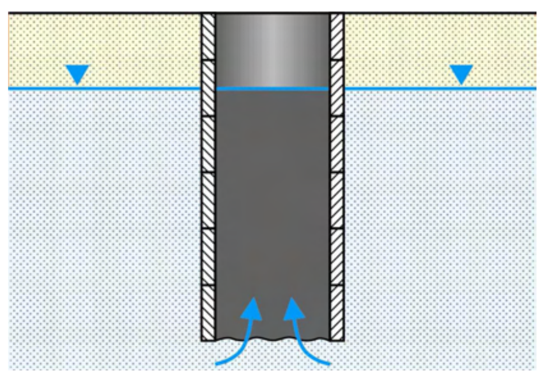
A hand dug well is a water hole, dug a few meters into the aquifer. Normally the water enters the well through the base.



Dug wells serve as water collectors and ground water reservoirs. Dug wells have bigger diameters than tube wells, ranging from 1 to 8m and a depth of at least 2 m below SWL. To achieve the needed depth, it is necessary to remove water while digging if possible by a sludge pump to make further digging possible. If digging takes place during the wet season, a depth of 4 m below SWL should be achieved, in order to prevent the well from drying up during the dry months. The total depth (TD) should be no more than 60 m, in order to enable the installation of the hand pump. The discharge rate of a dug well is low compared to a drilled well. In open wells the water is often contaminated, as the water is open to the atmosphere and human interference.

In unconsolidated rock the walls are often stabilized with bricks, concrete or prefabricated concrete rings. Casing the well may be necessary depending on the geological formation of the strata. Pre-cast concrete rings are used to prevent wells from collapsing. The concrete rings have a diameter of at least 0.8 meters and a height of approximately 45 cm, a thickness of 5 cm, and are reinforced with 3 mm steel wire. The upper part of the dug well is best protected from contamination with the installation of at least 2 concrete rings, sustained on a reducing slab. The annular outer space between the rings and the hole shall be filled by backfilling with a non permeable material, laid in successive layers of 20 cm and compacted after each 20 cm layer to ensure the perfect non-permeability of the backfill. The natural clay used for backfill has to be sieved to remove all sand and gravel possibly present.
A surface pre cast concrete ring, with diameter of 0.80 m, height of 0.90 m and thickness of 7 cm, reinforced with 5 mm steel rods and 3 mm galvanized wire, shall be installed, with cover slab. A drainage apron is constructed, as per requirements.





3 Tube wells

A tube well is a hole or a pipe in the ground that we can draw ground water from through a pump to the surface of the earth. Its design varies with the geological conditions of the formation and the purpose for which the ground water is to be used.

Percussion air rotary or mud rotary drilling systems can be used, according to the litho logical condition encountered, with minimum drilling diameter of 8″ (203 mm).

The drilling of tube well consists of the following steps:

- Site selection for drilling a tube well.
- Setting up the drilling rig system.
- Operation of well drilling.
- Logging (Sampling)
- Lowering of filter and casing pipes.
- Gravel packing.
- Construction of well the apron.
- Installation of the hand pump.

Annex D Percussion method (cable tool drilling)

In this method drilling can be conducted with 12, 16, or 22″ buckets.
When percussion drilling a well, appropriate, temporary, casing is used in unconsolidated, collapsing strata, and any time when drilling below the static water level (SWL).

1.1 Operating principles cable-tools (percussion) method:

Drilling is accomplished by regular lifting and dropping of the string of tools mechanically with the help of a cable. The drill bit dislodges or crushes both consolidated and unconsolidated rock into small fragments. After the bit has cut one to two meters through the formation, the string of tools are taken out and a bailer/bucket is inserted in the hole to remove the drill cuttings. When working in soft unconsolidated rock the drill bit loosens the material. The bucket essentially consists of a pipe like section with a valve at the bottom. The length of the bucket varies with its diameter, and may range from 3 – 12 meters. If no water is encountered in the hole, water is added from the surface to form a paste with the cuttings.

1.2The casing pipe

In this method a casing pipe is lowered as the drilling proceeds. Usually a starting hole about 3 meters (10 feet deep) is dug into which is placed the first piece of casing. Drilling by cable tool percussion method in unconsolidated formation is started. It is necessary that the casing should follow closely the drilling bit that deepens the hole. This is necessary to prevent caving of the formation. The casing is hammer driven into a few feet of the formation.

The casing is driven down by means of drive clamps, fastened to the drill stem. The up and down motion of the tools striking the top of the casing that is protected by a drive head, sinks the casing. The cutting tool and the bucket are operated through cables wound on reels. The cable passed over the pulley is fixed to a swivel tool. These are hung on a frame of a derrick of suitable height. The operation of the drilling is carried out through a spudding beam.

In some areas in Afghanistan, local, simple boring machines/augers are used. These machines are operated by hand instead of machine.

Another cable tool method includes the tube sampling or “shell” method, which advances the borehole by driving a tube into the strata formation and removing the tube with the retained solid cylinder of strata material cut from the formation.

A drilling rig set consist of engine, drum, wheel, girder, columns, casings of different sizes, at least two sizes of buckets, bits, and iron cable.

The necessary tools for a drilling rig set are a chain-pulley, large and small size leaver arms, lifting jugs, chain-wrench, set of pipe-wrenches, set of screw-wrenches, pliers, screw drivers, hacksaw, saw, iron clamps, wooden blocks and iron rods.

Use of telescopic boring pipes

If the formation to be drilled is hard and contains shingles and cobbles, abig size boring pipe only is suitable. At certain sites casing pipe of 22 inches diameter has been used. The bottom edge of the pipe is sharpened to help in cutting the formation. The bucket is correspondingly of bigger size and heavy. When boring to a depth of 300 to 400 feet is to be carried out use of a telescopic casing pipe is useful. The top 100 feet to 120 feet of the casing pipe is generally 18 - 22 inches in diameter. For deeper boring the size the size of the casing is reduced to 16 – 14 inches. The top 18 or 22 inches diameter pipe is left in position. Another pipe 16 inches in diameter is now lowered into the big size pipe and sunk say another r100 feet. Further boring is now carried out by a say 10 inch diameter pipe. These three pipes of different sizes are lowered one after another and after constructing the well are pulled out.

1.3 The Suitability of cable tool drilling

This type of drilling has been in use throughout the modern drilling era since 1859 and earlier. This type of drilling was used to drill the first oil well in the state of Pennsylvania, USA.

Despite many new developments introducing different types of drilling cable tool, spudding remains a useful technique in many drilling situations.

1.4 Advantages of the cable tool:

- Low capital investment and cheap maintenance. Capital cost is less than a third of rotary machines of similar capacity. Maintenance does not require, such specialized mechanical expertise and expensive parts as more complex machines. Many components can be fabricated in a machine shop and are all available “recycled” worldwide.
- A percussion drill produces high quality samples in unconsolidated formations. It is well suited for geological sampling tasks. Generally regarded as the most reliable sampling technique for alluvial (placer) mineral investigations.
- It is particularly suitable for water well work as it permits collection of detailed information on each water horizon as it is penetrated.
- It is suitable for remote area operation as only small supplies of water; fuel or other materials are necessary.
- It can drill economically and obtain samples in cavernous formations.
- In general, it can drill in a greater variety of lithologies (strata samples) with a single tool string. Bits can be renewed on-site. It is highly suitable for remote settings.

1.5 Disadvantages of the cable tool:

- Productive output measured by daily increase in depth of hole is relatively low in most cases.
- Hard rock penetration rates may be very low.
- When casing is required it is difficult to keep the casing free when drilling deep boreholes.
- The heavy hammering action causes disturbance and damage in some formations, resulting in mixed samples.

Trouble Shooting

Annex E. Rotary drilling:

Rotary drilling makes a borehole by turning the bit in the bottom of the hole. It is rotational drilling as opposed to the up and down action of percussion drilling.

The rotary method is used for drilling large bores in unconsolidated strata. This is fastest method and has been used for wells up to 45cm diameter (up to 150 cm with a reamer), and for depth over 1600m. Oil wells over 7000 meter deep has been drilled by this method

During last forty years several types of boring rigs have been developed to drill in different formations.

Rotary drilling system is divided into two types

A) Hydraulic Rotary Method:

In this method, the boring is done with the help of a drilling bit attached at the end of a string of hollow pipe. A mixture of clay and water, known as drilling mud, is continuously circulated through the drill shaft in the hole. Material loosened by the bit is carried upward in the hole by the rising mud. Ordinarily no casing is required since the drilling mud forms a clay lining and supports the walls of the hole.
The drill bits have hollow shanks and one or more centrally located orifices for jetting the mud into the bottom of the hole. The drill rod, made of heavy pipe, carries the drill bit at one end and is screwed to a square section known as *kelly*. A rotating table rotates the drill rod that slides downward as the hole deepens. The rising drilling mud carrying rock fragments is taken to the setting basin where the cuttings settle. The mud is re-circulated to the hole. To maintain the required consistency, clay and water is added to the circulating mud from time to time. A complete boring strata record is maintained to record the formations at various depths. When the desired level is reached, the drill rod, etc. is taken out and the well pipe containing strainer pipes at appropriate locations (opposite aquifers) is lowered. Since the well walls are coated with clay, it should be washed to get a greater discharge. Back washing is done by lowering the drill pipe and bit in the well-pipe, and forcing water-containing calgon (sodium hexameta phosphate). Calgon has the property of dispersing clay colloids. A collar, the size of the well pipe, is attached to the drill rod just above the bit. This forces the water through the strainer causing a washing action on the clay wall. At the same time, the drill rod is plunged up and down causing surging action. When washing of the bottom is done, the bit is raised some distance and operation is repeated.

(B) Reverse Rotary method:

Reverse rotary method, similar to the hydraulic rotary method is used much in Europe. This method, removes the cuttings by a suction pipe. A large capacity centrifugal pump is used for this purpose. A mixture of water and fine-grained material is circulated in the borehole. The procedure is essentially a suction dredging method. While drilling the walls of the borehole are supported by hydrostatic pressure acting against the film of fine-grained material deposited on the walls by the drilling water. The method of re-circulation of drilling water containing fine grained particles and cleaning the well after inserting the well pipe is similar to that of the hydraulic rotary method.

Annex F Operation of a drilling rig

Setting up the drilling rig system:

1.1 Setting up of Dando Rig System:
The Dando Rig parts, the engine, the wheel, the frame and the columns have a prefabricated joining system. The rig is easy to mount and takes little labor.

1.2. Setting up the Single /Double Drum System:
The Single/Double Drum rig system parts, girders, the wheel, and columns are separate from the rig frame, the mounting takes more time and is much more labor intensive.

2. Operation of drilling rig:
The operation of a drilling rig consists of the boring of the well hole by lifting and dropping the drill bucket into the borehole and taking out the slurry. Before starting drilling by machine a pit hole is dug at the well site with a depth of 2-3 meters. For the machine-drilling process, the pit should be filled with some water in order to make slurry. Whenever the stratum is loose, casing should be installed. It is not necessary to use casing for hard strata. As the well gets deeper the casing is lowered.(With the lowering the depth of tube-well casing also goes down.) When the depth of well reaches the capillary or saturated zone of the ground strata, the slurry will be produced by ground water. This procedure will continue until the desired depth is reached. Whenever the drilling process reaches a hard stratum like conglomerate and bedrock, a bit with a different weight will be used to brake down the rock. The bucket shoe cutter will be sharpened by steel welding spots.

2.1 Common accidents and solutions:
When drilling tube-wells, problems occur. For trouble shooting a skilled rig operator is necessary. An experienced operator will solve problems rapidly and make the process cost effective. Problems cause delays and increase costs

6.2 Some of the common problems are:
The dropping of the bucket, the casing, or the shoe-cutter, onto the well bed.
Dropping into the well the bit and the bucket.
Dropping into the well the casing and pipes.

2.3 Remedies:
2.31 The bucket and casing shoe cutter are on the well bed
For removing/pulling out the bucket and casing shoe cutter the first step is to use a hook or to give a slight impact with the bucket to the shoe cutter joining one or two of the threads.
It is not possible to pull out the casing shoe-cutter as we cannot pull out all the casings.

2.32 The falling of the bit and bucket into the well.

If the bucket or bit has fallen onto the bed of a well because of the severing of the extension cable it is possible to get them out by using a hook or fishing tool. The hooks and fishing tools should be made of hard iron.

If the bucket and bit are stuck in the middle of a well because of gravel falling in, give some knocks at the top to release it and pull it out.

2.33 The casings and pipes falling into the well.

To pull out the casing and a pipe from the bed of a well two techniques can be used.

First using a fishing tool with a hinged iron anchor attached to it. When the fishing tool enters into the pipe the anchor is in a flat position, when we pull out the cord the fishing tool anchor opens and sticks to the wall of the pipe or casing.

Second use a steel rod with a cone shape wooden block attached to the end. Lower the steel rod with the wooden cone block at the end into the well pipe or casing and put some gravel on the back of wooden block. The gravel helps the wooden block to catch in the pipe or casing and they can then be pulled out.

3. Maintenance

(a) Routine maintenance:

A drillmaster should do the following maintenance daily.

Service all rig systems, check the engine, check the fan belt for cuts or wear, check the rig drums and handle ball bearings for cracks and wear, check the cable for breaks and wear, check the level of the engine (mobile) oil, check the lubrication of the engine and cable.

(b) Exceptional maintenance:

Exceptional maintenance will be carried out often during the operation of a rig system. The exceptional maintenance includes servicing the engine, cable replacement, changing handle and drum ball bearings etc.

4 Logging/ Sampling:

An important part of drilling is to explore the strata formation and collect representative samples. This information is useful for both construction and for drawing water from the aquifer. This data is used to locate the tube well strainer and an estimate of the probable well yield.

4.1 Use of a tube well sample box:

A sample box containing many pigeonholes is used to keep ground strata samples separate during tube well exploration. The sample box represents the formation of the ground strata for the tube well. Sample boxes can be made of wood or iron. The total size of a sample box is approximately (45 x 45 cm) and the size of each pigeonhole is (15x15x15) cm.

4.2 The litho-logical description of the samples:

(a) Gravel (b) Sand (c) Silt (d) Clay

4.3 Reporting: Each sample must be clearly labeled with the date, time, depth of bore hole, coordinates, litho-logical description. It is advised to keep a scale diagram of the borehole starting at ground level.

4.4 Daily log: The drill man must record a daily log after each stratum change and each strata change soil sample should be kept in the sample box. This is essential information for placing the filter and pump.

4.5 Final strata sample report: DACAAR has 3 reporting formats for recording samples

Components of a tube well:

The main components of a tube-well are:

1. Screen (filter) pipe
2. Casing pipe
3. A bail plug or sand trap fixed at the bottom of a tube-well
4. A filter/gravel pack installed around the strainer or the blind pipe.

5.1 Screen (filter pipe):

a) Filter pipe: Wells that obtain water from sand and gravel aquifers – unconsolidated formations – require a filter pipe. A filter pipe is the most important component of a tube well. It is the medium through which water is drawn into the well.

A filter pipe is installed adjacent to the aquifer stratum and should extend the full depth of the aquifer.

5.11 Important features of filter pipe are its:

Diameter
Length
Slot size and open area
Limit of inflow velocity
The material the filter pipe is made of.

5.12 Diameter of a tube-well filter:

The relationship between the discharge of a tube-well and its filter diameter depends on the following equation:

$$Q = 2\pi\ Km\ (h_0 - h_w) \div 2.3 \log R/r_w$$

By doubling the diameter of a tube-well the increase in discharge is only from 8% to 11%.

Increase in yield of a tube-well by the increase in the tube well/filter diameter

Well Diameter Inches.	4	6	8	12	18	24	30	36	48
Discharge (gpm)	100	105	110	115	123	128	-	-	-
"	100	105	110	117	122	127	131	137	
"		100	105	113	118	123	-	132	
"			100	106	111	116	119	125	
"					100	104	108	112	117
"					100	104	107	112	
"							100	103	108
"						100	105		

The above table shows that with an increase in the diameter of a tube-well (filter) the increase in the discharge is not significant.

The added cost of a large diameter filter strainer is, quite disproportionate to the value gained from the increase in the discharge. A large diameter filter strainer must to be structurally strong. To install a large size strainer, the boring diameter even when using the percussion method has to be increased. This further increases the cost of well construction.

5.13 Length of tube-well filter:

One length of filter pipe measures 4 meters. DACAAR usually uses one length and occasionally two. The filter has to be placed in the water bearing formation (sand, gravel) . Some experts recommend the length of screen on the basis of certain velocity of flow at the interface of the screen.

5.14 Percentage of open area of a filter:

The most efficient operation of a TW is achieved when the open area of the filter is equal to 15% of the total screen. TW experts, who study the hydraulic properties of well screens, suggest a **limit** of 15%, beyond that the head loss is no longer a function of the filter open area and the shape of the opening in large capacity irrigation tube wells.

For a hand pump-operating tube wells DACAAR has experienced 3% open area and 0.5mm slot size on a 4" PVC pipe.

5.15 Material of filter pipe:

Filter pipes are made of different material such as mild steel, brass, fiberglass, or PVC. In Afghanistan usually different diameter brass and PVC strainers are used.

5.16 Slot width for strainer

A filter pack designed to hold the formation particles up to 0.2mm has a mean diameter between 1.5 to 2.5 mm. With provision of a filter pack the width of slots can be increased. The maximum width of slots found suitable when protected by filter is 0.062 inch or 1.6 mm. A strainer with slots wider than this limit cannot stop the inflow of sand

6 Casing pipe:

Casing or a blind pipe is a pipe that is installed in a tube- well in two phases. When the drilling of a well is in operation, heavy temporary casing pipe is driving into a well to prevent the collapse of the well sides. The second type of casing is permanent casing. This casing can be brass, iron or PVC. The wall thickness of brass and iron casings should be 5mm. DACAAR uses 6-bar B-Class PVC pipe for tube-wells with a hand pump.

7 Bail plug (sand trap):

A bail plug is a piece of pipe which is plugged at one end and fixed at the end of the casing or filter pipe at the bottom of a well for collection of sand and silt. A length of bail plug is from 5-10 ft long (1- 3 meters) and its wall thickness should be ½ or 2/3 inches. DACAAR, bends the bottom first length of PVC casing pipe and blocks it by the heating process.

8 Gravel packing:

An artificially gravel-packed well differs from the naturally developed well in that the zone immediately surrounding the well screen is made more permeable by removing the formation material and replacing it with artificially graded coarser material. In the naturally developed well, the fine material in the formation surrounding the filter is

removed by water pressure to create a more permeable zone. In either case, the net hydraulic result is an increase in the effective diameter of the well.

The best method to improve a borehole is to gravel pack the screen. The gravel pack should inter face the water- bearing formation A minimum thickness of 8 cm (3 inches) is acceptable although 15 cm to 20 cm is preferred (six to eight inches). Making it any thicker has no hydraulic advantage rather it adds to the cost.

The gravel that is used for a gravel pack in a tube-well should have the following specification.

- As uniform as possible (sieve fine and coarse gravel)
- Diameter has to be around 0,5cm for silt- sand.
- Formation, up to 1 cm for gravel formations
- It is important that the gravel pack fills the area parallel to the filter, with no gaps being allowed to form.

- If the gravel pack is dropped from the surface make sure no spaces or bridges are formed, shake the casing while the gravel is dropped and this should ensure the gravel is well packed.

9. Sealing & back filling of a tube-well:

When a tube well is being bored in a marshy area or stratum that contains salty water, to avoid mixing unpleasant or salty water with clean water the upper strata should be blocked. The blocking of strata is done with pure clay. Pure clay is moistened sufficiently to roll into1 kg weight balls. The clay balls are dropped into the well to block the unwanted stratum. The depth of the sealing depends on the depth of the undesirable stratum. During the clay packing operation the drilling casing should be drawn out slowly simultaneously with the clay packing procedure. When the clay packing procedure is finished the tube well should remain undisturbed for a maximum of 24 hours or at least 10 hours to settle the clay pack. The back filling of the tube well is done with ordinary soil up to the ground level. When doing the back filling the drilling casing is drawn out gradually.

10. Cleaning of a tube well:

The reason for 'back washing or fluid circulation' of a tube well is to clean the system so that water, free of sand can be pumped at the lowest possible depression head and to achieve a high capacity/yield. The purpose of 'back washing' is to remove the sand particles from the pores of the gravel pack (shrouding). The material close to the filter is cleaned of tiny particles. A similar action also occurs when sand is subjected to force washing and surging. Very fine particles of sand are sucked out leaving the coarse particles in position. Sometimes small particles are supported by bigger particles and obstruct their removal. This action is called bridging. By surging and back washing the bridge is disturbed and fine particles are drawn out, leaving coarse particles in position. When the fine particles are removed, the tube well starts yielding sand free water even when there is a low depression head.

10.1 Methods of well cleaning (developing):

Of the several methods used for the development of wells the most common are:

a) Development by air- lift.
b) Over pumping and exerting sudden suction jerks.
c) Development by a plunger, causing suction and back washing.
d) Development by a water jet.

10.2 Mechanical surging:

For hand pump operated tube well cleaning the DACAAR drill masters use the following procedure.

- After completion of the tube-well drilling, the well is left so that the suspended soil settles over night. The following day before installing the pipe and casing, the well is cleaned by pulling and dropping the bucket in the well and removing the settled soil.

- After the filter and casing are installed, a small drilling bucket with 3”diameter is moved up and down in the casing and filter pipes. This cleans the well and the gravel pack. This is one kind of surging.

Another method practiced for development is the use of a surge plunger or a surge block. A surge plunger contains two leather or rubber sheets sandwiched between the wooden discs, all being assembled over extra heavy pipe. A nipple with steel plates serves as a washer under the end coupling. The wooden discs should be strong enough not to split under pressure. The leather or rubber disc should fit reasonably well in the casing. A small hole is provided in the top discs. When the plunger is being pushed down some of the water is forced out through the disc openings.

11. Construction of the apron

An apron is a structure that prevents outside surface water from entering the well. The apron is to stabilize and hold the pump pedestal. This apron is made of plain concrete with (1:2:4) ratio. After putting concrete in the apron mould it must be cured for at least 7 days preferably 28 days. Tube well aprons when properly designed drain away from the well.

If a kitchen garden or natural ditch is not available near the site a soak pit should be considered with the size of 1m x1m and depth of 1m. The pit should be filled with granular gravel.

12. Installation of the hand pump:

The steps for installation of the Afridev hand pump are given below.
Keep all the pump parts and tools and consumables ready in preparation for installation.
Kabul pump is suitable to lift water 15 – 20 meters
Indus pump is suitable to lift water 45 meters
Pamir pump is suitable to lift water 60 meters (80 meters)

12.1. Mix 300 grams of bleaching powder thoroughly in 15 liters of water in a bucket and pour the solution into the borehole.

12.2. Slip one pipe centralizer on each rising mains pipe and the cylinder pipe.

12.3. Mark a length of 115 mm on the plain end of the cylinder pipe and the rising mains pipe. Marking should be done either at the base store or at the manufacturer’s works.

12.4 Clean with cleaning fluid the outside of the reducer end of the cylinder, the marked portion of the rising mains and the cylinder’s plain end, inside of the bell mouth of the suction pipe and rising mains. Roughen the cleaned surfaces with sand paper and clean again with cleaning fluid. After cleaning, store the pipes on wooden blocks to prevent contact with sand and dust.

12.5.Apply solvent cement to the cleaned bottom portion of the cylinder and the inside of the bell portion of the suction pipe.

12.6. Join them and allow the join to set for five minutes.

Note: While making a U PVC pipe joint, please follow instruction precautions.

12.6. Cut rope to length (cylinder setting x2 + 10 meters). Make a knot in the middle point of total length. Insert the nylon rope through the sleeve fitting on the suction pipe and pull the rope until it reaches the knot. Make a second knot on the other side of the sleeve as shown.

12.7. Join the top end of the cylinder with the bell end of the first rising mains pipe by applying solvent cement. Allow the join to set for five minutes before lowering down.

12.8. Insert the assembly of suction pipe, cylinder and rising mains into the borehole and tie the rope to the anchor bolts on the flange.

12.9. Whiled lowering the rising mains do not forget to support the weight of the cylinder, suction pipe and rising mains with the rope. Tie the rope ends to two bolts in the sand flange as shown for convenience of lowering and supporting.

12.10. Make sure that the rope passes through the locating slots in the pipe centralizer that are located close to the bell ends.

Caution: Wait for at least five minutes before joining the next two components. Always support the weight of the components belowground with the rope to minimize stress on the join during those critical five minutes when it is still gaining strength. Stressing the join during this period can result in the premature failure of the solvent cement.

12.11. Join the next rising mains pipe. Support the bottom pipe by hand (2 to 3 persons) while pushing in the top pipe. Do not push against the rope.

12.12. Repeat the process of joining the rising mains till the last pipe is connected.

12.13. Slip the steel cone onto the last rising mains. With two persons holding the pipe, push the rubber cone onto the rising mains.

12.14. Apply solvent cement to 30 mm of the end of the last rising mains, and also on the inside of the top sleeve and join the two together. Allow five minutes for the join to gain strength.

12.15. Lift the steel-cone and untie the rope knots on the anchor bolts.

12.16. Tie the rope onto the two hooks of the steel cone by making a double knot. Remove the anchor bolts. A small excess length of rope may be lowered into the borehole. (Keep the rope slack, just a bit longer than the rising main.) Hold the steel cone with the rubber cone close to the top sleeve. Lower down the steel cone slowly till the cone plate rests on the stand flange and the top sleeve rests on the rubber cone.

12.17. The rising mains rests on the sleeve. Move the cone plate so that all four holes in the cone plate and the pump stand flange are in line.

12.18. Install the pump head on the stand assembly and tighten the bolts. Now the rising mains and cylinder body is ready to receive the cylinder components and rods.

Caution: Keep all rods on a stand made out of a fork – shaped branch of a tree or in a clean place near the pedestal so that dirt cannot find its way into the borehole through the handling of the pump rods.

12.19. Slip the rod centralizers on each of the pump rod hooks.

12.20. Insert the foot valve assembly into the rising mains and let it drop.

12.21. Lower down the plunger rod with plunger assembly. Ensure the “U” seal is assembled with groove upward.

12.22. Insert first pump rod hood through the eye on the top end of the plunger rod at 90^0 as shown. Turn the pump rod upwards to bring it to a vertical position to form a join and then lower it down the well.

12.23. Keep joining pump rods and lowering them down till the last pump rod is connected and the plunger rests on the foot valve fitting.

12.24. Push the foot valve with plunger gently so that the foot valve gets located in the foot valve receiver.

12.25. Grab the top pump rod level with the top end of the rising mains, pull out and mark the rod.

12.26. Lift rod and remove top rod.

12.27. Take out the last rod and cut at the mark and put this back in position.

12.28. Slip the flapper on the last pump rod.

12.29. Fix the rod hanger and tighten the rod hanger bolt. Make sure the rod is inserted into the full length of the hole.

12.30. Lower down the top rod and insert the spanner handle into the rod hanger eye. Rest the spanner handle on the two slots on the pump head top. The rod-hanger with the rod is now supported by the spanner handle on the pump head.

12.31. Before the fulcrum housing enters the pump head, insert the fulcrum pin and bearing bushes into the fulcrum housing as shown.

12.32. Insert the bearing bushes and the hanger pin in the rod hanger. The lug on the other bearing bush should get locked in the rod hanger slot. The inner bush and the lock pin should point upwards.

12.33. Insert the handle assembly into the pump head.

12.34. Slip on the fulcrum pin ends into the slots provided in the pump head bracket. Ensure that the lock pin on the fulcrum is secure.

Annex G Disinfecting a well with chlorine

There are three major times when we chlorinate a well. When the well is newly constructed, or repaired, and when the community complain about the water. When possible a bacteriological test is done to measure the contamination. Hand pump mechanics are supplied with chlorine to disinfect wells after repair

After a new well is constructed the well and all of the parts of the pump are disinfected.

Step 1 Add 300 grams or 20 tablespoons of bleaching powder to a 10 liter bucket of water and mix it thoroughly.

Step 2 Open the pump head and the man hole and pour the chlorines solution in so that it splashes on the exposed parts of the pump and the walls of the well

Step 3 Close the head and the manhole and leave the solution in the well for at least one hour

Step 4 After one-hour start pumping the well until the smell of chlorine disappears from the water (the water is not for drinking).

Step 5 Leave the pump unused for another hour (preferred time is 6 hours)

Step 6 The water now coming from the pump is safe for drinking

Using powdered Chlorine

This method is used in open wells

Mix powdered chlorine with 2 kilograms of sand in a plastic bag. Cut the corners of the bag or make small holes all over it and lower it into the well

Liquid Chlorine Concentration

Add 1-2 milliliters of chlorine per liter of water and drop this into the well

Annex H Water on Earth

The earth is mainly a water planet. Oceans cover about three-fourth of the earth surface, and account for 97% of all the water on this planet.

But water in the oceans is very salty (33 g/l) and cannot be used by life on the surface.

Water available for human kind is the fresh water present in lake, rivers and streams. The total of this water, from a global point of view, is only 0.18% of the total. But fresh water is also found underground (groundwater), and the total of water underground is 50 times more than the one on the surface!

	Q.ty of water (Km^3)
Oceans	1340
Ice caps	24
Groundwater	10
Surface water	0.18

Total Salty water	1340
Total Fresh water	34.18

Table 01 – Distribution of water on earth

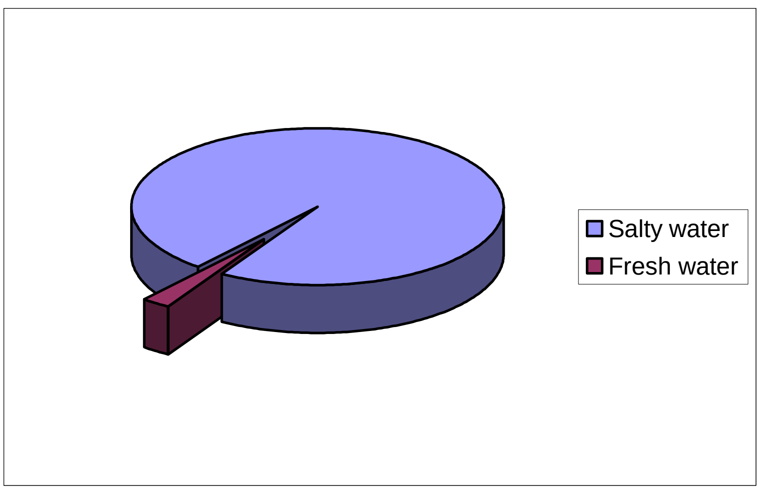


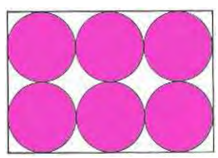
Chart 01 – Distribution of water on earth

Annex I Well hydraulics

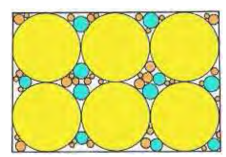
Porosity

The shape and arrangement of soil particles helps determine porosity. Porosity or pore space is the amount of air space or void space between soil particles. Infiltration, groundwater movement, and storage occur in these void spaces. The porosity of soil or geologic materials is the ratio of the volume of pore space in a unit of material to the total volume of material.

A mathematical equation of porosity looks like this: Porosity or $n = V_{void} / V_{total}$. Porosity is often expressed as a percentage of rock or soil void of material, so multiply the answer by 100.



High Porosity



Low Porosity

What could happen when smaller particles are mixed with larger particles? As the diagram shows, the smaller particles could fill in the void spaces between the larger particles, which would result in a lower porosity.

Not all particles are spheres or round. Particles exist in many shapes and these shapes pack in a variety of ways that may increase or decrease porosity. Generally, a mixture of grain sizes and shapes, results in lower porosity.

Material	Porosity (%)
well-sorted sand or gravel	25-50
sand and gravel, mixed	20-35
silt	35-50
clay	33-60

Tab 02 - Porosity Ranges for Sediments *(Based on Meinzer (1923); Cohen (1965); and MacCary and Lambert (1962))*

Permeability

Permeability is a measure of a soil or rock's ability to transmit water. Often the term hydraulic conductivity is used when discussing groundwater and aquifer properties.

Permeability differs from porosity because the void has to be interconnected to allow water to pass. We said before that a rock is porous when it contains voids: if those voids are not connected to each other, in order to form channels, water can not pass, and the permeability, that is the capacity of a rock to allow water to pass, is low.

For example, clay has high porosity and low permeability because pore spaces are not well connected. Clay often creates *confining layers* in the subsurface.

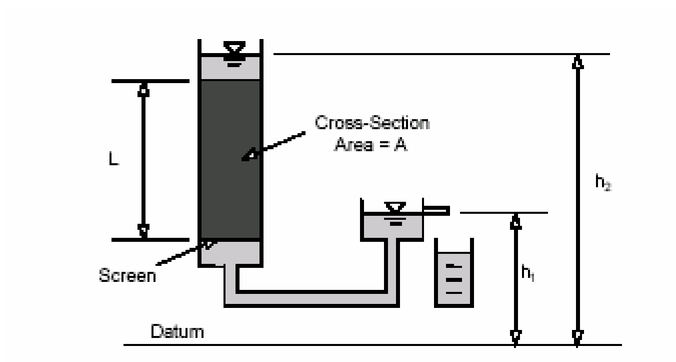
In rocks with fractures, there can be high permeability if the openings are large and are well connected.

Material	Permeability or Hydraulic Conductivity (cm/s)
well-sorted gravel	10-2 to 1
well-sorted sands	10-3 to 10-1
silty sands, fine sands	10-5 to 10-3
silt, sandy silts, clayey sands, till	10-6 to 10-4
clay	10-9 to 10-6

Tab 03 - Permeability Ranges for Sediments *(C.W. Fetter)*

Darcy’s law

The movement of water though a porous medium (underground) can be described using Darcy’s law.



$$V_D = ki$$

Where: V_D is Darcian Velocity

k is Permeability

i is hydraulic gradient ($\Delta h/L$)

In other words, the speed of water depends on the permeability of the media and the load!

V_D is called Darcian velocity because it is not the true velocity of water in the medium. We learned already that the water moves only through the voids of the rocks. Voids are only one part of all rock, and the ratio between the volume of voids and the total volume is defined porosity:

$$n = V_{void} / V_{total}$$

it means that the true velocity of water in the media is:

$$V = ki/n$$

This very simple law is the base of all the well hydraulics.

What Happens When the Pump Is Turned On?

When the pump is turned on, the water level drops in the well and in the aquifer adjacent to the well being pumped. The drawdown is the decline of water level observed in wells observed in the aquifer being pumped. The amount of drawdown is at a maximum at the pumping well and diminishes to zero some distance away. The region affected by drawdown from pumping is called the cone of depression (figure 04). The size of the cone of depression and the drawdown will increase until there is a balance between the pumping rate and the flow into the well from the surrounding aquifer. Once the pump is turned off, the cone of depression diminishes in size and water levels will recover to near pre-pumping levels as flow continues to move into that portion of the aquifer affected by drawdown. This process is called “Recovery”.

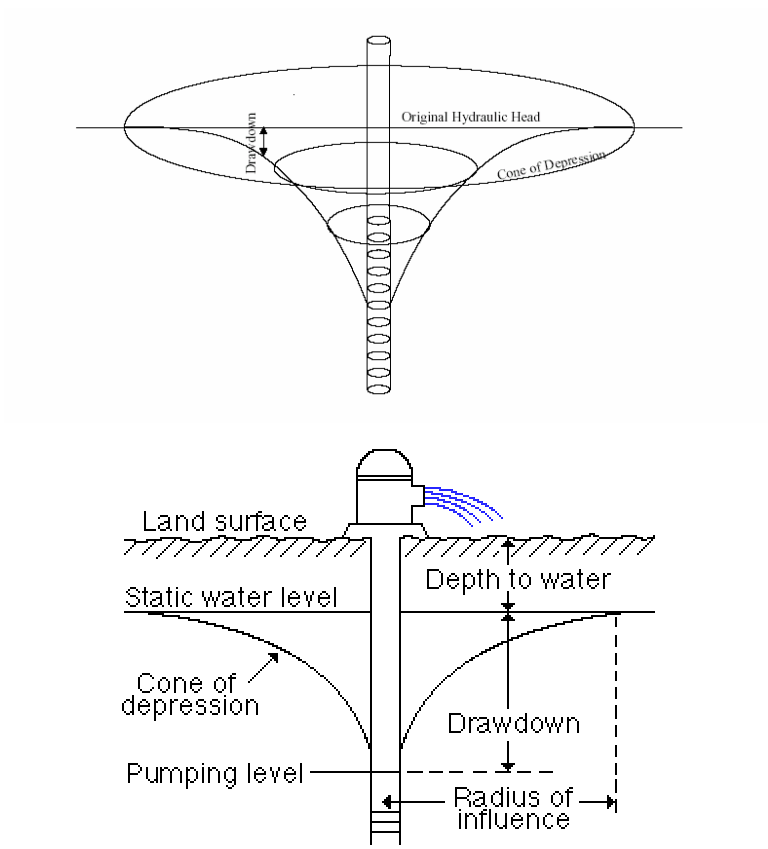
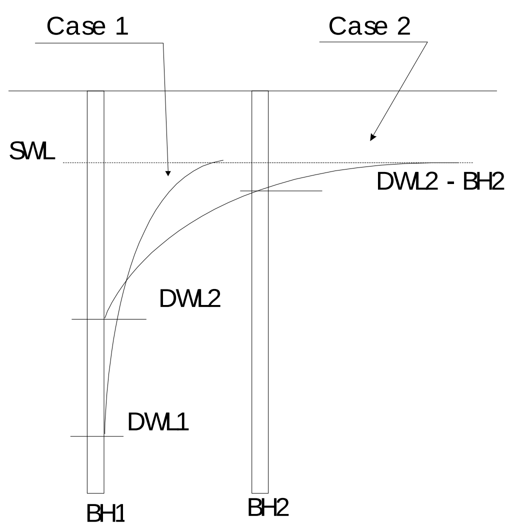


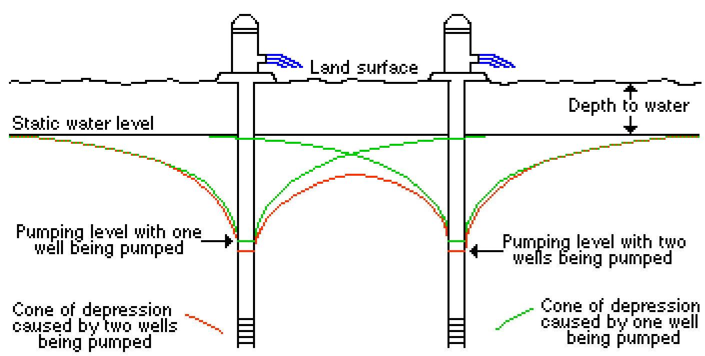
Figure 04--Cone of depression resulting from drawdown from pumping. (Internet)

The size of the cone of depression and the amount of drawdown depend on the pumping rate and the ability of the aquifer's material to transmit water to the pumping well. The aquifer's ability to transmit water to the well is directly related to its permeability (the capacity of a porous material for transmitting a fluid) and total thickness. Aquifers that are more permeable and have greater thicknesses allow larger volumes of water to flow toward the pumping well.

Every borehole, when pumped, creates a “depression cone” in the water table around. The shape and dimension of this depression cone can be calculated with great precision having appropriate pump test data and litho-stratigraphies (the drilling log) of the boreholes involved. The following drawing will explain what physically happens:

In this case we have 2 boreholes: BH1 and BH2. SWL is the static water level and it is common to the two boreholes, as long as they are drilled in the same aquifer. BH1 is pumped, so the water level will drop in the hole to the DWL (dynamic water level). The shape of the depression cone depends on the characteristics of the aquifer: in case 1 (deep DWL, narrow cone) we have a low (small) permeable aquifer, in case two (shallow DWL, large cone) we have a very permeable aquifer. It is clear that in this case BH2 can be influenced, being the SWL disturbed (or in the so called influence area of BH1). The extent of the cone varies with the yield and the time of pumping, getting bigger (with an inverse logarithmic low) with time. When pumping stops, the cone reduces and disappears, and after the recovery time things come back to a stationary status.





(RS , Internet)

Pump tests:

If you buy a TV, you want to try it, isn't it? The same if you rent a house, you want to check it, before paying the advance. Why shouldn't be the same with a well? A well, once it is completed, is underground, and you can't see it. But you can still check its performance, and, if you are good enough, catch up some defects. How? You have to perform a pump test. The pump test is the quality control of every well.

Transmissivity and Storativity

The dimension and the dynamics of the depression cone caused by pumping a well depends on the characteristic of the aquifer, and specifically:

Transmissivity (T) A measure of the amount of water that can be transmitted horizontally by the fully saturated thickness of the aquifer under a hydraulic gradient of 1. This is a product of the hydraulic conductivity and the saturated thickness of the aquifer.

Storativity (S) The volume of water that a permeable unit will absorb or expel from storage per unit surface area per unit change in head. It is a dimensionless quantity.

The theory of underground water flow and the scientific interpretation of a pump tests are quite complicated, and will be discussed in a specific training.

But there are also practical reasons why pump tests are performed, and there are practical reasons why every well should be pump tested.

In every well the level of water measured from the well-head (ground level) is called SWL (Static Water Level). When a pump (even a hand pump) is started, the level of water in the well drops (DWL that is, Dynamic Water Level), initially very fast, and then slower and slower, with a logarithmic law. Once the level drops it becomes the DWL. After some time the level of the water in the well (DWL) during constant pumping stabilizes. If you increase the pumping rate (yield) the level drops again, with the same modalities. When you stop pumping, the water comes back to SWL with the same modality: very fast at the beginning, than slower and slower, until the initial level is restored.

In practical terms, given the yield of the pump we install (i.e. hand pump) we want to know how much the level of water in the well will drop during pumping, and set the pump lower than that depth, to avoid the water running out. We also want to know how long the water table takes to come back to the original level when we stop pumping (how long it takes to re-fill the well).

Bailer test: A bailer test is a simple test used to calculate the discharge of water from an electric pump. If the discharge is low, of the order of 150 liters to 600 liters per minute, the discharge can easily be measured by an empty 220-liter drum. A stopwatch is used to measure the time it takes to fill the drum. A discharge of 220 liters per minute will take 60 seconds to fill the container**.**

Open channel pump test: Used to measure the discharge of a spring, river or stream. If the section of the channel is uniform, straight, and rigid, it is ideal for the estimation of discharge A small channel that is straight and uniform approximately 10 – 20 meters long is made. . A mean value of the area of the cross section of the length of the channel to be used for the study is determined. This area is multiplied by the mean velocity of flow, to give the discharge. The velocity of flow is determined by several methods. The simplest method is by a float. A small piece of wood or any floating body is thrown in the middle of the channel. The object is timed with a stopwatch to record how long it takes to travel the distance. The ratio of distance, S, in meters to time T in seconds, is the surface velocity

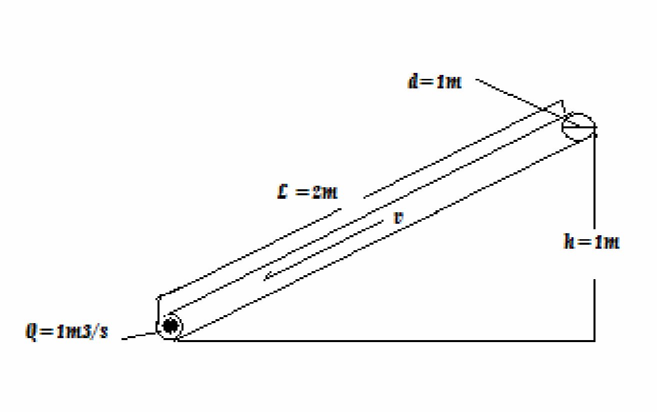
Discharge Q = Area x Velocity

Area = $\pi \times r^2$ Velocity = Discharge/Area

Gallon test is used to measure the discharge from a hand pump. How many liters per second (1 Gallon = 3.78541 liters)? The gallon test is commonly used in Afghanistan

Annex J Exercises

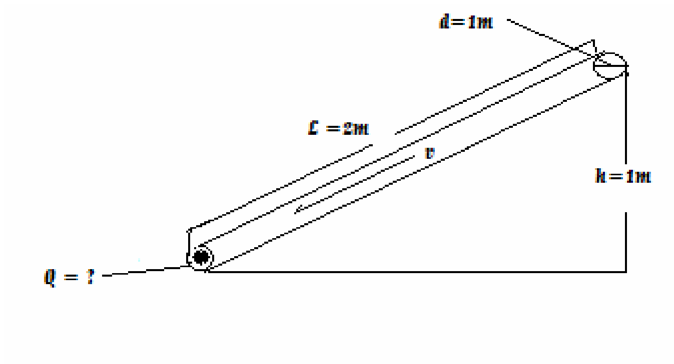
1. A pipe has 1meter diameter; it always discharges $1m^3/s$ of water. Find the velocity of water inside the pipe.



d=1m	Q= A x V
$Q=1m^3/s$	$A= \Pi \times r^2$
V=?	A= 3.14 x 0.5mx 0.5m = $\underline{0.785m^2}$
	V= Q/A
	$V=1m^3/s$ / $0.785m^2/s$=$\underline{1.27m/s}$

2. A pipe full of gravel has an internal diameter of 1 meter, the permeability of material inside the pipe is 7.8×10^{-5} m/s and porosity is 20%, the length of pipe is 2 meters and height is 1 meter.

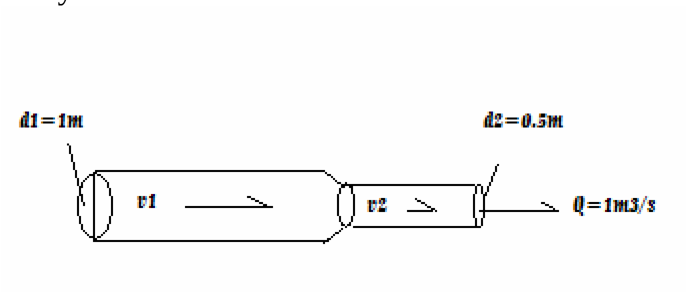
Find the yield and velocity of the water inside the pipe?



d = 1m	$V = V_D/n$	i = h/L = ½ =0.5
L = 2m	V = k x i/n	
h = 1m	$V = 7.8 \times 10^{-5}$ m/s x 0.5 / 0.2 = $\underline{1.9 \times 10^{-4}\ \text{m/s}}$	
K = 7.8×10^{-5} m/s	Q =V x A	
n =20%	$A = \Pi \times r^2$	
Q =?	A =3.14 x 0.5m x 0.5m = 0.785m^2	
V =?	Q = 1.9×10^{-4} m/s x 0.785m^2 = $\underline{1.4 \times 10^{-4}\ \text{m}^3/\text{s}}$	

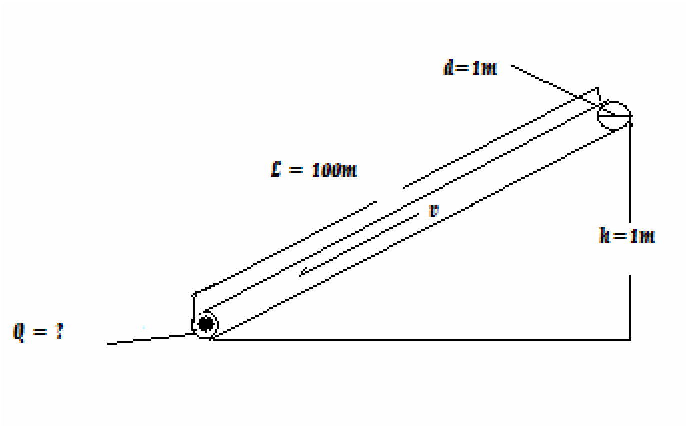
3. Pipe has two internal diameters, d_1= 1m and d_2= 0.5m. The water flow is set at $1m^3/s$.

Find the velocity of water inside each diameter?



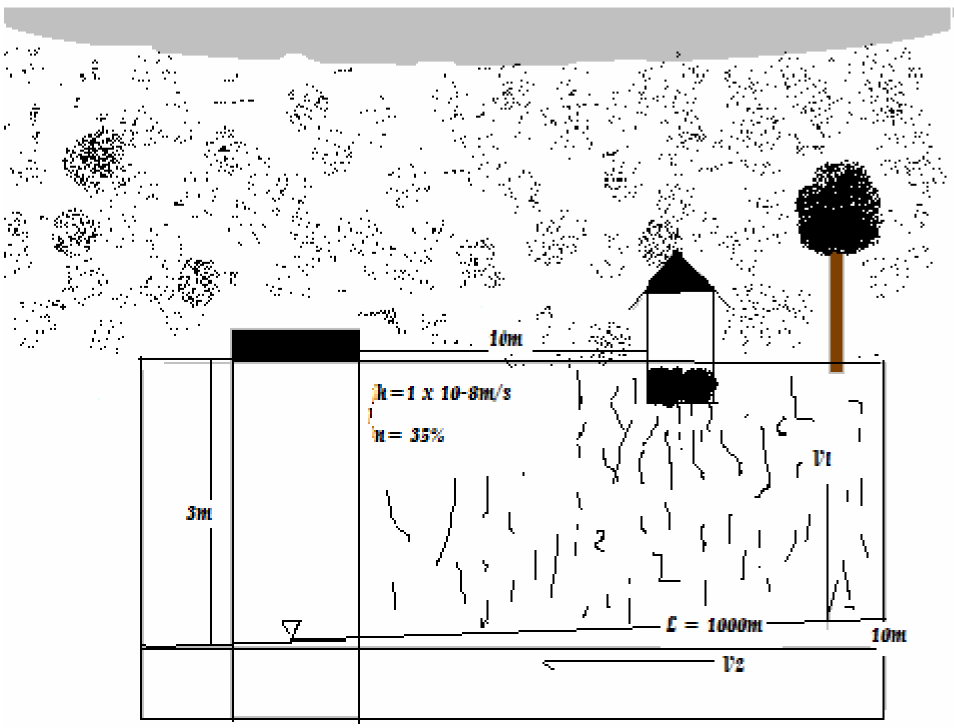
d_1 =1m	$A = \Pi \times r^2$
d_2 =0.5m	$A_1 = 3.14 \times 0.5m \times 0.5m = 0.785m^2$
$Q = 1m^3/s$	$A_2 = 3.14 \times 0.25m \times 0.25m = 0.196m^2$
V_1 =?	$Q = A \times V$
V_2 =?	$V_1 = Q_1/A_1 = 1m^3/s / 0.785m^2 = \underline{1.27m/s}$
	$V_2 = Q/A_2 = 1m^3/s / 0.196m^2 = \underline{5.1m/s}$

4. There is a pipe full of material with 1m diameter that permeability of material inside the pipe is 1 x 10^{-8}m/s, and porosity is 35%. The hydraulic gradient is 1m per 100m. Find the yield and velocity of water inside the pipe.



d =1m	i =h/L
k =1 x 10^{-8}m/s	i =1m /100m =0.01
n =35%	V =V_D/n = k x i /n
h = 1m	V =1 x10^{-8}m/s x 0.01 /0.35 =1 x 10^{-9}m/s
L =100m	Q =A x V
Q =?	A =Π x r^2
V =?	A =3.14 x 0.5m x 0.5m =0.785m^2
	Q =0.785m^2 x 1 x 10^{-9}m/s =7.8 x $10^{-10}$$m^3$/s

5. A dug well has a static water level of 3 meters. The permeability of the formation is 1 x 10^{-8}m/s, and porosity is 35%, the hydraulic gradient is 10 meters per 1km. On the surface of the ground there is a latrine 10m away from a dug well. When it rains the rainwater infiltrates the latrine waste. Find the velocity of water, and how long it take the contaminated water to reach the ground water table and inside the well.



$K = 1 \times 10^{-8}$m/s
$n = 35\%$
$i_1 = 1$
$i_2 = 0.01$
$d_1 = 3$m
$d_2 = 10$m
$V_1 = ?$
$T_1 = ?$
$V_2 = ?$
$T_2 = ?$

$i = h/L = 10m/1000m = 0.01$

$V_1 = V_D/n = k \times i_1/n = 1 \times 10^{-8}m/s \times 1/0.35 = \underline{2.8 \times 10^{-8}m/s}$

$T_1 = d_1/V_1 = 3m/2.8 \times 10^{-8}m/s = \underline{107142857s/3600}$

$= \underline{1240days/365 = 3.3years}$

$V_2 = k \times i_2/n = 1 \times 10^{-8}m/s \times 0.01/0.35 = \underline{2.8 \times 10^{-10}m/s}$

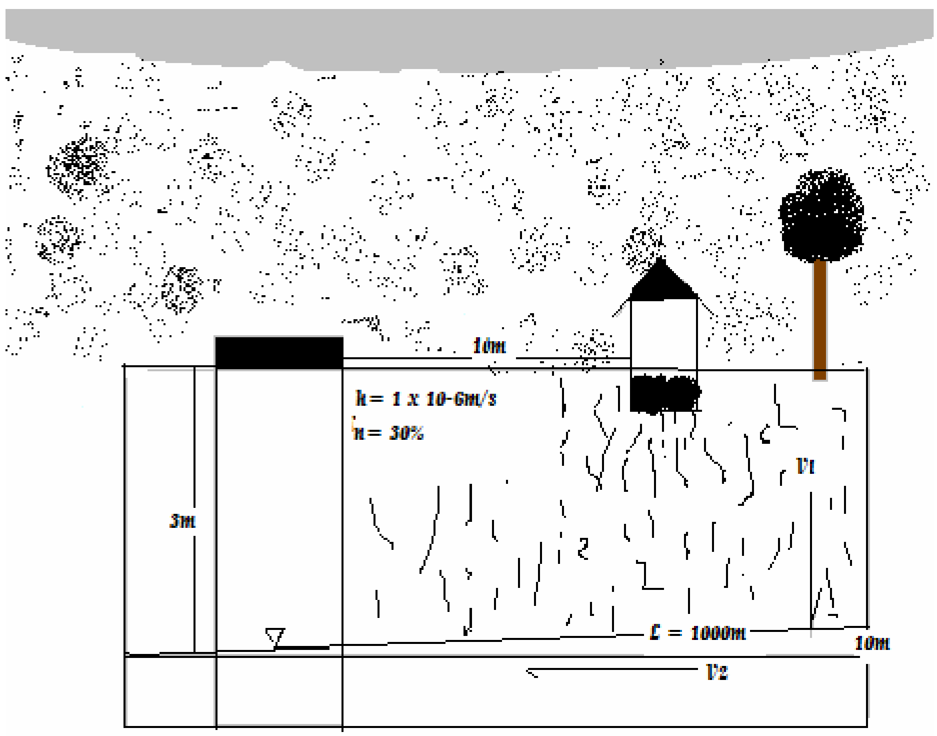
$T_2 = d_2/V_2 = 10m/2.8 \times 10^{-10}\ m/s = \underline{3.5 \times 10^{10}s/3600}$

$= \underline{9920634\ h./24}$

$= \underline{413359\ days/365}$

$= \underline{1132years}$

6. A dug well has a static water level of 3 meters. The permeability of the formation is 1 x 10^{-6}m/s, and porosity is 30%, the hydraulic gradient is 10 meters per 1km. On the surface of the ground there is a latrine 10m away from the dug well. When it rains water infiltrates the latrine waste. Find the velocity of the water, and how long it takes to reach and contaminate the ground water table and the well.



$k = 1 \times 10^{-6}$ m/s

$n = 30\%$

$i_1 = 1$

$i_2 = 0.01$

$d_1 = 3$m

$d_2 = 10$m

$V_1 = ?$

$T_1 = ?$

$V_2 = ?$

$T_2 = ?$

$V_1 = V_D/n = k \times i_1/n = 1 \times 10^{-6}$m/s x 1 / 0.3 = $\underline{3.3 \times 10^{-6}\text{m/s}}$

$T_1 = d_1/V_1 = 3\text{m}/3.3 \times 10^{-6}$m/s = $\underline{909090\text{s}/3600=252.5\text{ h.}/24}$

$\underline{= 10.5\text{ days}}$

$V_2 = k \times i_2/n = 1 \times 10^{-6}$m/s x 0.01 / 0.3 = $\underline{3.3 \times 10^{-8}\text{m/s}}$

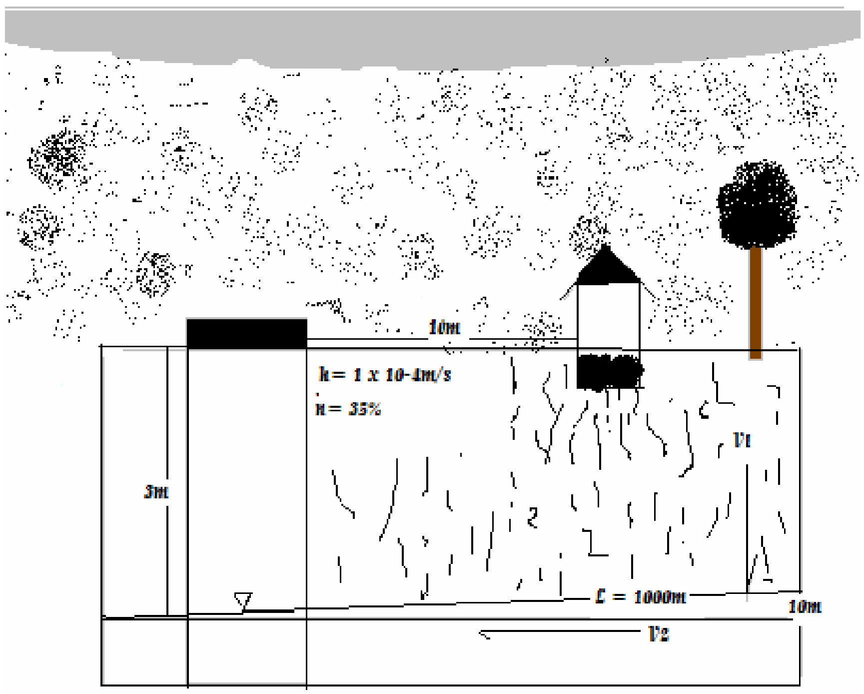
$T_2 = d_2/V_2 = 10\text{m}/3.3 \times 10^{-8}$m/s = $\underline{303030303\text{s}/3600}$

= $\underline{84175\text{ h.}/24}$

= $\underline{3507\text{ days}/365}$

= $\underline{9.6\text{ years}}$

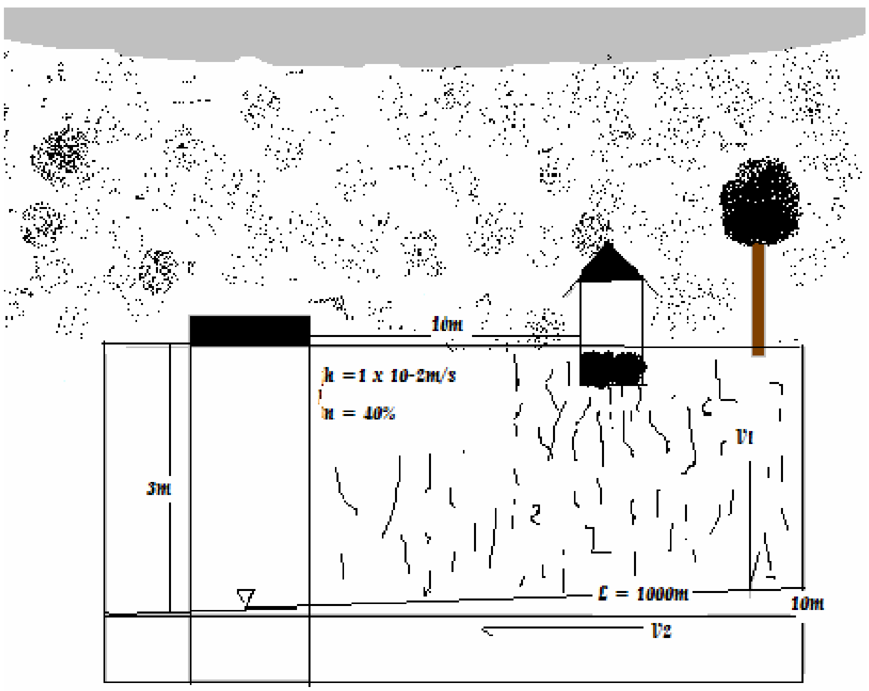
7. A dug well has a static water level of 3 meters. The permeability of the formation is 1×10^{-4}m/s, and porosity is 35%, the hydraulic gradient is 10 meters per 1km. There is a latrine located 10m away from the dug well. When it rains the rainwater infiltrates the latrine waste and seeps down to the water table. Find the velocity of the water, and how long it takes to contaminate and reach the ground water table and enter the well.



$k = 1 \times 10^{-4}$ m/s	$V = V_D / n = k \times i / n$
$n = 35\%$	$V_1 = k \times i_1 = 1 \times 10^{-4}$ m/s $\times 1 / 0.35 =$ <u>2.8×10^{-4} m/s</u>
$i_1 = 1$	$T_1 = d_1 / V_1$
$i_2 = 0.01$	$T_1 = 3$m $/ 2.8 \times 10^{-4}$ m/s = <u>10714s/3600 = 2.9h.</u>
$d_1 = 3$m	$V_2 = k \times i_2 = 1 \times 10^{-4}$ m/s $\times 0.01 / 0.35 =$ <u>2.8×10^{-6} m/s</u>
$d_2 = 10$m	$T_2 = d_2 / V_2$
$V_1 = ?$	$T_2 = 10$m $/ 2.8 \times 10^{-6}$ m/s = <u>3571428s</u> <u>/3600 = 992h. /24</u>
$T_1 = ?$	= <u>41 days</u>
$V_2 = ?$	

8- A dug well that the static water level of 3 meters. The permeability of the formation is 1 x10^{-2}m/s, and porosity is 40%, the hydraulic gradient is 10 meters per 1km.

There is a latrine located 10m distance from dug well. When it rains the rainwater infiltrates the latrine waste and seeps down to the water table. Find the velocity of the water, and how long it takes the contaminated water to reach the ground water table and into the well.



$k = 1 \times 10^{-2}$ m/s	$V = V_D / n = k \times i_1 / n$
$n = 40\%$	$V_1 = 1 \times 10^{-2}$ m/s x 1/0.4 = <u>0.05m/s</u>
$i_1 = 1$	$T = D/V$
$I_2 = 0.01$	$T_1 = d_1/V_1 =$ 3m /0.05m/s = <u>60s</u>
$d_1 = 3$m	
$d_2 = 10$m	$V_2 = V_D/n = k \times i_2 / n = 1 \times 10^{-3}$ m/s x 0.01 /0.4 = <u>0.00025m/s</u>
$V_1 = ?$	$T_2 = d_2/V_2 =$ 10m/0.00025m/s = <u>40000s /3600 = 11.1h.</u>
$T_1 = ?$	
$V_2 = ?$	
$T_2 = ?$	

Annex K Comparison of Water Point Types and their Suitability

Well construction and other water point methods

Water Point Type	Suitable formation for constructing	Unsuitable formation for constructing	Advantages	Disadvantages
Hand Dug Well	Clays, sands, gravels, small boulders	Hard and soft rock Where depth to water is more than 30m.	Low capital costs, Uses local skills, Possible to maintain at village level	Dangerous large diameter hole Limited depth
Tube Well percussion	Soft rocks, sands, gravels, silts and clays	Running sand, flint (or chert) hard rock boulders	Reasonable capital and running costs. Simple maintenance. Good sampling during drilling Up to 30m/ day in Soft rock	Experienced driller needed. Temporary casings needed in loose formations Slow in hard rock may be 2m/day
Dug Well deepened via percussion drilling rig	As above	As above	Site already chosen Its cheaper than a new well. Well rings, hand pump etc are already there	As above
Protected Spring	Only suitable in mountainous areas		Water is good quality	Only possible in mountain areas Makes up 9% of water supply in Afghanistan
Dug well deepened by hand			Needs very little money	

Annex L Well material prices

I

	Description	Unit			Price	Afs
1	Indus HP Short Pedestal	No			97.26 Euro	6,130
2	Indus HP Long Pedestal	No			104.95 Euro	6,620
3	Kabul HP Short Pedestal	No			78 Dollars	3,900
4	Pamir HP Short Pedestal	No			140.5 Euro	8,820
5	Pamir HP Long Pedestal	No			147.5 Euro	9,260
7	PVC 4" Casing	Meter			1,826 Euro	115
8	PVC 4" Filter	Meter			1,895 Euro	120
10	Pump Rod	3M				130
11	Cement	Bag			200 Afs	200
		6 Bags	6x200 Afs	1200		

	Parts	Unit		Afs
12	U Seal Washer	1		8
13	Plastic Bearing	1		20
14	Nut and bolt	1		25
15	Body Flanger and foot valve	1		60
16	Valve Bobbin	1		8
17	O-Ring	1		4
18	Solution 250 mg.	1 tin		35
19	Rod	1		130
20	Rising Main	1		125

How many bags of cement are needed for an apron?

Spare Part Shop Information Report **Part 6.**			
Province	District		Village
Lat	Lon		Shopkeeper Name
Source of Spares (Village Name)			Distance(Time)

Part	Given Quantity
1. U Seal washer	
2. Plastic bearing	
3. Nut and bolt	
4. Body flanger and foot valve	
5. Valve bobbin	
6. O-ring	
7. Solution 250 mg.	
8. Rod	
9. Rising mains	

Annex M

Water and Sanitation Statistics collated for Provinces of Afghanistan UNICEF 2005

Households with no safe drinking water from pump/protected spring.

PROVINCE	PERCENT	NUMBER
BADAKHSHAN	78.6	96,158
BADGHIS	73.6	49,371
BAGHLAN	93.5	106.488
BALKH	60.4	66,283
BAMYAN	92.3	71,280
FARAH	53.4	25,165
FARYAB	83.7	117,290
GHAZNI	61.1	117,386
GHOR	83.9	75,953
HERAT	54.5	152,814
HILMAND	33.3	34,276
JAWZJAN	86.7	50,379
KABUL	26.2	140,790
KANDAHAR	26.2	53,205
KAPISA	78.4	32,150
KHOST	46.4	27,563
KUNAR	57.1	21,841
KUNDUZ	84.0	66,257
LAGHMAN	47.8	23,883
LOGAR	38.9	19,033
NANGARHAR	42.5	53,356
NIMROZ	70.6	13,503
NURISTAN	80.6	14,161
PAKTIKA	69.3	15,857
PAKTYA	58.5	20,896
PARWAN	78.5	134,389
SAMANGAN	87.8	43,205
SARI PUL	93.1	107,597
TAKHAR	81.0	121,498
URUZGAN	84.4	127,062
WARDAK	44.8	44,283
ZABUL	59.5	23,883
URBAN	39.0	405,319
RURAL	68.8	1,661,937
NATIONAL	59.8	2,067,256

Best 5 provinces		Weakest 5 provinces	
By Percent	By Number	By Percent	By Number
KABUL	NIMROZ	BAGHLAN	HERAT
KANDAHAR	NURISTAN	SARI PUL	KABUL
HILMAND	PAKTIKA	BAMYAN	PARWAN
LOGAR	LOGAR	SAMANGAN	URUZGAN
NANGARHAR	PAKTYA	JAWZJAN	TAKHAR

Annex M

Diarrhoeal Diseases
Diarrhoea is one of the most common ailments in Afghanistan and is the cause of half the deaths among children under the age of five. Poor sanitation and hygiene are the main underlying reasons. There are seasonal variations, with diarrhoeal diseases most prevalent during the summer months.

Access to safe water and hygienic latrines is very limited in Afghanistan, particularly in rural areas. Water points wells and boreholes have always been scarce and many of them have been abandoned, neglected or destroyed during the prolonged conflict.
Large population movements have also put increased pressure on existing sources, operating them beyond there intended capacities without recourse to spare parts or maintenance..
Uncoordinated ground water schemes coupled with three consecutive years of drought have lowered the water table in many parts of the country, depleting aquifers to below their regenerative capacity. As a result, less than 40% of the population have access to safe drinking water. 71% of urban households use piped water or bore wells or protected springs, while in rural areas only 31% of the population use safe water sources.
Flush or pit latrines are used by 87% of urban and 59% of rural house holds. Traditional technologies have been adapted for excreta disposal but further innovative techniques are required to promote affordable and more hygienic technology options.

However the data collected revealed that in 33% of all households, the water source is within 15 metres of a latrine. This proximity of household latrines to water points implies that there might be contamination of drinking water through underground leaching of excreta, resulting in an increase of disease incidence. There is a need to increase household storage of water and introduce simple domestic purification methods to protect against disease. Another major factor contributing to faecal contamination is the low incidence of hand washing with soap. Only 28% use soap with hand washing and only 16% of mothers of under five children wash their hands at all after defecation. All of these factors contribute to very high levels of water born diseases, with significant implications for the health and development of children and the well being and productivity of whole communities

ACCES TO SANITATION BY PERCENTAGE OF HOUSEHOLDS IN AFGHANISTAN

LATRINE TYPE	**URBAN**	**RURAL**	**TOTAL**
Sewage	8.3%	0.5%	2.8%
Traditional Pit	73.1%	52.9%	59.0%
Open Pit	6.6%	6.4%	6.5%
Bush/ Field	13.0%	40.6%	32.3%
Other	0.5%	3.1%	2.3%

Annex M

HOUSEHOLDS NOT HAVING A SANITARY LATRINE.

PROVINCE	PERCENT	NUMBER
BADAKHSHAN	57.2	69,731
BADGHIS	72.8	48,140
BAGHLAN	59.5	67,637
BALKH	23.9	26,173
BAMYAN	70.5	54,450
FARAH	75.2	35,455
FARYAB	30.5	42,603
GHAZNI	33.6	64,506
GHOR	81.3	73,556
HERAT	8.6	24,146
HILMAND	35.2	36,246
JAWZJAN	47.1	27,393
KABUL	2.0	10,812
KANDAHAR	13.3	26,881
KAPISA	38.3	15,666
KHOST	80.4	47,734
KUNAR	63.1	23,931
KUNDUZ	43.7	34,372
LAGHMAN	45.3	22,636
LOGAR	4.2	2,033
NANGARHAR	40.9	51,241
NIMROZ	56.2	10,730
NURISTAN	36.0	6,308
PAKTIKA	58.4	13,290
PAKTYA	39.2	14,005
PARWAN	15.2	26,089
SAMANGAN	54.1	26,603
SARI PUL	27.2	31,351
TAKHAR	38.5	57,566
URUZGAN	75.8	113,908
WARDAK	8.4	8,279
ZABUL	51.4	20,548
URBAN	13.2	136,664
RURAL	41.4	997,357
NATIONAL	32.9	1,134,021

HOUSEHOLDS NOT HAVING A SANITARY LATRINE

Best 5 provinces		Weakest 5 provinces	
By Percent	By Number	By Percent	By Number
KABUL	LOGAR	GHOR	URUZGAN
LOGAR	NURISTAN	KHOST	GHOR
WARDAK	WARDAK	URUZGAN	BADAKHSHAN
HERAT	NIMROZ	FARAH	BAGLAN
KANDAHAR	KABUL	BADGIS	GHAZNI

Annex M

Diarrhea prevalence in last 15 days
(children less than 5 years old)

PROVINCE	BOY		GIRL		TOTAL		GIRL/BOY
	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	RATIO
BADAKHSHAN	29.6	23,762	29.6	20,431	29.6	44,193	1.00
BADGHIS	43.9	12,928	46.0	15,759	45.1	28,687	1.05
BAGHLAN	44.8	29,188	35.7	23,552	40.2	52,741	0.80
BALKH	38.5	27,085	35.9	23,101	37.3	50,185	0.93
BAMYAN	34.6	15,557	41.1	18,244	37.8	33,802	1.19
FARAH	27.0	8,981	22.9	6,361	25.1	15,342	0.85
FARYAB	35.0	28,928	32.5	24,983	33.8	53,911	0.93
GHAZNI	13.4	13,876	12.1	13,501	12.7	27,378	0.90
GHOR	20.2	11,245	25.6	14,564	23.0	25,809	1.27
HERAT	25.5	34,991	24.0	34,534	24.7	69,525	0.94
HILMAND	6.1	6,107	10.4	7,683	7.9	13,789	1.70
JAWZJAN	52.4	15,840	45.4	14,173	48.8	30,013	0.87
KABUL	37.6	112,591	27.0	78,503	32.3	191,094	0.72
KANDAHAR	26.1	38,382	24.7	31,449	25.5	69,831	0.95
KAPISA	39.7	9,727	40.2	9,652	40.0	19,379	1.01
KHOST	46.4	22,802	49.3	22,301	47.8	45,103	1.06
KUNAR	20.7	6,269	23.2	6,337	21.9	12,606	1.12
KUNDUZ	30.3	14,288	28.9	13,335	29.6	27,623	0.95
LAGHMAN	24.2	7,931	25.3	8,288	24.8	16,219	1.05
LOGAR	31.9	10,533	34.2	10,071	33.0	20,604	1.07
NANGARHAR	35.2	36,767	32.4	31,714	33.8	68,481	0.92
NIMROZ	24.8	3,466	19.2	2,179	22.3	5,645	0.77
NURISTAN	36.5	3,680	32.1	3,088	34.3	6,768	0.88
PAKTIKA	32.2	6,045	32.7	5,175	32.4	11,220	1.02
PAKTYA	27.0	6,595	27.5	6,928	27.7	12,893	0.99
PARWAN	40.4	41,560	33.1	33,673	36.8	75,,234	0.82
SAMANGAN	31.7	8,301	30.7	8,201	31.2	16,502	0.97
SARI PUL	27.7	19,563	28.6	17,306	28.1	36,869	1.03
TAKHAR	38.0	34,595	32.6	29,060	35.3	63,655	0.86
URUZGAN	28.0	25,748	28.1	19,871	28.1	45,619	1.00
WARDAK	28.4	17,906	20.4	11,475	24.6	29,651	0.72
ZABUL	27.0	8,685	29.8	7,444	28.2	16,129	1.10
URBAN	31.3	180,092	27.8	151,951	29.6	332,043	0.89
RURAL	30.8	483,831	28.7	420,627	29.8	904,458	0.93
NATIONAL	30.9	663,923	28.5	572,578	29.7	1,236,501	0.92

Best 5 provinces		Weakest 5 provinces	
By Percent	By Number	By Percent	By Number
HILMAND	NIMROZ	JAWZJAN	KABUL
GHAZNI	NURISTAN	KHOST	PARWAN
KUNAR	PAKTIKA	BADGHIS	KANDAHAR
NIMROZ	KUNAR	BAGHLAN	HERAT
GHOR	PAKTYA	KAPISA	TAKHAR

Water Well Equipped with Handpump for Rural Water Supply

TECHNICAL SPECIFICATIONS

DRAFT

CONTENTS

PREAMBLE

These specifications refer to the construction of public of wells, equipped with handpump, for rural water supply in Afghanistan.
The following specifications cover:

- Well siting
- Well construction
- Apron construction and pump installation
- Well testing and reporting

The following specifications does NOT cover:

- Construction of gravity flow water schemes
- The sanitation component of the intervention
- Hygiene education
- Training of pump mechanics , and
- Establishment of spare part shops

The latter are integral part of MRRD implementation strategy; nevertheless, they are likely to be covered by separated contracts, therefore separate technical specifications are prepared.

Design criteria are elaborated to comply as far as possible with the *Policy Framework of the Minister of Rural Rehabilitation and Development (MRRD, 2004*) thereafter called "*MRRD policy*". Specifically, the following principles are taken into account:

Basic principles:

- Some for all rather than all for some
- The technology used shall be low cost, affordable, maintainable by the communities
- Government will assist communities on an agreed cost-sharing basis
- Community shall be empowered to plan, construct, operate, maintain and own all infrastructures

Quantity:

- The system has to be able to produce 25 litres of safe water per capita per day. It means
- an average of 25 families beneficiaries per handpump

Quality:

- Water quality shall meet a minimum quality standard, and, in general, comply with the WHO recommendations for rural water supply (including the recommendations for household disinfection practices)
- The pumps installed must be of proven quality, checked and approved by MRRD

This is the reason why those specifications does not include the latest state-of-the-art, heavy rotary drilling technologies. The specifications have been conceived referring especially to hand digging and to the percussion drilling technology, widely spread in Afghanistan, and capable to satisfy the need for wells at an extremely competitive cost. The aim is to set some minimum

standards in the quality of the outputs, to protect the government, and donors, investment, but also to help the grow of a competent private sector with a number of good practice requirements, to be fulfilled as a normal routine.
Light rotary drilling is also considered, for its capacity to perform - at higher cost - where, for lythological reasons, the percussion drilling is at stake.

These specifications are effective part of the contractual conditions between MRRD and the contractor, and have legal binding value when attached to the contract regulating the provision of services to MRRD.

GENERALTIES

Well type

The type of the well to be constructed will be of one the following:

- Hand Dug Well
- Tube Well
- Dug Well deepened via drilling rig

The choice of the type of well is done according to the principles included in the MRRD policy, and <u>must</u> be approved, in writing, by the client's representative, on a case to case basis.

As a general rule, whenever technically feasible, the Dug Well shall be preferred first.
Normally, a tube well will be chosen when:

- The SWL is too deep for a Dug Well
- Strata are too hard for hand digging
- The seasonal fluctuation of the water table in the area exceeds 2 m/year
- In highly densely populated areas, where it is not possible to identify a suitable location far enough from contamination sources

Minimum technical targets:

This specifications aims to guarantee the fulfilment of the following minimum technical targets:

- ***The handpump does not run dry after a continuous use of 8 hours.*** *This specification equals a minimum sustained yield of 600 liters per hour (10 liters per minute) measured at the end of the development process.*

Should a borehole fail to fulfil the above mentioned requirement, shall be deepened - in case of a dug well - or a new drilling shall be attempted to a nearby suitable location - in case of tube well.

Should the well still be unsatisfactory, the location can than be abandoned unless special agreement between the parties.

Should a tube well (or a deepening via drilling rig) fail for any reasons due to drilling problems, verticality problems (see tube well construction), breakdown of the machinery, or any other reasons imputable to lack of meeting the specifications of this document, no charge will be recognized to the contractor and make another attempt shall be made without charge.

- ***The water is clear and colorless.*** *Equals a requirement of turbidity lower than 5 NTU.*

Turbidity is due to poor construction of the well. The first measurement shall be done after 48 hours from the installation of the pump. Should the turbidity persist after two weeks of pumping with the final pump, the borehole will be rejected, no payment due to the contractor, and a new well drilled nearby at complete cost of the contractor. The pump shall be removed and re-used for the new well. Turbidity is measured via turbidity tube, or via turbidity meter.

- ***The water is not salty.*** *Equals a requirement of Electro conductivity (EC) lower than 3,000 μS/cm.*

Should EC exceed this value, a complete chemical analysis of the water is recommended, to ensure no dangerous chemicals are present. On the base of the results of the analysis, amendment to this rule may be done in consultation with the community, provided that no other suitable source of water is present in the vicinity. Amendments have to be certified by the client's representative. In any other case, two options are possible: hider a new attempt is done in a more favorable area, or the well shall be abandoned. In this case, the pump shall be removed and re-used for the new well. EC is measured via conductivity meter.

- ***The water is bacteriologically pure.*** *Equals a requirement of 0 (zero) faecal coliforms per 100 ml.*

Contamination is due to poor construction or siting of the well. In case of poor backfilling, sealing or apron construction, the well has to be abandoned and re-drilled nearby, without payment due to the contractor. Should a contamination source be present *in the vicinities (i.e. latrine), this should be closed and re-located. Community should be informed and household disinfection practices, as per WHO recommendations, promoted. Final decision on appropriate action will be taken by the client's representative. Faecal coliforms are determined via H_2S test, Petri film, or membrane filtration method, being the latter more accurate.*

- ***The well is identified***

The identification number of the borehole should be engraved on the pump platform, or in other permanent way as per client's representative instructions. Other information (donor name, date, …) are specified in the contract. In case of deepening of a dry dug well, the original code, as well as the original name of the organization that first improved the well shall be maintained. If requested by the contract, a new indication of the new donor or implementing agency can be added.

- ***Appropriate reporting is provided***

Appropriate reporting formats, including information about the position, the geological formations, the aquifer characteristics, the water quality, the borehole construction and pump installation details are developed and shall be completed by the contractor at the completion of each well.

In any case, final well report has to be certified as true and accurate by the client's representative before payment is done to the contractor. Data shall also be transmitted to the National Database of rural water supply, with the modalities specified in the contract.

WELL SITING

The contractor will receive a list of villages to be served. The actual siting of the well within the village shall follow the MRRD policy. The siting of the well shall be conducted together with the local community, and shall be supervised, endorsed, and approved in writing, by the client's representative. The user group shall be clearly informed that the water point will be of property of the community, and the community shall meet the maintenance cost. The terms of the community contribution, plus the willingness of the community itself to provide to the maintenance of the water point will be assessed during this first phase.

The basic principles of well selections shall be:

- The well is PUBLIC, and shall remain public forever after the implementation
- The well shall not be close to any private compound
- If a water point is located on donated land then the owner donating the land must sign a traditional deed of transfer (waqf) to ensure that his donation is truly disinterested
- The well shall be accessible primarily to women
- The well shall not be visible from any main road, or
- A wall shall be constructed, by the community, in front of the well in order to hide it
- Sufficient number of beneficiaries families (25 for tube wells, 20 for dug wells)
- No sources of contamination (i.e. latrines) should be located within 15 m to the water point
- A caretaker, from the beneficiary community, shall be appointed

WELL CONSTRUCTION

Dug Well construction

A dug well has a diameter of approximately 1,1 meters, and a depth of at least 2 m below SWL. In order to achieve the needed depth, appropriate sludge pump shall be used, in order to evacuate the water from the hole and make the digging possible. Should digging take place during the wet season, a depth of 4 m below SWL should be archived, in order to prevent the well to dry during the dry months. In any case, the Total Depth (TD) shall not exceed 60 m, in order to permit the installation of the handpump.

If included in the contract, digging of the well may be part of the community contribution. Also in this case, the contractor is, in any case, responsible of the fulfilling of the above mentioned requirements.

The contractor shall be in charge to provide the community the de-watering pump for the time needed to complete the digging.

According to the geological formation drilled, casting of the well can be necessary. Pre-cast concrete rings shall be used to prevent the well from collapsing. The concrete rings shall have a diameter of at least 0.8 m, and a height of app. 0.45 m each, a thickness of 5 cm, and shall be reinforced with 3 mm steel wire. The pre-cast rings shall to be constructed according to the recommendations included in the "*Community Handpump Water Supply and Sanitation Guide for Afghanistan, (WSG, 1999)*"thereafter called "*WSG Watsan Guide*".

The upper part of the dug well shall be protected from the contamination with the installation of at least 2 concrete rings, sustained by a reducing slab. The annular space between the rings and the hole shall be filled by a sanitary backfilling in argillaceous material, laid in successive layers of 20 cm, properly compacted to ensure the perfect non-permeability of the backfill. The natural clay has to be sieved to remove all sand and gravel possibly present. Should the provision of material part of the community contribution, the contractor is, in any case, responsible of the fulfilling of the above mentioned requirements.

A surface pre cast concrete ring, with diameter of 0.80 m, height of 0.90 m and thickness of 7 cm, reinforced with 5 mm steel rods and 3 mm steel wire, shall be installed, with cover slab, as per "*WSG Watsan Guide*".

A drainage apron shall be than constructed, as per requirements later on in this specifications .

Water sampling and testing

After the completion of the borehole, and installation of the handpump, the community will be requested to pump the hole for two days without using the water for drinking purposes. After this period, the clients representative will sample the water for the following parameters: EC (electro conductivity), pH, Temperature, Turbidity. Should turbidity result to be higher than 5 NTU, the hole will be pumped again, up to a maximum of 14 days. Should the turbidity still be above 5 NTU. The hole will be rejected, no payment due to the contractor, and another hole constructed nearby.

Whenever requested by the client, a bacteriological test will be performed, with a procedure approved by WHO (H_2S, Petri film or membrane filtration).

Tube Well construction

Percussion, air rotary or mud rotary drilling system can be used, according to the lythological conditions encountered, with minimum final drilling diameter of 8" (203 mm). A final diameter of 6" may be acceptable in specific geological conditions, and shall be approved by the client's representative.

The contractor shall use the best possible drilling practice according to the drilling method chosen.

Unless in very specific geological context, approved in writing by the client's representative, the drilling depth shall be 10 meters below the SWL.

Percussion method

Drilling can be conducted with buckets of 8, 12, 16 or 22".

When drilling with the percussion method, appropriate temporary casing shall be used in collapsing formations, and any time when below the SWL.

If necessary, a telescopic well (decreasing diameter) is acceptable, provided that the minimum final diameter of 8" (6") is guaranteed.

The use of the temporary casing is at complete risk of the contractor, and no compensation will be recognized for material or time losses in case of stuck or lost material.

Should material be lost in the well in such a way to compromise the completion of works, the well shall be plugged and abandoned, at a contractor's cost, and a new well drilled nearby, without any compensation from the client.

Rotary method

When drilling with a rotary rig, the density of the drilling mud will be such not to compromise the primary permeability of strata.

Polluting chemical non-degradable additives (i.e. caustic soda) shall be avoided.

After the completion of the hole, the fluid will be circulated for at least two complete lag-times, but anyway not less than 30 minutes, in order to remove all cutting material from the hole.

Before the installation of the casing, the hole will be circulated with clear water and the mud panel completely removed.

No compensation will be recognized to the contractor for material or time losses in case of stuck or lost material in the hole, and fishing attempts will be at complete contractor's cost and risk.

Should material be lost in the well in such a way to compromise the completion of works, the well shall be plugged and abandoned, at a contractor's cost, and a new well drilled nearby, without any compensation from the client.

Bottom of the borehole

Boreholes should be drilled up to 10 meters below SWL. Amendments to this rule shall be approved in writing, and justified on a case by case basis, by the client's representative.

The bottom of the hole acts as a sedimentation sump and a support for the casing and screen. The sump shall be a bottom plain casing of 3 meters with the same diameter as the screen, and with its underside sealed with a bottom plug (wooden or PVC).

The casing shall smoothly run in the well without any friction. Shall the casing get stuck before TD, the casing has to be removed, the hole cleaned, and a new attempt done. Should the well collapse on bottom, the client's representative will decide according on the entity of the collapse. In any case, only the open and usable part of the well will be paid to the contractor, and no payment is due for the collapsed part. Should the collapse make the well unusable

Screening design

Screen design shall be determined according to the lithology log. Filters shall be in front of the most permeable part of the aquifer (i.e. sand and gravel) and only in front of the water bearing formation. Care shall be taken to avoid to put screens in front of argillaceous levels, in order to avoid development of turbidity.

The length and position of the screened section affects the yield of the borehole. The size of the screens shall be chosen according to the size of the particles of the aquifer, being the screens 2/3 of the minimum size of the formation.

Gravel Pack

Artificial gravel pack (filter pack) is required to prevent particles entering the well and to improve hydraulics properties in and around the catchment section of the borehole.

Gravel pack shall consist of siliceous material with rounded, smooth and uniform particles. Unstable minerals such as feldspars, calcite (limestone), laterite, etc. will easily decompose and change the properties of gravel pack. Flaky particles such as schist and micas will clog the screens.

Gravel pack should be clean and well-sorted, i.e. there must be no particles of clay or silt adhering to the individual sand or gravel grains of the packs. Filter material should be treated with care to avoid any kind of contamination.

The artificial gravel pack is combined with a suitable screen. Installation of gravel pack in the annular space between screens and borehole walls, plus 3 meters above the top of the first screen. Gravel pack is topped with a one-metre clay seal.

When using a rotary drilling machine, reverse circulation with clear water shall be performed during the installation of the gravel pack, to ensure a proper packing of the filtering material.

In any case, the gravel or any other filtering material shall be approved by the client's representative before installation. The contractor shall stock the filtering material on site before the completion of the well, and make it available for inspection. Should proper material not available at all, and only after written permission from the client's representative, local material may be used, provided that adequate sieving will improve its characteristics.

Should the provision of material part of the community contribution, the contractor is, in any case, responsible of the fulfilling of the above mentioned quality requirements.

Backfilling

The anular space above the filters shall, strictly, be filled with a proper backfill, to ensure a proper protection of the screens from contamination. Clay shall be used for at least 3 m above the gravel pack. Digging material can than be used to fill the rest of the annular space.

Cement plug

The upper 1.5 m of annulus shall be filled with a cement plug. Cement slug, SG 1.8, shall be used. It means approximately 1 jerry can of water per bag of cement will provide app. 42 l of required slug.

Head of the borehole

The top casing shall come out between 55 cm and 60 cm above of the ground level. It will be correctly cemented in the ground. If a hand pump is not installed immediately, then the top of the borehole must be sealed adequately.

Borehole verticality

Installed casing shall be round and straight. Straightness and plumb ness should be tested at the end of the casing screen installation. The minimum standard of quality can be controlled by lowering down a standard hand pump cylinder to the final depth of the borehole without opposing any resistance.

Soil sampling

During drilling, formation should be sampled at least every 5 m. Aquifer formation should be logged on the borehole completion form.

Water sampling and testing

After the completion of the borehole, and installation of the handpump, the community will be requested to pump the hole for two days without using the water for drinking purposes. After this period, the clients representative will sample the water for the following parameters: EC v(electro conductivity), pH, Temperature, Turbidity. Should turbidity result to be higher than 5 NTU, the hole will be pumped again, up to a maximum of 14 days. Should the turbidity still be above 5 NTU. The hole will be rejected, no payment due to the contractor, and another hole constructed nearby.

Whenever requested by the client, a bacteriological test will be performed, with a procedure approved by WHO (H2S or membrane filtration).

Deepening of dug wells via drilling rig

A dry dug well can be deepened via drilling rig, provided:

- The dug well can not be deepened further via traditional means by the community, because of hard strata or excessive depth
- The dug well is already improved, with an handpump installed
- The position of the well is according with MRRD policy
- The community based maintenance system of the dug well was working till the moment the well went dry
- There is enough space in the vicinity of the dug well to permit a drilling rig to be properly installed, in order to avoid that

- The deepening procedure is not going to destroy the upper superstructure of the dug well.
- The deepening is approved by the client's representative

The deepening shall be conducted ON ONE SIDE of the dug well. Deepening conducted at the centre of the well will not be approved, in any case.

The same drilling requirements of a new tube well will be applied to the deepened portion of the well.

The old coding of the well will be maintained.

New well in place of deepening

Should the operations of deepening too complicated, the contractor can request the client's representative to drill a new tube well in a suitable position nearby. The location of the new well shall be such to meet all requirements of a new well, plus the condition to <u>serve the same usergroup of the dry well</u>. This procedure shall be <u>approved in writing</u> by the client's representative. In this case, <u>the initial portion of tube well equivalent to the depth of the old dug well will NOT be paid to the contractor</u>, and the old well shall be plugged and made safe at contractor cost.

PUMPING EQUIPMENT & SUPERSTRUCTURE

Pump type

Only handpump from the AFRIDEF family will be installed. The manufacturer of the pumps must follow the SKAT specifications in terms of materials and dimensions, and the quality of the pump has to be approved by the client's representative. The recommendations of MRRD will be followed.

- Kabul handpump shall be installed up to a depth of 15 m.
- Indus Handpump shall be installed up to a depth of 45 m
- Pamir handpump shall be installed up to a depth of 60 m. The use of Pamir handpumps has to be limited to cases of effective need, and shall be approved by the client's representative.

Pump intake

The pump in-take shall be installed at least 1 m above TD, and the handpump shall not run dry after a continuous use of 8 hours. Should the handpump run dry, the contractor can deepen the cylinder up to 1 m above TD. Should the pump still run dry after a continuous use of 8 hours, the yield of the hole will be considered insufficient, and the borehole rejected.

Pump installation

The handpump shall be installed according to SKAT recommendations, as included in the Community Handpump Water Supply and Sanitation Guide for Afghanistan, (1999). A trained handpump mechanic shall be in charge and will be responsible for the proper installation. In case of installation in a dug well, or in a deepened dug well, the pump shall be installed on one side of the well, and the rising main shall be fixed to the walls of the well via iron clamps, to avoid any vibration in the rising main.

Pump platform

The platform consists of an apron, a standing slab, a drain and a soak-away pit.

The design of the apron has to be according the recommendations included in the *Community Handpump Water Supply and Sanitation Guide for Afghanistan, (1999).*

The minimum dimension of the platform should anyway not be inferior to 4 m^2 if a rectangular shape platform is built.

Annex O   Hand Dug Wells

Hand Dug Wells

Choosing the right type of well for a location

1. The type of the well to be constructed will be one of the following:

- Hand Dug Well
- Tube Well
- Dug Well deepened by drilling rig

2. MRRD policy on choosing the right type of well for a location

The choice of the type of well is done according to the principles included in the MRRD policy, and must be approved, in writing, by the client's representative, on a case by case basis.

The MRRD policy states that as a general rule, whenever technically feasible, the improved dug well shall be preferred. If the water table is too low or it is a densely populated area or the soil strata is too hard for hand digging then a dug well is not suitable.

3. When is a dug well appropriate?

- When a dug well has a hand pump installed, a well apron and drain constructed to remove wastewater to keep the water free of contamination.
- When the water table is higher than 50 meters
- When the seasonal fluctuation of the water table in the area is less than 2 meters in a normal year. If the well is dug during the dry season and a sludge-pump is used the well can be made deep enough to provide water during a dry year.
- When there are no roads to the location and the only transport is by animal. This is common in mountain areas.

4. Why construct a hand dug well?

A hand dug well can have a hand pump, a concrete apron and drain and if well maintained provide safe drinking water

An improved dug well is hand dug and costs much less that a tube well and enables more people to have a safe water supply.

We can construct two hand-dug wells for the cost of one tube well.

Community members with the guidance of a Water and Sanitation Engineer can do most of the work to construct a dug well thus reducing the cost even further.

Most communities already have the knowledge to construct wells and they have been very successful. Even when the stratum is conglomerate hard rock, communities find solutions and succeed in constructing wells.

. In some parts of Afghanistan it is much easier to hand dig a well than to use a drilling rig. At Alishing and Alinger in Laghman province the rock is very hard and DACAAR has found it is quicker to hand dig a well than to use a percussion drill. Percussion drilling can take more than three months to drill through the hard rock in these areas

Without sludge pumps communities have been able to dig hand dug wells deep enough to retain water during the drought

Many families have constructed open wells within their own compound but unfortunately these are often contaminated.

Open public wells are even more likely to be contaminated so they should be prioritised for replacement

Communities that dig their own well have independence and are not reliant on drilling rigs and mechanics and when parts of the country are unsafe to travel in they are still able to construct wells. Many communities lack the necessary organisation, motivation, and knowledge to keep their water supply safe.

The unsafe situation and political unrest in Afghanistan over the years has resulted few wells being constructed in Afghanistan. Since the war wells have become more common.

In some parts of Afghanistan it is much easier to hand dig a well than to use a drilling rig. At Alishing and Alinger in Laghman province the rock is very hard and DACAAR has found it is quicker to hand dig a well than to use a percussion drill. Percussion drilling can take more than three months to drill through the hard rock in these areas

5. Why did many dug wells go dry during the drought?

During the drought the water table dropped below the pump cylinders.

The people of Afghanistan had not experienced such a serious drought before so cylinders and filters had not been located deep enough to reach the water during the drought. The location of a well is best determined by a qualified hydro geologist or engineer based on a study of the location.

Most hand-dug wells were dug without a sludge pump. To deepen a hand dug well it is preferable to have a sludge pump. A sludge pump removes the water enabling the workers to dig deeper. It is difficult to dig while standing in water. When digging a well during the wet season the water column should be at least 4 meters

When assisting with the digging of some hand dug wells DACAAR used two sludge pumps for four days. These wells did not dry up during the drought. Unfortunately sludge pumps are often not available.

The water table for dug wells was affected by the drought more than the water in the deeper tube wells. A tube well has a much bigger water column than a hand dug well which usually has a water column of a minimum of two meters. In some parts of Afghanistan it is much easier to hand dig a well than to use a drilling rig. At Alishing and Alinger in Laghman province the rock is very hard and DACAAR has found it is quicker to hand dig a well than to use a percussion drill. Percussion drilling can take more than three months to drill through the hard rock in these areas

6. An improved hand dug well

A hand dug well is improved when the well is lined, has a concrete platform (apron) and a hand pump installed. The water enters the well from the bottom.

6.1Prefabricated Concrete rings

- Prefabricated rings are used to stop the well walls collapsing
- An inner diameter of 34 inches (96 centimetres) and a height of 18 inches (45 centimetres) is a suitable size. This size is suitable for transporting on foot which is frequently necessary..

- A uniform thickness of 5 centimetres. Uniformity and undamaged rings means that correct vertical placement of rings one on top of the other is more likely attained and stronger.
- To avoid spoilage of rings during the lining and transportation, the mix ratio of cement, and gravel of 1:2:4 for sorted aggregate or 1:5 should be used for all gravel.
- To avoid damage, rings should not be rolled when moved they should be lifted.
- Careful loading on a truck and careful driving is also necessary to avoid ring breakage and damage.
- When unloading rings, care must be taken not to drop them and cause cracks or damage.
- Rings that are damaged or not of a maximum strength should not be transported from the production site
- Children should not be allowed to play with any well components and damage rings. Even a small amount of damage can make ring placement difficult.

6.2Water column

The water column must be sufficient. If the water column is not enough, the well will go dry during the dry season. Local experienced people should be consulted and the depth of other reliable wells in the village measured.

The bottom of the well should be levelled so that the rings can be raised in a vertical line

6.3 Lining hand dug wells

Wells dug in loose materials such as sand require lining. A well can be lined with stone, baked bricks or concrete rings. Lining a well with concrete rings is the most suitable method. If parts of the well strata are solid then the parts with the loose strata may only need lining. All wells require a ring 0.90 mm high ring at ground level. If the mouth of the well is strong and regular a reducing slab can be directly installed. If the mouth of the well is damaged and irregular two beams are first installed and the reducing slab is positioned on the beams and the ring is placed on the reducing slab.

To lower a ring, fasten three short pieces of jute rope in three places (holes or foot places) on the ring. Connect these three pieces to the long jute rope used for lowering the ring. Two or three people then gradually lower the ring into the well.

After lowering the ring a skilled person enters the well to undo the rope from the ring and work to make the ring sit level on the floor of the well. As each ring is lowered the skilled person enters the well to arrange and position each ring until the lining is completed. If the thickness of the rings is uniform and rings are not damaged this work will proceed smoothly

6.4 Deepening dry hand dug wells

When deepening dry wells DACAAR has manufactured half rings. Half rings are easily made by placing a board in two places inside the ring mould.

Each piece is lowered separately and a skilled person positions them and joins them inside the well. If the thickness of the rings is uniform this makes this process alsomuch easier

6.5 Backfilling

Careful backfilling of the concrete rings with fine gravel is necessary up to 2.0 meters above the highest level of the water column in the well. This keeps the waterway to the well open. Also fine gravel placed in the bottom of the well stops sand from entering the bucket. All other back filling can be done with ordinary soil.

6.6 Platform Construction

Each well mouth must be sealed to prevent contamination from entering the well. A strong platform must be constructed to support the hand pump and its users. The drain and platform must be designed to transport wastewater away from the site. A soak pit or kitchen garden can provide safe disposal of the wastewater.

6.7 Construction Procedure

- Good quality materials are necessary-Portland cement, gravel, stone, and clean water.
- An apron mould should be used to construct a properly designed platform. A poorly designed apron can hold stagnant water instead of draining it away
- Mix cement and gravel in a 1:3:6 ratio for sorted aggregate and for unsorted gravel mix in a 1:7:5 ratio. Mix thoroughly using clean water and a vibrator.
- Pour the concrete into the apron mould.
- Level the concrete and compact it with a straight edge and wooden smoother.
- Finish the apron floor using a mix of sand and cement.
- Construct the drain and steps
- The drain and platform should be cured for at least seven days. For many concrete structures it is compulsory to cure for 28 days.

6.8 Soak pit:

The construction of a soak pit is essential if natural drainage or a kitchen garden is not available.

The pit should be 1.2 to 1.5 meters deep with a diameter of 1.0 meter. Fill the pit with pebbles, gravel and broken baked bricks and cover with course sand. A brick ring can be constructed around the top of the pit to stop the soil from collapsing . Guard the in flow point with a brick or stone.

6.9 Installation of a hand pump

- The pedestal slab is best constructed on the top ring on the day the platform concrete work is done.
- Tools and materials required for construction and the installation of the pedestal must be available
- Measure the water column and depth of the well. The well should have at least 2.0 meters of water in the dry season.
- The hand pump mechanic should be present during the installation.

- The agreement for the future maintenance should be signed by the elder of the community
- The wages of the hand pump mechanic should be collected.

Tools and consumables required for installation

Item	Quantity
Tools	
Fishing Tool	1
Hack saw with blade	1
Flat file	1
Round file	1
500 gram hammer	1
Gantry	1
Spanner for M 16 bolts	2
Flat spanner for M 12 fastener	2
Pliers	1
Knife	1
Half round file	1
Steel wire brush	1
Nylon rope 16 mm	60meters
Calibrated bucket (20 lit)	1
Consumables:	
Bleaching powder	300grams
Joining solution for joining PVC pipe	100 grams
Sand paper(300X200mm)	1 sheet
Cotton waste	1 meter

Trouble Shooting

Problem	Operation	Cause	Remedy
No Water	-Handle easy to operate -Difficult to operate -Handle normal operation	-Rods disconnected -Pipes disconnected Plunger seal defect -Water level gone below cylinder	-Pull out all rods and replace broken rods -Join the pipes Replace the seal -Add pipes and rods
Delayed flow	-Normal operation	-Leaky valves -Complete stroke not available -Leakage in pipe joints -Leaking in foot valve "O"	-Replace the valve bobbins -Adjust the length of the top rod -Take out the rising mains and replace Replace the "O" ring
Reduced discharge	-Difficult to operate -Operation normal	-U seal tight -Complete stroke not available -U seal completely worn out -Valve bobbins worn out -Pump cylinder cracked	-Replace U-seal with a new one -Correct the stroke by using required length of rod. -Replace the worn U-seal Replace the bobbins -Replace the cylinder
Abnormal noise during operation	-Operation normal -Operation inconvenient	-Rods rubbing -Worn out centralizer -Rods bent and rubbing -Worn out bearings -Handle fork touches pump head	-Straighten bent rods -Replace centralizer -Replace rods with good ones -Replace bearings
Pump handle	-Stand assembly shaking	-Cracked platform -Loose flanges Worn out bearings -Hanger pin loose -Fulcrum pin loose	-Repair platform -Tighten flange bolts and nuts Replace bearings -Tighten fully both nuts

Annex P

Hydrologic Cycle:

So, where is the fresh water coming from?

All fresh water, both above and underground, eventually comes from rain. And where is the rain coming from? From the cycle of water, also called "hydrologic cycle".

All the water of hearth is in continuous circulation, as moisture and water on our planet. Radiation from the sun evaporates water, mainly from the oceans, in to the atmosphere. The water vapor rises, then collects to form clouds. Under certain conditions, clouds condense and fall back to the earth as rain, or snow, the various forms of precipitation.

Precipitation that falls upon land areas, is the source of essentially all our fresh water supply. We depend upon it to replenish the quantity that is taken from lakes, streams, and wells for man's numerous uses.

Some of this precipitation, after wetting the foliage and ground, runs off over the surface to streams. Another part soaks into the soil. Much of the water that enters the soil is detained in the plant root zone and eventually is drawn back to the surface by soil capillary action. Some of it, however, soaks below the plant root zone and under the influence of gravity continues moving downward until it enters the ground water reservoir.

Upon joining the body of ground water, the percolating water moves through the pores of saturated subsurface materials. Ground water can sometimes discharge naturally as surface water in some places; this is a spring. Springs maintain the flow of streams in dry periods. Streams and rivers eventually lead to the oceans.

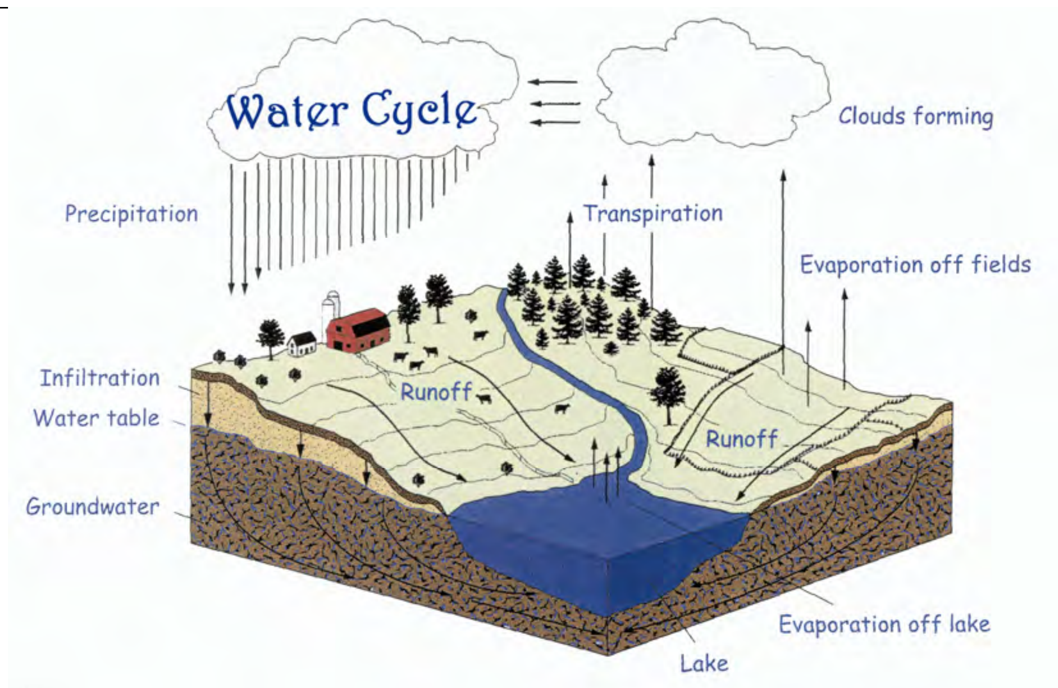


Fig. 01. The hydrologic cycle on the earth (Internet)

Evaporation:

Changing of liquids to the gas form is called evaporation. When we leave something wet and we find it dry the day after, it is because the water evaporated. Evaporation depends on temperature: the higher the temperature, the faster the evaporation.

Transpiration:

Plants absorb water from the soil through the roots, and they release vapor through leaves. This process is called transpiration. Normally, evaporation and transpiration are considered together, and their combination is called evapotranspiration**.**

Runoff:

After precipitation, part of the water skips away and eventually concentrates in streams and rivers.

Infiltration:

The amount of water that infiltrates the soil varies with the degree of land slope, the amount and type of vegetation, soil type and rock type, and whether the soil is already saturated by water. The more openings in the surface (cracks, pores, joints), the more infiltration occurs. Water that doesn't infiltrate the soil flows on the surface as runoff.

Rivers often lose part of their water underground. The yield of a river can be ¼ above the surface and ¾ just below the surface. So, even when a river is dry, maybe there is water just few meters deep: this is why close to rivers there is a good probability to find good water in the wells. In Northern and Southern Afghanistan, most of the rivers do not reach the sea because they just lose all their water underground!

Water can also infiltrate from fractures in the rocks and at the base of the mountains, and these therefore are good places in which to look for shallow groundwater.

The water continues to move underground vertically until it reaches the water table, and than it starts to move, very slowly horizontally. Water can move also for long distances and remain underground for long periods. This is why we find groundwater at big depths also in the middle of deserts: this is the rain that fell long time ago very far away!

The discipline that studies the movements of water underground is called Hydrogeology.

Annex Q Hydrogeology Glossary

Aeration zone: also known as the unsaturated zone the aeration zone is the zone above the water table.

Artesian well: The ground water in an artesian well is confined well below the natural top level of the ground water the water table. When artesian water is tapped it flows out without a pump by natural pressure.

Confined aquifers: Are aquifers that are not usually found in the saturated zone. They are locked in place by impermeable material.

Dynamic Water level (DWL): The level of the ground water measured from ground level after pumping. The multi stage pumping test keeps a record of the DWL while pumping over regular time spans. A greater rate of pumping (i.e. 1 liter per second compared with 2 liters per second) makes the DWL drop quicker.

See: Multi Stage Pumping Test

Fractured aquifers: fractured aquifers are rocks in which the ground water moves through cracks, joints or fractures in otherwise solid rock. Examples of fractured aquifers include granite and basalt. Limestone is often a fractured aquifer but here the cracks and fractures may be enlarged by solution, forming large channels or even caverns. Water can dissolve limestone and when the water circulates through the fractures it can enlarge them

Ground water movement: Ground water moves through the joined pore spaces in the aquifer. The movement of ground water through an aquifer is extremely slow, generally of the order of centimeters per day or meters per year. Ground water like surface water flows towards and eventually drains into streams, rivers, lakes and the ocean. Ground water flowing in the aquifer underlying surface drainage basins however is not always flowing in the same direction as the water on the surface.

Hydrologic cycle: Is the cycle of water, precipitating from the clouds to the earth then evaporating mainly from the seas and other water sources on earth and rising back to the sky where it accumulates as clouds and condenses, precipitates and the cycle starts all over again. All fresh water, both above and underground, eventually comes from rain. "hydrologic cycle".

All the water of earth is in continuous circulation, as moisture and water on our planet. The heat of the sun evaporates water, mainly from the oceans, in to the atmosphere. The water vapor rises, and collects to form clouds. Under certain conditions, clouds condense and fall back to the earth as rain, or snow, the various forms of precipitation.

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Igneous rocks: Are formed from hot liquid rock. Igneous rocks are divided into two types magmatic and volcanic. Magmatic igneous is found under the earth's crust. Volcanic igneous rocks are formed from lava
Interstice: An opening or void in a rock. Interstices may be filled with any type of gas or liquid but in an aquifer are usually filled with water.
Impermeable layer: A layer of material (clay, solid rock) in an aquifer through which water does not pass.
Limestone: Sedimentary rock consisting of at least 50% calcium carbonate (CaCo2) by weight. Rock caused by exposure to heat, pressures and chemical actions
Permeable: Capable of transmitting water (porous rocks, sediment, or soil).

Permeability: Allows water to pass through. The holes, cracks or spaces are joined together giving the water a passage to move through. Permeability is determined by the size of the spaces and the degree of inter-connectedness between the spaces. Permeability measures are expressed in units of velocity such as centimeters per second and assume a gradient of one foot of drop per linear drop.

Permeability

Permeability is a measure of a soil or rock's ability to transmit water. Often the term hydraulic conductivity is used when discussing groundwater and aquifer properties.

Permeability differs from porosity because the void has to be interconnected to allow water to pass. We said before that a rock is porous when contains voids: if those voids are not connected with each other, in order to form channels, water can not pass, and the permeability, that is the capacity of a rock to allow water to pass, is low.

For example, clay has high porosity and low permeability because pore spaces are not well connected. Clay often creates *confining layers* in the subsurface.

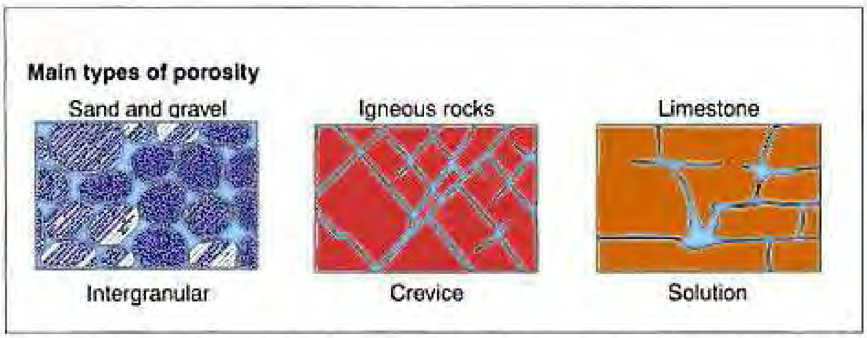
In rocks with fractures, there can be high permeability if the openings are large and are well connected.

Material	Permeability or Hydraulic Conductivity (cm/s)
well-sorted gravel	10-2 to 1
well-sorted sands	10-3 to 10-1
silty sands, fine sands	10-5 to 10-3
silt, sandy silts, clayey sands, till	10-6 to 10-4
clay	10-9 to 10-6

Tab 03 - Permeability Ranges for Sediments (C.W. Fetter)

Porous rock: A rock is porous when it contains voids: if those voids are not connected to each other, in order to form channels, water can not pass, and the permeability, that is the capacity of a rock to allow water to pass, is low. Some very porous materials are not permeable. For example Porous media where the grains are not cemented to each other are called unconfined aquifer If the grains are cemented together such aquifers are called consolidated.

Porosity: Porosity or pore space is the amount of air space or void space between soil particles or in a rock or sediment. It is usually expressed as a percentage. Infiltration, ground water movement and storage occur in these spaces. The pore spaces can include openings between grains, fracture openings and caverns. Some very porous materials are not permeable because even though there are many spaces the spaces are not joined up and the water cannot move along. Clay, for instance, has many spaces between its grains, but the spaces are not interconnected enough to permit free movement of water.



Where groundwater can be found. It fills the spaces between sand grains, in rock crevices, and in solution openings.

Saturation Zone: The portion below the earth's surface that is saturated with water is called the zone of saturation. The upper surface of this zone, open to atmospheric pressure, is known as the water table.

Static water level (SWL): The top level of ground water before pumping commences. After pumping the static water level takes some time to return. This level is used when pump testing for ground water measurement.