

BUILDING THE WELL

Dr. MARK KING

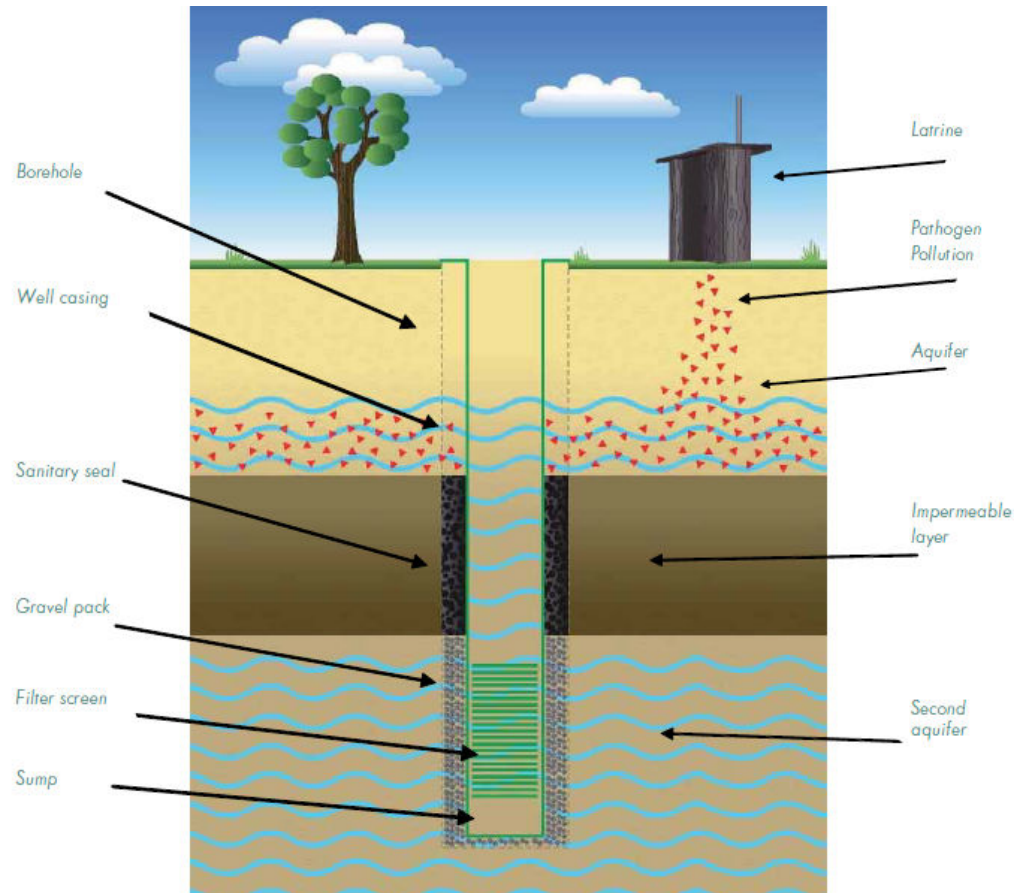


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Building a Well



WELL CONSTRUCTION



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WELL CONSTRUCTION - DESIGN



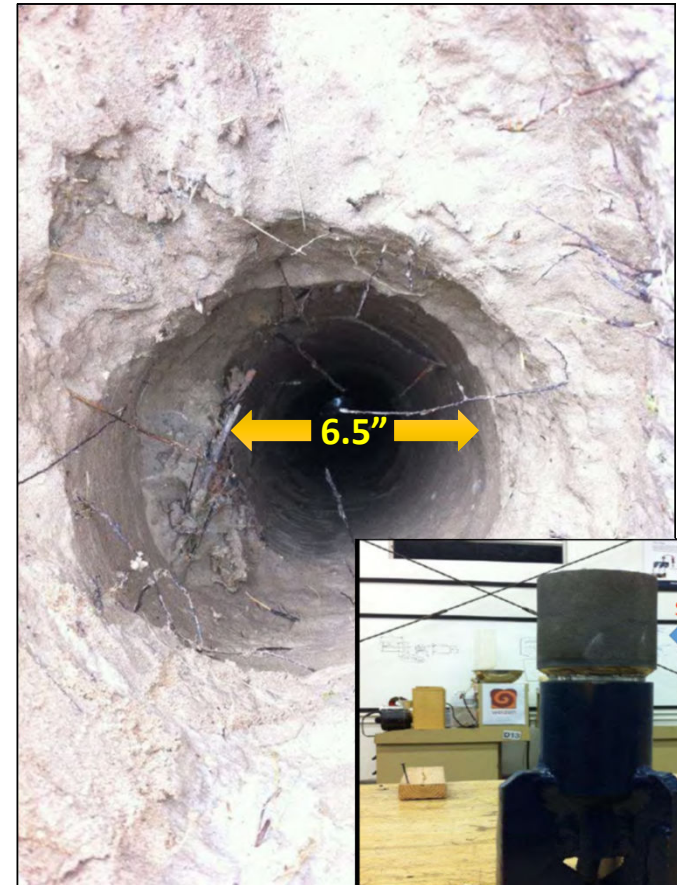
- A critical step in achieving a good well design is completion of a *drilling log*, during the drilling process.
- *Be sure to describe the drilling samples at least every 'break', as samples can easily get lost.*
- The drilling log will be used to determine the exact depth and length of the well screen, *gravel pack* and *sanitary seal*.

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WELL CONSTRUCTION — BOREHOLE DIAMETER

- In general, the casing and screen diameter is set by the following:
 - As large as possible, for flexibility in pump options
 - But small enough to permit placement of gravel and seal in the annular space
- The standard Village Drill bit provides a borehole of 6.5 inch
- This can accommodate casing of 3 to 4 inches
- The internal diameter of the casing must fit the outer pump diameter

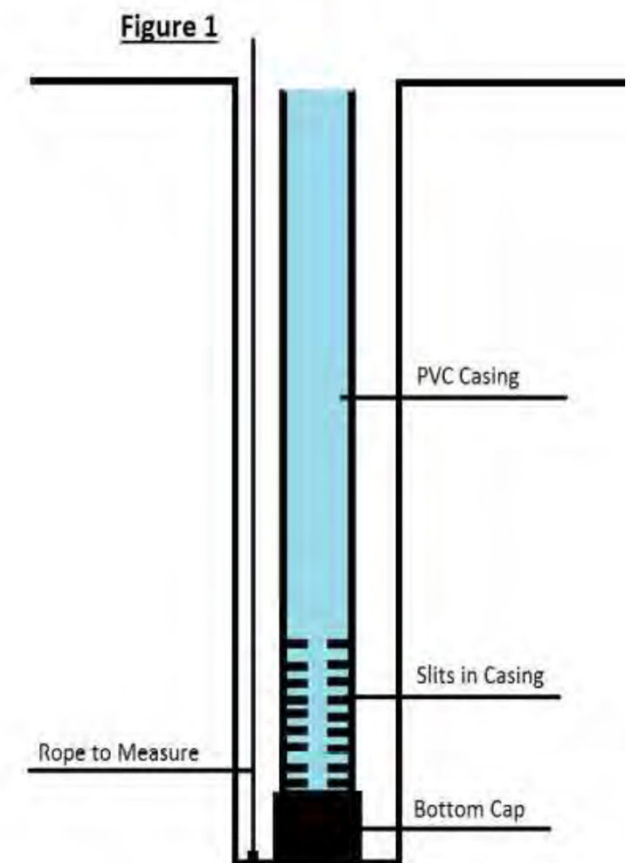


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WELL CONSTRUCTION — BOREHOLE DIAMETER

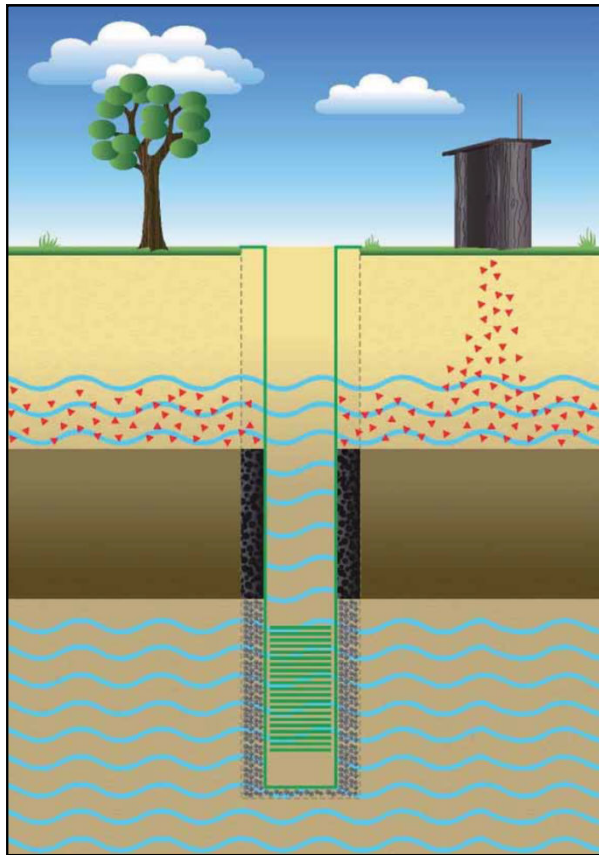
- For the diameter of the borehole it is important to realize the following: The drilled diameter of the borehole should be at least 2-inches larger than the outer diameter of the PVC well casing to be able to place the *gravel pack* and *sanitary seal*.
- If this rule is not applied and the space between the PVC well casing and the borehole wall is too small, the backfill may get 'stuck' on its way down (called 'bridging').



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WELL CONSTRUCTION — BOREHOLE DEPTH



- When the final depth for the bottom of the well-screen in the aquifer is reached an additional two meter should be drilled.
- This is to provide space for *fine soil particles* (mixed with the water), to settle.

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WELL CONSTRUCTION — COMPLETION

- Finally, before the drilling pipes are lifted, the fluid-filled borehole should be flushed with clean water to remove all fine particles suspended in the hole.
- If this is not done, the particles will settle at the bottom of the well (influencing the final installation depth)



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WELL CONSTRUCTION — MEASURING TOOLS



- Before the actual well construction starts it is important to double-check the final depth of the borehole with a measuring tape.
- Sometimes there may be confusion among the drill team members about the number of drill pipes in the ground.
- Further to this point, it is important to count all your drill pipes beforehand.

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WELL CONSTRUCTION – MEASURING TOOLS

- Depth measurements should be done with a measuring tape or specially made measuring tool.
- A inexpensive and accurate measuring tool can be made as follows:
 - 1 metre length of reinforcement bar, bent into a loop, is attached to a long piece of a 4mm thick rope.
 - At exact 3 foot intervals, knots are tied in the rope. The final depth of the borehole or depth of backfilling can be measured by counting the knots.



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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

- Several different PVC pipes exist, varying from cheap drain pipes to expensive, slotted well-screens and casing pipes. Your choice will often depend on availability.
- Three examples:
 1. For a *shallow irrigation well*, equipped with a treadle pump, a cheap 2-inch self-slotted drain pipe will be sufficient. In this case the diameter can be small (to fit a treadle pump suction hose) and the water quality for irrigation is not critical (shallow well, first aquifer). This well will be *relatively inexpensive*.



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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING



2. For a *potable water well* for use by a single household or a few households equipped with a rope pump or other low-cost hand pump, a deeper hole may be needed (to protect water quality, so preferably drilled to a second aquifer). In this case a self-slotted 4-inch PVC pipe can be used. In doing so, the well stays relatively *affordable*.

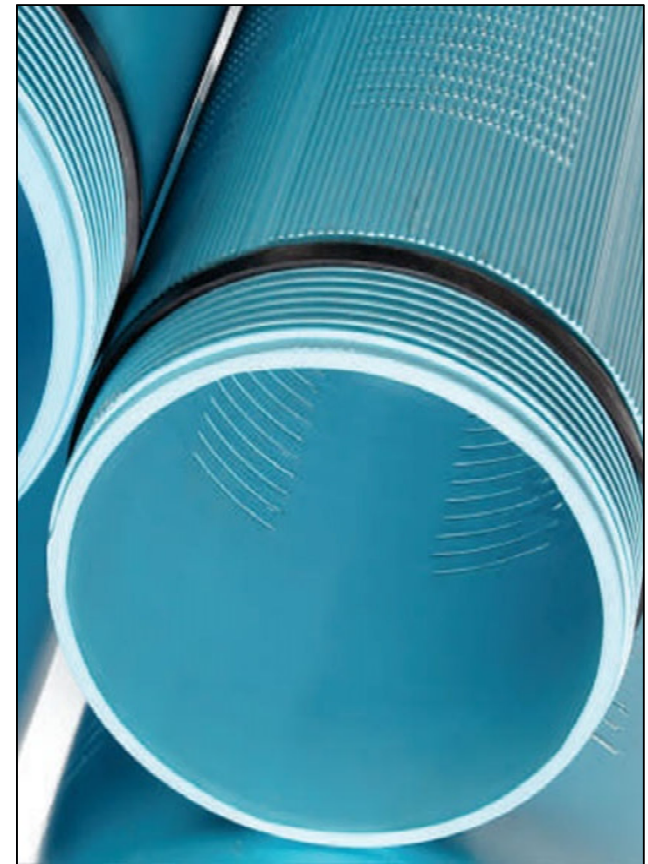
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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

3. In larger water projects for *communal potable water wells*, 4-inch factory slotted PVC well casing pipes may be required (to maximize yield, to ensure high construction quality, and to accommodate the pump)



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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING



- As these examples show, the choice of pipes depends on:
 - Outer diameter of the pump (pump should fit into the inner diameter of the casing pipe)
 - Type of the well (irrigation or potable water)
 - Intensity of use (household or communal)
 - User budget
 - Availability

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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

- **Diameter and wall thickness of well casing**

- There are two main internationally accepted standards for pipe size: *metric* (meters) and *English* (inch). However, in each country the actual size in millimeters differs from the size given in inches by the factory. As an indication, see the table on the right.

Nominal inch size	METRIC		ENGLISH	
	Outside Diameter	Approx Inside Diameter	Outside Diameter	Approx Inside Diameter
1.1/2"	40mm	33mm	48.1mm	40mm
2"	63mm	55mm	60.2mm	52mm
2.1/2"	75mm	65mm	75mm	65mm
3"	90mm	80mm	88.7mm	78mm
4"	110mm	98mm	114.1mm	102mm
5"	125mm	116mm	140mm	130mm
6"	160mm	148mm	168mm	154mm
8"	225mm	210mm	219mm	204mm

Table 6.1 Comparison between 'Metric' & 'English' uPVC pipe sizes

- **Important:** The wall thickness of the pipes should always be more than 3 mm. If a smaller wall thickness is used in deeper wells the pipes may break during use.

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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

- **Slots**
- Slots are the openings in the well-screen which allow groundwater to flow into the well. In theory the slot size (width) should be smaller than the mean size of the soil particles. However, in some countries only 1 factory-made slot size (1mm) is available.



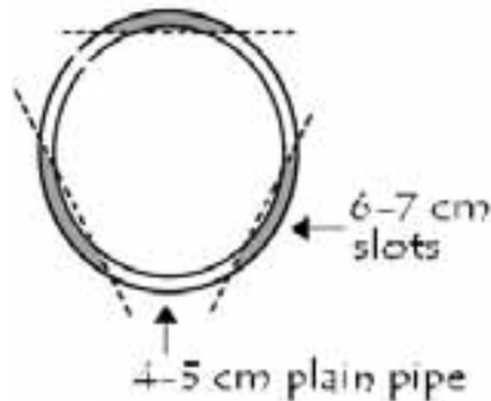
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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

- For low cost wells, one can make the slots by hand using a hacksaw.
- For a 4-inch screen, 6 parallel lines are drawn along the full length of the pipe with an in-between distance of about 4-5 and 6-7 cm. Within the 6-7 cm lineation the slots are sawn.
- The distance between the slots should be about one centimeter.



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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

- **Sump**
- To increase the lifetime of the well a 1-2 metre sump should be placed below the well-screen
- Particles entering the well screen will settle in the sump, without blocking the well-screen and pump.
- The sump simply consists of a 1-2 metre plain PVC pipe, which is capped at the bottom with a factory-made PVC cap



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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

Pipe joints

- Casing and well-screen pipes are usually joined by glued sockets. The more expensive purpose-made casings and well-screens with a wall thickness of at least 5 mm are threaded.
- When the pipes are glued together, it is important to clean and roughen both ends, the *inside* of the socket and the *outside* of the pipe to be glued. Then, put sufficient glue ALL around on both ends and put the pipes together in one move.



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WELL CONSTRUCTION

MATERIALS: PVC WELL-SCREEN AND CASING

Effective length

- Be aware that *sockets* and *threads* may influence the total length of the pipe. In other words, a 6 metre pipe could become 5.80 metres when glued together.
- When installing the pipes in a 30 metre deep borehole, over 1 metre of difference may be created, affecting the actual position of the filter screen.
- Measure to confirm



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WELL CONSTRUCTION

MATERIALS: GRAVEL PACK

- The gravel pack fills the space between the aquifer (sand particles) and the well-screen
- It prevents the wall of the hole from collapsing on to the well-screen
- It also increases the distance between the well and the formation, thus lessening particle entry to the well



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WELL CONSTRUCTION

MATERIALS: GRAVEL PACK

- The gravel should consist of a grain size (generally 1.5 - 3mm) which is just larger than, and no more than 2-3 times, the slot size of the well-screen.
- Good size gravel looks more like coarse sand, rather than gravel. The grains are best when round in shape. Such material can often be found in river beds or lake shores.
- Natural gravels should be washed and sieved before use



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WELL CONSTRUCTION

MATERIALS: SANITARY SEAL

- It is essential to install a sanitary seal
- The sanitary seal can consist of cement or bentonite pellets
- The volume of the bentonite pellets will increase many times when it gets wet, and so it seals the hole by expanding.
- Natural swelling clays can be used, but they are more difficult to handle than processed bentonite.
- In many countries bentonite pellets are expensive or not available. In these cases it is recommended to use a cement-water mixture (cement grout).



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WELL CONSTRUCTION

MATERIALS: SANITARY SEAL

- The water and cement are mixed until a thick slurry is created (26 liters of water to one 50 kg bag of cement will make about 33 liters of cement grout).
- If cement grout is used as a sanitary seal, a half meter of clay should be backfilled on top of the gravel pack to prevent the grout from penetrating the gravel pack.



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WELL CONSTRUCTION

- **Note: Fluid-drilled boreholes must be kept full of water during the entire installation process!**

Preparations

- Prepare all materials needed for the installation and backfilling. Measure out the *effective length* of the PVC pipes and cut the last pipe to a length, allowing at least 1 metre to extend above ground level, after installation. Number the pipes in order of installation.



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WELL CONSTRUCTION



Installation of the gravel pack

- The gravel pack is poured into the annular space around the pipe.
- At the same time the PVC pipe is moved from side to side to ensure easy passage for the gravel down to the screen.
- Pour in the gravel slowly, to prevent *bridging* (gravel getting stuck at the wrong level).

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WELL CONSTRUCTION



- Use the measurement tape or tool to measure the depth to the top of the gravel and fill to 1-2 metres above the top of the well-screen.
- In fluid drilled holes, water may *overflow* from the PVC casing pipe, as the gravel is dropped around the well-screen.
- Water will stop overflowing the PVC casing pipe when the entire length of the well-screen has been backfilled.

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WELL CONSTRUCTION

Installation of the sanitary seal

- When the gravel pack has settled to the design depth (always measure!), the sanitary seal can be installed.
- Prepare the cement grout, natural swelling clay or bentonite and pour it into the borehole in the same way (if cement grout is used for the sanitary seal remember to use clay for the first half meter on top of the gravel pack!)
- Measure to ensure the sanitary seal was installed to the target *depth*.



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WELL CONSTRUCTION

Filling the annular space

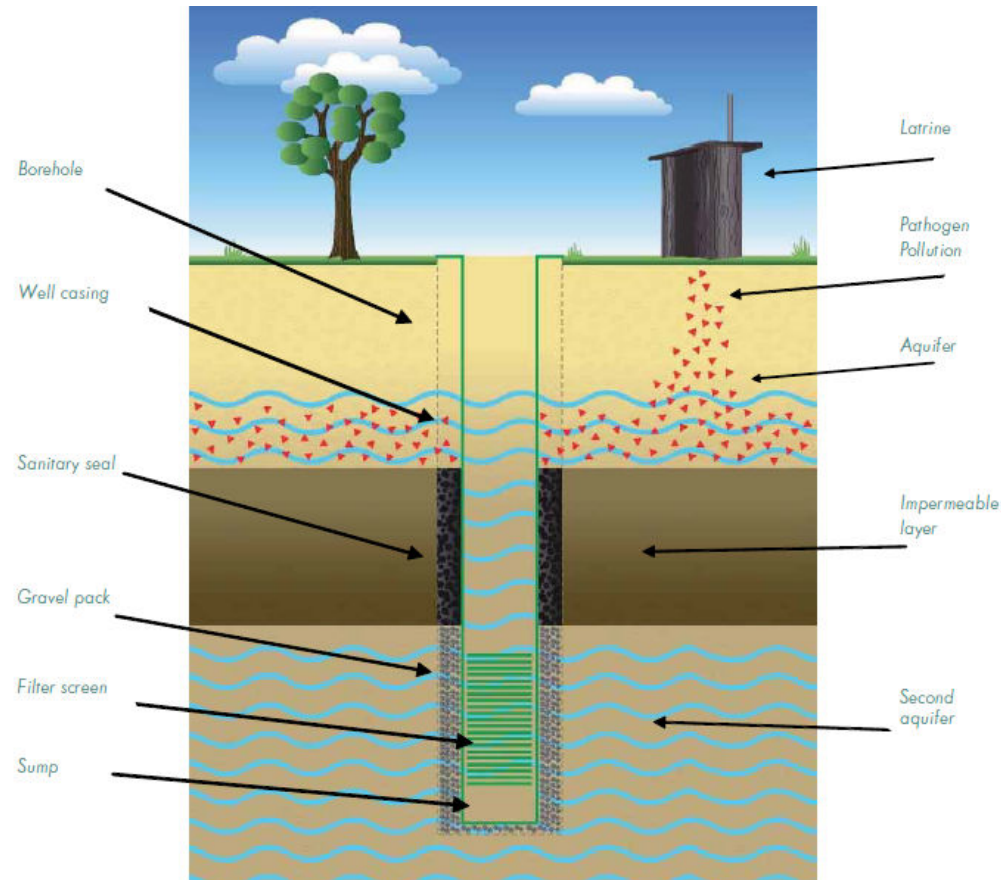
- Depending on the country regulations, the rest of the annular space may be filled with cuttings or cement grout to within 3-5 metres of the ground surface. Always pour in the material slowly, while moving the casing to prevent bridging.
- **Step 7, Installation of the top seal**
- The well packing should be finished with a sanitary seal on the top 3-5 metres. The top seal may be bentonite or cement grout.



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