Water for the World

Constructing Structures for Springs

Technical Note No. RWS. 1.C.1

There are two important reasons to build structures for springs and seeps. First, they protect the water from contamination caused by surface run-off and by contact with people or animals. Secondly, the structures provide a point of collection and storage for water. Water from springs and seeps is stored so it will be readily available to the users. This technical note discusses the construction of spring boxes and seep collection systems and outlines the construction steps to follow. The steps are basic to small construction projects and should be followed for the construction of most spring structures.

Useful Definitions

CONVEX - Curving outward like the surface of a sphere.

DISINFECTION - The process of destroying harmful bacteria.

EFFLUENCE - An opening from which water flows.

PUDDLED CLAY - A mixture of clay and a little bit of water used to make something watertight.

UNDERFLOW - Flow of water under a structure.

VOIDS - Open spaces in a material.

Materials Needed

Before construction begins, the project designer should give you the following items:

(1). A map of the area, including the location of the spring; locations of users' houses; and distances from the spring to the users, elevations,

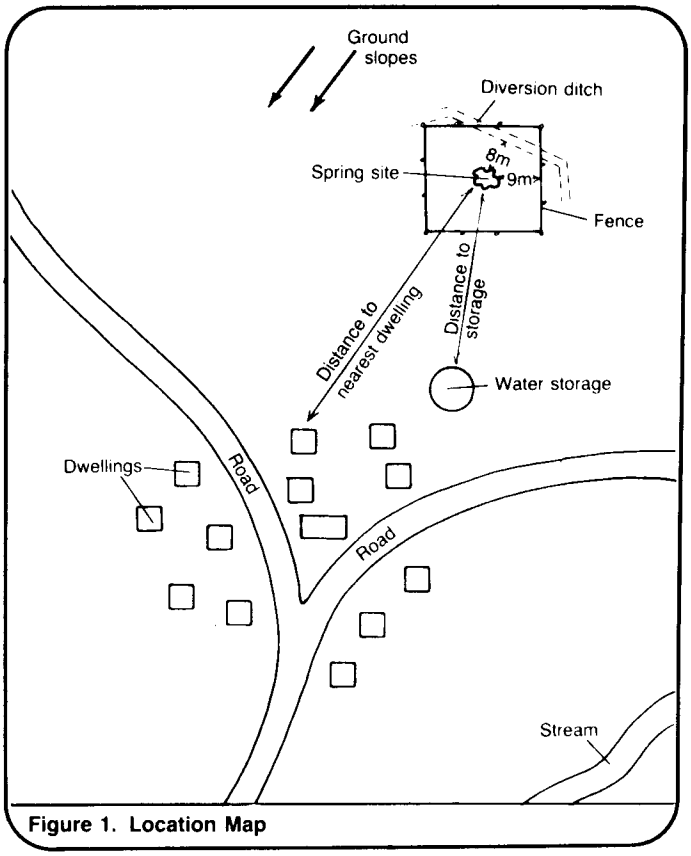


Figure 1. Location Map

and important landmarks. Figure 1 is a map of a small village with a spring located on high ground above it. Use your map to locate the construction site for the spring box.

(2) A list of all labor, materials and tools needed as shown in Table 1. Ensure that all needed materials are available and at the work site before work begins. Make sure that adequate quantities of materials are available to prevent construction delays.

(3) A plan of the spring box with all dimensions as shown in Figure 2. This plan shows a top, side, and front view, and the dimensions of a cover for a spring box 1m x 1m x 1m.

Table 1. Sample Materials List

Item	Description	Quantity	Estimated Cost
Labor	Foreman	____	____
	Laborers	____	____
Supplies	Portland cement	____	____
	Clean sand and gravel, if available, or locally available sand and gravel	____	____
	Water (enough to make a stiff mixture)	____	____
	Wire mesh or reinforcing rods	____	____
	Galvanized steel or plastic pipe (for outlets, overflow, and collectors)	____	____
	Screening (for pipes)	____	____
	Boards and plywood (for building forms)	____	____
	Old motor oil or other lubricant (for oiling forms)	____	____
	Baling wire	____	____
	Nails	____	____
Tools	Shovels and picks (or other digging tools)	____	____
	Measuring tape or rods	____	____
	Hammer	____	____
	Saw	____	____
	Buckets	____	____
	Carpenter's square or equivalent (to make square edge)	____	____
	Mixing bin (for mixing concrete)	____	____
	Crowbar	____	____
	Pliers	____	____
	Pipe wrench	____	____
	Wheelbarrow	____	____
	Adjustable wrench	____	____
	Screwdriver	____	____
	Trowel	____	____

Total Estimated Cost ____

General Construction Steps

Follow the construction steps below. Refer to the diagrams noted during the construction process.

1. Locate the spring site and with measuring tape, cord and wooden stakes, or pointed sticks, mark out the construction area as shown in Figure 3.

2. Dig out and clean the area around the spring to ensure a good flow. If the spring flows from a hillside, dig into the hill far enough to determine the origin of the spring flow. Where water is flowing from more than one opening, dig back far enough to ensure that all the water flows into the collecting area. If the flow cannot be channeled to the collection area because openings are too separated, drains will have to be installed. Information on the installation of drains appears in the section on the development of seep collection systems.

Flow from several sources may be diverted to one opening by digging far enough back into the hill. When digging out around the spring, watch to see if flow from the major openings increases or if flow from minor seeps stops. These signs indicate that the spring flow is becoming centralized and that most of the water can be collected

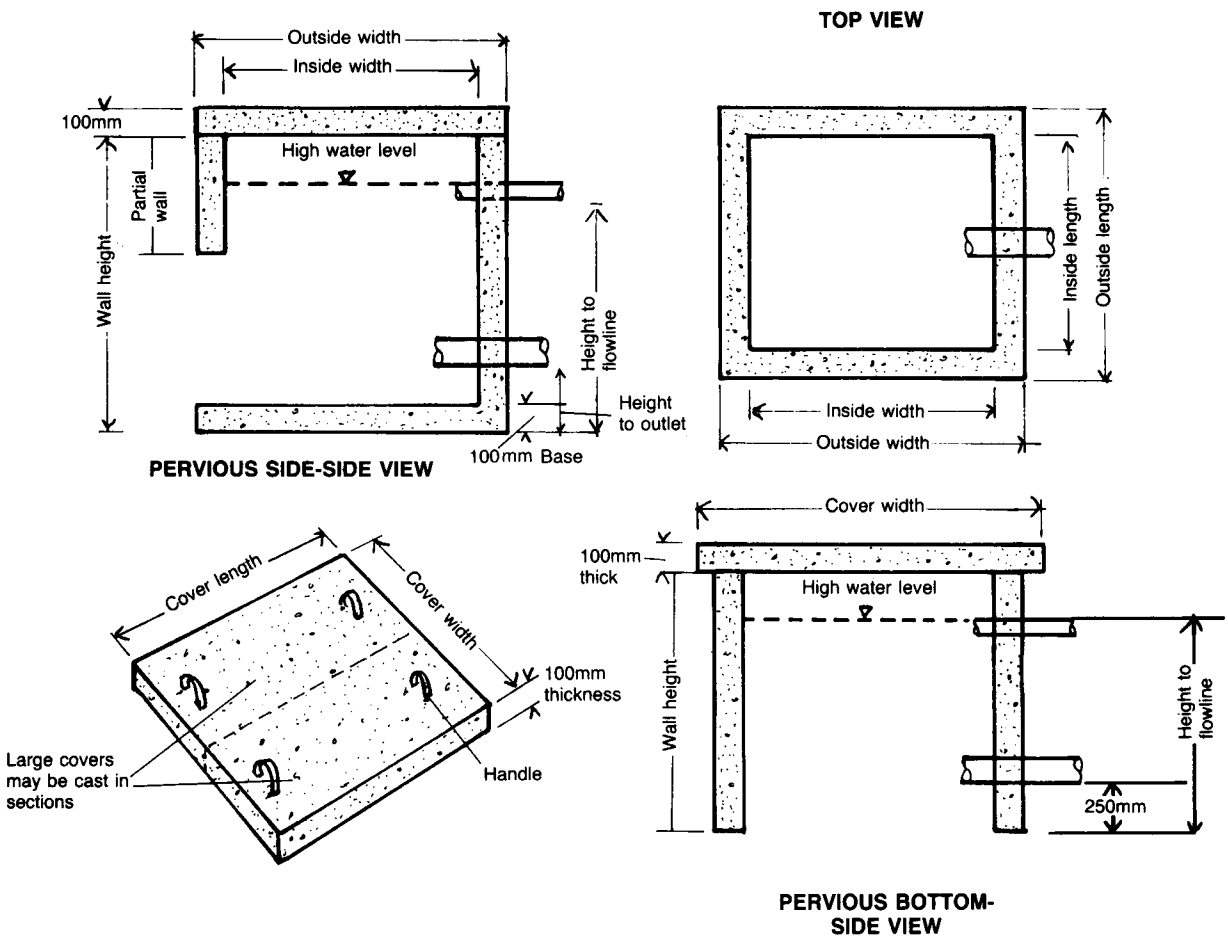


Figure 2. Spring Box Design

from one point. The goal is to collect all available water from the spring. It is generally easier to collect water from one opening than from several.

Dig down deep enough to reach an impervious layer. An impervious layer makes a good foundation for the spring box, and provides a better surface for a seal against underflow. If an impervious layer cannot be reached, attempt to construct the box in the most impermeable soil you can find.

3. Pile loose stones and gravel against the spring before putting in the spring box. The stones serve as a foundation for the spring box and help support the ground near the spring opening to prevent dirt from washing away. They also provide some sedimentation. For fast flowing springs, large stones with gravel between them should be placed around the spring to prepare a good solid base. Figure 4 shows an example of gravel and stone placed between the spring box and the spring.

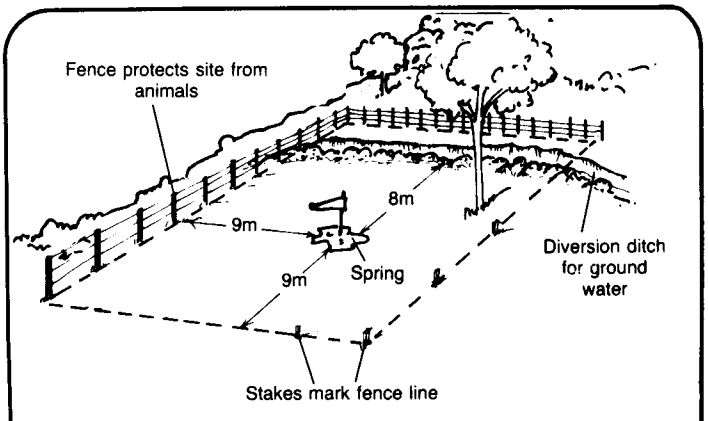


Figure 3. Preparation of Spring Box Site

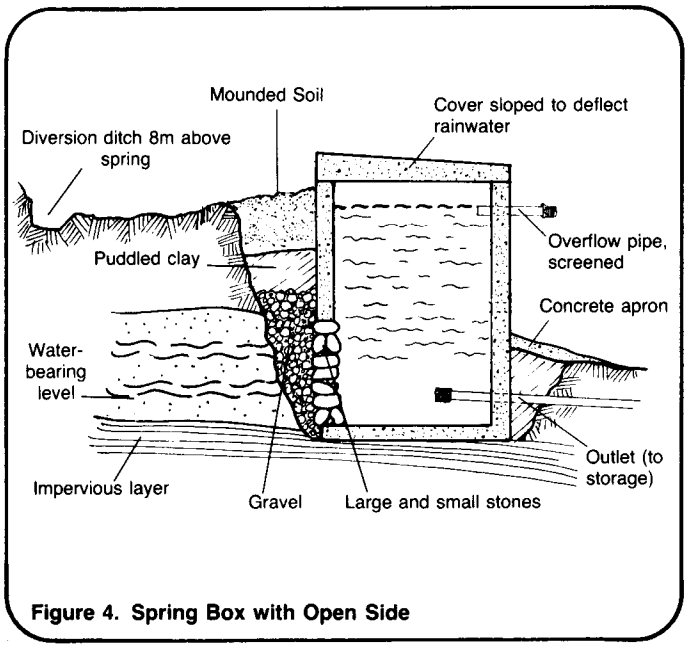


Figure 4. Spring Box with Open Side

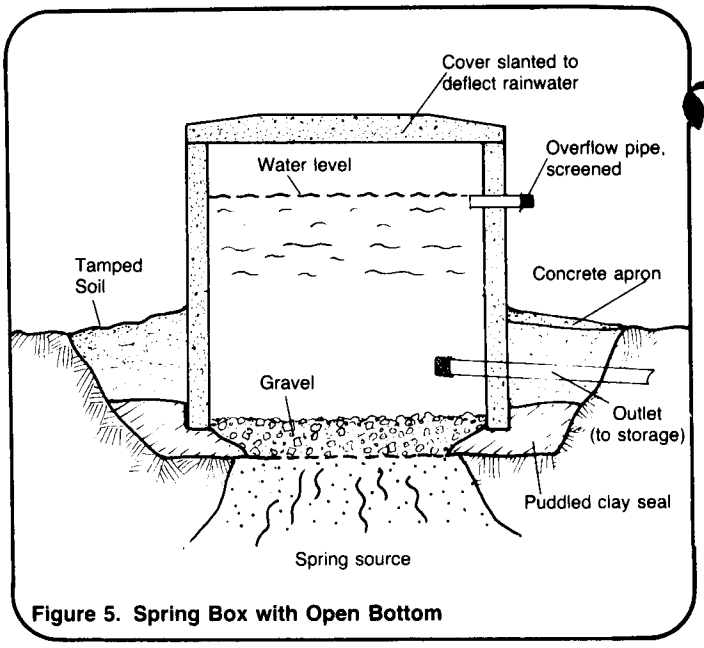


Figure 5. Spring Box with Open Bottom

If a spring flows from a single opening on level ground, dig out around the opening to form a basin. Be sure to dig down to impervious material to form the base. Line the basin with gravel so that the water flows through it before it enters the spring box. This is shown in Figure 5.

4. Approximately 8m above the spring site dig a trench for diverting surface run-off. The trench must be large enough to catch surface flows from heavy rains. If large stones are available in the construction area, use them to line the diversion trench to increase the rate of run-off and prevent erosion.

5. Mark off an area about 9m by 9m for a fence. Place the fence posts 1m apart and string the fence. A fence is useful to prevent animals from frequenting the spring site.

Concrete Construction Steps

In order to have a strong structure, concrete must cure at least seven days. Strength increases with curing time. Therefore, construction of the spring box should begin at the site during the first day of work. If the concrete is poured on the first day, seven days will be available for site preparation before the spring box is put in place. Be sure that all tools and materials needed to build the forms and mix the concrete are at the construction site.

1. Build wooden forms. Cut wood to the appropriate sizes and set up the forms on a level surface. The outside dimensions of the forms should be 0.1m larger than the inside dimensions. A form with an open bottom should be built for a spring flowing from one spot on level ground. For springs from hillsides, a spring box form with a partially open back must be constructed as shown in Figures 6 and 7. The size of the opening depends on the area which must be covered to collect the water. When building forms for a box with a bottom, be sure to set the inside forms 0.1m above the bottom for the floor. This is done by nailing the inside form to the outside form so that it hangs 0.1m above the floor. Make holes in the forms for the outflow and overflow pipes. Place small pieces of pipe in them so that correctly sized holes are left in the spring box as the concrete sets. A form for the spring box cover must also be built. Build all forms at the site.

Forms must be well secured and braced before pouring the concrete. Cement is heavy and the forms will separate if the bracing is not strong enough. One useful method is to tie the braces together with wire as shown in Figures 6 and 7. Drill holes in the forms and place wire through them. Using a stick, as shown, twist the wire to tighten it and force the forms together.

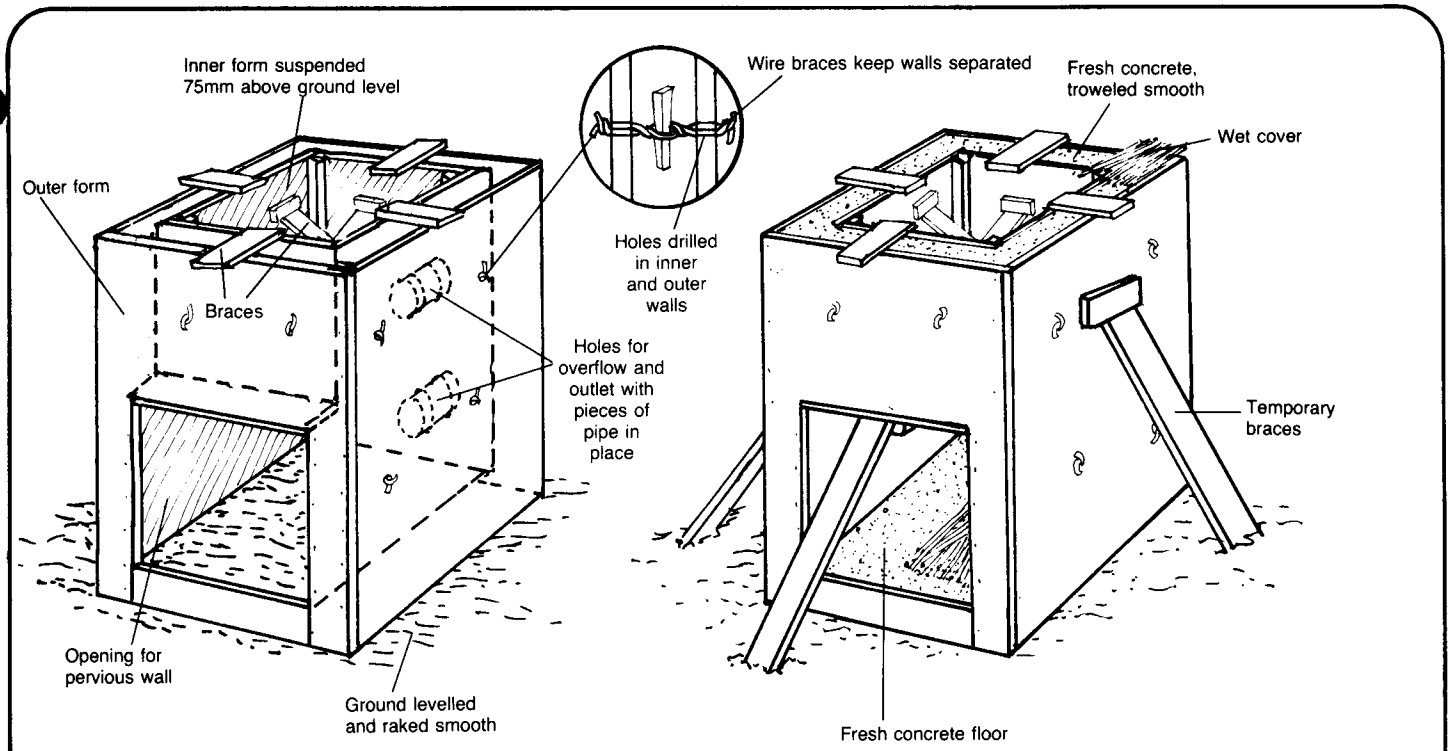


Figure 6. Forms for Spring Box with Open Side

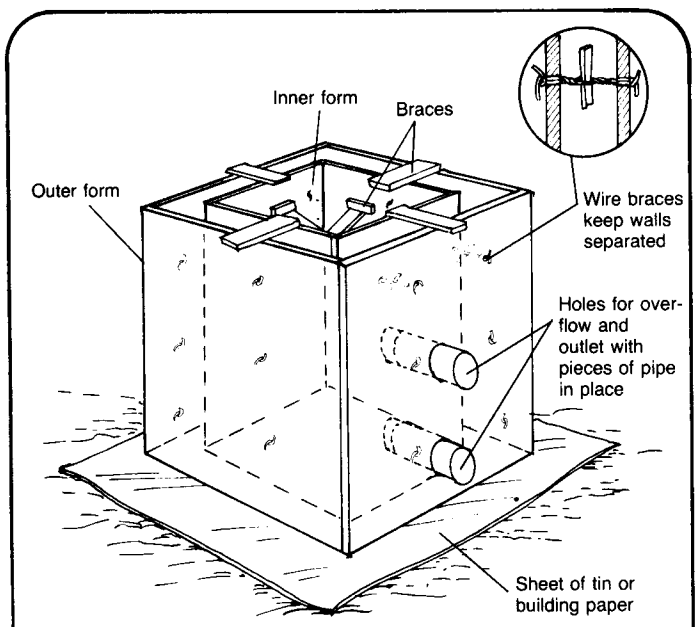


Figure 7. Forms for Spring Box with Open Bottom

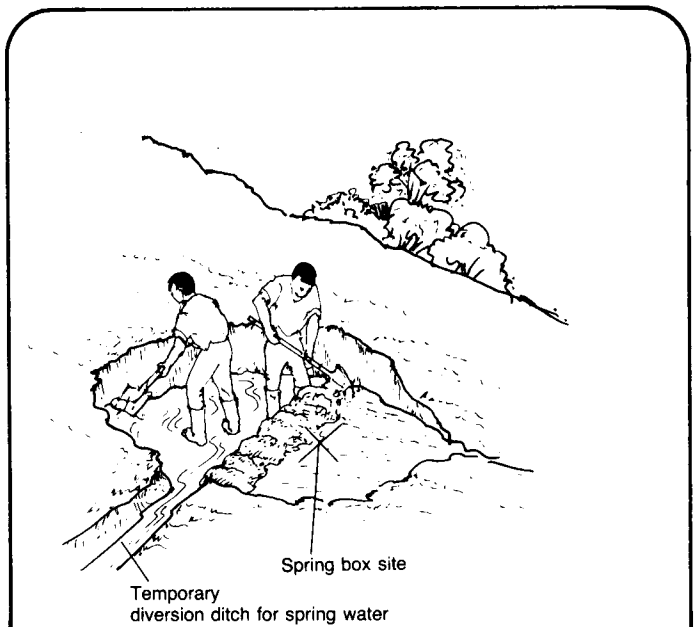


Figure 8. Excavating Spring Site

2. Set the forms in place. They should be either at the permanent site of the spring box or nearby so it will not be difficult to move the completed structure. If the forms are set and concrete is poured at the permanent site, water must be diverted from the area. This usually can be done easily by digging a small diversion ditch, as shown in Figure 8. Make sure that no water reaches the forms so that the concrete can cure.

If water diversion is difficult, build the forms and pour concrete on a level spot very near the spring. Once the concrete dries, remove the forms and set the completed structure in place. This will require six to eight people.

3. Oil the forms. Put old motor oil on the wooden forms so the concrete will not stick to them.

4. Prepare the reinforcing rods in a grid pattern for placement in the forms for the spring box cover. Make sure there is 0.15m between the parallel bars and that the rods are securely tied together with wire. Then position the reinforcing rods in the form. See Figure 9 for an example of reinforcing rod placement in the spring box cover. Major reinforcing is not needed for the spring box walls but some minor reinforcing around the perimeter of the walls is good to prevent small cracks in the cement. Four bars tied together to form a square should be placed in the forms.

5. Mix the concrete in a proportion of one part cement, two parts sand and three parts gravel (1:2:3). Add just enough water to form a thick paste. Too much water produces weak concrete. In order to save cement, a mixture of 1:2:4 can be used. This mixture is effective with high quality gravel.

6. Pour the concrete into the forms. Tamp the concrete to be sure that the forms are filled completely and that there are no voids or air pockets that can weaken it. Smooth all surfaces. Smooth the concrete for the spring box cover so the middle is a little higher than the sides (convex shape), as shown in Figure 10. This will allow water to run off the cover away from the spring box.

7. Cover the concrete with canvas, burlap, empty cement bags, plastic, straw or some other protective material to prevent it from losing moisture. The covering should be kept wet so water from the concrete is not absorbed. If concrete becomes dry, it no longer hardens, its strength is lost, and it begins to crack. Keep the cover on for seven days or as long as the concrete is curing.

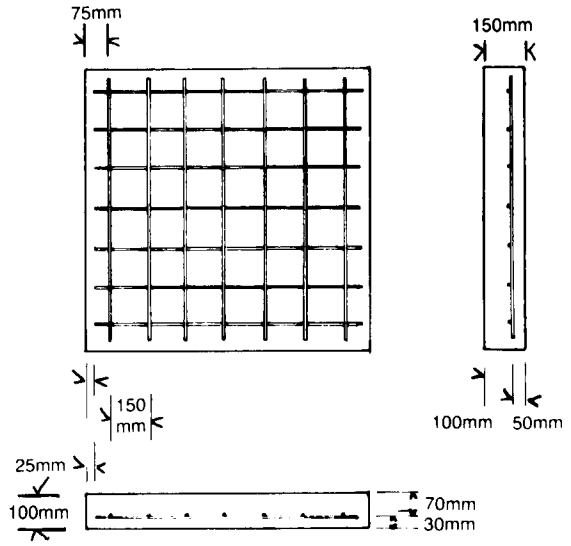


Figure 9. Placement of Rebar in Concrete Slab

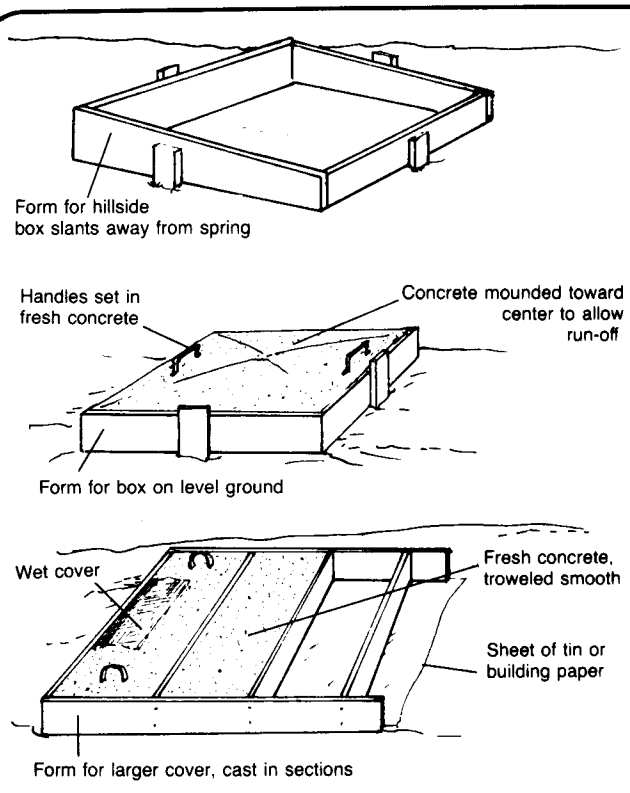


Figure 10. Forms for Spring Box Cover

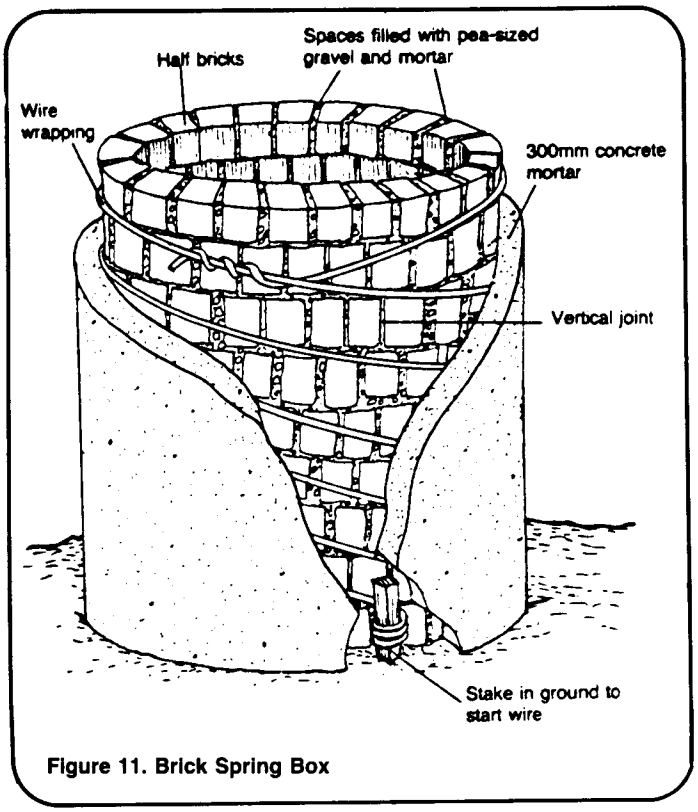


Figure 11. Brick Spring Box

8. Let the concrete structures set for seven days, wetting the concrete at least daily. After seven days, the forms can be removed and the box can be installed.

When constructing a masonry ring to protect a spring, follow the construction steps listed below.

1. Mark out a circle on the ground the diameter of the proposed masonry ring.

2. Using half bricks, place a circle of brick around the outside of the ring. Whole bricks broken in half or broken bricks can be used for the structure. In some places, broken bricks are available free.

3. Fill the spaces between the bricks with pea gravel and mortar mixed in a proportion of 1 part cement to 3 parts sand. As mortar is applied, add the next line of bricks. Be sure the vertical joints do not line up.

4. When reaching the desired height, strengthen the structure using baling, barbed or any available wire. Put a stake in the ground next to the ring and attach the wire to it. Wrap the wire around the ring several times as shown in Figure 11. Once the wire is wrapped around, secure and cut it.

5. Mix mortar in the proportion of 1 part cement to 3 parts sand. Cover the outside of the ring with a layer of mortar. The layer should be thick enough to cover the wire completely.

6. A circular cover should be built. Follow the same techniques as for the construction of concrete spring box covers.

Installing a Spring Box

The spring box must be installed correctly to ensure that it fits on a solid, impervious base and that a seal with the ground is created to prevent water seeping under the structure.

1. Place the spring box in position to collect the flow from the spring. If the flow comes from a hillside, the back of the spring box will be open. Stones should be placed at the back of the box to provide support for the structure and to allow water to enter the spring box. Figure 4 shows the placement of open-jointed rock in a completely installed spring box on a hillside. On level ground, be sure that the spring box has a solid foundation of imprevious material. Place gravel around the box or in the basin so that water flows through it before entering the box.

2. Seal the area where the spring box makes contact with the ground. Use concrete or puddled clay to form a seal that prevents water from seeping under the box.

3. Be sure that the area where the spring flows from the ground is well lined with gravel, then backfill the dug out area with gravel. The gravel fill should reach as high as the inlet opening in the spring box so that the water flowing into the structure passes though gravel. In Figure 4, the gravel layer reaches the same level as the open stone wall. For spring boxes on level ground, gravel backfill is unnecessary.

4. Place the pipes in the spring box. Remove the pipe pieces used to

form the holes and put in the pipe needed for outflow and overflow. On both sides of the wall, use concrete to seal around the pipes so water does not leak out from around them. Place screening over the pipe openings and secure it with wire.

5. Disinfect the inside of the spring box with a chlorine solution. Before the spring box is closed, wash its walls with chlorine. Follow the directions for disinfection in "Disinfecting Wells," RWS.2.C.9.

6. Place the cover on the spring box.

7. Backfill around the area with puddled clay and soil. On a hillside, place layers of puddled clay over the gravel so that they slope away from the spring box. The clay layer should nearly reach the top of the spring box and should be tamped down firmly to make the ground as impervious as possible. If only soil were used for backfill, it would have to be as least 1.5-2m deep so that contaminated water could not reach the gravel layer. For springs on level ground, clay should be placed around the box. The clay foundation should slope away from the spring box so that water runs away from the spring outlet.

8. Backfill the remaining areas with soil to complete the installation.

Constructing Seep Collection System

Sometimes springs flow from many openings over a large area. To collect the water, a system of collectors made of perforated pipe, an anti-seepage wall, and a spring box must be built.

The collectors must extend on both sides of the spring box and anti-seepage wall. Figure 12 shows an example. To install collectors dig trenches into the water-bearing soil until an impervious layer is reached. In this way, water is taken from the deepest part of the aquifer and most of the available water can be collected. The trenches should extend the necessary length for collecting all available water and should be about 1m wide.

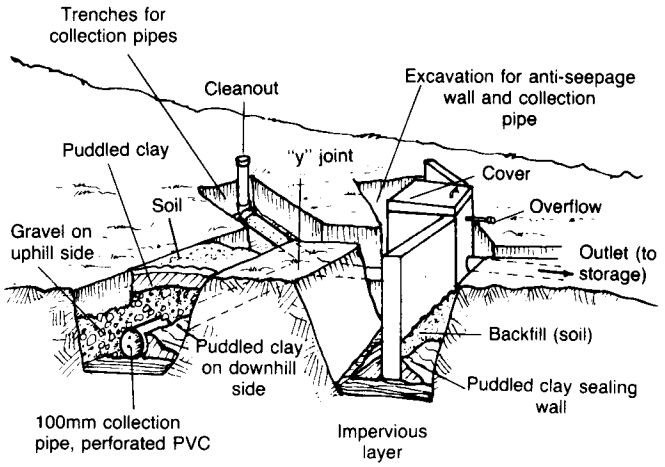


Figure 12. Seep Collection System

Lay 50-100mm diameter plastic perforated pipe or 100mm clay pipe in the trenches. Perforations in the plastic pipe should be about 3mm in diameter. On the uphill side of the trench, place enough gravel to cover the pipe. On the downhill side, build up a small clay wall to support the pipe. The pipe should have a 1 percent slope (0.01m slope per 1m distance) toward the point of collection. Flexible plastic tubing with slots already formed should be used if available. It is light and can be cut with a handsaw.

Clean-out pipes should be installed in the collection system. Attach lengths of pipe to the ends of the collection pipes. At the end of the clean-out pipes, place an elbow joint to which a vertical length of pipe is connected as shown in Figure 12. The pipe extends above ground level and is capped.

The next step is to build a concrete or impervious clay cutoff or anti-seepage wall. Dig down to an impervious layer for a good foundation. Make the forms for the cutoff wall 0.15m thick. Figure 13 shows a concrete cutoff wall 1.2m long and 0.9m high. Follow the same procedures for constructing the cutoff wall as for the spring box. There must be a good seal between the wall and the ground so that no water seeps underneath. Water must be

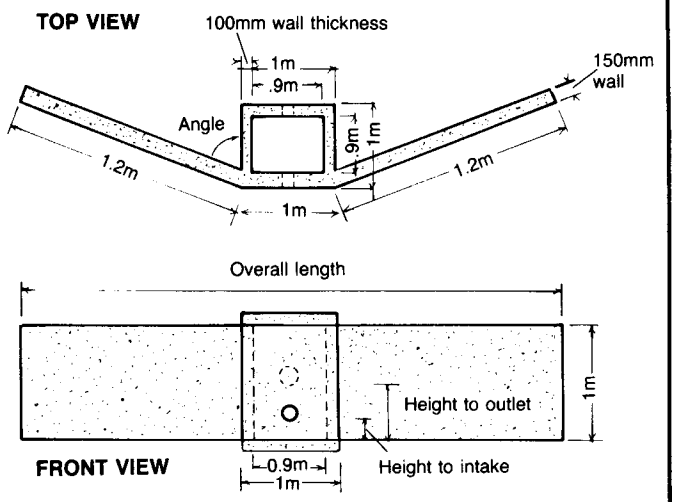
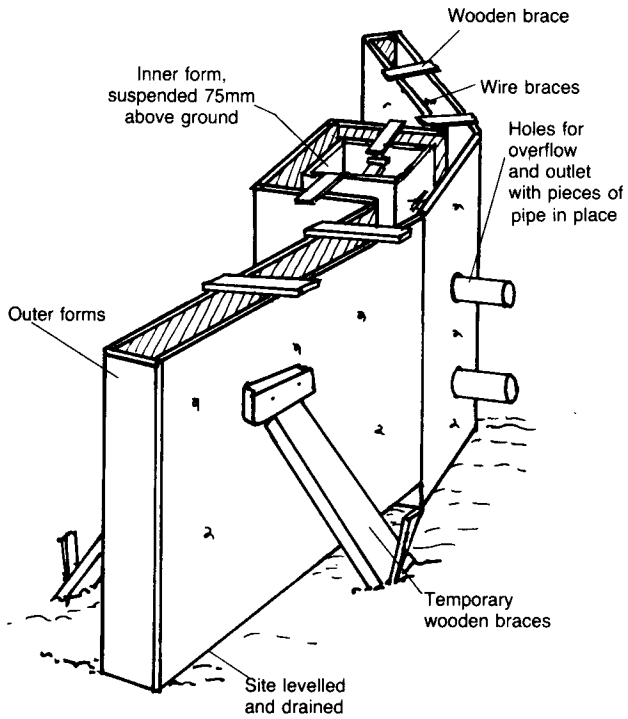


Figure 13. Anti-Seepage Wall and Collection Box

directed into the trenches and collectors. A small spring box can be built at the inside angle of the winged-wall with the wall forming two sides. If a spring box is built, the forms must be set at the same time as the cutoff wall. Water must be diverted from the construction area by small ditches for the seven days needed for the concrete to dry. Forms must be well braced and have holes for the inflow and outflow pipes as shown in Figure 14. Always pour the seep collection wall and spring box in place. The structure will be much too heavy to move after casting.

When using clay, be sure to remove any debris from the site and tamp the clay well so that the small dam or wall does not let water seep through. The clay walls should be built like walls of a dam with a 2:1 or 3:1 slope. Put



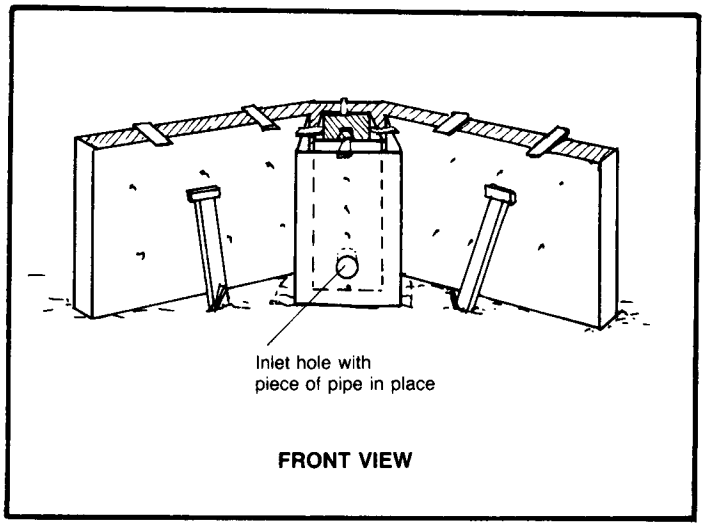


Figure 14. Forms for Anti-Seepage Wall and Collection Box

the clay down in layers 150mm thick and tamp each layer down well to ensure good compaction. Keep the clay moist. Lay and tamp each 150mm layer until the maximum height is reached. The walls should be well bonded to the spring box.

The construction of a seep collection system is more difficult and expensive than a simple spring box. Installation of collectors requires more work and some experience. Once the collectors are installed, however, the construction of the seep cutoff wall is no different from spring box construction. The same steps must be followed, the same mixture of concrete used and the same general rules for curing concrete and for placement must be followed.