Spring protection

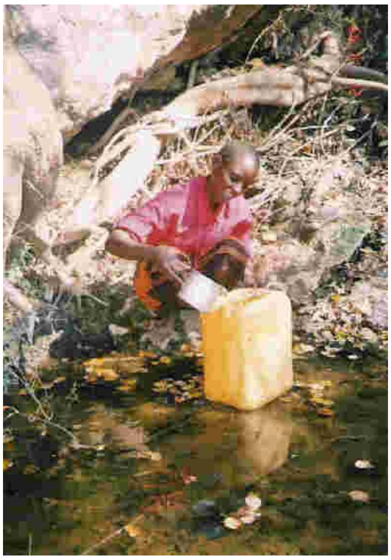
This Technical Brief looks at spring protection including the catchment area, the immediate area around the spring and the construction of spring boxes. It also highlights two methods of reducing sediments in the water coming from large springs and introduces alternative protection methods to spring boxes. This Technical Brief does not discuss the distribution system between spring box and supply.

Springs

Springs occur where water from an underground aquifer flows out of the ground to the surface. The spring can occur where the water flows out of the ground by gravity, or it could be an artesian spring where the water appears at the surface under pressure from a confined aquifer below. The point at which the water reaches the ground surface is known as **'the eye of the spring'.**

Spring water can be of good quality microbiologically if the spring is well protected. Spring water can in some areas however, can have the same levels of chemical constituents as other forms of groundwater. In particular this may include high levels of fluoride, or high levels of carbonate hardness in the water, such as found in some areas in Nepal where the Hill regions meet the Terai regions. This can lead to blocking of pipes through encrustation after even a few years of use.

Some springs flow all the year around and some springs only flow for part of the year. It is very important when deciding on which spring to protect that local knowledge is used, particularly the knowledge of women and elders, to identify which springs are known to be the most reliable.



Taking water from an unprotected spring in northern Tanzania

Effects of natural disasters on springs

Natural disasters such as earthquakes, droughts, volcanic eruptions, or landslides can affect springs. Some may move location and others may increase or decrease in yield. Earthquakes may also damage the structures associated with spring protection and the pipelines taking the spring water to villages. This can include the breakage of pipelines.

A reduction of vegetation cover and deforestation also pose risks for the stability of spring sources due to increased erosion and the risk of slope failures.

Challenges for spring users in the Caribbean island of Montserrat

In 1995 the Caribbean Island of Montserrat faced a volcanic eruption with a series of heavy ash falls. Montserrat's water supply is reliant on 16 springs. Two of the islands springs, which supplied 35% of the islands water, were on the face most exposed to the volcano. As the volcanic activity worsened the reliance had to be switched to other sources in other parts of the islands. Water catchments were also subject to acid rain and ash fall due to the volcanic activity and there was some concern that movements of joints could lead to the movement of springs and there could also be changes in water quality.

(Lashley, D.A, 1997, in House & Reed, 1997)

Outlet pipe from an 'open system' protected spring in a hill district in Nepal

Superstitions and beliefs surrounding springs

There may be local superstitions about springs and care should be taken to consult the communities so that appropriate traditions are followed where necessary and permission sought when upgrading springs.

The supernatural power of springs

In Midlands Province of Zimbabwe (2006) it was reported that in one area springs are seen as supernatural. This belief was reinforced during the 1992 drought in Southern Africa, as when the shallow wells of the area had mostly dried up, the springs continued to flow. It is believed that if someone undertakes construction near to a spring it will dry up. If this happens special rituals would be needed before the spring could recover.

A protected spring in eastern Zaire being used to supply two large refugee camps

Selecting a spring

The selection of springs to protect for emergency water supply should consider the springs' yield versus the demand, its reliability through the seasons and during years of drought, the quality of the water, vulnerability to landslides and erosion, and who the existing users are and in particular whether they will accept the spring being protected and used for new communities. Wherever possible the springs yield should be measured at the end of the dry season to determine the minimum expected flow.

Checks should be made that the spring is not in fact a stream which has passed underground and re-appeared downstream as the water quality is then likely to be poorer.

Sometimes water is also taken from a stream which is fed from one or more springs. The problem is that when it rains the water turbidity will have increase which will cause additional problems for treatment, particularly if chlorination without pre-treatment is being undertaken in a camp scenario or a local settlement.

Springs can be protected and supply water in the following ways:

1. Simply have a free flowing pipe passing through a catchment structure where water can be directly collected by users.
2. Have a collection chamber with valve chamber and an open system where the water flows freely through a pipe to the users. This system is called an **'open system'**.
3. Have a collection chamber with valve chamber and then the outlet pipe feeds into a storage reservoir where the water is collected over night. This reservoir feeds through another pipe to a tap. This system retains as much water as possible and is called a **'closed system'**. It is used when the yield is lower in proportion to the demand.
4. The second two systems may also have some form of sedimentation tank or filter after the spring box if there are particular problems with solids or turbidity in the water.

Yields

A flow in excess of 0.1 l/s is sufficient to fill a 20 litre container in just over 3 minutes. From such a spring a useful yield of about 3,000 litres can be expected which is enough water for 150 people @ 20 /p/d, or 200 people at the Sphere standard of 15 l/p/d.

If the flow were only at 0.05 l/s then it could supply the same number of people if a storage tank of 1,000 litres capacity was also incorporated into the system.

(Ref: WaterAid Technology Notes)

Protection principles

1. Protect the catchment area above the spring from animals and humans to prevent contamination.
2. Constructing a cut off drain above the spring prevents contaminated water from entering or mixing with the spring water.
3. No latrines should be located within 30m upstream or downstream of a spring.
4. After cleaning or opening up the area around the eye of the spring, the spring should be protected with loose stones and gravel and then a soil cover behind the catchment wall, in addition to possibly also a spring box and a pipe for delivering the water to the users.
5. The area around the spring should be fenced to prevent access by animals, but overflow water should be directed to an area outside the protection zone where the animals can take water, particularly in pastoral areas.
6. The spring box should be cleaned out on an occasional basis.
7. The local community and users of the spring should be trained in the correct maintenance of the spring inlet and system and in the rationale for the protection of the catchment areas. Local legislation may also be useful in protecting the catchment area above the spring.

Protection of catchment area

A surface water drainage ditch is dug above and around the spring area to divert surface water run off from polluting the source. This should be dug a minimum of 8m from the source and ideally further away. The area should then be fenced to keep animals and people out of the area.

Earth should also be mounded up against the collection tank walls to divert any surface water away.

If the stability of the area around a spring intake works is in doubt or erosion is a risk, then gabions or dry stone masonry can be used to stabilise the area.

Ideally an area leaving a minimum distance of 50m above the spring should be left where there is no human habitation and animals are not allowed to graze. Reforesting and the planting of grass and bushes in the area directly above a spring can help to protect the catchment area, to reduce run-off and erosion.

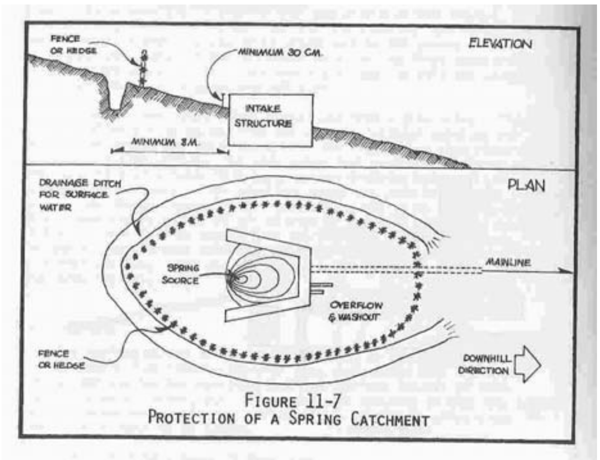
Opening up the eye of the spring

Opening up the eye of the spring:

1. This must be undertaken with great care as any form of **'back-pressure'** on the water could cause it to change its route and the eye of the spring to move. Spring water **'follows the path of least resistance'.**
2. A temporary drainage channel should be constructed to ensure that the water can continue flowing during construction and to prevent puddling.
3. The area immediately beneath the point of discharge (or seepage area) should be excavated until either the horizontal water layer or firm rock are reached.
4. The excavation should proceed into the slope until a height of earth above the discharge point is a minimum of 1m. A spring from a rock face requires minimal excavation, but a spring with widespread seepage may require an excavation of several cubic metres.
5. For artesian springs the excavation is likely to be vertical into the ground, and this poses additional problems for preventing back-pressure. Two recommended strategies are: a) construct a trench around the area and locate the intake several meters away from the eye of the spring, and b) sink large concrete rings around the eye of the spring as the excavation continues to prevent the surrounding soil from falling back in to the excavation hole. The spring may have to be left relatively exposed and hence a manhole cover may be required. The outlet should also be as low as possible to prevent back-pressure.
6. Place loose stones and gravel over the area of the eye of the spring for some initial protection.
7. After excavation the spring area should be left for 24-48 hours to enable it to stabilise, before additional construction work.

(Ref: Neku & Hillman, 1996)

If there is more than one spring or seepage point in an area then the excavation may need to be wider or drains or catchment structures and pipes can be constructed to allow the various sources of water to drain into one collection chamber.



Protection of a spring catchment
(Ref: Jordan, 1984)

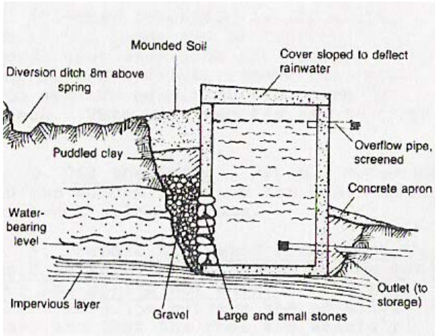
Constructing the catchment wall or spring box

The structure which is required to catch the water from a spring will depend on a number of factors. These include the size of the spring and whether the users will come to the spring or the water will be taken in a pipe to the users. A number of different designs are shown on the following few pages of this Technical Brief.

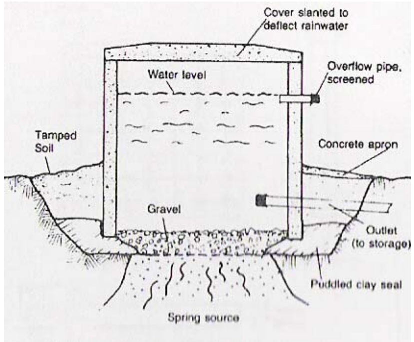
Construction of retaining wall, catchment dam or cut off wall, spring box and valve chamber

1. A dry stone retaining wall should be built against the excavated slope. This wall is built using brick sized stones and both acts as a retaining wall and allows the water to pass through into the collection areas with minimal sediment.
2. A catchment dam or 'cut-off' wall with wing walls, is designed to catch as much water as possible and direct it into the collection chamber (see the diagram below). It should be constructed in an excavated trench of minimum depth 20cm to help ensure that water does not seep under the wall.
3. The collection chamber and valve chamber are then constructed on the downstream side of the catchment wall and the bottom of the collection chamber should be concreted.
4. The overflow pipe from the collection chamber should be lower than the catchment dam wall to prevent back-pressure.
5. The area behind the catchment dam is filled with stones and gravel to the same level as the catchment chamber lid, with smaller stones nearer the eye and larger nearer the wall. Heavy duty sheeting is then placed over the catchment area and the edges sealed with clay. The sheet is then covered with the excavated soil and then a layer of topsoil. Shallow root thorny-type vegetation can then be planted to deter vandalism and stabilise the soil.

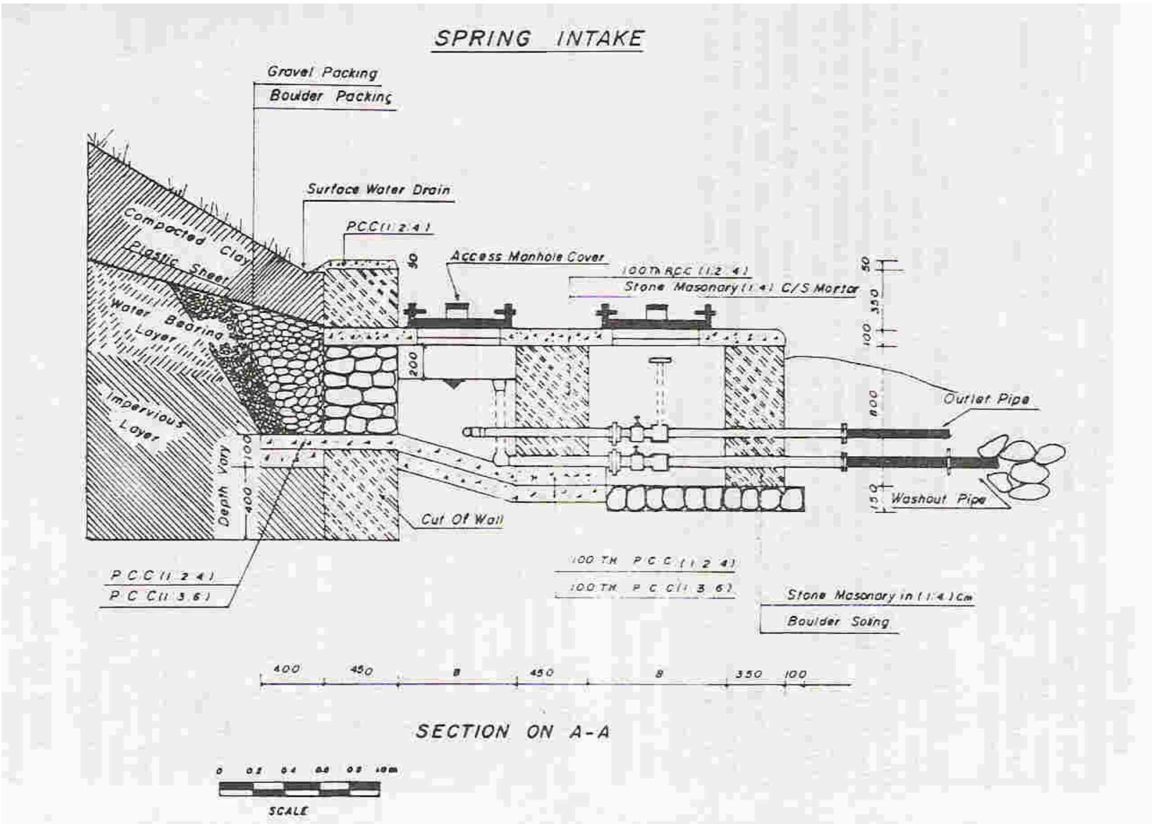
(Ref: Neku & Hillman, 1996)



Spring box with open side
(Ref: Water for the World, Technical Note No RWS.1.C.1)



Spring box with open bottom
(Ref: Water for the World, Technical Note No RWS.1.C.1)

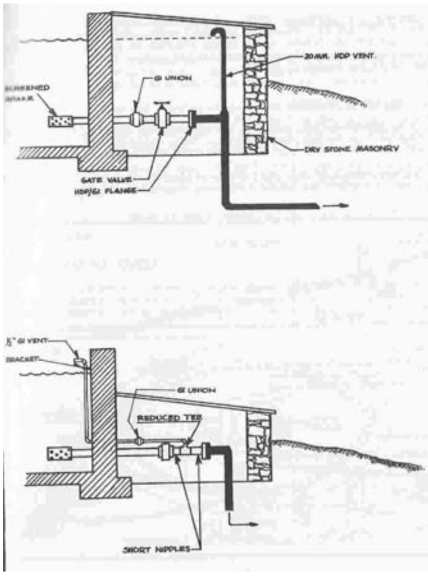


Catchment wall, spring box and valve chamber (Ref: Neku & Hillman, 1996)

Protecting a spring – works in progress, for a local community living near to a number of large refugee camps in eastern Zaire

An inner wall was being used to divert the water while the outer spring box wall was being constructed

Overflow, washout and outlet



Typical pipe-work from a spring box
(Ref: Jordan, T, 1984)

Overflows - The size of the overflow pipework must allow the maximum water flow to pass easily and safely away from the spring without causing erosion.

A GI pipe of 20-50 cm length with the following fall (H) will allow the following flow (l/s)
(Ref: Jordan, T. D. Jr, 1984)

GI pipe size	H = 5cm	H = 10cm
1"	0.62	0.85
1.5"	1.4	1.9
2"	2.1	3.0
3"	5.2	7.3

Washouts - These allow the intake box to be drained so that the chamber can be cleaned. They should be 2" to 3" and be set slightly into the bottom of the chamber and closed with an end cap.

Outlets – This is the starting point of a pipeline and should be the same size or larger than the pipe for the design at that point. The outlet should be screened and will require a gate valve with an air vent located just downstream (see the pictures above).

Filtering or sedimentation of solids coming from springs

Large springs may contain suspended particles which can sediment out in the system or be passed down the pipeline to the consumer. Where this is a problem, the system should be designed to settle or filter out the solids. See the photographs below for a roughing filter system which has been built onto the outlet of a large spring in Eastern Zaire.

Spring box with roughing filter on the outlet (to the right) prior to the water entering the pipeline

Covers to the roughing filter treating spring water, Eastern Zaire

Sedimentation tanks

The following retention times are recommended for sedimentation tanks to be constructed post the spring box:

1. Small, clean spring sources – no sedimentation tank needed although the intake should have a settling chamber and screening.
2. Systems with reservoir storage tanks – 15-20 mins
3. Systems without reservoirs – 60 mins minimum.

Capacity (l) = Flow (l/s) x T (retention time, s)

(For more info – Jordan, T.D. Jr, 1984, pp114-119)

Alternative protection for springs

Alternatives to spring boxes

If water from a spring can be collected without a spring box, and no sedimentation is needed because the water is of low turbidity, and no storage is needed, as the yield is high enough for the demand, then a spring box may not be necessary. Alternative methods include:

1. Digging a 1m deep trench down to relatively impermeable strata running from the eye of the spring to the collection point – Use 100mm depth of stones of size 10 to 40mm in the bottom of the trench and then add a layer of puddled clay about 100mm deep on top. The remainder of the trench should be backfilled with the excavated material. The final layer should be topsoil and this should be slightly heaped. Creeping grasses can be planted into the topsoil to prevent erosion. A marker should be put in place to remember the location of the eye of the spring (see the diagram below).
2. A 30-50mm internal diameter plastic pipe can be used to carry the water from the eye of the spring to the collection point (see the diagram below).
3. For both of the above construct a headwall through which a pipe can pass, with a small concrete slab to direct the water from the stone filled trench into the pipe, and a stone pack behind it. The headwall will also require wing walls for stability and a drainage platform for the users to stand on as they collect the water. The headwall should be placed at a lower position than the eye of the spring to prevent back pressure (see the diagrams below).

(Ref: Skinner & Shaw, in Shaw, ed, 1999)

Maintenance of the spring box and catchment area

A sanitary inspection should be undertaken once or twice a year to identify if there are any sources of potential contamination of the spring water.

Each year the catchment drain should be cleaned as well as the area inside the fencing. Repairs should also be made of any damage to the fencing or other protection works.

The spring box and the sedimentation chamber or roughing filter, where appropriate, should also occasionally be emptied of any sediment which may have accumulated and the inside of the spring box can be cleaned with disinfectant.

Further information

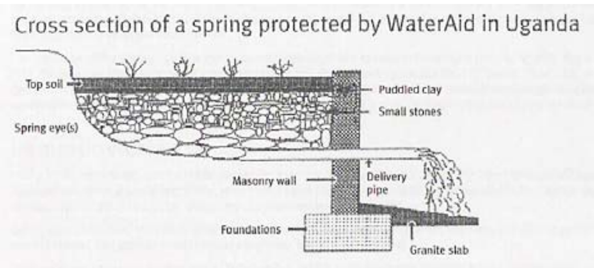
Jordan, T. D. Jr (1984) A Handbook of gravity-flow water systems for small communities, Intermediate Technology Publications

Neku, A & Hillmann, E (1996) Rural gravity flow water systems (Design Technique and Standard Structures), UNICEF, Nepal – the updated version of Jordan, T.D. Jr, above, but not published

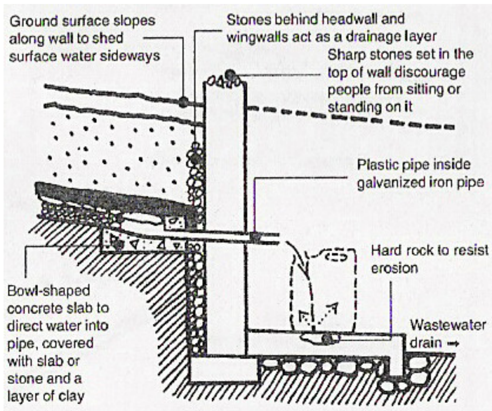
Skinner, B & Shaw, R in: Shaw, R (ed) (1999) Protecting springs – an alternative to spring boxes, Technical Brief No 34, In: Running Water: more technical briefs on health, water and sanitation, Intermediate Technology Publications

WaterAid (no date) Technology Notes

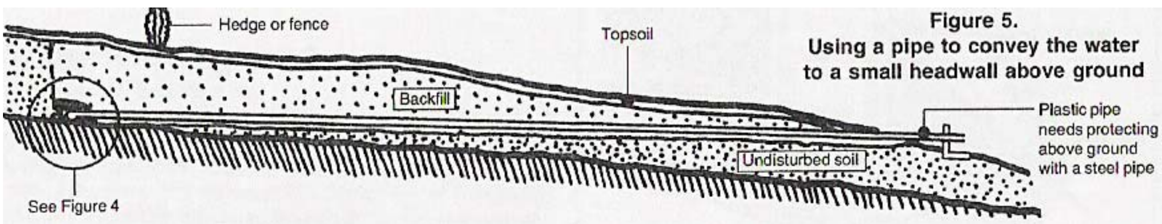
Water for the World (no date) Constructing Structures for Springs, Technical Note No RWS.1.C.1



(Ref: WaterAid Technical Notes)



Collection point headwall and drainage slab
(Ref: Skinner & Shaw, in Shaw, 1999)



Trench or pipeline from spring to collection headwall (Ref: Skinner & Shaw, in Shaw, 1999)