22nd WEDC Conference: *Discussion paper* New Delhi, India, 1996

REACHING THE UNREACHED: CHALLENGES FOR THE 21ST CENTURY

Development and protection of remote springs

Wouter Jan Fellinga, Bhutan

BHUTAN IS A mountainous country in the Himalayas with a small and scattered population. Most people live in small villages with 5 to 20 houses which are sometimes clustered together, but in many villages the houses are rather scattered on the mountain slopes. Also there are many solitary houses far away from any village. Providing water to all these scattered houses by means of the conventional techniques is very expensive due to the total length of pipe required. Further more, it also puts a high workload on the households because of the extensive labour inputs required for trench digging. Fortunately, in many cases small springs can be found relatively near to these houses. Developing these small springs and tapping the water for distribution is the subject of this paper. In fact, the spring protection technique discussed here can also be used for much bigger springs supplying water to Gravity Flow Water Supply Systems.

History and problems

Problem one

Till 1994 all water supply projects required a minimum of 5 user households and the design used by the department was based on the standards for Gravity-flow branched distribution systems. Typically such scheme consists of: an intake structure, a collection / valve box, a ferro-cement reservoir, some ferro-cement break pressure tanks and public tapstands. Treatment is normally not done although a few sedimentation tanks have been built. The source can be either spring or stream. Due to the requirement of a minimum of 5 households and a maximum investment cost per households combined with the typical village structure in Bhutan many households were not eligible for water supply from the Government managed RWS programme.

Problem two

Almost all Rural Water Supply schemes in Bhutan are Gravity-flow branched distribution systems. Small streams and springs are the sources. The traditional method for collecting water from a spring was to build a V shaped wall a little below the natural spring outlet and collect the water. The area between the wall is filled with gravel and stones but not sealed. The water collected by the wall is led in a pipe which leads to a collection chamber with control valves. However in this way solid materials are pick up and deposited in the collection chamber. The removal of these deposits lead to extra undesired maintenance. Furthermore there is a high chance of contamination of the water while exposed to the open. It was felt within PHE that this method needed improvement.

Alternative schemes

To provide water to single or few households with less risk of contamination than their traditional sources a new type of scheme was introduced in 1994 which is referred to as “Open Fountain System”. A nearby spring is the source and the system is smaller and relatively simple compared to typical Gravity Flow Distribution Systems. Because of its simplicity the Open Fountain System can even be cost effective for one or two households. In the introduction stage the idea was to develop and protect a nearby spring which most likely would already be the source and collection point for the household. The project would improve the intake point by developing the spring to avoid contamination. No pipe or tapstand would be provided from the project near the house as to keep the cost low. In this way detailed technical survey and hydraulic design with complicated calculations would be avoided. However, it soon appeared that the beneficiaries were not very interested if water was not coming nearer to their house. To overcome this problem PHE decided to provide a limited amount (maximum 300 meter) of HDP pipe (20 or 25 mm) and materials for the construction of one or two tapstands, when required. These changes have increased the popularity but reduced the principle advantage because of the increased cost. It is also clear that criteria like maximum pipe length are difficult to administer since in some cases the pre-set maximum can just not be met resulting in arbitrary decisions.

Development and protection of springs

Quite some literature already exist on the development and protection of springs therefore I shall mainly discuss our experiences and the problems we encountered. As mentioned earlier the described technique for the protection and development of a spring can be used for Open Fountain and Gravity-Flow Distribution Systems alike. The only differences are the yield and the sizes of pipe used for outlet and overflow.

Springs can be classified in two main types namely Gravity Springs and Artesian Springs. Since in Bhutan gravity springs are most common the discussion will concentrate on this type.

Gravity springs for the two types of rural water supply schemes (Open-Fountain and Gravity-Flow) are developed in the same manner. The construction is briefly described in the 8 different steps that follow below.

Step 1

Site clearing is done to get a clear view of the actual layout of the spring and at the same time it will create space for temporary storage of construction materials. All bushes and trees including the roots are removed in the vicinity of the spring. Large trees are normally left untouched as it is felt that removing them will do more bad than good. At some places site clearance and excavation of the spring is a very sensitive matter. People in Bhutan believe that local deities reside near the spring and protect the continuity and cleanliness of the water. Any human activity near the spring may make the deities angry and will result in drying up or shifting of the outlet. These feelings should never be taken lightly and discussions with the community are needed to resolve these problems. Monks are often consulted because of their influence in the community and their ability to perform religious ceremonies for the deities.

Step 2

Before the excavation starts it is important to mark the present level of the spring water table. The level of overflow should not be above this mark because else there will be a chance that the spring will shift to a nearby outlet with a lower hydraulic resistance. Excavation is done while the water is freely flowing out of the spring. During excavation no dams are built because an increase in the resistance (due to an increased outflow level) might cause the spring to disappear. For the same reason it is equally important not to disturb the impermeable layer. Excavation should continue up to the point where the water appears from the permeable layer. Depending on the layout of the spring, side branches in the excavation have to be made. This can result in a straight, Tee or Y shaped trench system. During excavation the stability of the slopes should always be guaranteed and excavated materials should be stored sufficiently away to avoid slope overloading resulting in collapsing of trenches. During excavation guidance from a experienced technician is essential because it is difficult to predict the final layout beforehand.

Step 3

Once trenching is done a final decision is made on the layout of the spring protection and shape of strainer pipe. HDP strainers will be in all individual trenches when the trench system is made in a Y or Tee shape. The outlet pipe and strainer(s) are placed in the trenches approximately 2-3cm above the floor. A temporary clay wall is built to create a dry working environment for the construction of the final wall or barrage. This wall is made in stone masonry with a strong plaster coat (Cement:Sand ratio 1:2) on the inside. The outlet pipe will temporarily function as drain during the construction. After the placing of the outlet-pipe the overflow pipes are placed 10-20cm above the outlet but not higher than the level mark of the original spring water-table.

Table 1. Pipe sizes open fountain system

Expected maximum yield	*Outlet pipe GI medium*	Overflow pipe HDP 6 kgf/cm^2
< 1.5 l/s	1”	1 x 63 mm
1.5 - 3.0 l/s	1”	2 x 63 mm
3.0 - 5.0 l/s	1”	3 x 63 mm

The materials for the spring development of Open Fountain Systems are standardised for reasons of simplicity. The outlet pipe and overflow pipe have fixed diameters regardless of the natural yield and distribution flow. For springs with a high yield the number of outlet pipes is doubled or even tripled (see Table 1). The outlet pipe is an approximately 2 meter long, slotted HDP strainer, of 32mm diameter. The slots with a width of 3-4mm are made with a hacksaw and are facing upward when placed in the trench. Burrs must be removed to reduce inflow resistance. The HDP strainer is shrunk over the 1” GI pipe. Also the overflow pipe is slotted because the pipe end is easily blocked. Both outlet and overflow pipe should maintain a slope of 1-2 per cent down in the outward direction.

When the yield is measured during the dry season an increase in yield in the rainy season can be expected with a factor 3 to 6 depending on the topography, geology and land use of the catchment area. Since it is difficult to predict the maximum yield, it is better to design safe and provide sufficient capacity for the overflow.

Figure 1. Schematic diagram of open fountain system

Figure 2. Cross section of spring under construction

Step 4

The stone-masonry wall must seal off at three sides. At the floor the stone dam is inserted for about 10-20cm in the impermeable layer and at the sides the stone wall is at least 20cm wider than the opening of the trench.. The cement plaster should be in direct contact with the impermeable clay layer to have maximum seal. An alternative option for the permanent wall is to built it completely out of clay. However, experiences have shown that this can easily be bored by small crabs resulting in leakage from the dam. There are also doubts whether the GI or HDP pipes will have a good bond with the clay. These are serious problems because for repair the complete spring needs to be opened again. Therefore PHE has decided to make the standard design with a stone masonry wall because cement solves both problems.

Step 5

Once the permanent wall is completed and cured for a minimum of two days, the temporary clay dam can and should be removed. Back filling behind the permanent wall is be done with stones of approximately 5-10cm diameter. Special care should be given to places where the water emerges from the ground. Here smaller gravel with a size of 1-2cm are placed to keep the water velocity as low as possible. A low velocity will have less scour and less solids will be carried by the water flow. The stones should be carefully placed around the outlet and overflow strainers and should reach a level of at least 10cm above the top of the overflow. On top of the stones a 5cm thick layer of gravel with a size of 1-2cm is placed. Stones and gravel should be clean (washed if necessary) and preferable rounded. However also stone chips will do well as long as they are strong and weathering resistant. Initially the design included a third layer of coarse sand on top of the gravel but this sand is normally difficult to get thus only fine sand is used. This sand can easily fall trough the pores between the gravel and is therefor not useful at all. As a result PHE has started with the development of springs without sand layer. The stone pack and the gravel layer need to have a slope of approximately 3-5 per cent down in the direction of the permanent wall to ensure proper drainage and to avoid stagnant water in the soil layer on top of the plastic sheet.

Step 6

On top of the gravel two layers of plastic sheet are placed. While placing the plastic sheets care have to be taken not to puncture them. The sheet prevents rain water to penetrate directly from the top. Lastly on top of the plastic sheet a thick layer of at least 30 cm soil is placed and compacted well. The growth of deep rooting shrubs should be avoided but grass is essential.

Step 7

The area directly around the spring and the collection point are normally fenced to protect the spring intake against damage from cows and wild boar. On the hillside of the spring a drain is dug to divert surface water run off to the sides of the protected spring intake.

Step 8

The end of the overflow pipe should be made in such a way that the flow of water can not be tampered by others.

Figure 3. Cross section of completed spring

In the outlet pipe a few meters after the spring intake an adapter or union is provided as to allow for checking of flow and maintenance of the tapstands at the lower end.

Conclusion

The new method for the development of a spring has clear advantages over the old open method. On the other hand it is also clear that while developing a new technology, gained experiences ask for adjustments of initial ideas. Engineers must be flexible and willing to incorporate this in the so called "standard design". Any way a standard design for a spring intake is difficult because no two springs are identical and the site condition is always different from the manual.