Rural Water Supply and Sanitation Project in Western Nepal Phase II

2016

Springshed approach to revive drying springs

RWSSP-WN BRIEF 9-2016

WHAT IS IT ABOUT?

Our problem: Majority of population living in the middle hills of Nepal depends on spring water as their main source of drinking water. Many springs are in declining condition – the amount of water they discharge is reducing – creating a situation of water scarcity in numerous communities. Any investment on water supply system becomes futile when the sources of water run dry.

RWSSP-WN II study "Source Yield and Climate Mapping of Tanahun district" analysed the yield changes of nearly 2,400 sources between the years 2004 and 2014. The findings show that the average yield of water sources has reduced 50%-22%, depending on type of spring. In the recent year, the condition has been worsened by the effects of El Nino.

Our solution: There are various simple options for improving recharge of groundwater. Recharge Ponds Handbook developed by RWSSP-WN I showcases such options. Planning for recharge however calls for understanding of sub-surface water flows and behaviour of springs. If the recharge interventions are wrongly located (i.e. outside the recharge area of a given spring), they will not help to increase the yield of the spring.

Capacity building: RWSSP-WN II organized a series of ´spring revival and groundwater recharge´ training events in the first half of 2016 to build the capacity and confidence of RWSSP-WN and district staff to plan for suitable recharge intervention in optimal locations. The trainings were facilitated by a team of hydrogeologists from the Tribuvan University, with the lead of Dr. Moti L. Rijal.

- Why are we talking about springshed?
  - Problem of depleting water springs in Nepal mid-hills
  - Watershed versus springshed?
- What is our methodology for assessing the spring recharge area?
  - Assessing geological attitude and topographical features
  - Determining spring type and discharge
  - Utilizing GPS and Google Earth for conceptual layout
- What should we consider when making a recharge plan?
  - Which recharge technology suits the local context
  - Land use and ownership
  - Cost and labour

This Brief is based on a series of Springshed trainings organized in the first half of 2016 by RWSSP-WN II and facilitated by Dr. Moti L. Rijal.

The Brief was prepared by Sini Pellinen and Dr. Moti L. Rijal.

SRINGSHED APPROACH

Spring is a location at the land surface where groundwater discharges from the underground aquifer creating a visual flow. Spring discharge is directly linked with the underlying groundwater flow system. Groundwater is formed and recharged after rainwater percolates underground and is stored in porous and fractured rock media. The groundwater-area from which the spring receives its water is called *springshed.*

How is springshed (*muladhar* in Nepali) concept different from watershed? Watershed is an area that drains surface water flow to a common outlet and it is defined by ridgelines and other highpoints. Groundwater flow is affected by the orientation of rock beddings. Watershed and springshed areas are often partly overlapping but rarely they are exactly the same.

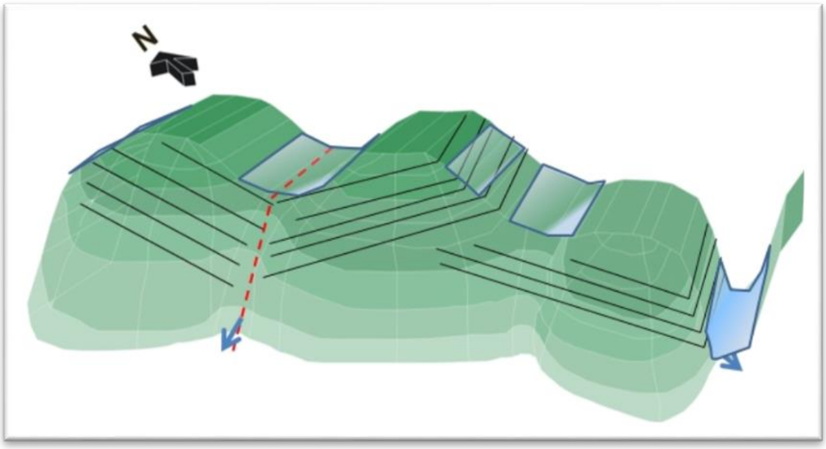

Figure 1: A sketch showing valleys (shape with blue lines), orientation of rocks (black layers) and springs (arrows). Groundwater divide and surface water divide is not equivalent to each other. Therefore, springshed approach is more suitable when we are addressing spring management and revival of drying springs in Himalayas.

Understanding of basic hydrogeology and types of springs is essential for designing spring recharge. Organizations such as ACWADAM in India and ICIMOD in Nepal have been developing the methodology for springshed development. Spring mapping and revival projects have been piloted for example in Sikkim, India and Khar VDC of Darchula district in Far-western region of Nepal.

The idea of replenishing groundwater reserves is not new in Nepal – conservations ponds have been used in the mid-hill region of Nepal for storing water and recharging groundwater for a long time and have also been supported by RWSSP-WN in the past years. Springshed approach helps us to design interventions where the recharge location is based on hydrogeological assessment of the spring recharge area at the site specific conditions.

What is RWSSP-WN approach?

Our spring revival approach has to cater for individual drinking water supply projects that are located across VDCs in 12 working districts in Western- and Mid-Western Regions of Nepal. The approach has to be scalable across the districts with focus on those water supply schemes where spring discharge is in declining condition or has become seasonal. Thorough spring and geological mapping is not possible in the scale that we work. Therefore, our geographic scope is narrowed down to only consider the springs that are used in a specific water supply project and their springshed area instead of mapping entire VDCs. Also the methodology is simplified to certain basic rules that can be applied by trained project and district staff.

STEP-BY-STEP APPROACH TO SPRING REVIVAL

This chapter describes the step-by-step methodology applied by RWSSP-WN II for any spring revival intervention. The methodology must be simple enough so that it can be scaled-up in individual water supply projects scattered around VDCs in RWSSP-WN II working hill districts.

1. Identification of springs in depleting condition

A) **During scheme design:** Condition of springs is assessed during the VDC-wide WASH Planning process and later during the design of drinking water supply schemes. Springs that are observed or told to be in depleting condition, or where water quantity is otherwise not adequate, are selected for recharge works.

B) **During Post-construction (PoCo) phase/Water Safety Plan (WSP++) preparation**: Condition of the water sources/springs is discussed firstly in the VDC level PoCo workshops and secondly during WSP++ preparation. Recharge works of PoCo phase schemes should be included in the WSP++.

2. Measurement of source discharge and WUSC orientation

- Spring discharge is the lowest in the driest months (i.e. April and May), so this is the time to measure the discharge. In most cases there is no data available to compare discharge between different years, therefore information given by water users is vital.
- Information about how soon after rain the spring discharge increases tells about recharge potential of springs. Again, the water users usually have a good knowledge about how the spring behaves.
- Monthly measurement of spring discharge should be continued after implementation of recharge works in order to document the changes in discharge.
- Users and WUSC members should be oriented on the process and can help in measuring and recording spring discharge.

3. Hydrogeological investigation

Geological attitude

To define the direction of groundwater flow we must identify the rock bedding plane – i.e. rock layer in its original position (Figures 2 & 3). A common error is to mistake a rock boulder or eroded and collapsed rock bedding to an in-situ bedding. Another error is to mistake rock joint direction with the actual bedding direction. To minimize risk of errors the rock bedding should be observed in various locations. Rock attitude – strike, dip direction and dip amount – is measured from the bedding or foliation plane.

What is needed: Brunton´s compass, hammer for identifying rock bedding, GPS for recording the location, paper and pen to note down the strike, dip direction and dip amount readings.

Figure 2: Layers of rock bedding clearly visible.

Figure 3: Rock bedding on the ground surface.

The direction of the line along which an inclined bed intersects a horizontal plane is known as the **strike** of the bed. **Dip direction** is the water flowing direction of the bedding plane. Dip direction is always perpendicular to strike. **Dip amount** is the angle of bedding plane relative to a horizontal plane (Figure 4 and 5).

The slope towards which rock bedding is dipping is called **'dip slope'** while the opposite slope away from which the bedding is dipping is called **'anti-dip slope'** or 'escarpment slope'. *Dip direction of bedding or foliation plane is a key factor for defining the springshed area.*

Rock type also matters. In common metamorphic rocks such as phyllite, quartzite and schist, groundwater is transmitted through the fracture and joint network of the rock. Therefore, in addition to dip direction of bedding, *directions of fractures and joints also tell about the groundwater flow.*

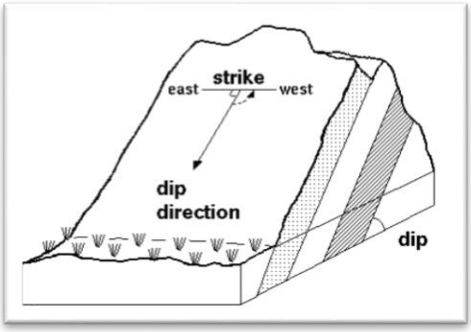

Figure 4: Strke, dip direction and amount

Figure 5: Measuring dip amount from a bedding plane. Red line indicates strike and blue line the dip direction.

Spring types

Definition of springshed area also depends on the type of spring. There are mainly three types of springs in the mid-hills of Nepal. A spring can be a combination of more than one spring type.

1) **Contact springs** are formed at the contact of loose and hard geologic media such as rock bedding or two different rock types. Contact springs are formed in either dip slope or anti-dip slope, but not in between. Orientation (dip direction) of the bedding plane is the main controlling factor for contact springs, although joint and fracture network also affect the springshed.
2) In case of **fracture springs**, water from the aquifer is transmitted through rock fracture. There are often series of springs along the fracture. Recharge area is defined by orientation of bedding plane as well as by fracture and joint network. The area along the fracture (often visible as a gully) above the spring is also potential for recharge.
3) **Depression springs** occur when water aquifer cuts the ground surface due to a sharp change in slope gradient, e.g. in natural depressions. Recharge area of depression spring is usually in the area above the spring.

4. Preparing conceptual layout

Combining topographic features with hydrogeological features is done using 3-dimensioanl Google Earth image and/or topographic map. The layout shows the recharge area of a particular spring.

1. **Locate the springs and rock bedding measurement sites** in Google Earth software either by entering the GPS coordinates manually using 'add placemark' command or by importing the coordinates from your GPS device (Figure 6). Your GPS must be set to **WGS84 projection** which is used by Google Earth. Select the best angle/view in Google Earth and save the image.

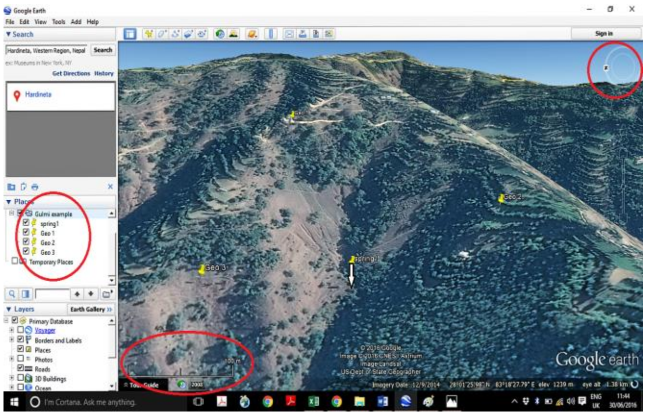

Figure 6: Locating springs and geological measurements in Google Earth. Note the North reference and scale-bar.

2. **Plot your strike and dip direction measurements** in the saved image. This can be done either in a print out of your image using a protector (Figures 7 & 8), or in AutoCAD or other software.

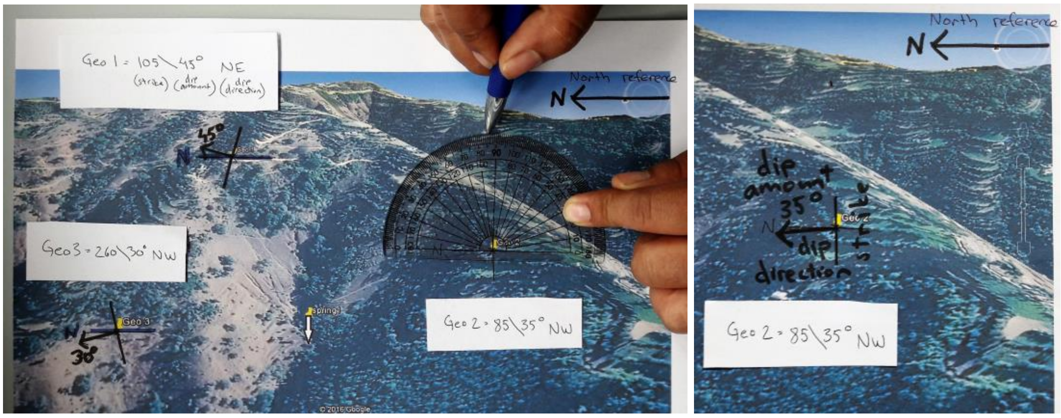

Figure 7 and 8: When plotting the strike, protector is placed along North reference line with 0 pointing to Geographical North. The strike line (in this example 85 degrees) is drawn across the measurement (Geo 2) point. Dip direction is drawn perpendicular to strike (in this example towards North/Northwest). This shows that the most optimal recharge area is on the right side of the spring.

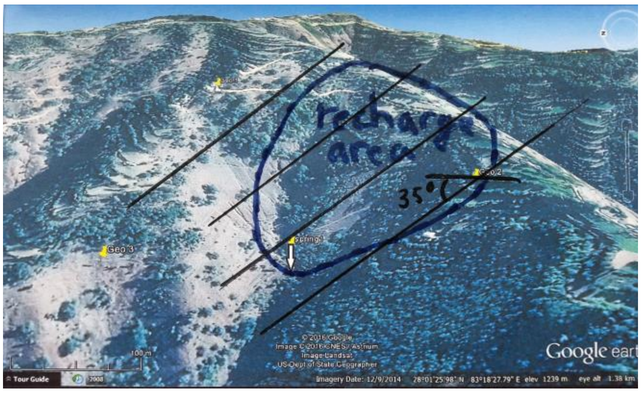

Figure 9: Interpolating rock dip direction/amount lines (in this example 35 degree angle) and defining recharge area of Spring 1.

3. Once you have defined strike and dip direction that affect the spring, you can draw **rock bedding lines that indicate the dip amount.** Take a horizontal line as reference line, measure the dip amount inclined towards dip direction and interpolate bedding lines over the area.
4. **Define the recharge area** based on bedding dip direction, spring type and the topography of the area (Figure 9).

5. Selecting recharge structure type and preparing cost estimate

Recharge structures must always be selected considering the features of the recharge area, such as **land use and land ownership, steepness of the slope and how much land is available, as well as amount of precipitation during rainy season.** Therefore the residents of the recharge area - who may not be the same as the water scheme beneficiaries! – must be involved in the planning. The principle of all recharge structures is the same: to slow down surface runoff so that more water percolates into groundwater. In general, it is advised to dig small structures across the recharge area rather than one large pond in one location. When structures such as trenches are dug in a steep slope, it is recommended to apply bioengineering methods to stabilize the slope.

Rectangular trenches or longer **contour trenches** are suitable for sloping lands and terraces (Figure 10). For a slope with less than 30° gradient the standard trench size is 2m x 1m x0.6m (length x width x depth). The steeper the slope, the smaller the trenches in order to control erosion. The higher the number of trenches, the more effective is the recharge effect. There are many variations of trench types depending on the land use. Options for private cultivated land are, for example, long and narrow contour trenches dug on the inner side of terraced fields or single trenches/pits dug on the side of a foot track or earthen road to capture drainage water.

Figure 10: Narrow trenches in steep slope.

Check dams (or embankment pond) are an effective recharge method particularly for fracture springs located in a gully (Figure 11). One or more check dams should be constructed on equal intervals above the spring along the gully. Check dams not only helps the recharge by slowing water runoff, but also protects the intake structure from erosion and landslips.

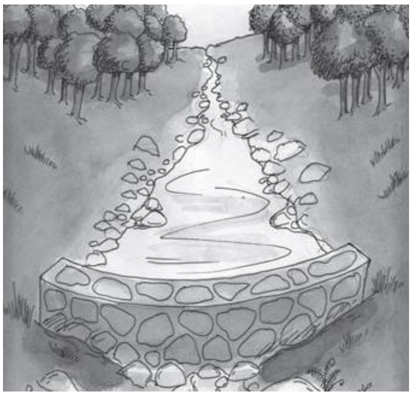

Figure 11: Embankment pond.

Unlined and lined ponds require either a natural depression or a flat land. It is not recommended to construct a pond on a slope due to the risk of triggering a landslide. Site should be selected considering how to maximize surface water flow into the pond – for this reason hilltops are not recommended. In private cultivated lands, small unlined ponds that also serve home garden and cattle can be excavated in household or community tap level (i.e. in private cultivated land; Figure 12).

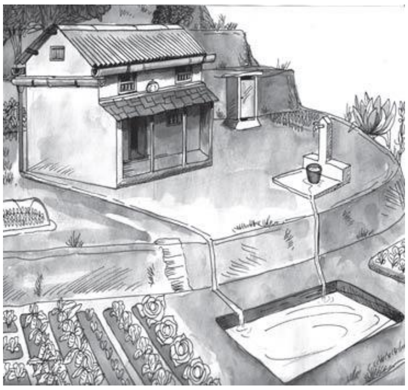

Figure 12: Household pond.

Plantation and protection of existing vegetation is the long-term solution for replenishing groundwater levels. Good vegetation cover (including trees, bushes and grasses) increases water infiltration and reduces surface runoff significantly. Therefore, especially in degraded lands plantation of grasses, bushes and indigenous broadleaf trees is recommended. District Soil Conservation Offices can often provide seedlings for plantation.

Figure 13: Different types of recharge structures.

Cost Estimate

Districts prepare cost estimates based on required labor and materials as per the district rates. Many structures, such as rectangular trenches, long contour trenches and unlined ponds require only a labor input.

6. Agreement and implementation

- When recharge structures are included in the design, the implementation agreement also covers the recharge intervention. Same water supply scheme contribution pattern is applied for the entire scheme.
- When recharge structures are introduced in PoCo phase, e.g. as part of WSP++, a separate PoCo agreement is signed if the intervention requires project investment.
- The main benefits accrue during the monsoon rains, and therefore the structures should be constructed before monsoon and their condition should be maintained during monsoon rains.
- Recharge structures that are part of RWSSP-WN water supply scheme (either from design phase or from PoCo phase) are reported within the DWS MIS. If recharge structures are implemented separately from water supply, then a separate Recharge Structure scheme card is filled in the MIS.

7. Monitoring of discharge and maintenance of structures

- It is recommended to continue recording spring discharge once a month to monitor the impact of recharge intervention. Some improvement should be visible already in the first dry-season following the monsoon, if the recharge structures were in place before monsoon rains!
- All structures need some maintenance especially during the monsoon rains. Trenches may need to be cleared of deposited sediments several times during the monsoon. Similarly ponds need to be cleared from sediments. Maintaining vegetation and grass cover in the runoff area of the structure reduces erosion and sedimentation.

DEFINITIONS

- **Groundwater** is water stored in interconnected pore spaces of rocks, regolith and soil.
- **Aquifer** is a body of permeable rock which contains and transmits groundwater. **Permeability** is the interconnectivity of the pore spaces within a rock which controls the flow of groundwater. **Porosity** of a rock defines how much groundwater it can store.
- **Confined aquifers** are overlain by an impermeable rock/dirt layer (e.g. clay) that prevents water from seeping into aquifer from above ground surface. In **unconfined aquifers** water seeps from the ground surface directly above the aquifer.
- **Springshed** is an area from which the spring receives water that contributes to the spring flow. This is also the spring recharge area.
- **Topography of an area** refers to the surface shapes and features, such as ridges, hills, valleys, creeks, depressions and flatland.
- **World Geodetic System (WGS)** is a global reference system for geospatial information. The latest version is WGS 84 which was established in 1984. WGS84 is generally used by GPS systems or any world-wide reference system.

REFERENCES & SUPPORTING DOCUMENTS

Acwadam – Advanced Center for Water Resources Development and Management.
http://www.acwadam.org/home.asp

India Water Portal - http://www.indiawaterportal.org/

Sikkim springs - Ensuring rural water security. Spring database and atlas, and information on conservation of springs, lakes and streams etc. http://www.indiawaterportal.org

Dhara Vikas Handbook – A user manual for springshed development to revive Himalayan Springs. Developed under the Sikkim springs project.
http://www.sikkimsprings.org/dv/report/Sikkim%20Dhara%20Vikas%20Handbook%202014%20(1).pdf

ICIMOD – International Centre for Integrated Mountain Development http://www.icimod.org/

RESULTS INDICATORS FOR RWSSP-WN II

This brief relates to the following RWSSP-WN II indicators:

2.1 **Safe water:** # of water supply schemes supported by the Project fund in the Phase I and Phase II apply a Water Safety Plan with CCA/DRR component.

2.2 **Improved services**: # of water supply schemes supported by the project in Phase II provide improved water supply services for previously unserved households. Scheme defined as improved and functional when it has the Service Level 1 for quantity, access, reliability and water quality.

Rural Water Supply and Sanitation Project in Western Nepal Phase II is a bilateral development cooperation project funded by the governments of Nepal and Finland, and implemented through local governments and users' groups under the Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR), Ministry of Federal Affairs and Local Development. RWSSP-WN II works in 14 districts in Western and Mid-Western development regions in Nepal.

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