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geohydrology of springs (WITH SOME OBSERVATIONS REGARDING LAKES)

report of ACWADAM's training at sird, sTATE OF SIKKIM

Advanced Center for Water Resources Development And Management

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INTRODUCTION

Water shortage has always been a problem for hamlets situated at a higher elevation, away from the main streams in many mountainous regions of India. It is glaringly true for the Himalayan region, where hamlets belonging to a village lie scattered throughout the area. Many such hamlets depend on springs. During a drought period, when the upper springs dry up, these habitations experience serious water shortages. Pipelines to carry water are costly ventures in such areas, especially if the true characteristics of the source are not known. Springwater management becomes imperative in such areas, especially when growing evidence points to large-scale depletion, on account of changing patterns of lifestyle and climate.

In the State of Sikkim, reduced discharge in springs and the drying up of hilltop lakes are issues that need immediate attention. Ongoing aquifer recharge through the *Dhara-Vikas programme* is a useful technique for revival of lakes and springs. Here again, incorporating the science of hydrogeology to these programmes becomes important.

ACWADAM team's visit to Sikkim, in September, was a follow-up to the 15 day capacity building training on groundwater that the SIRD field facilitators had undergone in Pune. It was mainly aimed at these facilitators to get a hands-on knowledge about the methodology to be followed in the field and to develop a few thumb-rules for identification of spring types and their recharge areas. The six day programme included three days of classroom and three days of fieldwork sessions. This report incorporates the findings of ACWADAM in the field and observations regarding springs and lakes that are selected for Dhara-Vikas works.

Inaugural session at the workshop

Simplifying hydrogeology in the field

Springs: the lifeline of the mountains

Lakes: an example of mismanagement of natural resources

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CHUKUDUM DHARA

10 September 2010

Location: 27°16’7”N 88°21’0”E Elevation: 2021m
Slope: Dip slope with reference to rock dips
Discharge: 100 lpm.

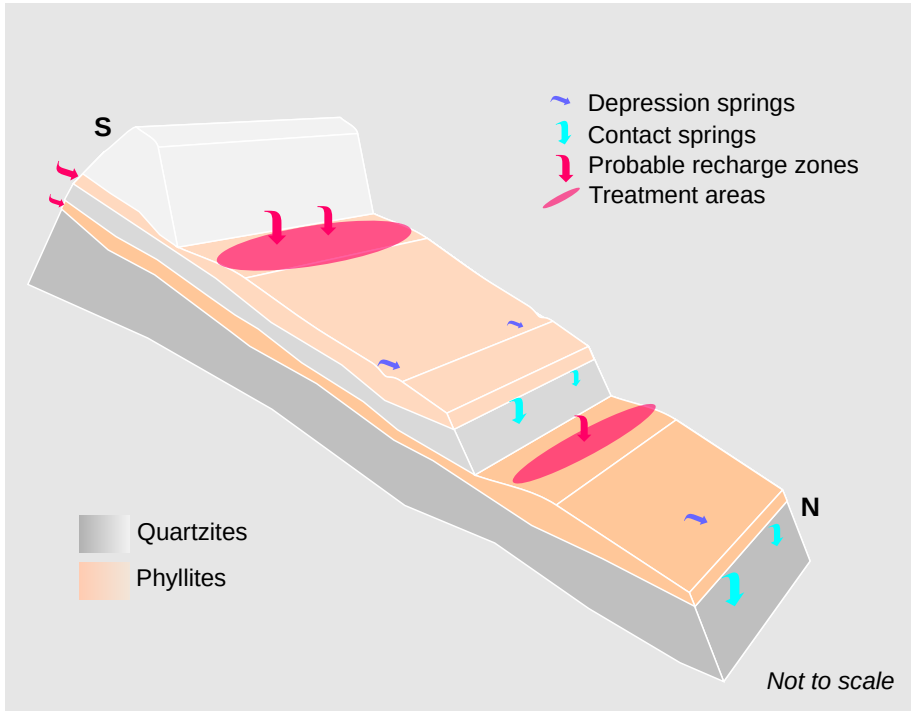
Hydrogeology

- Micaceous phyllites and quartzites; some schists also. Phyllites are generally *thicker* than quartzites.
- Phyllites are weathered and show partings / cleavages that dip by 35° towards 10° (i.e. towards NNE). Quartzites are relatively impermeable with *silica-sealed fractures*.
- Contacts between phyllites and quartzites are fractured.
- The main spring is a *contact spring* with associated *depression springs* - both tap the same hydrogeological system.

Other information

- No surface flows in streams except in the one fed by springs.
- Treatment in the 5 ha area can also be strategised as per geological features (fractured contacts) identified in the field.
- Treatment can be extended further upslope, if possible because the actual recharge zone for the spring is much larger than the 5 ha identified currently.

Chukudum spring: “Contact spring”



Landscape and vegetation: Rabong

Many streams in Chukdum area have little flow even after good rainfall

A trench located on the *fractured contact* between quartzites and phyllites
- a good recharge site for the spring downslope

A trench filled with water
- slow infiltration or exfiltration (?)

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LAMPATEY DHARA

11 September 2010

Location: 27°9'9"N 88°28'45"E Elevation: 1436m
Slope: Escarpment slope with reference to rock dips
Discharge: High discharge, at least 200 - 250 lpm
Water quality: *Temp.= 18.9°C; pH= 7.04; TDS= 84ppm*

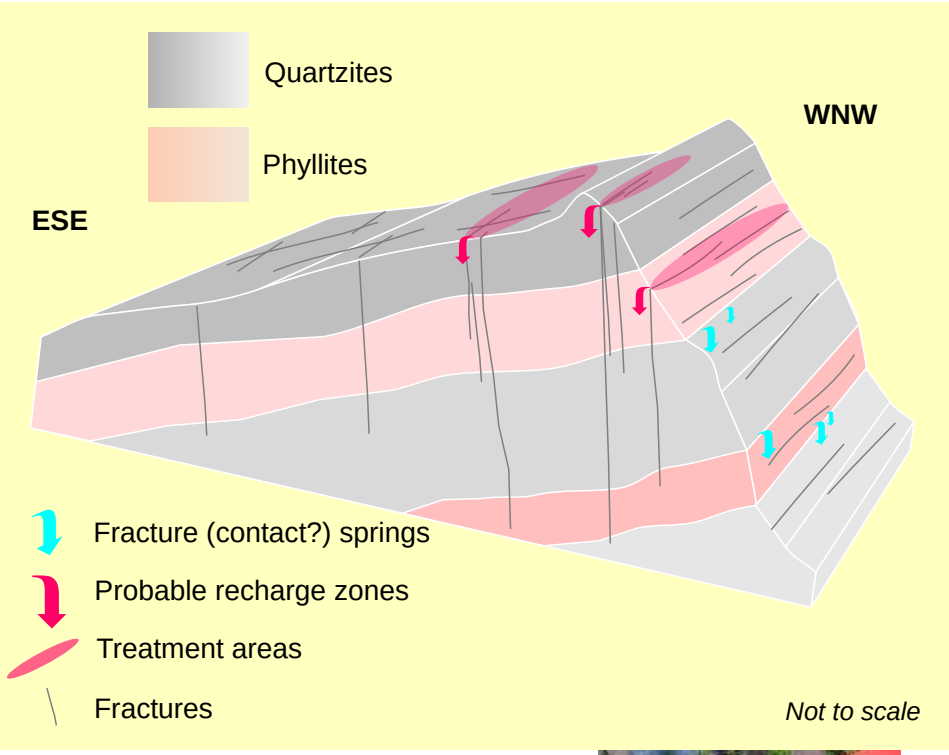
Hydrogeology

- Fractured phyllites and quartzites; schists at places
- Phyllites and quatzites are fractured show partings / cleavages that dip by 20 - 45° towards 74° (i.e. towards ENE). Phyllites are more weathered than quartzites.
- Contacts between phyllites and quartzites are highly fractured.
- Main spring is a *fracture spring*.

Other information

- High discharges in streams; partly direct runoff & partly base flow due to spring discharges. *Large fluctuation in maximum and minimum spring discharges is reported.*
- High transmission rates and (?) limited aquifer storage imply highly fluctuating annual discharge.
- Treatment can be extended further towards the NE of the spring, especially in zones where fractures trending 20° and 74° are evident.

Lampate *dhara*: "Fracture spring"



Landscape and vegetation: Namthang
Part of recharge area for spring

Quartzites and phyllites exposure

Measuring dips and fractures

Regional fracture at the contact of phyllites (P) and quartzites (Q)

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DEVITHAN DHARA

13 September 2010

Location: 27°20’34”N 88°21’30”E Elevation: 1710m
Slope: Along fracture zone in the rock
Discharge: 35 lpm.
Water quality: *Temp.= 18.4°C; pH= 6.97; TDS= 96ppm*

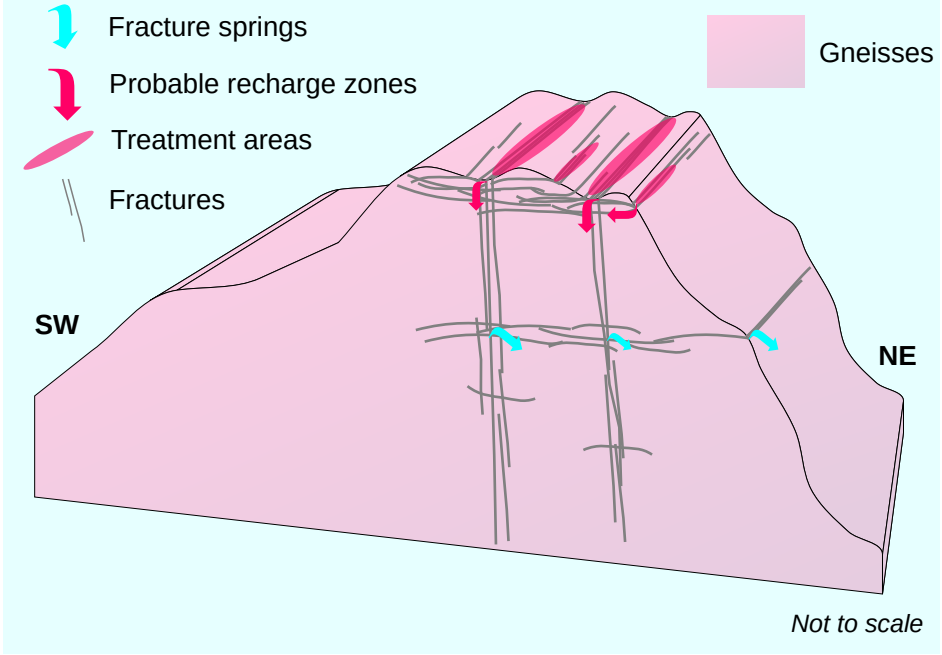
Hydrogeology

- Mainly gneisses found in the area. They range from pure Biotite gneiss to feldspar and garnet bearing Augen gneisses at places .
- Foliation fractures along the gneissosity direction are not open enough for transmission of water.
- Main fractures trend in 140°-320°.
- Fractures in this direction are quite open and form the main avenues for storage and transmission of groundwater.
- The spring is a *fracture spring.*

Other information

- No surface flows in streams except in the one fed by springs.
- Treatment in the 5 ha area can also be strategised as per geological features (fractured contacts) identified in the field.
- Main recharge zone is on the flat topped plateau region where these fractures are open.
- Drainage line structures like check-dams also can be tried out as a recharge mechanism.

Devithan *dhara*: “Fracture spring”



Open nature of fractures along NW-SE direction

Only springfed streams like this have water throughout the year

Devithan *dhara* emerging from a fracture

Foliation seen in gneisses

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ASENG DHARA

10 September 2010

Location: 27°8’6”N 88°14’23”E Elevation: 1349m
Slope: Dip slope with reference to rock dips
Discharge: Approx. 60 lpm.

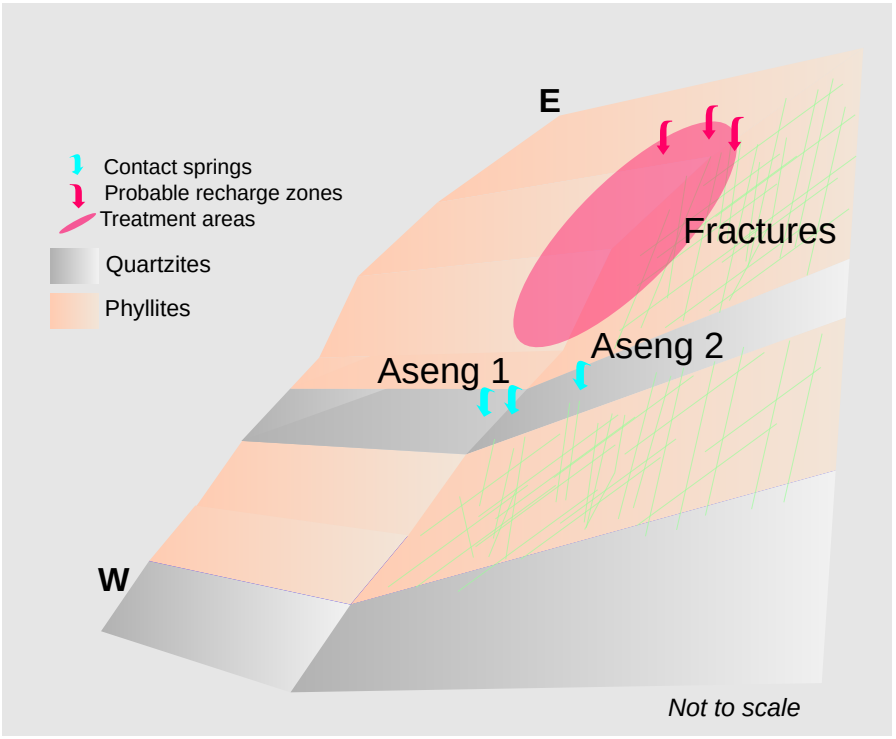
Hydrogeology

- Mainly phyllites and quartzites. Phyllites are generally *thicker* than quartzites.Field exposures of Quartzites difficult to find due to steep slope and dense vegetation.
- Phyllites are weathered and show partings / cleavages that dip by 30° towards 270° (i.e. towards W). Quartzites are relatively impermeable with few fractures that are generally *silica-sealed fractures*.
- Contacts between phyllites and quartzites are fractured.
- The two springs are next to each other and are both a combination of *contact spring* and *fracture spring* - both tap the same hydrogeological system.

Other information

- Springs in the form of seepage through the rocks in monsoons. In lean season behave more as shallow wells through which the water overflows.
- Treatment can be extended further upslope opposite the dip direction of the rocks .

Aseng *dhara*: “Contact cum Fracture spring”



Landscape and vegetation: Aseng

Discussion with locals: indicating reduction in spring discharges

The shallow dugwell like structure that overflows in the dry seasons

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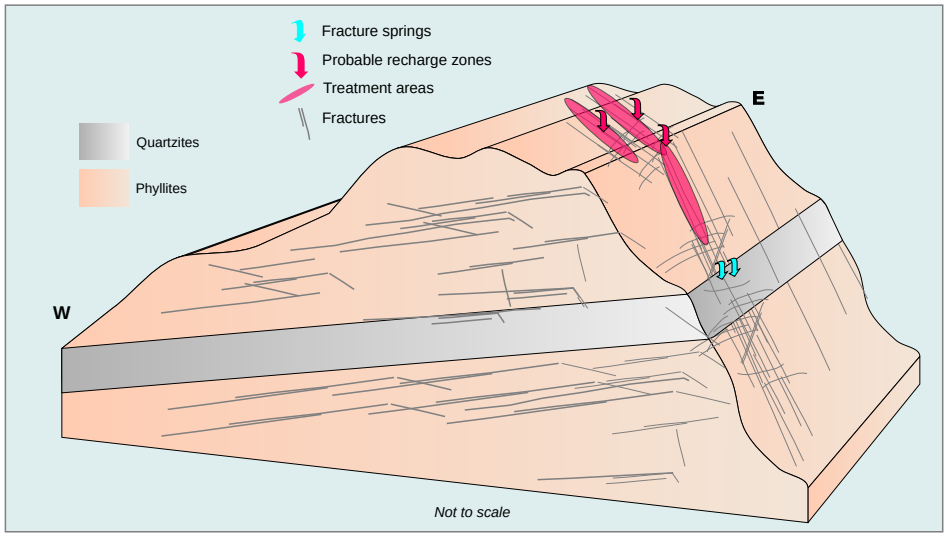
KUANPAANI DHARA

10 September 2010

Location: 27°8’7”N 88°14’36”E Elevation: 1421m
Slope: Escarpment slope with reference to rock dips
Discharge: Approx. 30 lpm.



Hydrogeology

- Mainly phyllites and quartzites. Phyllites are generally *thicker* than quartzites. Field exposures of Quartzites difficult to find due to steep slope and dense vegetation.
- Phyllites are weathered and show partings / cleavages that dip by 30° towards 270° (i.e. towards W). Quartzites are relatively impermeable with few fractures that are generally *silica-sealed fractures*.
- Contacts between phyllites and quartzites are fractured.
- Open fractures seen along the dip direction i.e. trending 90°-270°.
- The spring is in the form of a shallow dugwell, with one outlet through which water flows out of the structure.

Other information

- Springs in the form of seepage through the rocks in monsoons. But the actual discharge of the spring cannot be calculated due to silt accumulation at base of structure.
- It is required to de-silt the structure and observe the ischarge behavior of the spring before planning any spring-development and distribution structures.

Kuapani *dhara*: “Fracture spring”

Discussing the geohydrology of Kuanpaani dhara

Dense vegetation in the vicinity of the spring

Fractures in rock near the spring

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LAKES IN SOUTH AND WEST CECUM
Some preliminary observations

1. All the lakes that we visited (in South and West Districts) seemed to be largely fed by groundwater discharges, either by spring systems or through base flows of streams, which in turn would be fed by springs and seepages upstream.
2. Many of the lakes are situated within highly porous (and sometimes laterally permeable) media bounded laterally and vertically (?) by relatively low-permeability material. *Many of the lakes were situated within loose, unconsolidated sediment (?fluvio-glacial-gravity flow).*
3. Nagi lake was situated within a section of intensely weathered quartzo-phyllitic material, which is both porous and permeable.
4. The drying up of lakes in Sikkim is probably a result of many factors including the effect of Climate Change. At the same time, it would be too premature to attribute the entire cause to factors such as glacial retreat and decline in rainfall.
5. The 4 lakes that we visited in South and West Sikkim clearly show evidences of *aquifers* in close connection with the *lake system*. Therefore, any significant change in aquifer recharge, storage and discharge is also likely to cause major changes in lake storages. Many of the lakes are simply systems of multiple *depression springs* that have a clear connection to underlying aquifers.
6. Hence, the underlying cause for the dried up lakes (effect) is not within the lake itself, but within the systems that are linked to the lake (aquifers, their recharge and discharge zones). Understanding these systems hold the key to lake restoration. Any major *engineering-fix* such as 'concreting' and 'desilting' should be avoided until the *cause-effect relationship* is established.
7. Aquifers or groundwater systems are relatively *slow* systems when compared to surface water sytems – streams and rivers, although these two are clearly interconnected. The drying up of lakes is <u>not</u> an overnight phenomenon. The recovery to normalcy would, in all probability, be a long-drawn process and would require systemic understanding.
8. The *Dhara Vikas* programme for springs holds the process to look to the challenge of reviving Sikkim's lakes. A similar programme or a programme that is an extension of the Dhara Vikas is the best option to addressing the challenge of reviving Sikkim's lakes, with allied aspects such a forestry and surface hydrology being tied into studying the basic hydrology of lake systems.
9. A small beginning towards improved understanding of the Nagi lake was proposed during discussions with the Dhara Vikas team – taking a test trench in the southwestern corner of the lake, to check shallow water table behaviour – deduced (on the basis of field obvervations) to be responsible in feeding the lake system...

Some holy lakes like Khechiperi are still in a healthy state

Water quality:
Temp.= 20.2°C; pH= 6.99; TDS= 96ppm

Dried up Nagi lake in Namthang. *Note the cemented walls of the lake*

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