Hydrogeological conditions in the southern part of Dang valley, mid-western Nepal

Birendra Sapkota*

Amrit Campus, Kathmandu, Nepal

* *For correspondence, E-mail: birendrasapkota@hotmail.com*

The Dang valley consists of several patches of confined and unconfined aquifer systems. Drilling data reveals that the northern portion of the study area has more permeable surfaces than the southern and central portions. Annual domestic draft and safe yield were calculated to be 7.43 x10^6 m^3/year and 3.16 x 10^7 m^3/year, respectively. The fact that the safe yield is higher than the annual draft indicates the presence of good groundwater potential in the study area.

Key words: terrace, lithology, aquifer, tubewell, yield, draft, piezometric surface, water table

Him J Sci **1**(2): 119-122
URL: www.himjsci.com/issue2/hydrogeology

Received: 27 Apr 2003
Accepted after revision: 15 July 2003

Introduction

Bounded on three sides by the Siwaliks, the Dang valley is approximately 80 km in length and 30 km in width and thus its area is approximately 2400 km^2. The elevation of the valley floor ranges from 550 to 750 m asl. The study area stretches from below the Ghorahi-Tulsipur highway in the north down to the Babai River in the south, from Ghorahi in the east to Tulsipur in the west **(Figure 1)**.

The Dang valley has an undulating terrain sloping towards south. The terrain, consisting mainly of alluvium and outwash deposits from the hill slopes, comprises six terraces- the highest terrace, higher terrace, middle terrace, lower first terrace, lower second terrace and lower third terrace (Yamanaka and Yagi 1984). These are fill-top terraces composed of consolidated detritus. The valley is filled in the central part with fluviolacustrine sediments. Ancient river terraces are more prominent in the northern part of the valley than in the south. The fluvial terraces include soils of diverse types in different regions. Red soil is observed in the northern area, brown in the middle and black in the south and eastern parts of the valley.

The Babai River is one of the major rivers in the Dang valley, flowing east to west and passing through the southern end of the valley. Other perennial streams, such as the Sisne and the Katwa, originate in the lesser Himalaya and join the Babai River on the south, creating alluvial fan plains, sand and gravel bars, depositional basins and other depositional landforms. The erosional activity of the rivers has indented the river terrace of the valley by 8 to 15 m and has created badland topography in the northern part.

Climate in the Dang valley is tropical to sub-tropical, characterized by monsoon rainfalls from June to September, which on average account for 85% of the total annual rainfall (Uprety and Karanjac 1989).

Study area

The subsurface lithology obtained from borehole logs of deep tubewells (DTWs) and shallow tubewells (STWs) consists primarily of sand, gravel, silt and clay, mixed in differing proportions. The comparative study of these wells shows that the northern part of the valley has more sand and gravel. Towards the south and especially along the Babai River, clay and silt are dominant. Intermixing of gravel and fines is dominant in the middle part of the study area.

Materials and methods

A field survey was undertaken to determine the hydrogeological conditions in the study area, and the preliminary data was collected at the Groundwater Resource Development Board (GWRDB), Kathmandu and Groundwater Field Office, Lamahi.

Various types of wells (dugwells, deep tubewells and shallow tubewells) selected for present study were located in a location map **(Figure 1)**. The study was conducted in June 1999 (during the monsoon) and February 2000 (post-monsoon). The depth of water from the ground surface in the dugwells both in monsoon and post monsoon was noted. Geological information regarding the dugwell section of the fluvial terrace was correlated with the nearest columnar section but data from shallow tube-wells and deep tubewells was obtained from borehole logs.

Transmissivity was calculated using figures for well discharge obtained from secondary data. Water table measurements taken from dugwells of study area were useful in determining the direction of groundwater flow.

Safe yield of the groundwater reservoir was calculated for the entire aquifer system based on the piezometric surface fluctuation. This was relevant since the clay zones occur as isolated patches in most of the areas, with laterally interconnected deep and shallow aquifers. Thus, safe yield can be calculated on the basis of the following formula:

Safe yield = area of aquifer × storage coefficient × mean piezometric surface fluctuation (cf. Driscoll 1987)

Typical storage coefficient for confined aquifers ranges from 10^{-5} to 10^{-3} (Driscoll 1987). The above parameters showed the potential of groundwater in the valley and the possibility of future well development for irrigation and drinking water purpose.

Results and discussion

Aquifer setting

The general pattern of aquifers, as revealed from the lithological logs, is irregular and discontinuous with lenses or layers of sediment admixture at different levels. Unconfined aquifers are observed in Dhikpur and Dangigaun. Confined ones are commonly observed at Bangain, Dhikpur and in many other places. The presence of confined aquifers may be due to the shifting of the river course within the valley.

As far as shallow tubewells in the study area are concerned, the best granular zone is found in the well of Ammapur (DG/STW-7), which has a total of 14.6 m thick permeable material (sand and gravel) out of the total well depth of 20.1 m **(Table 1)**.

As for deep tubewells, the thickness of permeable materials varies from 18.5 m in TG-2 (Bangain) to 84.7 m in DG/DTW-5 (Dhikpur). The thickest clay zone, 49.3 m appears in NISP/INV/DTW-3 (Khausapur) **(Table 2)**. Most lithologs of the wells reveal the permeable material to be greater than 40%, indicating good presence of aquifers in the valley **(Table 1** and **2)**.

Piezometric surface

The piezometric surface in deep tubewells as recorded by GWRDB ranges from 5.1 m in DG/DTW-27 (Dangigaun) to 37.5 m in DG/DTW-21 (Lalpur), and in shallow tubewells ranges from 0.7 m in NISP/STW-7 (Ammapur) to 5.0 m in DG/STW-6 (Dundre) **(Table 4)**. The general pattern observed in the area is an increase in depth to piezometric surface towards the northern part of the valley.

Water table

The greater fluctuation of water level, as revealed by the dugwell inventory data, takes place in central and northern parts of the valley **(Table 3)**. The depth to water level in dugwells is found to be less toward the south and near the banks of river. This may be due to high transmissivity in wells toward the north, resulting in rapid recharge of storage during the monsoon season and quick release of water to the south during post-monsoon (Uprety and Karanjac 1989).

Yield

The maximum yield is greater in the central and southern part of the area, in places such as Dundre (DG/STW-6) and Dangigaun (DG/DTW-27) **(Table 4)**. This suggests that the southern and central parts of the study area would offer better venues in which to develop tubewells for irrigation purposes.

Transmissivity

Transmissivity in the deep tubewells of Dangigaun (DG/DTW-27) and Ammapur (DG/STW-7) is greater than in other wells of the valley. Hydraulic conductivity, calculated as the ratio of transmissivity to cumulative aquifer thickness, is also greater in these wells. Even wells adjacent to each other, for example NISP/STW-7 and DG/STW-7 may vary in transmissivity. The discontinuous

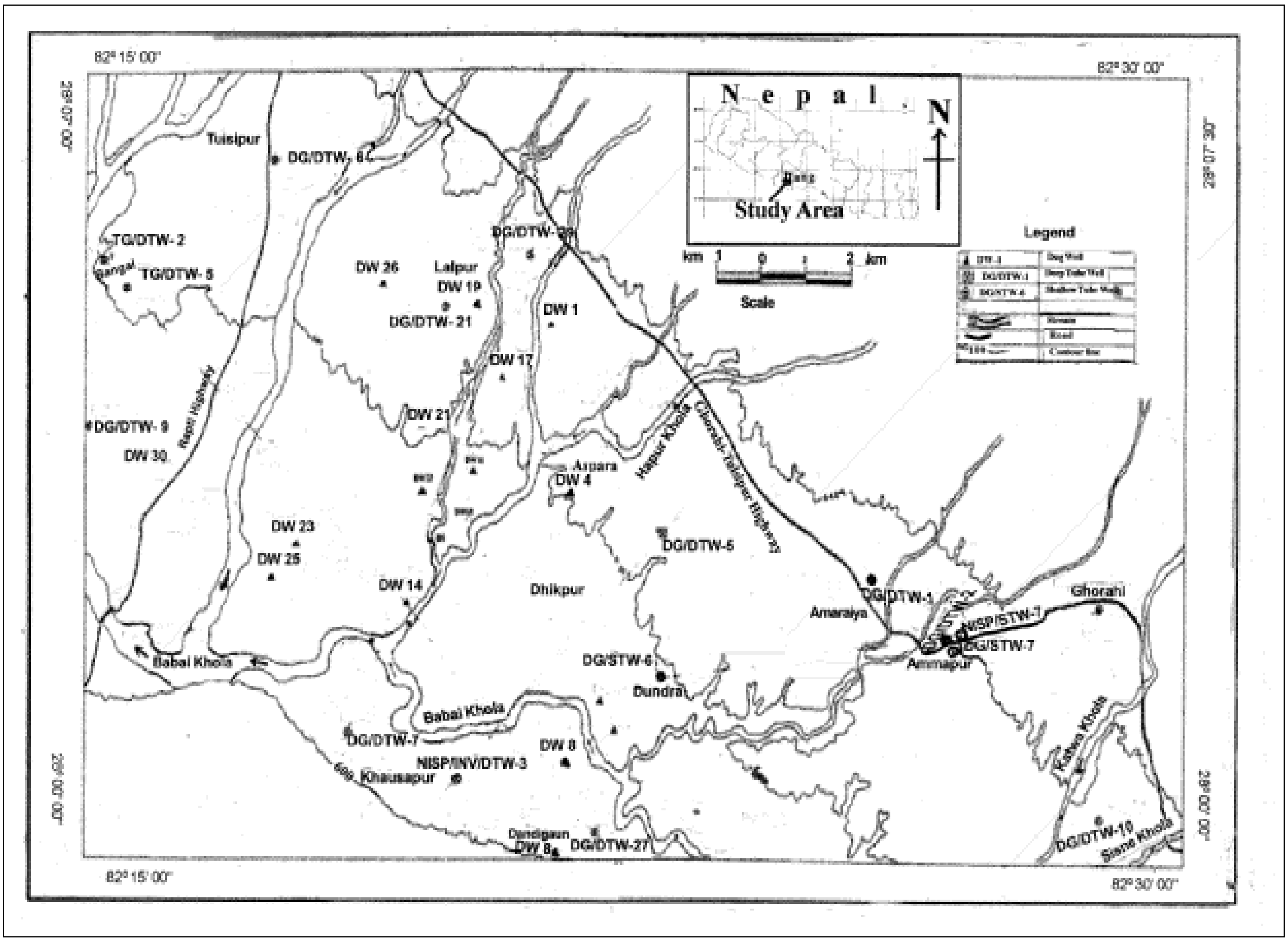

FIGURE 1. Location map of the study area

TABLE 1. Thickness of permeable, semi-permeable and impermeable layers in STWs

Well No.	Location	Depth of well drilled* (m)	Thickness of (m)			% of permeable materials
			Permeable layer	Impermeable layer	Semi permeable layer	
DG/STW-6	Dundre	37.5	18.3	9.4	9.7	48.8
Saibahani	Ghorahi	29.0	15.5	8.0	5.6	53.4
NISP/INV/STW-7	Ammapur	36.0	13.0	22.0	1.0	36.1
DG/STW-7	Ammapur	20.1	14.6	4.6	0.9	72.8

GWRDB (1996)

TABLE 2. Thickness of permeable, semi-permeable and impermeable layers in DTWs

Well No.	Depth of well drilled* (m)	Thickness of (m)			% of permeable materials
		Perme-able layer	Imperme-able layer	Semi-permeable layer	
DG/DTW-2	68.9	41.4	11.9	15.6	60.1
NISP/INV/DTW-3	106.1	45.5	49.3	11.2	42.6
DG/DTW-27	111.2	58.2	41.0	12.0	52.3
TG-5	107.0	49.0	6.5	52.0	45.8
TG-2	105.0	18.5	7.0	79.5	17.6
DG/DTW-29	113.5	63.5	29.5	20.5	55.9
DG/DTW-5	140.2	84.7	43.9	11.6	60.4
DG/DTW-7	111.2	76.0	18.0	17.2	67.7
DG/DTW-9	80.2	38.7	27.1	14.3	48.3
DG/DTW-6	70.1	54.9	-	15.2	78.2
DG/DTW-1	149.3	64.6	-	71.3	43.3
DG/DTW-21	74.4	49.9	18.9	5.6	67.1

GWRDB (1996)

TABLE 3. Dugwell inventory preparation data of study area

Well No.	Location	Well depth (m bgl)	Post monsoon water level depth (m asl)	Monsoon water level depth (m asl)	Water level fluctuation (m)
DW 1	Mangari	16.0	612.7	513.2	0.5
DW 4	Aspara	6.0	592.4	596.0	3.6
DW 8	Dhikpur	6.0	585.3	587.8	2.5
DW 9	Dangigaun	10.0	583.4	587.5	3.5
DW 10	Duruwa	10.0	581.0	584.0	3.0
DW 14	Duruwa	9.0	582.7	586.9	4.2
DW 15	Manoharpur	10.0	582.6	584.8	2.2
DW 17	Bankatta	8.0	610.7	613.9	3.2
DW 19	Lalpur	8.0	619.5	621.9	2.4
DW 21	Bhituria	13.0	593.6	594.2	0.6
DW 23	Malawar	7.0	581.6	584.5	2.9
DW 25	Karanga	9.0	569.4	573.9	5.5
DW 26	Sajnewar	8.0	607.6	608.5	0.9
DW 30	Hemnagar	7.0	581.8	584.9	2.7

Source: GWRDB (1996); m bgl: meters below ground level, m asl: meters above sea level

clay layers present in the aquifer differ in percentage of the permeable material. Thus, wells with more cumulative thickness of the aquifer tapped zone give more transmissivity.

Groundwater recharge

In the study area, the aquifers are mainly recharged by rainwater infiltration. In addition, parallel streams flowing across the valley assist in recharging the valley. Since the northern fringe of the valley consists of coarse materials (gravels and boulders), major recharge occurs in this zone.

Safe yield

The storage co-efficient is much lower in confined aquifers because they are not drained during pumping. Any water released from storage is obtained primarily by compression of the aquifer and expansion of the water when pumped. Thus, assuming the higher value for the aquifer in the study area, which is 10^{-3} (Driscoll 1987),

Safe yield = area of aquifer × storage coefficient × mean piezometric surface fluctuation

$$= \sim 24 \times 10^{8}\ m^{2} \times 10^{-3} \times 13.2\ m/year^{*}$$
$$= \sim 3.16 \times 10^{7}\ m^{3}/year$$

*mean piezometric surface fluctuation = 13.2 m/ year (Piya 1993)

Groundwater draft

In the valley groundwater is extracted through dugwells, deep tubewells and shallow tubewells. The requirement for drinking and domestic use per person per day as per WHO (1984) standard is 45 l (0.045 m^3). The estimated population of Dang valley in 1995 was 411149 (CBS 1996). Therefore the total amount of groundwater draft by that population is 411,149 × 45 l/day = 18,501,705 l/day.

For livestock, total draft of groundwater as estimated by WHO (1984) is 1/10 of population demand. This is equal to 1,850,171 l/day. Total groundwater draft for domestic purposes comes to be 20351876 l/day, or 7.43 x 10^{6} m^3 / year. This is about 48.7% of the groundwater storage.

Thus, the annual draft for domestic use is less than safe yield, or in other words, the recharge rate is much higher than the draft. Therefore, with proper planning and management, extensive well development can be carried out in the valley in the future. However, irrigation of maximum land surface can ➔

TABLE 4. Hydrogeological characteristics of deep and shallow aquifers

Well No.	Water level (m asl)	Depth of well (m)	Total cumulative thickness of aquifer (m)	Piezometric surface (m bgl)	Discharge/ maximum yield (m^2/day)	Transmissivity (m^2/day)	Hydraulic conductivity (m/day)
DG/DTW-6	632.0	70.1	9.18	15.8	1483.5	3394.0	369.7
TG-5	608.0	107.0	30.0	21.0	691.2	632.5	21.1
DG/DTW-9	633.0	113.5	37.2	6.0	-	-	-
DG/DTW-21	618.0	74.4	16.5	37.5	-	-	-
DG/DTW-7	580.0	111.2	21.4	-	630.0	-	-
DG/DTW-3	583.0	106.1	-	11.0	-	-	-
DG/STW-7	638.0	20.1	7.1	3.2	950.4	3477.5	-
DG/DTW-5	610.0	140.0	22.0	9.2	167.1	101.9	4.6
NISP/STW-7	636.0	36.0	6.1	0.7	661.8	712.5	117.3
DG/STW-6	580.0	37.5	6.1	5.0	1987.2	-	-
DG/DTW-27	586.0	111.2	33.9	5.1	2592.0	3953.0	116.4
DG/DTW-1	619.0	149.4	11.0	15.2	194.4	14.2	1.3
DG/DTW-2	641.0	68.9	11.1	23.7	-	-	-
Saibahini	666.0	29.0	-	-	0.1	-	-
TG-2	604.0	105.0	30.4	28.9	1036.2	2709.3	89.1

Source: GWRDB (1996); m asl : meters above sea level; m bgl: meters below ground level

be achieved through combined use of both the surface water and groundwater. ■

References

CBS. 1996. *Statistical pocket book*. Kathmandu: Central Bureau of Stastics, HMGN. 301 p

Driscoll FG. 1987. *Groundwater and wells*, 2nd ed. St. Paul (Minnesota): Johnson Filtration System Inc. 5512. 1089 p

GWRDB. 1996. *A compilation of tube-well inventory data of Dang valley, mid-western Nepal*. Kathmandu: Groundwater Resource Development Board. 52 p

Piya B. 1993. *Hydrogeological studies in parts of Dang valley, western Nepal* [thesis]. Kathmandu: Central Department of Geology, Tribhuvan University. 120 p

Uprety SR and J Karanjac. 1989. Shallow well drilling, testing and monitoring in 1987/88: Basic documentation and preliminary interpretation, Dang valley. Technical report no 8. Kathmandu: UNDP and HMGN. 19+ 38 p

WHO. 1984. *Guidelines for drinking water quality*, Vol 1. Geneva: World Health Organization

Yamanaka H and H Yagi. 1984. Geomorphological development of the Dang dun. *J Nep Geol Soc* **4**: 151-9

Acknowledgements

I am grateful to Megh R Dhital, Central Department of Geology, TU, for supervising this study, and to Madhav Belbase, GWRDB, Lamahi, for providing materials and allowing the field observation of the running tube wells.