CHAPTER XI

HYDROGEOLOGICAL AREA CATEGORISATION

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INTRODUCTION

Area categorisation based on the hydrogeological evaluation forms an important criteria in the hydrogeological studies of any region, since it brings out the detailed hydrogeological set up of the region, a pre requisite for any groundwater development programmes. The hydrogeological regime of any area is a function of three basic inputs *viz.*, lithology, structure and geomorphology. A detailed hydrogeological evaluation based on geohydrological characteristics has already been dealt in the preceding chapter. In order to ascertain an overall distribution and potential of groundwater, hydrogeological categorisation of the study area has been carried out. In the devised methodology of hydrogeological categorisation, the author has scrutinised various parameters, in accordance to their favourability to recharge and run off and have been designated as:

(a) Hydro-lithology
(b) Hydro-structure, and
(c) Hydro-geomorphology

LITHOLOGICAL CONTROL : HYDRO-LITHOLOGY

Hydro-lithologically, the rocks of the study area have broadly been classified into three as unconsolidated, semi-consolidated and consolidated sediments. The hydro-lithological categorisation of the study area, showing different rock types, their hydrogeological significance and areas of their occurrence is given in the Table 11.1.

The study has revealed that a major part of the study area is occupied by unconsolidated sediments, followed by the consolidated and semi-consolidated sediments. The Luni block of the study area is predominated by the unconsolidated and semiconsolidated classes. Groundwater in these parts occur both in the hard rocks as well as the non-indurated Quaternary sediments. The formations which constitute the major aquifers in this region are Quaternary alluvium, Palaeozoic limestones and sandstones; the Precambrian gneisses, schists, phyllites and quartzites of the Delhi Supergroup and post-Delhi intrusive granites. Of these, the alluvium and limestone are the most potential aquifers. In the northern parts of this block, Quaternary alluvium and aeolian sands form the most important water-table aquifers around most parts of Nagaur district.

The unconsolidated and consolidated classes comprising the Quaternary alluvial and aeolian sediments and the Precambrian hardrocks respectively constitute the major hydro-lithological categories in the Kantli block. The Quaternary sediments form the principal and most potential aquifers in this block, comprising of the aeolian and fluviatile deposits of sand, gravels and pebbles. Schists, amphibolites, phyllites, granites, quartzites, etc., constitute the hardrock aquifers.

STRUCTURAL CONTROL : HYDRO-STRUCTURE

The structure of geologic formations in a region, to a large extent controls the occurrence, distribution and movement of groundwater. By and large, the structural elements of any area would have their influence in defining lateral and vertical extent of an aquifer and groundwater channelisation, particularly in hard rock terrain. It has already been discussed in the preceding chapters that the study area is dissected by a series of NE-SW, NW-SE, N-S and E-W

Table 11.1. Hydrolithological categorisation of study area

Hydro-lithological category	Lithology	Hydrogeological Significance	Localities
Non-indurated or unconsolidated	Colluvial, alluvial, aeolian and lacustrine deposits comprising clay, silt, sand, gravel, pebbles and boulders.	Highly porous and permeable aquifers are of considerable lateral extent and of semiconfined to unconfined nature encountered at shallow depths.	**Luni block:** Sarswati and Sagarmati valleys (Pushkar and Budha-Pushkar valleys, Pisnagam), Roopnagar valley, Lilri valley, Kekind, Badauli, Lambiya, Anandpur Kalu, Luni (Chawan), Merta, Chandarun, Jusri, Thakarwas, Jayal, Chhajoli, Pipar, Rian, Phabadi, Degana, Sambhar, Didwana, Napasar, Gangashaher. **Kantli block:** Kantli valley, the valleys of Sabi, Mendha, Sota, Chandrawati rivers, Sikar, Nowalgarh, Singhana, Makundgarh, Danta Ramgarh, Fatehpur, Losal, Patoda, Ramgarh Shekhawati, Rajgarh, Surajgarh, Jhunjhunu, Mandawa, Dighal Jodhpur, Chirawa.
Semi-consolidated	Sandstones, limestone, phyllite, conglomerate, slates, schists, grits, marbles	High to moderate porosity and permeability. Good aquifer system. Water table usually encountered at medium depths.	**Luni block:** Malpuriya, Ransigaon, Jhak, Nimbaj, Balera, Daulatpura, Gachipura, Ladnu, Nawa, Gotan, Nokha Jodhan, Jaitaran, Nagaur, Budsu, Butati, Balunda, Dangawas, Kairap, Kasnau, Punlauta, Nimbi Jodhan **Kantli block:** Dighal, Thai, Khoor, Talab ki Dhani
Indurated or Consolidated	Igneous and Metamorphic rocls like granites, gneisses, amphibolites, Quartzites, schists, rhyolites, epidiorites and shales.	Moderate to low porosity and permability. Predominantly phreatic aquifers.	**Luni block:** Kishangarh, Nasirlad, Dabrela, Bhinai, most part of Ajmer district, Roopnagar, Beawar, Ganhera, Barr, Nimbol, Kuchman, Jodhpur, Pisangaon, Parbatsar, Harsor, Latoti, Girbhakar **Kantli block:** Lachhmangarh, Khandela, Nim ka Thana, Ajitgarh, Sri Madhapur, Palsana, Ringus, Khatu, Basi, Gawala, Trilokpura, Khetri, Samod, etc.

fault/fracture systems attributed to the multiple episodes of tectonism. These tectonic linears have certainly played an important role in shaping the groundwater regimen of the study area. Numerous structural parameters *viz.*,folds, faults, shear zones, fracture zones, master joints, lithological contacts, intrusive bodies and other lineament features have been considered for the detailed hydro-structural categorisation of the study area. In all, three hydro-structural categories *viz.*, Major, Medium and Minor hydro-structural classes have been worked out (Table 11.2).

It is observed that the nature and scale of the structural elements have played a vital role in shaping the overall groundwater conditions of the area especially in the hardrock terrain. These structures have imparted the secondary porosity and permeability to the rocks. Wherein, the minor structures act as recharge streaks and at places are helpful in developing narrow linear aquifers of potential yield. However, the major regional structures are responsible for regulating the groundwater movement and recharge. In the study area, large scale structures with linear extensions ranging up to a few kilometers or more have significantly contributed to the development of aquifer systems. These are well exemplified by the Luni-Sukri linears, the Sardarshahar lineament, etc. The small scale local structures do not form any aquifer systems but they have controlled the initial drainage pattern, thus, increasing the rate of infiltration and enhancing the weathering process.

The Upper Luni and Kantli river basins, forming a part of the northeastern Thar is dominantly influenced by the major fault systems, *viz.*, the Luni-Sukri fault, the Sardarshahar fault, the Kasganj-Dausa-Didwana fault, etc. Most of these fracture systems have directly or indirectly affected the groundwater conditions of the study area. It is observed that the courses of the Luni and its tributaries are mainly controlled by the Luni-Sukri fault system, whereas the Kasganj-Didwana-Dausa fault, the Sardarshahar fault and other associated faults were responsible for the disruption of the palaeo-courses of the Luni. Manifestations of these are the fresh water aquifer systems of good potential developed along the Luni river course and in the northeastern parts adjacent to the river courses of Sabi, Dohan-Dongar, Chandrawati, Sota and Mendha. The E-W and NE-SW trending fault/fracture systems (Riedel and anti-riedel shears) developed in the northeastern parts of the study area, especially in the areas drained by the Mendha and its tributaries have caused the development of horst and graben configuration that have directly

Table 11.2. Hydrostructural categorisation of study area

Hydro-structural Category	Structure	Hydrogeological Significance	Localities
Major	Major shear and fracture zones, regional faults, tight folds, master joints, intrusive bodies, lithological contacts, etc.	Significant hydro-fractures produced and associated aquifers provide a medium yield. Medium to good aquifer systems.	Saraswati and Sagarmati valleys, Pushkar valley, Ana Sagar, Pisangan, Ajmer, Pipar, Khetri, Beawar
Medium	Intermediate level shears, fractures, fault zones, conjugate joints, intrusives, open folds, etc. of local extent	Good aquifer systems with medium to high yield.	Kantli, Mendha and Chandrawati valleys, Merta, Phalodi, Rian, Degana, Nagaur, Sambhar, Didwana, Napasar, Palsana, Ringus, Rupangarh, Danta Ramgarh, Sikar, Losal, Fatehpur, Chirawa, Jhunjhunun
Minor	Columnar joints, local fault and fracture zones, bedding planes, local intrusives, etc.	Regulate the initial drainage network, thereby increasing infiltration and enhencing weathering processes, but directly they do not form any definite aquifer systems.	Catchment areas of Luni, Lilri, Rupangarh, Mendha, Kantli rivers, Nimbi Jodhan, Harsor, Roja, Ren, Run, Barr, Nimbol, Khandela, Ajitgarh, Nim Ka Thana, Udaipurwati

affected the groundwater conditions of the area. The large scale folded structures in the Precambrian rocks of the Aravalli Mountain Range have mainly acted as recharge zones in this part of the study area.

The major faults, shear zones and intrusives located in the hardrock terrain of the study area have produced characteristic hydrofractures and the associated aquifers provide a medium yield. These are categorised into major hydro-structural class, the NE-SW trending Aravalli Mountain Belt and adjacent hardrock terrain, right from Beawar in the SW to Khetri in the NE falling under this category. Numerous shear zones of intermediate and small scale occurring in the area are grouped under the medium and minor hydro-structural categories. The medium hydro-structural class characterising good aquifer systems with medium to high yield, are typical of the area falling within the limits of Kantli, Sabi, Sota, and Chandrawati watersheds and in the central parts around Mendha and its tributaries, the Sambhar lake area and the Rupangarh watershed. The central to northern parts of the area covering the Nagaur district around Kuchaman, Didwana, Degana, Merta city and Jayal also form good aquifer systems.

The minor hydro-structural category, characterised by the local joints, fractures, small scale intrusives, etc., is typical of the catchment areas of the Luni river around Ajmer, Pushkar, etc., the Lilri river around Beawar, the Rupangarh river around Ajmer, Rupnagar, etc., the Mendha river in the uplands of Ringus, Samod, etc., the Kantli river around Guhala, Nim ka Thana, Udaipurwati, etc., and the areas drained by the other minor streams and rivulets of the study area. In these areas, the aquifer systems are not well developed, but they form good recharge areas as evidenced by the high intensity of structurally controlled drainage network.

Hydro-fractures from the hard rock areas extend into the unconsolidated Quaternary sediments, thereby, forming major recharge sources especially in the northeastern parts of the study area, in the Kantli basin and in the southwestern parts covering the Luni basin. The limestone terrain in and around Banthri, Khimsar, Kolia, Rol, etc., generally shows the development of solution cavities and forms potential sources of fresh groundwater.

GEOMORPHOLOGICAL CONTROL : HYDRO-GEOMORPHOLOGY

Geomorphology plays a decisive role in the development of hydrogeological regime, conducive from the point of groundwater storage and movement. Geomorphic controls in terms of numerous morphogenetic features *viz.*, landforms, drainage, slope, weathering, etc., in combination with the surficial processes by and large govern the infiltration and overland flow of rainwater input to the watershed area.

Morphometric parameters like drainage density and slope characteristics provide a basis for the evaluation of run off and groundwater potentials of river basins. The total drainage area of the Upper Luni and Kantli river basins determines the total quantity of water that is available in the two watersheds. The drainage network is relatively high in the northeastern and eastern parts covering the Kantli basin, wherein the groundwater conditions are good. In the Luni block, the drainage network is comparatively high in the catchment areas around Ajmer, Pushkar, Pisangan, Surajgarh, etc., and further southwest around Alniyawas, Jaitaran, Nimbol, Pichak, etc. Towards the extreme southwestern parts, the drainage network is limited to the Luni channel and its minor tributaries. Moderate to good groundwater conditions occur in these parts of the Luni block. In the western and northwestern parts of the study area, poor groundwater conditions occur. This conspicuous paradoxic condition is attributed to unfavourable lithology, i.e., the predominance of Tertiary rocks of clayey nature. Low drainage network is a secondary factor that has led to poor groundwater conditions in these areas, the groundwater generally occurring in the deeper aquifers. The lack of perennial drainage system has adversely affected the groundwater quality of the study area due to lack of flushing, resulting in accumulation of salts.

The hilly terrains of the Aravalli Mountain Range are characterised by high drainage density and run off. Highly permeable nature of the alluvial and aeolian cover along the hill pediments and pediplains have resulted in low drainage density, thereby contributing towards the development of potential aquifer systems.

SLOPE CHARACTERISTICS

Slope of the terrain has a dominant effect on the contribution of rainfall to streamflow and to the groundwater reservoir. The ground slope characteristics have a significant bearing on the subsurface infiltration and thereby groundwater recharge. The depth to the water table, distribution of head and artesian pressure in aquifers are also controlled up to some extent by the slope of terrain.

The percentile ground slopes in the study area have been categorised into three classes, *viz.*, steep slopes (>15%), intermediate slopes (15-5%) and gentle slopes (<5%), each corresponding respectively to increasing groundwater recharge. Accordingly, the NE-SW trending Aravalli Mountain belt is predominated by the slopes of more than 15% and characterised by low groundwater potential. The intermontane valleys and the narrow linear zones extending from the hill flanks to the alluvial and aeolian plains (the pediment zone and pediment plains), with intermediate slopes (15-5%) belonging to the Luni and Kantli watersheds have medium to high groundwater potential. The present day alluvial plains of the Luni-Kantli rivers, the Mendha, Rupangarh, Sabi, Sota, Dohan, Dongar, Chandrawati rivers, the past alluvial plains and palaeochannels concealed under the aeolian cover, the areas surrounding the inland lake basins of Sambhar, Didwana, Kuchaman, etc., with predominant slopes less than 5% form the areas of relatively high groundwater potential. However, the groundwater is invariably brackish to saline in these areas.

The rugged topography created by aeolian activity in the areas surrounding Nagaur, Ladnun, Napasar, Fatehpur, Jhunjhunun, etc., show poor to moderate groundwater potential, the water-table aquifers generally confined to deeper horizons. The quality of groundwater in large parts of this zone is brackish due to the abundance of dissolved salts. The northeastern and eastern parts of the study area, drained by numerous small ephemeral streams and underlain by well-knitted palaeochannel network have significantly developed potable groundwater conditions of moderate to high yield.

BEDROCK TOPOGRAPHY

The bedrock topography is another important geomorphic control that has distinct effect on the water-table of the study area. Karanth (1987) had observed that symmetrical U/V shaped valleys with steep slopes are developed in the steeply dipping quartzite-schist sequence of Delhi Supergroup of rocks, asymmetrical valleys in the gently dipping sandstone-shale sequence of Palaeozoic rocks, gently rolling topography in the rocks of the Banded Gneissic Complex, etc. Maximum thickness of aquifer is generally found in the middle of the valleys of Delhi rocks, especially in the Kantli basin. In the areas where Palaeozoic rocks form the bedrock, especially in the Luni block, the thickness of aquifer is intermediate, whereas in the areas around Harsor, Alniyawas, Rian, etc., comprising B.G.C. rocks, the aquifers are restricted to the weathered zones and are of moderate to poor yield.

Based on the above geomorphological parameters, the study area is hydrogeomorphologically categorised into three classes, *viz.*, high, medium, and low potentials. Table 11.3, gives a gist of the hydrogeomorphological categorisation, the hydrogeological significance of each class and the areas of their occurrence.

On the basis of the above studies, the author has made a detailed hydrogeological categorisation of the study area (Fig. 11.1), depicting the general boundaries of the various groundwater potential categories, i.e. high, moderate and low. Based on the above mentioned parameters and other important factors like geohydraulic characteristics, groundwater chemistry, rainfall, etc., a detailed geohydrological map of the study area has been prepared (Fig. 11.2).

Table 11.3 Hydrogeomorphological categorisation of study area

Hydrogeomorpho-logical Categories	Landforms	Characteristic Features (Hydrogeological Significance)	Localities
Low	Steep hilly terrain, rocky ridges and stony wastes.	Steep slopes > 15%, (very steep to steep). Radial drainage pattern, high drainage density, high rate ofweathering, shallow weathered zone, poor soil cover, Low porasity and permeability, poor aquifer system with low fields.	Aravalli Mountain belt, Ajmer, Kishangarh, Parbatsar, Barr, Beawar, Danta, Udaipurwati, Khetri
Intermediate	Rugged terrain with local depressions, hill slopes, pediment plains, alluvial/colluvial cones and talus fans in foothills, pediments, etc.	Intermediate slopes 15%-5%, (moderate to steep). Trallis, pinnate and rectangular drainage patterns, moderate drainage density, moderate weathering profile, moderately thick soil and vegetation cover; medium porosity and permeability mainly controlled by joints and fractures in hard rocks. Good aquifer system when the slope is moderate.	Khandela, Nim Ka Thana, Mangliawas, Nagaur, Nimaj, Jayal, Khatu, Govindgarh, Pisangan, Rupangarh, Makarana, Gudha, Gurha
High	Flat and/or gently undulatory terrain, low lying plains and large surficial depressions, flood plains, river terraces, natural levees, broad intermontane valley floors, pediplains and plaeo/buried channels.	Gentle slopes < 5% (Moderate to gentle) centripetal, internal and braided drainage patterns, thick weathering profiles, thick soil and vegetation cover; highly porous and permeable litho units. Good to very good aquifer system giving high groundwater yield.	Luni, Kantli, Mendha alluvial plains, Jaitaran, Bilara, Bhawi, Alniyawas, Ladnun, Sujangarh, Didwana, Kuchaman, Sambhar, Merta, Pipar, Degana, Ringus

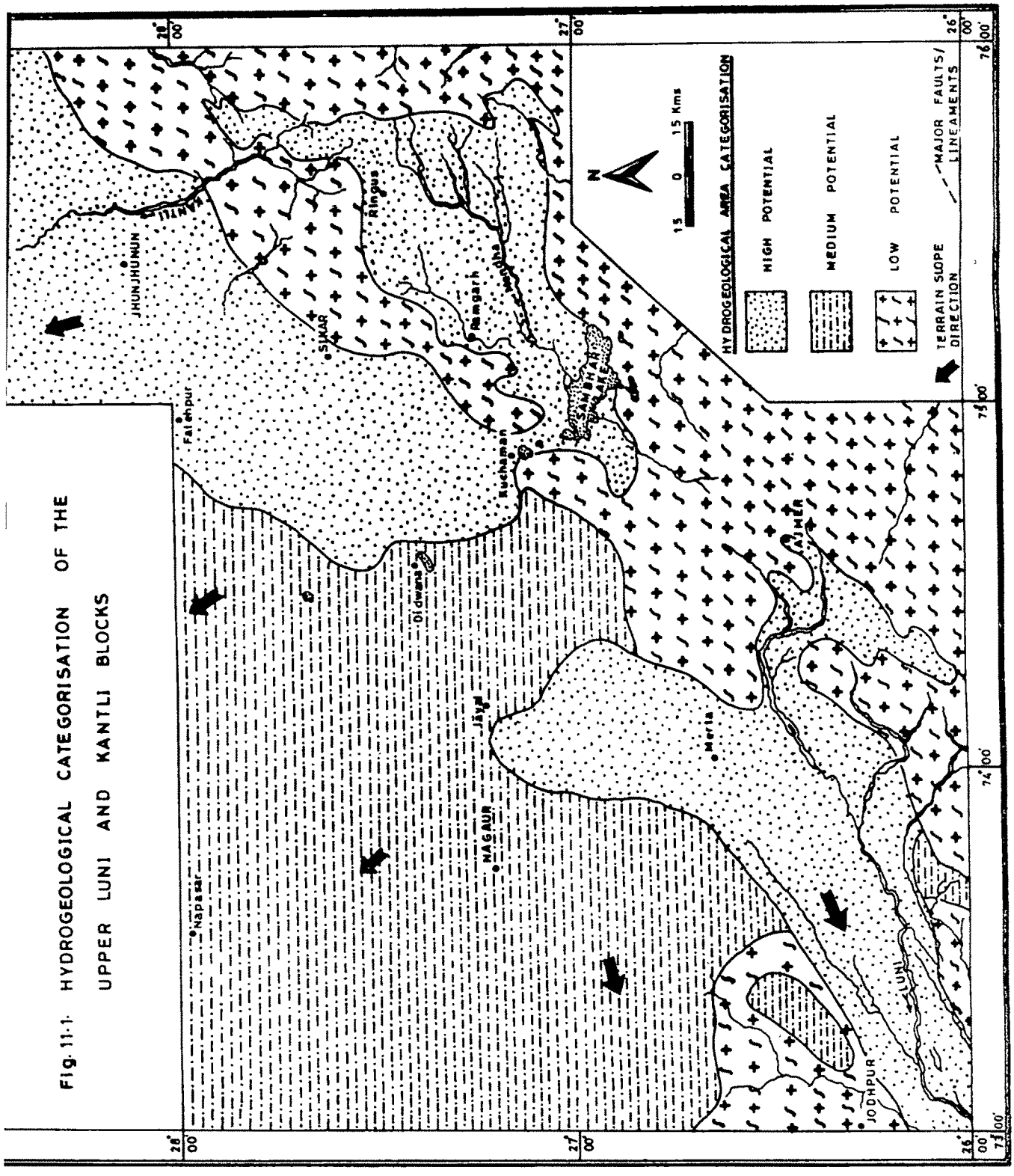

Fig. 11.1: HYDROGEOLOGICAL CATEGORISATION OF THE UPPER LUNI AND KANTLI BLOCKS

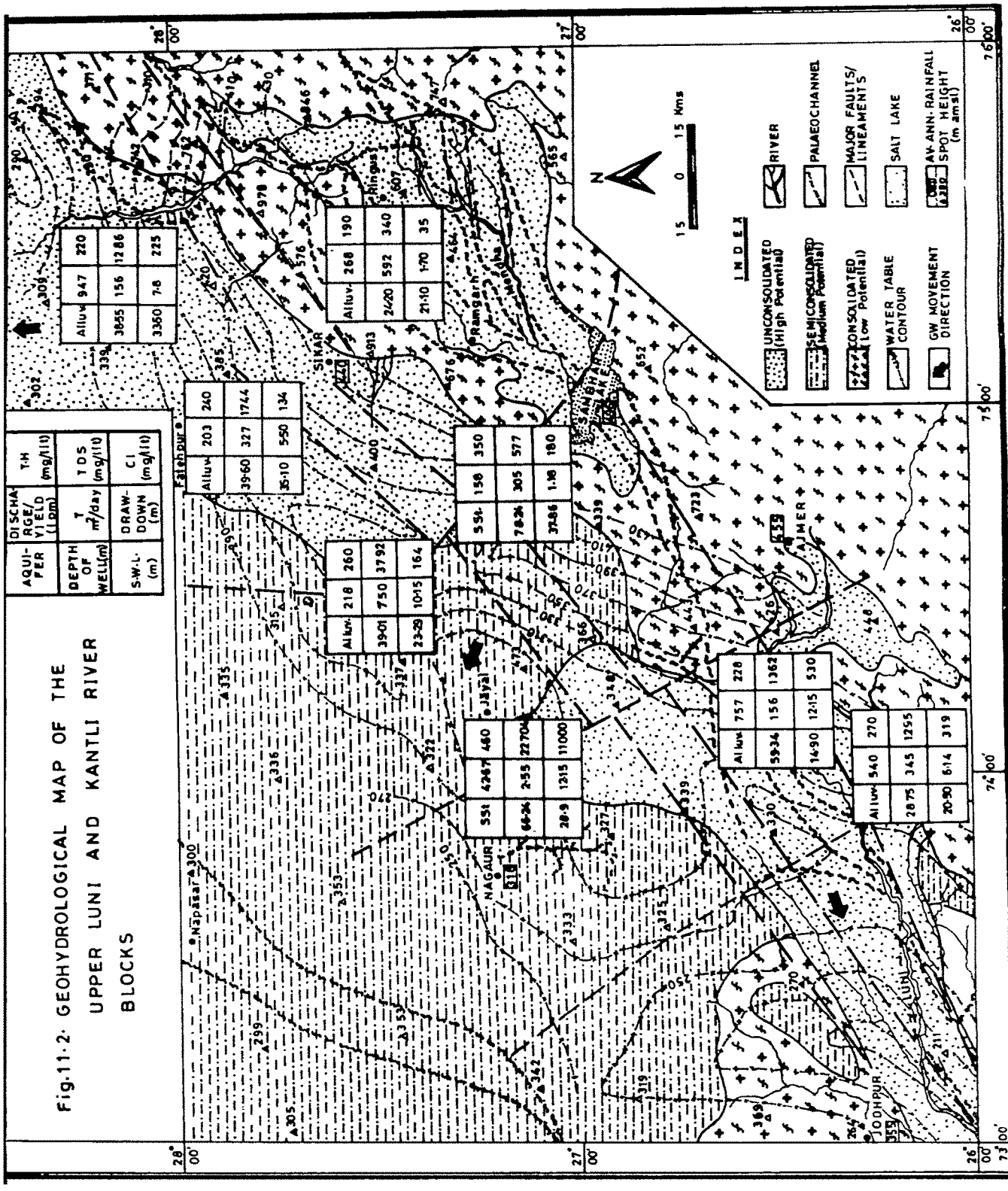

Fig.11.2. GEOHYDROLOGICAL MAP OF THE UPPER LUNI AND KANTLI RIVER BLOCKS