केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report
on

AQUIFER MAPPING

Outer Plains of Jammu Province, Jammu &Kashmir

उत्तर पश्चिम हिमालय क्षेत्र, जम्मू

North Western Himalayan Region, Jammu

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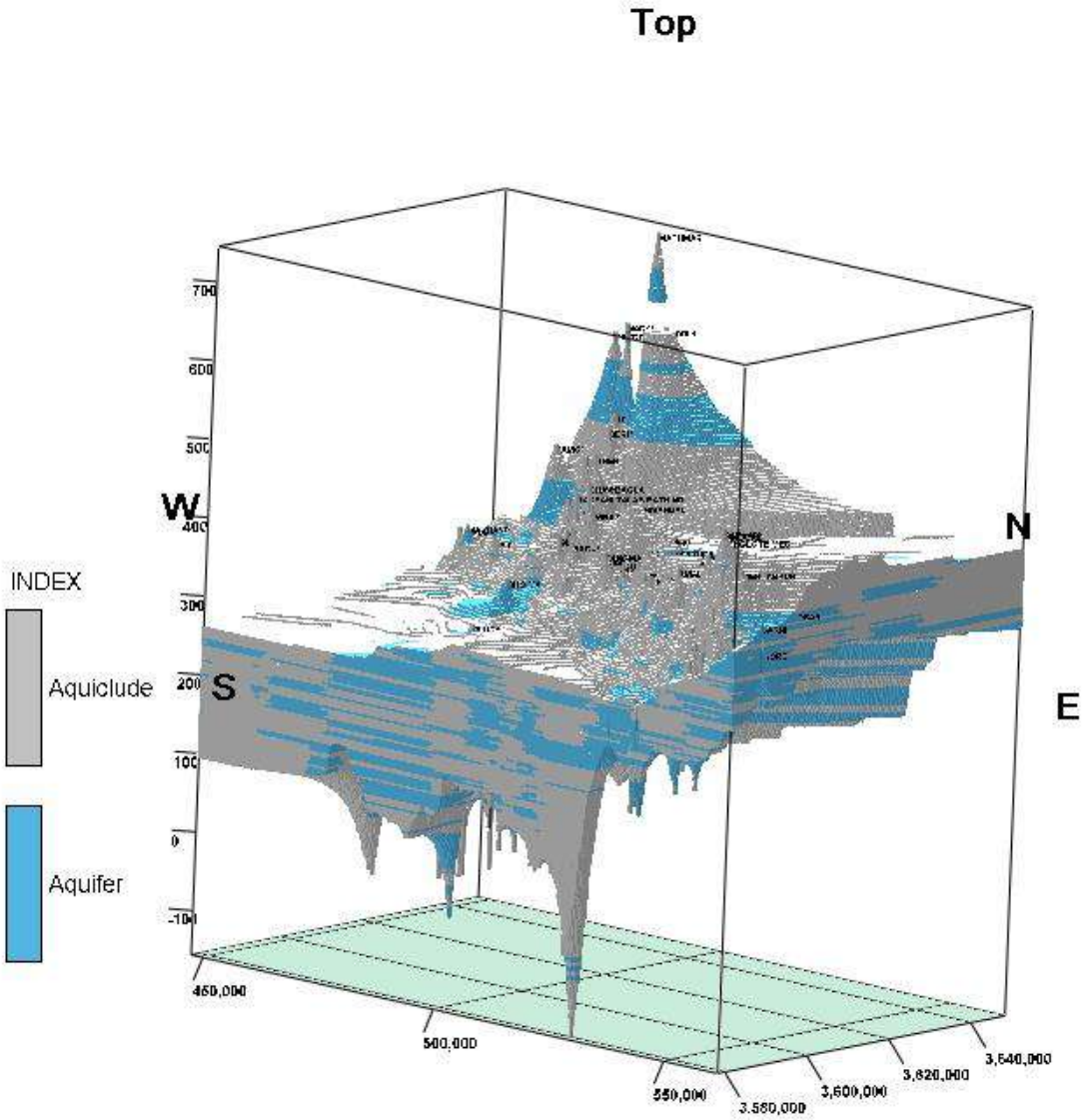

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES,
RIVER DEVELOPMENT AND GANGA REJUVINATION
CENTRAL GROUND WATER BOARD
North Western Himalayan Region
Jammu

REPORT ON
AQUIFER MAPPING IN
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(BETWEEN MUNNAWAR TAWI AND RAVI RIVERS)

CONTRIBUTORS

Sh. Vinod Sharma **Scientist D**	**:**	**Nodal Officer, Aquifer Mapping**
Sh. Kanwar P. Singh **Scientist B (Geophysics)**	**:**	**Geophysical Input**
Sh. Jitesh Tatiwal **Scientist B**	**:**	**Processing in Rockworks**
Ms. Priya Kanwar **Asstt.Hydrogeologist**	**:**	**Report Preparation,** **Data Compilation, Maps Preparation** **& Preparation of Power Point Presentations.**

PREFACE

Aquifer mapping studies have been carried out in the Outer Plains of Jammu Province, J&K State with an objective to identify and map the aquifers at micro level, quantify the availability of ground water resource and suggest Aquifer Management Plans to address the basic ground water related issues in the area. Aquifer Mapping study involves integration and analysis of multi-disciplinary scientific aspects including geological, hydrogeological, geophysical, hydrological and hydro-chemical. These studies help to characterize the quantity, quality and ground water movement in the aquifers and devise their optimal management plans. The representative area of the study was in the State of Jammu & Kashmir, forming parts of the Jammu Outer Plains in the alluvial tract and spread over an area of 3,000 Sq. Km. The study area includes parts of the present day Jammu, Samba and Kathua districts of the State.

The report on "Aquifer Mapping in Outer Plains of Jammu Province, J&K" elaborates the outcome of the Aquifer Mapping Study, in particular, the vertical and lateral extent of the aquifer units, their characteristics and response of the aquifer units to different stress conditions and their redressal through appropriate management plans. Various water stress mitigation options by integrating technical and scientific measures are also recommended for sustainable ground water development and management in the area.

The untiring efforts put forth by a team of Scientists of North Western Himalayan Region, Jammu namely Shri Vinod Sharma, Shri K.P. Singh, Shri Jitesh Tatiwal and Smt. Priya Kanwar, in bringing this report are duly appreciated, as this report would not have seen the light of the day without their hard work and dedication.

The report shall be of immense use for the planners and managers as well as academicians / researchers as a guide and reference volume in the field of Ground Water Resource Management.

Place: Jammu **Dr. Uma Kapoor**
Date : 02-09-2016 **Regional Director**

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The authors also acknowledge their sincere thanks to various State and Central Govt. Departments like Public Health & Engineering (PHE), Tube Well Irrigation (TWI), Irrigation & Flood Control (I&FC), Ravi Tawi Irrigation Complex (RTIC), Department of Geology & Mining (DGM), India Meteorological Deptt. (IMD) etc., the local administration from the study area, for providing valuable concerned data.

Last but not the least, the authors express their sincere thanks to every person, who directly or indirectly helped in carrying out this study and bringing out this report in presentable form.

REPORT ON
AQUIFER MAPPING IN
OUTER PLAINS OF JAMMU PROVINCE, J&K
(BETWEEN RIVERS MUNNAWAR TAWI AND RAVI)

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Aquifer Mapping in Outer Plains, Jammu Province, J&K

(Between Munnawar Tawi and Ravi Rivers)

1 INTRODUCTION

The delineation of aquifers along with their extent and potential through ground water surveys, exploration and monitoring is an on-going activity of Central Ground Water Board. The entire country including the valley areas of Jammu & Kashmir has already been covered under Systematic Hydrogeological Surveys to generate basic hydrogeological data. Reappraisal Hydrogeological Surveys/ Ground Water Management Studies have been conducted to study the changes in the groundwater regime over a period of time. The hydrogeological map of the entire country was compiled on 1: 2,000,000 scale and was first published in 1984. Subsequently, it was revised and again published in 2002 based on the data collected by CGWB through ground water survey, investigation and exploration program supported by exploratory drilling, geophysical investigations and hydro chemical studies. Aquifer Atlas of Jammu & Kashmir was prepared on 1:250,000 scale.

In today's scenario, increasing population, rapid urbanization and industrial development and human interventions in the ecosystem pose a challenge for water resource managers. Any strategy for management of ground water resources on sustainable basis depends on proper understanding of the characteristics of the aquifer system. In view of the emergent challenges in the ground water sector in the country, an urgent need was felt for comprehensive and realistic information pertaining to various aspects of ground water resources available in different hydro-geological settings through a process of systematic data collection, compilation, data generation, analysis and synthesis.

In view of this the micro level aquifer mapping programme has been taken up by Central Ground Water Board (CGWB) during the XII Five Year Plan. Aquifer mapping is a multidisciplinary scientific process wherein a combination of geological, hydrogeological, geophysical, hydrological and water quality data are integrated to characterize the quantity, quality and movement of ground water in the aquifers. Under the **N**ational **Aqui**fer **M**anagement Programme (NAQUIM) North Western Himalayan Region had undertaken aquifer mapping of outer plains of Jammu Province, Jammu & Kashmir.

Objectives

The objective of aquifer mapping is delineation of geometry of the underlying aquifer systems in horizontal as well as vertical domain and their characterization, estimating their yield potential and formulation of aquifer management plans to ensure water availability on sustainable basis.

Scope of the study

The scope of the present study is broadly within the framework of NAQUIM being implemented by CGWB. There are four major components of this activity viz.: (i) Data

collection /compilation (ii) Data gap analysis (iii) Data generation, and (iv) Preparation of aquifer maps and management plan.

Data compilation included collection, and wherever required procurement, of all the maps from concerned Agencies, such as the Survey of India, Geological Survey of India, State Governments, etc., computerization and analyses of all acquired data, and preparation of a knowledge base.

Identification of Data Gap was included to ascertain the requirement for further data generation in respect of hydrogeological, geophysical, chemical, hydrological studies, etc.

Data generation included those pertaining to exploratory drilling and aquifer characteristics, sub-surface geophysics, chemical quality of ground water and geophysical survey. Generation of chemical quality data of ground water was accomplished by collection of water samples and their laboratory analyses for all major parameters and heavy metals. Sub-surface geophysical studies incorporated Vertical Electrical Sounding and borehole logging.

Based on integration of data generated from various studies of hydrogeology & geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out Characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical), quality, water level and potential (quality & quantity). Finally, a suitable strategy for sustainable development and management of the aquifer in the area has been evolved based on the acquired data.

Approach and Methodology

The study involves collection of existing data from various sources including CGWB records, State Government agencies, available literature and other sources relevant for the purpose of aquifer mapping and management. During 1966-67, the Geological Survey of India (GSI) carried out Systematic geohydrological survey of the foot hill zone of Jammu and Kathua Districts. In 1967, in J&K first Ground Water Exploratory Tubewell was drilled at Keso-Kamore that falls in the current aquifer mapping area. Thereafter there has been continuous groundwater exploration in the area till date. Some other baseline reports on the project area include estimation of water resources along spring line in Kathua and Jammu Districts for drinking water supply to Kandi Region (CWC & CGWB, 2000), District Reports (1986 & 2011), report of Reappraisal Hydrogeological surveys in parts of Outer Plains (2002 & 2010), Report of a study on the water logged areas of Jammu district (2000), Ground Water Development of Urban Sector of Jammu (1999 & 2008), Hydochemistry and Pollution Study of Gangyal and Bari Brahmna (1999) and District Ground water Brochures (2011). The data was compiled, analysed, examined, synthesized and interpreted from available sources. Since these sources had predominantly non-computerized data, all the data available and collected was converted into computer based GIS data sets, which were used to prepare various thematic layers. These layers were integrated to generate aquifer maps. Finally an attempt was made to formulate aquifer management plans.

Location

An area of 3000 sq. Km. has been covered in parts of Jammu and Kathua Districts. The area under study falls along south western edge of the state of Jammu and Kashmir. The Jammu and Kathua Districts are bounded in the east by Chamba District (H.P.), Kangra District (H.P.) in south-east, Gurdaspur (Punjab) in south, Udhampur District in North and has International Border (IB) with Pakistan in the south west. The area lies between the north latitude of 32°16'12": 32°52'36" and the East longitude of 74°24'50": 75°40'32" and falls in parts of Survey of India Toposheet nos. 43L/5, 43L/9, 43L/10, 43L/13, 43L/14, 43L/15, 43P/2, 43P/3, 43P/7 and 43P/11. The area is extended between river Ravi in the East and Munnawar Tawi on the West (figure 1).

The national highway NH-1A (Delhi-Srinagar) and Pathankot - Jammu railway line connect the area with the remaining parts of the country. The area forms the part of Jammu, Samba and Kathua Districts.

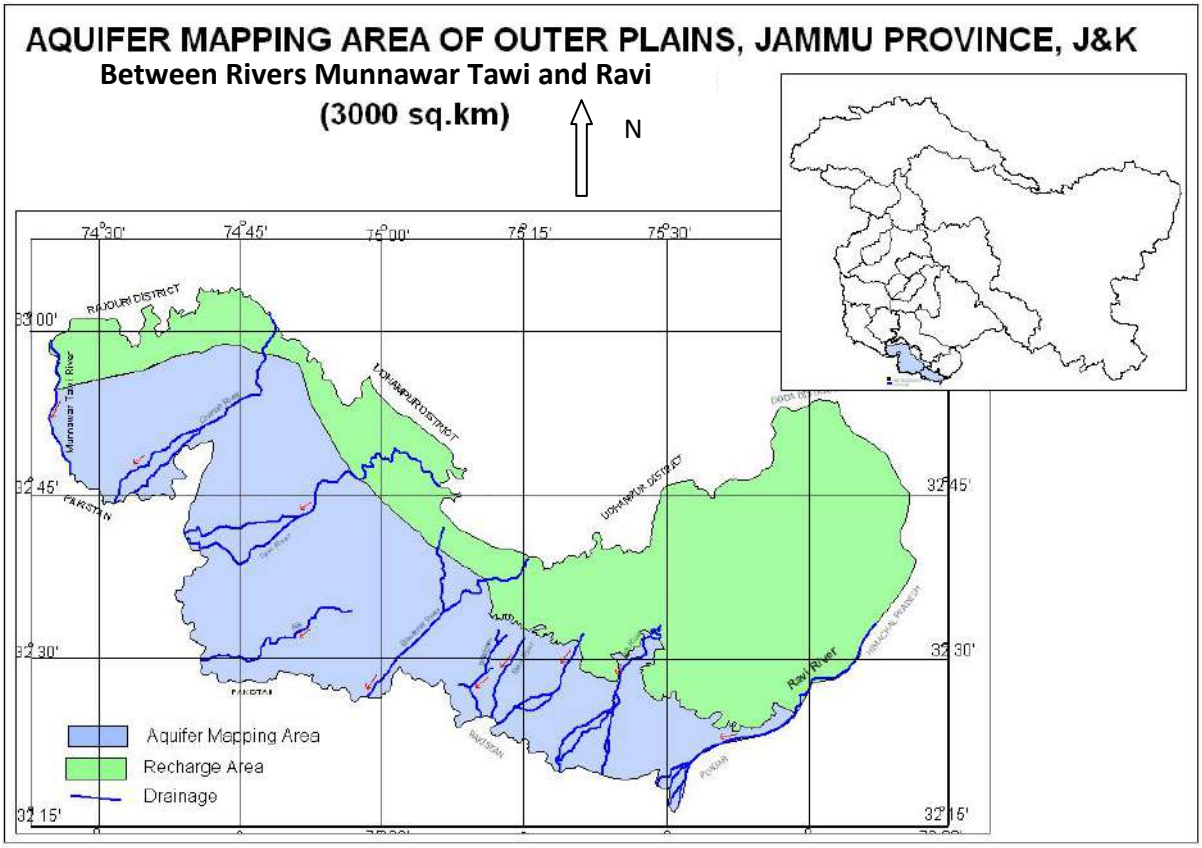


Figure 1: Location Map of Aquifer Mapping Area

Climate

The climate of the area is sub-tropical. The area experiences hot summers and severely cold winters. The average annual rainfall in the area is around 1100 millimeters of which more than 80 % is received during the monsoon period i.e. from June to September. There are winter rains also which are generally received between December and February and constitute about 10 % of the annual precipitation and only 5.6 % of the total rainfall occurs from March to May.

Physiography

The northern part of the Outer Plains is occupied by high hill ranges known as Siwalik Hills. The topography of the area is typically piedmont/alluvial deposits. The altitude of these plains varies between 280 and 440 m above mean sea level. These plains are divided in two parts parallel to Siwalik Hills throughout their length viz. Kandi and Sirowal that are equivalent to Bhabar and Tarai formations of Indo-Gangetic Plains (figure 2).

The Kandi Belt starts from the foot of the outermost Siwalik and slopes towards south and southwest. It has average width of 6 km. The Kandi Belt has steep gradient varying between 1:90 and 1:120 with an altitude of 320-440 m above mean sea level.

The Kandi Belt imperceptibly merges with the Sirowal Belt southwards. Altitude of this Sirowal belt is less than 300 m above mean sea level. It is gentler (1:250 to 1:300) than Kandi Belt because here coarser sediments are replaced by finer sediments.

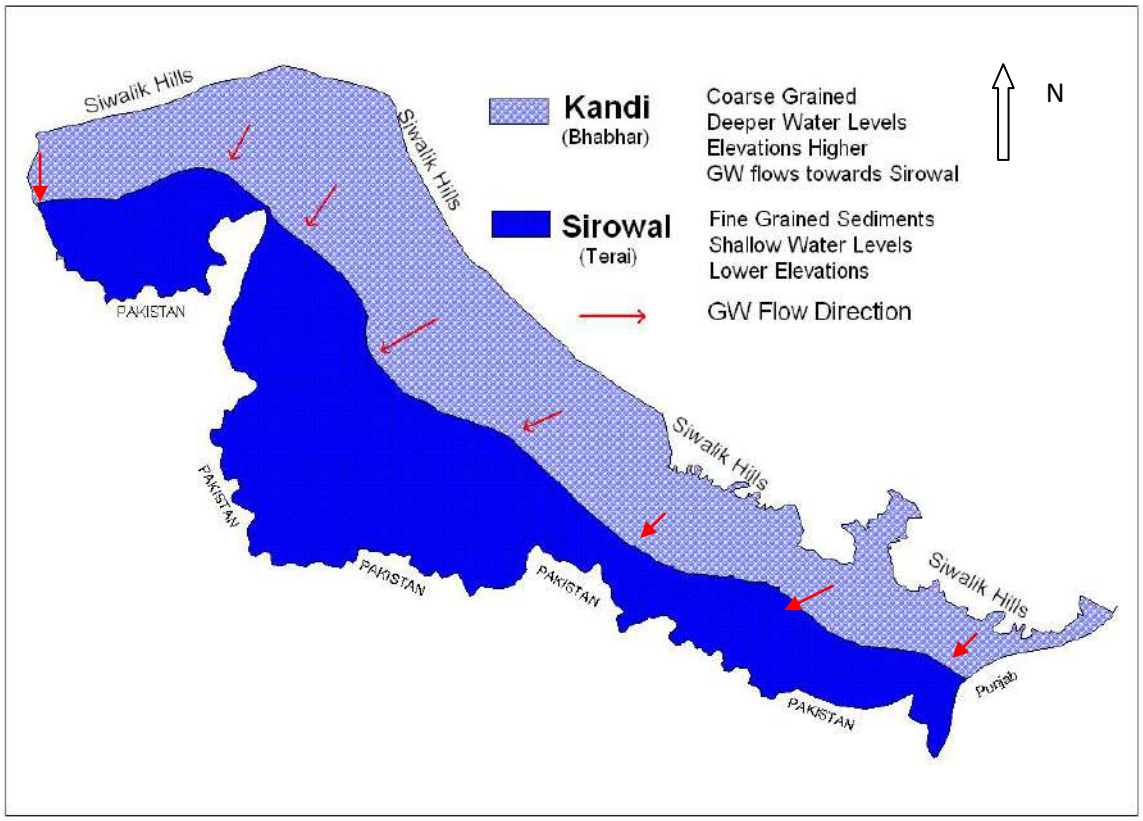


Figure 2: Formations in Outer Plain Aquifer Mapping Area

Drainage

The Munnawar Tawi, Chenab, Jammu Tawi, Aik, Devak, Basantar Bein, Tarnah, Ujh and Ravi Rivers with their tributaries drain the area (figure 3). All of them originate in the hilly tract on the north and flow in south west direction. The Munnawar Tawi and Ravi Rivers mark the north western and south eastern boundary respectively of the aquifer mapping area. All the rivers on the east of Basantar River are the tributaries of Ravi River and join it in Pakistan. The rivers on the west of Basantar River are tributaries of Jammu Tawi River which in turn is a tributary of Chenab River which flows about 35 km

west of the mapping area. Of all the rivers the Munnawar Tawi, Chenab, Jammu Tawi, Basantar, Ujh and Ravi are perennial through out their entire course in the area while the rest of the rivers are perennial in nature only in the Sirowal Tract i.e. in Kandi area rivers are dry for most parts of the year. The rivers, which are dry in Kandi tract, are seen to gain water through groundwater seepage immediately to the south-west of the spring line. Several Khuds in addition to all these rivers also traverse the area and are ephemeral and perennial in nature in Kandi and Sirowal sections respectively.

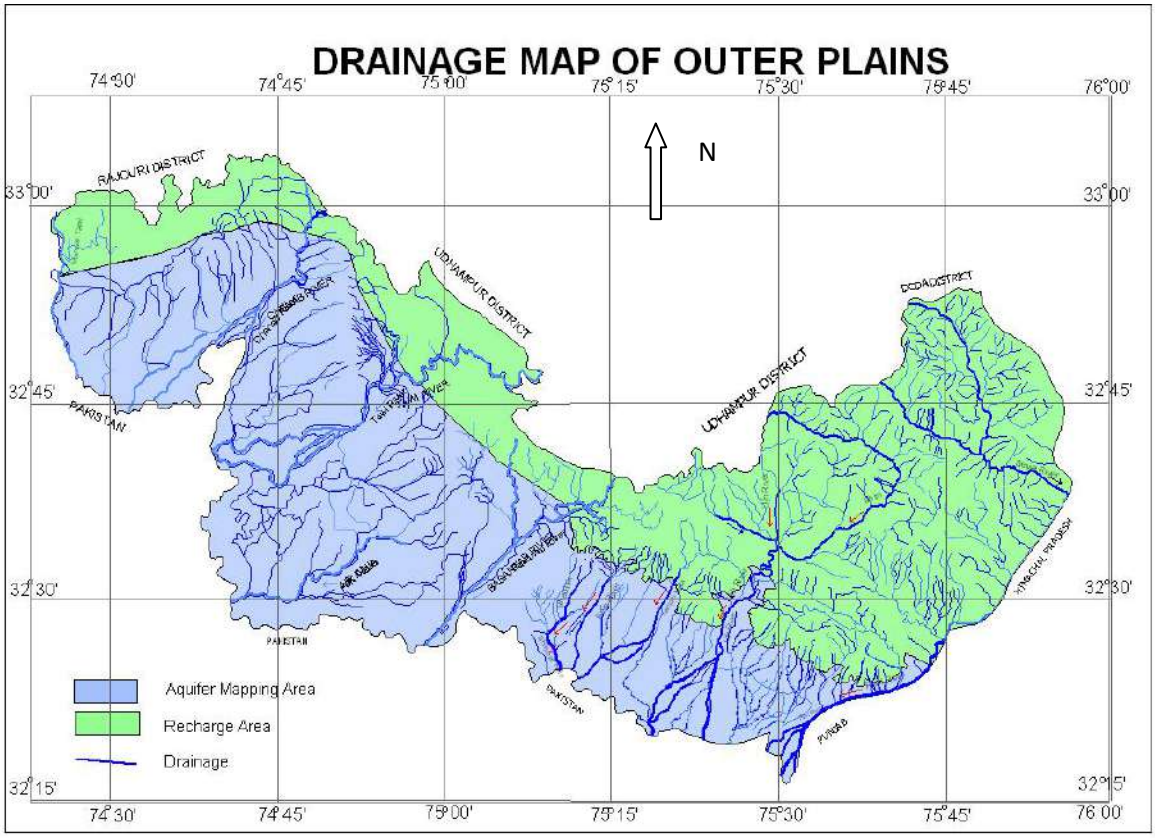


Figure 3: Drainage Map of Aquifer Mapping Area

Water Table Contours

In Kandi belt the water table lies at a great depth i.e. between 45 and 84 m bgl in deeper aquifers. However, in major part of the Kandi belt depth to water varies between 7 and 30 m bgl in unconfined zones, during pre-monsoon seasons.

In the Sirowal belt the depth to water is less than one metre to about ten metres below the land surface. In the major part of Sirowal the depth to water ranges of two to five metres below ground level. Towards south western extremity of this belt shallow water table conditions have given rise to water logging. Flowing wells at occur at Hiranagar, Rajpura, Jangi Chak, Airwan and Nagri.

The spring which roughly marks the boundary between the Kandi and the Sirowal are the locations where the water table crops out at the surface. The nalas which are dry north of this point contain water downstream. The important spring locations in the area are a) immediately to the south of Kathua. (b) section of Khateru khud immediately to the south of the old samba-Kathua road in the proximity of the villages Badal and Sherpur, (c) section of Tarnah near Bathalchak and north east of Takhatpur (d) Bein

nalla section immediately to the south of old samba Kathua road (e) north of Rajpura (f) the Babbar nalla section immediately to the north of the old samba Kathua road (g) Aik river section immediately to the south of the Pathankot Jammu national highway and (h) road bridge over Balwal Khud on the Jammu R.S. Pura road. It is observed that the spring line roughly follows 320 meter contour. In the north western part it slightly shifts south westwards.

Contours of water table and flow direction for May 2015 are shown in figure 4. Ground water moves in the direction of maximum hydraulic gradient i.e. perpendicular to water table contour. It is observed that there is variation in the rate of movement of ground water from the hills to the south west. In Kandi tract there is a general uniformity in the pattern of water table contours suggestive of homogeneity of sediments with fairly similar rate of movement of groundwater. In the Sirowal, such uniformity in pattern of water table contours is comparatively widely spaced. The movement of groundwater in Kandi and Sirowal clearly brings out the nature of streams. Most of the streams have effluent tendencies in the Sirowal.

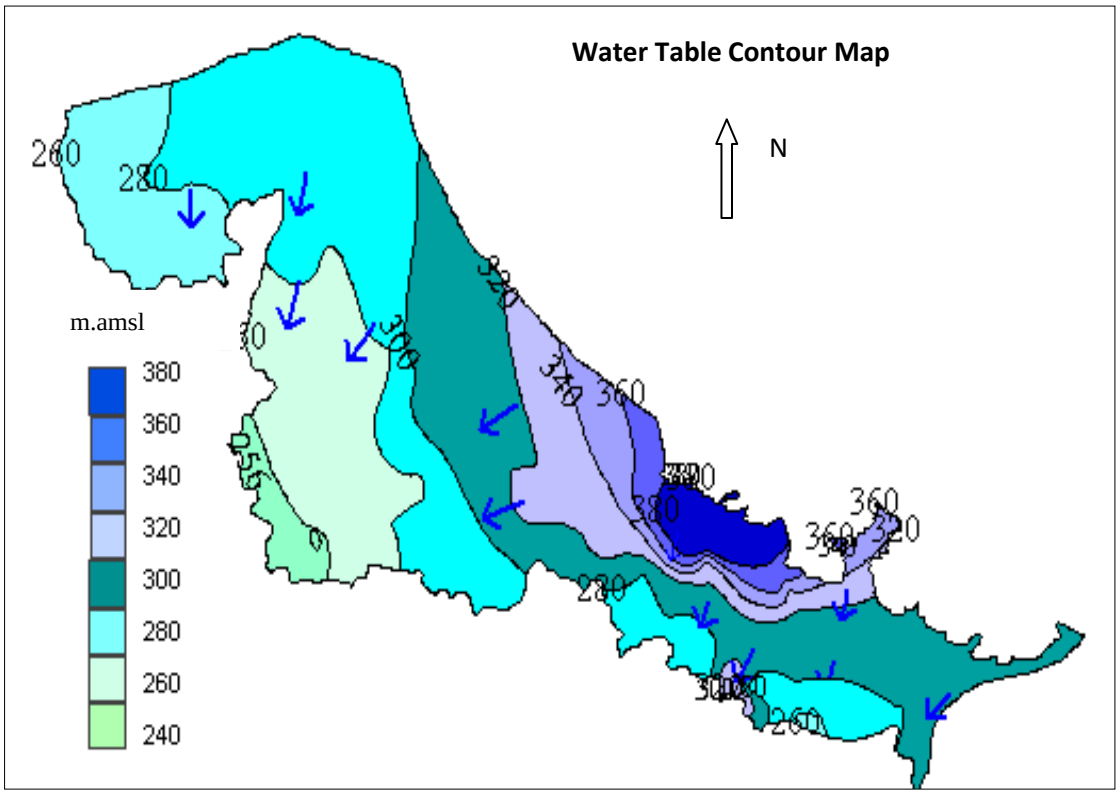


Figure 4: Water Table Contour Map of Outer Plains

Geomorphology

The different geomorphological units of the area are

Active Flood Plain

It is the youngest geomorphic unit in the study area and composed of unconsolidated river borne sediments such as pebbles, cobbles, sand, silt and clay formed by the active flood plain of the rivers Ravi, Ujh, Basantar, Jammu Tawi, Chenab and Munnawar Tawi

Braided Bar

The Munnawar Tawi, Jammu Tawi, Chenab, Basanter and Ravi Rivers exhibit braiding when they enter into the plain tract. In the plain tract, the energy available to rivers rapidly diminishes which results in the development of braided bars.

Data Gap Analysis

Geomorphological features existing in the area needs to be digitized and presented in GIS platform, by CGWB so that the same can be used in hydrogeological interpretations and formulation of ground water management plan.

Soil

Soil profile is commonly considered the upper weathered zone of the earth and characteristics invariably control the infiltration of surface water in to an aquifer system. It has a significant impact on the amount of recharge water, which can infiltrate into the ground and is directly related to the rate of infiltration, percolation and permeability. The various hydrological soil groups present in the study area are a) skeletal such as loam sandy, sandy, sandy loam b) silty loam, c) fine loamy such as sandy clay, loam and the d) fine silty soil such as clay loam, silt clay loam

Landuse

The district-wise landuse and landcover map prepared by the National Natural Resource Centre and National Remote Sensing Centre of ISRO, Hydrabad was downloaded from bhuvan-noeda.nrsc.gov.in/theme (figure 5 & 6). It has been observed that major parts of the area are covered by agricultural land. The wasteland, gullied/ravenous land is observed adjoining to the river and drainage channels. Almost whole of the aquifer mapping area has spread of settlements.

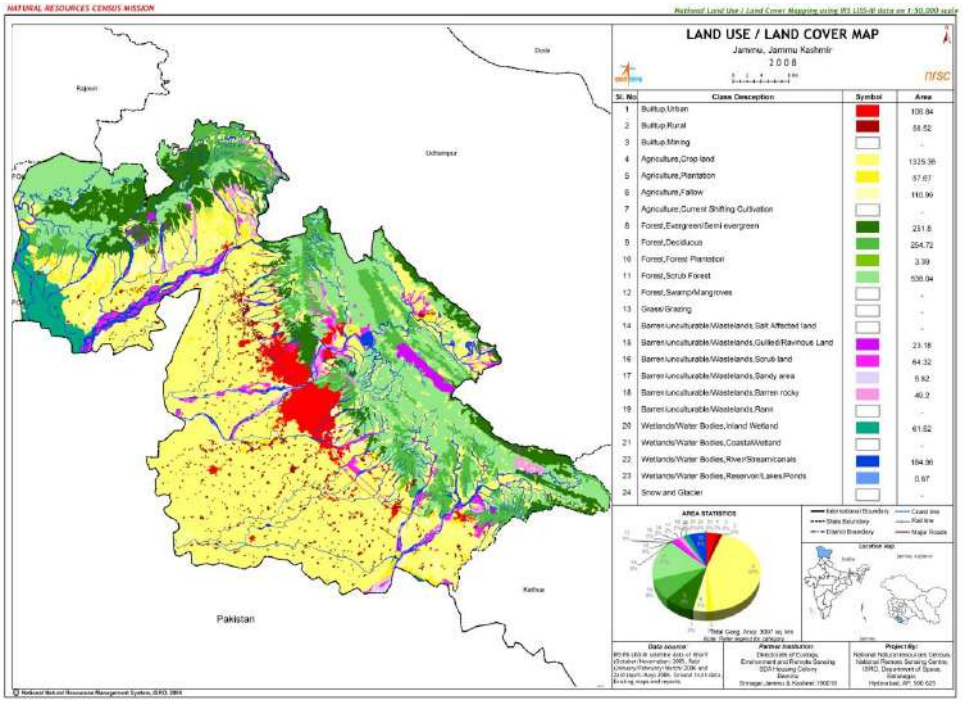


Figure 5: Landuse/ Landcover Map of Jammu District

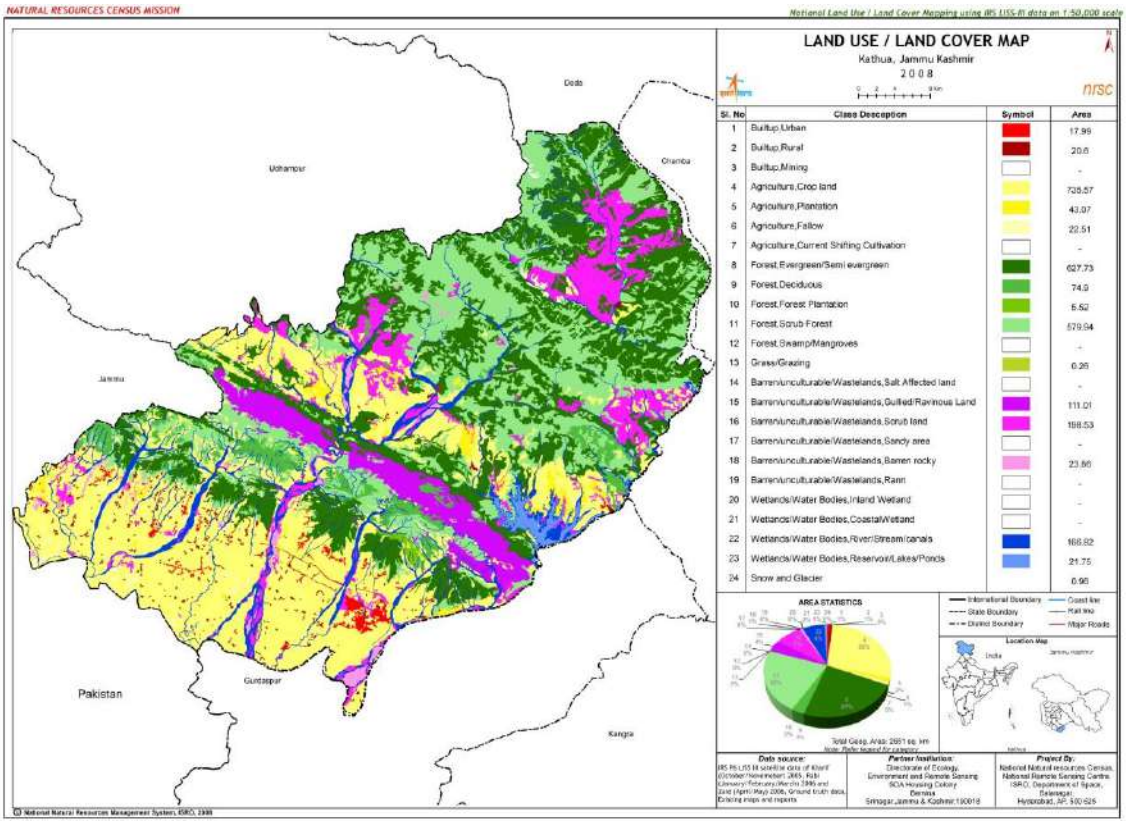


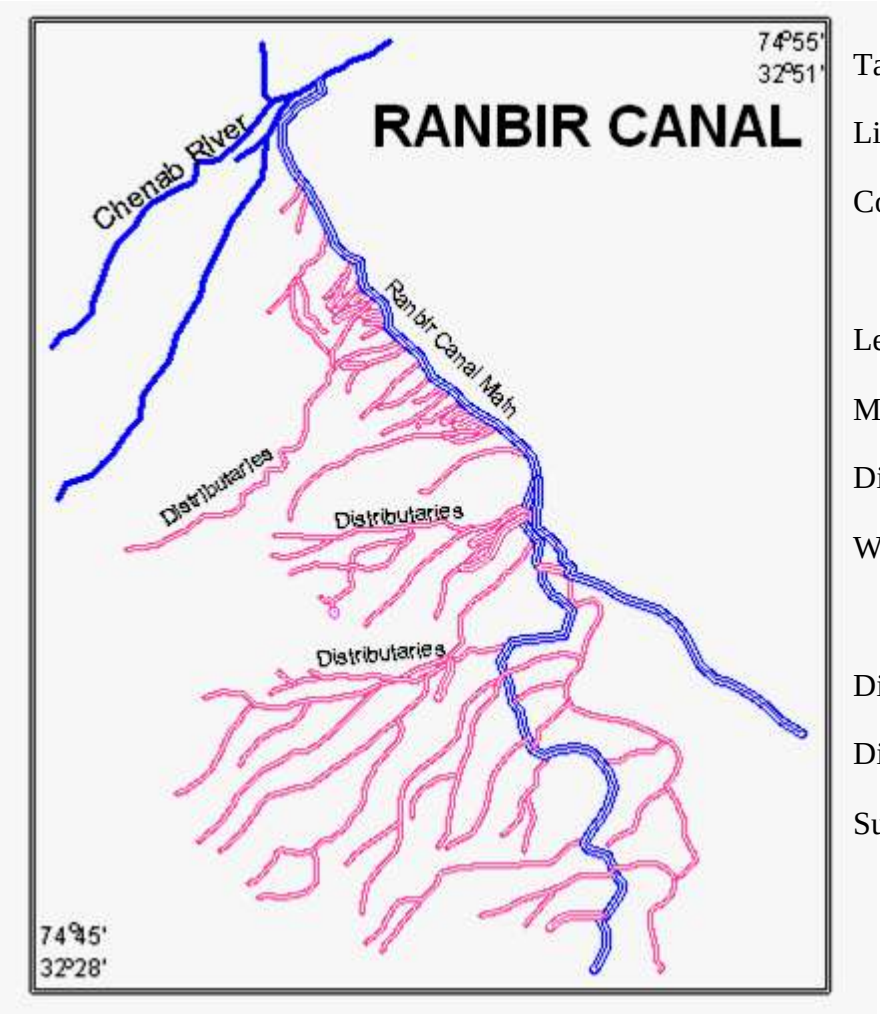
Figure 6: Landuse/ Landcover Map of Kathua District

Agriculture

Agriculture plays a vital role in the economy of the study area. The Sirowal Belt of the Jammu Outer Plain is the most fertile part and covers 73% of the cropped area. Rice is main Kharif crop which comprises 26.6 % of the total cropped area. Other Kharif crops viz. Jawar, Bajra and Maize are sown in small area. Pulses are produced in both Rabi and Kharif seasons. Wheat which constitutes 43.8% of the total cropped area is principal Rabi crop. Food crops occupy about 90% of the area. Crop water requirement of Rabi crops is met through irrigation. Paddy use additional water. (Source: Digest of Statistics 2011-12)

Irrigation

The entire area is covered by network of canals. The New Pratap Canal and Ranbir Canal take off from the river Chenab near Akhnoor. The old and new Pratap Canal irrigates the western part of the Outer Plains i.e the area between Munnawar Tawi River and Chenab River. The Ranbir Canal flows through the north western part, numerous distributaries issuing out from this main canal irrigate the north western part of the area (figure 7). A canal takes off from Tawi River near Bagh-e-Bahu fort and joins the Basantpur Canal connecting Ujh and Ravi with its distributaries, jointly called as Ravi-Tawi Canal irrigates the Sirowal Belt between the Ujh and Ravi (figure 8). Apart from this lift irrigation system, tubewells both private and government are also used for irrigation purpose.



Takes off from Akhnoor

Lifeline of Jammu

Constructed in 1905.

Lengths

Main Canal - 60 Km.

Distribution System - 400 Km.

Watercourses - 810 Km.

Distribution System

Distributaries - 17

Sub-distributaries - 22

Figure 7: Index Plan of Ranbir Canal

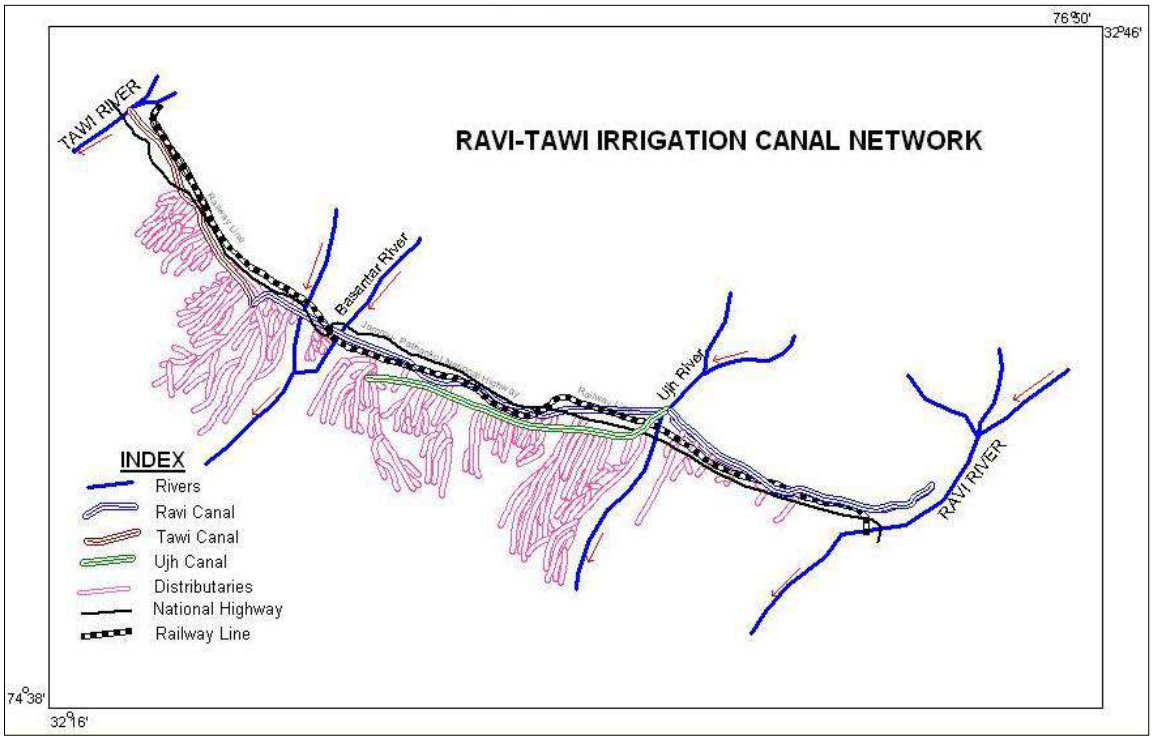


Figure 8: Index Plan of Ravi-Tawi Canal

Cropping Pattern

Agriculture is the main source of livelihood in the area as in the rest of the State. The crop calendar of the district is given in table 1.

Table 1 : Crop Calendar of the Area

S.No	Crop	Period of Sowing	Period of Harvesting
1	Rice	June to end of July	October and November
2	Jawar	April	September
3	Bajra	July	October
4	Wheat	October	April
5	Barley	October and November	April and May
6	Maize	April and May	September and October
7	Kharif	June and July	September and October
8	Rabi	October and November	April and May

Area under different crops in Hectares in Jammu district during 2012-13 is shown in table-2.

Table 2: Area under different crops in Aquifer Mapping Area

Crop	Area in 000 Ha
Rice	99,171
Bajra	17,776
Maize	38,816
Wheat	172,764
Barley	2090
Pulses	63,020
Fruits & Vegetables	2057
Oil seeds	7869
Fodder crop	18,483
Total Non Food Crops	26,391
Spices	370
Fibres	38
Total Area sown	**3,70,902**
Area sown more than once	**1,90,899**
Net Area Sown	**1,80,003**

Source: Digest of Statistics 2012-13

Water Conservation

Construction of ponds for harvesting rainwater for drinking and irrigation purposes has been a traditional way in Kandi Belt of Jammu region. Ponds played a crucial role in the Kandi Belt and were the main source of drinking water till 1960s. Most ponds were so designed that a part of the runoff from adjoining rivulets could be trapped. This helped in reduction of runoff, erosion and downstream floods. Also the ponds helped in improving the ground water levels in the surrounding area. Over the years, the design of ponds, stone pitching of their berms and the role of clay in checking heavy seepage in the highly porous Kandi Belt evolved. As per the study carried out by NIH (2000), 365 ponds exist in Kandi Belt of Outer Plains (figure 9). Out of these, 249 ponds exist in Jammu District and 116 in Kathua District. 165 ponds are perennial. By the middle of 20th century, piped drinking water supply led to the neglect of these ponds. Most of the ponds in the Kandi Belt of Jammu are in a state of utter neglect and disuse. The Village institutions, which used to organize annual desilting through voluntary labour and guards the ponds against garbage dumping / pollution, have collapsed. In some cases, drains have been diverted to the ponds.

These ponds hold great potential for harvesting rainwater in the area. Monitoring the state of village ponds is very useful in dry regions, as most of them are the only source of water supply during non-monsoon periods, and their water level is entirely constrained by the intensity of local rainfall.

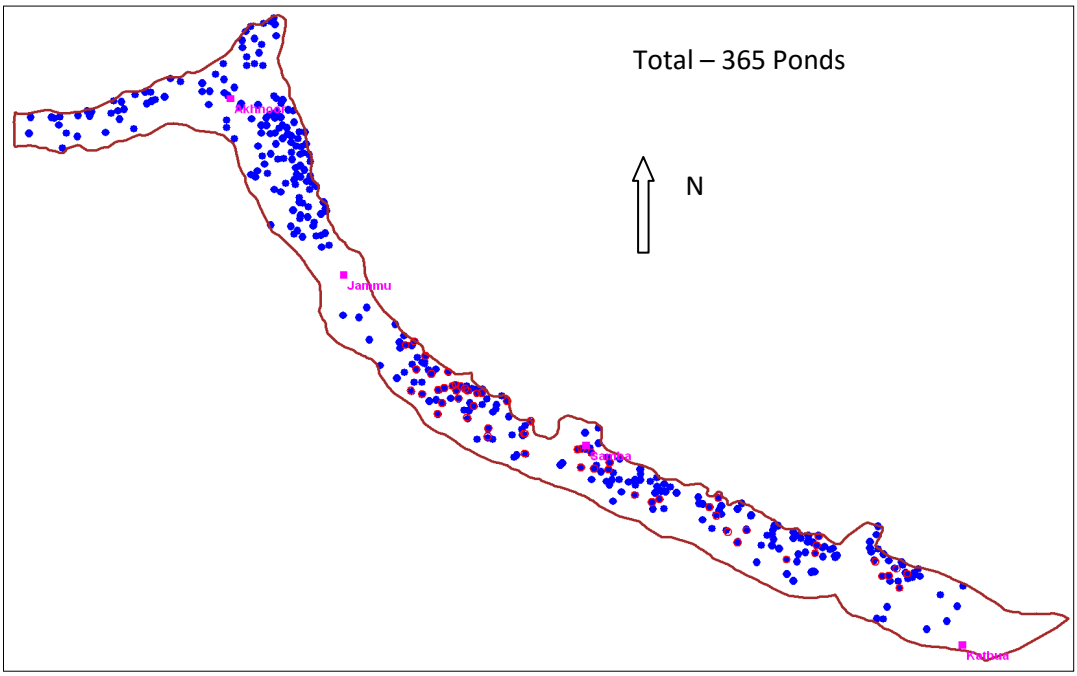


Figure 9: Locations of Ponds in Kandi Belt of Outer Plains.

Ground Water Recharge

The primary source of recharge of groundwater is rainfall. The overall pattern of water table contours and flow direction in the area is suggestive of recharge of groundwater body from north east and towards the south west. The Kandi Belt is underlain by boulder, gravel, which acts as a very good medium for the recharge of groundwater body.

The Ranbir canal and the Basantpur canal with their distributaries irrigate a part of the Sirowal Belt. These canals also play a vital rule in recharging the groundwater.

Data Availability

The compiled data were plotted on 1:50000 scale map and an analysis of data gap was carried out. The summarized table presenting the data requirement, data availability and data gap analysis is presented in table 3.

Table 3. Data Availability and Data Gap Analysis in Aquifer Mapping Area

S. No.	Items	Data Requirement	Data Availability	Data Gap
1.	Rainfall Data	Meterological Stations spread over the project area	District-wise Rainfall Data	No Data Gap
2.	Soil	Soil map and Soil Infiltration Rate	Not Available on any Scale	Soil Infiltration Rate across study area
3.	Land use	Latest Land Use pattern	Land use data of 2002-03	Latest data required in GIS Platform
4.	Geomorphology	Digitized Geomorphological map	Downloaded from NRSC, ISRO, Hydrabad.	To obtain digitised Geomorphological map
5.	Geophysics	Geophyiscal data in each Quadrant	87 VES	117 VES
6.	Exploration Data	EW in each Quadrant with Aquifer Parameters	140 EW's	Deep EW's especially in Kandi Belt **(Annexure I)**
7.	Aquifer Parameters	Aquifer parameters for all the quadrants	Only 30% wells	
8.	Recharge Parameters	Recharge parameters for different soil and aquifer types based on field studies	Recharge parameters given in Resources Estimation	
9.	Discharge Parameters / Draft Data	Discharge parameters for different GW abstraction structures	Discharge parameters given in Resources Estimation	
10.	Geology	All the maps on 1:50,000 Scale. Hard and digitized copies.	Hard copies of only few geological maps	Soft copies of entire study area

2 DATA COLLECTION AND GENERATION

Data on various attributes of Aquifer Mapping has been generated based on the data availability and data gap analysis discussed in previous section. The data generated and data collected from various state government departments is summarized in table 4.

Table 4. Data Generated and Data Collected for Aquifer Mapping Area

S. No.	Items	Data Generated	Data Collected
1	Rainfall Data		2 metereological stations
2	Geophysical data	Carried out 70 VES, 6 E-logging	Geophysical data is not available with any other department in the State.
3	GW Exploration	Construction of 14 EW and 6 OW. Carried out Pumping Tests for determination of Aquifer parameters	Tubewell details of about 300 wells collected from State Government Departments (PHE and I & FC)
4	GW Regime Monitoring	Established additional 68 monitoring stations. Total 146 monitoring Stations in the aquifer mapping area	Monitoring data not available with any other Department

Rainfall

Rainfall data collected from IMD for 110 years (1901-2011) have been analyzed. It is observed that the average annual rainfall of the aquifer mapping area is 1151 mm. The area experienced rainfall less than 500 mm in 7 years of which the lowest rainfall in Jammu was observed in 1963 viz. 375 mm and in Kathua in 1952 viz. 401 mm. Of 110 years more than 1000 mm of rainfall was received in more than 20 years. The highest rainfall received by Jammu District i.e 1469 mm was in 2011 and by Kathua District in 2007 viz. 1854 mm (figure 10).

Rainfall occurs between June to September due to south-west monsoon. Winter rainfall occurs in the months of December to March During this period rains occur mainly due to the western disturbances. It is extra tropical storm that brings sudden winter rain and snow to the north-western parts of the Indian subcontinent.

The departures and the cumulative departures of the yearly rainfall from the long term mean (1901-2011) has been calculated and given in Annexure II. For departures and cumulative departures curves are also drawn (figure 11). The departure percentage of the rainfall from long term mean rainfall for Jammu and Kathua Districts ranges from -73.1 to 193.9 and -74.7 to 227.7 respectively.

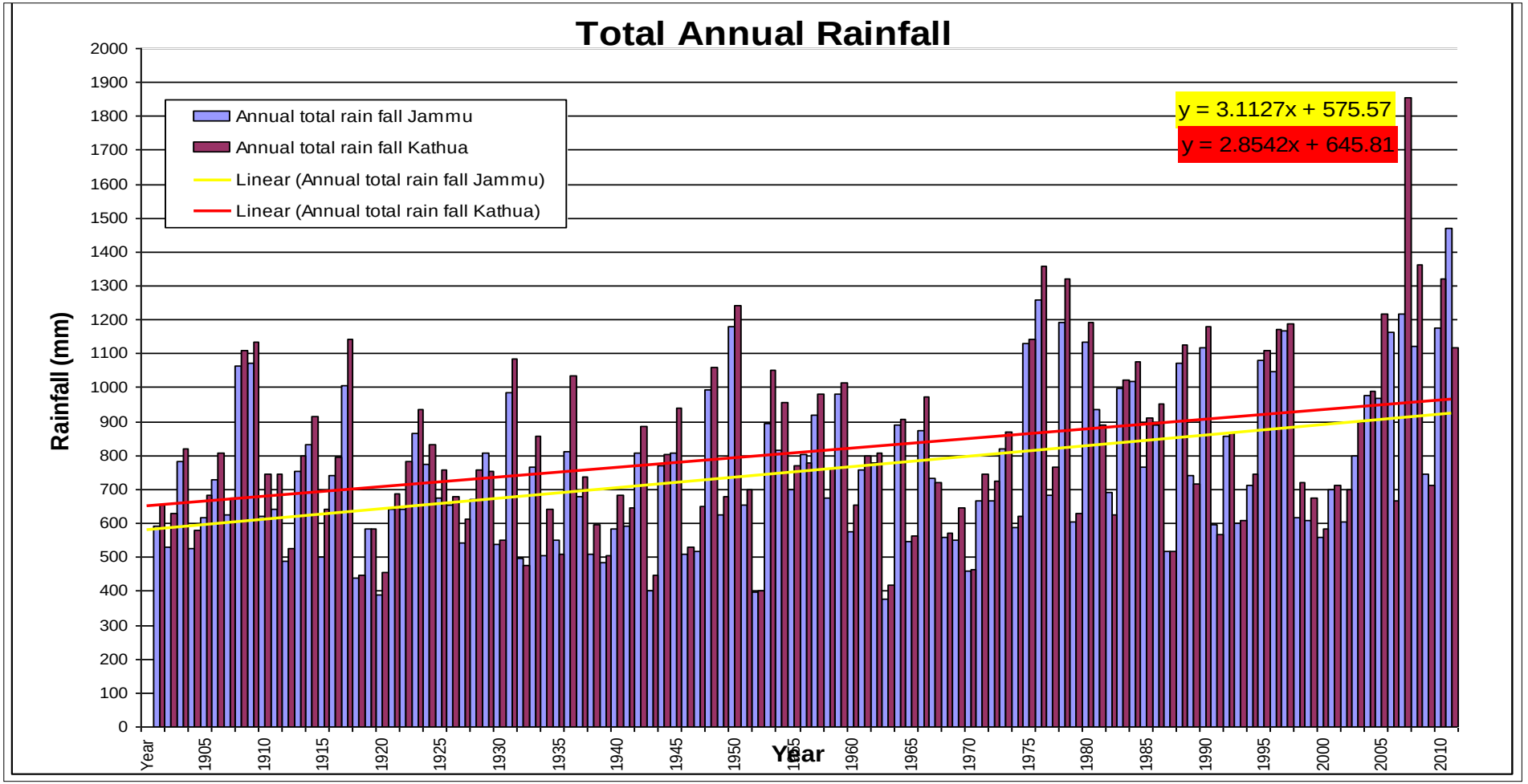


Figure 10: Total Annual Rainfall of Jammu and Kathua Districts

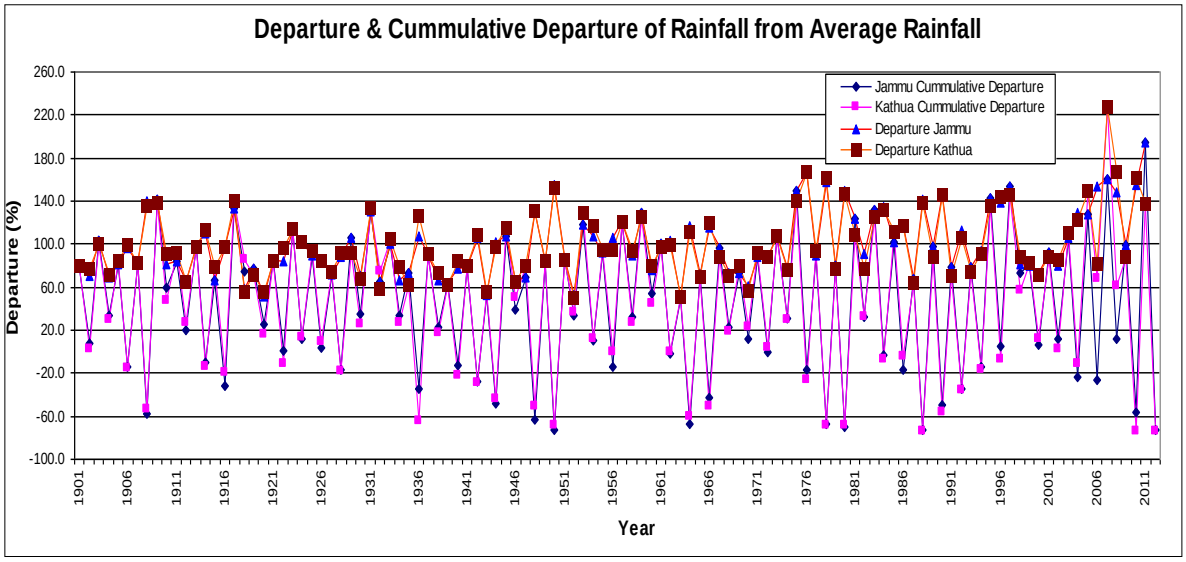


Figure 11. Departures, Cummalative Departures from Average Rainfall.

Water Level Monitoring

At the onset of the aquifer mapping in 2012, 88 monitoring wells including dugwells and piezometers existed for water level measurement. Inventory of 85 wells was done during field survey of the aquifer mapping area. Out of these 85 stations, 58 were selected for inclusion in the monitoring network making the network denser. A total of 146 monitoring wells were therefore monitored to study the impact of various development related activities on the ground water regime. Locations of monitoring wells are shown in figure 12.

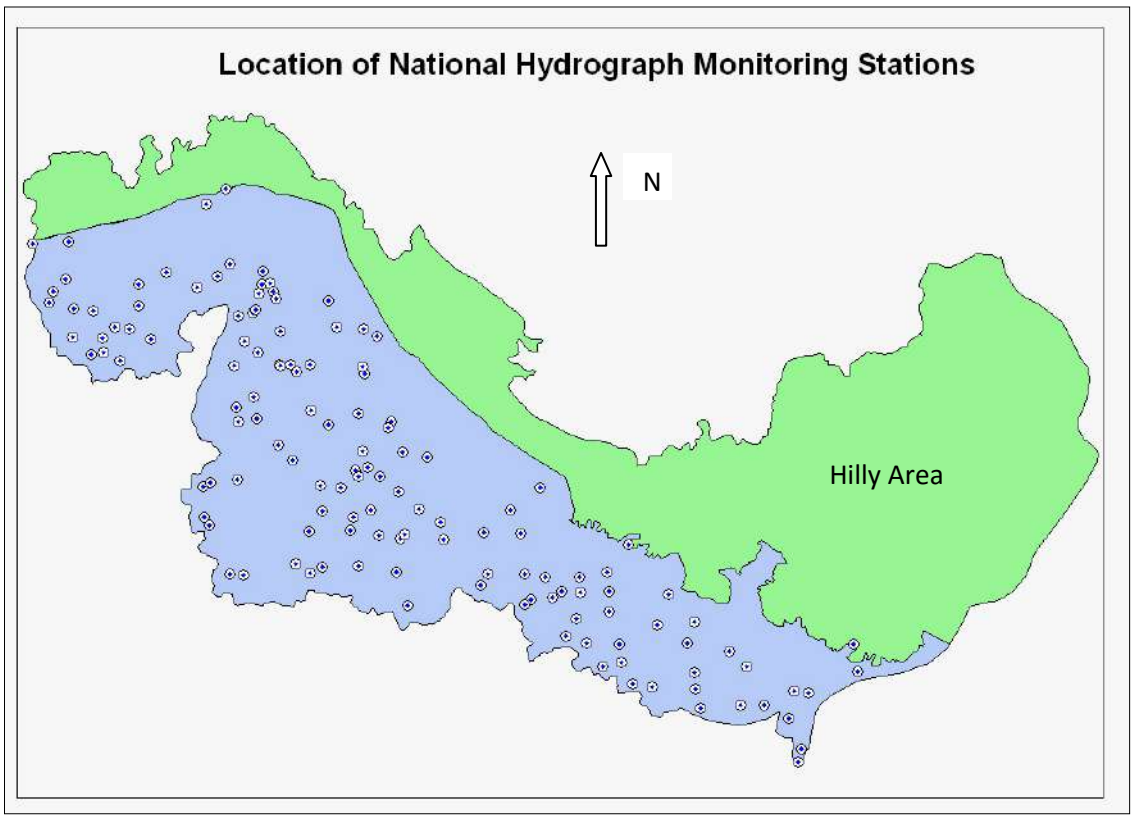


Figure 12 : Locations of Monitoring Stations

Decadal Fluctuation

The water level fluctuation for the month of May 2013 w.r.t. (May 2003 to May 2012) has been worked out, which shows that there is falling trend of water levels in Kandi belt in the range of 2 m except for the Kootah area where fall is more than 4 m has been observed. In Kathua District, decline in water levels has been observed in the range of 2 m in Sirowal belt also except for a few patches where there is a rise in the range of 2 m. In Pallanwala area, there is a rise in Kandi belt which extends in the Sirowal Belt of Jammu District (figure 13).

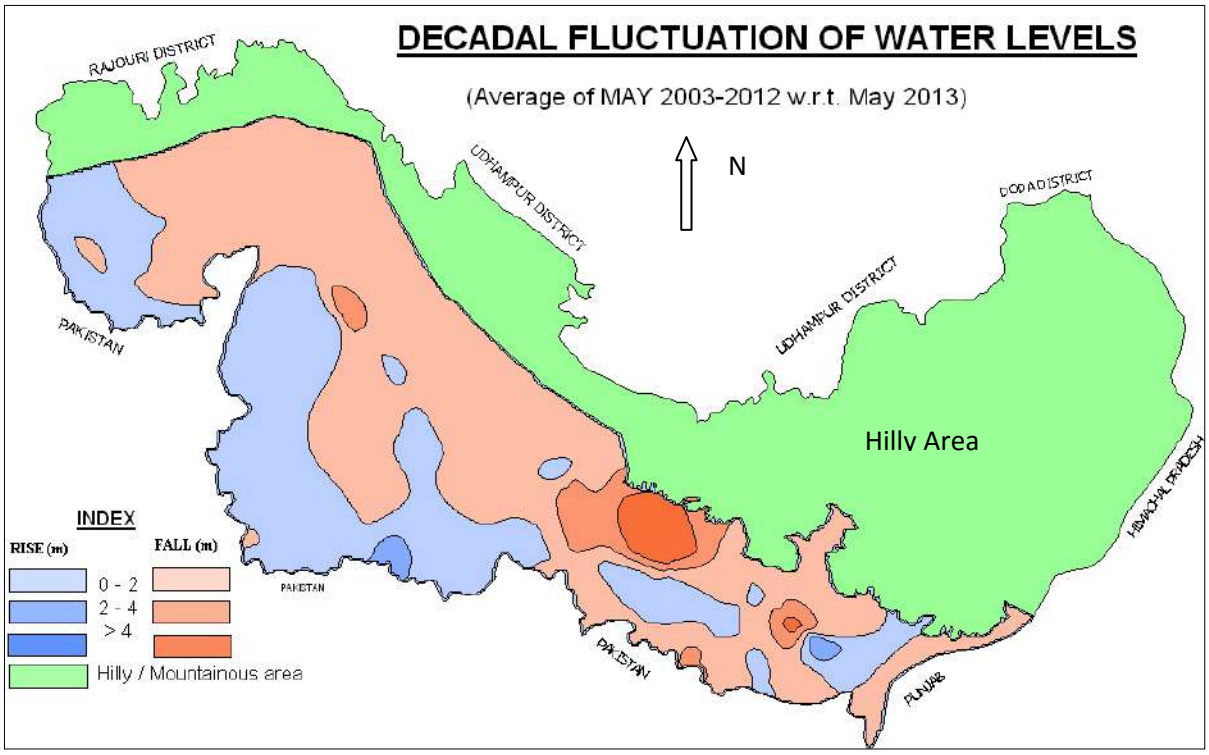


Figure 13: Decadal Fluctuation Map of Aquifer Mapping Area

Water Quality

The basic chemical parameters determined for evaluating the groundwater quality of Outer Plains are pH, EC, CO_3, HCO_3, Cl, NO_3, $S0_4$, F, Ca, Mg, TH, Na, K, TDS, Alkalinity and Fe. Water samples were collected from both dug wells and tubewells. The chemical analysis results are given in Annexure-III. The water quality distribution maps for EC, Nitrate and Iron were prepared and it was observed that overall quality of ground water is fresh and potable except for a few localized patches where higher concentrations of EC, Nitrate and Iron have been reported.

Electrical Conductivity in the area varies from 180 µS/cm at 25˚C at Lakhanpur to 2400 µS/cm at 25˚C. EC > 2250 µS/cm at 25˚C has been observed at Londhi, Kathua District (figure 14).

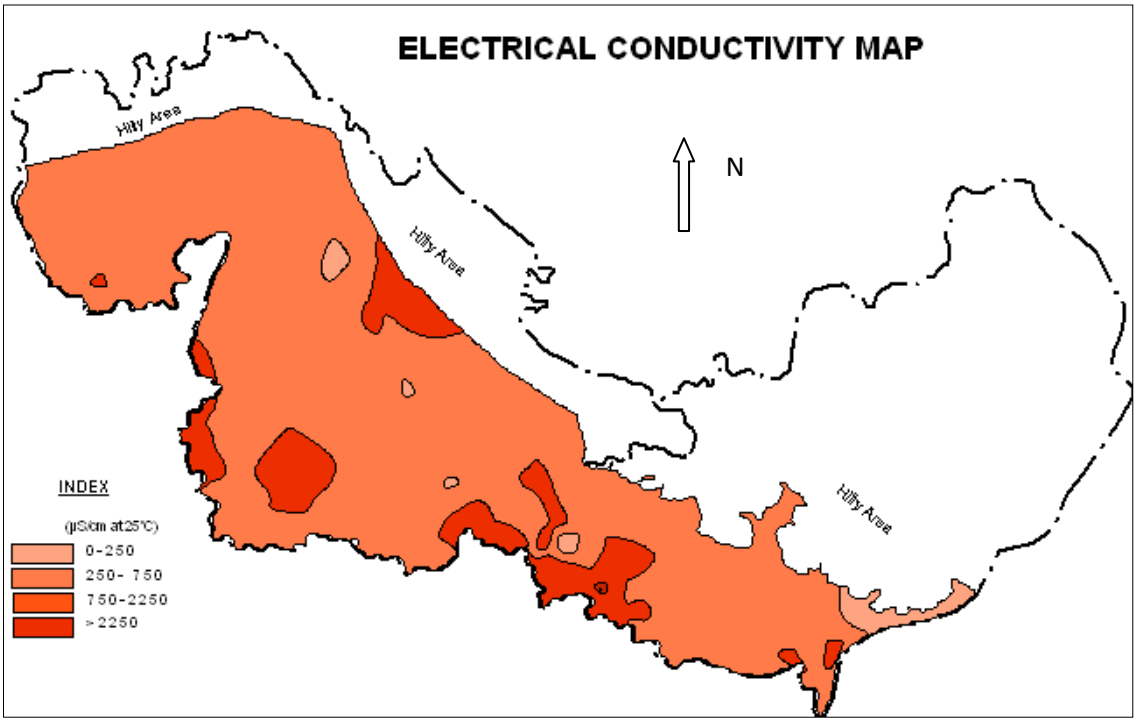


Figure 14 : Electrical Conductivity Map

Nitrate Concentration in most part of the study area is well within the permissible limit of BIS viz. 45 mg/l. It varies from nil at Nikowal to 216 mg/l at Hamirpur Kohna. Higher concentrations of Nitrate have been reported from isolated pockets in Gangu Chak (178), Jandi (106), Londi (121), Bega (115), Jaswan (134), Hamirpur Kohna (216), Dhanpur (115) (figure 15).

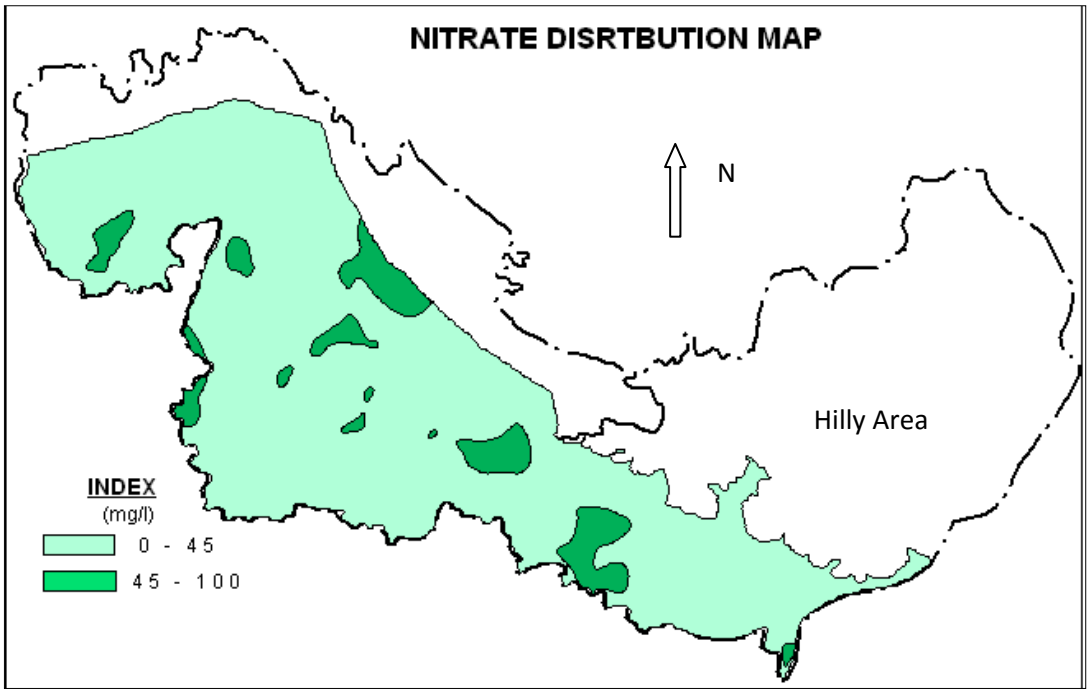


Figure 15 : Nitrate Distribution Map

Iron concentration varies from nil at Kotli Charkan to 4.98 mg/ at Gajansoo, in Kathua District. In most parts of the Outer Plains Iron concentration is within the permissible

limit of 0.3 mg/l. The localities where the concentration of Iron is more that 0.3 mg/l are shown in figure 16.

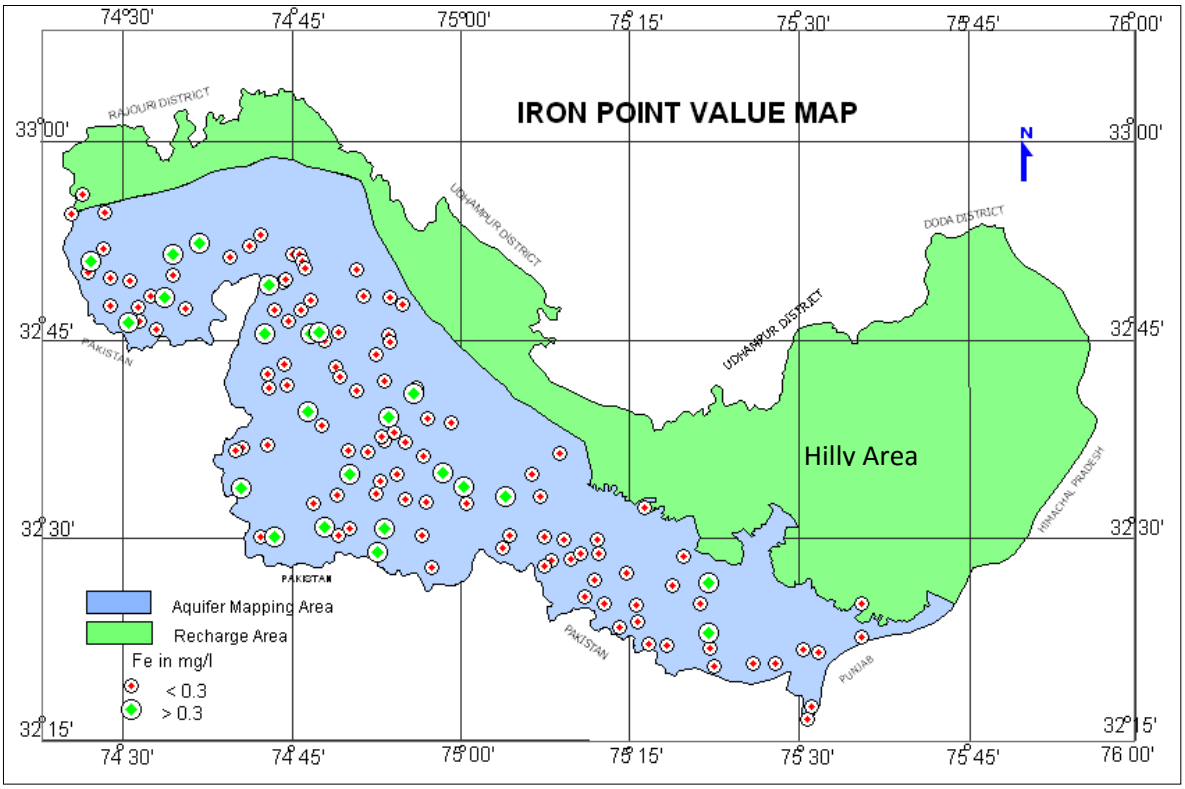


Figure 16: Iron Distribution Map

Ground water Pollution study was carried out in the Bari Brahamana Industrial area, District Samba, J&K. Bari Brahamana industrial area is situated at 10-20 kms south east of Jammu city. The study was carried out in 5 square kilometer area. A total of 42 numbers of samples were collected from shallow, deep ground water aquifers and effluent/drain. The water samples were analysed for trace elements.

The concentrations of Copper, Zinc and Chromium for all the samples meet the maximum permissible limit (MPL) of BIS. The concentration of Iron, Manganese, Nickel, and Lead were found more than MPL of BIS in pre as well as post-monsoon seasons. The iron and steel manufacturing units are the main polluting source of Manganese. Its concentration is found more than MPL of BIS in one sample during pre-monsoon and in three samples during post-monsoon season. Nickel and Cadmium are released in atmosphere from iron and steel furnaces or from effluents of electroplating wastes, nickel and steel alloy industries, dyes and textiles and nickel-cadmium batteries. Effluents of industries of paints, batteries, printing and dyeing are the sources of lead in ground water. The locations of sampling sites from where concentration of heavy metals like Iron, Manganese, Lead and Nickel are found to be more than maximum permissible limit (MPL) are shown in figure 17 and 18.

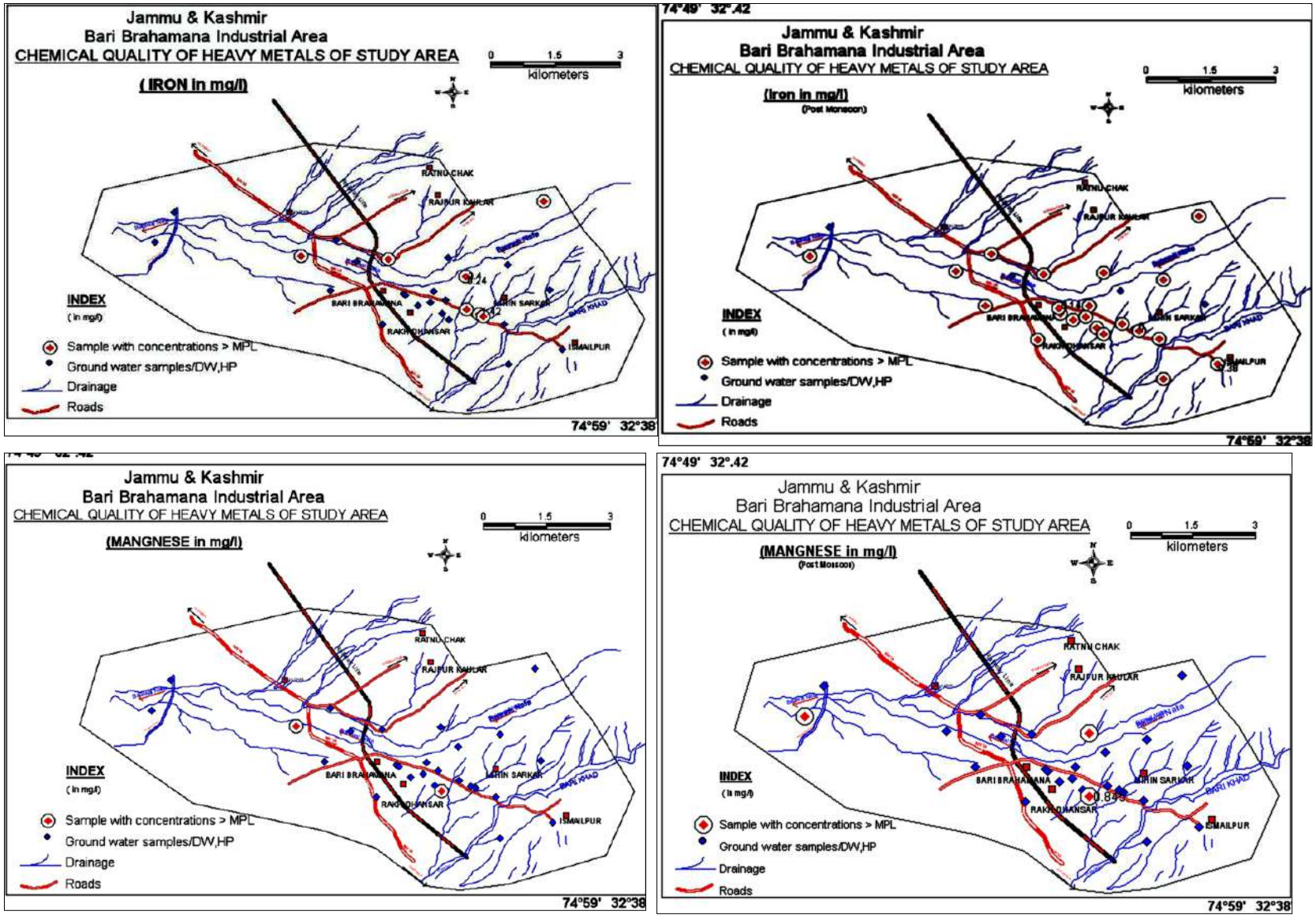


Figure 17: Iron and Manganese Concentration in Bari Brahmna Industrial Area

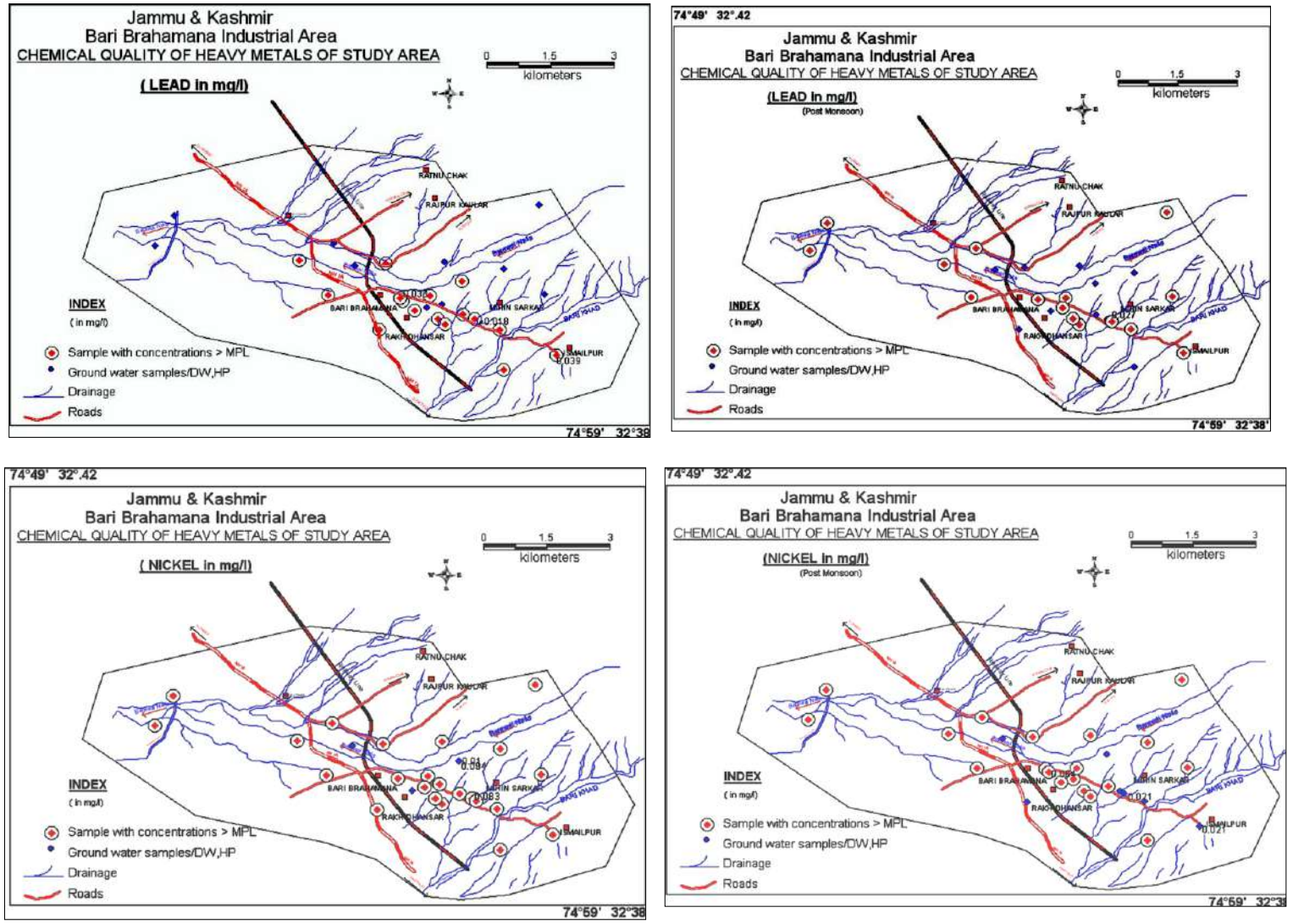


Figure 18: Concentration of lead and Nickel at the sampling sites, Bari Brahmna Industrial Area.

Geophysics

Geophysical studies carried out in the Outer Plain area includes VES and need based Borehole Electrical Loggings. As per the Data Gap Analysis carried out upto March-2013, the geophysical data available is 87 VES and data gap i.e. required VES are 117. A total of 97 E-logs are also available for this area (Jammu – 78 & Kathua -19). From AAP 2013-14 onwards, a total of 51 VES and 5 nos. of electrical loggings were conducted in this aquifer mapping area. Locations of VES are shown in figure 19.

The electrical resistivity survey in parts of Jammu and Kathua Districts reveals the lithology down to depth of 300 - 320 m below the surface. The resistivity soundings indicates high resistivity value of 1260 to 1350 Ohm-metre, near surface followed by a sharp fall in resistivity down to a depth of 200 metres which is suggestive of loose boulders, cobbles pebbles etc. at the top followed by sand, gravel, cobbles etc., with increase in percentage of clay content. Beyond a depth 200 m bgl, the presence of highly conducting layer (probably clay mixed sediments) is indicated.

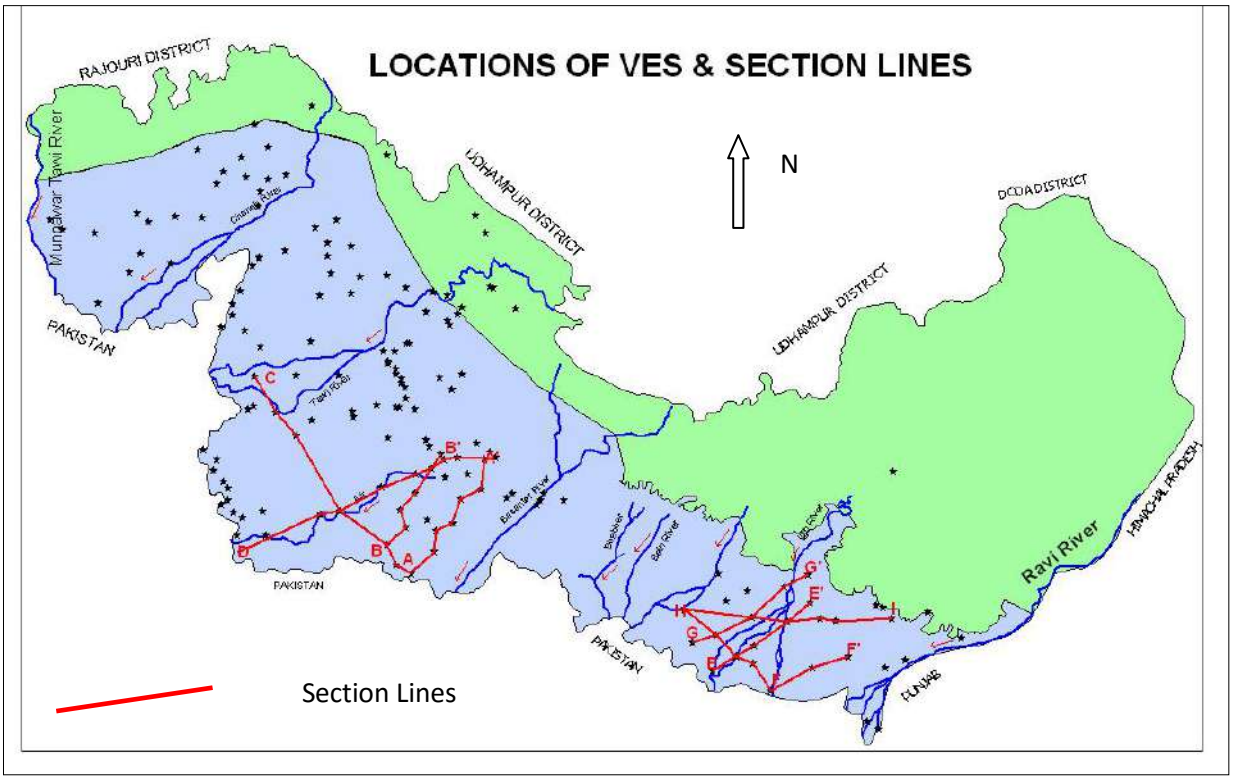


Figure 19 : Locations of VES in Aquifer Mapping Area

Geo-electrical cross-sections are drawn. A-A' cross-section is between SM Pur and Sunghwal by joining the resistivity surveys conducted in between at Dhupsari – Radwan – Sarwa - Chak Baglan and Channi Manhasan (figure 20). This section reveals that the harder sediments in the Sunghwal area extend up to Sarwa and consist of coarser Kandi sediments with higher resistivity values as compared to the sediments found at the lower gradients towards SM Pur, which consist of fine to medium sand of low resistivity values.

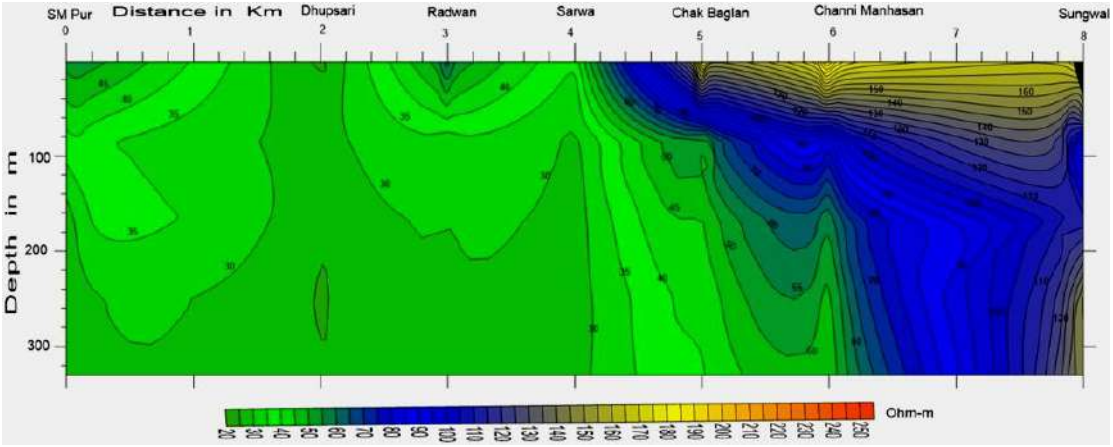


Figure 20: Geo-electric Cross Section along A – A'

Cross section has been drawn along B-B' between Deolichak and Tarore by joining the resistivity surveys conducted at Stake Chak - Chak Chimna - Majua and Gadwal (figure 21). This section reveals that the coarser sediments at Tarore area is having higher resistivity values from 340 to 140 ohm m. In Gadwal area, abrupt decline in the resistivity values gives the feel of Sirowal sediments of finer nature but at Majua the higher resistivity values of 500 ohm m reveal the extension of coarser Kandi sediments upto Chak Chimna after which the Sirowal formations of finer sediments extend far beyond. It can also be inferred that from Chak Chimna to Chak Deoli, there is a thick clay layer at the depth of around 250 m bgl.

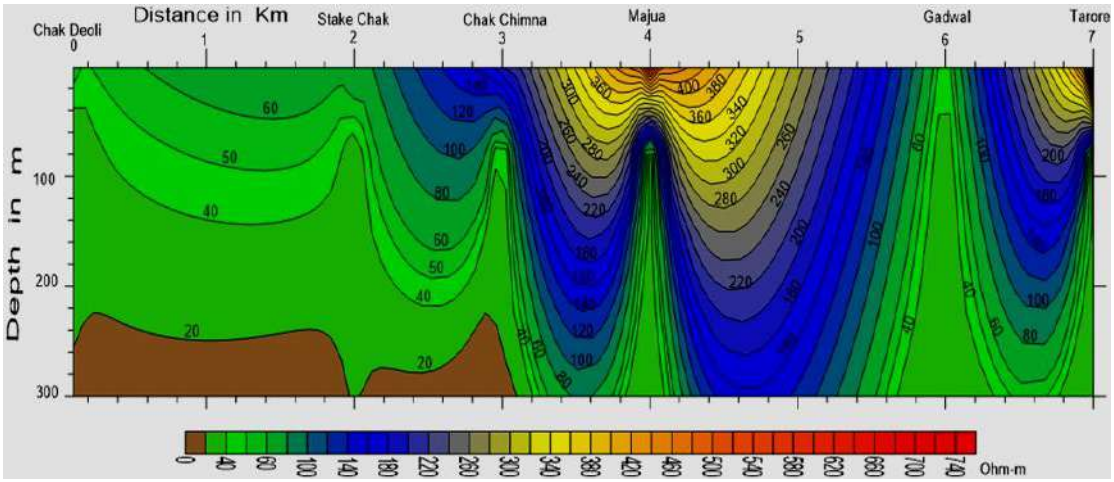


Figure 21: Geo-electric Cross Section along B – B'

Cross sections C - C' has been drawn is between Makwal and SM Pur by joining the resistivity surveys conducted at Kadyal - Gurah Kullian – Pachel - Deoli and Chamliyal (figure 22). The consistent low resistivity values throughout the section indicates the

presence of finer Sirowal sediments consisting of coarse to fine sand deposits in this section. However, The presence of some coarser sediments is indicated by the resistivity values that are quite higher in Makwal and Kadyal areas as they fall in the flood plain of Tawi River.

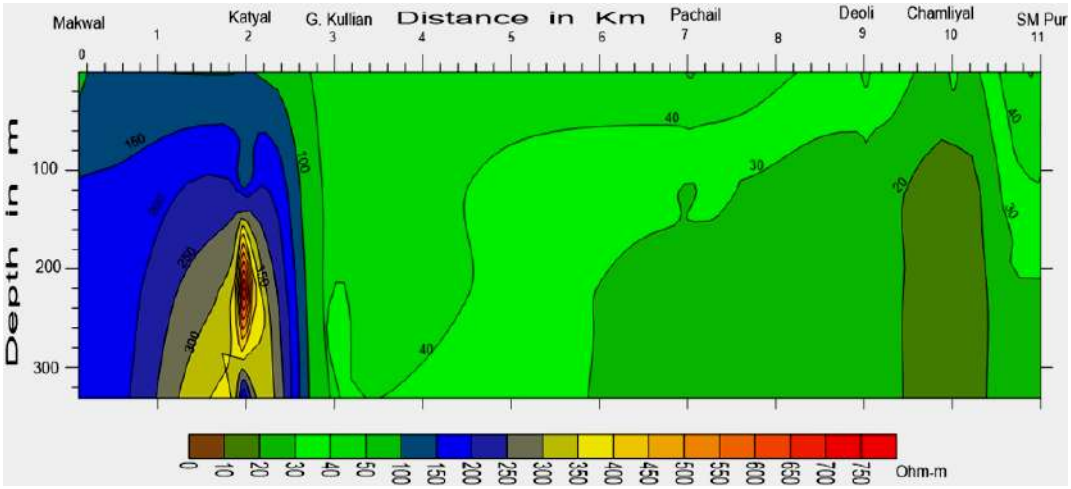


Figure 22: Geo-electric Cross Section along C – C'

Cross sections are drawn D-D' is between Chamliyal to Channi Manhasan by joining the resistivity surveys conducted at SM Pur - Dhupsari – Radwan Kalan - Sarwa and Chak Baglan (figure 23). The consistent low resistivity values throughout the section indicates the presence of finer Sirowal sediments consisting of coarse to fine sand deposits. The presence of high resistivity values at Chak Baglan and Channi Manhasan can be attributed to the coarser sediments deposited there.

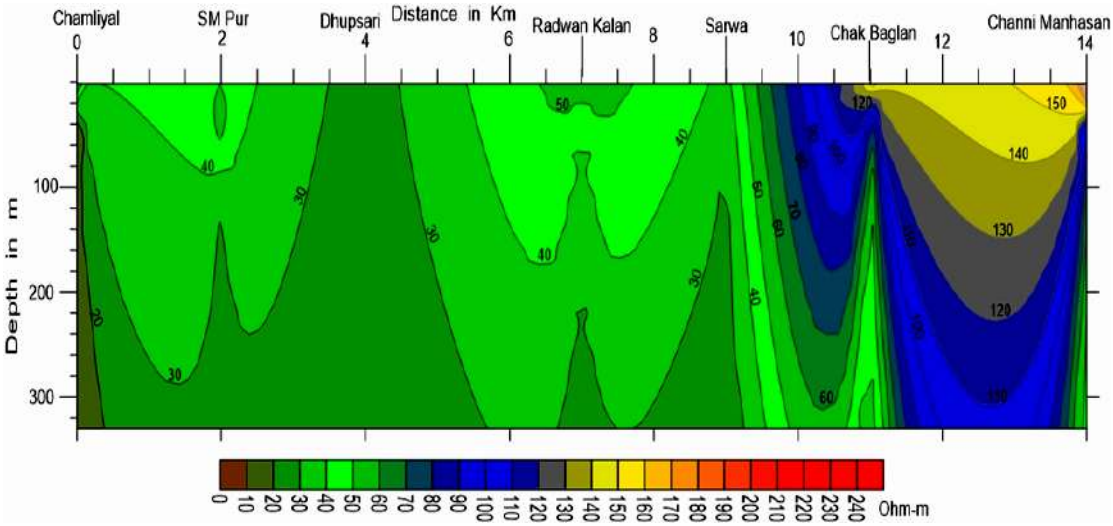


Figure 23: Geo-electric Cross Section along D – D'

Geo-electrical cross section E-E' drawn between Sei to Raya by joining the resistivity surveys conducted at Arnia – Pachail – Rehal – Khojipur – Gadwal - Raya Morh and Suchani, clearly shows that the section traverses through the fine to medium sand deposits dominated area as shown by consistent low resistivity values throughout the section (figure 24). The presence of medium to high resistivity values at shallow depths of Arnia, Rehal, Khojipur and Suchani can be attributed to the coarser sediments deposited by local drainage there.

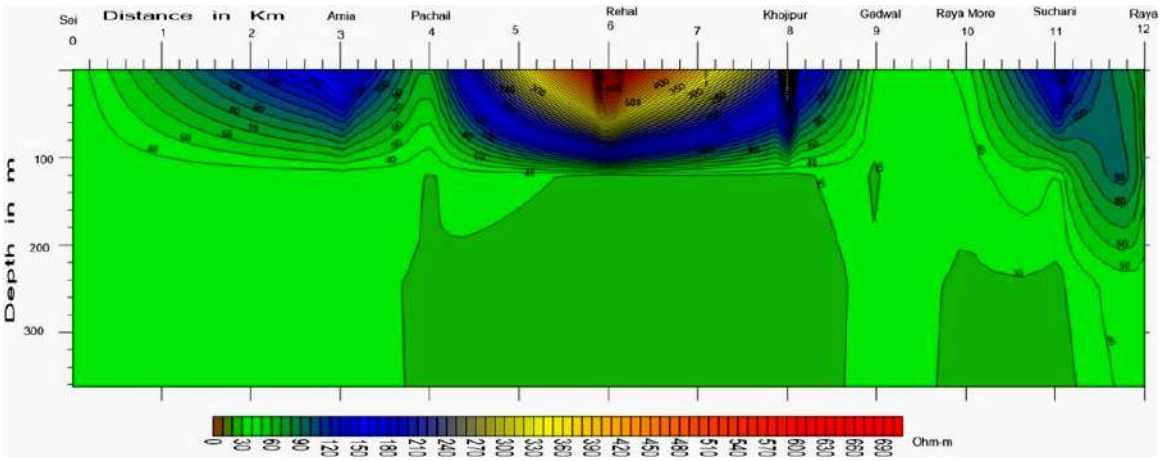


Figure 24: Geo-electric Cross Section along E –E'

Cross section F - F' prepared between Budhi and Mini Pansar by joining the resistivity surveys conducted at Mahi Chak- Haria Chak and Sultanpur, clearly shows the contact between Sirowal and Kandi formations, at a distance of 7 kms in the section (figure 25). Higher resistivity values on the left of the section can be attributed to the predominance of boulders, conglomerate, pebbles etc. in the sub-surface. Whereas there is low resistivity area extending from Hariya Chak to Pansar, indicating medium to fine sand deposits of Sirowal.

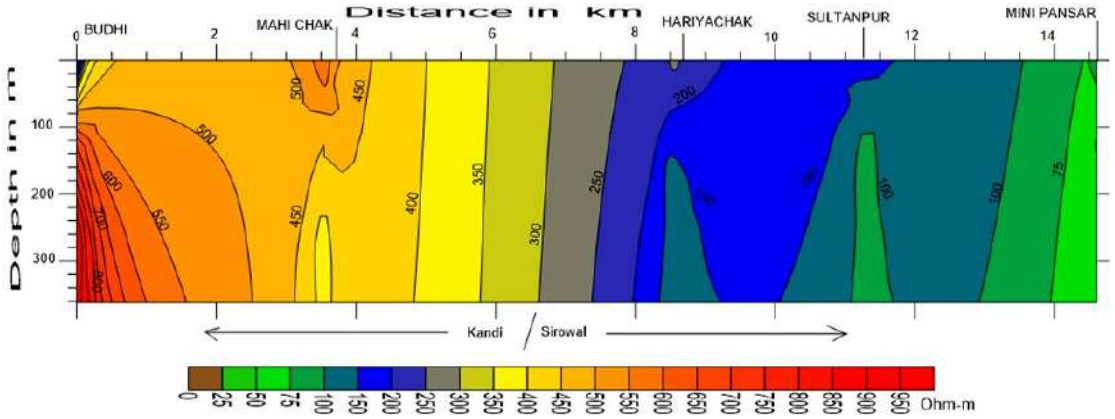


Figure 25: Geo-electric Cross Section along F- F'

Cross section G – G' drawn between Changran, Nagri and Kore Punnu depicts the boundary between Kandi and Sirowal (figure 26). The Kandi extends towards Nagri, with transition zone of Kandi – Sirowal near Nagri. The medium resistivity values at Kore Panu is due to its proximity to the Ujh River, where there are chances of encountering coarse to medium sediments.

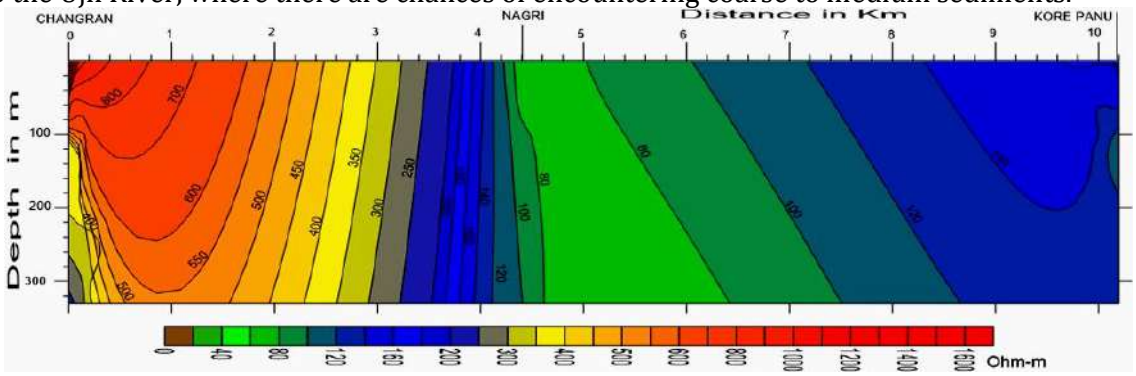


Figure 26: Geo-electric Cross Section along G- G'

Cross section H – H' drawn between Ghatti and Debu Chak by joining the resistivity surveys conducted at Jasrota – Hamirpur and Marheen (figure 27) clearly depicts the boundary between Kandi and Sirowal. The Kandi extends from Ghati to Hamirpur, with transition zone of Kandi – Sirowal near Madheen. The low resistivity values from Madheen towards Debu Chak are due to clay mixed with fine to medium sand.

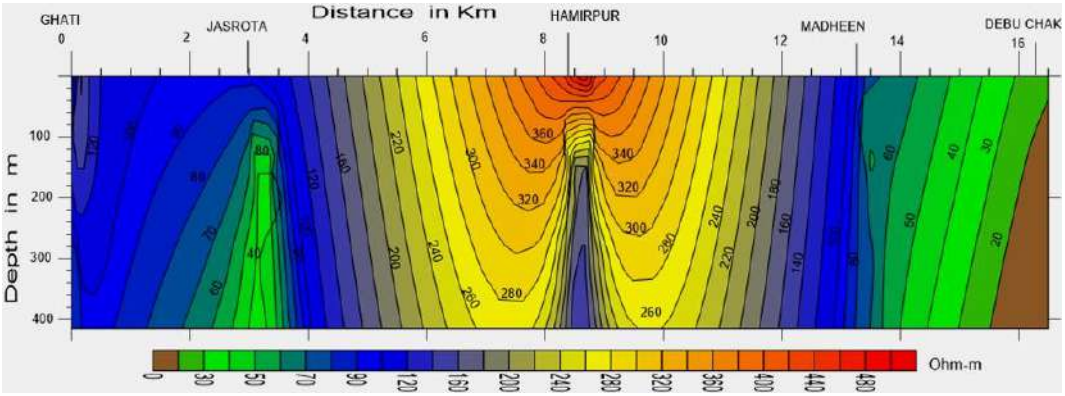


Figure 27: Geo-electric Cross Section along H – H'

Cross section I – I' drawn between Mathura Chak and Kharote, by joining the resistivity surveys conducted at Hamirpur – Mahi Chak - Nihalpur and Barwal clearly shows the Kandi – Sirowal demarcation (figure 28). The low resistivity zone near Mathura Chak reveals the Sirowal formation of fine to medium sand. From the distance of 4 kms on section i.e. transition zone, the kandi formation extends upto Kharote.

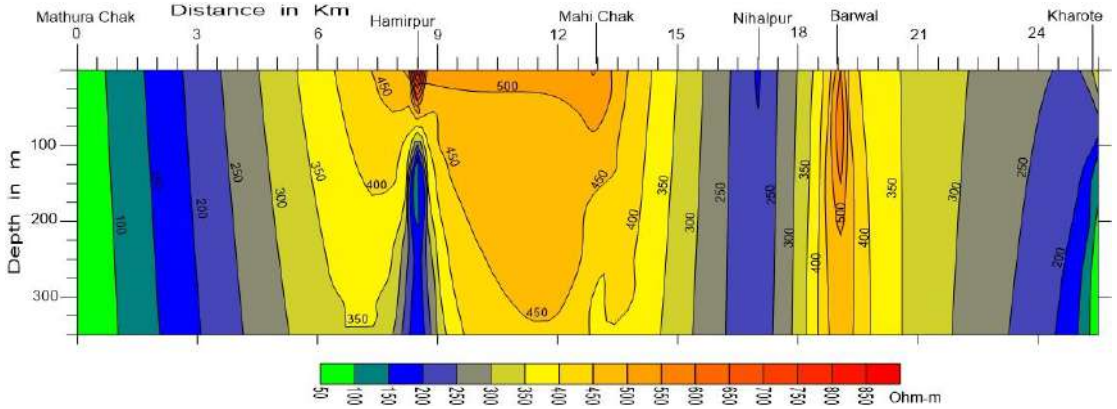


Figure 28: Geo-electric Cross Section along I – I'

Geo-electrical cross section J – J' drawn between Mathura Chak and Kore Punnu by joining the resistivity surveys conducted at Madheen – Sultanpur and Mukundpur, clearly shows the Sirowal from Mathura Chak to Sultanpur (figure 29). This can be inferred from the low resistivity values from Mathura Chak to Sultanpur. The high resistivity values indicate the Kandi formation from Mukandpur to Kore Pannu, which is also identified in other cross-sections, at these places.

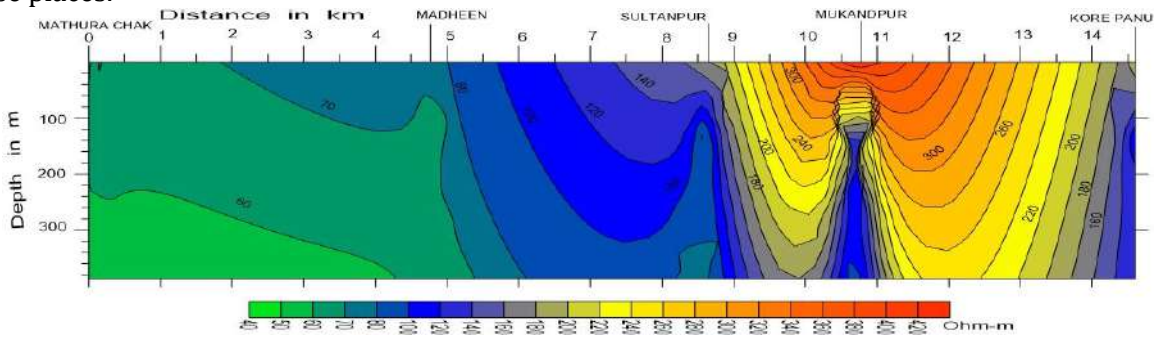


Figure 29: Geo-electric Cross Section along J – J'

GROUND WATER EXPLORATION in AQUIFER MAPPING AREA

Under Ground Water Exploration, more than 200 wells were drilled by CGWB in Outer Plains till date (as on March-2016).

Under Ground Water Exploration, 14 exploratory wells and 4 observatory wells were drilled in Outer Plains, since 2012, namely at Raipur Domana, Jindrah, Bamyal-I, Bamyal-II, Sitlee Nagrota, Bain Bajalta-I, Bain Bajalta-II, Jajjhar Kotli, Kot Bhalwal, Baspur Banglow, Rakh Dhiansar II, Rakh Barotian, PRSS Samba, Data Talab and Chann Datyal and 2 OW's at Sitlee Nagrota, 1 OW at Chann Datyal and 1 OW at Rakh Barotian.

STATE GOVERNMENT WELLS

Strata Charts, water level data, their discharges, assembly details were collected for 300 tubewells from Public Health Engineering and Irrigation and Flood Control Departments.

3. DATA INTERPRETATION, INTEGRATION AND AQUFIER MAPPING

Data of 289 wells drilled by state agency along with 124 wells drilled by CGWB was used for deciphering the lithology beneath by preparing model, fence and cross sections with the help of Rockworks Software. The locations of the tubewells used in preparation of aquifer maps, cross sections etc. are shown below in figure 30 and Annexure IV.

As there is no Ground Water Department in Jammu and Kashmir and no other department is working in this field except for making ground water abstraction structures and extracting huge amount of water, the data of Central Ground Water Board was the only reliable source. However, strata charts of tubewells constructed by private agencies for State Government were used in the preparation of 3 D Aquifer Maps.

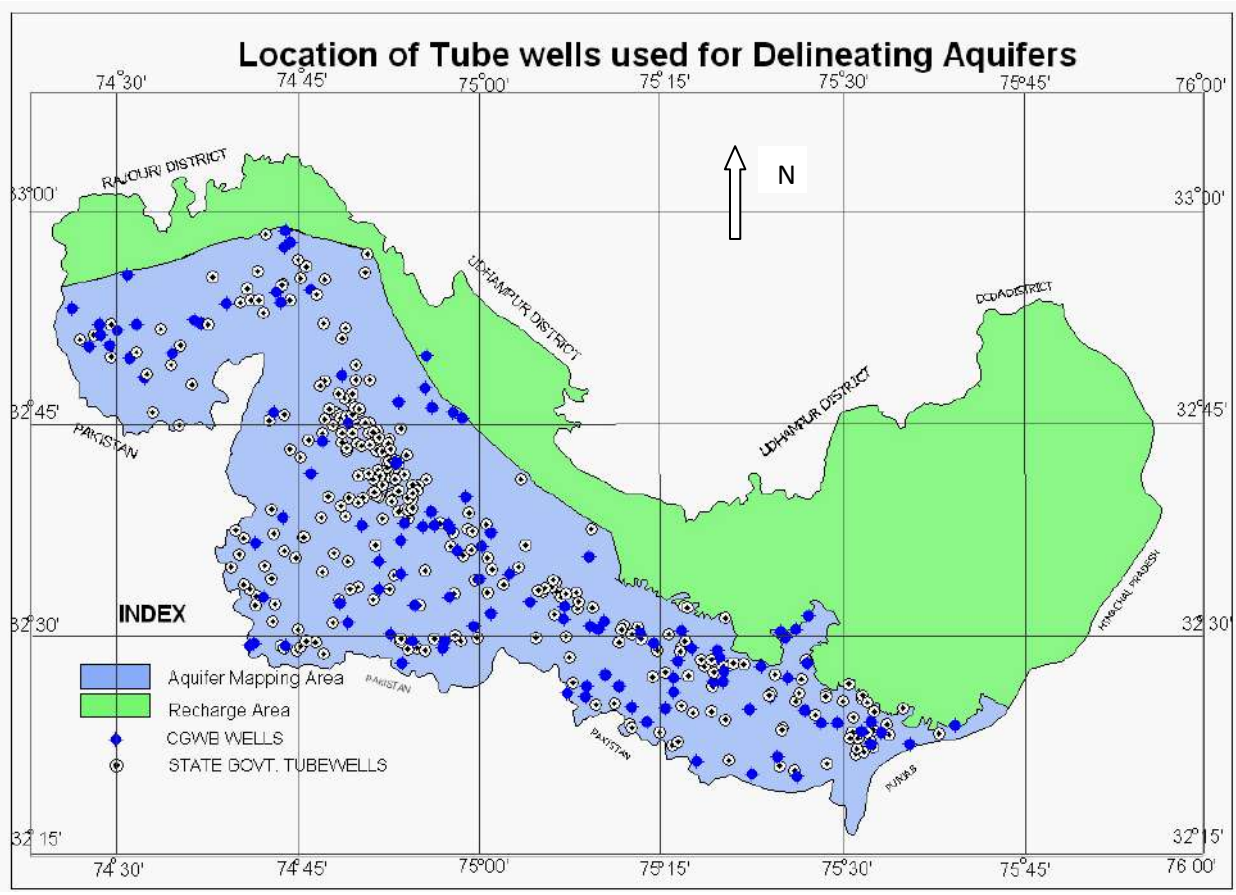


Figure 30: Locations of Tubewells used in preparation of Aquifer Maps

Nature of Aquifer Available

KANDI BELT

The Kandi sediments comprising of boulders and gravels, allow the rain water to percolate down to great depth till it meets an impervious layer and then starts rising up. The static water level in Kandi belt is very deep.

In Kandi area of Jammu District explored depth is about 201 m bgl. The depth ranges of these exploratory tubewells in Kandi formation vary from 42.00 m at Marh Khullian to 302.67 m bgl at Rayapatti. Depth to water level ranges from 5.24 m at Supwal site to 65.0 m bgl at Pangiari site.

In Kathua District, true to its characteristic, deep water level condition prevails in Kandi Belt. Depth to water level ranges between 9.78 m bgl at Naran and 71.25 m bgl at Jatwal. In general the water table stands below 18.0 m bgl. In spite of deep water levels prevailing, Kandi formation has a reputation of having rich ground water potential.

SIROWAL BELT

In Sirowal area, multi layered aquifer system exists. Aquifers are made up of sand and sand mixed with gravel and boulders and the water levels are quite shallower.

In Jammu District, the depth of the boreholes drilled in Sirowal ranges between 26.00 m at Matoo -I and as deep as 350.81 m at Chamliyal. Depth to water level varies from 2.8 m bgl at Pounichak to 45.00 m bgl at Chowdharywala.

In Kathua District, the depth range of the nine bore holes drilled in Sirowal varies from 123.80 m at Beliyan to 450.39 m at Pansar. Depth to water level ranges between 12.00 m and 15 m bgl. More than 50% of the wells are under flowing condition, piezometric head rising from a meter to more than 9 m agl with a free flow discharge ranging from 300 to 500 lpm.

Table 5 summarizes the aquifer properties, its yield potential, quality and rig suitable for drilling.

Table 5: Aquifer Type, its Quality & Suitability of Rig

Belt	Prominent Lithology	Average Explored Depth (m bgl)	Maximum depth drilled (mbgl)	Yield Potential (lpm)	Suitability for Drinking & Irrigation	Remarks
Kandi	Coarse Sediments (Boulder, Gravels, sand etc with clay)	80-135	302.67 (Rayapatti)	0.31-1873	Yes	Direct Rotary rigs suitable for drilling, Unconfined to semi-confined Declining GW level, Quality problem in isolated pockets (Nitrate, Iron)
Sirowal	Fine Sediments (Gravels, sand, silt and clay)	180-200	450 (Pansar)	160 - 3542	Yes	Direct Rotary rigs suitable for drilling Artesian Conditions Quality problem in isolated pockets (Nitrate, Iron)

Aquifer Characteristics

The aquifer characteristics including its thickness, depth to water level are given in table 6.

KANDI BELT

In Jammu District the yield of the wells varies from 160 lpm at Sailawali to 3532 lpm at Sei and the drawdown of 3.66 m at Prithipur to 28.3 m at Pungali. The Transmissivity values range from 21.1 to 1197 m^2/day. In Kathua District, the yield of the wells being in the range of 378 lpm for a drawdown of 8.25 m at Jatwal to 1873 lpm for a drawdown of 6.85m at Sunjwan. The Transmissivity values range between 692 and 2613 m^2/day at Chak Sheikhan and Lachhipur respectively unfortunately no data on specific yield or storativity value is available.

SIROWAL BELT

In Jammu District, the yield of the wells varies from 0.31 lpm at BSF Paloura to 2074 lpm at Pallanwala and the drawdown of 0.1 m at Ashram Colony to 9.53 m at Pallanwala. The Transmissivity values ranges from 3.9 to 2296 m^2/day. In Kathua District, the yield of the wells varies from 1628 lpm for a drawdown of 17.15 m at Karol Krishna to 3145 lpm for a drawdown of 12.85 m at Chachwal. The Transmissivity value ranges from minimum110 m^2/day to maximum of 448 m^2/day.

Table 6: Aquifer Characteristics

Belt	Prominent Lithology	Depth to water level (mbgl)	Average Aquifer Thickness Range (m)	Desaturated thickness (m)	Saturated thickness (m)	Quality
Kandi	Coarse Sediments (Boulder, Gravels, sand etc. with clay)	30-50	110	28-48	50-70	Fresh, potable and fit for irrigation except higher concentrations of Fe and NO3 at a few places
Sirowal	Fine Sediments (Gravels, sand, silt and clay)	2 – 10	25	0	25	Fresh, potable and fit for irrigation except higher concentrations of Fe and NO3 at a few places

The data of ground water exploration of Central Ground Water Board in the shape of lithologs was extracted from old files and was computerized in MS Excel. The strata charts from Public Health Engineering Department, Irrigation & Flood Control Department, Industries and other State Government Departments were collected and their co-ordinates and elevations were worked out in the field and on toposheets. This data was also brought into digital form. The unified lithologs were prepared according to the standard legend decided.

The lithological layers are generated using borehole data. The layers are broadly classified into eight types– sand; clay; shale; sandstone; conglomerate, boulder, cobble, pebble, gravel, kankar, sand; boulder, cobble, pebble, gravel, kankar, sand; clay with boulder, cobble, pebble, gravel, kankar, sand; and sand, boulder, cobble, pebble, gravel, kankar with clay.

Lithological Disposition and Aquifer Disposition

The lithological disposition and the aquifer disposition interpreted through the models, fence and cross sections prepared using the rockworks software. The sections drawn for sub-surface formations and aquifers, have vertical and horizontal scales in meters.

The lithological and aquifer model (figure 31) of the complete aquifer mapping area depicts that the northern part is at higher elevations and the depth of exploration is limited to 100 m in this part. There is an abundance of granular horizon but the water levels are deep. The southern part is at shallow elevations and water levels are very shallower in this part. In the north-eastern part the water bearing zone is encountered at the top but the deeper aquifer is separated by thick aquiclude. In the western part there is an absence of water bearing horizon.

The fence diagram delineating the lithology and aquifer disposition is drawn between Munnawar Tawi and Ravi River (figure 32) depicts that the granular sediments consisting of Boulder, Cobble, Gravel, Pebble, Kankar and Sand forms the north-east section of fence with conglomerate and sandstone and thin lenses of clay intermingled with it. The south-east edge of the fence forms the Sirowal Belt where sand replaces the granular horizons of Kandi formation and acts as aquifer occurring at shallow depths in this belt. The deepest well drilled at Pansar lies on the southern end is located on a clay mound and bears aquifer zones within 150 m and another zone at very deeper depth i.e more than 300 m bgl.

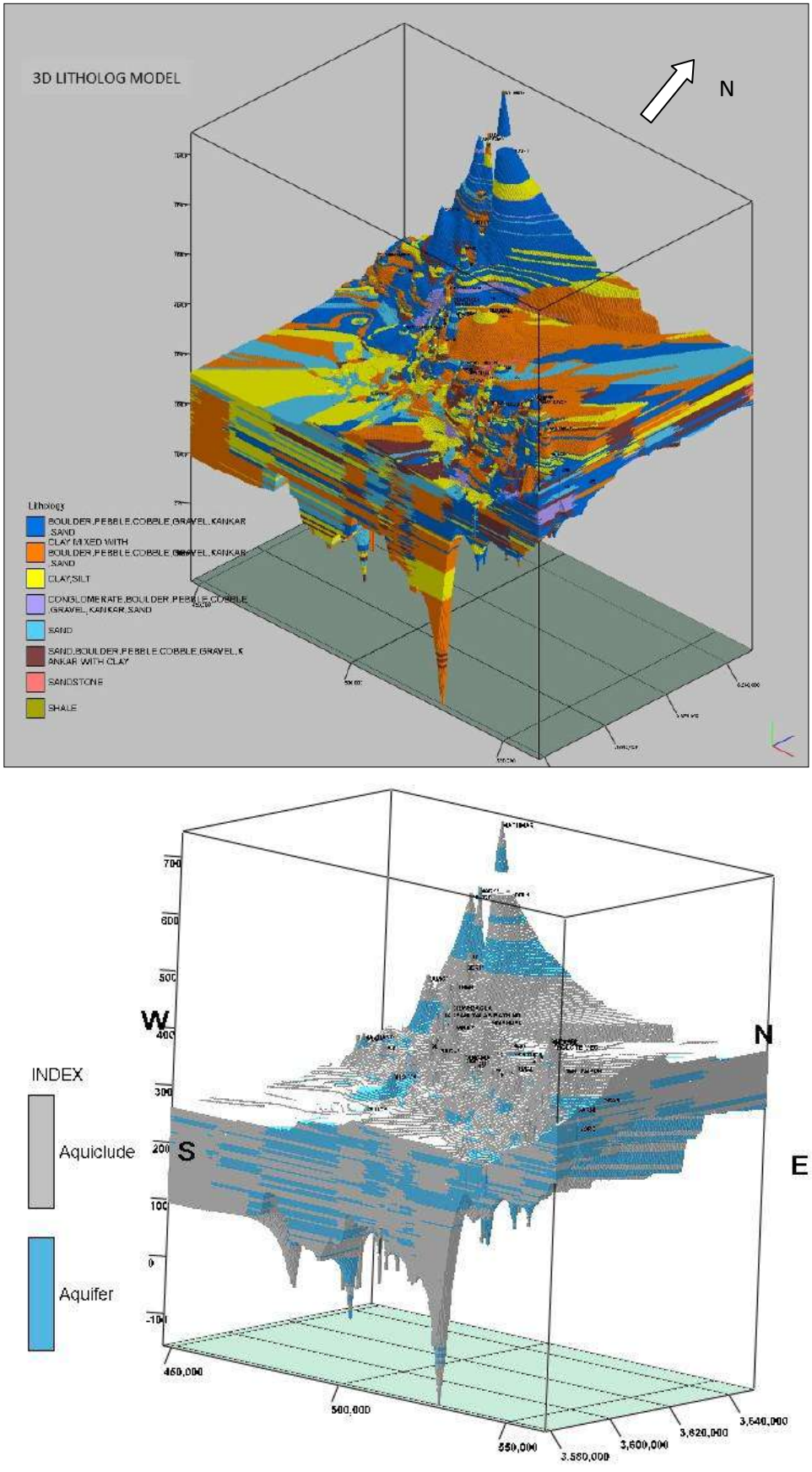


Figure 31: 3 D Model depicting Lithology and Aquifer in the Outer Plains.

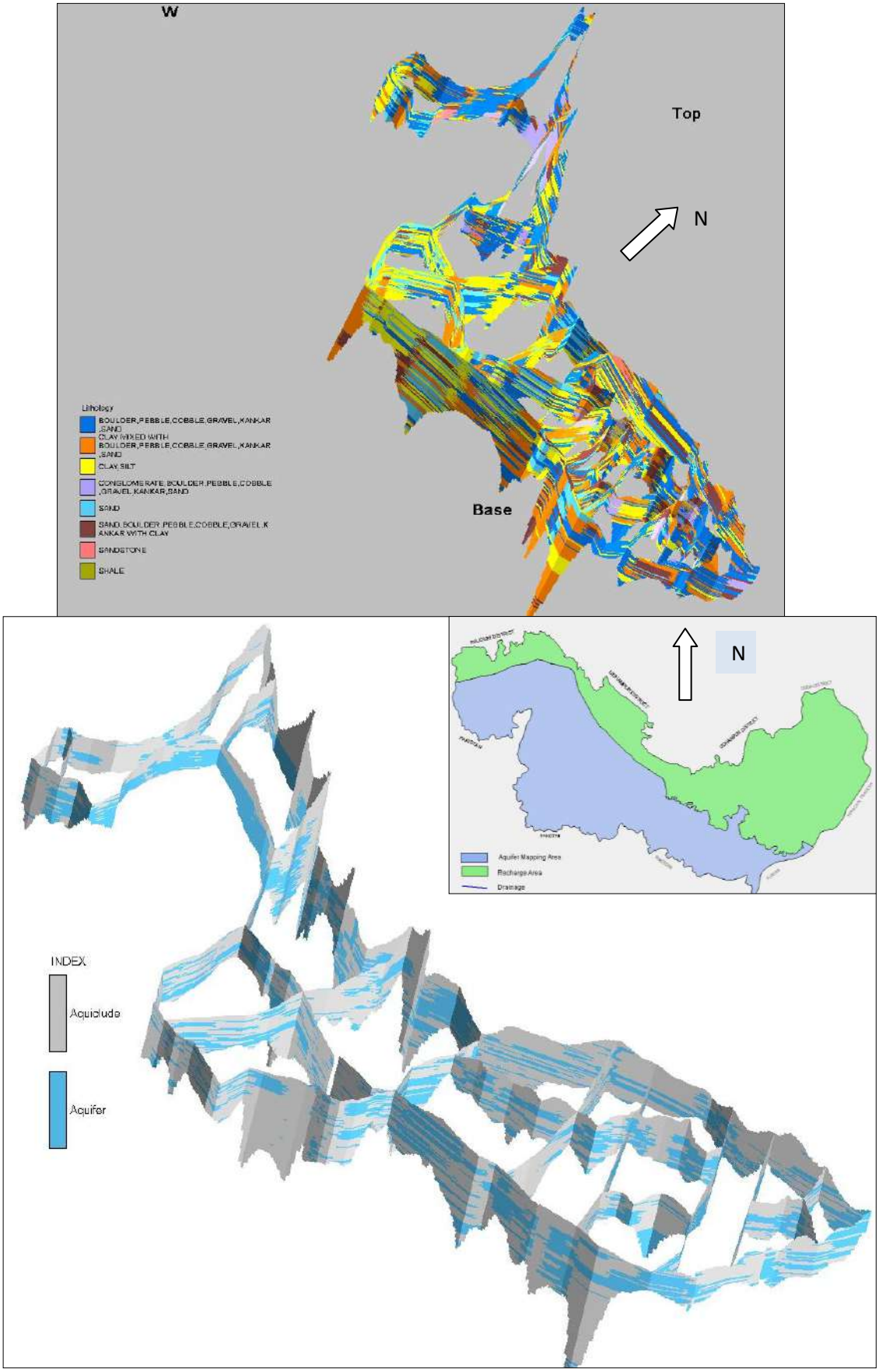


Figure 32 : Fence Depicting Lithological and Aquifer Disposition between Rivers Munnawar Tawi and Ravi

The fence diagram drawn for lithology between Munnawar Tawi River and Basantar River depicts that there is an abundance of pure granular horizon comprising boulder, cobble, pebble, gravel, kankar and sand especially in the vertical right block is Kandi formation. The finer clay and sand rich left block is Sirowal belt (figure 33). But the granular horizon which can yield huge volumes of water is devoid of water here in Kandi part as grain sizes of sediments are large and porosity is high rather than permeability. Conglomerate beds of probably upper Siwalik group occurs at many places in Kandi formation and also yields considerable quantity of water. The conglomerate beds are predominantly seen in the northern part of the fence. Clay and sand mixed with gravels are dominant on the south western edge of the fence. This part bears aquifers of considerable thickness with shallow water levels (figure 34).

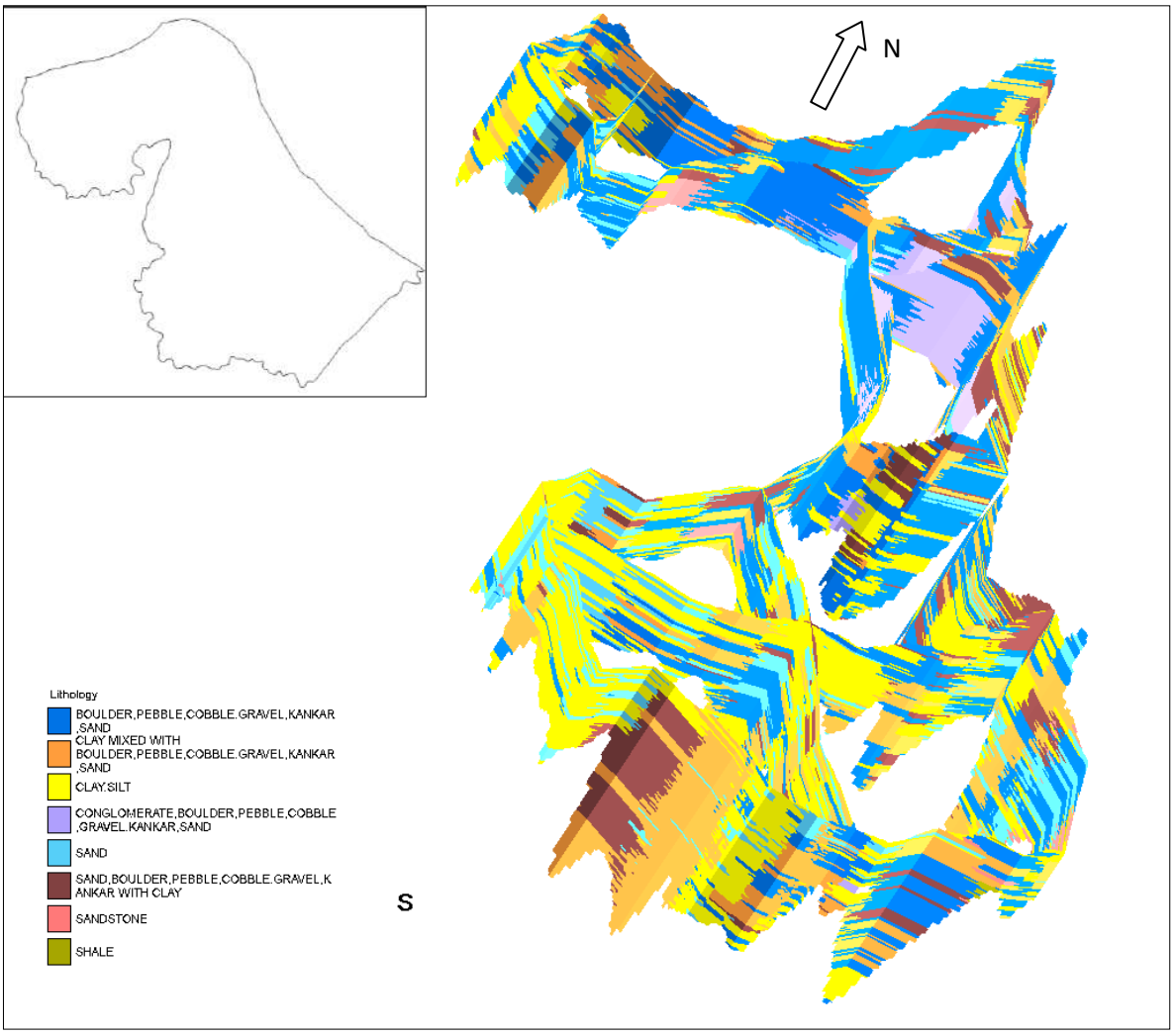


Figure 33: Fence depicting Lithological Disposition between Munnawar Tawi and Basantar Rivers.

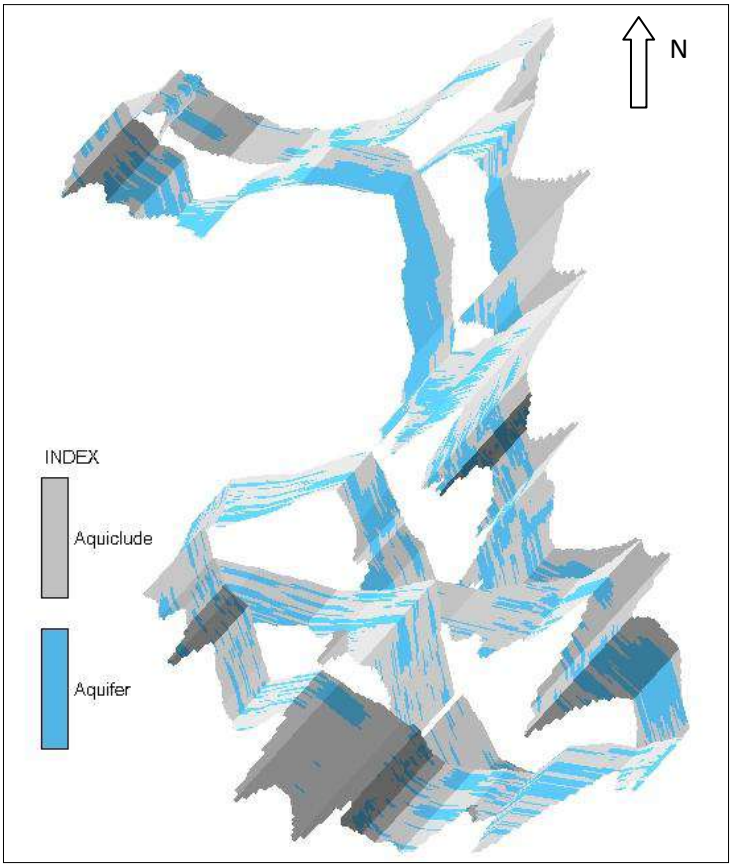


Figure 34: Fence Diagram Depicting the Aquifer Disposition of Area between Rivers Munnawar Tawi and Basanter.

Cross sections were drawn by joining lithologs of tubewells for delineating the depth-wise lithological and aquifer scenario of the area underneath (figure 36 & 39). The section lines along which these cross sections are drawn are shown in figure 35.

The cross section A'A' drawn along Shamoo Chapreal to Prangla depicts the occurrence of coarse grained sediments from i.e. Boulder, Cobble, Pebble and sand from the top itself from Shamoo Chapreal to Kot Meira (figure 36). But all these sediments allows water to percolate down very fast viz. typical characteristic of Kandi Belt thus the water levels are deep and ranges from 30 m at Sailawali to 70 m bgl at Thanger Pattian. Tub wells drilled at Khour and Prangla bears finer sediments of clayey and sandy nature due to which the water levels range from 5 to 10 m bgl.

The cross section B- B' drawn along Prangla to Meira Mandrian (figure 37), depicts that there is abundant granular sediments comprised of pebble, gravel, sand and kankar that are extended throughout the area from top itself except at Sohal and Meira Mandrian where the granular sediments are clay rich. From Prangla to Sohal intermediate clay lenses separates the granular horizons at depths, whereas clay mixed sediments separates the granular horizons from each other in the tubewells of Kandi formation i.e. Sohal to Meira Mandrian. The aquifers are encountered at shallow depths in Sirowal area viz. Prangla to Mandiala. The depth of water table goes deeper and deeper from Naiwala to Meira Mandrian. The Siwalik sandstone is encountered at a depth of about 35 m bgl at

Jourian and Mandiala. Conglomerate is encountered at Dhok Khalsa at a depth of about 80 m bgl which is a water bearing horizon.

The section C - C' drawn along Gajansoo to Jhang depicts the nature of sediment deposition from Sirowal to Kandi zone especially the behavior of water bearing zones in the transition zone from Sirowal to Kandi formation (figure 38). The water levels in the Sirowal section are at almost ground level at Gajansoo, Gho Manhasan and Gulama Chak. The sediments that form the top of these wells bear predominantly. This sedimentation pattern extends till Skaust Chattha. At Prahladpur that lies between Gulama Chak and Khundwal thick clay lenses occur due to which water bearing zone occur below 45 m. The sedimentation pattern from Miran Sahib to Jhang is quite variable as it is considered as transition zone between Sirowal to Kandi formations. Occurrence of mixed type of sediments is seen here with wide variation in the water levels, which are quite shallow at Prithipur and Kanhal and more than 15 m deep at Miran Sahib, Bishnah, Kothey Saini, Chakra and Jhang.

The section drawn along D - D' from Bikram Singhyal to Phinder, all the wells are in Sirowal belt in which the granular sediments are found only at Phinder (figure 39). Water levels are shallow in this section. At Bikram Singhyal, Badyal Brahmana & Kotli Shah Doula water bearing zones starts below 25 m whereas at Langotian Benagarh and Phinder water levels are almost within 0 to 2 m bgl. Thick water bearing zone of nearly 50 m cumulative thickness is encountered at Langotian Benagarh, in total drilled depth of 157 m bgl.

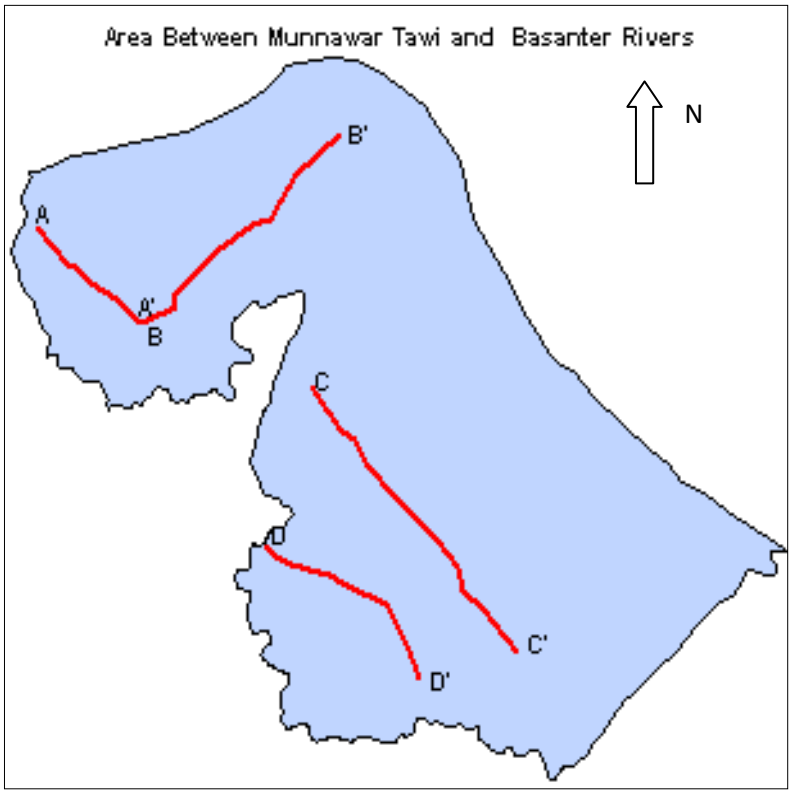


Figure 35: Map showing Cross Section Lines

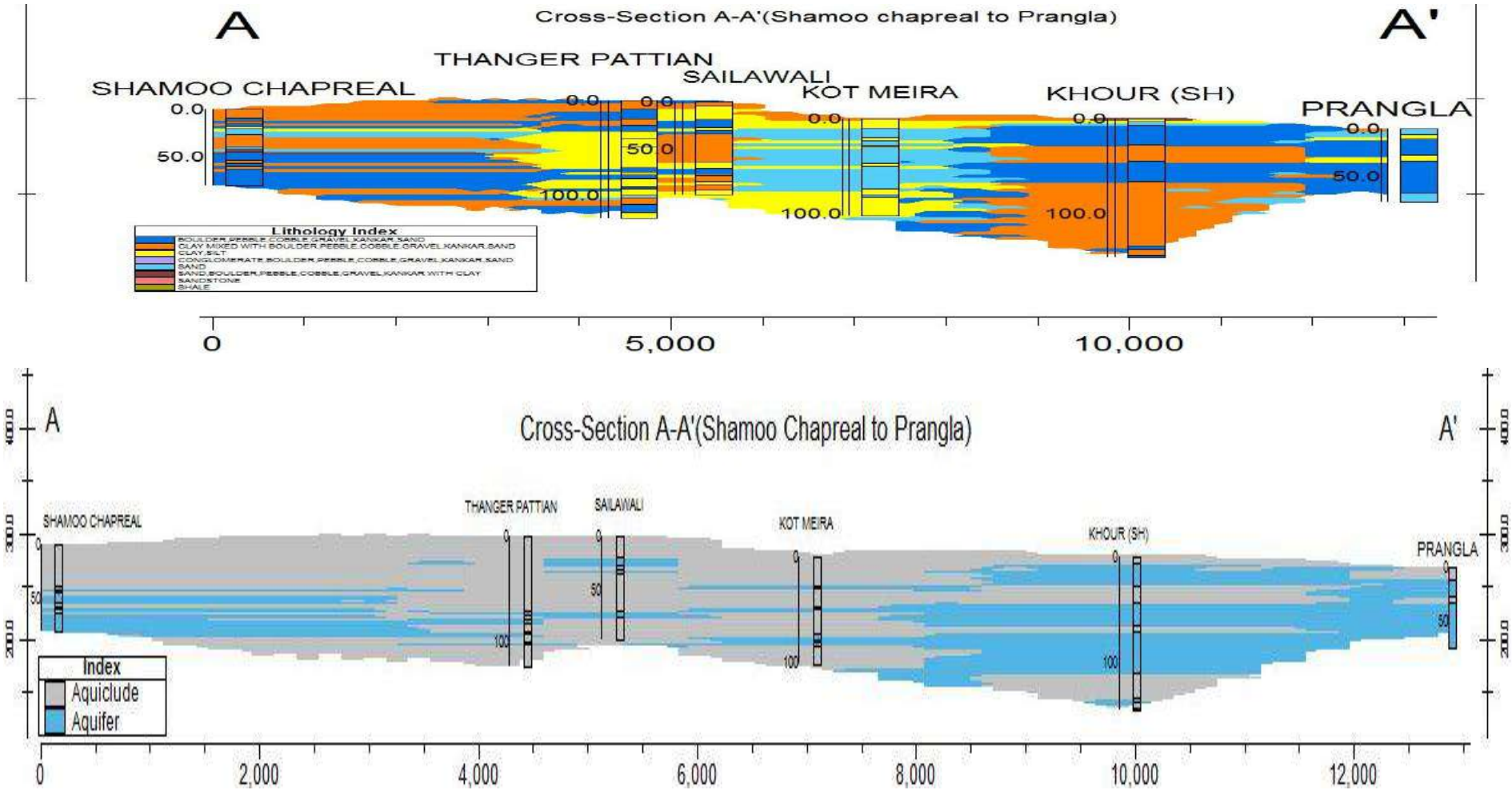


Figure 36: Cross Section Depicting Lithological and Aquifer Disposition along A – A'

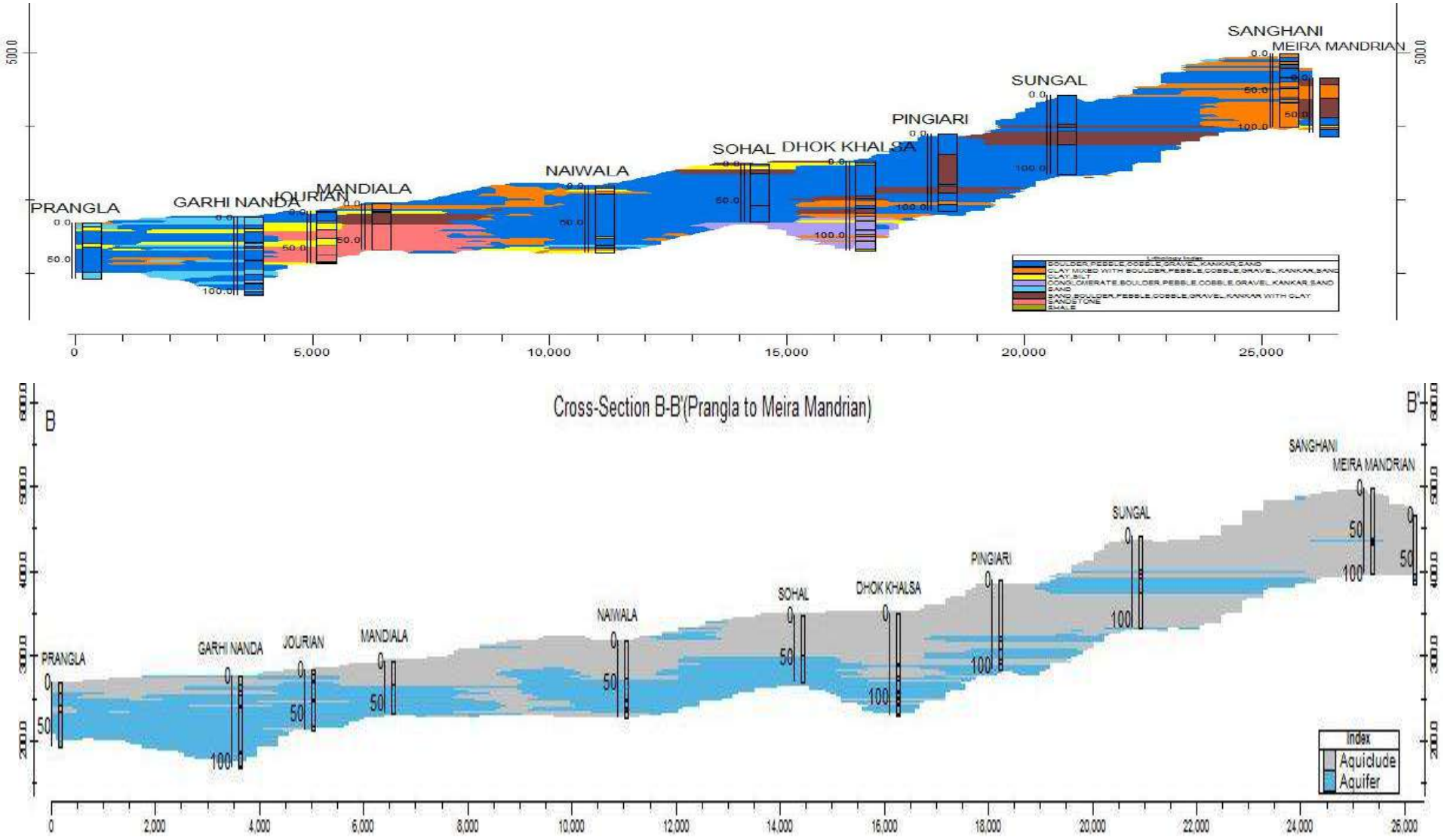


Figure 37: Cross Section Depicting Lithological and Aquifer Disposition along B-B'

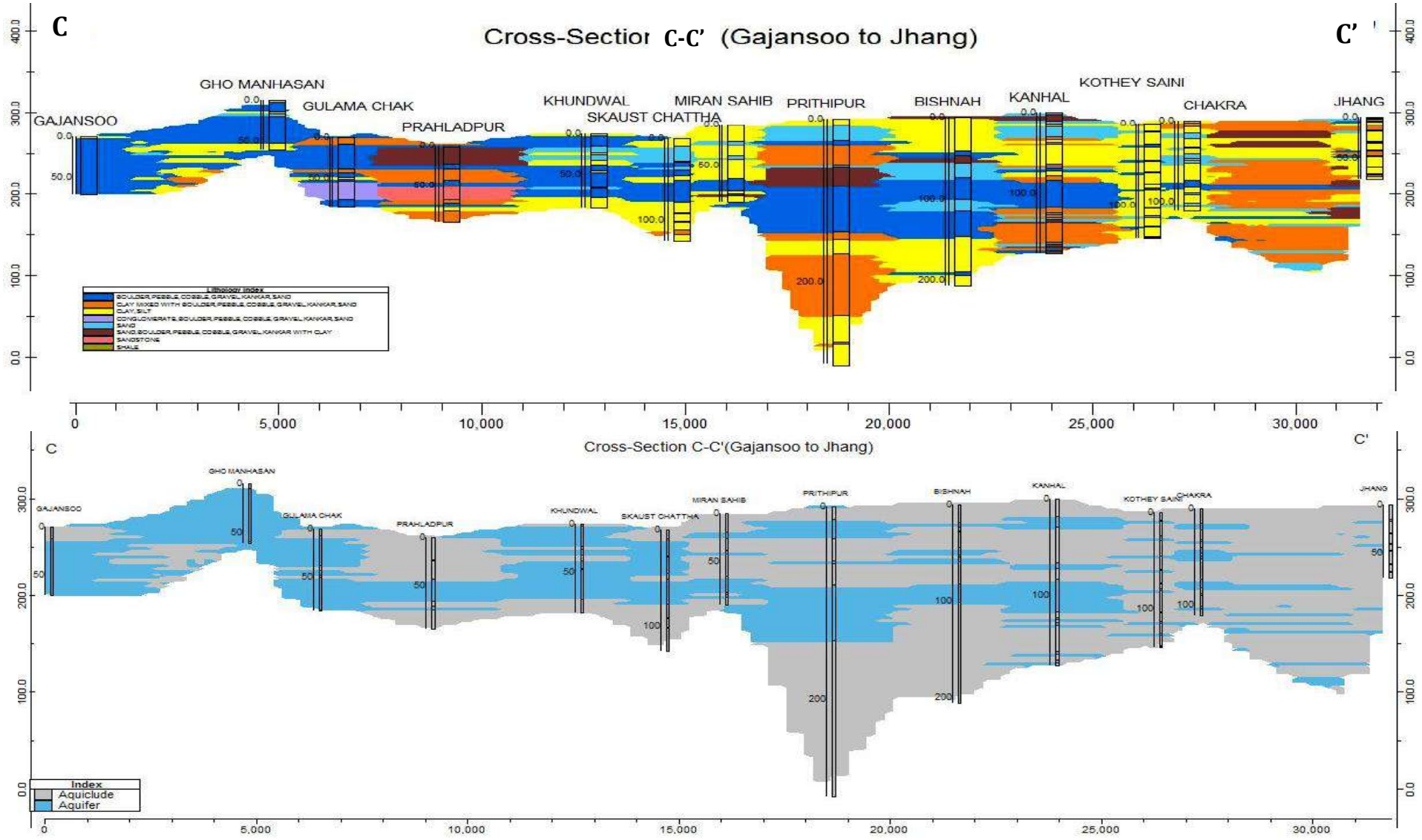


Figure 38: Cross Section Depicting Lithological and Aquifer Disposition along C-C'

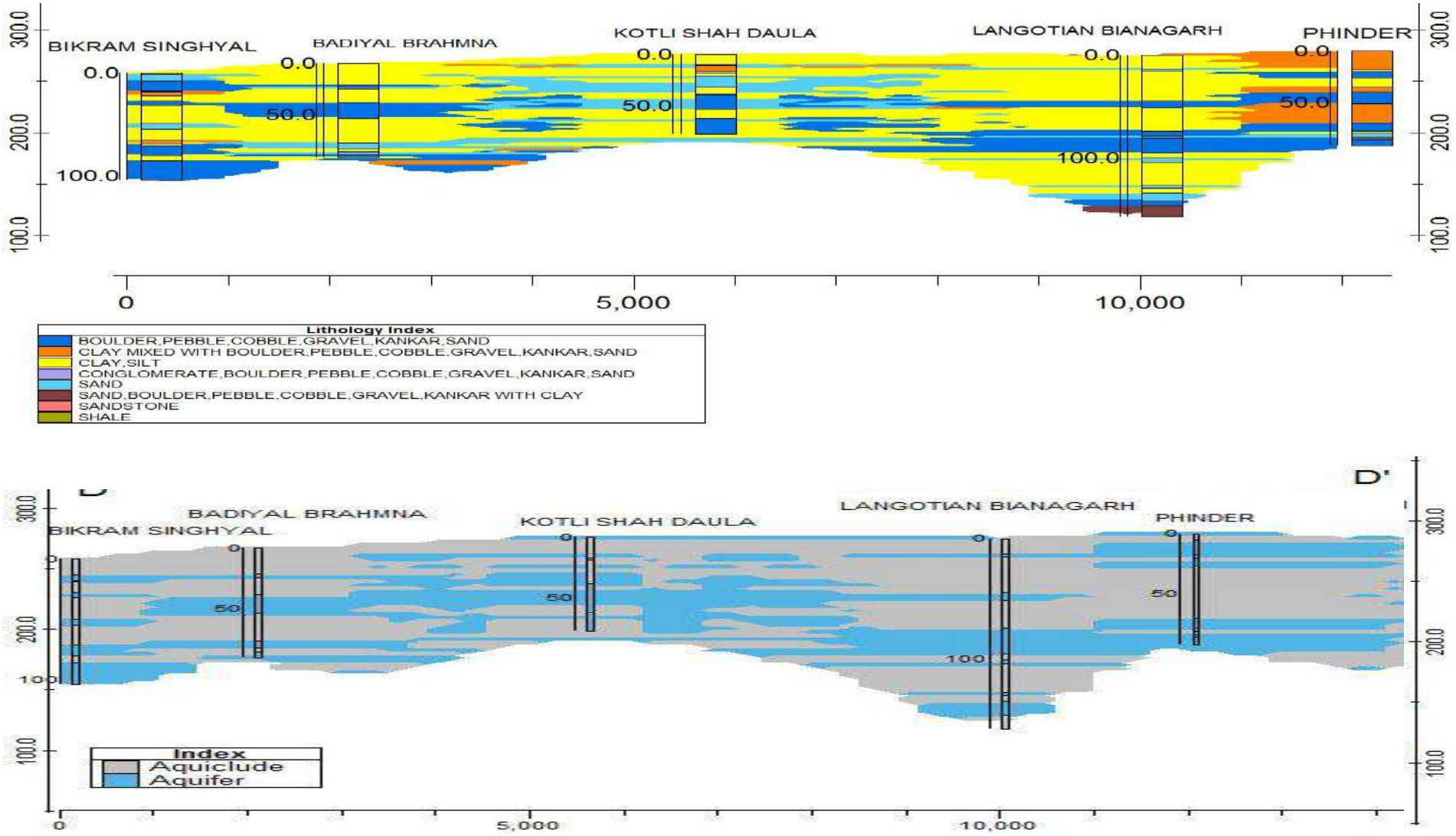


Figure 39: Cross Section Depicting Lithological and Aquifer Disposition along D-D'

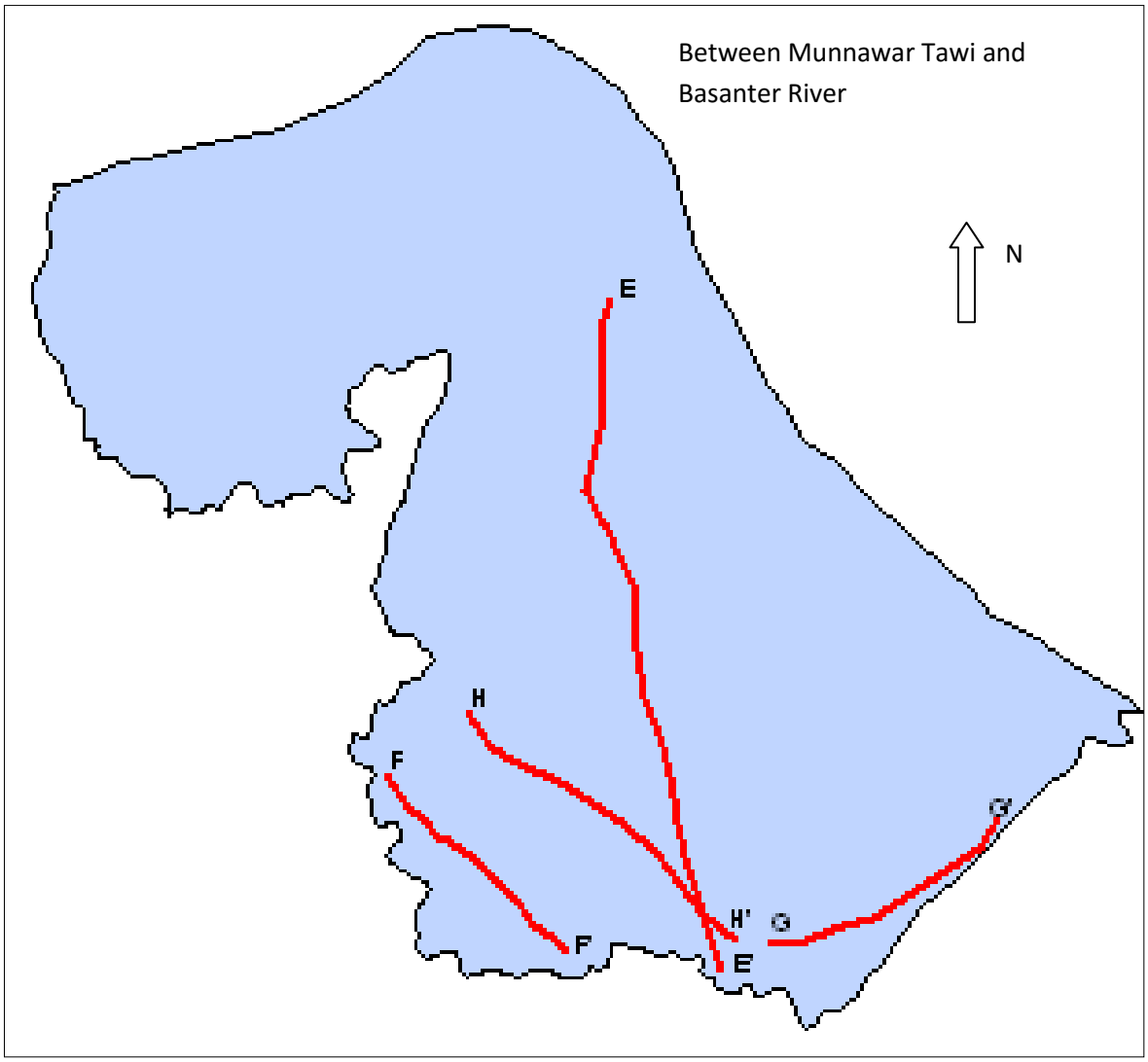


Figure 40: Map showing Cross Section Lines

Section E-E' from Seri Panditan to Chamliyal drawn, depicts the sequence of Kandi to Sirowal formation (figure 41). Typical Kandi formation comprises dry coarse grained sediments at the top from Seri Panditan to Barnai, Lale da Bagh. The water levels are deep in the tube wells of this section i.e. Seri Panditan and Burn > 100 m bgl. Raipur Domana, Thathar and Barnai > 50 m bgl. The transition zone of Kandi to Sirowal formation starts from Lale da Bagh and extends to Kanhal via Himmat Colony, Satwari, Brij Nagar, Prithipur and Bishnah. In this part the sediments of coarse nature are mixed with the finer sediments and thus the water levels comes up within a range of 20-30 bgl. Sediments are relatively finer in the section from Pandhorian Bangla to Deolichak, where there is an abundance of clay and sand. Thus only sandy layer is acting as an aquifer which is found as lenses at deeper levels in Pandhorian Banglow, Ratnal and Deolichak. In Chamliyal tube well sandy horizons bearing water occurs at very shallow levels.

The section drawn along F-F' from Karotana Khurd to Kot Kubba (figure 42) seems to have mostly clay and sand. At sand mixed with gravels and pebbles is encountered almost in each well but at a depth of around 70 m and 120 m bears water sediments

mixed with clay is encountered at Chakroi tube well at a depth of about 35 m which is continues up to 130m intervened by a very thin sand bed containing water. In general water levels are shallow in this section, viz. within 2 m bgl.

The section G - G' drawn along Deolichak to Nandini (figure 43), depicts that the area has thick aquifer zones in the Sirowal Belt at a shallow depths whereas the depth to water table goes down from Gagore to Nandini, where the coarseness of sediments also goes on increasing. From Dhupsari to Gagore thick aquifer zones are encountered as this part falls in the flood plains of Devak River.

The section H – H' drawn along Agrechak to Dug (figure 44), depicts that the sediments are finer viz, sand and clay in this section, typical of Sirowal Belt. Thick and many layers of aquifers separated by clay lenses are encountered from Agrechak to Saleher. At Ratnal and Dug the aquifer layers are at deeper levels viz. more than 120 m bgl.

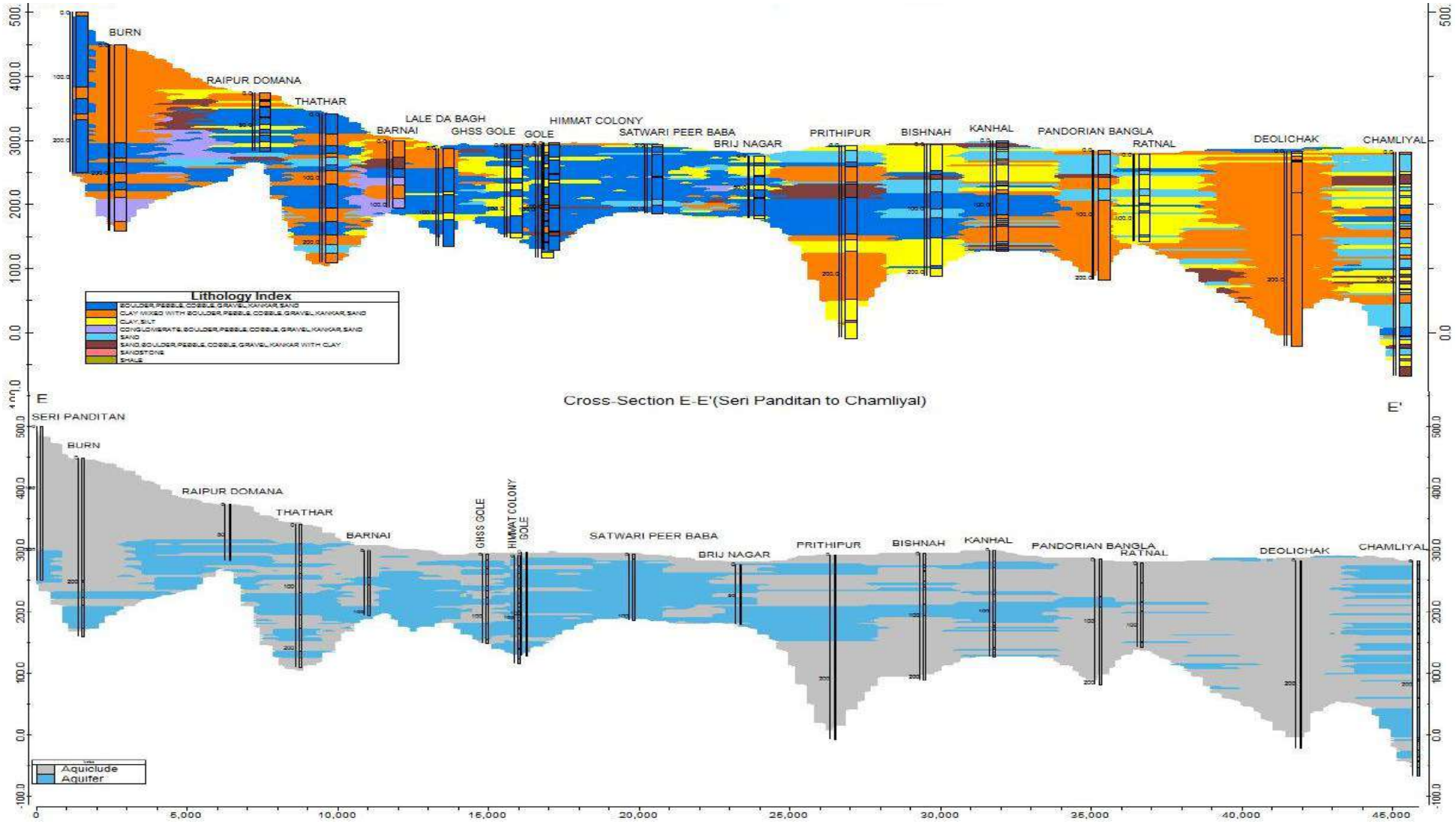


Figure 41: Cross Section Depicting Lithological and Aquifer Disposition along E – E'

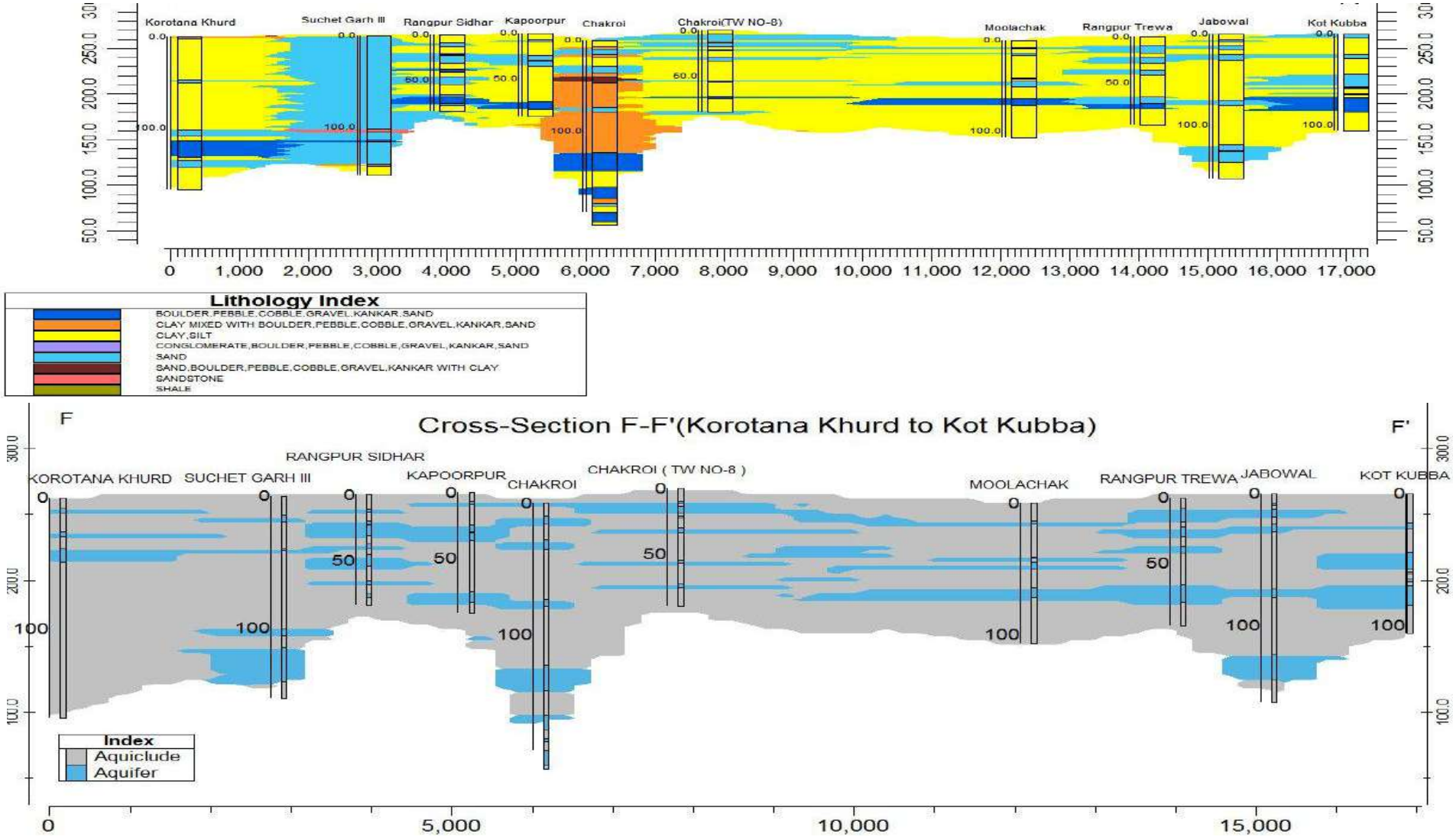


Figure 42: Cross Section Depicting Lithological and Aquifer Disposition along F – F'

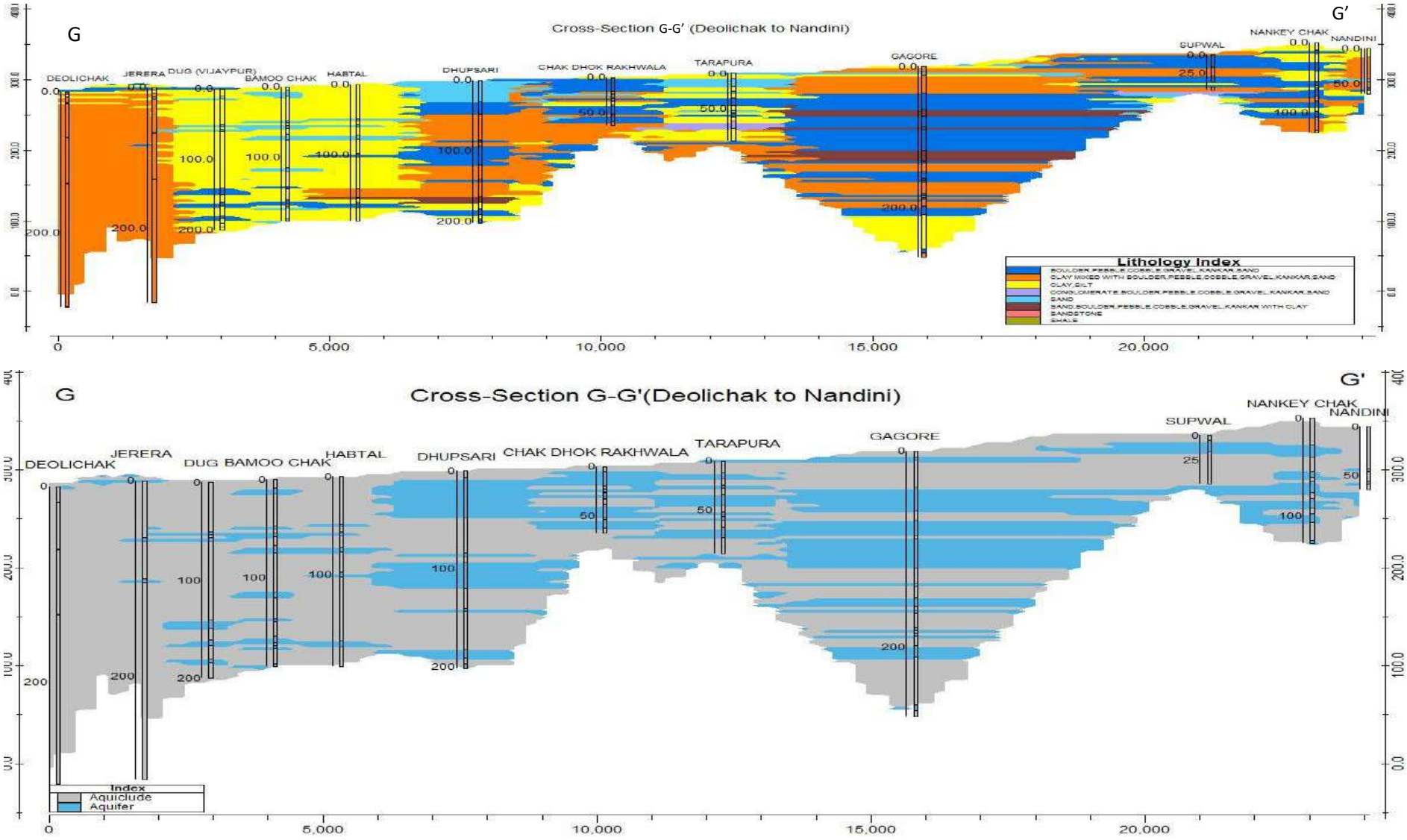


Figure 43: Cross Section Depicting Aquifer Disposition along G – G'

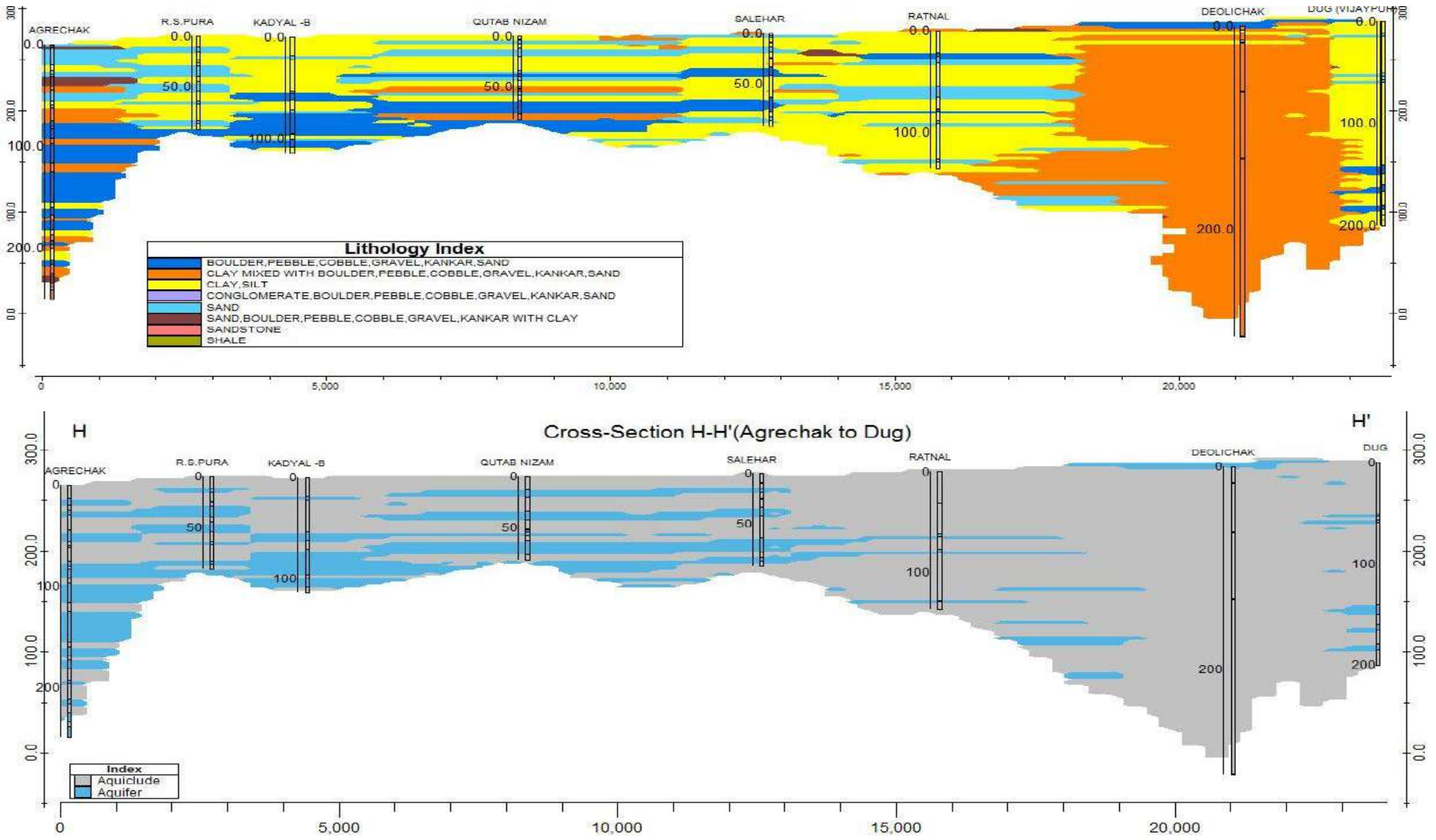


Figure 44 : Aquifer Disposition along H-H'

The fence diagram drawn by the lithology between Basantar to Ravi River (figure 45) depicts that the granular sediments consisting of Boulder, Cobble, Gravel, Pebble, Kankar and Sand are abundant in the right half of the fence. This part does not bears pure clay bearing horizons except for one prone left half where pure clay formation seems to occur with the abundance of mixture of clay and granular sediments. In the left pure sand horizons also occur at various depths. The water bearing horizons are encountered at deeper depths in the northern half of the fence where Kandi formation lies. The water level slowly reaches to almost ground level on the southern edge where Sirowal sediments are there.

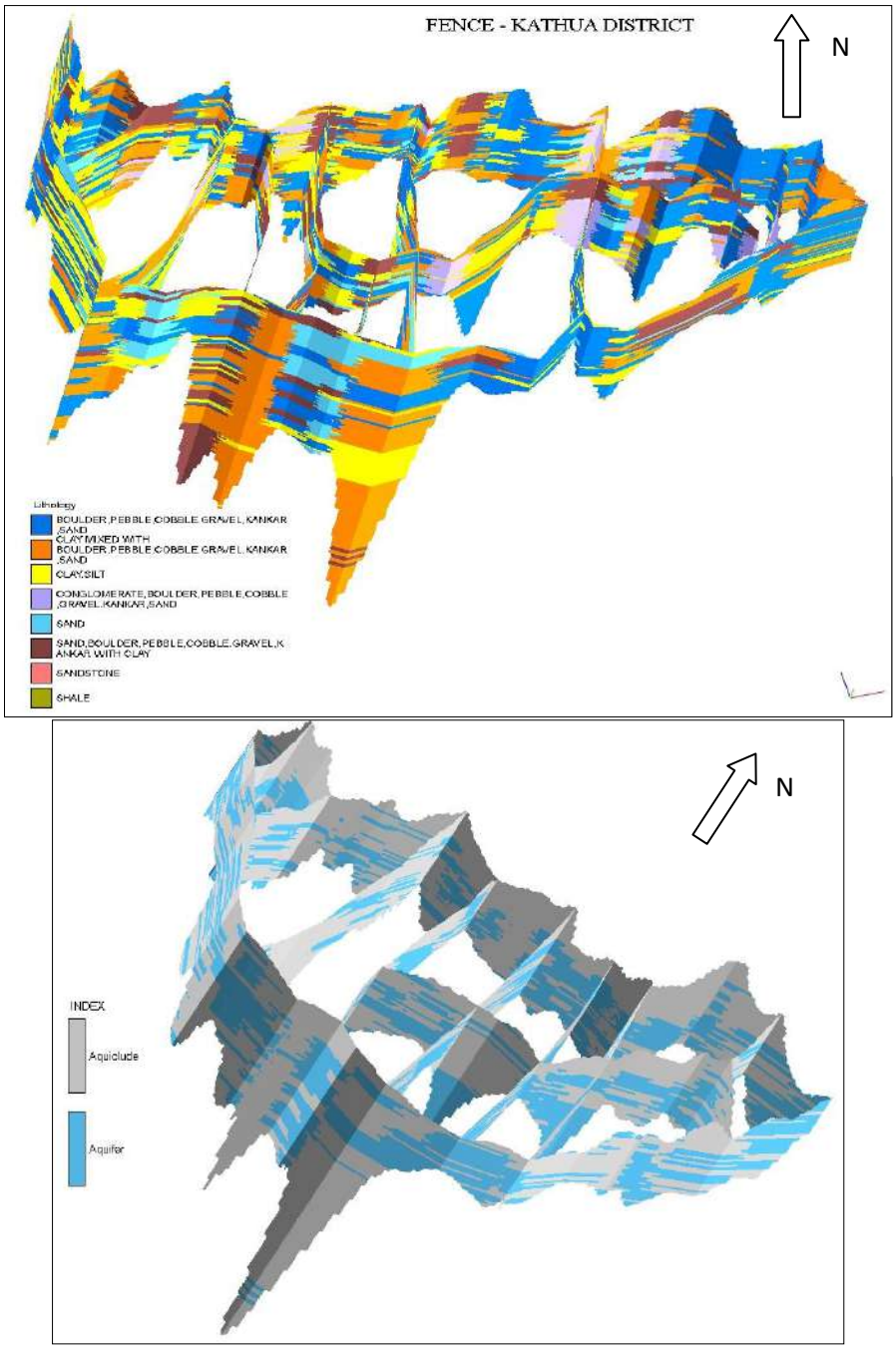


Figure 45: Fence Depicting Lithology and Aquifer Disposition between Basanter and Ravi Rivers with aquifer mapping boundary in Kathua district in insat

The cross sections drawn along various lines by joining the lithologs of tubewells depicts the lithology and aquifer disposition and their lateral extension beneath the earth. The map showing section lines drawn in area between Basanter and Ravi Rivers is given in figure 46.

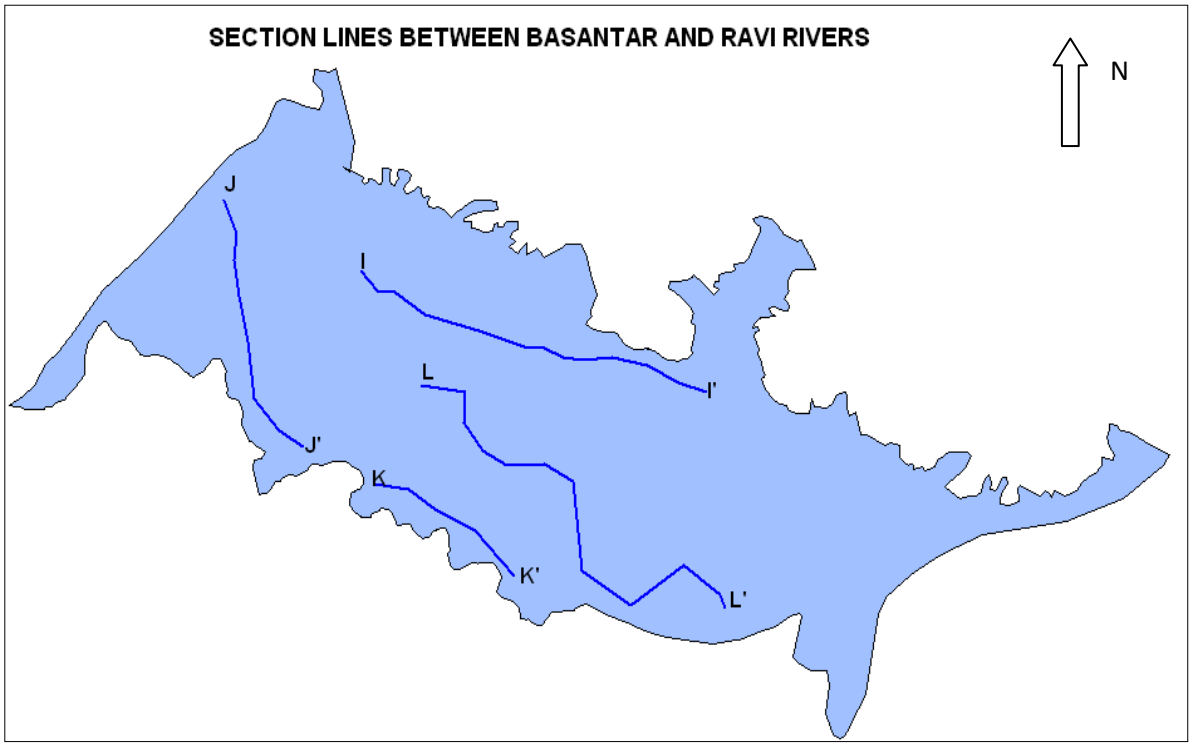


Figure 46: Map Showing Section Lines

The section drawn along I-I' from Nonath to Ghatti (figure 47) depicts the picture of pure Kandi formation with abundance of coarse sediments of pure boulders, cobbles, pebbles, gravels, kankar, sand, and also the admixture of clay with their granular sediments and abundance of sand with granular sediments. Pure clay formation also occurs at various depth except for well at the water levels in this section are between 30 to 50 m bgl except for Jasrota where it is nears to ground and at Nonath it is about 70 m bgl and at Thandiyari the water level encountered below 120 m.

The section J- J' drawn along from Mangu Chak to Bhim Lines (figure 48) depicts the depositional sequence of sediments from Sirowal to Kandi and in between viz. in the transition. At Mangu Chak where there is occurrence of pure layer with thick water bearing zones up to throughout its depth i.e. >100m bgl with the intervention of granular zones with and without clay at four places including the top soil. The top layers up to 15m extend up to Madoon where the water bearing horizon is separated by pure clay layers. Clay mixed with granular sediments is encountered at a depth > 110m which extends up to Mawa. At Sarthi Dera this clay mixed granular zone is encountered at top also but this pinches out instead of extending laterally. Challarian, Mawa and Rehian very thin layered horizons are encountered. The water levels are shallow at Mawa whereas on it left at Chillarian and it right at Rehian lies at around 50 m bgl. The Kandi formation is

evidenced by the presence of coarse sediments are encountered from BSF campus to Bhim lines. At BSF campus the water level is with 10 m from grand levels where as it is deeper at around 50 m at Manohar Gopala and Rakh Amb Tali and still deeper at Bhim lines.

The section K -K' drawn along Bobiya to Pansar (figure 49) typically in Sirowal Belt. The sediments are mainly sand and clay layers with some layers having admixture of sand with clay and gravel. Bobiya is located on the flank of the clay mound. Karol Krishna and Pansar are located on the clay mounds and Karol Matrian and Kadyala is located between these two mounds. The tubewells drilled on the flanks of the clay mounds have intercepted some granular horizons whereas the wells drilled on the clay mounds have encountered very thin granular horizons.

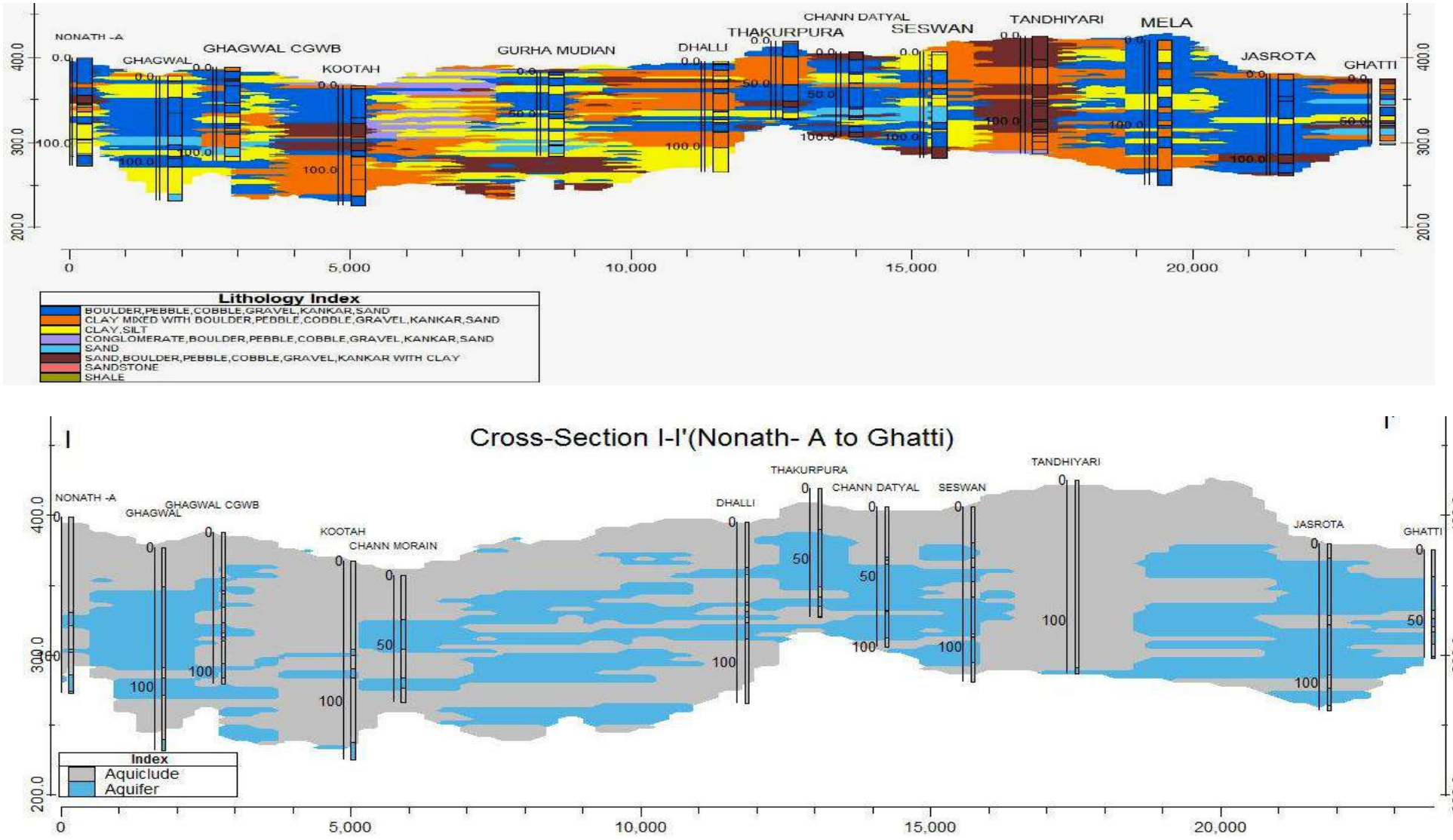


Figure 47: Cross Section depicting lithological and aquifer disposition along I – I'

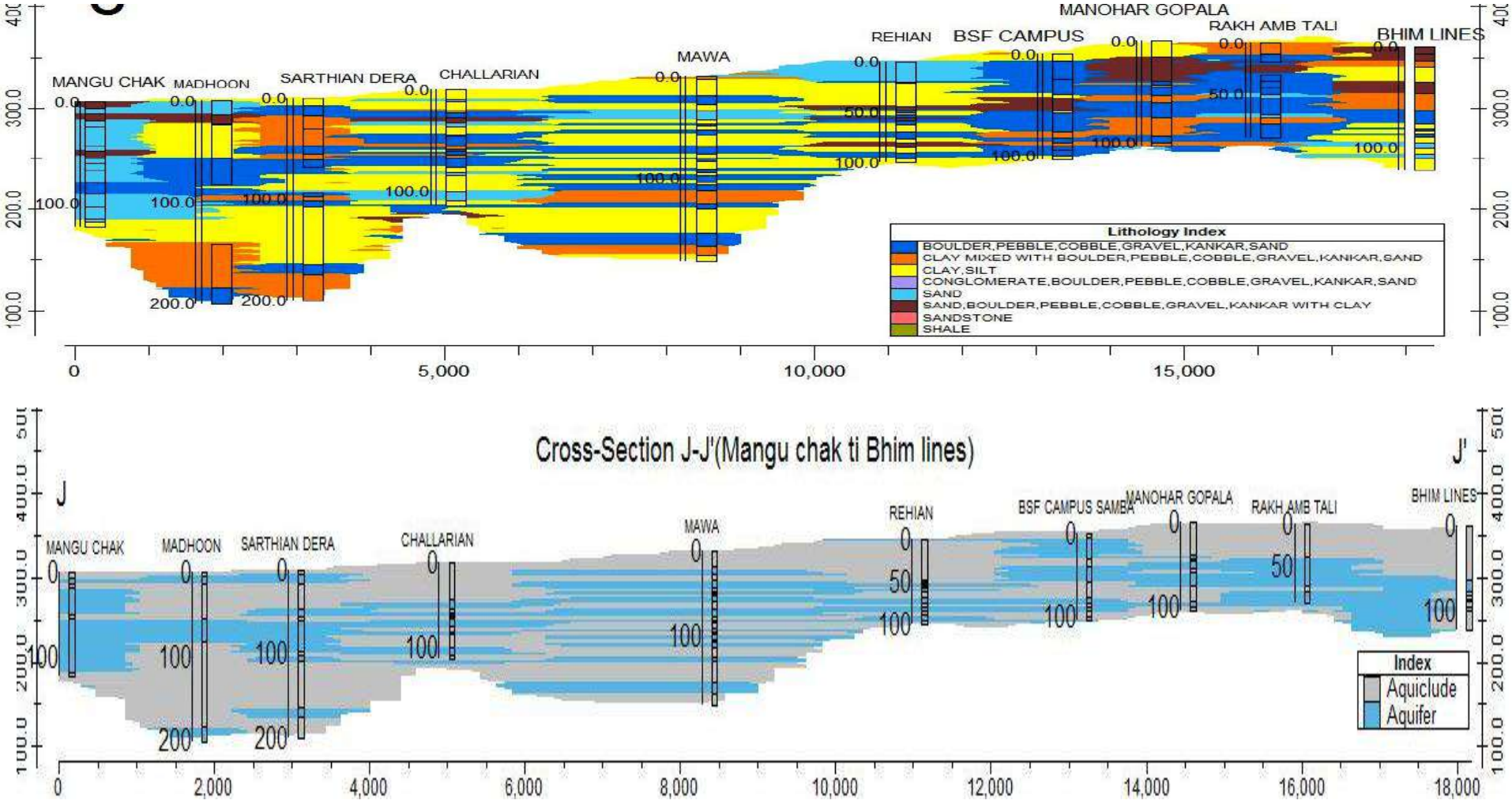


Figure 48: Cross Section depicting lithological and aquifer disposition along J-J'

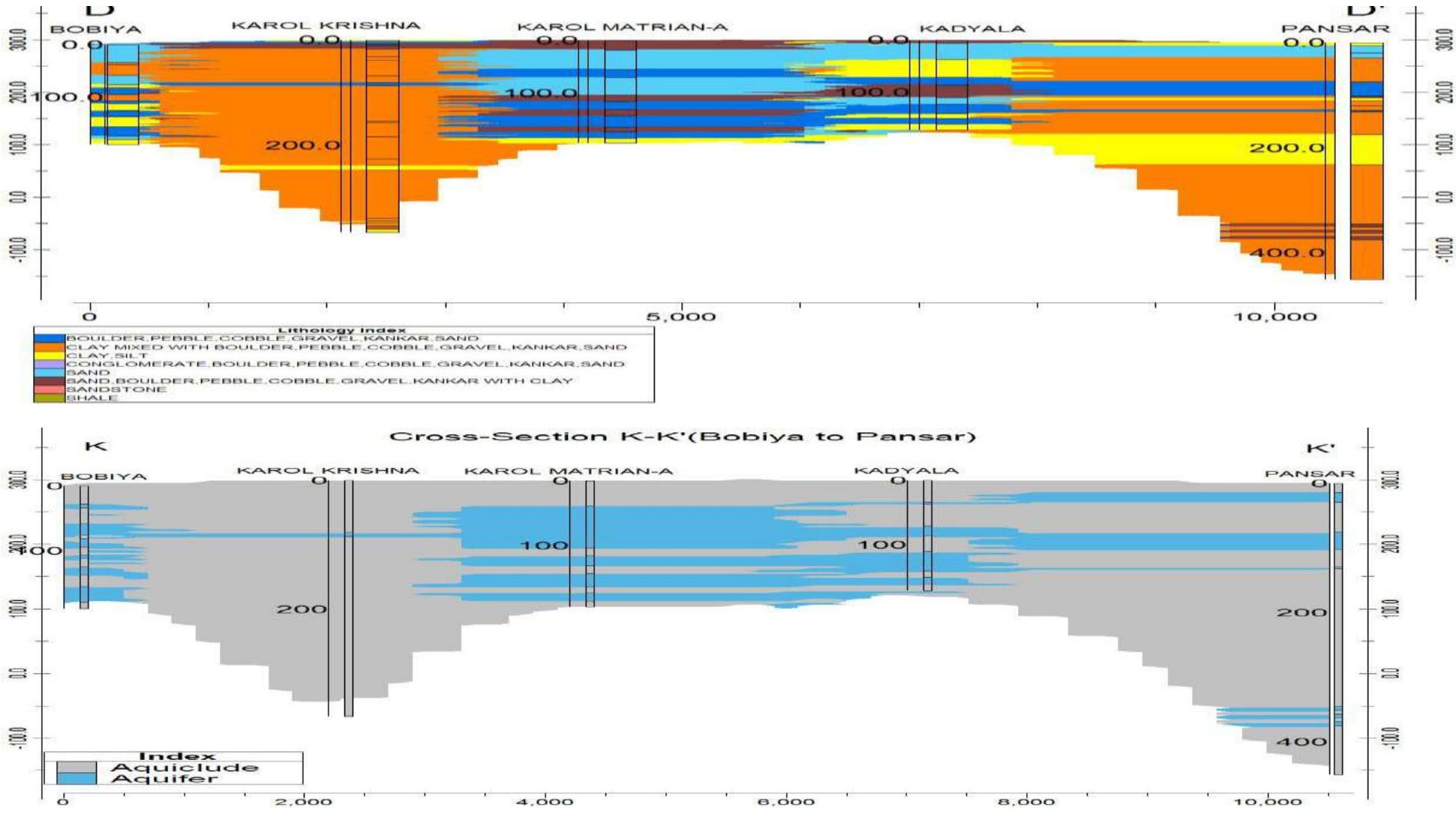


Figure 49: Cross Section Depicting Lithological and Aquifer Disposition along K – K'

Aquifer Conditions

Kandi Aquifers – under unconfined conditions

The static water level in the case of such artesian wells is above the ground surface and can be measured in the well if the casing extends high enough above the ground surface to prevent the flow out of the pipe on the land surface. This hydrostatic head can also be determined by capping the well near the ground surface and measuring the shut-in head with a pressure gauge.

Sirowal Aquifers – under unconfined and confined conditions

In parts of Jammu and Kathua Districts of J&K State, such artesian conditions exist in the Outer plains area between the Basanter and the Ravi River in the Sirowal Belt. The areas of high hydrostatic head are mostly found along the topographic contour of 320 metres above the mean sea level forming a spring line.

Ground water in the area occurs both under water-table and confined conditions. Near surface .i.e. dug well aquifers yield water under water table conditions whereas the deeper aquifers yield water under confined conditions. Water table aquifers in the area are getting replenished by in situ infiltration of rainwater as well as return flow of irrigation water. Top most effective clay bed occurs at a depth of about 30 metres below ground level and the same demarcates upper water table aquifers from the underlying confined aquifers. Recharge area of the confined aquifers is the Kandi and even the contact of the upper Siwaliks with the Kandi. Confined aquifers in the area seem to be in hydraulic continuity with the water table aquifers of the Kandi.

The confined aquifers are under tremendous hydrostatic pressure and wherever pierced through drilling, result into artesian (free flowing) conditions and have a free flow of one cubic metre or even more. Piezometric head of such aquifers lies at about 10-12 metres above ground surface. Some of the artesian wells are located in the following villages in the area, namely at Beliyan, Hiranagar, Nagri, Airwan, Kore Punnu, Marheen, Jangi Chak, Haripur Patil, Sunjwan, Tanda, Nauchak, Haria Chak, Kissan Nagar, Sadwal etc. General discharge of autoflow tubewells varies from 36 lpm to 4600 lpm. Highest discharge autoflow well is located at Nagri which is yielding 4668 lpm and depth of this well is 107m bgl. The piezometric head ranges from a meter to more than 9 m agl in these wells. The transmissivity values range from 150m^3/day to 400 m^3/day. The water available from these artesian aquifers is fresh, potable and fit for drinking and allied purposes. Locations of artesian wells are shown in figure 50.

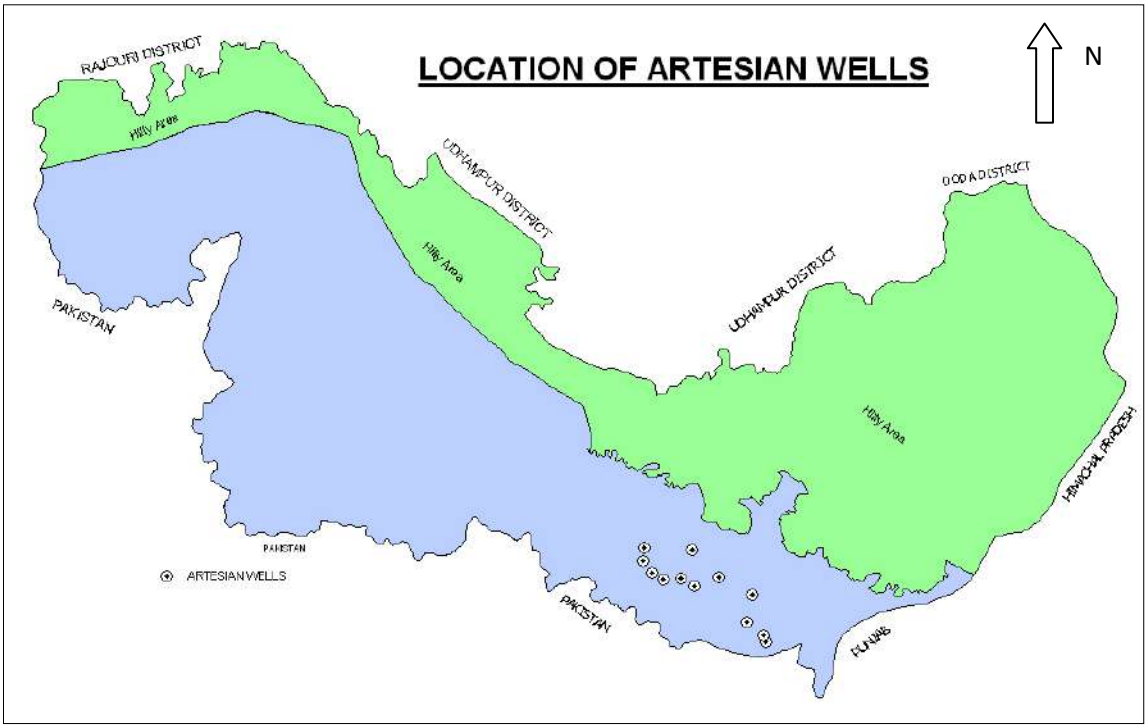


Figure 50: Locations of Artesian Tubewells.

A cross- section is drawn by including the artesian wells from Jandi to Nagri including lithologs of Hiranagar- Beliyan – Methra Chak – Haripur – Marheen – Chak Desa Singh – Chak Attar Singh – Kore Punnu – Airwan- Nagri Parole is depicted in figure 51. The elevation of these boreholes range from 318 m amsl at Hiranagar to 284 m amsl at Nagri. The depth ranges from 55.58 m at Airwan to 122.83 m at Beliyan. The wells included are although artesian and the piezometric heads rising from a meter to more than 9 m agl, the confining layer of clay building up the piezometeric head is no so thick and prominent in any of the wells. Here the piezometeric head and the free flow are assumed to be due to the clay mounds existing in this area which may be acting as barriers. This assumption needs to be confirmed by conducting the resistivity surveys in the area. Photographs of some of the free flowing wells are shown in figure 52.

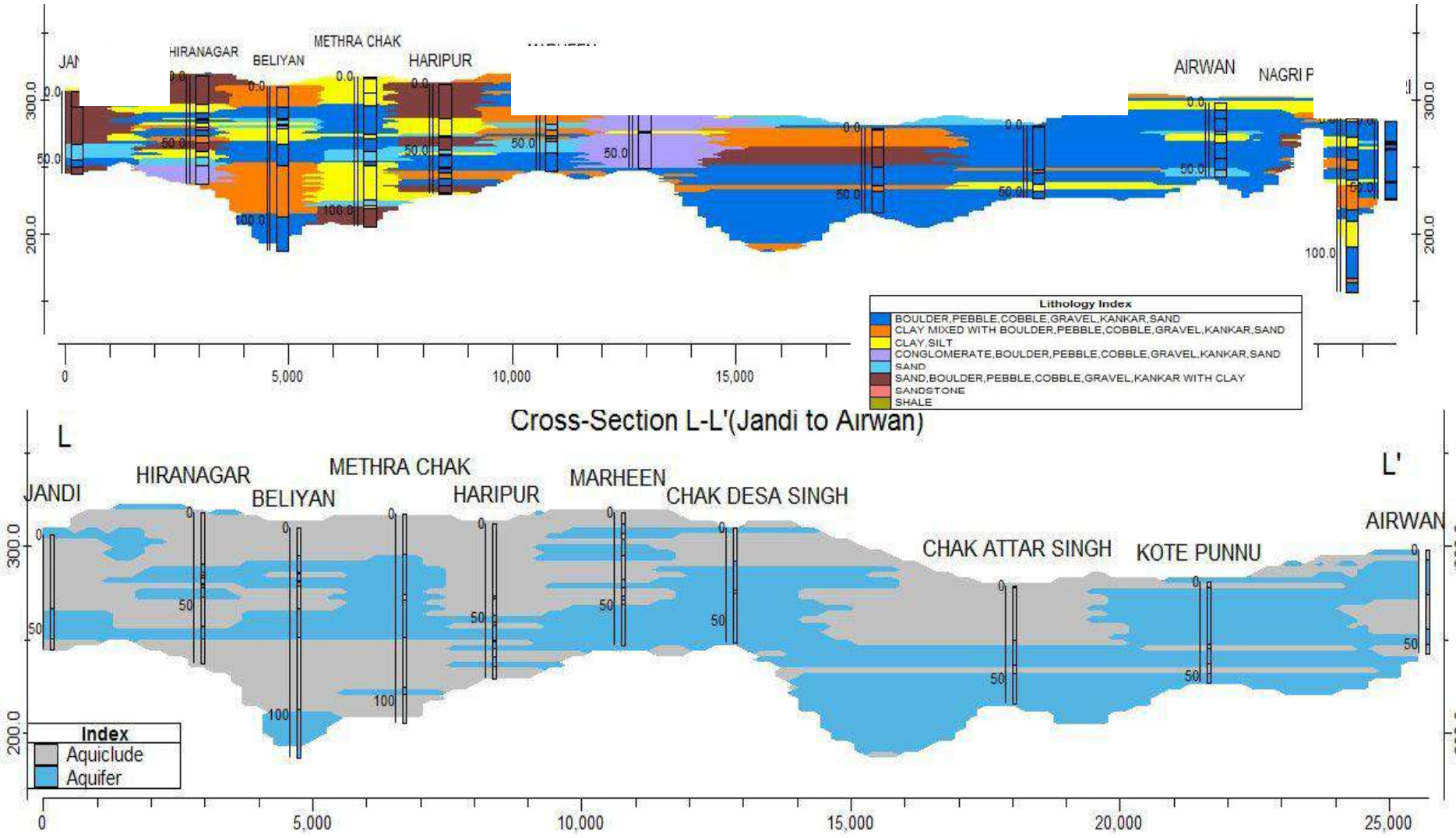


Figure 51: Cross Section of Artesian Wells.

Figure 52: Artesian Wells, Sirowal Belt, Kathua District.

GROUND WATER RESOURCES

The quantitative estimation of various inputs to ground water resources and their temporal variation in space and time is imperative for a planned management and development of ground water resources. The resources in the surveyed area are computed on the basis of methodology recommended by the Ground Water Estimation Committee of Ministry of Water Resources, Govt. of India, 1997.

The entire aquifer mapping area, except for 125 sq. km area i.e. the part extended towards the Siwalik Hills (tubewell data available) falls under command area and has been covered under ground water resource assessment. The estimation of ground water resource in the surveyed area is taken as on March 2011.

Methodology adopted

The primary source of recharge of groundwater in Outer Plains is rainfall. Therefore rainfall infiltration method has been used for estimating the resources. Rainfall recharge factor or Infiltration factor is a recharge parameter that indicates a quantum of water recharged to the groundwater system in relation to the rainfall. It is a function of rate of infiltration and ability of the system to accept the infiltrated water. The infiltration factor can be expressed as follows

IF = (Qi/Qa) X SY,

Where,

IF = Infiltration Factor

Qi = Quantum of water infiltrated over the test period in m

Qa = Quantum of water applied in m

SY = Specific Yield

Recharge of ground water involves several components and the rainfall being the major one. The other components are return irrigation flow from surface water and ground water.

Rainfall infiltration factor for Kandi & Sirowal formations is taken as 20%. The Return Flow Factor for recharge from surface water irrigation has been taken as 15-25 % for non-paddy crops and 50-60 % for paddy crops. In case of ground water irrigation, the return flow factor has been taken as 15-25 % for non-paddy crops. Canal seepage factor for lined and unlined canals has been taken as per GEC' 97 norms. The recharge from other sources i.e. ponds and lakes has also been estimated based on the spread area of the water bodies. The areas of ponds of Kandi belts of Jammu and Kathua Districts have been taken from the study carried out by NIH.

DYNAMIC GROUND WATER RESOURCES (As on March 2011)

As per the ground water resource assessment of dynamic resources of Outer Plains the net ground water availability is 165396.1 ham. The overall stage of ground water development is 19.52 %, falls under safe category. The details are given in table 7.

Table 7: Dynamic Ground Water Resources of Aquifer Mapping Area

S. No.	Assessment Unit/ District	Command / non-Command / Total (ha)	Total Annual Ground Water Recharge (ham)	Provision for Natural Discharges (ham)	Net Annual Ground Water Availability (ham)	Existing Gross Ground Water Draft for All uses (ham)	Provision for domestic and industrial requirement supply to 2025 (ham)	Net GW Availability for future irrigation development (6-7-8)	Stage of Ground Water Development {(7/6) * 100} (%)
1	2	3	4	5	6	7	8	9	10
1	Jammu	230000	130102.19	13010.22	117092	21495.87	9162.34	94936.63	18.36
2	Kathua	70000	44024.83	4402.483	48304.15	8596.2	3792.54	39042.6	17.79
TOTAL Outer Plains		300000	174131.0	17417.703	165396.1	30099.0	12962.8	133988	19.52%

The assessment of total availability of ground water resources encompasses two components namely Dynamic Resources and In-storage resources. The In-storage resources include In-storage unconfined and In-storage confined resources. For unconfined aquifer, In-storage resources are computed based on specific yield of the aquifer and of confined aquifer they are based on storativity of confined aquifer.

The In-storage resources of unconfined aquifer were calculated as per above norms and summarized in table 8.

Table 8: In-Storage Ground Water Resources of Unconfined Aquifer of Outer Plains

S. No.	Name of Assessment Unit	Type of formation	Average Pre-monsoon Water Level(m)	Depth to Bottom of Unconfined Aquifer (mbgl)	Total Thickness of formation below Pre-monsoon Water Level (m)	Thickness of Granular Zone below Pre-monsoon WL(m)	Average Specific Yield (%)	In Storage Ground water Resources (ham)
1	Jammu	Alluvium	12	110	91.7	96	16%	1398535.1
2	Samba	Alluvium	12	110	91.7	90	16%	398697.79
3	Kathua	Alluvium	8	110	94	102	16%	641824
	TOTAL				277.4	288		2439056.9

The In-storage resources of confined aquifer were calculated as per above norms and summarized in table 9.

Table 9: In-Storage Ground Water Resources of Confined Aquifer of Outer Plains

S. No.	Name of Assessment Unit	Type of formation	Depth to Bottom of Unconfined Aquifer (mbgl)	Average Explored depth (mbgl)	Total thickness of Confined aquifer down (m)	Thickness of Granular zones in confined aquifer down to explored depth (m)	Average Value of Storativity	In Storage Fresh Ground water Resouces (ham)
1	Jammu	Alluvium	110	318	208	96	0.000305	4230.32
2	Samba	Alluvium	110	318	208	90	0.000302	1363.23
3	Kathua	Alluvium	110	320	210	102	0.000126	709.26
			330	318.66	626	288		6302.81

The total ground Water availability of Outer Plains is calculated by adding up the dynamic and In-storage resources and the total ground water resources are 2445359.66 ham or 24.53 bcm. (Table 10).

Table 10: Availability of Total Ground Water Resources in Outer Plains

(as on March 2011)

Sl. No.	Name of Assessment Unit	Net Ground Water Availability Dynamic Ground Water Resources As on 31st March 2011) (Ham)	Fresh In Storage Ground Water Resources (Ham)		Total Fresh In - Stoarge Ground Water Resources (Ham) (3+4+5)
1	2	3	4	5	6
			Confined	**Unconfined**	
1	Jammu*	117092	4230.31	1398535.056	1402765.37
2	Samba*		1363.24	398697.792	400061.03
3	Kathua*	48304.15	709.26	641824	642533.26
TOTAL OUTER PLAINS		165396.15	6302.81	2439056.848	2445359.66

4. ISSUES AND AQUIFER MANAGEMENT STRATAGIES

Major ground water related issues

KANDI Formation

- Deeper Water Levels
- Decline in Water Levels
- Comparatively Steeper slopes
- Large no. of Ponds - 365 (mostly in a state of utter neglect and disuse)
- Open Dug Wells losing their Utility
- High NO_3 and Fe at a few places
- Higher concentrations of Fe, Mn, Ni and Pb in Bari Brahmana industrial area
- Deforestation led to reduced recharge

SIROWAL Formation

- Artesian Conditions: Ground water is lost through natural drainages
- Surface flows: Huge volume of unaccounted water flowing waste
- Water Logged Area – Reduced – declining ground water levels
- High NO3 at a few isolated places

In higher reaches above Kandi, river bed material mining is rampant, which leads to reduced recharge and increased runoff.

Issues in Kandi Belt

1. Deeper Water Levels

There is acute shortage of water in the Kandi formation where the water tables are deep seated. The lithology in the area is highly pervious and capable of receiving large volumes of recharge.

2. Decline in Water Levels

The decadal water level fluctuation for the month of May 2013 w.r.t. (May 2003 to May 2012), shows that there is falling trend of water levels in Kandi belt in the range of 2 m except for the Kootah area where fall is more than 4 m has been observed.

3. Comparatively Steeper slopes

The master slope of the area is towards the S.S.W to South-West. In Kandi Belt the slope is steep in the order of 8 to 20 metres per kilometers due to coarse sediments i.e. boulder gravels etc. Immediately to the south west of Siwalik hills slope is steepest. It becomes gentle towards the spring line.

4. Large number of Ponds

There are a large number of ponds/tanks in the study area, 365 in number. In earlier days water from these ponds was being used for washing, bathing and even drinking at places. These ponds also acted as recharge structures. With the coming up of piped water supply these ponds have been put to dis-use and have even been encroached upon, and their inlets have been disturbed. Some ponds are being filled up by tubewells installed near them which are putting stress on aquifers. Field photograph of a pond filled through ground water and in lean period are shown in figure 53.

Figure 53 : Pond (Filled by Tubewell (at Jakh), Dried (at Sungwal).

5. Open Dug Wells losing their Utility

There exist a large number of dug wells (open wells and most of them belong to the village community) in the area, which have lost their utility with the coming up of piped water supply (figure 54). These dug wells are either being filled up with garbage or they are being covered up with RCC slabs to avoid falling of children and animals in them.

Figure 54: Dug well – Abandoned.

6. High NO_3 and Fe at a few isolated places

Contamination of water from septic tanks occurs under various conditions viz, Poor placement of septic leach fields, high density placement of tanks, leakage from sewer lines. Nitrate is also mostly found in the return flow from the agriculture area.

7. Higher concentrations of Fe, Mn, Ni and Pb in Bari Brahmana industrial area

The concentration of Iron, Mangnese, Lead and Nickel were found more than MPL of BIS in pre as well as post-monsoon seasons. The iron and steel manufacturing units are the main polluting source of Mangnese. Lead salts are used as anti knocking compounds in gasoline engines. It is also released by smelting operations. Effluents of industries of paints, batteries, printing and dyeing are the sources of lead in ground water. Nickel is being released in atmosphere from iron and steel furnaces or from effluents of electroplating wastes, steel alloy industries, dyes and textiles and nickel-cadmium batteries

8. Deforestation led to reduced recharge

Earlier Kandi belt was covered by dense forests, but with the increase in population and upcoming industrial areas huge area was deforested. This led to soil erosion, reduction in rainfall as well as recharge to ground water.

Issues in Sirowal Belt

9. Artesian Conditions:

Huge amount of ground water is lost through the free flow artesian wells. Number of tubewell is being constructed in this area of free flow wells for irrigation purposes. The ground water emerging through these free flow tubewells can be channelised and utilized for irrigating the fields. Absence of water and electricity budgeting provisions are a cause of wastage of fresh utilisable ground water.

10. Surface flows: Springs

There exist a large number of fresh water springs in the study area, which emerges out of the ground as spring line in Sirowal Belt. This large volume of fresh water after emerging out in the shape of spring line flows into nearby Pakistan, where as our areas in the Kandi and in places in the Sirowals also faces water scarcity both for drinking and irrigation purposes.

The large volume of fresh water emerging out from the spring line in Sirowal Belt should be collected (figure 55) and lifted back to the Kandi area and used for drinking purposes, irrigation and to provide good quality water to the large Industrial Estates coming up at Ghatti, Govindsar, Samba, Kootah and Hatli. Excess water from the above mentioned use may be utilized for artificial recharge through the natural drainage in the area which is highly porous. Presently these industrial areas are completely dependent on ground water through tube wells, which is causing stress to the aquifers.

Figure 55: Image from Google Earth, Hiranagar Area, Kathua District

11. High NO_3 at a few isolated places.

Contamination of ground water by nitrate is due to septic tanks in urban areas and from agricultural return flow and cow dung heaps in the rural areas.

Management Options- DEMAND SIDE

1. Spring water emerging as surface flow going unaccounted into drains

► It is proposed that the state government should be impressed upon to locate all future water based industry at locations where it can use the perennial fresh water of springs flowing waste as surface runoff.

The present water requirement of the industrial estates in Kathua District is gathered and is given below:

Present water requirement by industry in the area

- Samba industrial estate : 6976 m^3/day
- Govindsar industrial estate : 7264 m^3/day
- Hatli industrial estate : 4649 m^3/day
- Ghatti industrial estate : 3487 m^3/day

Total : 22376 m^3/day

► It is proposed that a large volume of spring water flowing in the perennial Bein, Nalla, Tarnah Nalla Bhag Nalla and the Wajju Nalla and flowing into nallas should be tapped through a lift irrigation scheme, to irrigate our agricultural land on these mounds. Since these mounds are located on a higher elevation a part of the water from the left irrigation scheme can be useful to irrigate the vast tract of agricultural land in the upstream, through gravity. Approximately an area of 300 sq. have can be irrigation through this proposal (figure 56). This agricultural land should be leveled by laser levelers for effective irrigation.

Figure 56: Perennial Springs, Kathua District

- Large tract of agricultural land located on clay mounds exactly along the LOC is presently (figure 57) being irrigated through tube wells. Since the area comprise of clay mounds /deposits these tube wells are prone to become defunct in a short span of time. In the area a large volume of spring water is flowing into the neighboring country whereas our own agricultural land in the absence of assured tube wells irrigation becomes rainfed.

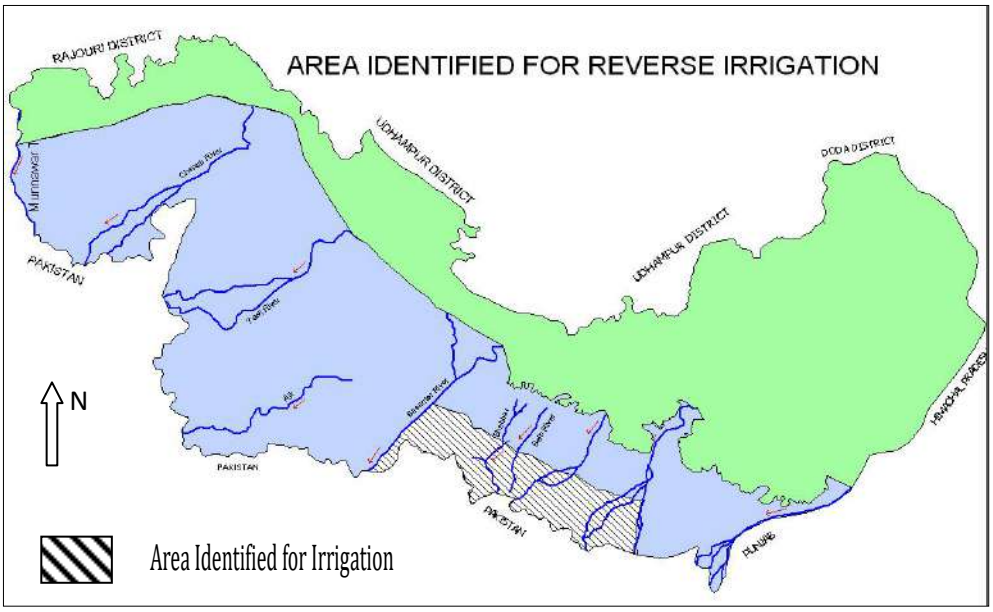


Figure 57: Area Identified for irrigation.

2. Artesian flows

Huge amount of ground water is lost through the free flow artesian wells. The ground water emerging through these free flow tubewells can be channelised and utilized for irrigating the fields.

Management Options - SUPPLY SIDE

3. Artificial Recharge to Ground Water

Groundwater recharge should be taken up on a massive scale by construction of small check dams, gully plugging, contour bunding (figure 58), upstream of the Jammu-Pathankot National Highway. Area identified for taking up artificial recharge activities is demarcated in figure 59.

Figure 58: Artificial Recharge Structures.

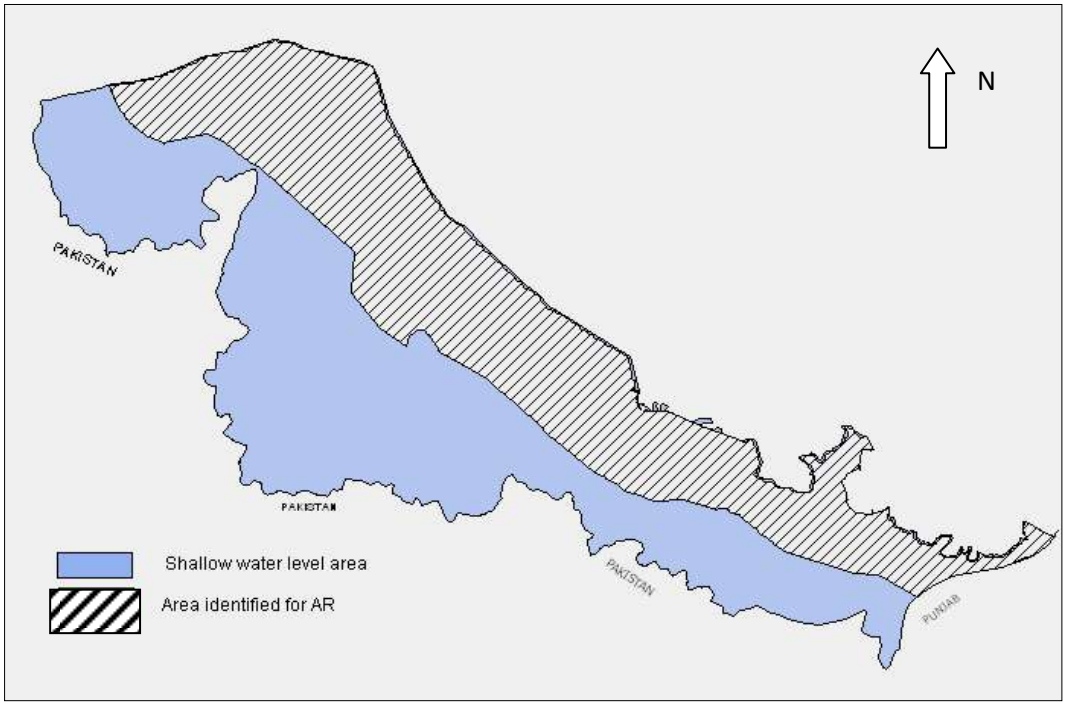


Figure 59: Area Identified for Artificial Recharge Structures

4. Roof Top Rain Water Harvesting

Rooftop rainwater harvesting (figure 60) should be made mandatory, especially in Government buildings having rooftop area of more than 500 sq.m located upstream of the Jammu-Pathankot National Highway falling in Kandi belt.

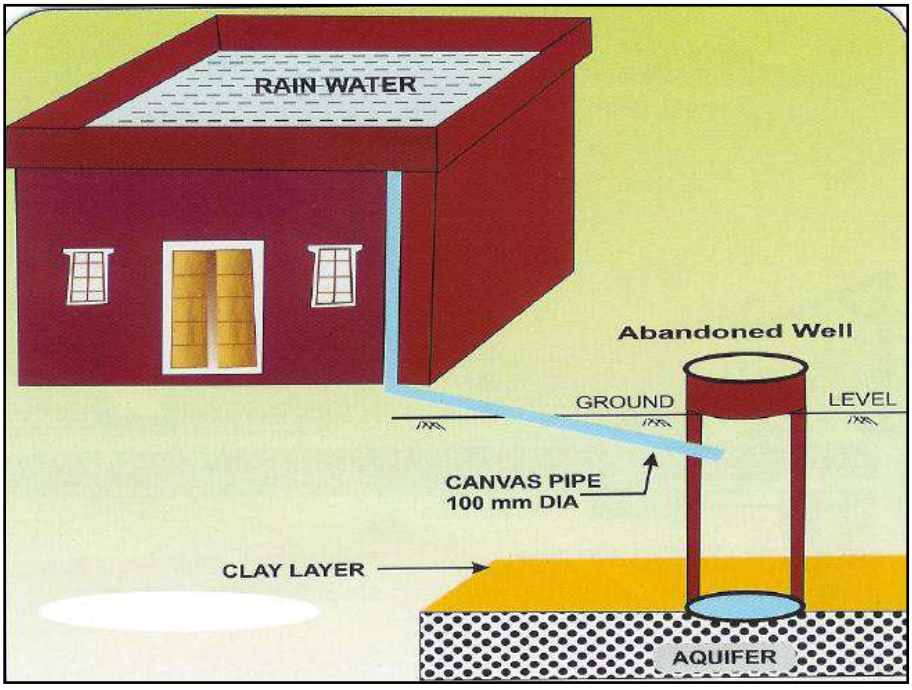


Figure 60: Roof Top Rain Water Harvesting Structure.

The number of structures and their cost components based on the report on District-wise Artificial recharge Plan (2009) is given in table 11. The cost component is enhanced as per 2015 scenario.

Table 11: Cost Component of Artificial Recharge Structures

Project Type	Approx. No. of Structures	Estimated Unit Cost (Rs.)	Total Cost (Rs.)
Revival and restoration of village ponds (restorable)	200	40,00,000	80,00,00,000
Gabion structures/ Nala bunds/Sub-surface bandharas	50	80,00,000	4,00,00,000
Rooftop rainwater harvesting structures and artificial recharge structures	40	18,00,000	7,20,00,000
Diversion of flows from Perennial Nalas/Springs in RCC storage tanks	200	17,00,000	34,00,00,000
Total	**490**		**45,20,00,000**

5. Recharge wells in the beds of Canals

Forty to fifty meters deep boreholes (depending upon the location) should be drilled in the bed of Ranbir Canal (first 40 kms of main canal) and Rawi-Tawi Canal after every 200 meters distance to recharge the stressed aquifers. Actual field photograph of Ranbir Canal is shown in figure 61.

Figure 61: Irrigation Canals.

6. Recharge wells on the banks of Perennial Rivers

There are five perennial rivers in the study area namely the Munnawar Tawi, the river Chenab, the river Tawi, the river Basanter and the Ravi River. Out of the 365 days in a year, on an average these rivers carry clear water for about 300 days.

Recharge tube wells should be constructed along the periphery of these rivers and the stressed aquifers should be recharged. A perennial river (figure 62) and the design of a recharge well is shown in figure 63.

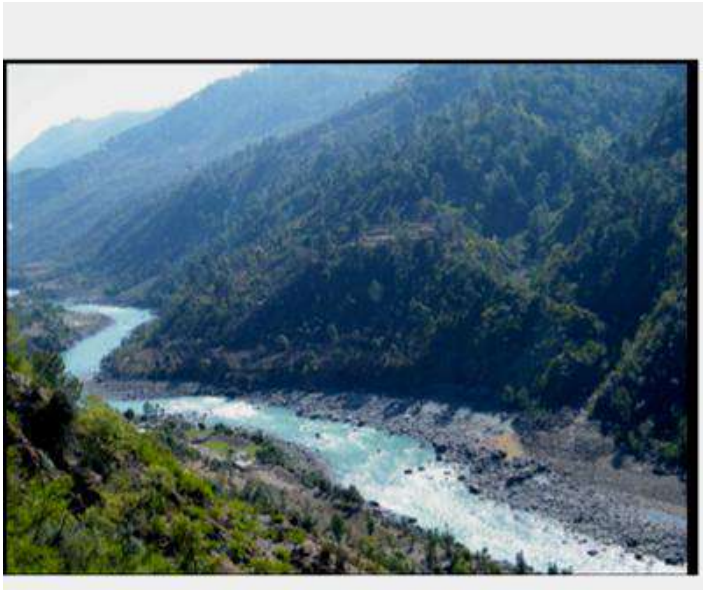


Figure 62 : Perennial River (left)

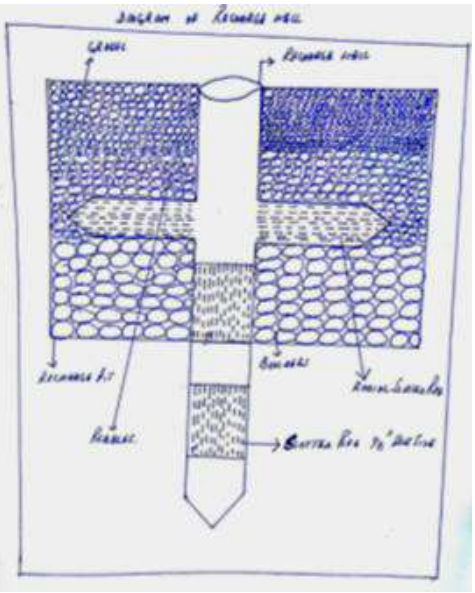


Figure 63: Design of a recharge well (right)

7. Afforestation

In Kandi Belt, afforestation will help in better soil condition, increase in rainfall and increased ground water recharge and the problem of water scarcity faced by inhabitants of Kandi area especially in summers can be worked out.

8. Dug wells (open wells)-

Open Dug wells have lost their utility with the coming up of piped water supply. These dug wells are being filled up with garbage. The dug wells can be converted into recharge structures with little modifications

9. PONDS put to dis-use and have even been encroached upon

The large number of ponds available should be put to use as recharge structures by removing their encroachments and clearing there inlets (figure 64) and the practice of filling up of a pond through tubewells should be stopped.

Figure 64: Renovation of Ponds

Regulatory Measures

1. Irrigation Wells

The tube wells of state government departments are used, both for irrigation as well as drinking water supply purposes (figure 65) are being pumped continuously for 20-22 hours in a day, during lean periods, and it is only because of power cuts that pumping is stopped thus putting the aquifers into stress

This practice is more prevalent during the months of May-June-July-August, when the demand for water increases on the higher contours i.e. the Kandi s and during the same period wells located on the lower contours i.e. the Sirowals are pumped non-stop for irrigation purposes because it is the sowing season of the world famous Jammu Basmati rice.

Figure 65: Irrigation Well

The wells should be given proper recuperation time and the capacity of pumps should be adhered to the recommended safe discharge.

2. In industrial areas Effluent Treatment Plants must be installed and waste disposal should be strictly monitored to protect the aquifer from pollution.

Gist of the Presentation of Aquifer Mapping & Management Plans (3,000 sq. Kms area), made to Secretary, PHE & IFC, J&K Govt. on 30-04-2016.

During the meeting with the Sh. Sanjeev Verma, Secretary, PHE & IFC, J&K Govt. with the Dr. Uma Kapoor, Regional Director, CGWB, NWHR, Jammu on 29-04-2016, it was decided that presentation of Aquifer Mapping & Management Plans of 3000 sq. Kms area, be made to the Secretary, PHE & IFC, Chief Engineers of PHE & IFC, concerned Executive Engineers of Aquifer Mapping area on 30-04-2016.

Accordingly, the presentation was delivered to the Secretary, PHE & IFC, Chief Engineers of PHE & IFC, concerned Executive Engineers of Aquifer Mapping area, at the Institute of Engg, Gandhi Nagar, Jammu at 10:00 hrs on 30-04-2016, by the officers of CGWB, NWHR, Jammu comprising of Sh. Vinod Sharma, Scientist 'D', Sh. K. P. Singh, Scientist 'B' & Smt. Priya Kanwar, AHG. During the course of presentation, Choudhary Shyam Lal, Hon'ble Minister of PHE & IFC, Sh. Kavinder Gupta, Hon'ble Speaker of Legislative Assembly, Sh. Rajesh Gupta, MLA Jammu (East), also walked in, conveying that they are also interested in seeing the presentation.

During the presentation Choudhary Shyam Lal, Hon'ble Minister of PHE & IFC, interacted on various issues related with the development and conservation of ground water. He appreciated the efforts put by CGWB in aquifers mapping and in envisaging development plans. When the presentation was nearing completion Sh. Shamsher Singh Manhas, Member Parliament, also joined the august gathering.

During the presentation & discussion following points emerged :

- Secretary, PHE & IFC, agreed upon to take up the matter with State Govt. for creation of independent State Ground Water Department.
- Secretary, PHE & IFC, insisted CGWB for providing the organizational setup for creating new State Ground Water deptt.; scientific instruments required, etc.
- Secretary also desired, till the time department is created, CGWB, NWHR, may provide all necessary technical and scientific assistance viz. identifying suitable sites for development of ground water sources, resistivity surveys, electrical loggings, pumping tests, sustainability inputs of existing GW structures etc. in stress / problematic areas, to the State Deptts.
- Executive Engg., Tube Well Irrigation Division, Jammu, agreed to provide a list of the defunct tubewells for converting them into Piezometer or Recharge Structure, depending upon the site characteristics.
- Choudhary Shyam Lal, Hon'ble Minister of PHE & IFC, agreed to our suggestion in management plan, that he will provide 1 to 2 recharge boreholes in the bed of Ranbir Canal for recharge to ground water in Kandi area, on experimental basis.
- Secretary, PHE & IFC, J&K Govt., emphasised that there should be more interaction & data sharing among CGWB & State deptts.

The Secretariat of Jammu and Kashmir is at Srinagar (Summer Capital). The Meeting with Principal Secretary could not be held due to Law and Order problem in Kashmir Valley.

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ANNEXURE I

Data gap identification in Exploration in Outer Plains								
S. No.	District	Formation	Toposheet no.	Quadrant no.	Total no. of existing wells	Aquifer Parameters		Total no. of sites Porposed
						Availabe no. of T values	Available no. of S values	
1	Jammu	alluvium	43L/9	A3	4	*	*	1
2	Jammu	alluvium		B3	nil	*	*	1
3	Jammu	alluvium		C1	3	*	*	1
4	Jammu	alluvium		C2	6	2	*	1
5	Jammu	alluvium		C3	3	*	*	1
6	Jammu	alluvium	43L/10	A1	NIL	*	*	1
7	Jammu	alluvium		B1	NIL	*	*	1
8	Jammu	alluvium		B2	NIL	*	*	1
9	Jammu	alluvium		B3	NIL			2
10	Jammu	alluvium		C1	Nil	*	*	1
11	Jammu	alluvium		C2	2	2	*	1
12	Jammu	alluvium		C3	2	*	*	1
13	Jammu	alluvium	43L11	C1	2	2	*	1
14	Jammu	alluvium	43L/13	A1	NIL	*	*	1
15	Jammu	alluvium		A3	nil	*	*	1
16	Jammu	alluvium	43L/14	A1	3	1	*	1
17	Jammu	alluvium		A3	1	1	*	1
18	Jammu	alluvium		B1	3	1	*	1
19	Jammu	alluvium/ sandstone		C1	nil	*	*	1
20	Jammu	Alluvium		C2	5	5	*	1

S. No.	District	Formation	Toposheet no.	Quadrant no.	Total no. of existing wells	Aquifer Parameters		Total no. of sites Porposed
						Availabe no. of T values	Available no. of S values	
21	Jammu	Alluvium	43L/15	A1	NIL	*	*	1
22	Jammu	Alluvium		C1	2	*	*	1
23	Jammu	Sandstone /alluvium	43P/2	A3	3	2	*	1
24	Jammu	alluvium		B3	2	1	*	1
25	Jammu /Kathua			C3	3	1	*	1
26	Jammu	Alluvium	43P/3	A1	1	*	*	1
27	Jammu /Kathua	Alluvium		B1	4	3	*	1
28	Kathua	Alluvium		B2	nil	*	*	1
29	Kathua	Alluvium		C1	2	1	*	1
30	Kathua	Alluvium		C2	1	*	*	1
31	Jammu /Kathua	sandstone	43P/6	A3	2	*	*	1
32	Kathua	Sandstone /alluvium		C3	2	*	*	1
33	Kathua	Alluvium	43P/7	A2	1	*	*	1
34	Kathua	Alluvium		B1	4	1	*	1
35	Kathua	Alluvium		B2	2	*	*	1
36	Kathua	Alluvium		B3	nil	*	*	1
37	Kathua	Alluvium		C1	5	2	*	1
38	Kathua	Alluvium		C3	nil	*	*	1

S. No.	District	Formation	Toposheet no.	Quadrant no.	Total no. of existing wells	Aquifer Parameters		Total no. of sites Porposed
						availabe no. of T values	available no. of S values	
39	Kathua	alluvium/ sandstone	43P/11	A1	1	*	*	1
40	Kathua	Alluvium		A3	nil	*	*	1
41	Kathua	alluvium/ sandstone		C1	nil	*	*	1
42	Kathua	Alluvium		C2	1	*	*	1

ANNEXURE II

Results of Chemical Analysis of Water Samples collected from NHS

S. No.	Location	Type of Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO3	HCO3	Alkalinity	Cl	SO4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
1	Akhnoor	T/W	24/5/13	21	7.93	530	0	293	240	18.0	24	14.0	0.13	64	29	5.7	6.5	280	281	0.30
2	Bakore	H.P	24/5/13	20	7.72	610	0	214	175	46.0	53	43.0	0.11	50	34	28.0	3.7	265	323	4.55
3	Baradow	D.W	24/5/13	19	7.83	360	0	189	155	14.0	2	17.0	0.06	46	15	6.8	0.43	175	191	0.14
4	Bareri	D.W	24/5/13	21	7.96	470	0	235	193	25.0	2	7.1	0.09	56	21	3.7	1.2	225	249	0.31
5	Bhagwanchak	D.W	24/5/13	21	8.28	420	0	171	140	14.0	45	40.0	0.10	30	16	45.0	1.3	140	223	1.83
6	Devipur	D.W	24/5/13	20	7.91	360	0	189	155	18.0	3	9.7	0.08	52	13	1.9	1.3	185	191	0.06
7	Dhanpur	H.P	24/5/13	22	7.63	630	0	232	190	28.0	2	115.0	0.03	80	21	18.0	1	285	334	0.14
8	Dharam Khoo	D.W	24/5/13	21	8.24	280	0	134	110	18.0	20	9.5	0.13	28	20	5.1	2.3	150	148	0.05
9	Gajansoo	H.P	24/5/13	19	8.01	580	0	220	180	64.0	43	0.9	0.14	38	28	45.0	5.9	210	307	4.98
10	Garhi	D.W	24/5/13	20	8.66	470	18	134	140	35.0	56	13.0	0.16	14	34	33.0	9.3	175	249	0.21
11	Gho Manhasan	D.W	24/5/13	21	8.01	680	0	323	265	32.0	16	5.8	0.26	20	54	27.0	2	270	360	0.23
12	Gigrial	D.W	24/5/13	20	8.27	320	0	183	150	18.0	2	5.4	0.19	34	15	16.0	1.6	145	170	0.01
13	Gura	D.W	24/5/13	20	8.35	420	12	159	150	25.0	35	34.0	0.16	24	37	17.0	1.3	210	223	1.00
14	Hazuribag	H.P	24/5/13	21	8.07	280	0	73	60	14.0	75	4.5	0.13	34	10	4.1	22.1	125	148	0.43
15	Hamirpur Kona	D.W	24/5/13	21	8.49	270	6	128	115	7.0	18	2.0	0.11	34	13	2.5	0.72	140	143	0.13
16	Hamirpur Sidhar	D.W	24/5/13	21	7.67	1190	0	152	125	113	145	216.0	0.25	50	34	116	73	265	631	0.13
17	Jaswan	D.W	24/5/13	22	7.8	450	0	82	67	50.0	0	134.0	0.16	18	26	16.0	48	150	239	0.20

S. No.	Location	Type of Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO 3	HCO 3	Alkal inity	Cl	SO 4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
18	Jhiri	D.W	24/5/13	19	8.45	310	12	104	105	14.0	32	11.0	0.10	24	22	5.9	3.4	150	164	0.04
19	Jourian	D.W	24/5/13	19	8.26	580	0	177	145	53.0	47	48.0	0.08	48	17	46.0	14	190	307	0.26
21	Kachrial	D.W	24/5/13	21	7.78	690	0	232	190	25.0	57	16.0	0.11	70	18	10.0	20	250	366	0.20
22	Kalah	D.W	30/5/13	19	7.95	510	0	213	175	28.0	3	38.0	0.10	80	0	14.0	14.2	200	270	0.02
23	Kana Chak	D.W	30/5/13	21	7.89	480	0	183	150	25.0	23	13.0	0.05	40	22	9.0	8.2	190	254	1.11
24	Kangar	D.W	30/5/13	19	8.24	260	0	128	105	18.0	3	9.7	0.14	24	16	6.4	1.7	125	138	0.23
25	Khairi	D.W	30/5/13	20	8.27	220	0	98	80	14.0	0	18.0	0.11	30	6	6.2	1.6	100	117	0.09
26	Khour	H.P	30/5/13	19	7.71	490	0	177	145	18.0	25	16.0	0.10	46	15	15.0	1.43	175	260	0.13
27	Lam	D.W	30/5/13	19	8.13	520	0	214	175	21.0	2	4.1	0.00	54	9	11.0	13	170	276	0.13
28	Lehherian	D.W	30/5/13	19	8.44	330	12	134	130	18.0	27	12.0	0.14	22	24	16.0	2.4	155	175	0.40
29	Marh	H.P	30/5/13	19	8.07	640	0	207	170	36.0	73	54.0	0.19	38	46	24.0	1.8	285	339	0.37
30	Marjholi	D.W	30/5/13	21	8.15	350	0	159	130	14.0	9	6.3	0.05	18	17	5.3	2.5	150	186	0.00
31	Muthi	D.W	30/5/13	21	8.25	500	0	195	160	36.0	64	4.0	0.26	32	34	26.0	3.00	220	265	0.09
32	Nagbani	D.W	30/5/13	19	8.19	380	0	189	155	11.0	25	0.0	0.38	26	23	16.0	1.30	160	201	0.40
33	Nandni	D.W	30/5/13	18	8.37	310	6	146	130	18.0	2	0.0	0.02	30	15	8.9	2.6	135	164	0.10
34	Pallanwala	D.W	30/5/13	21	8.28	300	0	128	105	14.0	16	7.0	0.10	20	18	10.0	0.70	125	159	0.97
35	Paltan	D.W	30/5/13	19	8.31	320	6	98	90	28.0	33	14.0	0.08	28	18	14.0	0.90	145	170	0.08
36	Pangli Colony	D.W	30/5/13	18	8.11	340	0	128	105	18.0	47	7.4	0.11	30	18	14.0	3.90	150	180	0.04
37	Pata Khu	D.W	30/5/13	20	7.91	360	0	189	155	11.0	5	7.0	0.05	34	20	6.0	2.50	165	191	0.01
38	Patyale Chak	D.W	30/5/13	19	8.1	380	0	177	145	14.0	49	4.2	0.20	22	28	22.0	1.50	170	201	0.01
39	Purkhoo	H.P	30/5/13	19	8.42	370	6	159	140	25.0	26	29.0	0.10	20	30	22.0	2.06	175	196	1.49
40	Sandhwan	H.P	31/5/13	20	8.07	620	0	232	190	43.0	88	14.0	0.13	24	46	41.0	11.00	250	329	0.33

S. No.	Location	Type of Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO 3	HCO 3	Alkal inity	Cl	SO 4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
41	Sajwal	D.W	31/5/13	19	8.01	390	0	165	135	14.0	11	6.2	0.07	38	16	4.0	2.40	160	207	0.25
42	Senth	D.W	31/5/13	19	7.99	560	0	275	225	18.0	21	17.0	0.26	58	22	18.0	9.00	235	297	2.13
43	Shamechak	D.W	31/5/13	20	8.38	380	12	137	132	18.0	37	22.0	0.08	46	12	17.0	1.20	165	201	0.05
44	Barnai	H.P	31/5/13	19	8.174	450	0	189	155	21.0	19	14.0	0.03	32	24	12.0	8.00	180	239	0.94
45	Kaloo Chak	H.P	31/5/13	20	8.06	570	0	305	250	21.0	4	0.0	0.06	60	22	14.0	11.00	240	302	0.08
46	Arnia-I	DW	24-5-13	19	8.07	720	0	220	180	46.0	45	60.0	0.14	20	22	65	46	140	382	0.05
47	Arnia-II	DW	24-5-13	21	7.6	1180	0	494	405	78.0	9	42.0	1.00	56	40	63.0	91	305	625	0.57
48	Alla	DW	25-5-13	20	8.2	250	0	79	65	11.0	1	5.8	0.36	26	13	3.6	0.6	120	133	0.57
49	Arge Chak	DW	25-5-13	21	7.94	490	0	183	150	14.0	0	11.0	0.27	45	21	8.7	0.7	160	260	0.23
50	Bera	DW	25-5-13	19	7.95	500	0	238	195	14.0	3	2.6	0.32	20	26	29.0	2.01	155	265	0.06
51	Bega	DW	25-5-13	21	8.2	1510	0	519	425	113.0	124	115.0	0.56	8	61	65.0	310	270	800	0.16
52	Bishna	DW	28-5-13	18	8.28	630	0	287	235	50.0	11	6.6	0.10	18	30	52.0	30	170	334	0.20
53	Bassi Kalan	DW	28-5-13	19	8.36	380	6	159	140	21.0	5	18.0	0.23	20	24	15.0	1.6	150	201	0.08
54	Birpur	TW	28-5-13	19	8.28	220	0	98	80	14.0	4	17.0	0.05	30	18	7.6	1.03	100	117	0.07
55	Channi	DW	28-5-13	20	7.9	640	0	171	140	36.0	5	48.0	0.01	40	20	24.0	1.4	180	339	0.00
56	Chamlia	DW	29-5-13	21	7.99	590	0	293	240	36.0	15	2.9	0.28	12	22	85.0	2.9	120	313	1.73
57	Didyal	DW	29-5-13	20	7.91	460	0	226	185	21.0	2	20.0	0.11	24	24	32.0	3.3	160	244	2.02
58	Gho-Brahmana	DW	29-5-13	20	7.87	580	0	219	180	43.0	3	27.0	0.03	26	21	52.0	1.9	150	307	0.59
59	Gudwal	DW	29-5-13	19	8.15	230	0	110	90	28.0	5	12.0	0.06	34	11	8.4	1.2	125	122	0.02
60	Gho-Rakhwala	DW	29-5-13	20	8.02	740	0	311	255	71.0	2	17.0	0.17	26	39	67.0	0.5	225	392	0.08
61	Kainthpur	DW	30-5-13	21	8.07	270	0	128	105	21.0	0	6.2	0.19	20	17	8.8	1.4	120	143	0.46
62	Kaluchak	DW	30-5-13	21	8.16	400	0	153	125	29.0	39	10.0	0.01	18	29	21.0	3	165	212	2.58

S. No.	Location	Type of Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO 3	HCO 3	Alkalinity	Cl	SO 4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
63	Khairi	DW	30-5-13	19	8.33	670	36	171	200	60.0	57	47.0	0.17	16	46	63.0	12	230	355	0.47
64	Kothey-Saini	DW	30-5-13	20	8.28	530	0	171	140	29.0	28	46.0	0.25	32	23	32.0	1.2	175	281	0.15
65	Kotli-Charkan	DW	31-5-13	18	8.31	350	12	153	145	11.0	19	15.0	0.53	36	20	7.7	0.62	170	186	0.00
67	Karnaile Chak	DW	31-5-13	19	8.17	350	0	159	130	18.0	4	18.0	0.00	36	16	7.5	2.6	155	186	0.01
68	Lalyal	DW	31-5-13	19	8.09	320	0	177	145	21.0	1	2.3	1.00	30	14	19.0	5.1	130	170	0.43
69	Laswara	DW	31-5-13	19	7.88	740	0	140	115	71.0	68	36.0	0.30	58	27	27.0	0.8	255	392	2.04
70	Makwal	DW	31-5-13	20	8.21	260	0	134	110	14.0	3	0.3	0.02	24	14	7.2	2	115	138	0.07
71	Majuha Laxmi	DW	31-5-13	21	8.35	380	12	183	170	21.0	3	16.0	0.18	16	27	29.0	2.3	150	201	0.16
72	Mahal Kalandarian	DW	6-1-13	19	7.85	540	0	293	240	21.0	24	12.0	0.82	18	23	75.0	1.1	140	286	0.27
73	Meen-Charkan	DW	6-1-13	19	8.38	480	18	226	215	18.0	2	39.0	0.21	56	21	15.0	1.08	225	254	0.05
74	Miransahib	DW	31-5-13	21	7.44	700	0	171	140	96.0	120	48.0	0.14	14	39	75.0	0.6	245	371	0.07
75	Nndpur	HP	31-5-13	20	8.23	450	0	183	150	53.0	2	1.7	0.37	18	16	34.0	35	110	239	1.08
76	Nikowal	DW	29-5-13	19	8.25	510	0	330	270	18.0	13	0.0	0.57	20	38	46.0	2.5	205	270	0.37
77	Patli	DW	29-5-13	21	8.47	510	6	214	185	43.0	33	11.0	0.88	20	35	42.0	1.90	195	270	0.26
78	Palli	DW	29-5-13	20	8.05	750	0	360	295	43.0	24	12.0	0.98	18	32	98.0	1.80	175	398	0.14
79	Poal	DW	29-5-13	20	8.18	480	0	207	170	25.0	18	13.0	0.31	40	26	13.0	0.7	205	254	0.07
80	Qudarpur	HP	31-5-13	21	7.91	860	0	177	145	60.0	158	22.0	0.21	44	37	69.0	1.60	260	456	0.03
81	Rehal	DW	31-5-13	19	8.7	530	0	262	215	36.0	4	1.7	0.25	14	32	45.0	1.60	170	281	0.22
82	Saleahar	DW	31-5-13	19	8.22	1580	0	720	590	71.0	133	4.5	0.31	42	50	90.0	255.00	310	837	0.36
83	Satwari	DW	28-5-132	18	8.6	430	12	116	115	36.0	27	46.0	0.01	20	30	27.0	1.80	175	228	0.03

S. No.	Location	Type of Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO 3	HCO 3	Alkalinity	Cl	SO 4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
84	Sei Khurd	DW	28-5-13	18	8.52	480	6	262	225	11.0	23	0.1	0.28	18	27	49.0	2.10	155	254	0.83
85	Sohanjan	DW	28-5-13	19	8.44	720	12	195	180	53.0	104	23.0	0.38	20	38	43.0	61.00	205	382	0.07
86	Suchetgarh	DW	31-5-13	21	8.61	482	6	232	200	18.0	36	0.2	0.07	16	33	39.0	2.50	175	2555	0.98
87	Supwal	DW	31-5-13	20	8.17	510	0	153	125	50.0	4	51.0	0.33	30	26	28.0	0.20	180	270	1.09
88	Swankha	DW	31-5-13	19	7.94	460	0	189	155	25.0	3	45.0	0.12	32	11	47.0	1.17	125	244	0.95
89	Upralakanha	DW	31-5-13	19	8.69	570	6	275	235	1.9	2	7.9	0.21	12	27	91.0	0.70	140	302	0.22
90	Tirkutanagar	DW	31-5-13	18	8.35	460	6	159	140	39.0	4	61.0	0.18	56	9	26.0	1.30	225	244	0.07
91	Chata	HP	31-5-13	20	8.27	400	0	183	150	18.0	16	15.0	0.03	44	17	10.0	1.60	180	212	0.61
92	Greater Kailash	DW	31-5-13	19	8.25	390	0	146	120	28.0	40	46.0	0.21	30	27	24.0	1.20	185	207	1.03
93	RS Pura	DW	31-5-13	18	8.39	400	6	140	125	11.0	21	8.7	42.0	42	11	8.7	0.50	150	212	0.24
94	Banglar	DW	28-5-13	27.5	7.3	1680	BD	353.8	290	170	228	4.2	0.45	72	18	202.5	59.0	255	874	0.16
95	Barni	DW	30-5-13	24.5	7.92	320	BD	183	150	14	4	23.50	0.48	46	13	10.0	0.8	170	166	0.40
96	Bhagwal	DW	30-5-13	24	7.95	390	BD	201.3	165	18	12	17.00	0.33	52	13	13.4	2.0	185	203	0.43
97	Chak Hariya	DW	30-5-13	26	7.65	530	BD	311.1	255	11	30	5.30	0.33	70	17	22.1	9.5	245	276	1.21
98	Challan	DW	30-5-13	24	8.1	790	BD	158.6	130	92	95	74.00	0.39	48	33	69.7	9.7	255	411	0.67
99	Chanranga	DW	30-5-13	26	8.3	340	BD	128.1	105	14	49	15.00	0.33	36	13	15.5	7.0	145	177	ND
100	Chapki Kalan	DW	30-5-13	24	8.02	350	BD	195.2	160	11	16	9.60	0.33	44	15	12.1	2.5	170	182	0.16
101	Daboh	DW	29-5-13	22	7.95	410	BD	170.8	140	32	47	7.70	0.39	40	15	34.6	3.9	160	213	0.12
102	Dulme Chak	DW	30-5-13	23	8.1	1200	BD	500.2	410	78	155	40.00	0.39	44	43	100	165.0	285	624	0.15
103	Feruchak	DW	30-5-13	26	7.99	360	BD	189.1	155	11	31	11.00	0.36	32	21	20.5	1.0	165	187	0.36
104	Gangu Chak	DW	30-5-13	26	7.92	1030	BD	170.8	140	107	165	178.0	0.23	74	40	87.4	51.4	350	536	0.23
105	Jandi	DW	30-5-13	26	7.96	1220	BD	549	450	78	164	106.0	0.68	88	71	74.8	112.0	510	634	0.34

S. No.	Location	Type of Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO 3	HCO 3	Alkalinity	Cl	SO 4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
106	Jasath	DW	30-5-13	23.5	8.02	570	BD	280.6	230	28	31	15.00	0.54	54	26	32.5	3.3	240	296	0.21
107	Karol Krishna	DW	28-5-13	24	8.36	920	6	353.8	300	71	129	53.00	0.48	32	53	114	24.6	298	478	ND
108	Kathua	DW	30-5-13	26.5	8.05	870	BD	183	150	128	138	22.00	0.45	74	28	80.0	13.6	300	452	0.16
109	Kerian Gandyal	DW	30-5-13	24	7.31	690	BD	237.9	195	107	1	50.00	0.07	84	26	22.6	15.4	315	359	0.07
110	Kerian Ramnagar	DW	30-5-13	24	7.69	520	BD	268.4	220	7	61	3.90	0.48	76	19	9.1	5.0	270	270	0.27
111	Khanpur	DW	30-5-13	27	8.1	350	BD	207.4	170	7	19	6.90	0.39	70	0	13.1	1.3	175	182	
112	Khukhial	DW	30-5-13	24	8.04	870	BD	323.3	265	46	38	2.20	0.39	46	12	54.8	68.3	165	452	
113	Konthal	DW	28-5-13	23.5	8.13	460	BD	262.3	215	18	27	10.00	0.48	66	9	32.4	4.3	200	239	
114	Kote Panu	DW	30-5-13	24	7.97	420	BD	237.9	195	11	35	1.80	0.39	52	12	26.0	8.5	180	218	
115	Kothian	DW	30-5-13	26	7.96	340	BD	183	150	18	5	9.40	0.39	32	16	17.5	3.5	145	177	
116	Lakhanpur	DW	30-5-13	25	8.15	180	BD	91.5	75	7	9	5.60	0.33	32	0	7.7	1.5	80	94	
117	Lalechak	DW	28-5-13	27.5	8.1	650	BD	250.1	205	53	102	7.10	0.48	52	24	60.7	23.3	230	338	
118	Lokli	DW	29-5-13	21.5	8.2	270	BD	146.4	120	7	4	9.90	0.33	44	5	4.4	1.8	130	140	
119	Londi	DW	28-5-13	25	7.98	2400	BD	536.8	440	312	542	121.0	1.25	100	126	335	34.0	770	1248	
120	Madun	DW	28-5-13	25	8.24	720	BD	420.9	345	28	35	18.00	0.39	96	27	36.3	5.8	350	4	
121	Mukandpur	DW	30-5-13	24	7.87	690	BD	353.8	290	28	54	5.40	0.39	82	23	27.3	24.1	300	359	
122	Nagri	DW	30-5-13	25	8.2	360	BD	183	150	14	32	0.90	0.57	22	23	22.5	4.0	150	187	
123	Naran	DW	30-5-13	22	8.23	820	BD	384.3	315	46	2	2.90	0.39	32	12	107.	16.9	130	426	
124	Nilcha	DW	29-5-13	24	7.34	270	BD	170.8	140	4	23	4.00	0.29	42	12	6.7	1.8	155	140	
125	Nouni	DW	29-5-13	23.2	7.41	400	BD	207.4	170	21	19	5.80	0.33	42	21	14.8	2.0	190	208	
126	Nud	DW	29-5-13	23	7.54	600	BD	213.5	175	46	84	23.00	0.39	74	18	35.5	7.0	260	312	
127	Pangdour	DW	29-5-13	35	8.1	490	BD	250.1	205	14	13	36.00	0.58	76	13	9.8	1.3	245	255	
128	Pansar	DW	30-5-13	23	8.12	570	BD	384.3	315	7	43	1.00	0.12	28	38	64.9	3.5	225	296	

S. No.	Location	Type of Source	Date of collection	Temp °C	pH	Sp Cond ms/cm 25°C	CO3	HCO3	Alkalinity	Cl	SO4	NO3	F	Ca	Mg	Na	K	TH	TDS	Fe
129	Patiari	DW	29-5-13	21.5	Data not Available															
130	Phalora	DW	30-5-13	23	8.21	940	BD	225.7	185	36	324	25.00	0.39	22	18	211.5	2.5	130	489	
131	Raghu Chak	DW	30-5-13	24	7.91	390	BD	219.6	180	11	15	0.50	0.22	52	11	15.1	2.4	175	203	
132	Raiyan	DW	28-5-13	24.5	7.95	560	BD	317.2	260	21	27	4.30	0.07	86	10	29.5	1.9	255	291	
133	Sadoh	DW	28-5-13	24.5	7.98	710	BD	427	350	18	8	30.00	0.35	134	0	32.6	1.4	335	369	
134	Samba	DW	28-5-13	22	8	810	BD	201.3	165	71	66	94.00	0.12	66	13	81.9	9.4	220	421	
135	Snoora	DW	29-5-13	22	8.36	230	12	103.7	105	3.55	11.7	2.10	0.07	26.05	9.73	8.2	0.9	105	120	

Annexure III

Rainfall Data of Jammu and Kathua Districts (1901 to 2011).

Year	Annual Rainfall Jammu (mm)	Annual Rainfall Kathua (mm)	Departure from Average RF Jammu (%)	Departure from Average RF Kathua (%)	Cummulative Departure Jammu (%)	Cummulative Departure Kathua (%)
1901	591.67	654.67	78.03	80.39	78.0	80.4
1902	531.45	630.97	70.09	77.48	7.9	2.9
1903	782.20	821.61	103.16	100.89	103.2	100.9
1904	527.59	579.34	69.58	71.14	33.6	29.8
1905	617.15	683.64	81.40	83.95	81.4	83.9
1906	727.60	808.25	95.96	99.25	-14.6	-15.3
1907	625.47	676.22	82.49	83.04	82.5	83.0
1908	1062.45	1110.63	140.13	136.38	-57.6	-53.3
1909	1071.95	1132.97	141.38	139.13	141.4	139.1
1910	619.70	744.53	81.73	91.43	59.6	47.7
1911	640.15	747.37	84.43	91.78	84.4	91.8
1912	490.10	527.04	64.64	64.72	19.8	27.1
1913	752.07	797.57	99.19	97.94	99.2	97.9
1914	832.58	916.30	109.81	112.52	-10.6	-14.6
1915	502.03	641.27	66.21	78.75	66.2	78.7
1916	741.51	795.53	97.80	97.69	-31.6	-18.9
1917	1006.92	1143.94	132.80	140.47	132.8	140.5
1918	439.78	446.45	58.00	54.82	74.8	85.7
1919	582.10	582.42	76.77	71.52	76.8	71.5
1920	387.18	454.76	51.07	55.84	25.7	15.7
1921	643.50	689.41	84.87	84.66	84.9	84.7
1922	641.02	783.03	84.54	96.15	0.3	-11.5
1923	865.76	934.09	114.18	114.70	114.2	114.7
1924	773.94	832.21	102.07	102.19	12.1	12.5
1925	675.24	759.31	89.06	93.24	89.1	93.2
1926	652.44	680.78	86.05	83.60	3.0	9.6
1927	540.85	612.46	71.33	75.21	71.3	75.2
1928	672.53	756.90	88.70	92.95	-17.4	-17.7
1929	805.60	754.87	106.25	92.70	106.3	92.7
1930	538.30	551.34	71.00	67.70	35.3	25.0
1931	987.46	1085.17	130.24	133.26	130.2	133.3
1932	496.09	476.11	65.43	58.46	64.8	74.8
1933	765.86	855.52	101.01	105.06	101.0	105.1
1934	507.06	641.56	66.88	78.78	34.1	26.3
1935	550.86	509.95	72.65	62.62	72.7	62.6
1936	811.20	1034.48	106.99	127.03	-34.3	-64.4
1937	677.27	736.97	89.33	90.50	89.3	90.5
1938	507.80	597.49	66.97	73.37	22.4	17.1
1939	482.84	504.01	63.68	61.89	63.7	61.9
1940	583.21	684.32	76.92	84.03	-13.2	-22.1

Year	Annual Rainfall Jammu (mm)	Annual Rainfall Kathua (mm)	Departure from Average RF Jammu (%)	Departure from Average RF Kathua (%)	Cummulative Departure Jammu (%)	Cummulative Departure Kathua (%)
1941	593.43	648.02	78.27	79.58	78.3	79.6
1942	807.08	886.64	106.45	108.88	-28.2	-29.3
1943	401.36	446.60	52.94	54.84	52.9	54.8
1944	771.61	801.35	101.77	98.40	-48.8	-43.6
1945	809.28	938.53	106.74	115.25	106.7	115.2
1946	508.16	531.82	67.02	65.31	39.7	49.9
1947	518.73	649.32	68.42	79.74	68.4	79.7
1948	993.38	1061.59	131.02	130.36	-62.6	-50.6
1949	626.20	680.47	82.59	83.56	82.6	83.6
1950	1179.31	1242.97	155.54	152.63	-72.9	-69.1
1951	653.38	699.01	86.17	85.84	86.2	85.8
1952	398.61	401.81	52.57	49.34	33.6	36.5
1953	893.18	1051.66	117.80	129.14	117.8	129.1
1954	814.80	956.17	107.46	117.42	10.3	11.7
1955	698.78	768.63	92.16	94.39	92.2	94.4
1956	801.76	777.76	105.74	95.51	-13.6	-1.1
1957	917.85	982.49	121.06	120.65	121.1	120.6
1958	676.16	763.19	89.18	93.72	31.9	26.9
1959	980.87	1012.53	129.37	124.34	129.4	124.3
1960	575.17	654.54	75.86	80.38	53.5	44.0
1961	759.19	800.90	100.13	98.35	100.1	98.3
1962	777.34	808.84	102.52	99.32	-2.4	-1.0
1963	375.23	417.12	49.49	51.22	49.5	51.2
1964	889.19	906.94	117.28	111.37	-67.8	-60.1
1965	546.79	563.02	72.12	69.14	72.1	69.1
1966	875.15	974.14	115.42	119.62	-43.3	-50.5
1967	734.88	722.31	96.92	88.70	96.9	88.7
1968	558.95	572.60	73.72	70.31	23.2	18.4
1969	551.65	647.74	72.76	79.54	72.8	79.5
1970	460.19	462.23	60.69	56.76	12.1	22.8
1971	666.19	747.12	87.86	91.74	87.9	91.7
1972	667.35	722.61	88.02	88.73	-0.2	3.0
1973	821.44	868.58	108.34	106.66	108.3	106.7
1974	587.63	622.84	77.50	76.48	30.8	30.2
1975	1131.33	1141.95	149.21	140.23	149.2	140.2
1976	1258.86	1359.18	166.03	166.90	-16.8	-26.7
1977	683.23	765.66	90.11	94.02	90.1	94.0
1978	1194.40	1319.93	157.53	162.08	-67.4	-68.1
1979	604.59	630.61	79.74	77.44	79.7	77.4
1980	1134.74	1194.59	149.66	146.69	-69.9	-69.3
1981	934.47	889.00	123.25	109.17	123.2	109.2
1982	692.62	625.83	91.35	76.85	31.9	32.3
1983	998.71	1022.14	131.72	125.52	131.7	125.5

Year	Annual Rainfall Jammu (mm)	Annual Rainfall Kathua (mm)	Departure from Average RF Jammu (%)	Departure from Average RF Kathua (%)	Cummulative Departure Jammu (%)	Cummulative Departure Kathua (%)
1984	1020.02	1076.88	134.53	132.24	-2.8	-6.7
1985	766.89	911.56	101.15	111.94	101.1	111.9
1986	892.14	953.81	117.66	117.13	-16.5	-5.2
1987	517.10	516.41	68.20	63.41	68.2	63.4
1988	1071.57	1125.07	141.33	138.16	-73.1	-74.7
1989	740.84	716.94	97.71	88.04	97.7	88.0
1990	1117.39	1180.58	147.37	144.97	-49.7	-56.9
1991	596.43	568.84	78.66	69.85	78.7	69.9
1992	855.51	865.48	112.83	106.28	-34.2	-36.4
1993	600.34	610.35	79.18	74.95	79.2	74.9
1994	711.69	744.45	93.87	91.42	-14.7	-16.5
1995	1082.20	1111.57	142.73	136.50	142.7	136.5
1996	1049.24	1173.18	138.38	144.06	4.3	-7.6
1997	1167.79	1186.39	154.02	145.69	154.0	145.7
1998	618.07	719.47	81.52	88.35	72.5	57.3
1999	608.64	676.55	80.27	83.08	80.3	83.1
2000	558.58	583.95	73.67	71.71	6.6	11.4
2001	699.13	713.09	92.21	87.57	92.2	87.6
2002	605.70	698.14	79.89	85.73	12.3	1.8
2003	800.00	900.00	105.51	110.52	105.5	110.5
2004	979.00	991.40	129.12	121.74	-23.6	-11.2
2005	969.90	1215.80	127.92	149.30	127.9	149.3
2006	1165.10	666.50	153.67	81.84	-25.7	67.5
2007	1217.70	1854.20	160.60	227.69	160.6	227.7
2008	1123.10	1361.60	148.13	167.20	12.5	60.5
2009	746.40	713.40	98.44	87.60	98.4	87.6
2010	1176.90	1320.80	155.22	162.19	-56.8	-74.6
2011	1469.90	1119.80	193.87	137.51	193.9	137.5
Minimum	375.23	401.81				
Maximum	1469.90	1854.20				
Average	758.21	814.35				

Annexure IV

Details of Wells used for Aquifer Map Preparation

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-01	AAJPUR	74.7483	32.49	265	135.66
BH-02	ADARSH ENCLAVE	74.8833	32.6942	297	147.86
BH-03	AGRECHAK	74.7167	32.625	265	250
BH-04	AGRICULTURE COMPLEX (Talab Tillo)	74.8314	32.7303	304	77.45
BH-05	AIR FORCE STATION	74.84	32.695	293	83.53
BH-06	AIRWAN	75.4119	32.3658	298	55.58
BH-07	AJAL MALAL	74.5275	32.8367	285	115.85
BH-08	AJIT NAGAR	74.8514	32.6725	286	106.7
BH-09	AKHNOOR	74.7392	32.8958	320	87.23
BH-10	AMALA DHALOTI	75.39444	32.4694	439	157.01
BH-11	AMB	74.7856	32.8697	386	146.951
BH-12	AMBARAN	74.7683	32.9072	344	62
BH-13	AMOWAL	75.0181	32.5839	369	62.27
BH-14	APNA VIHAR	74.88	32.6633	309	137.1
BH-15	ARJAN CHAK	75.2744	32.4761	360	151
BH-16	ARNIA	74.7983	32.5222	272	88.4146
BH-17	ASHRAM COLONY	74.7203	32.905	341	59
BH-18	B.K.BARI	74.9375	32.6333	326	207.87
BH-19	BABLIANA	74.9081	32.6728	365	112.1
BH-20	BADIYAL BRAHMNA	74.73	32.6425	267	90.83
BH-21	BADORI	74.9836	32.6308	418	153.42
BH-22	BAGUNA	75.0042	32.6097	407	103
BH-23	BAIN BAJALTA	74.9633	32.7644	397	100
BH-24	BAKHTA	75.4225	32.5036	419	96
BH-25	BALMIKI NAGAR	74.8725	32.7036	320	153.47
BH-26	BAMOO CHAK	74.9136	32.4925	290	190.5
BH-27	BANTALAB	74.8197	32.7797	360	305.4
BH-28	BARI KI KHAD	74.9578	32.6347	370	100
BH-29	BARMORA	75.4144	32.3556	295	94
BH-30	BARNAI	74.8028	32.7669	299	105
BH-31	BARNI	75.6569	32.4011	409	60
BH-32	BARNOTI MORE	75.4367	32.4314	353	133.2
BH-33	BARUI	74.7611	32.9347	398	155.8
BH-34	BARWAL	75.4789	32.4386	424	152.4
BH-35	BASANTER BRIDGE	75.1061	32.5686	344	87.6

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-36	BASPUR	74.6908	32.6133	267	103.5
BH-37	BASSI KHURD	74.8961	32.6369	317	186
BH-38	BC ROAD	74.8583	32.7361	351	210
BH-39	BEGIAL	75.4642	32.415	355	145.4
BH-40	BEIN BAJALTA	74.9344	32.7708	339	235
BH-41	BELIYAN	75.2672	32.44	310	122.83
BH-42	BHAGOCHA CHAK	75.2786	32.4942	401	290
BH-43	BHAIYA	75.2839	32.5011	427	106.7
BH-44	BHATINDI	74.8844	32.7108	363	146.95
BH-45	BHIM LINES	75.1094	32.5567	361	122
BH-46	BIASPUR	74.7256	32.4956	261	85.3659
BH-47	BIDHIPUR JATTAN	74.6683	32.6011	263	146.56
BH-48	BIKRAM SINGHYAL	74.7139	32.6536	258	103.93
BH-49	BIRPUR	74.8889	32.6508	307	280
BH-50	BISHNAH	74.8569	32.6122	294	205.79
BH-51	BOBIYA	75.2072	32.4044	290	189.93
BH-52	BRI -KAMILA	75.0636	32.6122	375	126
BH-53	BRIJ NAGAR	74.8325	32.6611	276	97.561
BH-54	BSF CAMPUS SAMBA	75.1161	32.5256	353	103.65
BH-55	BSF PALOURA	74.8183	32.7533	307	48
BH-56	BUDHI	75.4417	32.4408	365	130
BH-57	BUDHWAR	74.6833	32.4944	262	296.5
BH-58	BUDWAL	74.9939	32.5719	339	100
BH-59	BURN	74.8103	32.8519	449	290
BH-60	C.P.S. SAINIK COLONY.	74.9156	32.6817	402	335.36
BH-61	CHACHWAL	75.1217	32.4389	316	292.13
BH-62	CHADWAL	75.3231	32.4642	368	53
BH-63	CHAK ATTAR SINGH	75.3447	32.3628	279	63.0936
BH-64	CHAK BAGLA	75.01	32.6367	479	400
BH-65	CHAK CHANGA	75.2661	32.3797	297	213
BH-66	CHAK DESA SINGH	75.3394	32.4094	310	61.5696
BH-67	CHAK DHOK RAKHWALA	74.975	32.5006	303	68
BH-68	CHAK DRAB KHAN	75.5203	32.3697	319	110.48
BH-69	CHAK MANGA GUJRA	75.1011	32.5644	340	150
BH-70	CHAK RAMDASS	74.8181	32.5206	270	302.68
BH-71	CHAK SAJAN	75.5272	32.3944	344	125
BH-72	CHAK SHEIKAN	75.5439	32.3772	315	117.5
BH-73	CHAKRA	74.8919	32.5775	290	111.28

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-74	CHAKROI	74.7028	32.55	259	188.48
BH-75	CHAKROI (TW NO-8)	74.7189	32.5436	270	89.6341
BH-76	CHALLARIAN	75.1297	32.4525	318	114.3
BH-77	CHAMLIYAL	74.8931	32.4744	282	350
BH-78	CHANDWAN	75.3358	32.4708	396	116.27
BH-79	CHANDWAN CGWB	75.3381	32.4647	377	70
BH-80	CHANN DATYAL	75.3325	32.4811	406	100
BH-81	CHANN MORAIN	75.245	32.4897	357	90.85
BH-82	CHANNI HIMMAT	74.8892	32.6939	352	120.427
BH-83	CHANNI HIMMAT SECT-1	74.8969	32.6939	385	164.79
BH-84	CHANNI RAMA	74.8878	32.7028	354	128.04
BH-85	CHATTA -CHOWADHY	74.9266	32.6889	354	125
BH-86	CHAUDHARIWALLA	74.4756	32.8675	332	101
BH-87	CHENAB TEXTILE LTD.	75.5389	32.3869	357	107
BH-88	CHER KHAD	74.99	32.6281	410	98.17
BH-89	CHICHI MATA	75.0881	32.5581	335	137.2
BH-90	CHILK	75.2822	32.5414	456	156.5
BH-91	CULTURAL ACADEMY	74.855	32.7269	305	70.12
BH-92	DAMIYAL	75.2614	32.5083	425	118.26
BH-93	DATTA TALAB I	74.9333	32.65	352	96
BH-94	DAYALA CHAK	75.3117	32.4711	374	62.19
BH-95	DEEP NAGAR	74.8786	32.6728	310	186.02
BH-96	DENTAL COLLEGE	74.86	32.7444	372	306
BH-97	DEOLICHAK	74.8783	32.5072	283	305.05
BH-98	DEVIGARH	74.7311	32.4925	265	94
BH-99	DHAGORE	75.0553	32.5869	360	133.537
BH-100	DHALERI NARIANA	74.5272	32.8667	314	100
BH-101	DHALLI	75.3069	32.4797	395	129.57
BH-102	DHANORE	75.6336	32.3933	373	106.68
BH-103	DHARMAL	74.8078	32.7636	317	116
BH-104	DHOK KHALSA	74.6703	32.8939	351	121.95
BH-105	DHOKU CHAK	74.7861	32.8025	338	81
BH-106	DHOUNTHLY	74.8764	32.7354	319	79.27
BH-107	DHUPSARI	74.95	32.4917	299	202.26
BH-108	DIANI	75.1558	32.5397	416	152.43
BH-109	DIGIANA	74.8658	32.6814	295	130.41
BH-110	DILLI	74.8794	32.6697	312	131.098

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-111	DREAM LAND MUTHI	74.8086	32.7603	303	76.82
BH-112	DUG	74.9011	32.4917	287	200
BH-113	DURGA NAGAR	74.8283	32.7719	375	304
BH-114	EXHIBITION GROUND	74.8586	32.7219	302	82.3
BH-115	FLOAT	75.4028	32.4403	359	68.58
BH-116	FLORA	74.7306	32.7636	271	119.51
BH-117	GADWAL	75.0111	32.5572	337	200
BH-118	GAGORE	75.0161	32.5319	319	271
BH-119	GAJANSOO	74.7103	32.7572	271	71.3
BH-120	GANDLI	74.8064	32.5489	268	108.232
BH-121	GANGYAL	74.8611	32.6689	294	158.05
BH-122	GARAH SATURA	75.2797	32.5119	445	128.75
BH-123	GARHI (PURKHOO)	74.7806	32.7969	302	150
BH-124	GARHI NANDA	74.5753	32.8214	275	106.7
BH-125	GDC AKHNOOR	74.6842	32.8961	353	138.5
BH-126	GHAGWAL	75.2108	32.5086	377	145
BH-127	GHAGWAL CGWB	75.2217	32.5083	388	109
BH-128	GHARANA	74.6911	32.5422	265	121.95
BH-129	GHATTI	75.4264	32.4564	375	77.5
BH-130	GHO BRAHMNA	74.9583	32.55	314	300
BH-131	GHO MANHASAN	74.7394	32.7228	315	60.97
BH-132	GHSS GOLE	74.81	32.7319	293	145
BH-133	GOLE	74.8175	32.7222	296	168
BH-134	GOUSAIN KA TALAB	75.3514	32.475	424	130
BH-135	GOVINDSAR	75.5442	32.3983	382	102
BH-136	GREATER KAILASH	74.9081	32.6661	328	325
BH-137	GSI OFFICE TPT NAGAR	74.8861	32.7078	363	106
BH-138	GULAMA CHAK	74.7542	32.7144	269	85
BH-139	GURA JATTAN	75.2189	32.5169	421	106.7
BH-140	GURAH BRAHMANA	74.7022	32.8811	313	60
BH-141	GURHA MUDIAN	75.2775	32.4883	383	99.39
BH-142	HABTAL	74.9261	32.4897	293	193.45
BH-143	HAKKAL	74.8197	32.6673	270	77.74
BH-144	HAMIRPUR KOHNA	74.55	32.7669	254	65.5
BH-145	HARIPUR	75.295	32.4181	312	82.62
BH-146	HATLI MORH	75.5542	32.3931	388	141
BH-147	HIMMAT COLONY	74.8167	32.7244	292	175
BH-148	HIRANAGAR	75.2683	32.4561	318	80.77

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-149	HOUSING COLONY AKHNOOR	74.7264	32.8925	316	70.5
BH-150	IID CENTRE GOVINDSAR	75.5631	32.4039	413	120
BH-151	INDIRA VIHAR	74.8489	32.7544	383	304.87
BH-152	INDUSTRIAL ESTATE, (BIRPUR)	74.9017	32.6428	318	280
BH-153	ISMAILPUR	74.9608	32.6292	371	122.561
BH-154	JABOWAL	74.7736	32.4989	266	158.53
BH-155	JADH	74.6069	32.8719	328	80
BH-156	JAGATPUR	75.5658	32.3917	389	150
BH-157	JAGTU CHAK	74.8333	32.5639	272	92.9878
BH-158	JAINTI	74.7506	32.9433	424	182.32
BH-159	JAKH	74.9775	32.5994	327	100
BH-160	JAKHOL	75.4536	32.5289	432	48.7
BH-161	JAMMU UNIVERSITY	74.8664	32.7211	311	74.7
BH-162	JAMOTIAN	74.6331	32.9228	451	150
BH-163	JAMWAL RESIDENCY	74.8836	32.6883	332	146.88
BH-164	JANDI	75.2389	32.4597	306	61
BH-165	JANGLOTE	75.5172	32.4125	404	90
BH-166	JANGLOTE MES	75.5292	32.4339	498	155.48
BH-167	JARAIN	75.1928	32.4475	314	200.74
BH-168	JASROTA	75.4081	32.4614	380	119.81
BH-169	JATWAL	75.1728	32.5225	382	147.52
BH-170	JERERA	74.8928	32.5	289	305.05
BH-171	JHANG	74.9169	32.5431	294	76.2195
BH-172	JINDORE	75.5294	32.4383	506	130
BH-173	JOURIAN	74.5769	32.8339	283	70.1
BH-174	KADYAL -B	74.7467	32.5972	272	114.329
BH-175	KADYALA	75.2747	32.3836	299	170.73
BH-176	KAIL DI KHAD	75.1133	32.5519	355	138.68
BH-177	KALI BARI	75.5144	32.3953	366	135.03
BH-178	KALUCHAK	74.8981	32.6553	322	91.7683
BH-179	KANHAL	74.8619	32.5917	300	172.88
BH-180	KAPOORPUR	74.6934	32.5526	267	91.4634
BH-181	KARAN BAGH	74.8394	32.6672	289	96.2
BH-182	KAROL KRISHNA	75.2306	32.4053	299	365.63
BH-183	KAROL MATRIAN-A	75.2483	32.3953	298	195.03
BH-184	KARORMA BHALWAL	74.73	32.9156	406	108.5

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-185	KARYANI TALAB	74.9	32.7161	444	330
BH-186	KATHUA NEW	75.5308	32.3717	327	93.2688
BH-187	KATHUA PHE OFFICE	75.5219	32.3761	347	78.33
BH-188	KATLLI MANDI	75.1364	32.5389	385	195.12
BH-189	KERAN	74.8258	32.7875	399	316
BH-190	KESO KAMOR	74.9083	32.5	291	202.67
BH-191	KHADWALA	74.8731	32.7022	316	185
BH-192	KHALKA BARDAL	74.7286	32.9144	368	93
BH-193	KHANAK SPALMA	75.2108	32.4	297	161.58
BH-194	KHARAH MAIDANA	74.9806	32.6675	411	163.1
BH-195	KHAROT	75.5456	32.4186	463	109.4
BH-196	KHAROT MORH	75.535	32.3953	373	137.16
BH-197	KHERI	74.8486	32.8044	477	338.41
BH-198	KHOUR (SH)	74.5169	32.8283	279	146.42
BH-199	KHUKHIAL	75.4806	32.3592	290	51.2
BH-200	KHUNDWAL	74.7924	32.6691	274	91.46
BH-201	KISSAN NAGAR	75.4194	32.4	326	59.04
BH-202	KONTHAL	75.2561	32.4222	312	91
BH-203	KOOTAH	75.2414	32.4969	367	141.53
BH-204	KOROTANA KHURD	74.6578	32.5867	263	167.68
BH-205	KOT	74.8292	32.8208	410	150
BH-206	KOT KUBBA	74.7847	32.4856	266	106.49
BH-207	KOT MEIRA	74.491	32.843	279	102
BH-208	KOTE PUNNU	75.3767	32.3447	281	54.35
BH-209	KOTHEY SAINI	74.8817	32.5772	286	140.24
BH-210	KOTHIAN NETAR	74.7831	32.7417	278	91
BH-211	KOTLI (R.S.PURA)	74.7572	32.6211	277	91.4634
BH-212	KOTLI SHAH DAULA	74.7581	32.6214	276	77.74
BH-213	KUL KALAN	74.8069	32.5439	269	204.1
BH-214	KUNJWANI	74.9008	32.6672	315	192.07
BH-215	LACCEHIPURA	75.4717	32.4039	352	182.7
BH-216	LADWAL	75.3219	32.4481	352	144.78
BH-217	LADWAL CGWB	75.3231	32.4528	356	70
BH-218	LAKHANPUR	75.5944	32.3806	340	100
BH-219	LALE DA BAGH	74.7983	32.7514	288	153.09
BH-220	LAMBA BARA	74.9867	32.65	440	139.32
BH-221	LANGOTIAN BIANAGARH	74.7995	32.6026	275	157
BH-222	LAXMI NARAIN MANDIR	74.8603	32.6992	305	182

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-223	LOGATE	75.5019	32.4311	430	181
BH-224	LOGATE CGWB	75.4942	32.4044	384	88
BH-225	LOWER BARNAI	74.7869	32.7583	286	151
BH-226	LOWER KHROTE	75.5411	32.4061	413	102
BH-227	M.B.S. COLLEGE BABLIANA	74.8583	32.6703	286	125
BH-228	MADHOON	75.1461	32.4358	307	201.11
BH-229	MAHAL SHAH	74.9378	32.5039	297	83.84
BH-230	MAHEEN CHARKAN	74.9572	32.6356	369	198.17
BH-231	MAHESHWAR TATRA	75.1369	32.5461	398	290
BH-232	MAKHANPUR GUJRAN	74.4917	32.8681	337	85.81
BH-233	MALINI	75.4156	32.5108	440	77.5
BH-234	MANDIALA	74.5883	32.8439	294	62.8
BH-235	MANGU CHAK	75.1614	32.4275	306	123.47
BH-236	MANOHAR GOPALA	75.1042	32.5322	366	103.96
BH-237	MANSAR MORH SAMBA	75.1028	32.5717	346	121
BH-238	MARH KULLIAN	74.7172	32.7653	272	40
BH-239	MARHEEN	75.3203	32.4189	318	70.94
BH-240	MATHWAR	74.8431	32.9289	745	86.89
BH-241	MATOO	74.5389	32.8056	270	26
BH-242	MAWA	75.1253	32.4828	331	182.93
BH-243	MEERTH	75.445	32.4572	397	125
BH-244	MEHTABPUR	75.5856	32.4236	465	101.5
BH-245	MEIRA MANDRIAN	74.7389	32.9625	465	75
BH-246	MELA	75.2936	32.4919	420	170
BH-247	METHRA CHAK	75.2797	32.4258	317	111.28
BH-248	MIRAN SAHIB	74.815	32.6461	285	94.51
BH-249	MOOLACHAK	74.7506	32.5144	259	106.707
BH-250	MOTHLI KHURD	75.041	32.577	349	62
BH-251	MUTHI	74.8144	32.7539	304	137.2
BH-252	MUTHI GAON	74.8175	32.7617	330	314
BH-253	NADAI	74.7325	32.9758	611	65
BH-254	NAGRI	75.4392	32.3433	284	58.15
BH-255	NAGRI PAROLE	75.4353	32.3503	286	130
BH-256	NAGROTA I	74.9278	32.8306	368	100.5
BH-257	NAGROTA II	74.9256	32.7931	361	281.5
BH-258	NAIWALA	74.6267	32.8681	318	90.85
BH-259	NAKRIAN	74.8725	32.7097	324	130.66

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-260	NANAK NAGAR	74.8631	32.6919	303	85.36
BH-261	NANAN	75.4525	32.4736	447	124.97
BH-262	NANDIALA KHUNDA	74.4922	32.8311	274	145.42
BH-263	NANDINI	75.0914	32.5628	344	64
BH-264	NANKEY CHAK	75.0808	32.5603	353	128.04
BH-265	NARAN	75.1647	32.5125	354	185.79
BH-266	NARWAL	74.8839	32.7092	365	192.5
BH-267	NIHALPUR	75.4503	32.4197	343	112
BH-268	NIKOWAL	74.6889	32.4969	261	302.14
BH-269	NITCO LANE (TALAB TILLOO)	74.8381	32.7278	295	73.34
BH-270	NONATH	75.1956	32.5144	386	20.72
BH-271	NONATH -A	75.1994	32.5194	399	126.52
BH-272	NUD	75.1542	32.6306	385	225
BH-273	PAINTHI	75.1514	32.5981	358	105
BH-274	PAKHRI	74.9917	32.5167	308	200.34
BH-275	PALLANWALA	74.4625	32.8417	267	201.5
BH-276	PALLI	74.8922	32.6164	300	75
BH-277	PALOURA	74.8317	32.7531	338	244.5
BH-278	PALWAN	74.6958	32.8958	348	83.5
BH-279	PANDORIAN BANGLA	74.8617	32.56	285	203.53
BH-280	PANDRAR	75.4506	32.4797	463	150
BH-281	PANGDORE	75.0786	32.505	342	96.92
BH-282	PANJTUT	74.4494	32.8503	267	131
BH-283	PANSAR	75.3003	32.3606	294	450.39
BH-284	PARMANDAL	75.0583	32.6889	454	292
BH-285	PATEL NAGAR	75.5225	32.3878	350	106.8
BH-286	PATHWAL	75.2886	32.4606	359	85.36
BH-287	PATOLI BRAHAMNA	74.7931	32.7703	304	124.39
BH-288	PATYARI	75.5353	32.43	510	152.43
BH-289	PC BAN TALAB	74.8147	32.7831	356	304
BH-290	PEERKHO	74.8747	32.7304	310	92.4
BH-291	PHINDER	74.8181	32.5931	279	92
BH-292	PINDI	74.7531	32.4939	265	82.3171
BH-293	PINGIARI	74.68	32.9097	389	106
BH-294	PLUTA	74.8928	32.5033	302	99
BH-295	POUNICHAK	74.7842	32.7319	277	70.73
BH-296	PRAHLADPUR	74.7683	32.6936	260	94.5
BH-297	PRANGLA	74.5408	32.81	268	76.21

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-298	PRANJALI	75.34	32.5283	437	125
BH-299	PRANTHA	75.5411	32.3808	290	105.5
BH-300	PRITHIPUR	74.8372	32.6331	292	300
BH-301	PURKHOO	74.78	32.7972	300	57.92
BH-302	PURMANDAL MORE	74.9044	32.6533	326	125
BH-303	QUADRECHAK	74.925	32.5833	292	203.46
BH-304	QUTAB NIZAM	74.7844	32.5814	273	82.3171
BH-305	R.S.PURA	74.7314	32.6056	273	91.4634
BH-306	Rabta -II	74.8464	32.9503	622	58.48
BH-307	RAILWAY STATION	74.8764	32.7106	335	94.5122
BH-308	RAIPUR	74.83	32.8044	439	300
BH-309	RAIPUR DOMANA	74.8108	32.8078	374	91.2
BH-310	RAIPUR SAIDAN	74.6753	32.6197	262	121.95
BH-311	RAJBAGH	75.4008	32.4378	357	89.26
BH-312	RAJBAGH CGWB	75.4019	32.4353	350	131.72
BH-313	RAJINDER VIHAR	74.9603	32.6114	337	143.2
BH-314	RAJIV GANDHI HOS--GANGYAL	74.8556	32.6733	280	214.26
BH-315	RAJPURA (PARAGWAL)	74.5854	32.7517	250	70.12
BH-316	RAJPURA CGWB	75.1744	32.4611	307	203
BH-317	RAJPURA MAGOTRIAN	74.8472	32.7425	346	306
BH-318	RAJWAL	74.5608	32.8631	327	96.645
BH-319	RAKH AMB TALI	75.1175	32.5392	364	93.8
BH-320	RAKH BAROTIAN	75.0167	32.625	349	301
BH-321	RAKH DHYANSAR	74.9219	32.6317	330	53
BH-322	RAKH JHANG	74.9111	32.5417	287	300
BH-323	RAMGARH	74.9661	32.5072	301	152.4
BH-324	RAMLOO	74.9528	32.5	301	251
BH-325	RANDWAL	75.1939	32.4989	350	115.85
BH-326	RANGPUR SIDHAR	74.6839	32.5608	265	83.8415
BH-327	RANGPUR TREWA	74.7617	32.5006	263	97.561
BH-328	RANJAN	74.7764	32.9036	329	70.1
BH-329	RANJRI	74.9897	32.6064	369	86.89
BH-330	RARA	74.9647	32.5561	320	264.24
BH-331	RATNAL	74.8533	32.5497	278	136
BH-332	RATNU CHAK	74.9014	32.6531	318	76
BH-333	RATNUCHAK (MES)	74.9086	32.655	336	185.366

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-334	RATTI	75.4361	32.5131	414	65
BH-335	RAYAPATTI	74.9708	32.6042	354	302.95
BH-336	REHAL	74.8761	32.5614	285	192.85
BH-337	REHARI	74.8533	32.7442	367	154.54
BH-338	REHIAN	75.1197	32.5067	346	100
BH-339	RELIEF COMMISSIONERS OFFICE	74.8486	32.7292	303	170
BH-340	ROOP NAGAR STAGE-II	74.835	32.7708	384	304
BH-341	RUDRAKSH TEMPLE	74.8422	32.7544	365	280
BH-342	SADDE CHAK TWID	75.1869	32.4289	299	68.29
BH-343	SAGAL	75.1536	32.5169	348	116
BH-344	SAIDA	75.2869	32.5403	459	153.32
BH-345	SAILAWALI	74.4772	32.8544	297	98
BH-346	SAINIK COLONY SEC-C	74.9081	32.6814	386	329.27
BH-347	SAINIK COLONY SEC-D	74.9136	32.6747	381	184.45
BH-348	SAINIK COLONY SEC-G	74.9081	32.6719	359	154.55
BH-349	SAJWAL	74.6036	32.7983	267	96.65
BH-350	SALEHAR	74.8219	32.5606	276	91.46
BH-351	SAMBA	75.1025	32.5719	348	135.63
BH-352	SANGHANI	74.7308	32.9569	498	100
BH-353	SANGRAL	74.665	32.6302	258	103.93
BH-354	SANGWALI MANDI	75.1347	32.5569	417	298.78
BH-355	SANJAY NAGAR	74.8544	32.6889	303	151.26
BH-356	SAROT	74.7875	32.9208	374	86
BH-357	SARTHIAN DERA	75.1492	32.4467	310	200.25
BH-358	SATWARI	74.8467	32.695	295	79.2683
BH-359	SATWARI PEER BABA	74.8333	32.6931	293	108.23
BH-360	SEI	74.7333	32.4944	263	153.97
BH-361	SEODA	74.7647	32.7344	273	128.04
BH-362	SEOHRA BISHNAH	74.8672	32.6431	295	128.04
BH-363	SERI PANDITAN	74.8153	32.8636	500	250
BH-364	SESWAN	75.3453	32.4733	406	125
BH-365	SHAMOO CHAPREAL	74.4383	32.8856	289	81
BH-366	SHER KOTLA	75.5103	32.4517	472	85
BH-367	SHERA CHAK	74.7147	32.5236	262	83.8415
BH-368	SHERPUR	75.2114	32.4228	294	352.58
BH-369	SHIV MANDIR ROOP NAGAR	74.8347	32.7681	376	320.22

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-370	SHIV NAGAR	75.5117	32.3889	350	90.85
BH-371	SIDHRA	74.8917	32.7481	312	330
BH-372	SIMBAL CAMP	74.7814	32.6442	273	61.2805
BH-373	SITLEE	74.8881	32.7769	335	62
BH-374	SKAUST CHATTHA	74.8092	32.6578	268	125.9
BH-375	SMAILPUR	74.9642	32.6275	367	182.9
BH-376	SOHAL	74.6511	32.8906	348	79.26
BH-377	SPRAIN	75.3281	32.4889	398	83
BH-378	STATION BAHURAKH	74.8777	32.7239	315	77.7439
BH-379	SUBE CHAK	75.2564	32.4644	320	53.35
BH-380	SUCHANI	74.9458	32.6375	404	300
BH-381	SUCHET GARH III	74.675	32.5667	264	153.48
BH-382	SUNAIL	74.7539	32.9225	366	85
BH-383	SUNGAL	74.695	32.9303	442	107.92
BH-384	SUNGWAL	75.0119	32.5969	383	124.96
BH-385	SUNJWAN KATHUA	75.3739	32.4203	327	200
BH-386	SUPWAL	75.0708	32.5456	335	49.27
BH-387	SURAJ BELI	75.4175	32.3975	322	65.57
BH-388	SURYAVANSHI NAGAR	74.8244	32.7636	351	304
BH-389	SWANKHA MORE	75	32.5717	337	93
BH-390	TANDA	75.3358	32.4531	355	183.73
BH-391	TANDHIYARI	75.3644	32.4742	425	138.71
BH-392	TAPYAL	75.2228	32.5042	379	180
BH-393	TARAPUR	74.9975	32.5044	309	94.51
BH-394	TAROODIAN	74.7058	32.9725	597	112.75
BH-395	TERAI	74.6161	32.8686	323	102
BH-396	THAKURPURA	75.3203	32.4794	419	92.37
BH-397	THANDI CHOI	74.5139	32.925	345	305
BH-398	THANGER PATTIAN	74.4686	32.8567	298	123.45
BH-399	THATHAR	74.8064	32.7872	341	231.7
BH-400	TIBA BHAIAN	74.7136	32.5733	267	155
BH-401	TIPPU LINES SUNJWAN	74.8881	32.6747	333	115
BH-402	TOHANA	74.7038	32.5886	267	67.0732
BH-403	TRANSPORT NAGAR	74.8886	32.7072	370	106
BH-404	TRANSPORT NAGAR, NARWAL	74.885	32.7064	362	110
BH-405	TRIKUTA NAGAR	74.88	32.6903	320	264.24
BH-406	TUTAN WALI KHUI	74.9772	32.7583	378	300
BH-407	UDHEYWALA	74.8114	32.7417	289	99.09

Bore	LOCATION	LONGITUDE	LATITUDE	ELEVATION	TOTAL DEPTH (m bgl)
BH-408	UPPER MASHIAL	74.5	32.8608	315	100
BH-409	UTTARI	75.4775	32.4369	416	156
BH-410	VEER BHOMI PARK	75.1203	32.5553	385	82
BH-411	VIJAYPUR	75.0331	32.5661	342	190
BH-412	WAZIRAN WALI GALI	74.8256	32.7425	302	170
BH-413	ZANANA PARK	74.8611	32.7369	362	60.97