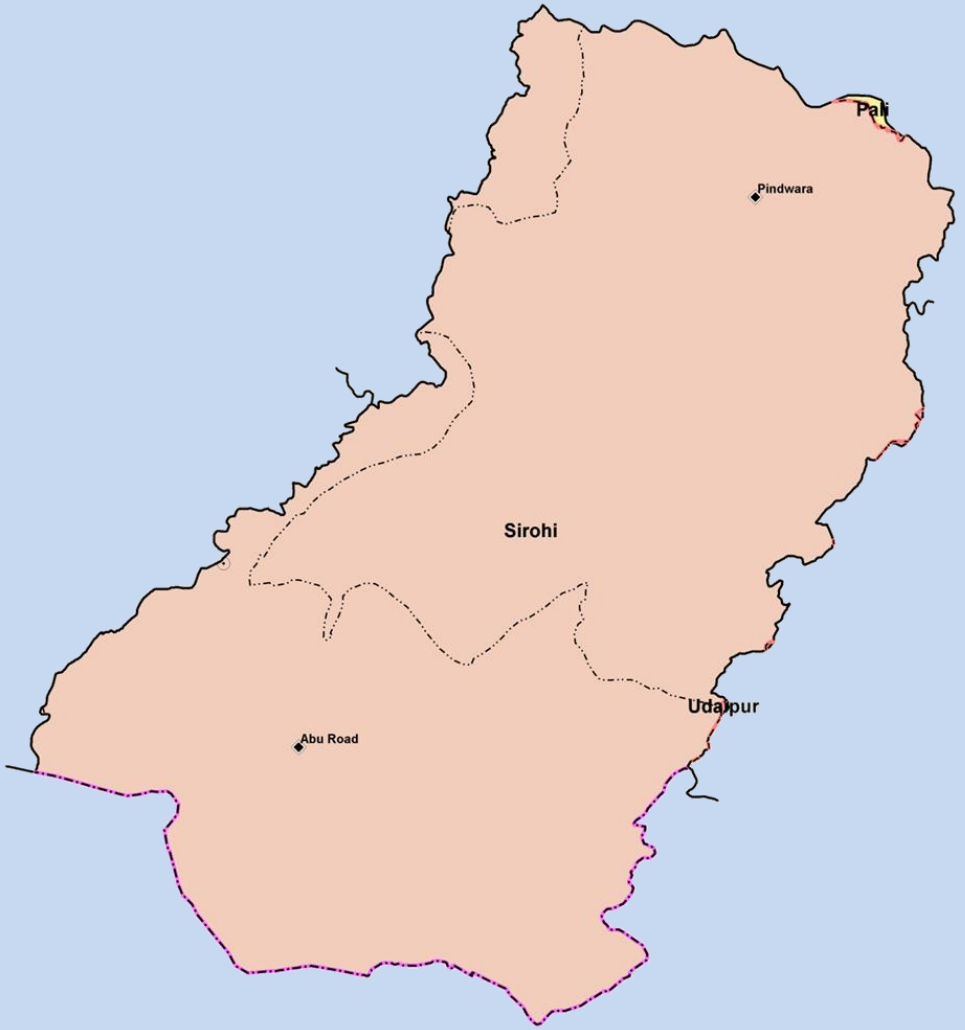
Ground Water Department,
Rajasthan

Hydrogeological Atlas of Rajasthan

West Banas River Basin

European Union
State Partnership Programme



2013

ROLTA
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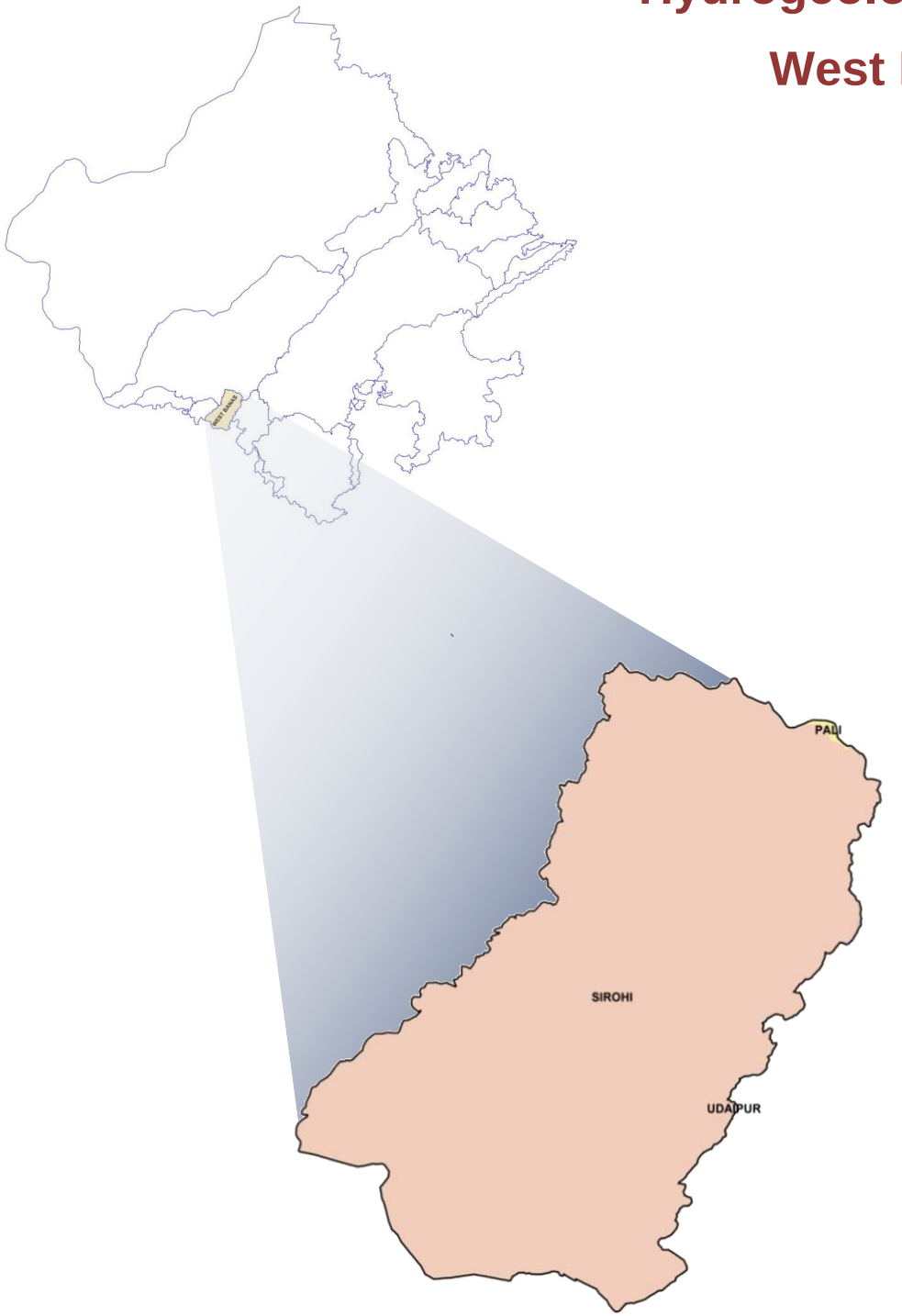
Hydrogeological Atlas of Rajasthan

West Banas River Basin



Contents:

2013

ADMINISTRATIVE SETUP

WEST BANAS RIVER BASIN

Location:

The West Banas River Basin is located in the southwestern part of Rajasthan. It stretches between 24° 19' 55.98" to 24° 54' 51.02" North latitude and 72° 35' 22.07'' to 73° 10' 03.50'' East longitudes. The basin extends in a broadly N-S direction and is bounded by the Sabarmati River Basins in the eastern side, the Sukli River Basin in the west, Luni River Basin in the north and northwest; and the southern and southeastern part of the border is shared administratively with Gujarat State. The basin extends over parts of Sirohi, Pali and Udaipur Districts. The total catchment area of the basin is very small and extends over an approximate area of 1,876 sq km.

The West Banas River originates the hills south of Sirohi and Pindwara towns. It initially flows through a valley near Sirohi and Pindwara in the Mount Abu range of Aravalli hills. It flows for a distance of 50 kms in Rajasthan state before entering Gujarat. The basin has a well-developed drainage system and the main tributaries of West Banas River are Kukli Nadi, Danot Nadi, Sangbaria Nala, Gangari Nala, Gabir Nala, Batriya Nadi, Kaleri Nadi, Gomati Nadi etc.

Administrative Set-up:

Administratively, West Banas River Basin extends over parts of Pali, Sirohi and Udaipur districts encompassing 6 Blocks divided into 182 towns and villages. Major part of the river flows through Sirohi district where its catchment is about 99.8% implying that very minimal parts fall within the other two districts accounting for a total of just 0.2% of its basin area.

S. No.	District Name	Area (sq km)	% of Basin Area	Total Number of Blocks	Total Number of Towns and Villages
1	Pali	2.5	0.2	1	**1**
2	Sirohi	1,873.0	99.8	4	**180**
3	Udaipur	0.8	-	1	**1**
Total		**1,876.3**	**100.0**	**6**	**182**

Climate:

The West Banas River basin is very small and falls at the fringe of Arid climatic region. Bye and large it is a dry area however surrounded by hills. It is extremely cold from October to February while turning hot from March to September. Summer records very high temperatures in the range of 47^{o}C – 48^{o}C but winters are chilly when temperature falls to about 2^{o}C. The basin receives fairly low rainfall because the mean annual rainfall over West Banas River Basin was 767.7 mm, of which most of the rainfall is received during the four Monsoon months (June-September).

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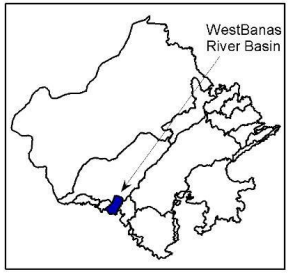
PLATE - I

WEST BANAS RIVER BASIN

Administrative Map



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- **River Basin Boundary**

Roads:

- National Highway
- State Highway

Railway:

- Broad Gauge

Water Bodies:

- River / Streams
- Ponds / Reservoirs
- **Hills**

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TOPOGRAPHY

The basin is bounded both in the east and west by prominent hills of Aravali range. The hills on the western side are higher and are part of Mt. Abu range. The streams originating from hills flow in E-W directions as well as in south-southwestern to contribute to the drainage to West Banas River's main course flowing towards southwest. Being part of the Mt. Abu range, the maximum elevation seen within the basin is about 1695m amsl. While the general elevation within hilly part is in the 250-750m range, the same in the non-hilly part is generally under 500m amsl. The hills in the eastern part re not as high as those in the west. The overall slope of the terrain is from a broad north to south – southwest. The lowest point is also in Sirohi district itself and is located near the exit point southwest of Abu road stands at just less than 220m amsl which leaves a relief difference presence in the valley to 217.5m amsl.

Table: District wise minimum and maximum elevation

S. No.	District Name	Min Elevation (m amsl)	Max. Elevation (m amsl)
1	Pali	392.5	499.8
2	Sirohi	217.4	1,695.0
3	Udaipur	454.6	892.3

RAINFALL

The general distribution of rainfall across the West Banas River Basin can be visualized from isohyets presented in the Plate III where, it is seen that the central part of the basin receives highest rainfall and also in in the western and southwestern part. There are two operational rain gauge stations operating within the basin which reveal a total average annual rainfall of 852 mm in the year 2010. Rainfall reduces as one moves towards northwest and southwest. The general rainfall range in the basin had been in the range of 800 to 1000mm. The rainfall data for available rain gauge stations is presented below.

Table: District wise total annual rainfall (based on year 2010 meteorological station recordings (http://waterresources.rajasthan.gov.in)

S. No.	Rain gauge Stations	Total Monsoon Rainfall (mm)	Total Non-Monsoon Rainfall (mm)	Total Annual Rainfall (mm)
1	Abu Road	678.0	97.0	775.0
2	Pindwara	768.5	161.2	929.7

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Rajasthan

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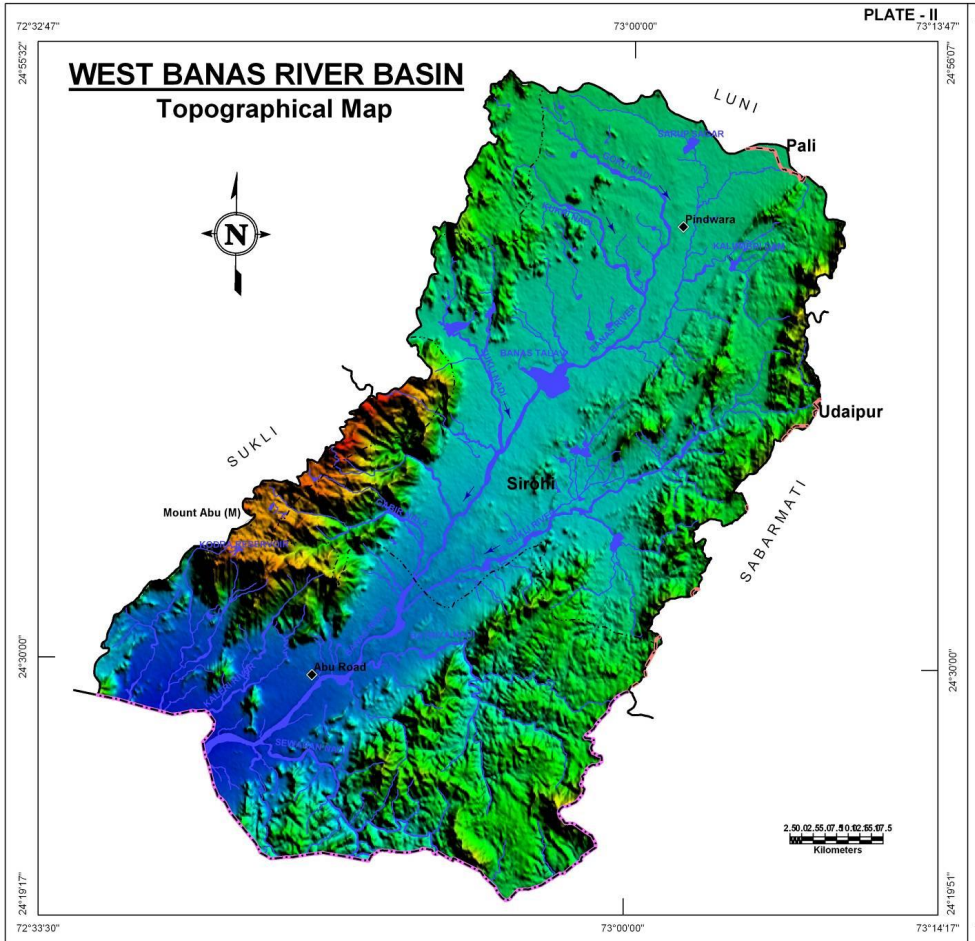
PLATE - II



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary

River Basin Boundary

Water Bodies:

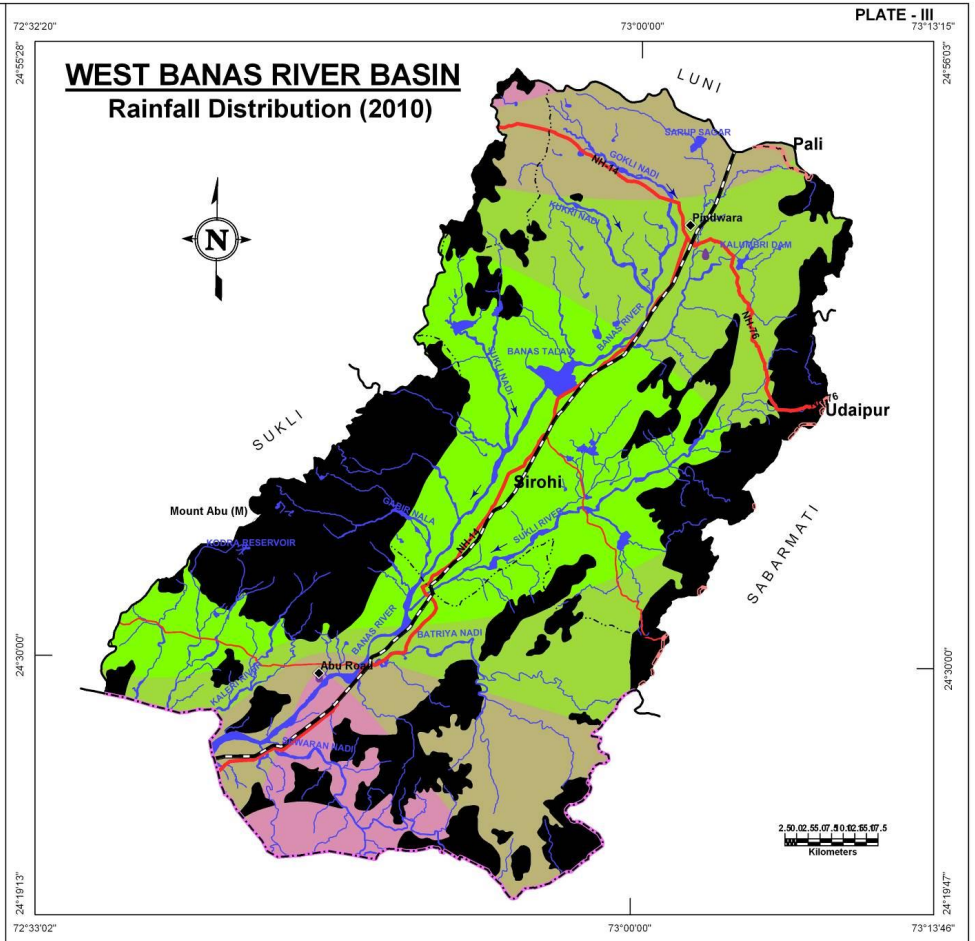
- River / Streams
- Ponds / Reservoirs

Elevation(m amsl):

1694 m
1500 m
1250 m
1000 m
750 m
500 m
250 m
217 m

Source : SRTM DEM

PLATE - III



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- Raingauge Station
- State Boundary
- District Boundary
- Block Boundary

River Basin Boundary

Roads:

- National Highway
- State Highway

Railway:

- Broad Gauge

Water Bodies:

- River / Streams
- Ponds / Reservoirs

Hills

Isohyets (mm):

- 700-800
- 800-900
- 900-1000
- > 1000

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GEOLOGY

WEST BANAS RIVER BASIN

The West Banas River Basin is covered mainly by the rocks belonging to the Pre-Cambrian rocks (Delhi Super Group) to Aeolian and Fluvial deposits of Recent to Sub-Recent age. Aravalli Super Group being the oldest in the area is represented by phyllites, and crystalline limestones whereas the quartzites, schists and phyllites primarily form the Delhi Super Group rocks in this basin.

Age	Super Group	Group/ Formation	Rock Types
Recent to Sub recent		Alluvium	Stream laid deposits, sand and gravel mixed with clay silt and kankar
-------x----------x---------x--------x-------Unconformity----------x----------x--------x--------			
Lower to Upper Precambrian	Post Delhi	Malani	Rhyolite, Dolerite, Basalt, Jalore & Erinpura Granite
	-------x----------x---------x--------x-------Unconformity----------x----------x--------x--------		
	Delhi	Ajabgarh Series	Phyllite, schist, gneiss, marble, amphibolites, calc-siticates, quartzite, mica schist etc.
-------x----------x---------x--------x-------Unconformity----------x----------x--------x--------			
Lower Precambrian	Aravalli		Phyllite, crystalline limestone, quartzite and conglomerates with tuffs and lavas.

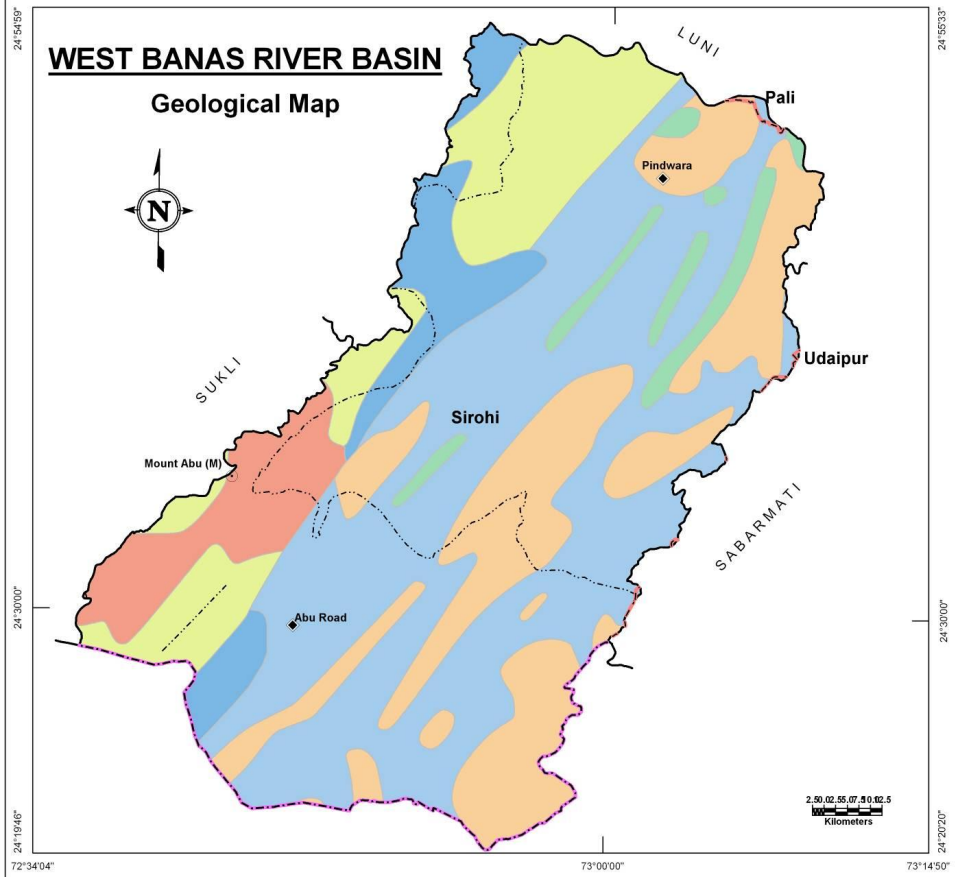
GEOMORPHOLOGY

Origin	Landform Unit	Description
Denudational	Buried Pediment	Pediment covers essentially with relatively thicker alluvial, colluvial or weathered materials.
	Pediment	Broad gently sloping rock flooring, erosional surface of low relief between hill and plain, comprised of varied lithology, criss-crossed by fractures and faults.
Fluvial	Alluvial Plain	Mainly undulating landscape formed due to fluvial activity, comprising of gravels, sand, silt and clay. Terrain mainly undulating, produced by extensive deposition of alluvium.
	Valley Fill	Formed by fluvial activity, usually at lower topographic locations, comprising of boulders, cobbles, pebbles, gravels, sand, silt and clay. The unit has consolidated sediment deposits.
	Ravine	Small, narrow, deep, depression, smaller than gorges, larger than gulley, usually carved by running water.
Hills	Denudational, Structural Hill, Linear Ridge	Steep sided, relict hills undergone denudation, comprising of varying lithology with joints, fractures and lineaments. Linear to arcuate hills showing definite trend-lines with varying lithology associated with folding, faulting etc. Long narrow low-lying ridge usually barren, having high run off may form over varying lithology with controlled strike.

PLATE - IV

WEST BANAS RIVER BASIN

Geological Map



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary

River Basin Boundary

Structural Features:

- Fault

Geology:

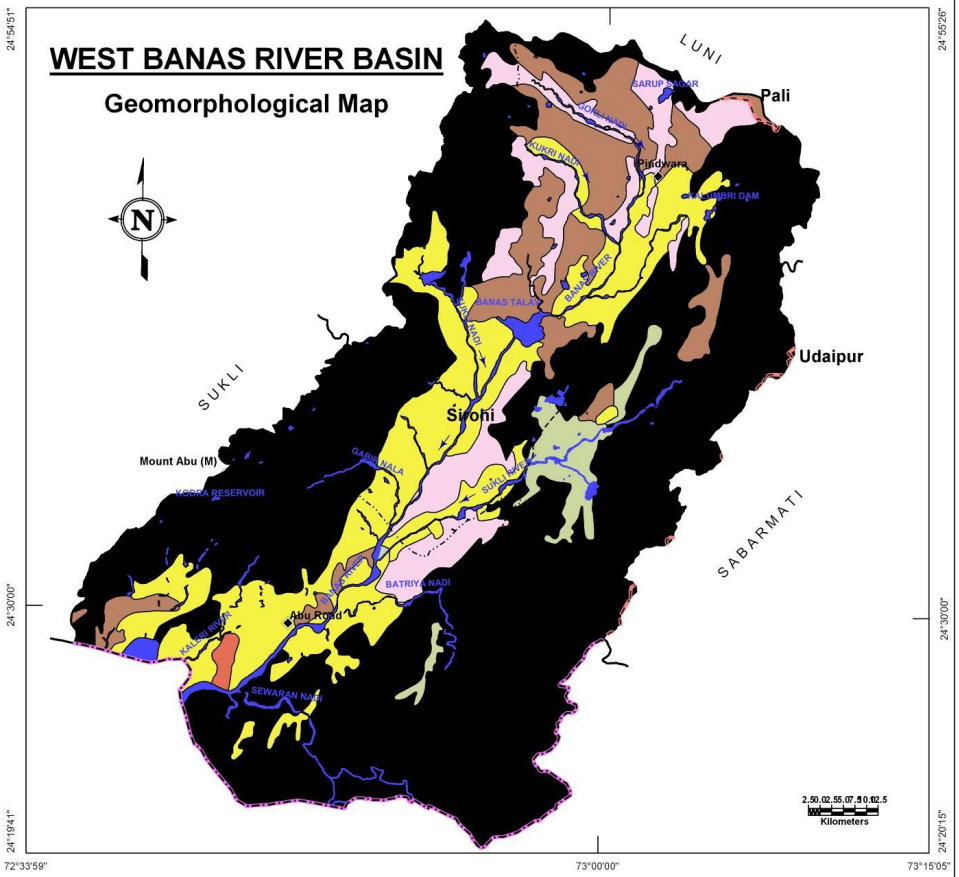
- Sirohi Group
- Kumbhalgarh Group
- Malani Plutonic
- Erinpura Granite & Gneiss
- Sendra-Ambaji Granite & Gneiss
- Phulad Ophiolite Suite

Source : District Resource Map of Rajasthan - GSI

PLATE - V

WEST BANAS RIVER BASIN

Geomorphological Map



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary

River Basin Boundary

Water Bodies:

- River/Ponds / Reservoirs

Structural Features:

- Fault/Fractures/Lineament

Hills:

- Structural/Denudational/ Linear Ridge

Landform Units:

Fluvial Origin:

- Alluvial Plain
- Valley Fill
- Ravine

Denudational Origin:

- Pediment
- Burried Pediment

Source : Ground Water Atlas of Rajasthan - SRSAC & GWD, Rajasthan

AQUIFERS

WEST BANAS RIVER BASIN

Weathered and fractured hardrocks seem to constitute most of the aquifer material in this basin since alluvium only contributes to 3.7% of the aquifer area of the basin. The schistose rocks occupy the central strip of the basin and longitudinally present all along the basin from north to south whereas, on either side of it, granite aquifer are formed. A thin strip of alluvial aquifers is seen along the course of West Banas River in the southern part where water is retained in primary pores of aeolian and fluvial sand, occasionally in gravels. Hills occupy very large part of the basin amounting to about 27% of the basin area.

Aquifer in Potential Zone	Area (sq km)	% of Basin Area	Description of the unit/Occurrence
Younger Alluvium	69.6	3.7	It is largely constituted of Aeolian and Fluvial sand, silt, clay, gravel and pebbles in varying proportions.
Phyllite	4.7	0.3	These include meta sediments and represented by carbonaceous phyllite.
Schist	613.6	32.7	Medium to fine grained compact rock. The litho units are soft, friable and have closely spaced cleavage.
Granite	652.7	34.7	Light grey to pink colour, medium to coarse grained, and characteristically have porphyritic texture.
Non-Potential zone	535.7	28.6	Hills
Total	**1,876.3**	**100.0**	

LOCATION OF GROUND WATER MONITORING WELLS

The basin has a well distributed network of large number of ground water monitoring stations (94) in the basin owned by RGWD only. CGWB incidentally, has no observation wells within the basin. Benchmarking study has revealed that the existing well network is appropriate and does not need any addition of wells to it.

District Name	CGWB	RGWD	Total	Recommended additional wells for optimization of monitoring network	
				Water Level	Water Quality
Pali	-	-	**-**	-	-
Sirohi	-	94	**94**	-	-
Udaipur	-	-	**-**	-	-
Total	**-**	**94**	**94**	**-**	**-**

PLATE - VI

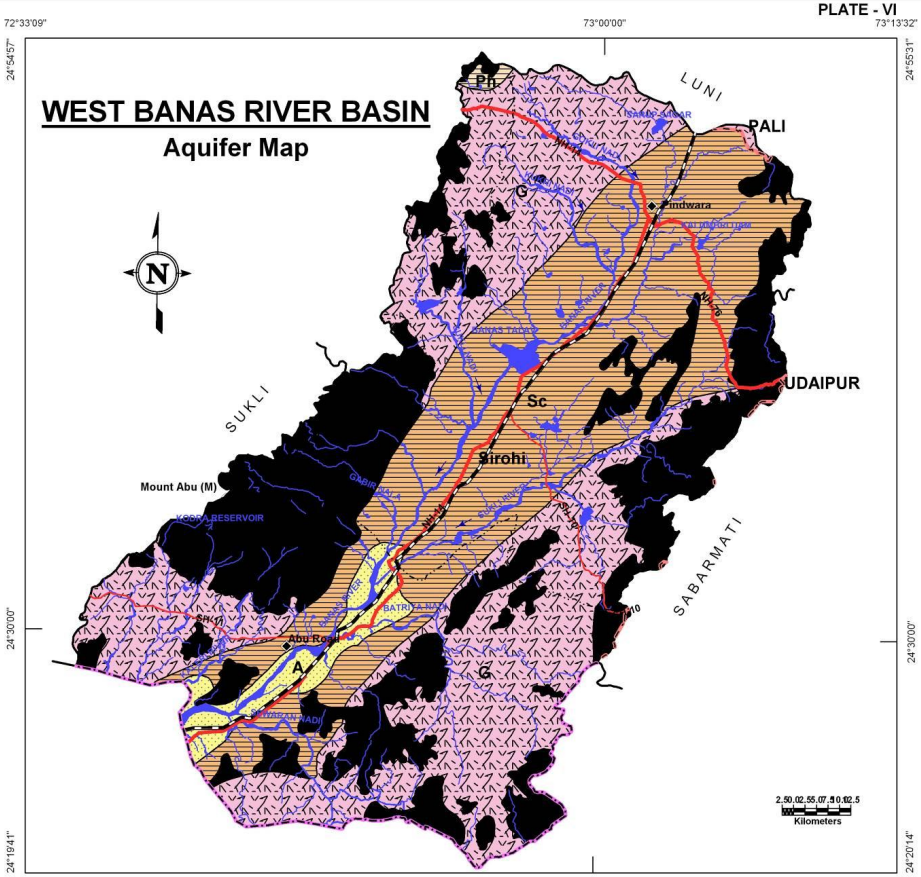
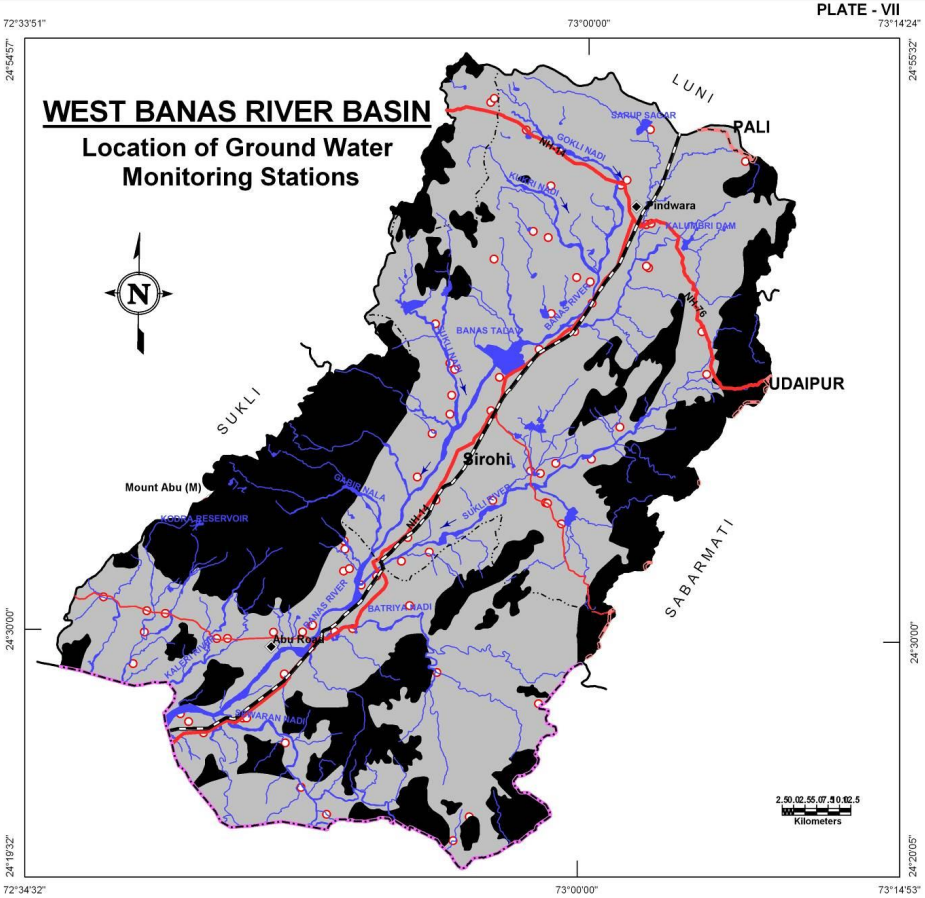


PLATE - VII



LEGEND

Admin Boundary:
- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary

River Basin Boundary

Roads:
- National Highway
- State Highway

Railway:
- Broad Gauge

Water Bodies:
- River / Streams
- Ponds / Reservoirs

Hills

Aquifer:
- Younger Alluvium
- Phyllite
- Schist
- Granite

Source: Ground Water Potential Zone Map - GWD,Rajasthan

LEGEND

Admin Boundary:
- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary

River Basin Boundary

Roads:
- National Highway
- State Highway

Railway:
- Broad Gauge

Water Bodies:
- River / Streams
- Ponds / Reservoirs

Hills

Ground Water Monitoring Stations:
- RGWD

LOCATION OF EXPLORATORY WELLS

WEST BANAS RIVER BASIN

In all there are 52 exploratory boreholes present in the basin drilled in the past by RGWD (36) and only one by CGWB (16) that form basis for delineation of sub-surface aquifer distribution. Map (Plate – VIII) reveals that while there are number of exploratory wells, evenly distributed in the basin.

District Name	CGWB	RGWD	Total
Pali	-	-	**-**
Sirohi	16	36	**52**
Udaipur	-	-	**-**
Total	**16**	**36**	**52**

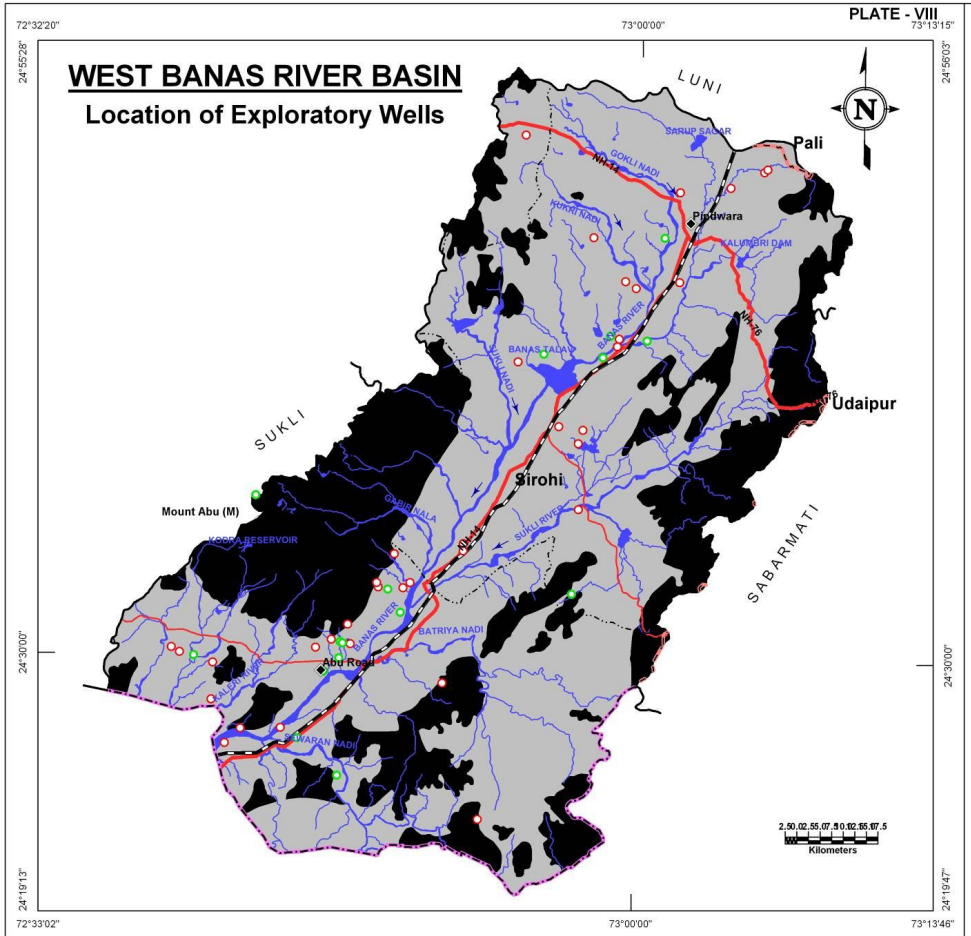
DEPTH TO WATER LEVEL (PRE MONSOON – 2010)

The general depth to water level in the basin ranges from 10 to 20 meters below ground level, accounting for about 82% of the basin. There are some patches in the central and northern parts of the basin which have shown slightly greater depth water level in ground water reaching to more than 20m bgl. In the southeastern part of the basin, south of Abu Road, the ground water occurs at shallow depths of less than 10m bgl.

Depth to water level (m bgl) Pre Monsoon - 2010	District wise area coverage (sq km)*			Total Area (sq km)
	Pali	Sirohi	Udaipur	
< 10	-	37.1	-	**37.1**
10 - 20	2.5	1,098.6	0.1	**1,101.2**
> 20	-	202.3	-	**202.3**
Total	**2.5**	**1,338.0**	**0.1**	**1,340.6**

* The area covered in the derived maps is less than the total basin area since the hills have been excluded from interpolation/contouring.

PLATE - VIII



LEGEND

Admin Boundary:
- Block Headquarter
- Town
- State Boundary
- District_Boundary
- Block Boundary

River Basin Boundary

Roads:
- National Highway
- State Highway

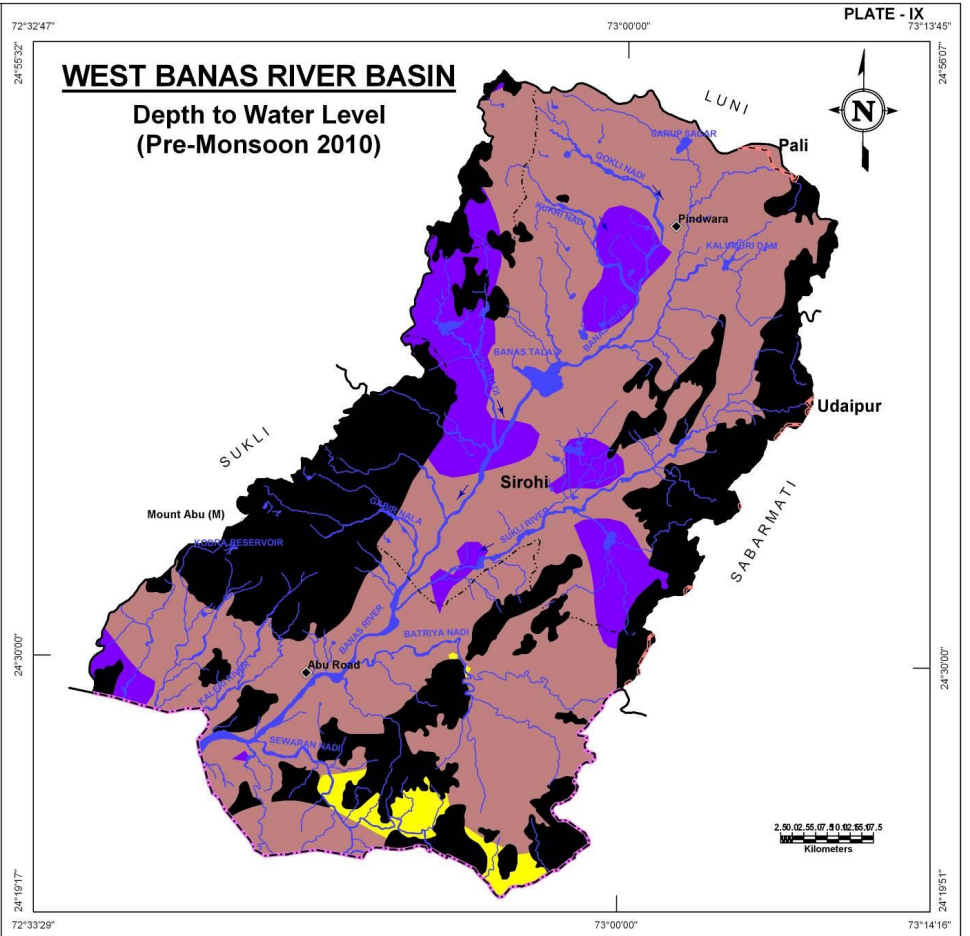
Railway:
- Broad Gauge

Water Bodies:
- River / Streams
- Ponds / Reservoirs

Hills

Exploratory Wells:
- CGWB
- RGWD

PLATE - IX



LEGEND

Admin Boundary:
- Block Headquarter
- Town
- State Boundary
- District_Boundary
- Block Boundary

River Basin Boundary

Water Bodies:
- River / Streams
- Ponds / Reservoirs

Hills

Depth to Water Level (m bgl):
- < 10
- 10 - 20
- > 20

WATER TABLE ELEVATION (PRE MONSOON 2010) WEST BANAS RIVER BASIN

Plate – X presents the distribution of ground water in the area and its flow directions. Water table elevation shows large variation (of about 220m) since the topography in the basin reaches a high of about 1700m amsl and low of about 220m amsl. Since the water table generally follows the topography, such variations are not exception. The overall flow direction of ground water in the basin is from northeast to southwest. High water table is seen in the vicinity of hills in northwest, northeast and southeastern parts which contribute to the ground water flow. In the middle of the basin where the topography is relatively flat, the ground water flow assumes a general southwesterly trend. The flow gradients are steeper in the vicinity of hills and flatter in plain areas and very sluggish in the area around Abu Road.

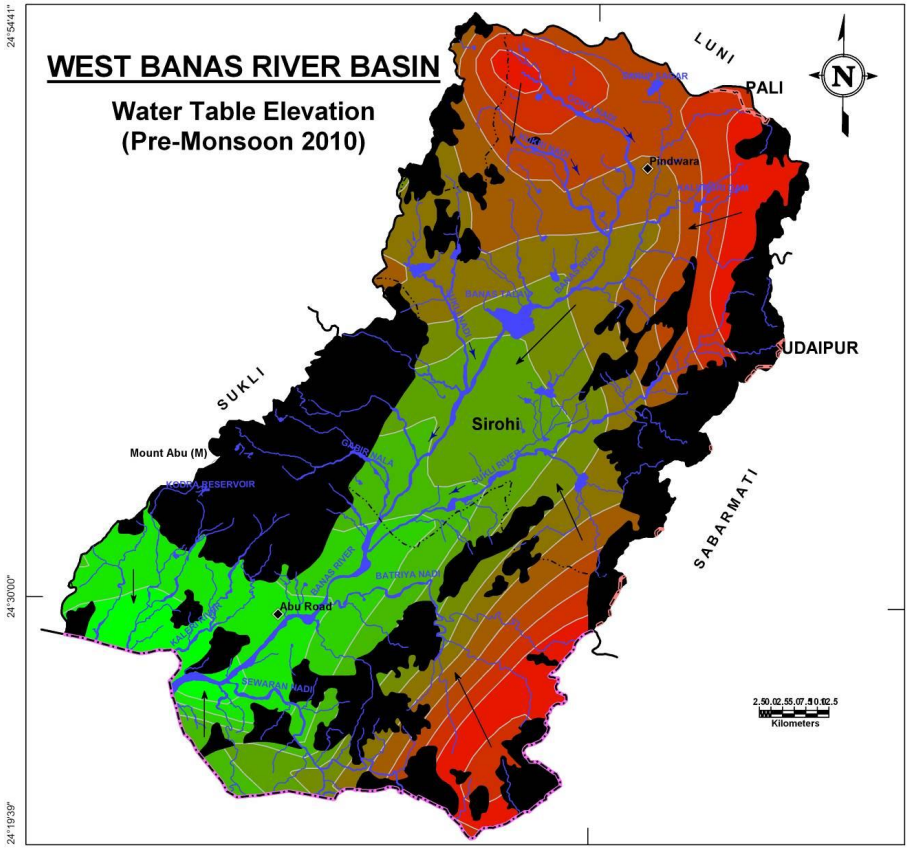
Water Table Elevation (m amsl) Pre Monsoon - 2010	District wise area coverage (sq km)			Total Area (sq km)
	Pali	Sirohi	Udaipur	
< 220	-	49.8	-	**49.8**
220 - 240	-	114.8	-	**114.8**
240 - 260	-	72.3	-	**72.3**
260 - 280	-	102.5	-	**102.5**
280 - 300	-	146.1	-	**146.1**
300 - 320	-	110.9	-	**110.9**
320 - 340	-	178.6	-	**178.6**
340 - 360	-	163.3	-	**163.3**
360 - 380	-	167.9	-	**167.9**
380 - 400	2.1	132.6	-	**134.7**
> 440	0.4	99.2	0.1	**99.7**
Total	**2.5**	**1,338.0**	**0.1**	**1,340.6**

WATER LEVEL FLUCTUATION (PRE TO POST MONSOON 2010)

The Basin is primarily a hardrock aquifer terrain and the aquifers formed in alluvial area are very limited in distribution. The water level fluctuation map is presented in Plate – XI which indicates a large fluctuation range from less than 2m to more than 18m. The area with highest rise in ground water level is located in the northern part of the basin. Other than this pocket, the rest of the basin area has shown moderate fluctuation that is within 2m to 10m rise. In the southern part a general rise in ground water level between 2m to 6m is noticed. There is no area that has shown negative fluctuation.

District Name	District wise area coverage (sq km) within fluctuation range (m)										Total Area (sq km)
	< 2	2 to 4	4 to 6	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16	16 to 18	> 18	
Pali	-	-	-	-	1.0	1.5	-	-	-	-	**2.5**
Sirohi	8.6	211.9	324.3	226.3	346.6	103.6	57.6	39.0	17.6	2.5	**1,338.0**
Udaipur	-	-	-	0.1	-	-	-	-	-	-	**0.1**
Total	**8.6**	**211.9**	**324.3**	**226.4**	**347.6**	**105.1**	**57.6**	**39.0**	**17.6**	**2.5**	**1,340.6**

PLATE - X



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- River Basin Boundary

Water Bodies:

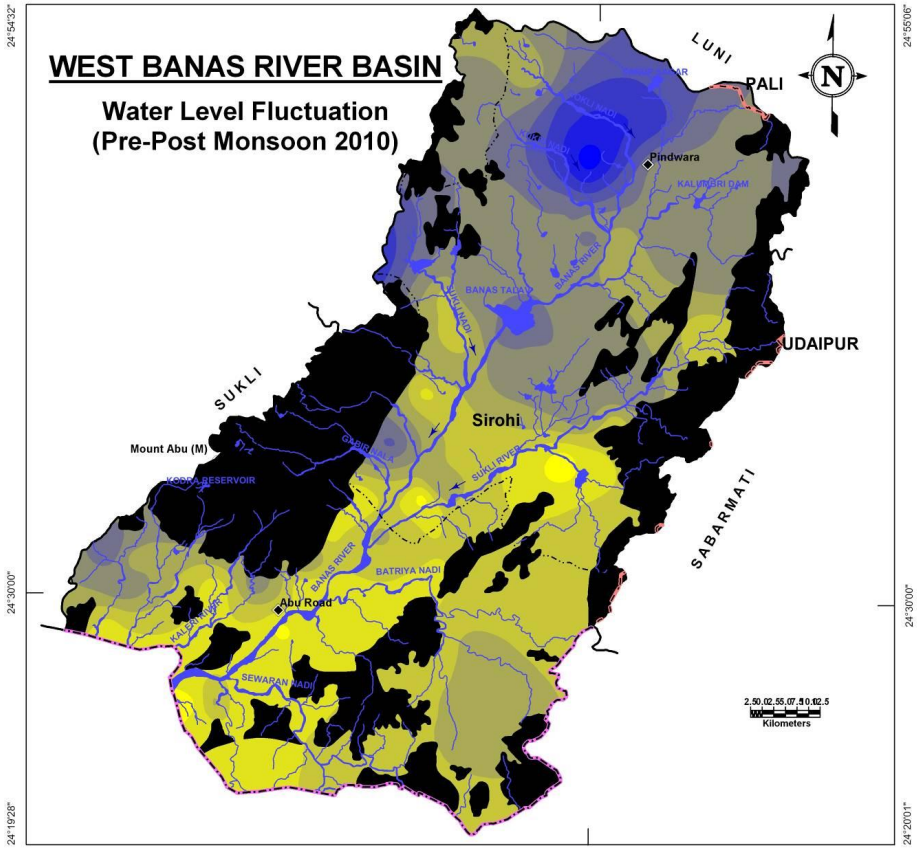
- River / Streams
- Ponds / Reservoirs
- Hills

Water Table Elevation

Water Table Elevation(m amsl):

- <220
- 220 - 240
- 240 - 260
- 260 - 280
- 280 - 300
- 300 - 320
- 320 - 340
- 340 - 360
- 360 - 380
- 380 - 400
- 400 - 440
- >440

PLATE - XI



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- River Basin Boundary

Water Bodies:

- River / Streams
- Ponds / Reservoirs
- Hills

Water Level Fluctuation(m):

- < 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- 14 to 16
- 16 to 18
- > 18

ELECTRICAL CONDUCTIVITY DISTRIBUTION — WEST BANAS RIVER BASIN

The Electrical Conductivity (at 25°C) distribution map is presented in Plate XII. Overall the basin has fairly good water quality from EC perspective since about 72% of the basin area has shown the EC to be less than 2000 µS/cm (represented by yellow coloured regions). If we add the moderately high EC ground water areas to the low EC areas, about 93% of the basin area falls within <4000 µS/cm category leaving just 7% of the area (EC > 4000 µS/cm) as not fit for domestic purposes. The high EC areas are located in the central part of the basin along the course of West Banas River.

Electrical Conductivity Ranges (µS/cm at 25°C) (Ave. of years 2005-09)	District wise area coverage (sq km)						Total Area (sq km)
	Pali		Sirohi		Udaipur		
	Area	% age	Area	% age	Area	% age	
< 2000	2.5	100.0	965.1	72.1	0.1	100.0	**967.7**
2000-4000	-	-	275.4	20.6	-	-	**275.4**
> 4000	-	-	97.5	7.3	-	-	**97.5**
Total	**2.5**	**100.0**	**1,338.0**	**100.0**	**0.1**	**100.0**	**1,340.6**

CHLORIDE DISTRIBUTION

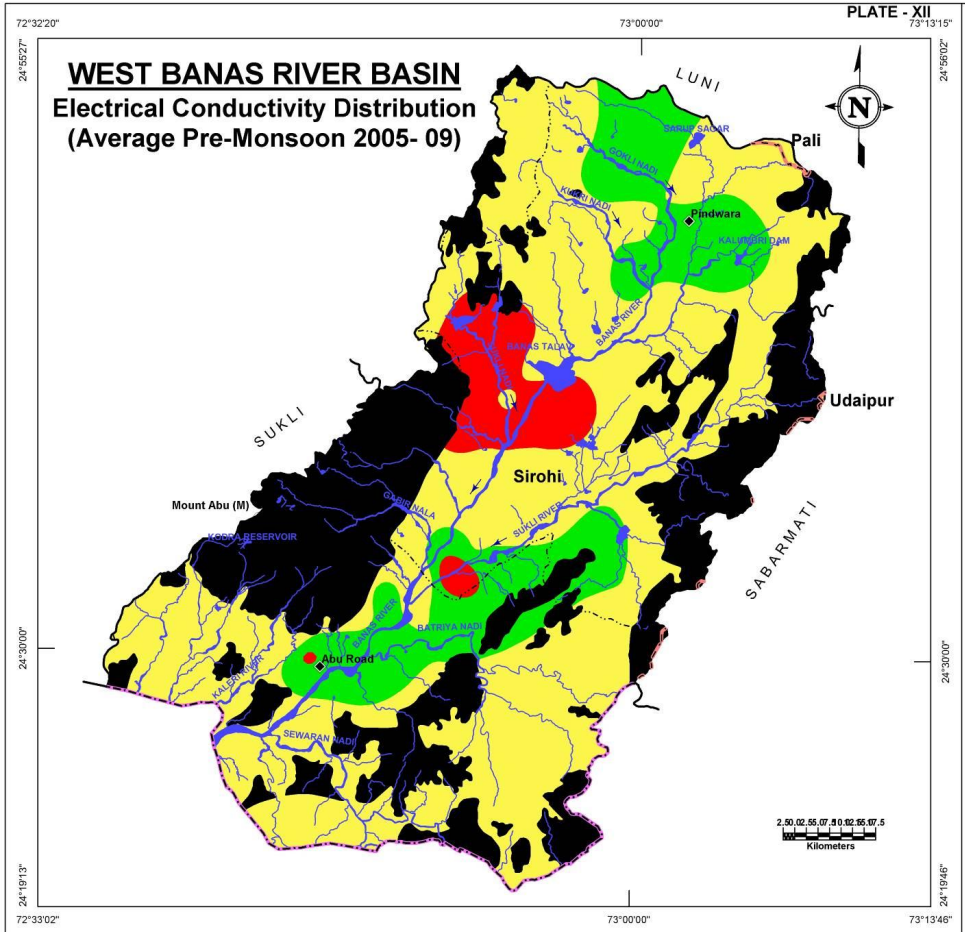
The Chloride concentration map Plate XIII shows the distribution of the same in ground water of West Banas River Basin. Very small area (about 3 sq km only) has high chloride concentration (>1000 mg/l). Interestingly, the low (<250 mg/l) chloride and moderately high (250-1000 mg/l) chloride concentration areas are equally distributed in the basin (48% and 52% area respectively). A closer perusal of the map reveals that the low chloride areas are present along the fringes of the hilly areas whereas the moderately high chloride areas are seen to be spread along the sides of the river course.

Chloride Ranges (mg/l) (Ave. of years 2005-09)	District wise area coverage (sq km)						Total Area (sq km)
	Pali		Sirohi		Udaipur		
	Area	% age	Area	% age	Area	% age	
< 250	2.5	100	639.8	47.8	0.1	100	**642.4**
250 - 1000	-	-	694.9	51.9	-	-	**694.9**
> 1000	-	-	3.3	0.3	-	-	**3.3**
Total	**2.5**	**100.0**	**1,338.0**	**100.0**	**0.1**	**100.0**	**1,340.6**

PLATE - XII

WEST BANAS RIVER BASIN

Electrical Conductivity Distribution (Average Pre-Monsoon 2005- 09)



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- **River Basin Boundary**
- **Water Bodies:**
- River / Streams
- Ponds / Reservoirs
- **Hills**

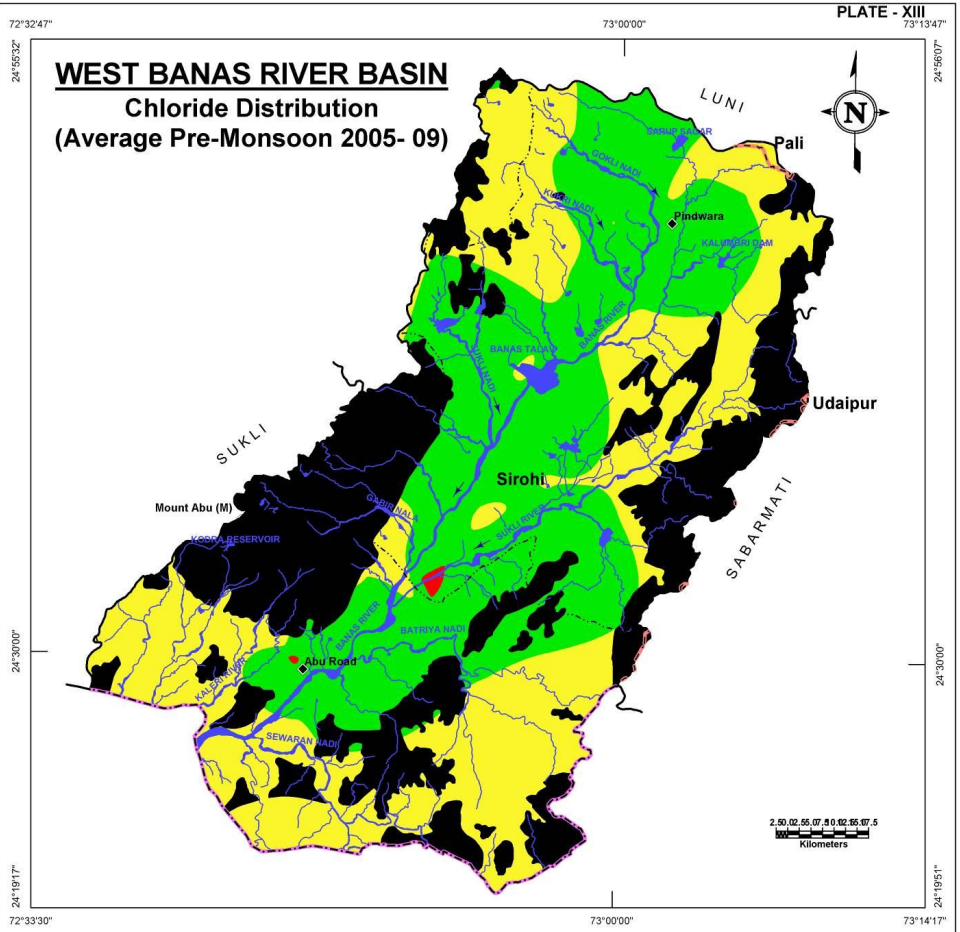
Electrical Conductivity (µS/cm at 25°C):

- < 2000
- 2000-4000
- > 4000

PLATE - XIII

WEST BANAS RIVER BASIN

Chloride Distribution (Average Pre-Monsoon 2005- 09)



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- **River Basin Boundary**
- **Water Bodies:**
- River / Streams
- Ponds / Reservoirs
- **Hills**

Chloride Concentration (mg/l):

- < 250
- 250 - 1000
- > 1000

FLUORIDE DISTRIBUTION

WEST BANAS RIVER BASIN

The Fluoride concentration map (Plate – XIV) displays multiple scattered patches of high fluoride concentration (>3 mg/l) which is surrounded but an even larger area having 1.5 – 3.0 mg/l of fluoride in ground water. Together these two areas combined (i.e., > 1.5 mg/l), occupy close to 43% of the basin rendering the ground water of limited use from fluoride concentration point of view. Correlating this with aquifer map (Plate – VI) further reveals that these areas directly correlate with the areas where the aquifer is formed in Granite flanking the hills. The more central part of the basin where aquifers are formed in alluvium or schist hold better ground water quality since fluoride concentration is, in general, low (<1.5 mg/l) within them.

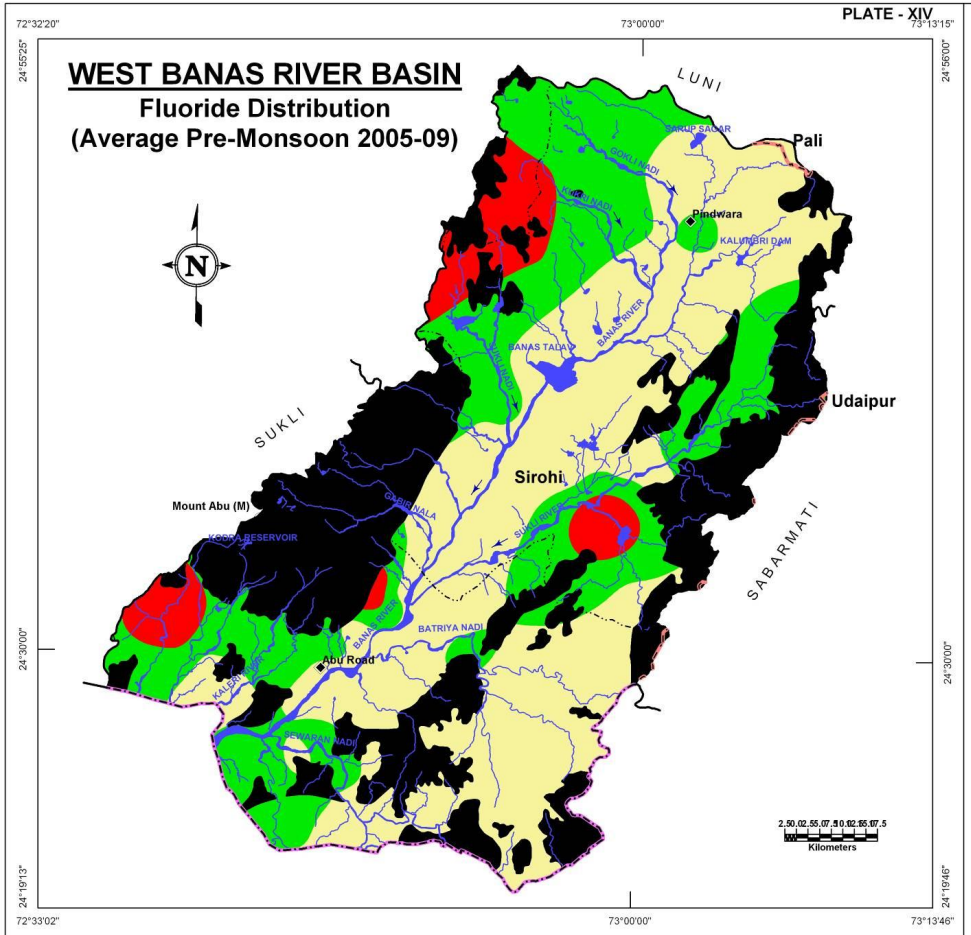
Fluoride Ranges (mg/l) (Ave. of years 2005-09)	District wise area coverage (sq km)						Total Area (sq km)
	Pali		Sirohi		Udaipur		
	Area	% age	Area	% age	Area	% age	
< 1.5	2.5	100.0	762.7	57.0	0.1	100.0	**765.3**
1.5-3.0	-	-	472.5	35.3	-	-	**472.5**
> 3.0	-	-	102.8	7.7	-	-	**102.8**
Total	**2.5**	**100.0**	**1,338.0**	**100.0**	**0.1**	**100.0**	**1,340.6**

NITRATE DISTRIBUTION

Plate – XV shows distribution of Nitrate in ground water of West Banas River Basin. High ground water Nitrate concentration areas are seen as a very large patch in the northwestern part of the basin and some scattered patches further downstream along the river. Such areas encompass about 21% of the basin area rendering it unsuitable for agriculture purposes. Surrounding these high areas are the moderately high areas (50-100 mg/l) shown in green colour that occupy about 31% of the basin area. Together the high and moderately high Nitrate concentration areas add up to about 42% leaving the remaining 48% area only where ground water is well suited for agriculture.

Nitrate Ranges (mg/l) (Ave. of years 2005-09)	District wise area coverage (sq km)						Total Area (sq km)
	Pali		Sirohi		Udaipur		
	Area	% age	Area	% age	Area	% age	
< 50	2.1	84.6	637.6	47.7	0.1	100.0	**639.8**
50-100	0.4	15.4	413.6	30.9	-	-	**414.0**
> 100	-	-	286.8	21.4	-	-	**286.8**
Total	**2.5**	**100.0**	**1,338.0**	**100.0**	**0.1**	**100.0**	**1,340.6**

PLATE - XIV



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- **Basin Boundary**

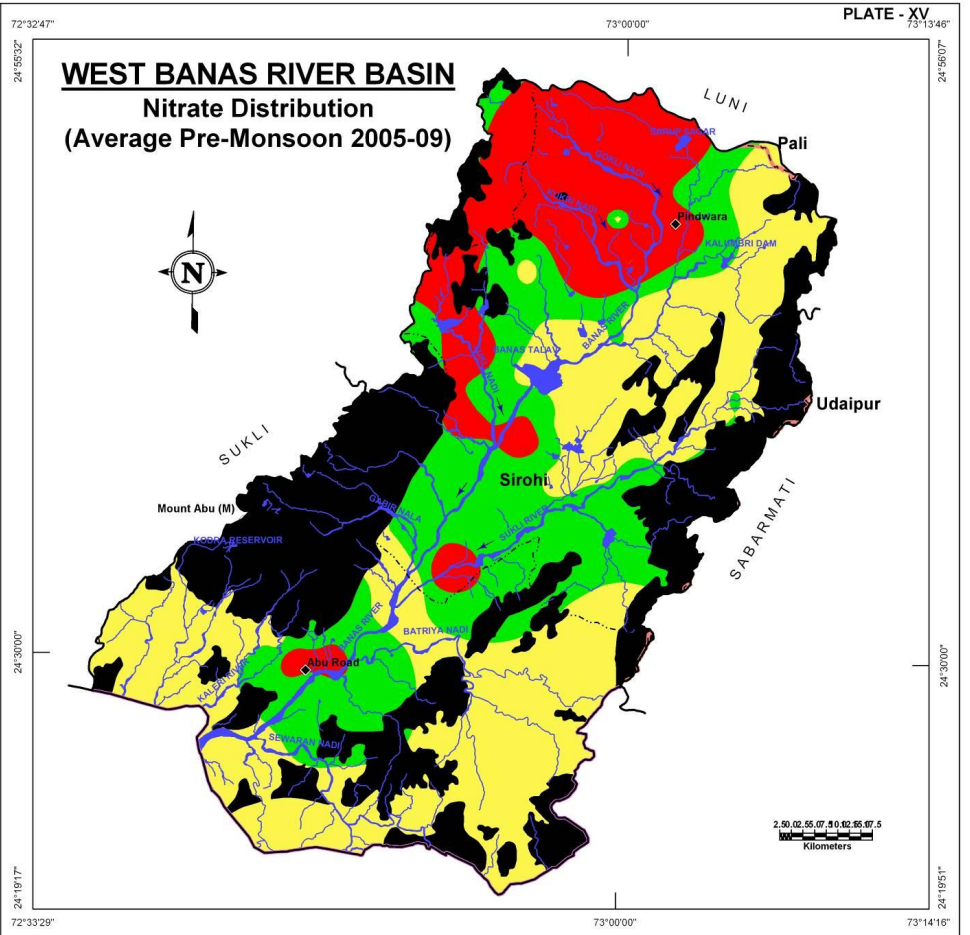
Water Bodies:

- River / Streams
- Ponds / Reservoirs
- **Hills**

Fluoride Concentration(mg/l):

- < 1.5
- 1.5-3.0
- > 3.0

PLATE - XV



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- **Basin Boundary**

Water Bodies:

- River / Streams
- Ponds / Reservoirs
- **Hills**

Nitrate Concentration (mg/l):

- < 50
- 50-100
- > 100

DEPTH TO BEDROCK

WEST BANAS RIVER BASIN

The hilly areas expose the bedrock and gradually into the plains, the thick alluvial pile conceals the bedrock under sand, clay and mix. From an aquifer perspective, the beginning of massive bedrock is taken to mark the start of bedrock and thus the weathered and fractured part of bedrock and alluvial cover constitutes the material above the bedrock. Plate XVI represents depth to bedrock in meters below ground level (bgl). 20m contour interval adopted for presenting the depth distribution reveals, that the central part of the basin has more than 20m indicating a greater depth of occurrence of massive bedrock whereas the areas to the north and south of this deeper bedrock zone, a lesser depth of <20m is seen.

Depth to Bedrock (m bgl)	District wise area coverage (sq km)			Total Area (sq km)
	Pali	Sirohi	Udaipur	
< 20	2.5	730.0	0.1	**732.6**
> 20	-	608.0	-	**608.0**
Total	**2.5**	**1,338.0**	**0.1**	**1,340.6**

UNCONFINED AQUIFER

Hydrogeological properties are different for alluvial and hard rock aquifers and therefore, this aquifer has been mapped as two separate regions viz, unconfined aquifers in alluvial and in hard rock areas. The same is presented in Plate XVII.

The alluvial aquifer is present in the southwestern part of the basin and is predominantly of eolian or fluvial origin represented by sand, clay and gravel. The thickness of unconfined aquifer in alluvial areas is often less than 10m (about 87% of alluvial aquifer part of basin) and only about 13% of the basin area has more thickness than 10m. In hardrock areas also the thickness of unconfined aquifer (weathered and fractured hard rock) is more as indicated by <20m thickness occupying about 33% of hardrock aquifer area and that about 99% of the area falls under the <60m depth category distributed all over the basin. In general, the northern part has lesser thickness of hardrock aquifer and the southern part has relatively more thickness of hardrock aquifers. The rock types that constitute these aquifers are mostly weathered/fractured Granite and Schist.

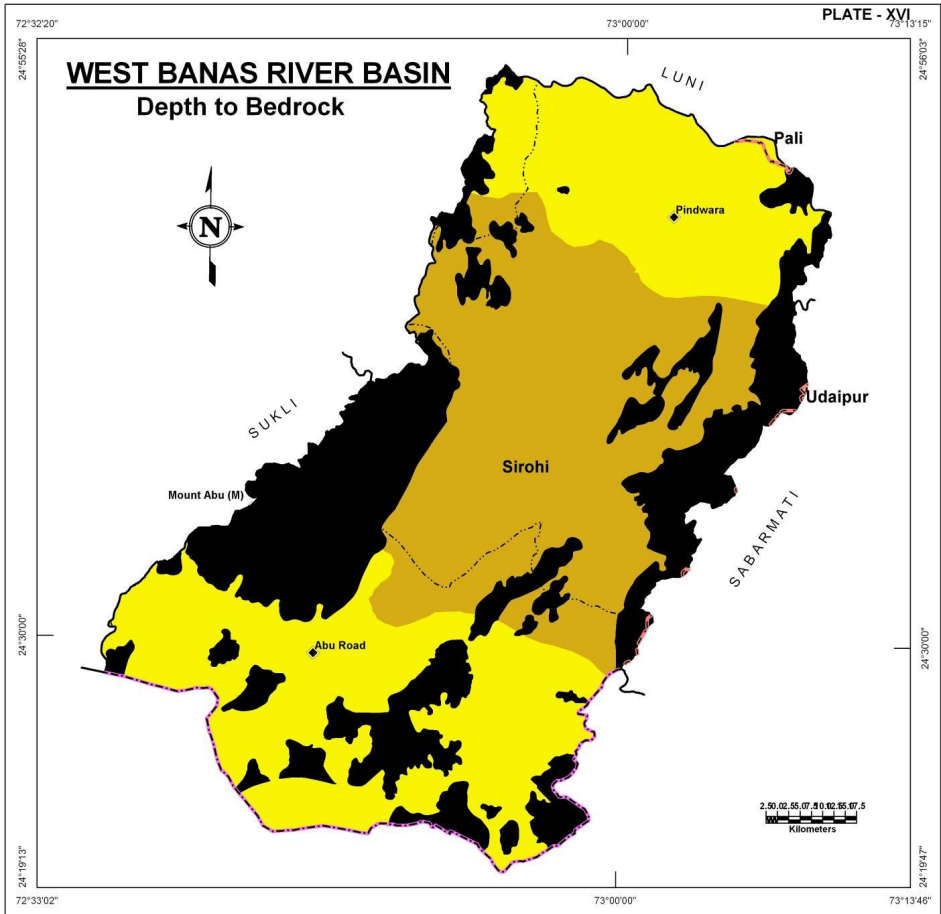
Alluvial areas

Unconfined aquifer Thickness (m)	District wise area coverage (sq km)			Total Area (sq km)
	Pali	Sirohi	Udaipur	
< 10	-	60.7	-	**60.7**
10-20	-	6.6	-	**6.6**
20-30	-	2.3	-	**2.3**
> 30	-	0.1	-	**0.1**
Total	**0**	**69.7**	**0**	**69.7**

Hardrock areas:

Unconfined aquifer Thickness (m)	District wise area coverage (sq km)			Total Area (sq km)
	Pali	Sirohi	Udaipur	
<10	1.3	86.7	-	**88**
10-20	1.2	329.5	0.1	**330.8**
20-30	-	215.6	-	**215.6**
30-40	-	259.9	-	**259.9**
40-50	-	159.3	-	**159.3**
50-60	-	198.4	-	**198.4**
60-70	-	12.7	-	**12.7**
70-80	-	3.4	-	**3.4**
80-90	-	2.2	-	**2.2**
> 90	-	0.6	-	**0.6**
Total	**2.5**	**1268.3**	**0.1**	**1270.9**

PLATE - XVI



LEGEND

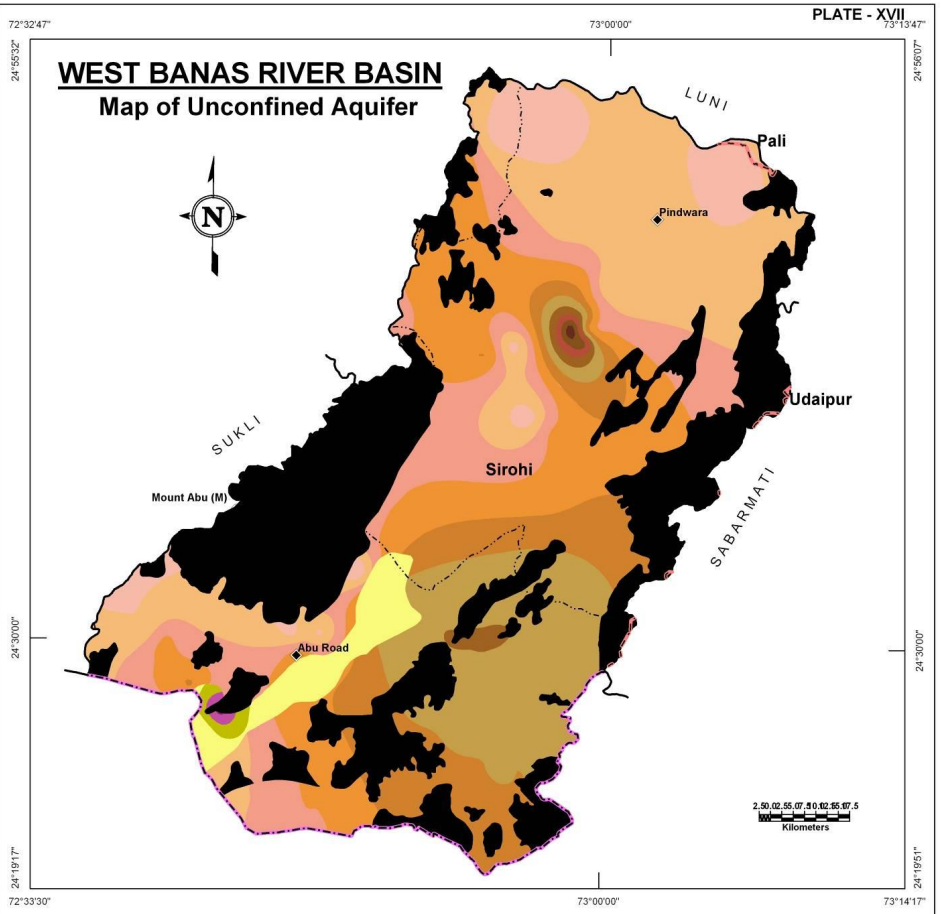
Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- River Basin Boundary
- Hills

Depth to Bedrock (m bgl):

- < 20
- >20

PLATE - XVII



LEGEND

Admin Boundary:

- Block Headquarter
- Town
- State Boundary
- District Boundary
- Block Boundary
- River Basin Boundary
- Hills

Aquifer Thickness (m):

Alluvial Area:

- <10
- 10-20
- 20-30
- >30

Weathered & Fractured Zone in Hardrock Area :

- <10
- 10-20
- 20-30
- 30-40
- 40-50
- 50-60
- 60-70
- 70-80
- 80-90
- >90

CROSS SECTIONS

WEST BANAS RIVER BASIN

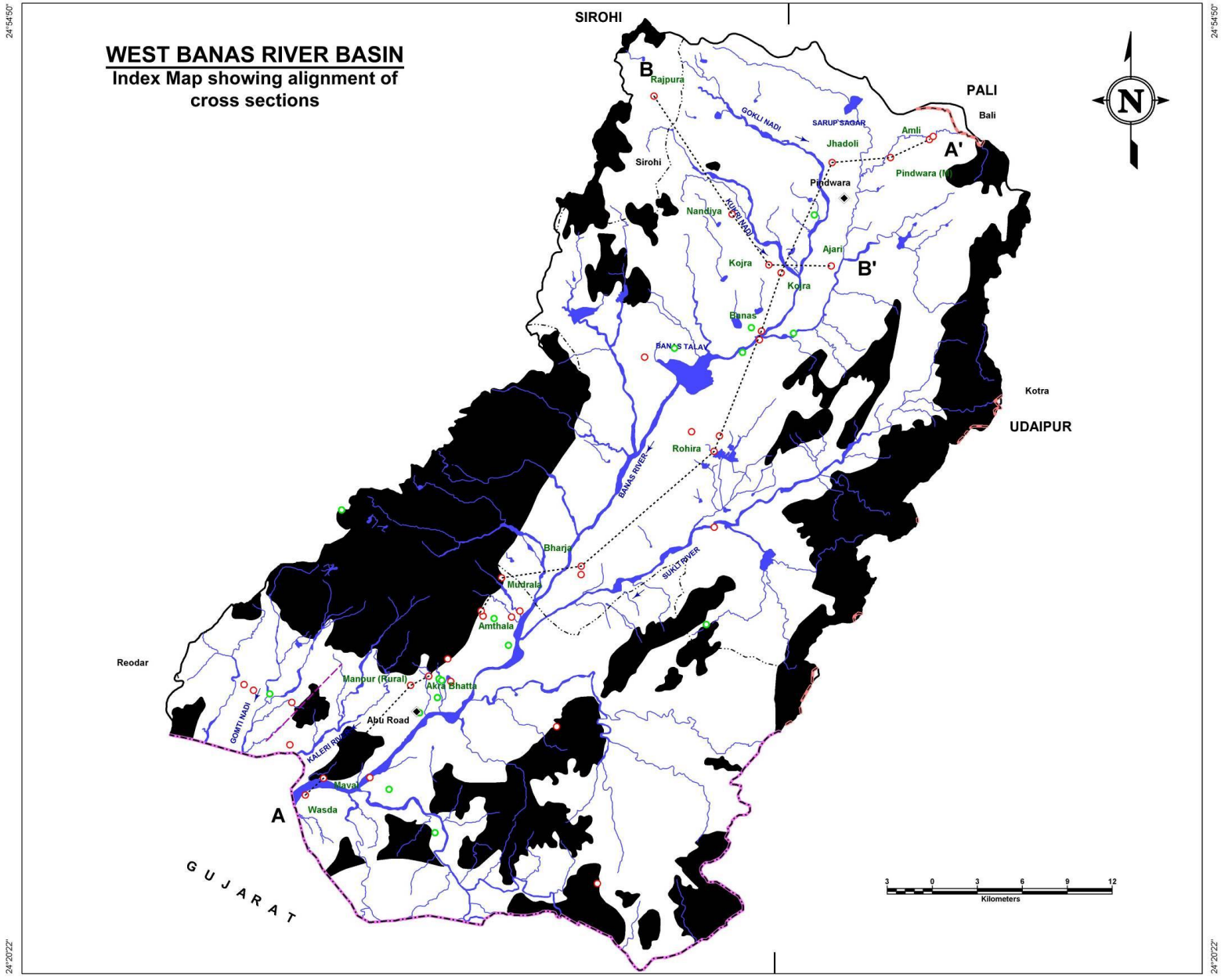
Several hydrogeologic cross sections have been drawn to better decipher the sub-surface distribution of lithology. These sections have been overlaid with geological maps and structural faults if there are any have been transferred for verification of their impact on sub-surface material disposition. The alignment of the cross sections is shown in Plate – XVIII and corresponding sections are presented in Plates – XIX to XX. The broad alignment of the sections is as given below:

Name of Section Line	Orientation
Section AA’	SW – NE
Section BB’	NW – SE

PLATE - XVIII

WEST BANAS RIVER BASIN

Index Map showing alignment of cross sections



Legend

- Block Headquarter
- State Boundary
- District Boundary
- Block Boundary
- River Basin Boundary
- Fault
- Section Lines
- Major Streams / River
- Pond / Reservoir
- Hills

Exploratory Wells

- Amli — Well location for Sections
- CGWB
- RGWD

Section A-A':

The section A-A' (Plate – XIX) has been chosen with trend in SW-NE direction extending for a length of about 64 kms. The lithologs of 12 boreholes along with surrounding well information has been taken into account while preparing the section. The section depicts the disposition of different layers of sand and clay along with dolerite, schist and granite. On perusal of the cross section, it is apparent that the area is predominantly within hard and massive rock types. As the cross section is taken along the West Banas River, the southwestern and northeastern part the sandy aquifer is found. Clay occurs as thin lenses in the cross section. Two faults running almost parallel to each other separate schist from granite. The dolerite has intruded into the sequence as a dyke. The granite constitutes the bedrock that marks its presence throughout the section.

The water table elevation varies from 215m amsl to 370m amsl following the surface topography. The overall slope is from northeast to southwest.

Section B-B':

The section B-B' (Plate – XX) has been selected to represent a NW-SE profile of the sub-surface covering a length of about 17.5km. The lithologs of 4 boreholes along with surrounding well information is taken into account while preparing the section. The streams Kukri and Gokli cut across the section in the southeastern part. Granite is predominant in this section overlain by topsoil for its most part. In the southeastern part of the profile a fault is present separating granite in the northwest from schist in the southeastern side.

Water table elevation varies from 340m amsl to 380m amsl in this profile and water from northwest to southeast which also is the topographic slope in the section.

PLATE - XIX

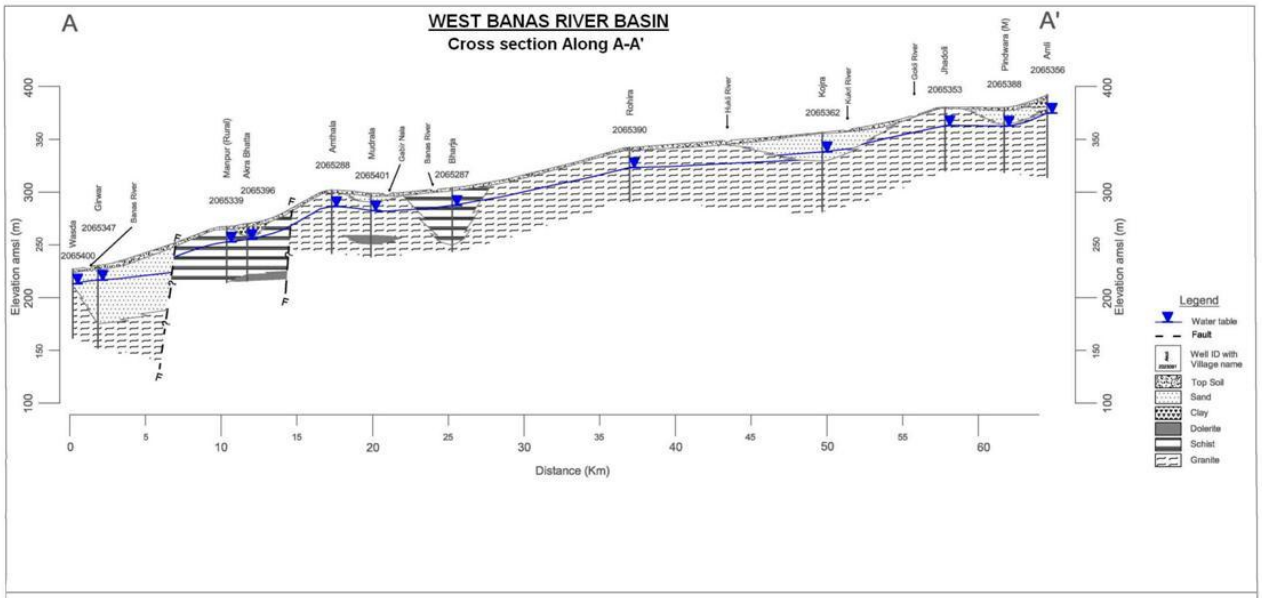
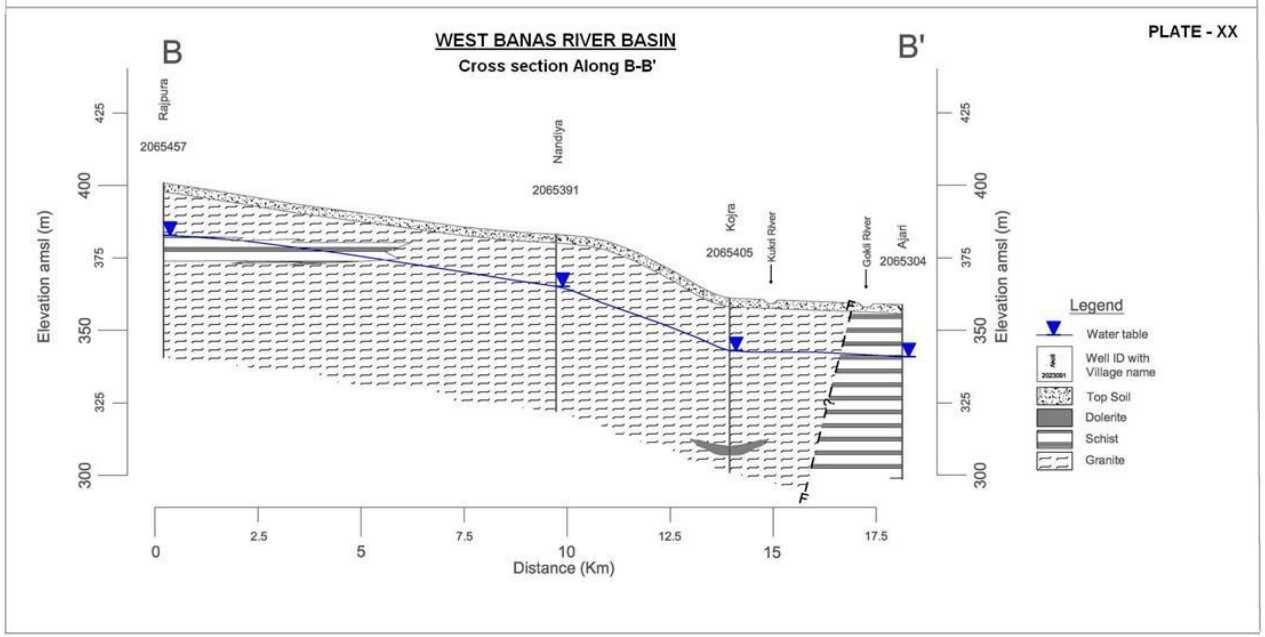


PLATE - XX



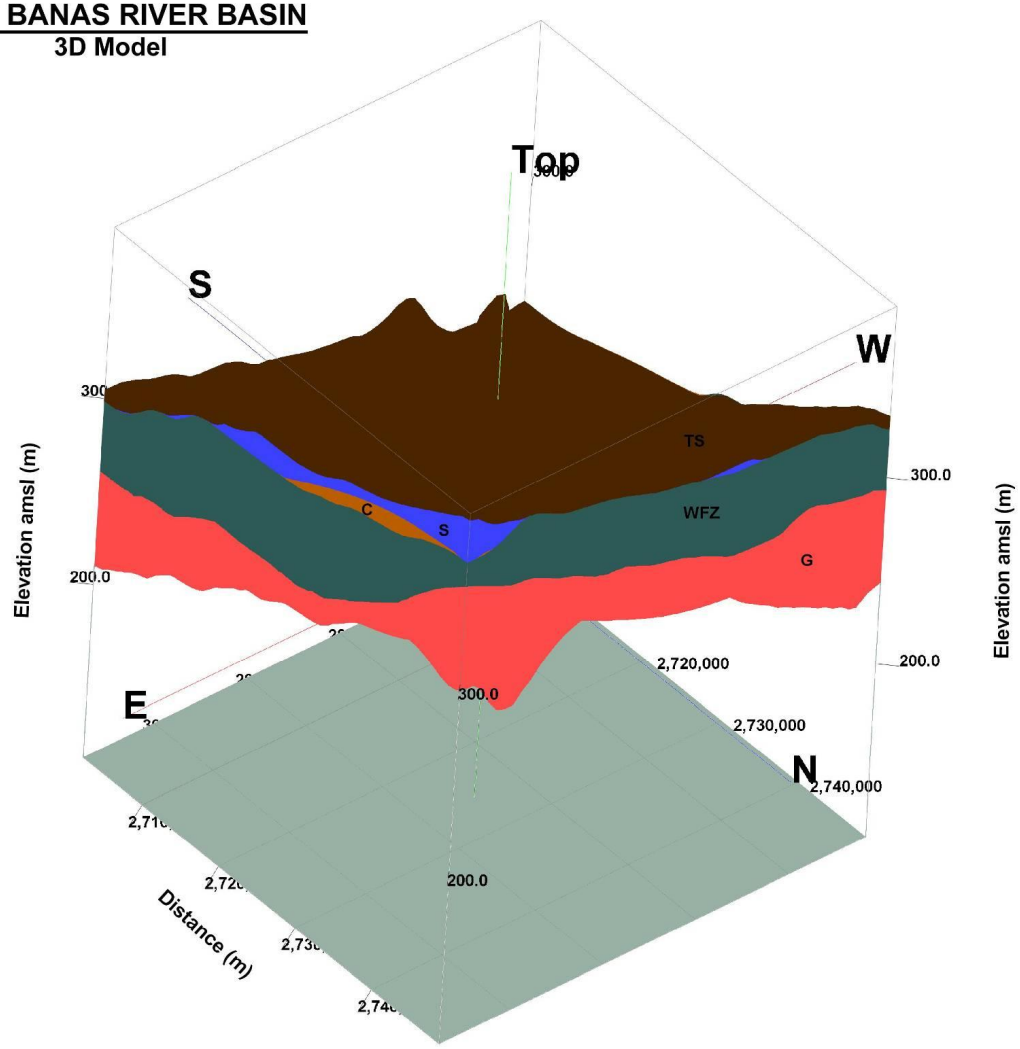
3D MODEL OF AQUIFERS

WEST BANAS RIVER BASIN

The continuous litho-stratigraphic model has been developed for the West Banas River Basin using the data of scattered wells as input. 3D model depicts the sub-surface aquifer disposition of litho-stratigraphic units forming aquifers, aquicludes and aquitards in the area. Plate XXII presents 3D model depicting the various litho-stratigraphic units in the entire river basin. From this model it is apparent that beneath the top soil there is a persistent weathered and fractured bed rock acting as unconfined aquifers. Alluvium consisting mainly of sand, having limited spatial distribution in the southern part of the area is acting as unconfined alluvial aquifer in the basin. The limestone aquifer (first confined aquifer) occurs in south eastern part are found overlain by weathered and fractured bedrock in the basin.

PLATE - XXI

WEST BANAS RIVER BASIN
3D Model



Legend

TS	Top Soil
S	Sand
C	Clay
WFZ	Weathered & Fractured Zone
L	Limestone
Q	Quartzite
Ph	Phyllite
Sc	Schist
G	Granite

Glossary of terms

S. No.	Technical Terms	Definition
1	AQUIFER	A saturated geological formation which has good permeability to supply sufficient quantity of water to a Tube well, well or spring.
2	ARID CLIMATE	Climate characterized by high evaporation and low precipitation.
3	ARTIFICIAL RECHARGE	Addition of water to a ground water reservoir by man-made activity
4	CLIMATE	The sum total of all atmospheric or meteorological influences principally temperature, moisture, wind, pressure and evaporation of a region.
5	CONFINED AQUIFER	A water bearing strata having confined impermeable overburden. In this aquifer, water level represents the piezometric head.
6	CONTAMINATION	Introduction of undesirable substance, normally not found in water, which renders the water unfit for its intended use.
7	DRAWDOWN	The drawdown is the depth by which water level is lowered.
8	FRESH WATER	Water suitable for drinking purpose.
9	GROUND WATER	Water found below the land surface.
10	GROUND WATER BASIN	A hydro-geologic unit containing one large aquifer or several connected and interrelated aquifers.
11	GROUND WATER RECHARGE	The natural infiltration of surface water into the ground.
12	HARD WATER	The water which does not produce sufficient foam with soap.
13	HYDRAULIC CONDUCTIVITY	A constant that serves as a measure of permeability of porous medium.
14	HYDROGEOLOGY	The science related with the ground water.
15	HUMID CLIMATE	The area having high moisture content.
16	ISOHYET	A line of equal amount of rainfall.
17	METEOROLOGY	Science of the atmosphere.
18	PERCOLATION	It is flow through a porous substance.
19	PERMEABILITY	The property or capacity of a soil or rock for transmitting water.
20	pH	Value of hydrogen-ion concentration in water. Used as an indicator of acidity (pH < 7) or alkalinity (pH > 7).
21	PIEZOMETRIC HEAD	Elevation to which water will rise in a piezometers.
22	RECHARGE	It is a natural or artificial process by which water is added from outside to the aquifer.
23	SAFE YIELD	Amount of water which can be extracted from ground water without producing undesirable effect.
24	SALINITY	Concentration of dissolved salts.
25	SEMI-ARID	An area is considered semiarid having annual rainfall between 10-20 inches.
26	SEMI-CONFINED AQUIFER	Aquifer overlain and/or underlain by a relatively thin semi-pervious layer.
27	SPECIFIC YIELD	Quantity of water which is released by a formation after its complete saturation.
28	TOTAL DISSOLVED SOLIDS	Total weight of dissolved mineral constituents in water per unit volume (or weight) of water in the sample.

(Contd…)

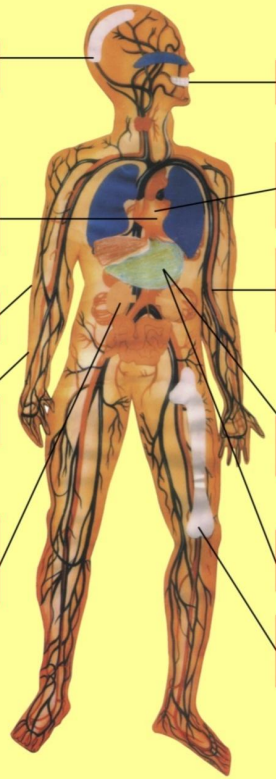
S. No.	Technical Terms	Definition
29	TRANSMISSIBILITY	It is defined as the rate of flow through an aquifer of unit width and total saturation depth under unit hydraulic gradient. It is equal to product of full saturation depth of aquifer and its coefficient of permeability.
30	UNCONFINED AQUIFER	A water bearing formation having permeable overburden. The water table forms the upper boundary of the aquifer.
31	UNSATURATED ZONE	The zone below the land surface in which pore space contains both water and air.
32	WATER CONSERVATION	Optimal use and proper storage of water.
33	WATER RESOURCES	Availability of surface and ground water.
34	WATER RESOURCES MANAGEMENT	Planned development, distribution and use of water resources.
35	WATER TABLE	Water table is the upper surface of the zone of saturation at atmospheric pressure.
36	ZONE OF SATURATION	The ground in which all pores are completely filled with water.
37	ELECTRICAL CONDUCTIVITY	Flow of free ions in the water at 25C mu/cm.
38	CROSS SECTION	A Vertical Projection showing sub-surface formations encountered in a specific plane.
39	3-D PICTURE	A structure showing all three dimensions i.e. length, width and depth.
40	GWD	Ground Water Department
41	CGWB	Central Ground Water Board
42	CGWA	Central Ground Water Authority
43	SWRPD	State Water Resources Planning Department
44	EU-SPP	European Union State Partnership Programme
45	TOPOGRAPHY	Details of drainage lines and physical features of land surface on a map.
46	GEOLOGY	The science related with the Earth.
47	GEOMORPHOLOGY	The description and interpretation of land forms.
48	PRE MONSOON SURVEY	Monitoring of Ground Water level from the selected DKW/Piezometer before Monsoon (carried out between 15th May to 15th June)
49	POST-MONSOON SURVEY	Monitoring of Ground Water level from the selected DKW/Piezometer after Monsoon (carried out between 15th October to 15th November)
50	PIEZOMETER	A non-pumping small diameter bore hole used for monitoring of static water level.
51	GROUND WATER FLUCTUATION	Change in static water level below ground level.
52	WATER TABLE	The static water level found in unconfined aquifer.
53	DEPTH OF BED ROCK	Hard & compact rock encountered below land Surface.
54	G.W. MONITORING STATION	Dug wells selected on grid basis for monitoring of state water level.
55	EOLIAN DEPOSITS	Wind-blown sand deposits

Ground Water Department,
Rajasthan

European Union
State Partnership Programme

भूजल में घुले मुख्य तत्वों की अधिकता का मानव शरीर पर दुष्प्रभाव

- बोरोन-स्नायु तन्त्र पर प्रभाव
- क्लोराइड-सोडियम के साथ मिलकर उच्च रक्त चाप
- कैल्शियम-जोड़ों में कड़ापन
- आर्सेनिक-त्वचा रोग, कैंसर
- लेड-बच्चों के शारीरिक व मानसिक विकास में बाधा वयस्कों में गुर्दे के रोग
- फ्लोराइड - दंत क्षरण
- सोडियम-हृदय, गुर्दा व रक्त परिसंचरण रोगों से ग्रसित लोगों को हानिकारक
- नाइट्रेट-नवजात शिशुओं में ब्लू बेबी बीमारी (मेथमोग्लोबिनिमिया)
- सल्फेट-अधिकता में मैग्नेशियम के साथ मिलकर दस्तावर
- आयरन-आयरन जीवाणु से आमाशय संबंधी रोग
- फ्लोराइड-जोड़ों में अकड़न, हड्डियों में मुड़ाव



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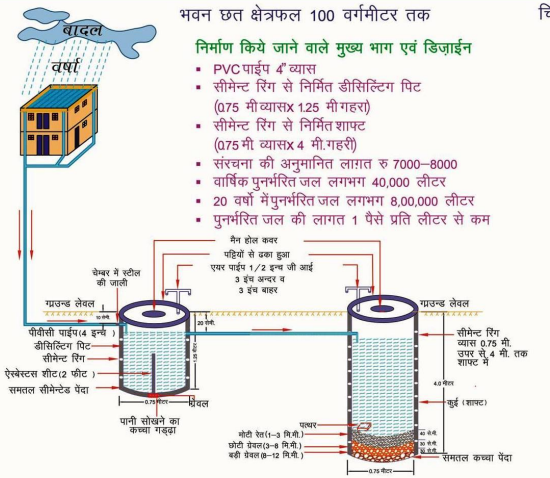
e-mail:cgwbwr@sancharnet.in

भूजल अमूल्य है इसे प्रदूषित न करें।

चित्र–1 भवन छत क्षेत्रफल 100 वर्गमीटर तक

निर्माण किये जाने वाले मुख्य भाग एवं डिज़ाईन

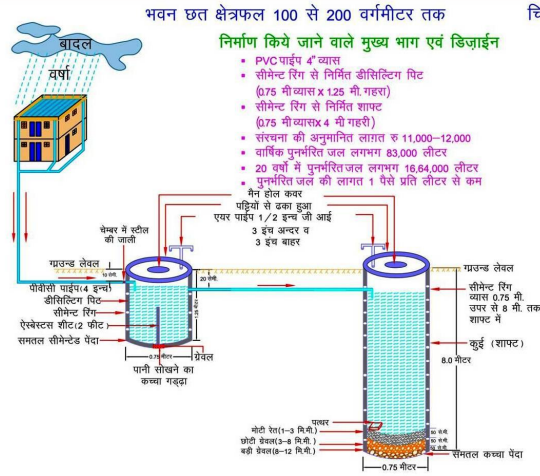
- PVC पाईप 4" व्यास
- सीमेन्ट रिंग से निर्मित डीसिल्टिंग पिट (0.75 मी व्यास x 1.25 मी गहरा)
- सीमेन्ट रिंग से निर्मित शाफ्ट (0.75 मी व्यास x 4 मी गहरी)
- संरचना की अनुमानित लाग़त रु 7000–8000
- वार्षिक पुनर्भरित जल लगभग 40,000 लीटर
- 20 वर्षो में पुनर्भरित जल लगभग 8,00,000 लीटर
- पुनर्भरित जल की लागत 1 पैसे प्रति लीटर से कम



चित्र–2 भवन छत क्षेत्रफल 100 से 200 वर्गमीटर तक

निर्माण किये जाने वाले मुख्य भाग एवं डिज़ाईन

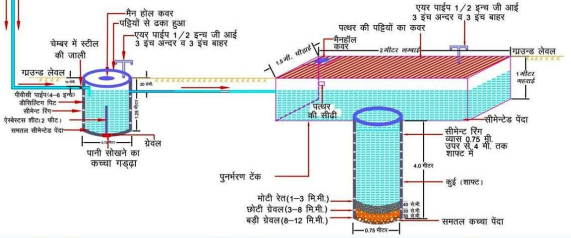
- PVC पाईप 4" व्यास
- सीमेन्ट रिंग से निर्मित डीसिल्टिंग पिट (0.75 मी व्यास x 1.25 मी. गहरा)
- सीमेन्ट रिंग से निर्मित शाफ्ट (0.75 मी व्यास x 4 मी गहरी)
- संरचना की अनुमानित लाग़त रु 11,000–12,000
- वार्षिक पुनर्भरित जल लगभग 83,000 लीटर
- 20 वर्षो में पुनर्भरित जल लगभग 16,64,000 लीटर
- पुनर्भरित जल की लागत 1 पैसे प्रति लीटर से कम



चित्र–3 भवन छत क्षेत्रफल 200 से 300 वर्गमीटर तक

निर्माण किये जाने वाले मुख्य भाग एवं डिज़ाईन

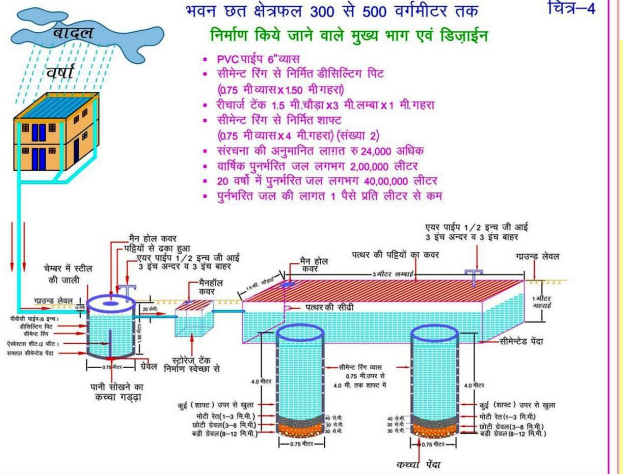
- PVC पाईप 4"– 6" व्यास
- सीमेन्ट रिंग से निर्मित डीसिल्टिंग पिट (0.75 मी व्यास x 1.25 मी गहरा)
- रीचार्ज टेंक 1.5 मी.चौड़ा x 2 मी.लम्बा x 1 मी.गहरा
- सीमेन्ट रिंग से निर्मित शाफ्ट (0.75 मी व्यास x 4 मी.गहरी)
- संरचना की अनुमानित लाग़त रु 15,000–16,000
- वार्षिक पुनर्भरित जल लगभग 1,25,000 लीटर
- 20 वर्षो में पुनर्भरित जल लगभग 25,00,000 लीटर
- पुर्नभरित जल की लागत 1 पैसे प्रति लीटर से कम



चित्र–4 भवन छत क्षेत्रफल 300 से 500 वर्गमीटर तक

निर्माण किये जाने वाले मुख्य भाग एवं डिज़ाईन

- PVC पाईप 6" व्यास
- सीमेन्ट रिंग से निर्मित डीसिल्टिंग पिट (0.75 मी व्यास x 1.50 मी गहरा)
- रीचार्ज टेंक 1.5 मी.चौड़ा x 3 मी.लम्बा x 1 मी.गहरा
- सीमेन्ट रिंग से निर्मित शाफ्ट (0.75 मी व्यास x 4 मी.गहरा) (संख्या 2)
- संरचना की अनुमानित लाग़त रु 24,000 अधिक
- वार्षिक पुनर्भरित जल लगभग 2,00,000 लीटर
- 20 वर्षो में पुनर्भरित जल लगभग 40,00,000 लीटर
- पुर्नभरित जल की लागत 1 पैसे प्रति लीटर से कम



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Myths and Facts about Ground Water

S No	Myths	Facts
1	What is Ground Water • an underground lake • a net work of underground rivers • a bowl filled with water	Water which occurs below the land in geological formations/rocks is Ground water
2	Ground Water occurs everywhere beneath the Land Surface	Not really, it depends on the nature of rock formation
3	There is a relationship between ground water and surface water	Not all the places. Near streams/rivers there is relation
4	Groundwater is not renewable resource	It is renewable source and every year it is being recharged through rain/applied irrigation etc
5	Ground water is unlimited and deeper you drill more discharge	It is limited to annual recharge from rain/applied irrigation. The discharge may not increase if you go deeper
6	Ground Water moves rapidly	The movement of ground water is very slow
7	Ground water pumped from wells is thousands of years old	Generally the ground water being tapped through wells is a few years old
8	If water taste good—it is safe to drink	It may have other chemicals e.g. fluoride, nitrates etc which are harmful
9	Water from free flowing tube wells is very pure	This water can also be contaminated so test before use
10	If I recharge my TW/DW/HP it will not benefit me	It will also benefit you and also adjoing wells
11	There is no static ground water resources in Rajasthan	Rajasthan is also having Static GW resources, and being tapped in most of areas as GW annual withdrawal is more than annual recharge
12	I cannot meet annual cooking and drinking water requirement by rain water harvesting	The water requirement for drinking and cooking is only 8 lit/day. You can harvest this water for family of 5 persons from roof top or paved area of 75 Sq m to meet annual requirement
13	You can increase ground water recharge	This can be done by harvesting the rain water and storing in sub surface reservoir (GW) by constructing the recharge structures
14	You cannot use abandoned TW/HP/DW for ground water recharge	These should be used as recharge structures as harvested rain water is directly put into GW reservoir
15	Putting waste near HP/TW will not cause any problem	Such actions will pollute wells and water

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