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Technical Report Series

GROUNDWATER BROCHURE

PANCHMAHAL DISTRICT

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PROFILE OF PANCHMAHAL DISTRICT

SL No.	Items	Statistics
1	General Information	
	i) Geographical area as per state territory/as per village papers (Sq. Km)	5210/5138
	ii) Administrative Divisions (As on 3/2011) Number of Talukas Number of Villages	 11 1210
	iii) Populations (As per 2011 census)	2,38,8267
	iv) Average Annual Rainfall (mm)	823
2.	GEOMORPHOLOGY	
	Major Physiographic Units : Undulating plain, highly dissected plateau and hills	
	Major Drainages: Perenial river – Mahi river, Non-perenial river - Panam, Hadap, Goma, Kharod, Mesari, Chikni, Kun, Anas, Kali, Machchhan and Chibota.	
3.	LAND USE (Sq. Km) (2004-05)	
	a) Forest area b) Net area sown c) Cultivable area	1168 2810 3091
4.	MAJOR SOIL TYPES**:** Sandy soils, Yellowish brown & black soils, Black cotton soils	
5.	AREA UNDER PRINCIPAL CROPS (sq.km) (2004-05) Rice 760 , Jowar-40, Bajra-170, Wheat-170, Maize-1210,Total cereals-2370, Gram - 50, other pulses-330, Total pulses-380, Total food crops- 2750, Ground nut-30, Seasam -10, Rapes and Mustard-0, Total oil seeds-80.	
6.	IRRIGATION BY DIFFERENT SOURCES (Area in Sq Km/ no of structures)	
	Dugwells	369/25507
	Tube wells/Borewells	15/52
	Tanks/Ponds/Water conservation structures	12
	Canals	33
	Other Sources	22
	Net Irrigated area (sq. km.) (2004-05)	551
	Gross Irrigated area (sq. km.) (2004-05)	690
7.	NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on 31-03-2011) No of Dug Wells No of Piezometers	28 19 9
8.	PREDOMINANT GEOLOGICAL FORMATIONS: Meta-sediments of Aravalli super group such as Phyllites, quartzites; post Delhi intrusive of Godhra granite and gneiss; Infra-trappean of lameta beds; sandstones and limestone; Deccan trap basalts and alluvium deposit along river channels and valley fills.	
9.	HYDROGEOLOGY Major Water Bearing Formation**:** Groundwater occur in unconfined to semi-confined condition in phyllite, schist & quartzite, Granite and gneiss, deccan trap formation in weathered mantle and factures zones and under unconfined condition in alluvium along river courses, valley fills, flood plain & abandoned Palaeochannel deposits.	
	Depth to water Level during 2011-12	

	Period	Phreatic Aquifer (DTW)		Semi-confined /Confined Aquifer (PZ head)	
		Min	Max	Min	Max
	Pre Monsoon	**1.5 (Lunawada)**	**14.10 (Pandarwada)**	**NA**	**NA**
	Post Monsoon	**1.0 (Shehra)**	**9.32 (Santroad)**	**NA**	**NA**
	Long Term (10 Years) Water Level Trend (2003 to 2012)				
	Trend	Pre-Monsoon		Post- Monsoon	
	Rise (m/Yr)	0.05 (Tuwa) to 0.35 (Gadhar)		0.004 (Timbi) to 0.53 (Pandarvada)	
	Fall (m/Yr)	0.002 (Kothamba) to 0.72 (Lunawada)		0.002 (Jambughoda) to 1.05 (Lunawada)	

10.	GROUND WATER EXPLORATION BY CGWB (As on 31-03-2011)	
	No of wells drilled (EW, OW, Pz, SH, Total) EW: 45,OW: 04, PZ :09, SH:0, Total: 58	
	Depth Range(m)	25.70 m to 202.60
	Discharge (Litres per minute)	60 to 600
11	GROUND WATER QUALITY	
	Presence of chemical constituents more than permissible limit)	High Fluoride
	Type of water	Potable in general
12.	DYNAMIC GROUND WATER RESOURCES (As on 2011)	
	Annual Replenishable Ground Water Resources (MCM)	739.39
	Net Ground water Availability (MCM)	702.40
	Projected Demand for Domestic and industrial Uses upto 2025 (MCM)	70.07
	Stage of Ground Water Development (%)	41.48
13	AWARENESS AND TRAINING ACTIVITY (as on 3/2012)	
	Mass Awareness Programmes organized No of Participants	Nil
	Water Management Training Programmes organized (No of Participants)	Nil
14	EFFORTS OF ARTIFICIAL RECHARGE & RAIN WATER HARVESTING (31-3-2011)	
	Projects completed by CGWB (No & Amount spent)	Nil
	Projects under technical guidance of CGWB (Numbers)	NA
15	GROUND WATER CONTROL AND REGULATION (2009)	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	Number of Semi Critical Blocks	Nil
	Number of Safe Blocks	11
	Number of Saline Blocks	Nil
	No. Of Blocks Notified by CGWA	Nil
16	MAJOR GROUND WATER PROBLEMS AND ISSUES	

i) Declining Groundwater levels/ Piezometric heads in user aquifers
ii) Increasing depth of tube wells
iii) Increasing instances of high fluoride
iv) Groundwater contamination due to unplanned construction and poor technical design of tube wells
v) Awareness amongst villagers on water conservation techniques
vi) Demand supply management

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GROUNDWATER BROCHURE OF
PANCHMAHAL DISTRICT

1. INTRODUCTION

Panch-mahal means "five tehsils/talukas" (5 sub-divisions) and refers to the five sub-divisions namely - Godhra, Dahod, Halol, Kalol and Jhalod that were transferred by the Maharaja Sindhia of Gwalior to the British. After formation of Gujarat State in 1960, the district head quarters established at Godhra. Initially, Panchmahal and Dahod are one district and later in the year 1997, Dahod separated from Panchmahal as a district. The district with its total area of 5210 sq km, comprises 11 talukas at present such as Godhra, Halol, Kalol, Lunawada, Santrampur, Kadana, Jambughoda, Shahera, Morva-Hadaf, Khanpur, Ghoghamba. It was surrounded by the Sabarkantha district and Rajasthan state in the north, Dahod and Vadodara districts in the south, Kheda district in the west and Madhya Pradesh state in the east. Panchmahal district is one of the important tribal districts of Gujarat State. It is a border district in the eastern part of the Gujarat and is situated between $22^0$30' and $23^0$30' latitudes and $73^0$15' and $74^0$30' longitudes, covered by toposheets no. 46E, 46F, 46J and 46I of Survey of India. The district head well connected with road and rail with Ahmedabad. Fig. 1 Location Map of Panchmahal District.

1.1. DEMOGRAPHY

According to the 2011 census, the total population of Panchmahal district is 23,88,267 persons. Out of this nearly 73% population is spread in 434 villages while 27 % of population is spread in 28 towns. The density of population in rural area is 365 souls per sq km while in urban area it is around 3049 souls per sq.km. The district had a population of 20,25,277 as of 2001 and 23,88,267 as of 2011 with an decadal growth of 17.92%. The demographic analysis reveals that during last two decade there has been rapid growth in urban population. Panchmahal has a sex ratio of 945 females for every 1000 males and a literacy rate of 72.32%.

1.2. CLIMATE

Panchmahal district is located in east of *Gujarat,*comes under heavy rainfall areas in Gujarat, having sub-tropical climate with moderately low humidity. The main seasons prevailing in the district are (a) monsoon - mid of June to October, (b) winter - November to February, and (c) summer – March to June.

The maximum daily temperature during the year ranges from 27.7 °C in January to 39.7 °C in May while minimum temperature ranges from 11.9 °C in January to 25.6°C in May. Maximum humidity ranges from 98.2 % to 79.6 % while minimum range is from 28 to 83.5 %. The wind speed ranges from 105.2 to 479.6 km/day, where as evapo - transpiration ranges from 3.4 to 11.1 mm/day.

Table 01: Climatological Data								
Station:	Godhra				District:	Panchmahal		
Altitude:		m AMSL			HA	13	**0.7187828**	
Latitude:	22°45'57"		N		Longitude:	73°36'29"		E
Month	**Max Temp (Deg.C)**	**Min Temp (Deg.C)**	**Humidity (%)**	**Wind Spd. (Kmpd)**	**Sunshine (Hours)**	**Solar Rad. (MJ/m2/d)**	**Eto (mm/d)**	**Rainfall (mm)**
January	27.7	11.7	41.0	138.0	9.6	17.7	3.8	0.0
February	30.6	14.1	33.5	169.1	10.2	20.6	5.2	0.0
March	35.0	19.1	27.5	220.8	9.3	21.8	7.1	0.0
April	38.6	23.7	28.0	293.3	10.0	24.5	9.3	0.0
May	39.7	25.6	38.0	438.2	10.6	25.9	11.1	0.0
June	35.8	24.8	60.5	479.6	8.8	23.2	8.4	0.0
July	30.8	23.6	79.0	405.4	4.6	16.8	4.7	168.0
August	28.9	22.7	83.5	351.9	4.3	16.0	3.9	637.0
September	30.6	22.2	75.0	265.7	6.7	18.5	4.7	136.0
October	33.7	20.0	50.5	132.8	9.5	20.4	4.9	0.0
November	31.6	16.2	42.5	105.2	9.7	18.3	3.9	0.0
December	28.7	12.9	44.0	112.1	9.5	16.8	3.4	0.0
Total	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**941.0**
Average	**32.6**	**19.7**	**50.3**	**259.3**	**8.6**	**20.1**	**5.9**	**78.4**

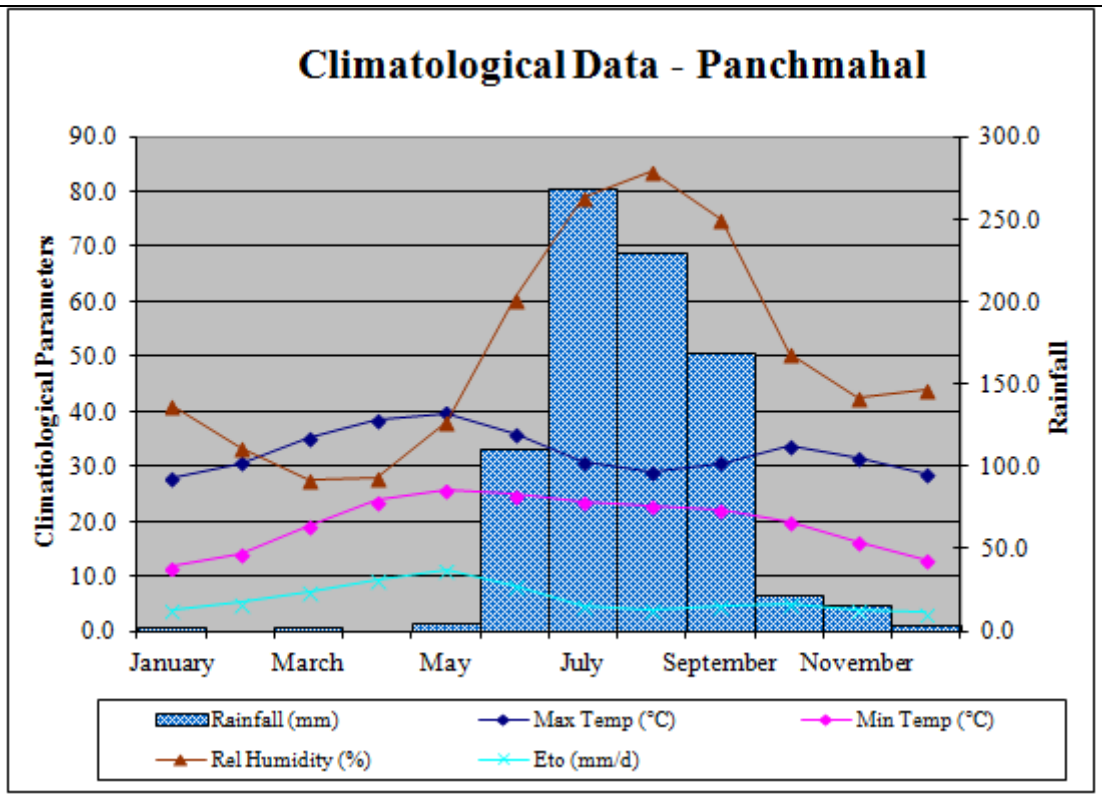

Fig 02: Climatological data analysis of Panchmahal district

1.3. Rainfall

Panchmahal district receives much of its rainfall from the south-west monsoon during the period between June & October; its maximum intensity being in the month of July & August. Total rainy days ranges from 30 to 40 days/year. Long term annual rainfall data of 11 rain-gauge stations of the district from year 1981-2011 are statistically analyzed and presented in table No 8. The distribution of mean annual rainfall over the Panchmahal district.

Table 02 - Statistical Analysis of Rainfall Data Rainfall in mm

Name of the stations	No of Years	Average Annual RF	Standard Deviation	Highest RF - Year		Lowest RF - Year	
Morva	1981 - 2011	814	380.52	1664.5	2010	225.5	1982
Godhra	1981 - 2010	648.75	373.07	1588	1983	212	2010
Ghoghamba	1981 - 2011	754.92	366.17	1620.9	1983	184	2000
Halol	1981 - 2011	908.73	365.38	1599.0	1994	295.0	2000
Kalol	1981 - 2011	923.21	600.44	3254.2	1995	122.0	2010
Khanpur	1993 - 2011	728.05	364.05	1862.3	2006	281.6	2000
Lunawada	1981 - 2011	828.01	341.41	1710.9	1997	216.0	2002
Shehra	1981 - 2011	738.67	343.47	1511.0	1990	236.0	1985
Santrampur	1981 - 2011	836.48	356.20	1821.9	2006	231.5	2002
Zhalod	1999 - 2011	702.17	386.89	1539.5	2006	234.5	2010

1.4. STUDIES / ACTIVITY BY CGWB

Systematic hydrogeological survey were carried out by different officers of CGWB between 1975 – 76 to 1980 – 81.

1. Doshi S.K. & Bhatnagar G.C. 1974 – 75
2. Bhatnagar G.C. 1975 – 76
3. Venkatraman S. 1976 – 77
4. Sharma V. 1977 – 78
5. Venkatraman S. 1978 – 79
6. *Arun Kumar* 1980 – 81
7. *P.K.Jain,A.Kawade,P.R.Gupte* *1987 – 88*

The findings of the report during these investigations are summarised as follows:

a. Major part of the district is underlain by hard rocks.
b. Mainly the groundwater is developed by dugwells
c. The hard rock formation forms most extensive aquifers in the district.
d. The yield of the wells in the hard rock depends mainly on the thickness of weathered mantle and degree of fracturing.
e. In isolated patches, particularly in the vicinity of the rivers, valley fills, palaeochannel deposits forms potentials aquifers.

f. Later on groundwater exploration work also carried out as part of the AAP during 1985 – 86, 1987 – 88, 1988 – 89, 2002 – 03, 2003 – 04, 2007 – 08, 2008 – 09, 2009 – 10 and 2010 – 11.

2. Geomorphology

2.1. PHYSIOGRAPHY

The district has high variation in topography which represents the diverse geological condition. The western part of the district constitute Pediplain, composed of weathered, unconsolidated medium to coarse grained material having gentle to moderate slope. There are scattered alluvial deposits such as flood palin, valley fills etc formed along major river courses composed of clay, silt, sand, gravel and kankar deposits with gentle slope. There are small scattered sedimentary and volcanic dissected hills. Pavagadh hills, south of the district near Halol, rises abruptly to a height of 829.36m amsl and is with high relief and steep slopes. The northern, eastern and southern part of the district have undulated topography ranging the elevation morethan 400m, constitute moderately to highly dissected hills of Aravallis range. They have high relief and steep slopes. The area occupies by the quartzite has an undulating topography where as phyllite and mica schist occupy broad intermontane valley. The southern border of the district is marked by a hill range with roughly east – west and forms a surface water divide particularly between Narmada and Mahi basin.

2.2. DRAINAGE

The entire district except parts of the Jambughoda and Halol talukas, forms a part of the Mahi river basin. The Mahi is a perennial river, enters the district from north west near Khedapa and departs near Timba in the western part. It has a length of about 126m in the district. Almost other rivers are namely Panam, Hadap, Goma, Kharad, Mesari, Chikni, Kun, Anas, Kali, Machchhan Chibata and Suki river are tributary of the mahi river. Out of these, only Panam and Hadaf are only perennial. All the rivers originate in the eastern highland and flow towards west direction to the Arabian Sea. The flow of the water in the rivers is more during the rainy season. The drainage is dendrite to sub-dendrite type.

2.3. SURFACE WATER RESOURCES

There is one major irrigation project on Mahi river, namely Kadana reservoir project (Santrampur – Lunawada talukas) and medium projects such as (i) Bhadar Dam project (Lunawada) on Bhadar river, (ii) Panam dam project on Panam river (Lunawada).

2.4. SOILS

The soil of the district can be divided broadly into three categories depending upon the source rock, namely the phyllite, granites and basalts. The granite normally gives rise to sandy soil but where weathering is intense, sandy loam is produced. The phyllite produced yellowish brown light soils but where weathering is deep, black soil produced. The basaltic rock gives rise to variegated soil depending upon the degree of weathering. The first stage of weathering produce light soil with splinters of morum where as in the second stage medium soil of light brown to brownish black colour are produced. These medium soils are more than a meter depth. The black cotton soils produced by intense weathering of basalts are however deep, heavy and become sticky when saturated. They have high fertility value.

2.5. LANDUSE PATTERN

The data on land utilisation and irrigated are shows that, the land brought under cultivation and sowing in the Panchmahal district covers 3031 Ha, where area sown more than once covers 235 Ha. The details Geographical area covers 5210 sq km where forest area cover 1170 Ha. The Fallow land covers 265 Ha.

3. HYDROGEOLOGY

3.1. GEOLOGY

Geologically, Panchamahal district is the manifestation of diverse geological extension from Lower Proterozoic to Holocene with different rock types such as granitic to basalt and limestone to alluvium. The stratigraphy of Panchmahal district is presented in table 9. The oldest formation in the area is Aravallis Supergroup comprises of various meta-sediments belongs to Lower Proterozoic. The post-Delhi intrusive, Godhra granite and gneisses were intruded into older Aravalli. Both Aravallis and granite-gneiss have undergone many orogenic movement. They are overlain at places by Lower cretaceous fluvial and marine sequences, namely Bagh beds and Lametas. Lower Cretaceous rocks are overlain by Deccan basalts, extrusive rock formation; occur as sporadic exposure in the form of cappings over older rocks. The youngest formation found in the district is the alluvium, occur as pediments, sand dunes, valley fills and flood plain as isolated patches. (Fig 03: Geological map of Panchmahal district)

Aravallis Supergroup: It comprises of meta sediments, divided in to three major group such as: Udaipur group, Lunawada group, Champaner group.

The Udaipur group of rocks (Balicha formation) is exposed in the east of the Santrampur as a narrow belt and comprises of Phyllite, mica schist and quartzite. It is overlain by Lunawada group of rocks, which comprises of Phyllite, mica schist, metasubgraywacke, chlorite schist, phyllite quartzite, protoquartzite and minor bands of dolomite.

Table 03: Stratigraphy of Panchamahal District

Geological Age	Supergroup	Group	Formation	Lithology
Holocene			Katpur Formation	Alluvium - Sand, Kankar and Clay
Pliocene			Pandu Mewasa Formation	Mottled clay & sandstone
Cretaceous to Eocene		Deccan Traps		Basalts & Rhyolite
Upper Cretaceous		Bagh/Lameta Group		Infra - Trappeans - Lameta Beds, Limestone, Nodular marls and Sand stones
Upper Proterozoic		Godhra Granites		Granite & Granodiorite
Lower Proterozoic	Aravalliies Super Group	Champaner Group	Rajgarh Formatiom	Phyllite, Slate and Mica schist with inter calations of Limestone, Subgraywacke & quartzite
			Shivrajpur Formation	Phyllite & manganiferous phyllite, quartzite & dolomitic limestone
			Jaban Formation	Phyllite, metasubgraywacke, quartzite and metaconglomerate
			Narukot Formation	Quartzite, phyllite & metaconglomerate
			Khandia Formation	Quartzite, quartz-biotite schist, dolomitic limestone, phyllite, metasubgraywacke & meta conglomerate
			Lambia Formation	Quartzite, mica schist, metasubgraywacke, conglomerate and migmatite
		Lunawada Group		Phyllites, mica schist, metasubgraywacke and chlorite schist, quartzite & Phylitic quartzite, quartz - mica schist, protoquartzite, dolomite.
		Udaipur Group	Balicha Formation	Phyllite, mica schist, quartzite

The Champaner group of rocks overlain Lunavada group occur in the southern part of the district, has been subdivided in to six formation, mainly due to interformational conglomerate horizon. These formation are the Lambia, the Khandia, the Narukot, The Jaban, the Shivrajpur and the Rajgarh. The main lithounits of this group are quartz-mica schist, metasubgraywacke, metaconglomerate, dolomitic limestone, manganiferous phyllite, slate, migmatite etc. These meta sediments have been intruded by the Godhra Granites. Infratrappean Bagh and Lameta group of rocks consisting of Limestone, shale, sandstone and conglomerate, exhibit presence of marine and freshwater fossils. Dinosaurian egg and bone fossils are found in the Lameta group.

Basalts and rhyolite comprises the Deccan volcanic exposed around Pavagadh as hills. A small patch of mottled clay and sandstone, belonging to the Pandu Mewasa formation is exposed in the western part of the district. Flood plain and channel fill deposit of the Katpur formation are found in the south western part of the district.

3.2. OCCURRENCE & DISTRIBUTION OF GROUND WATER

The groundwater in Panchmahal district occurs under confined and unconfined condition. Unconsolidated shallow alluvium and weathered, jointed and fractured rock support unconfined aquifers whereas interflow zones of basalts, inter trappean beds, encountered at depth, deep seated fractures and shear zones give rise to confined conditions.

Generally, water level follows topographic configuration. The hot springs at Tuwa is associated with deep seated shear zones in the granitic rock with several pegmatite intrusive. The shearing of pegmatites indicate post pegmatite tectonic activity.

As part of the hard rock, phyllites, quartzites, schists, basalts, sandstone and limestones are forming aquifers. Alluvium and valley fills materials form potential aquifers in the vicinity of rivers and piedmont zone but their distribution is patchy with limited extension, rarely exceeding a few square kilometer in area. The groundwater condition in different formation is as follows:

a) **Phyllites, schists and quartzites as aquifers:** Groundwater occurs under unconfined conditions. The ground water is restricted to weathered mantle and fractured/sheared zones. Quartz veins act as good barriers and prevent ground water subsurface outflow. The depth to weathering normally does not extend below 10m. The fractures and joints are wide near surface or just below the weathered mantle and are effective as groundwater conduits only for 0 to 20m below which they tend to be only like hair cracks unable to allow passage for groundwater movement. Intense weathering of phyllites and schist results in production of impervious clayey matrix whereas quartzite produce sandy material. However, weathering in quartzite is very rare on account of their uniform and resistant nature. The depth to water level vary from 3 to 20m.

b) **Granites & Gneisses as aquifer:** Groundwater occurs under unconfined to confined condition. The aquifer materials are weathered/fractured granite. The thickness weathered zone varies from 0 to 20m. The weathering of granite produces porous granular materials as quartz and feldspar being major constituents. The depth of dugwell varies from 6 to 20m. Dug cum borewell in the area have up to 46m depth. In axploratory well at Vejalpur, a fracture struck below 50m, indicates that the possibility of occurrence of ground water occurrence. The depth to water level vary from 3 to 15m.

c) **Infretrappean:** Infratrappean beds form aquifer in isolated patches with limited extensions, as their occurrence is sporadic. Groundwater occurs under confined to unconfined condition restricted to solution cavities in calcareous formation and in the weathered mantle. The cavernous nature of the formation is more pronounced at the contact of formation. The confined condition are observed wherever the formation are overlain by basalts. Maximum thickness of this formation is 42m (EW Tarkhanda & Pavagadh) and maximum dugwell depth is around 25m. In general, they are poor aquifers on account of low permeability and limited horizontal extensions. The depth to water level vary from 5 to 15m.

d) **Basalts:** The basalts form aquifer in western and southern part of the district around Halol. Ground water occur under unconfined to confined condition in the weathered mantle, joints, fractures and interflow zones. Intertrappean sediments often carry granular sediments which form good aquifer locally. Vesicular basalts are porous but not permeable as the vesicles are not interconnected. The joints and fractures help in connecting the vesicles and thus give rise to more permeable aquifer. The depth to water level vary with in 4 to 12m .

e) **Alluvium:** The alluvium form aquifer in discontinuous isolated patches. The major river like Panam and Mahi have alluvium deposits of shallow depth on either bank almost all along the river courses but extended to limited area of 1 to 2m from the banks. The maximum thickness of alluvium is 35m in the vicinity of Mahi river near Lunavada (Chariya EW). The depth of dug well in alluvium ranges from 15 to 25m. The alluvium often comprises pebbly materials at the bottom, which support wells with very high yields. The dept to water level is vary from 1 to 22m while it less than a meter in the canal command area of Santrampur taluka.

3.3. GROUNDWATER REGIME MONITORING

Ground water regime monitoring is the basic component of groundwater management and it is carried out in parts of Panchmahal district through National Hydrograph Network Stations (NHNS or NHS). NHSs are observation wells, comprising of dug wells and purpose built bore wells – known as piezometers. There are 19 NHS and 9 piezometers as part of the NHS. Depth to water level map of pre monsoon and post monsoon period and annual fluctuation of water level are prepared with data of NHS for year 2012. With available data of systematic and

reappraisal hydrogeological surveys carried out in the district. The water level of the district is described bellows. Figure 12: Hydrogeological map of Panchmahal district

Depth to Water Level (May 2012)

The figure 15 shows depth to water level map of Panchmahal district, prepared on the basis of NHS data of May 2012. In most part of the district, the water level ranged in between 5 to 10m, western part of the Shehra and Godhra taluka has the water level range in between 2 to 5m. On the northern part of the Kadana, Khanpur taluka, eastern part of the Morva and parts of the Kalol and Ghoghamba taluka ranged in between 10 to 20m. An isolated patches in Ghoghamba talukashown the water level in between 20 to 40m. (Figure 04: DTW May 2012 map of Panchmahal district.)

Depth to Water Level (Nov 2012)

The figure 16 shows depth to water level map of November 2012. The northern and northwestern part of the district underlain by hard rock formation have water level in range of 0 to 5m bgl while western part of Lunavada taluka of the district ranged within 5 to 20m bgl. Areas along eastern part of the district from north to south have water levels of 5 to 20m bgl. Isolated patches of 10 to 20m bgl water level observed in the southern part of the Ghoghamba taluka, western part of the Kalol and Lunawada taluka. (Figure 05: DTW November 2012 map of Panchmahal district.)

Water Level Fluctuation (May - Nov 2012)

The figure 17 shows water level fluctuation map of the district for May- November 2012 period. In the fluctuation map, it shown rise in water level in all parts of the district. In the range of morethan 4m shown in northern part of the Kadana and Khanpur taluka, eastern part of the Santrampur and Morva Hadaf taluka. Rest part of the district has a rise in water level ranged within 0 to 2 m and 2 to 4m. (Figure 06: Annual water level fluctuation May to November 2012 map of Panchmahal district.)

Water Level Trend (2003 - 2011)

From the analysis of the water level trend of the Panchmahal district from 2003 to 2012, it is observed that, during pre-monsoon, the water level has a rise of 0.05 m/yr (Tuwa) to 0.35 m/yr (Gadhar) and also has a fall of 0.002 m/yr (Kothamba) to 0.72 m/yr (Lunawada). Similarly from the analysis of the post-monsoon data of 2003 to 2012, the rise shown by water level is vary from 0.004 m/yr (Timbi) to 0.53 m/yr (Pandarvada) and also has a fall of 0.002 m/yr (Jambughoda) to 1.05 m/yr (Lunawada). Hence, from the analysis it is observed that, at Lunawada, during both pre-monsoon and post-monsoon has a trend of falling water level.

3.4. GROUNDWATER EXPLORATION

The boreholes drilled by CGWB as a part of Ground Water Exploration work, in various parts of Panchmahal district have indicate that the sub surface geological formation in the district comprises of layered sequences of Deccan Trap lava down to 250 m of explored depth. The yield of bore wells varies widely from few lps to more than 20 lps. Overall, deep ground water quality is suitable for both irrigation and domestic uses. Map showing location of exploration is shown in figure 02 in Geological map of Panchmahal district.

The depth range of exploration varies from 90 to 200 m. The litholog reveals varied lava flows of few m to more than 20 m thick. At very few locations, infra-trappean red bole 0.2 to 1.2m of thickness is reported. Lateral correlation of lava flow is not extensive.

The perusals of exploratory drillings data and hydrogeological sections reveal that, Aravalli group of rocks form the basement in the area. Aravalli encountered at different depths are i.e. 15m at Chauki to 66m at Pavagadh. At different sites, the depth to Aravallis group and thickness of overlying formation are as follows

Table 04: Depth to bedrock at different sites

Sl.No.	Locations	Depth to Aravalli	Thickness of overlying formation
1.	Pavagadh	66m	44m Infratrappean 22m Deccan Trap
2.	Charia	35m	35m Alluvium
3.	Kachumber	16m	8m Infratrappean 8m Deccan Trap
4.	Chauki	15m	6m Infratrappean 9m Deccan Trap
5.	Paroli	32m	27m Granite 3m Alluvium
6.	Eral	33m	27m Granite 6m Alluvium
7.	Tarkhanda	42m	42m Infratrappean
8.	Khajuri	49m	17m Infratrappean 32m Deccan Trap

Godhra granite and gneisses are the post-Delhi intrusive encountered at depth of 5 mbgl at Paroli, 12 mbgl at Eral and 12 mbgl at Timbagam. Exposures are cropping out at Vejalpur and Tuva. During exploratory drilling, pegmatitic veins and shear zones were encountered at Vejalpur and Tuva. At Tuva, shear zones is associated with hot spring. Both Aravallis and post-Delhi intrusive are overlain by Lower Cretaceous fluvial and marine sequence namely Bagh beds and Lametas at Tarkhanda, Pavagadh and Chauki. They comprises of a sequences of shale, sandstone and limestones. Shale vary in colour (buff white to dark pink colour).

Sandstone is medium to very coarse grained, conglomeratic at places and in general cherty. The light pink shale formation, of this group is exposed around Tarkhanda. The thickness of these groups varies from few meters to 42.5, as observed in lithology of various bore holes.

Lower Cretaceous rocks are overlain by basalts. Basalts area observed as sporadic exposures in the form of cappings. They interbedded by intertrappean sediments at some places. Intertrappeans are of localized nature and have variable composition and thickness. Each flow of basalts is separated by intertrappean sediments or red bole. Six flows of basalts were recorded at Rupapura up to a depth of 79m while at Khajuri, three flows were recorded down to a depth of 90m. The red bole bed represents zones of palaeo weathering and subsequent baking of soil as formed. The alluvium formations, in forms of valley fills deposit is encountered at Chariya, along bank of Mahi river with 35m of thickness. (Table 05:Data of exploratory wells drilled in Panchmahal district.)

4. HYDROCHEMISTRY

The Panchmahal district has two main hydrogeological provinces consisting of hard rock types and soft rock. In the hard rock, it is constituted of meta sediments and Deccan traps. In soft rock type, it has alluvium and sandstone. Each terrain has varied hydro-geochemical regime. Groundwater of the district originates as rainwater that infiltrates through soil into flow system in the underlying geologic material. In Panchmahal district, higher plateau and hill zones of eastern part constitute as recharge areas, which is underlain by granitic rocks and metasediments. The discharge area constitutes alluvium plain in western and south western part of the district, facing Arabian Sea. As groundwater moves along flowlines from recharge areas to discharge areas, the chemistry of groundwater is altered by the effects of variety of geochemical processes. The range analytical result of major ions of representative samples collected during various surveys and exploration works along with NHS data are compiled and the range of major constituents and parameters are given below in table 12.

Table 06: Summarised chemical data of Panchmahal district

Chemical Parameter	Min	Max	Average	Chemical Parameter	Min	Max	Average
pH	7.56	8.7	8.02	F	0.27	2	0.85
EC	508	2860	1282	Alk	120	640	311
TDS	340	1916	859	Ca	24	180	75
CO_3	0	18	0.9	Mg	22	119	55
HCO_3	110	781	378	TH	160	680	407
Cl	21	419	167	Na	42	402	111
NO_3	1	175	47	K	0.2	105	10
SO_4	6	137	61	Fe	0	2.2	0.23

*All values are in mg/l except pH and EC in µS/cm at 25°C

Table 07: Chemical quality of groundwater for drinking and domestic purpose in Panchmahal district

Sl.No	Chemical Parameter	BIS – 2012 (IS 10500)		Variation of chemical data during May 2012		No of sample exceeding the HDL	No of sample exceeding the MPL
		Highest Desirable Limit	Maximum Permissible Limit	Min	Max		
1	pH	6.5 to 8.5	No Relaxation	7.56	8.7	1	No Relaxation
2	Total Dissolved Solids	500	2000	340	1916	16	Nil
3	Total Hardness (as CaCO3)	200	600	160	680	14	3
4	Calcium	75	200	24	180	9	Nil
5	Magnesium	30	200	22	119	15	Nil
6	Sodium	-	200	42	402	-	3
7	Pottassium	-	12	0.2	105	-	2
8	Bicarbonate	-	-	110	781	-	-
9	Chloride	250	1000	21	419	5	Nil
10	Sulphate	200	400	6	137	Nil	Nil
11	Nitrate	45	No Relaxation	1	175	9	No Relaxation
12	Fluoride	1	1.5	0.27	2.0	3	2
13	Alkalinity	200	600	120	640	18	1
14	Iron as Fe (mg/l)	0.3	No Relaxation	0.0	2.2	4	No Relaxation

*Except pH all values are in mg/l

4.1. Ground Water Quality

Variation in chemical quality of ground water is due to hydrogeological factors controlled by rock types, depicting aerial distribution of various water quality features. In terms of electrical conductance (EC), measure of total dissolved salts in ground water is vary in between 508 to 2869 µS/cm with an average of 1282 µS/cm during May 2012. The chloride content of the district also vary with in 21 to 419 mg/l with average of 167 mg/l. Nitrate content in the district is very high varying within 1 to 175 mg/l with an average of 47 mg/l. At nine places, namely Bavaliya (45mh/l), Kothamba (49 mg/l), Lunawada (75 mg/l), Pavagadh (48 mg/l), Ranipura (135 mg/l), Santroad (175 mg/l) Shehra (135 mg/l), Timbi (49 mg/l) and Suliyar (49 mg/l), where found above 45 mg/l is unsuitable drinking and domestic purpose. Similarly, fluoride content is vary within 0.27 to 2.0 mg/l with an average of 0.85 mg/l. At Ranipura (2.0 mg/l) and Natapur (1.80 mg/l) are found above the maximum permissible limit and not suitable for the drinking purpose. Iron is the heavy metal that found in the groundwater of the district is varying from 0 to 2.2 mg/l with an average of 0.23 mg/l. The maximum value found at Lunawada is 2.20 mg/l. At Bavaliya (0.74 mg/l), Pandarwada (0.56 mg/l) and Pavagadh (0.57 mg/l) is found unsuitable for drinking purpose comparing to BIS 2012: IS10500 as limit set for 0.3 mg/l only. In other chemical ion, total hardness in terms of $CaCO_3$, is found above the BIS maximum permissible limit of 600 mg/l at Lunawada (680 mg/l), Ranipura (680 mg/l), Santroad (610 mg/l) and Vejalpur (670 mg/l). In other area, TH vary within 160 to 560 mg/l.

4.2. WATER POLLUTION

Panchmahal district has a number of medium and small scale industries ste up in the southern part of the district in Kalol, Halol and Godhra talukas focusing mainly on the minerals, engineering, and automobiles, tourism, irrigation, dairy farming. Major players are General Motors India ltd., Maruti Koatsu Pvt. Ltd., Inox India Ltd., MJ Pharmaceauticals Ltd., Panchmahal steel Ltd. The major key business involved are enginnering, steel and steel rolling, chemical and food products. No major chemical quality problem reported so far, but looking at the quality problems in other parts of the Gujarat due industrial set up, enforcing regulatory measures mandatory before releasing of industrial effluents only after due treatment in ETPs and solid waste disposal at designated sites.

Table 08: Medium and large scale industry in Panchmahal district

Name of Company	Location	Items of Manufacture
Inox India Ltd.	Kalol	Vacuum Insulated Cryogenic Tanks
Maruti Koatsu Cylinders Pvt. Ltd.	Halol	Gas Cylinders
M.J.Pharmaceuticals	Halol	Medicines
Panchmahal Steel Limited	Kalol	Ingots/Billets
General Motors India Pvt. Ltd.	Halol	Automobiles and Spare parts
Alembic	Halol	Medicines/Formulation Division

Source: Panchmahal District Booklet 2006- 07,District Collectorate of Panchmahal

5. GROUND WATER RESOURCES

Annual ground water recharge of Panchmahal district, (GWRE 2011), is 730.39 MCM and after natural discharge of 36.97 MCM due to environmental / runoff purposes, net annual ground water availability is worked out to be of 702.42 MCM. The gross annual ground water draft in the district is 291.37 MCM out of which 235.68 MCM per year is due to irrigation while remaining 55.69 MCM is accounted for domestic and industrial uses.

The stage of ground water development at year 2011, for all the talukas of the Panchmahal district computed range from 22.74% to 52.39% and all units of assessment (talukas) have been categorized as *Safe,* based on the stages of ground water development and the long-term trend of pre and post monsoon ground water levels. The average stage of groundwater development for district is 41.48%. Taluka wise ground water resources and categorization for each assessment unit is presented in table 09.

6. Mass Awareness and workshop Programme in Panchmahal District

Nil

7. CONCLUSION AND RECCOMENDATION

a. The Panchmahal district having an area of 5210 sq km forms a border district in the eastern part of the Gujarat and comes under the tribal and drought prone area.

b. The district in general poses an undulating topography with an elevation of morethan 400m a msl. The southern border of the district is marked by hill ranges which strikes E – W and forms water divide between Narmada and Mahi river. The famous Pavagadh hill abruptly rises to 829.36m amsl and forms the highest landmark in the district.

c. District receives medium intensity monsoon rainfall of 702 to 924 mm during SW monsoon. It will be good to harness the available monsoon rainfall runoff for artificial recharge to the ground water through construction of check dams, recharge shaft, percolation tanks, site specific recharge bore wells / dug wells, etc., in eastern high land areas and adjoining intermediate plain areas underlain by piedmont zones / weathered hard rock (*muram*) deposit. All such measures can augment groundwater resources at local levels and can make drinking water supply schemes efficient and sustainable in long term.

Table 09: Taluka wise dynamic groundwater resources and development in Panchmahal district (2011)

Sl.No	Talukas	Annual Ground Water Recharge	Natural Discharge	Net ground Water Availability	Annual Ground Water Draft			Projected demand for domestic & industrial uses up to 2025	Ground Water Availability for future irrigation	Stage of Ground Water Development	Category
					Irrigation	Domestic & Industrial uses	Total				
1	Ghoghamba	55.5	2.77	52.72	17.69	5.43	23.12	6.8	28.23	43.85%	Safe
2	Godhra	99.95	5	94.95	23.9	7.44	31.34	9.31	61.74	33.01%	Safe
3	Halol	67.38	3.37	64.01	22.57	5.65	28.22	7.39	34.05	44.09%	Safe
4	Jambughoda	16.38	0.82	15.56	6.07	1.09	7.16	1.38	8.11	46.02%	Safe
5	Kadana	70.61	3.53	67.08	12.75	2.5	15.25	3.14	51.19	22.73%	Safe
6	Kalol	77.22	3.86	73.36	24.79	5.81	30.6	7.27	41.3	41.71%	Safe
7	Khanpur	51.97	2.6	49.37	20.93	2.57	23.5	3.23	25.21	47.60%	Safe
8	Lunawada	103.98	5.2	98.78	44.8	6.95	51.75	8.7	45.28	52.39%	Safe
9	Morva-Hadaf	46.77	2.34	44.43	15.97	4.62	20.59	5.79	22.67	46.34%	Safe
10	Santrampur	72.81	3.64	69.16	25.46	6.63	32.09	8.3	35.4	46.40%	Safe
11	Shahera	76.82	3.84	72.98	20.75	7.00	27.75	8.76	43.47	38.02%	Safe
District Total		739.39	36.97	702.40	235.68	55.69	291.37	70.07	396.65	41.48%	Safe

Compute by RIF method

All values are in MCM except stage of GW development

d. In Panchmahal district, the overall stage of groundwater development is moderate (41.18%), however, there is constraint of quality in few areas and low yield in inland hard rock areas. Rapid urbanization and concurrent industrial activities are affecting ambient hydrogeological regime lately. With strategy of conjunctive use and by employing multidisciplinary approach for ground water development in eastern hard rock terrain, sustainable development of water source can be accomplished.

e. Major part of the districts is underlain by hardrock formations of Aravalli Super Group and Granie and Gneisses. Small out crops of Deccan trap and Infratrappean are also observed. Hard rock formations in general have vertical to sub-vertical joints. Alluvial deposits occur in the vicinity of the river and in intermontane valleys. The thickness and extent of alluvial formation is however very limited.

f. There is relatively medium ground water development, which also have limited thickness of good quality aquifer system.

g. Sustainable groundwater management strategy to conserve existing resources and preventive actions to control contamination of freshwater resources are essential.

h. Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future.

i. The southern part of the district is highly industrialized. Periodic monitoring of ground water along with quality should be mandatory for post-monsoon and pre-monsoon.

j. The Central Ground Water Board has not conducted any ‘Mass Awareness Program’ and ‘Water Management Training Program’ in the district. Taking into consideration of tribal domination and drought prone area, such programs in regular basis can be arranged in the district for awareness on the depletion of groundwater resources and quality problems.

k. Water Management Training Programme for capacity building measures for technical officers / officials & Vos/NGOs working in the field of ground water development and management may be trained to create awareness among the people for consequent ground water resources depletion and quality problems.

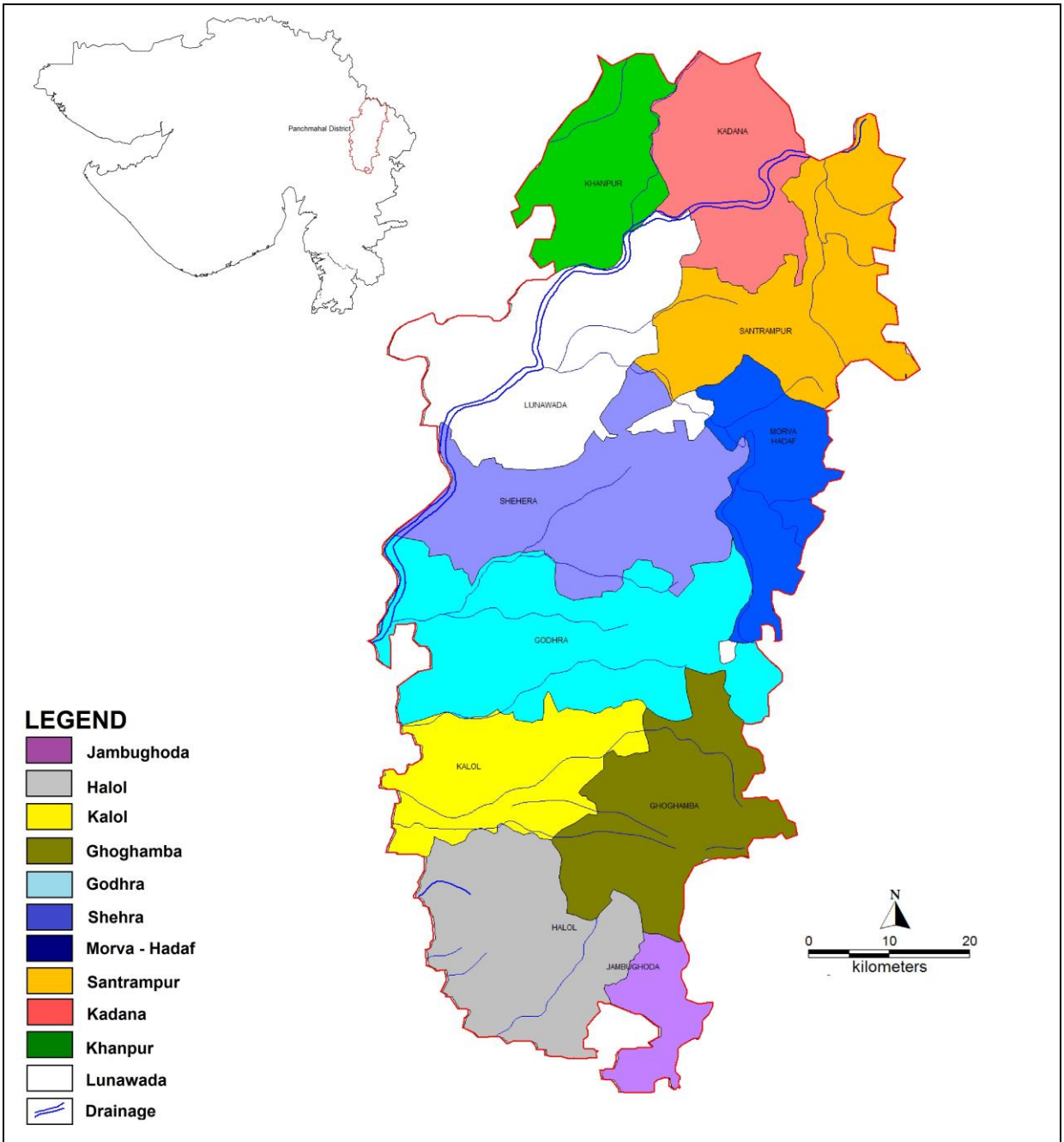

Fig 01: Administrative map of the Panchmahal district

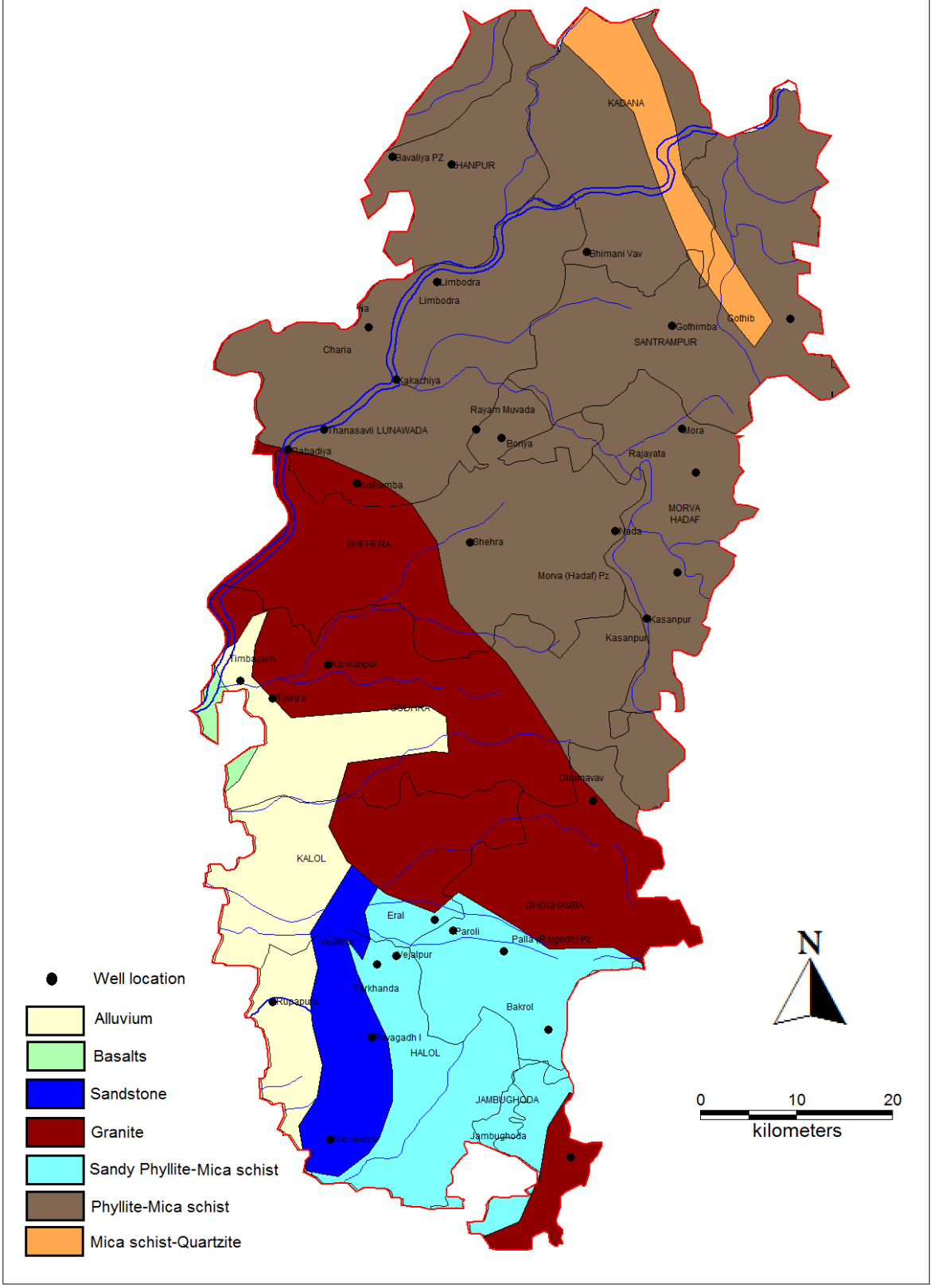

Fig 03: Geological map of Panchmahal district alongwith EW location.

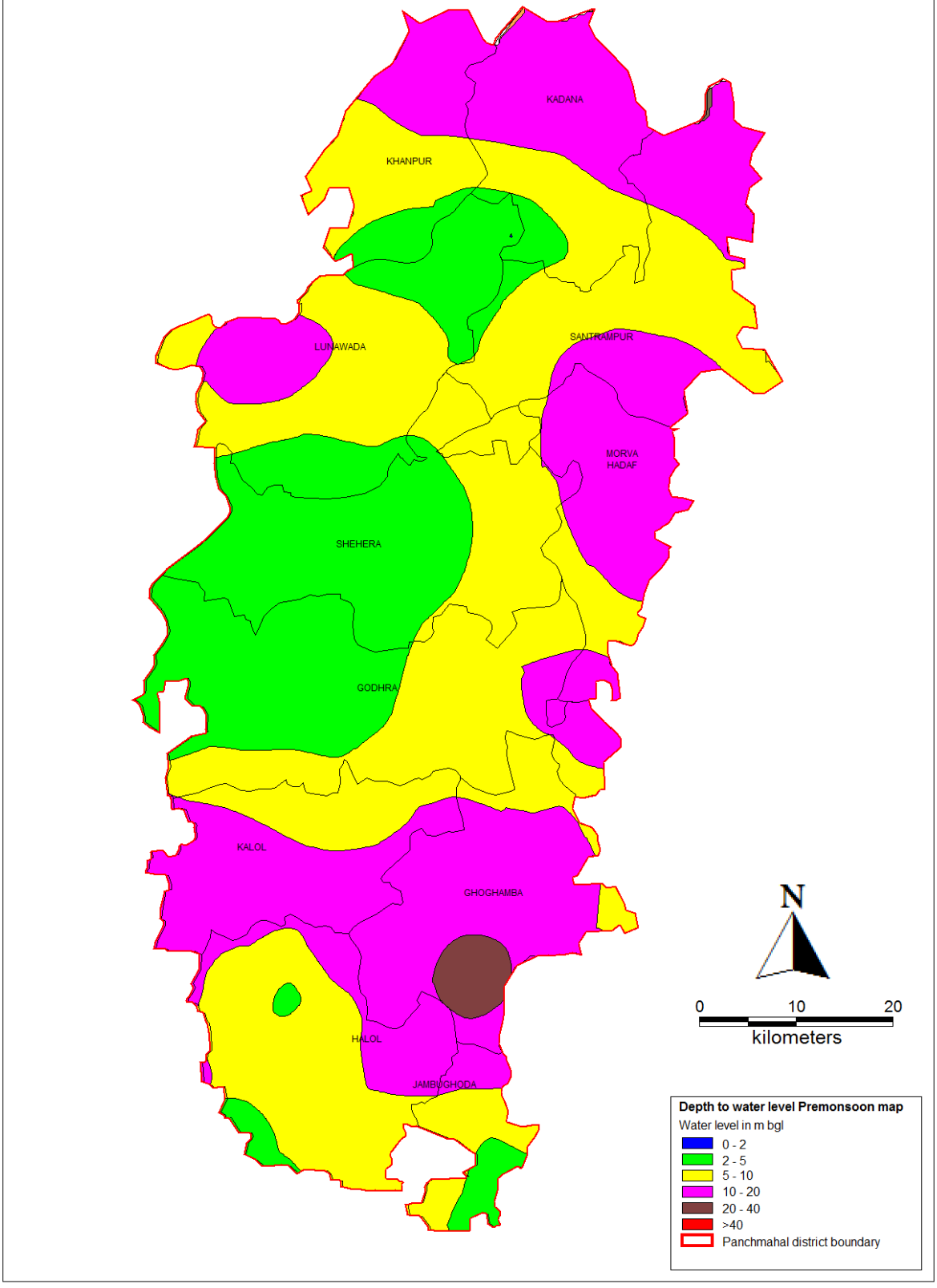

Fig 04: Depth to water level map of Panchmahal district during May 2012

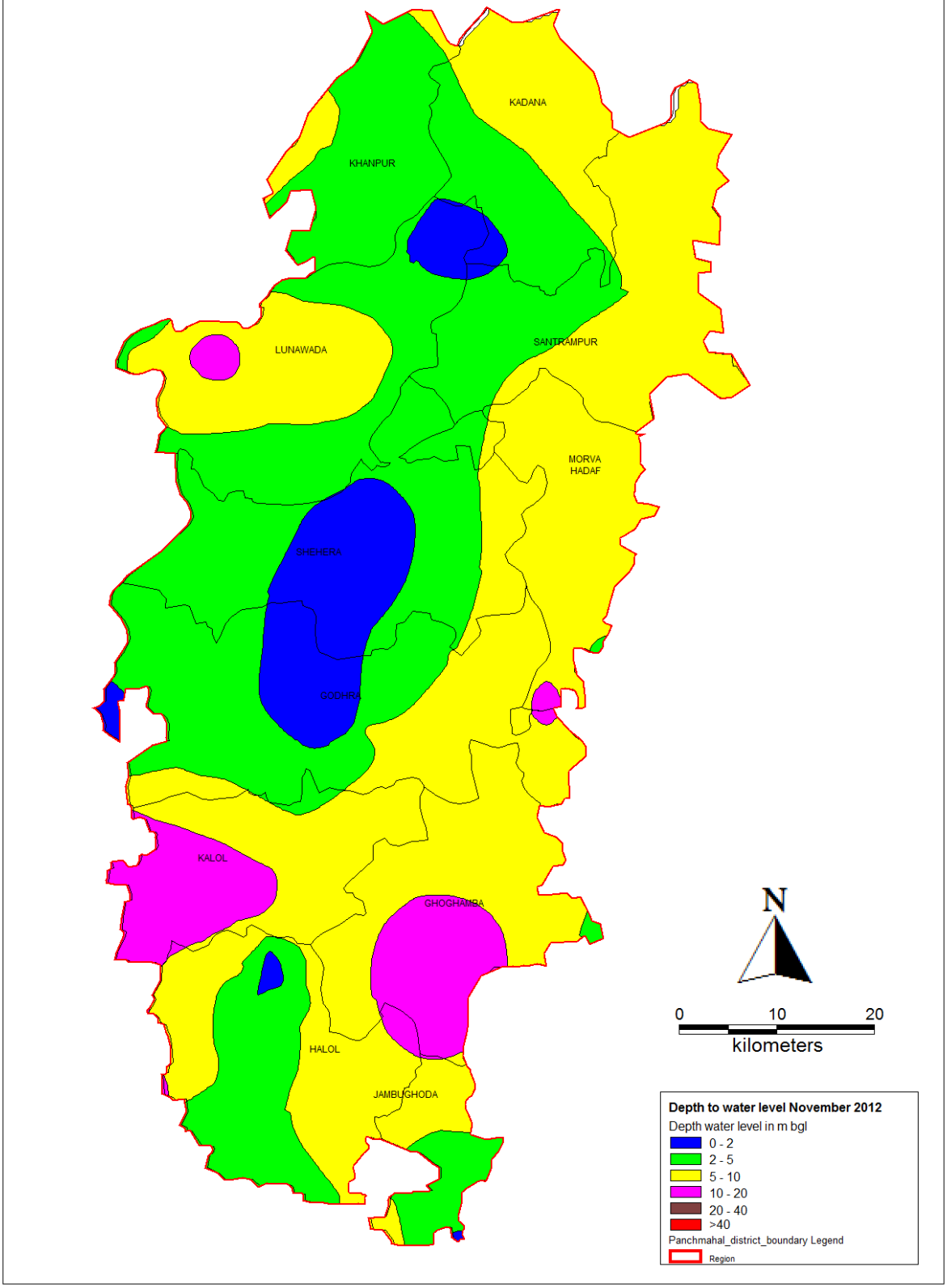

Fig 05: Depth to water level map of Panchmahal district during Nov 2012

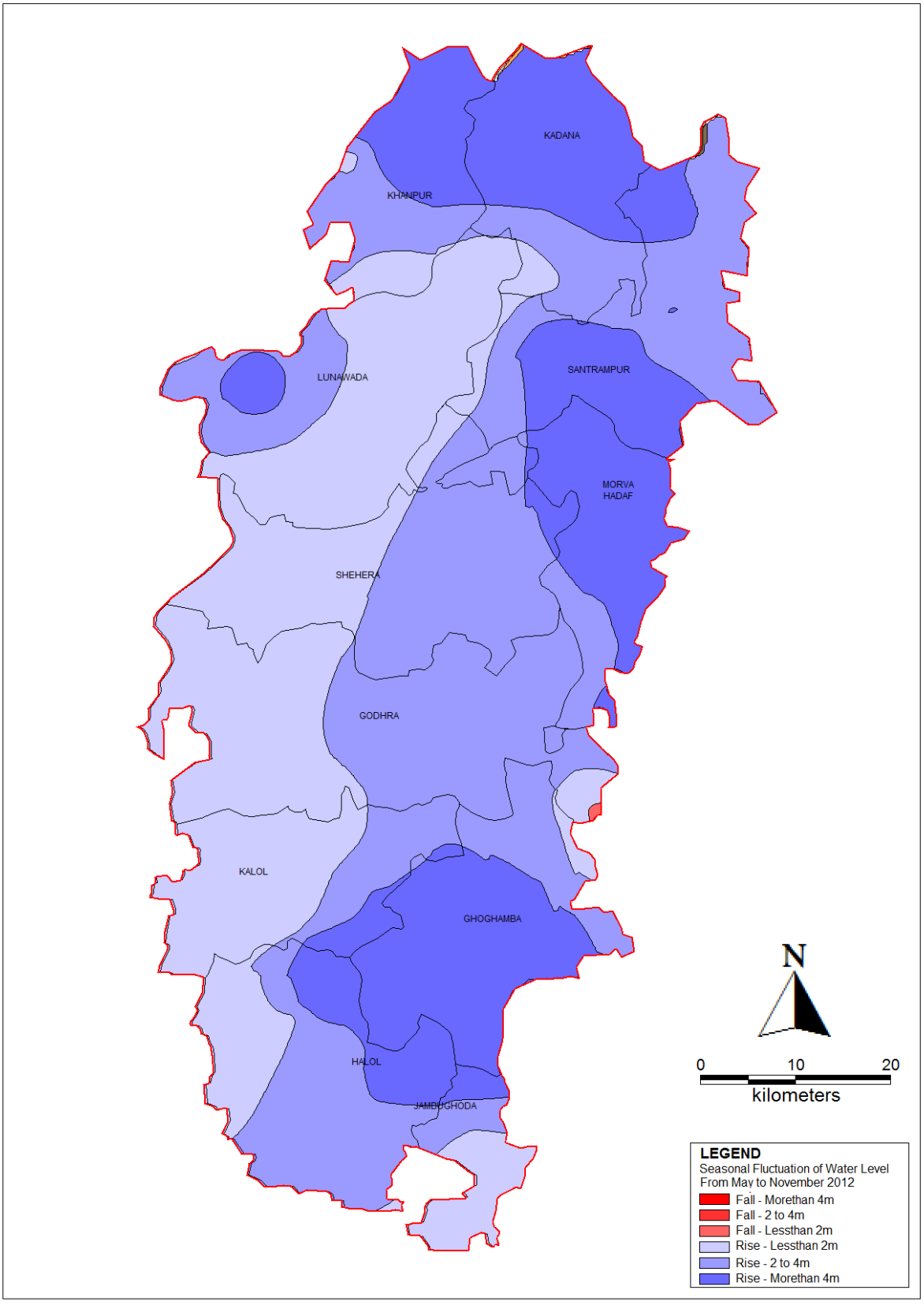

Fig 06: Annual water level fluctuation map of Panchmahal district during May to Nov 2012

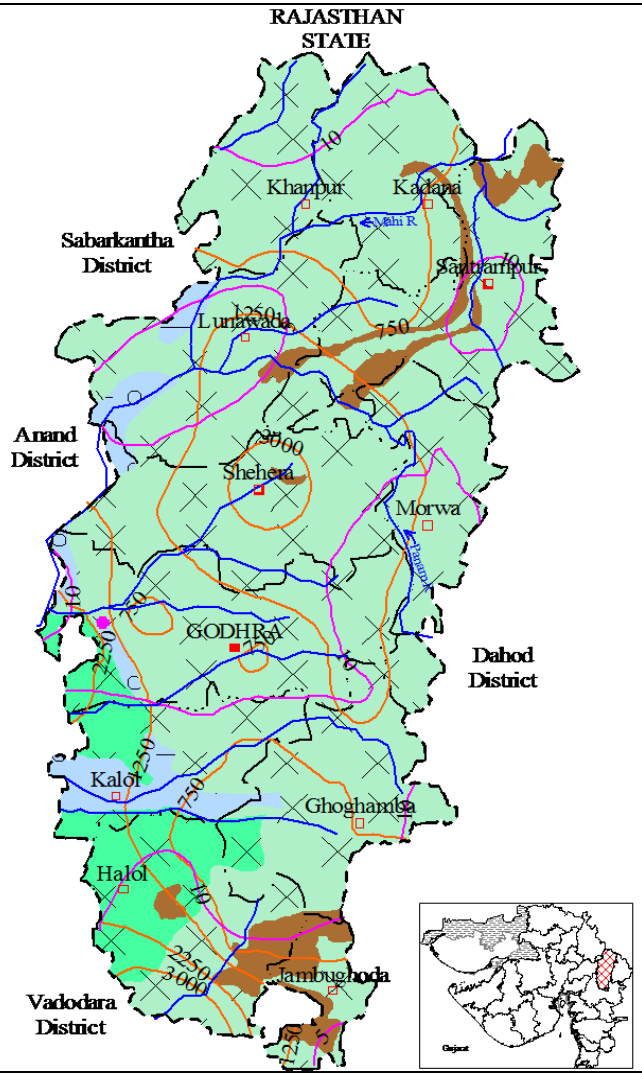

Fig 07: Hydrogeological map of Panchmahal district

LEGEND

Rock type	Wells Feasible	Rigs Suitable	Depth of Well (m)	Discharge (lpm)	Artificial Recharge Structure Suitable
Rock Aquifer	Dug Well Tubewell	Manual Direct Rotary, Reverse Rotary	10-25 50-100	200-300 300-600	Percolation Tanks/ Ponds, Recharge Wells,
Hard Rock Aquifer	Dug Well Borewell	Manual Down the Hole Hammer (DTH)	10-20 50-100	60-100 60-150	Percolation Tanks/ Ponds, Recharge Wells, Check Dams, Nalla Bunds.
Hard Rock Aquifer	Dug Well Borewell	Manual Down the Hole Hammer (DTH)	10-25 100-150	80-150 100-240	Percolation Tanks/ Ponds, Recharge Wells, Check Dams, Nalla Bunds.
Hilly Areas	Not Suitable				Check Dam, Nalla Bund, Gully Plug
20	Pre-monsoon Decadal mean (1993-2000) Depth to Water Level (mbgl)		2000	Electrical Conductivity (µS/cm at 25° C)	
	Drainage		✉/☎	District/Taluka HQ	
	Spring (Hot)				

Table 05:Detailed data of exploratory wells drilled in Panchmahal district.													
Sl. No	Location	Taluka	Type of Well	AAP	Depth Drilled (mbgl)	Depth Constructed (mbgl)	SWL (mbgl)	Disc. (Comp.) lps	Aquifer / Formation	EC	Cl (ppm)	T in m/day	Remarks
1	Rupapura (22°31'00" 73°26'00")	Halol	EW	1985 - 86	79.0	79.0	9.39	4.5	Alluvium, Basalts with intertrappean	1600	264	1024	
2	Vejalpur (22°33'35" 73°33'30”)	Halol	EW-1	1985 - 86	92.0	92.0	7.7	Negigible	Granite	2420	216		
3	Vejalpur (22°33'35" 73°33'30”)	Halol	EW-2	1985 - 86	90.0	90.0	6.95	0.5	Granite	790	88		
4	Vejalpur (22°33'35" 73°33'30”)	Halol	EW-3	1985 - 86	90.0	90.0	7.09	0.8	Granite	1620	112		
5	Vejalpur (22°33'35" 73°33'30”)	Halol	EW-4	1985 - 86	46.0	46.0	4.15	0.5	Granite with quartzite and sandstone	330	80		
6	Vejalpur (22°33'35" 73°33'30”)	Halol	EW-5	1985 - 86	91.0	91.0	4.13	0.5	Granite	620	72		
7	Vejalpur (22°33'35" 73°33'30")	Halol	EW-6	1985 - 86	90.0	90.0	5.96	0.9	Granite	3200	568		
8	Rupapura (22°31'00" 73°26'00")	Halol	OW	1985 - 86	79.0	79.0	9.61	4.38	Alluvium, Basalts with intertrappean	1600	264		
9	Paroli (22°35'00" 73°37'00")	Ghoghamba	EW	1987 - 88	77.9	77.9	13.67	8	Granite and phyllite	1115	92	239.09	

Sl. No	Location	Taluka	Type of Well	AAP	Depth Drilled (mbgl)	Depth Constructed (mbgl)	SWL (mbgl)	Disc. (Comp.) lps	Aquifer / Formation	EC	Cl (mg/l)	T in m/day	Remarks
10	Timbagam (22°49'00" 73°24'00")	Godhra	EW	1987 - 88	90.0	90.0	12.48	0.7	Granite	1115	107	0.23	
11	Tarkhanda (22°33'05" 73°32'20")	Halol	EW	1987 - 88	90.0	90.0	9.53	0.1	Phyllite and shale				
12	Eral (22°35'35" 73°35'50")	Kalol	EW	1987 - 88	78.4	78.4	9.81	10	Alluvium, granite and phyllite	618	43	121.69	
13	Charia (23°08'50" 73°31'50")	Lunawada	EW	1987 - 88	37.0	37.0	23.75	2.1	Phyllites	1290	107	1290	
14	Pavagadh I (22°29'00" 73°32'00")	Halol	EW-1	1987 - 88	90.0	90.0	9.15	1	Basalts, Baghbeds and phyllite	998	99	0.193	
15	Pavagadh II (22°29'00" 73°32'00")	Halol	EW-2	1987 - 88	90.0	90.0	15.06	0.5	Do	540	28	0.0988	
16	Charia (23°10'00" 73°30'00")	Lunawada	EW	1988 - 89	220.0	220.0			Phyllites				
17	Tuwa-I (22°48'00" 73°26'00")	Godhra	EW-1	1988 - 89	90.0	90.0	3.3	5	Granite and Pegmatite			1600	
18	Tuwa II (22°48'00" 73°26'00")	Godhra	EW-2	1988 - 89	130.0	130.0			Granite and Pegmatite				
19	Kankanpur (22°49'55" 73°29'22")	Godhra	EW	2002 - 03	202.6	202.6			Granite and phyllite				

Sl. No	Location	Taluka	Type of Well	AAP	Depth Drilled (mbgl)	Depth Constructed (mbgl)	SWL (mbgl)	Disc. (Comp.) lps	Aquifer / Formation	EC	Cl (ppm)	T in m/day	Remarks
20	Rameshra (22°23'15" 73°29'30")	Halol	EW	2002 - 03	202.0	202.0			Sandstone				
21	Jambughoda (22°22'17" 73°44'08")	Jambughoda	EW	2002 - 03	202.6	202.6			Granite				
22	Bhimani Vav (23°13'03" 73°45'06")	Kadana	EW	2002 - 03	202.6	202.6			Phyllite-mica schist				
23	Kothamba (23°00'05" 73°31'08")	Lunawada	EW	2002 - 03	202.6	202.6			Granite				
24	Rabadiya (23°02'00" 73°26'55")	Lunawada	EW	2002 - 03	202.6	202.6			Granite and phyllite				
25	Rayam Muvada (23°03'07" 73°38'22")	Lunawada	EW	2002 - 03	172.1	172.1			Phyllite and shale				
26	Thanasavli (23°03'07" 73°29'08")	Lunawada	EW	2002 - 03	202.6	202.6			Phyllite-mica schist				
27	Mora (23°03'08" 73°50'55")	Morva Hadaf	EW	2002 - 03	202.5	202.5			Phyllite-mica schist				
28	Khuntelav (23°18'00" 73°36'52")	Khanpur	EW-1	2002 - 03	191.4	191.4			Phyllite-mica schist				

Sl. No	Location	Taluka	Type of Well	AAP	Depth Drilled (mbgl)	Depth Constructed (mbgl)	SWL (mbgl)	Disc. (Comp.) lps	Aquifer / Formation	EC	Cl (ppm)	T in m/day	Remarks
29	Khuntelav (23°18'00" 73°36'52")	Khanpur	EW-2	2002 - 03	111.1	111.1			Phyllite-mica schist				
30	Limbodra (23°11'24" 73°36'00")	Lunawada	EW - I	2003 - 04	25.7	25.7	16.00	2.00	Meta-sediments	2750	702		6.0-25.0
31	Limbodra (23°11'24" 73°36'00")	Lunawada	EW - II	2003 - 04	202.6	202.6	6.78	0.25	Meta-sediments	684	50		
32	Palla (Rajgadh) Pz (22°33’50” 73°40’03”)	Ghoghamba	Pz	2007 - 08	38	38	11.53	4	Meta-sediments	Good			19.00 - 4.0 lps
33	Morva (Hadaf) Pz (22°55’05” 73°50’40”)	Morva Hadaf	Pz	2007 - 08	38	38	10.42	3.5	Weathered /fractured phyllite and phyllite quartzite contact.	400			13.60-15.0, 3.5 lps
34	Bavaliya PZ (23°18’24” 73°33’18”)	Khanpur	Pz	2007 - 08	38	38	10.5	0.8	Meta sediments	Good			18.70-0.4 lps; 26.8 - 0.75 lps
35	Ucharpi Pz (23°46’42” 72°17’10”)	Lunawada	Pz	2007 - 08	44.1	44.1	10	1.25	Weath./Fract. phyllite & phyl.-quart. contact	225			41.0 - 42.0 : 1.25 lps

Sl. No	Location	Taluka	Type of Well	AAP	Depth Drilled (mbgl)	Depth Constructed (mbgl)	SWL (mbgl)	Disc. (Comp.) lps	Aquifer / Formation	EC	Cl (ppm)	T in m/day	Remarks
36	Kakachiya (23°05'55" 73° 33'30")	Lunawada	EW	2008 - 09	202.7	202.7	>150	-	Schist	1572	341	1053	Dry
37	Kasanpur (22°52'30" 73°48'45")	Morva Hadaf	EW	2008 - 09	202.7	202.7	16.05	0.25	Qtzt/Phyllite	568	36	381	Dry
38	Gothimba (23°08'55" 73°50'20")	Santrampur	EW	2008 - 09	135.6	135.6	16.05	8	Meta-sediments Qtzt/Phyllite	584	43	391	
39	Nada (22°57'26" 73°46'50")	Shehra	EW	2008 - 09	168	168	11.65	2.1	Meta-sediments Qtzt/Phyllite	515	21	345	
40	Shehra (22°56'46" 73°38'00")	Shehra	EW	2008 - 09	160	115	5.68	2.22	Meta-sediments Mica schist	1960	284	1313	High F
41	Boriya (23°02'38" 73°39'56")	Shehra	EW	2008 - 09	180.3	180.3	4.78	5	Qtzt/Phyllite	481	57	322	
42	Gothimba (23°08'55" 73°50'20")	Santrampur	OW	2008 - 09	196.6	196.6	16.62	2	Meta-sediments Qtzt/Phyllite	800	35	536	
43	Boriya (23°02'38" 73°39'56")	Shehra	OW	2008 - 09	178.3	178.3	5.29	6.3	Qtzt/Phyllite	460	50	308	
44	Bakrol (22°29'25" 73°42’46")	Ghoghamba	EW	2009 - 10	202.7	202.7	6.95	2.25	Phyllites	5300	1704	3551	Inferior Quality
45	Dhamavav (22°42'16" 73°45'30")	Godhra	EW	2009 - 10	200.7	200.7	6.06	Negigible	Granite				

Sl. No	Location	Taluka	Type of Well	AAP	Depth Drilled (mbgl)	Depth Constructed (mbgl)	SWL (mbgl)	Disc. (Comp.) lps	Aquifer / Formation	EC	Cl (ppm)	T in m/day	Remarks
46	Kakachiya (23°05'55" 73°33'30")	Lunawada	EW	2009 - 10	202.7	202.7	>150	-	Schist	1572	341	1053	Dry
47	Rajayata (23°00'42" 73°51'45")	Morva Hadaf	EW	2009 - 10	202.7	202.7	8.63	0.5	Quartzite & Phyllites				
48	Kasanpur (22°52'30" 73°48'45")	Morva Hadaf	EW	2009 - 10	202.7	202.7	16.05	0.25	Qtzt/Phyllite	568	36	381	Dry
49	Gothib (23°09'18" 73°57'30")	Santrampur	EW	2009 - 10	139.5	139.5	21.17	0.4	Quartzite & Phyllites				
50	Gothimba (23°08'55" 73°50'20")	Santrampur	EW	2009 - 10	135.6	135.6	16.05	8	Meta-sediments Qtzt/Phyllite	584	43	391	
51	Nada (22°57'26" 73°46'50")	Shehra	EW	2009 - 10	168	168	11.65	2.1	Meta-sediments Qtzt/Phyllite	515	21	345	
52	Shehra (22°56'46" 73°38'00")	Shehra	EW	2009 - 10	160	115	5.68	2.22	Meta-sediments Mica schist	1960	284	1313	High F
53	Boriya (23°02'38" 73°39'56")	Shehra	EW	2009 - 10	180.3	180.3	4.78	5	Qtzt/Phyllite	481	57	322	
54	Gothimba (23°08'55" 73°50'20")	Santrampur	OW	2009 - 10	196.6	196.6	16.62	2	Meta-sediments Qtzt/Phyllite	800	35	536	
55	Boriya (23°02'38" 73°39'56")	Shehra	OW	2009 - 10	178.3	178.3	5.29	6.3	Qtzt/Phyllite	460	50	308	

Sl. No	Location	Taluka	Type of Well	AAP	Depth Drilled (mbgl)	Depth Constructed (mbgl)	SWL (mbgl)	Disc. (Comp.) lps	Aquifer / Formation	EC	Cl (ppm)	T in m/day	Remarks
56	Mora-EW (23°02'50" 73°51'00")	Morva Hadaf	EW	2010 - 11	202.7	202.7	22.9	Negligible	Quartzite & Phyllites	1110	85		High F=1.42
57	Naroda-EW (23°17'33" 73°35'10")	Khanpur	EW	2010 - 11	202.7	202.7	22.46	0.65	Phyllites	1528	270		
58	Saraswa-EW (23°25'10" 73°48'35")	Kadana	EW	2010 - 11	200.6	200.6	11.36	3.75	Quartzites	710	64		