केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Panchmahal District
Gujarat

पश्चिम मध्य क्षेत्र, अहमदाबाद

West Central Region, Ahmedabad

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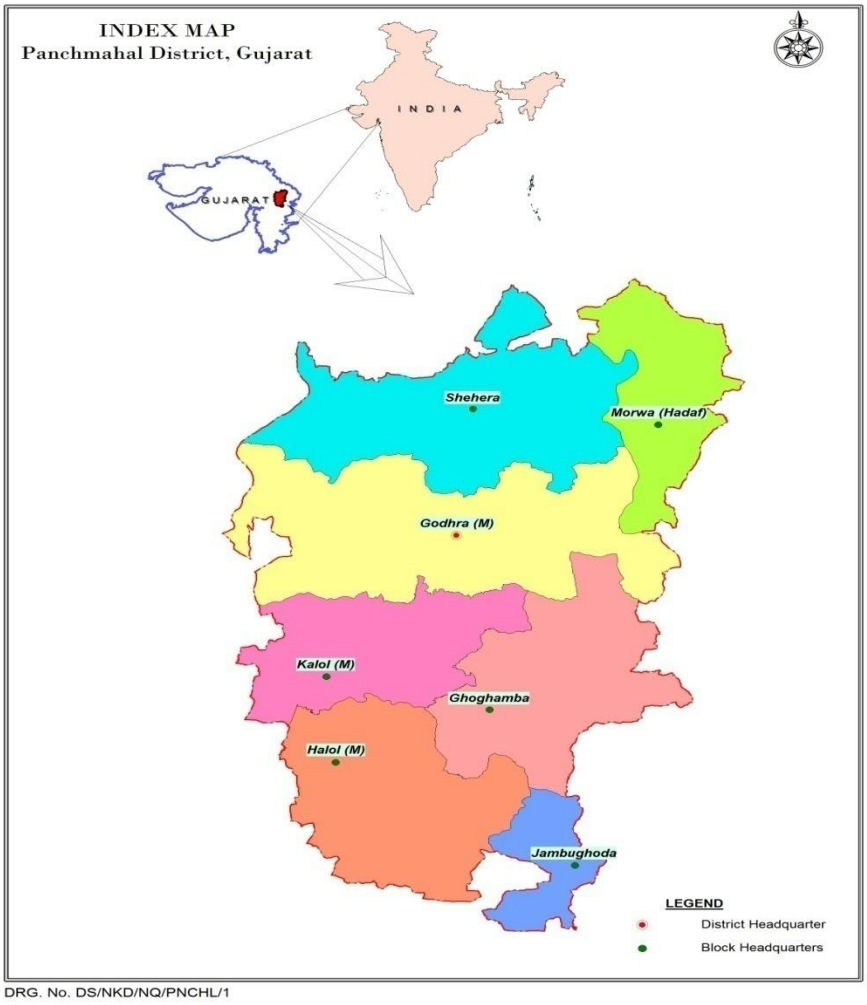
Technical Report Series

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES PANCHMAHAL DISTRICT, GUJARAT STATE



Government of India
Ministry of Jal Shakti
Department of Water Resources, RD and GRCentral Ground Water Board
West Central RegionAhmedabad

JULY-2022

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES PANCHMAHAL DISTRICT, GUJARAT STATE

Contributors' page

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AQUIFER MAP&MANAGEMENT PLAN OF
PANCHMAHAL DISTRICT GUJARAT
(3281 sq. km)

PANCHMAHAL DISTRICT AT GLANCE

Sl.No	Items	Statistics
1	General Information	
	i) Geographical area (Sq. Km)	3281
	ii) Administrative Divisions (As on 3/2011) Number of Talukas Number of Villages	 7 591
	iii) Populations (As per Census 2011)	1,642,268
	iv) Average Annual Rainfall (mm)	897
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) (Directorate of Agriculture Gujarat)	
	a) Forest area b) Area under waste Land c) Gross Cropped Area d) Net area sown e) Area Sown more than once f) Cropping Intensity	742 73.51 2286 1762 525 109.34%
4.	MAJOR SOIL TYPES**:** Sandy soils, Yellowish brown & black soils, Black cotton soils	
5.	AREA UNDER FOOD CROPS (sq.km) (2017-18) Rice 59, Bajra-7, Wheat-125, Maize-533, Total cereals-725, Total pulses-35.	
6.	IRRIGATION BY DIFFERENT SOURCES (Area in Hectares/ no of structures)	
	Dug wells	1800/24991
	Tube wells/Bore wells	25800/106
	Tanks/Ponds/Water conservation structures	10500
	Canals	59800
	Net Irrigated area (sq. km.) (2017-18)	63,700
	Gross Irrigated area (sq. km.) (2017-18)	97,900
7.	NUMBERS OF GROUND WATER MONITORING WELLS.	
	a) CGWB-Dug Wells b) CGWB-Piezometers c) GWRDC-Dug Wells d) GWRDC -Piezometers	17 07 33 31
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 2018-19				
Period	Phreatic Aquifer (DTW)		Semi-confined /Confined Aquifer (PZ head)	
	Min	Max	Min	Max
Pre Monsoon	1.60 (Morva)	22.40 (Suliyat)	NA	NA
Post Monsoon	0.80 (Limbodra)	10.19 (Timbi-2)	NA	NA

Long Term (10 Years) Water Level Trend (2010 to 2019)		
Trend	Pre-Monsoon	Post- Monsoon
Rise (m/Yr)	0.0014 (Pavagadh) to 1.958 (Godhra UR3)	0.010485 (Shehra) to 1.012 (Katol)
Fall (m/Yr)	0.00994 (Santhroad-I) to 0.894 (Ranipura)	0.00279 (Chhabanppur) to 1.07332 (Timbi 2)

10.	GROUND WATER EXPLORATION BY CGWB (As on 31-03-2018)	
	No of wells drilled (EW, OW, Pz, SH, Total) EW: 30,OW: 03, PZ :07, SH:0, Total: 40	
	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 & Nitrate at isolated pockets
	Type of water	Potable in general
12.	DYNAMIC GROUND WATER RESOURCES (As on 2017)	
	Annual Replenishable Ground Water Resources (MCM)	422.68
	Net Ground water Availability (MCM)	401.55
	Projected Demand for Domestic and industrial Uses up to 2025 (MCM)	31.48
	Stage of Ground Water Development (%)	36.55
13	GROUND WATER CONTROL AND REGULATION (3/2017)	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	Number of Semi Critical Blocks	Nil
	Number of Safe Blocks	7
	Number of Saline Blocks	Nil
	No. Of Blocks Notified by CGWA	Nil
14	MAJOR GROUND WATER PROBLEMS AND ISSUES	
	i) Low Groundwater Development ii) Pollution Geogenic and Anthropogenic (Flouride & Nitrate in localised pockets) iii) Limited Yield Potential in Hard Rock. iv) Demand supply management.	

AQUIFER MAP AND MANAGEMENT PLAN
PANCHMAHAL DISTRICT

INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. There has been a paradigm shift from "groundwater development" to "groundwater management". An accurate and comprehensive micro-level picture of groundwater in India through aquifer mapping indifferent hydrogeological settings will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India as well. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus the crux of NAQUIM is not merely mapping, but reaching the goal – that of ground water management through community participation.

Objective:

The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. This is an activity where the Government and the Community work in tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

Methodology:

Methodology involves creation of database for each of the principal aquifer. Delineation of aquifer extent (vertical and lateral). Standard output for effective presentation of scientific integration of Hydrogeological, geophysical, geological, hydro chemical data facts and on GIS platform, identification of issues, manifestation of issues and formulation of strategies to address the issues by possible interventions at local and regional level.
The activities of the Aquifer Mapping can be grouped as follows.

Data Compilation & Data Gap Analysis:

One of the important aspect of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The

data were assembled from the available sources, analyzed, examined, synthesized and interpreted. These sources were predominantly non-computerized data, which was converted into computer based GIS data sets and on the basis of available data, data gaps were identified.

Data Generation:

There a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, remote sensing, and hydrogeological surveys to delineate multi aquifer system to bring out the efficacy of various geophysical techniques and a protocol for use of geophysical techniques for aquifer mapping in different hydrogeological environs.

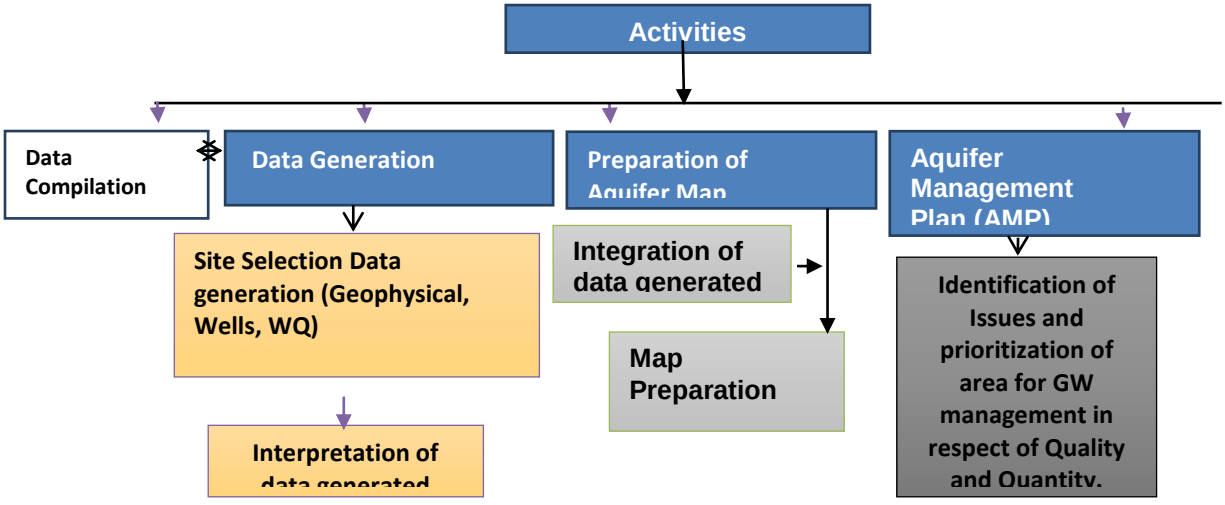
Aquifer Map Preparation:

On the basis of integration of data generated from various studies of hydrogeology & geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out details of Aquifers, these are termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities (i.e. quality & quantity).

Aquifer Management Plan Formulation:

Aquifer response Model has been utilized to identify a suitable strategy for sustainable development of the aquifer in the area.
All the above activities under the ground National Aquifer Mapping programme is depicted/elaborated in Annexure –I and presented in figure 1.

Figure – 1 Activities under National Aquifer Mapping Programme



Locations, Extent and Accessibility

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 is one district and later in the year 1997, Dahod was separated from

Panchmahal as a district. The district with its total area of 5210 sq km, comprises 11 taluka such as Godhra, Halol, Kalol, Lunawada, Santrampur, Kadana, Jambughoda, Shahera, Morva-Hadaf, Khanpur, Ghoghamba.But at present the district with its total area of 3281 sq km, comprises 7 taluka they are Godhra, Halol, Kalol, , Jambughoda, Shahera, Morva-Hadaf & Ghoghamba It is surrounded by the Sabarkantha district and Rajasthan state in the north, Dahod in east and Vadodara districts in the south and Kheda district in the west. 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 22'23" and 23'08" latitudes and 73'17" and 73'47'' longitudes, covered by toposheets no. 46E, 46F, 46J and 46I of Survey of India. The district head is well connected with road and rail with Ahmedabad. Fig. 2 Location Map of Panchmahal District.

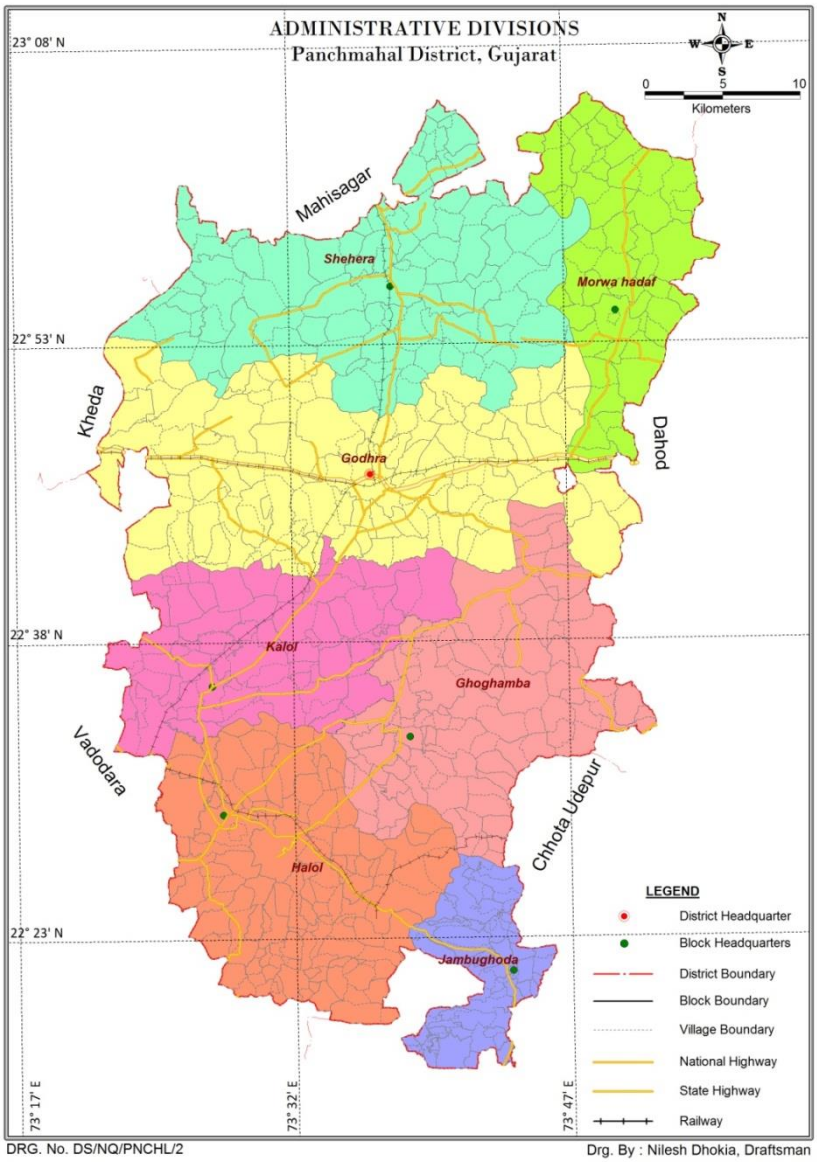


Figure 2. Administrative map of Panchmahal district

Panchmahal district is divided 7 talukas. Details of the Talukas and numbers of revenue villages are given in Table no: 1

Table: 1 Details of Taluka area & No of Villages of Panchmahal District.

Sr.No	Taluka	Area (Sq.km)	No. Villages
1	Ghoghamba	465.55	101
2	Godhra	757.30	116
3	Halol	470.70	122
4	Jambughoda	146.30	55
5	Kalol	398.00	68
6	Morva Hadf	321.70	51
7	Shehra	610.50	93
	Total	**3281.05**	**591**

(Source Panchmahal Dsitict Irrigation Plan 2016-2020)

Demographic Perticulars

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%.

LAND USE PATTERNS, IRRIGATION & AGRICULTURE

Seasons & Crops Record, Panchmahal District -year 2017-18, has been refereed for land use, irrigation & agriculture statistics of the district.

Land Use Patterns

As per Seasons & Crops Record, 328100 hectares of land is accounted for land use record. Brief account of land use classification for the district, in general, is given in table No.2

.

Table No. 2 Land Use Classification of Panchmahal District (2017-18)

Sl	Name of the Block	Total Geographical Area	Area under Agriculture (Ha)				Area under forest	Area under wasteland	Area under other uses including fallows and pastures
			Gross Cropped Area (1)	Net Sown Area (2)	Area sown more than once (1-2)	Cropping intensity (%)			
1	Godhra	69586	46428	42528	3900	109.17	15981	769	9054
2	Morva (H)	32331	23205	19138	4067	121.25	5059	610	6749
3	Halol	51942	28057	25907	2150	108.3	6335	1641	13113
4	Kalol	39798	27993	25458	2535	109.96	3595	970	8799

5	Ghoghamba	49744	29544	27694	1850	106.68	9669	1791	6389
6	Jambughoda	14630	7149	6100	1049	117.2	6202	158	1692
7	Shehera	57979	30679	29744	935	103.14	17171	1407	7059
	District	328100	228666	176279	52587	109.34	74215	7351	52889

(Land Use & Season –Crop Record – Panchmahal District – Year 2017-18 – Agriculture Directorate, Government of Gujarat.)

Irrigation

Details of area irrigated by surface & ground water resources are given in table No 3

Table No. 3 Details of Irrigated Areas

Source	Irrigated Area (Hectares)	
	Net	**Gross**
Tanks	6100	10500
Canals	40300	59800
Total Surface Water	**46,400**	**70,300**
Govt. Tube Wells	1800	4100
Pvt. Tube Wells	14600	21700
Dug Wells	900	1800
Total Ground Water	**17.300**	**27,600**
Total Irrigated Area	**63,700**	**97,900**

Agriculture

The district areas have varied agriculture crops, both food crops & non food crops. Main food crops consist of food grains such as paddy, wheat, *jowar, bajra*, maize etc., and pulses. Other food crops are sugarcane, fruits & vegetables. Non food crops consist of cotton, oil ground nut, castor, tobacco, fodder etc. As per *Season & Crops Records, there* were 228,600 hectares of gross area under various crops in the district, out these 176,200 hectares were under net crops area.

Urban and Industrial area

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.

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 04 : 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**

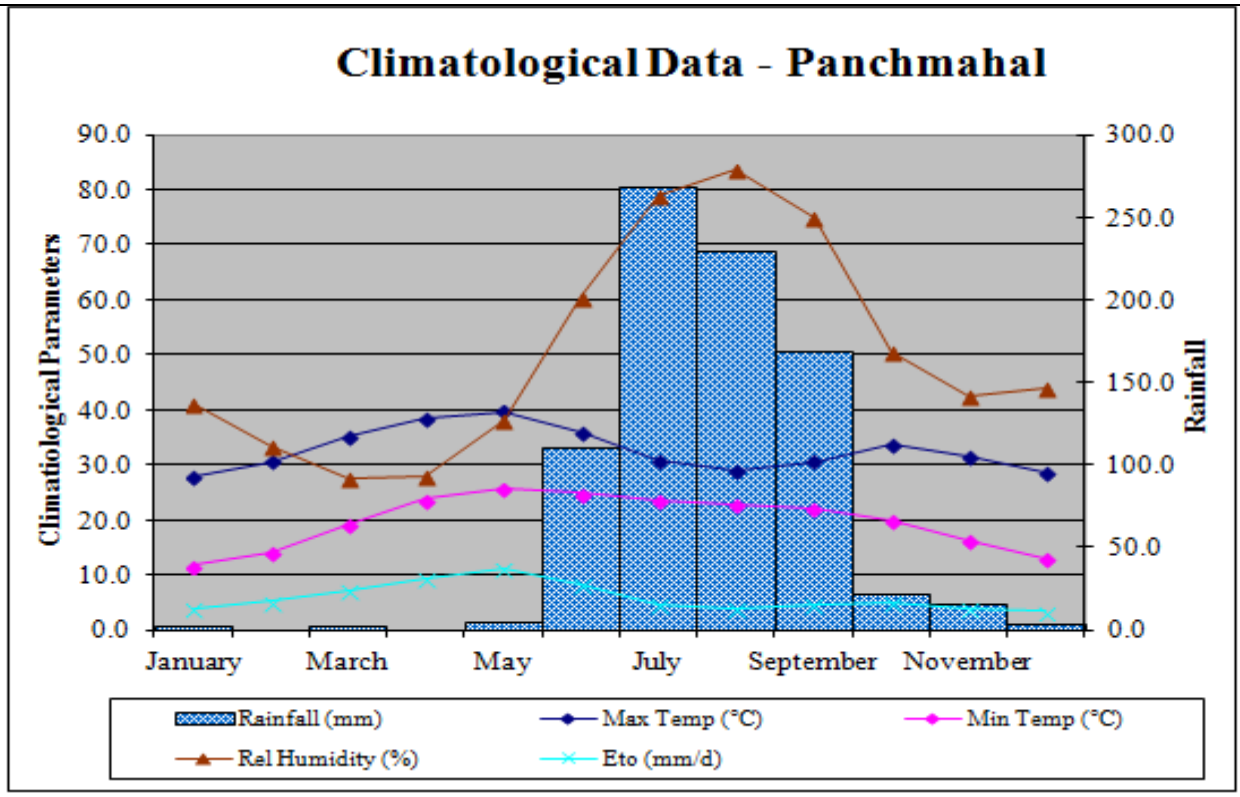


Fig 03: Climatological data analysis of Panchmahal district

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 6 rain-gauge stations of the district from year 1963-2017 are statistically analyzed and presented in table No 5. The distribution of mean annual rainfall over the Panchmahal district.

Table No-5, Statistical Analysis of Rain Fall Data Rain Fall in mm

Name of the stations	No of Years	Average Annual RF	Standard Deviation	Highest RF - Year	Lowest RF - Year
Morva	1963-2017	928	371.72	1986-1976	320-1999
Godhra	1963-2017	945	524.93	3747-2009	320-1999
Ghoghamba	1963-2017	882	398.94	2181-1976	389-1986
Halol	1963-2017	1031	395.77	2602-1976	329-2015
Kalol	1963-2017	977	1081.89	8392-1989	306-1999
Shehra	1963-2017	792	486.98	1967-1976	286-1985

GEOMORPHOLOGY

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. (Fig No 4 Shows Geomorphology map of Panchmahal District)

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. (Fig No 5 Shows Drainage map of Panchmahal District)

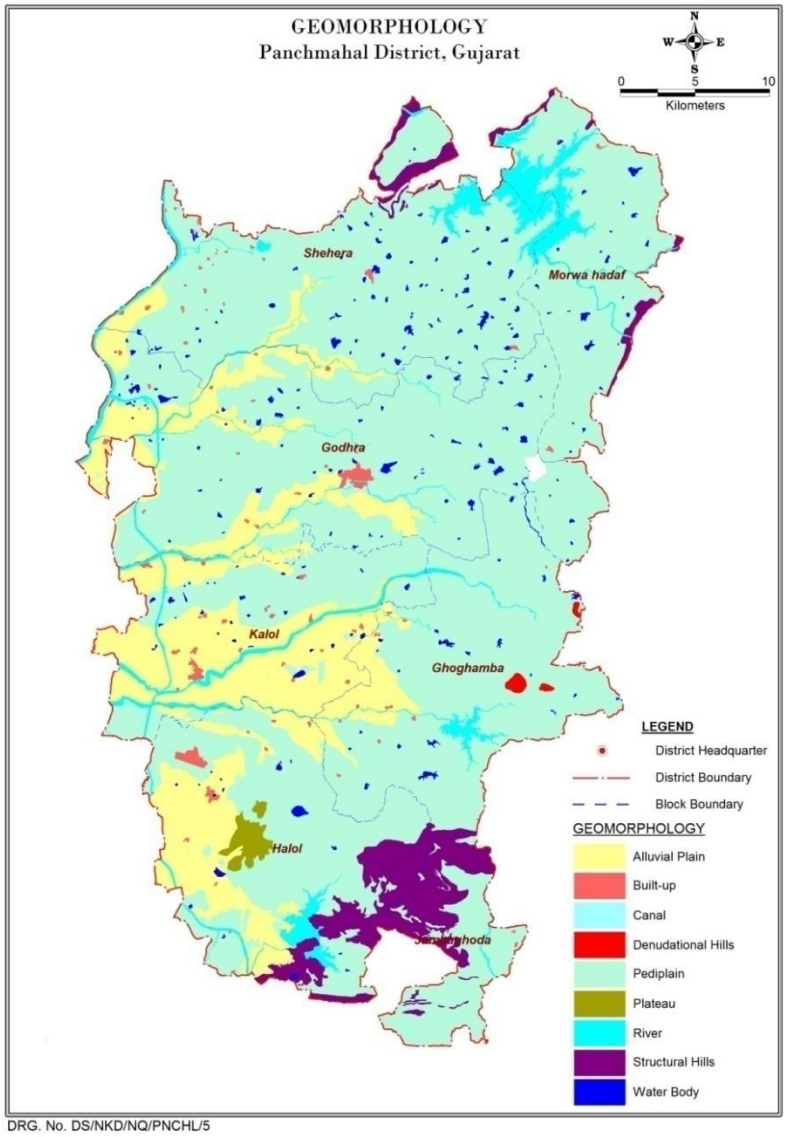


Fig No 4 Shows Geomorphology map of Panchmahal District

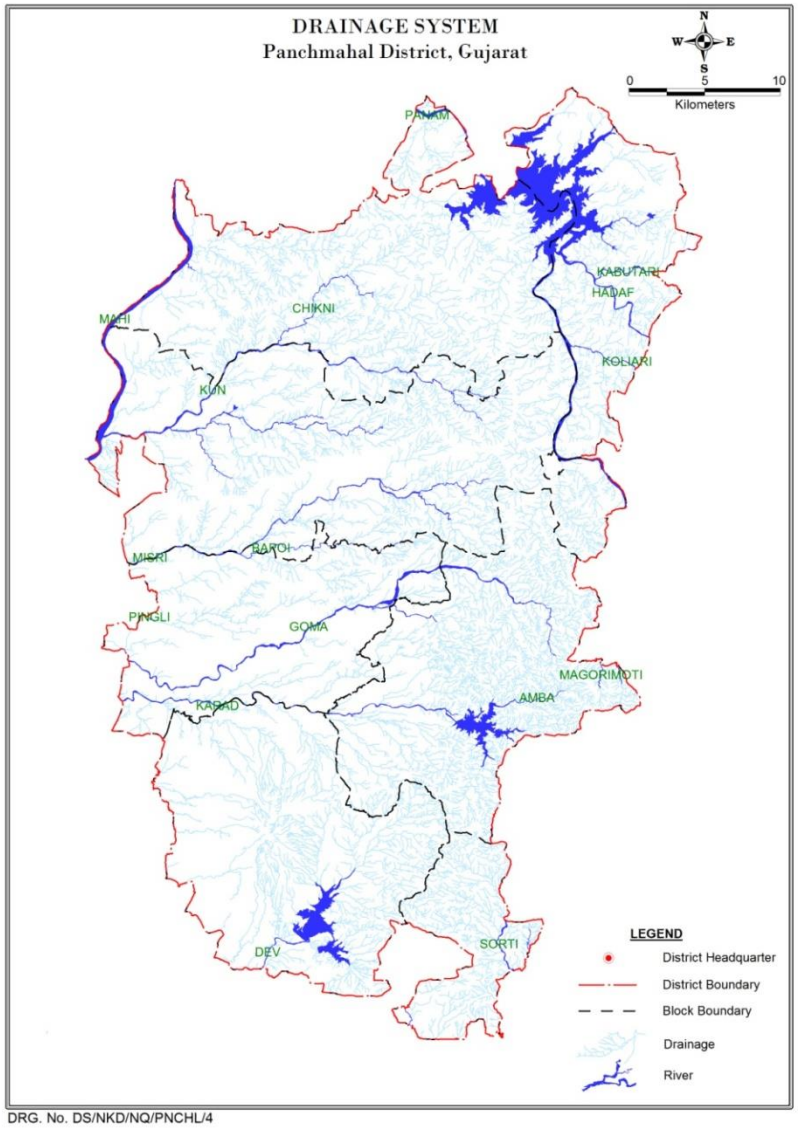


Fig No 5 Shows Drainage map of Panchmahal District

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.

HYDROLOGY

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).

STUDIES / ACTIVITY BY CGWB

Systematic hydrogeological surveys 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. GEOLOGY AND HYDROGEOLOGY

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 3. 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 06: 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.The Stratigraphy of Panchamahal District is given in following table no 6

Table 06: Stratigraphy of Panchamahal District

Geological Age	Super group	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.

HYDROGEOLOGY

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. Fig no 7 shows hydrogeology map of Panchmahal district. 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 quartzites 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.Yield of this aquifer in between 0.5 to 6.3 lps.

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 varies from 3 to 15m. Yield of this aquifer in between 0.5 to10 lps.

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 conditions 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. Yield of this aquifer is 4.5 lps.

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. Yield of this aquifer in between 1 to 4.38 lps.

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. Yield of this aquifer in between 4 to 10 lps.

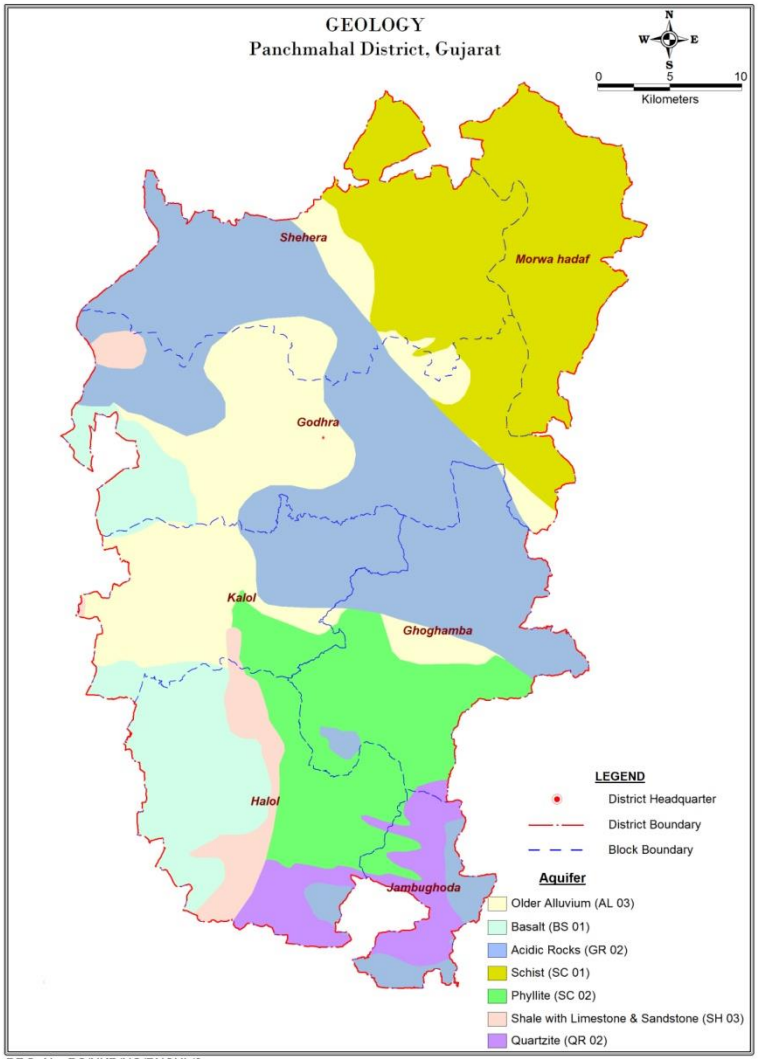


Fig No-6 Geology map of Panchmahal District

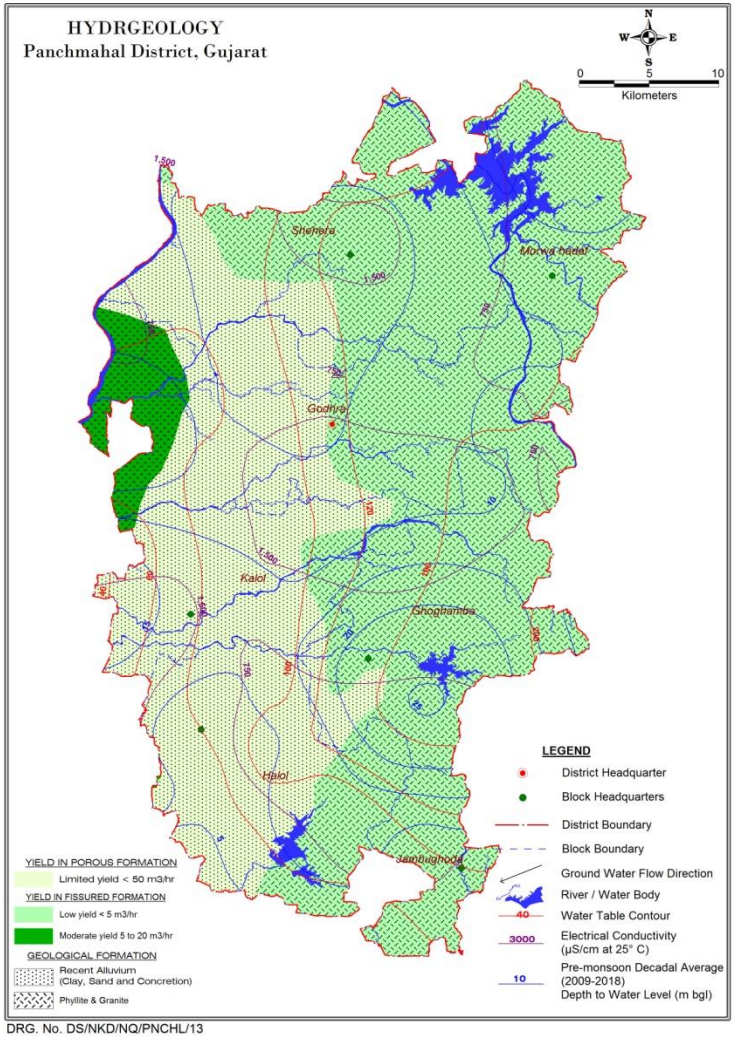


Fig No-7 Hydrogeology map of Panchmahal District

SUBSURFACE GEOLOGY

Exploration Details

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.

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 07: 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. (Annexure 09:Data of exploratory wells drilled in Panchmahal district.)

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 17 Dug wells and 07 piezometers as part of the NHS from CGWB and there are 33 Dug wells and 31 piezometers from GWRDC Ltd. The following maps have been generated to understand the behaviour of ground water regime.

Depth to Water Level Pre monsoon (May 2019)

The figure 08 shows depth to water level map of Panchmahal district, prepared on the basis of NHS data of May 2019. In major part of the district, the water level ranged in between 8 to 12 m bgl while northern and southern part of Shehera and jambhugoda have water level ranges 2 to 8 m. Northern part of Morwahadaf taluka and central & western part of Kalol taluka have water level ranges 12 to more than 20m.(Figure 08: DTW May 2019 map of Panchmahal district.)

DEPTH to Water Level Post monsoon (Nov 2019)

The figure 09 shows depth to water level map of November 2019. The major part of the district have water level in range of 2 to 8 m bgl while western part of the Kalol & halol taluka have water level ranges of 8 to 16 m. Northern part of the Shehera and central part of Morva hadaf have water level less than 2 mbgl.(Figure 09: DTW November 2019 map of Panchmahal district.)

Water Level Trend (2010 - 2019)

From the analysis of the water level trend of the Panchmahal district from 2010 to 2019, it is observed that, during pre-monsoon, the water level has a rise of 0.0014 m/yr (Pavagadh) to 1.958 m/yr (Godhra UR3) and also has a fall of 0.00994 m/yr (Santhroad-I) to 0.894 m/yr (Ranipura). Similarly from the analysis of the post-monsoon data of 2010 to 2019, the rise shown by water level is vary from 0.010485 m/yr (Shehra) to 1.012 m/yr (Katol) and also has a fall of 0.00279 m/yr (Chhabanppur) to 1.07332 m/yr (Timbi 2).

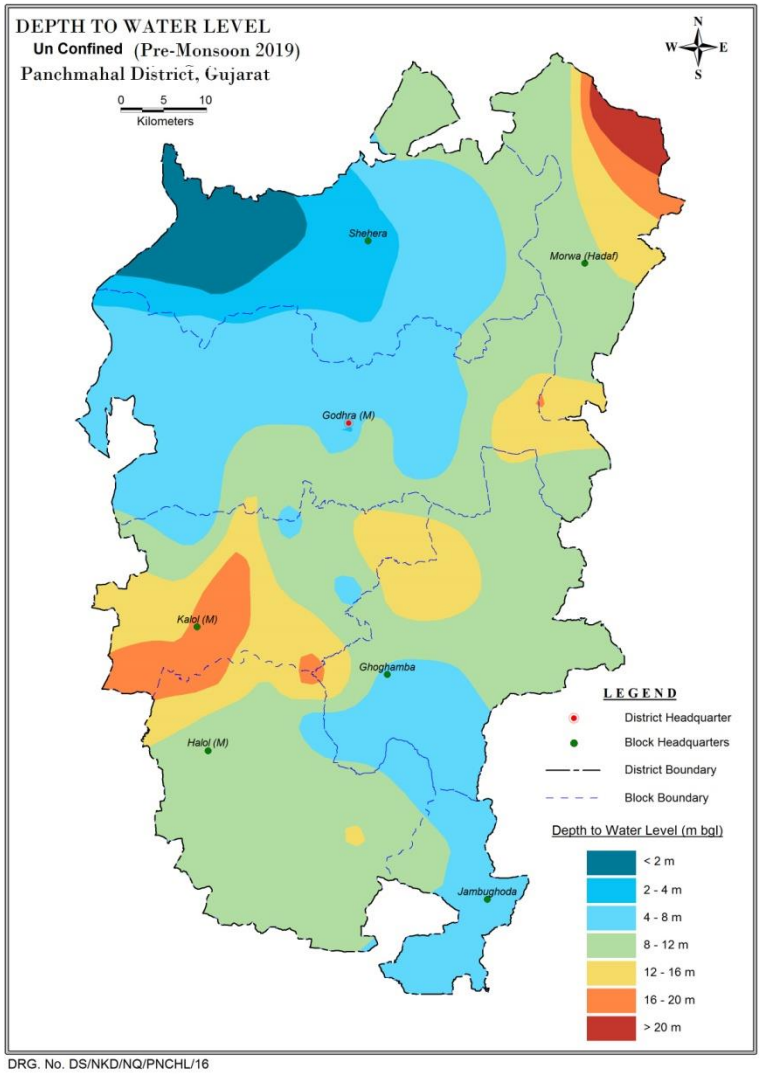


Figure 08: DTW May 2019 map of **Panchmahal District.**

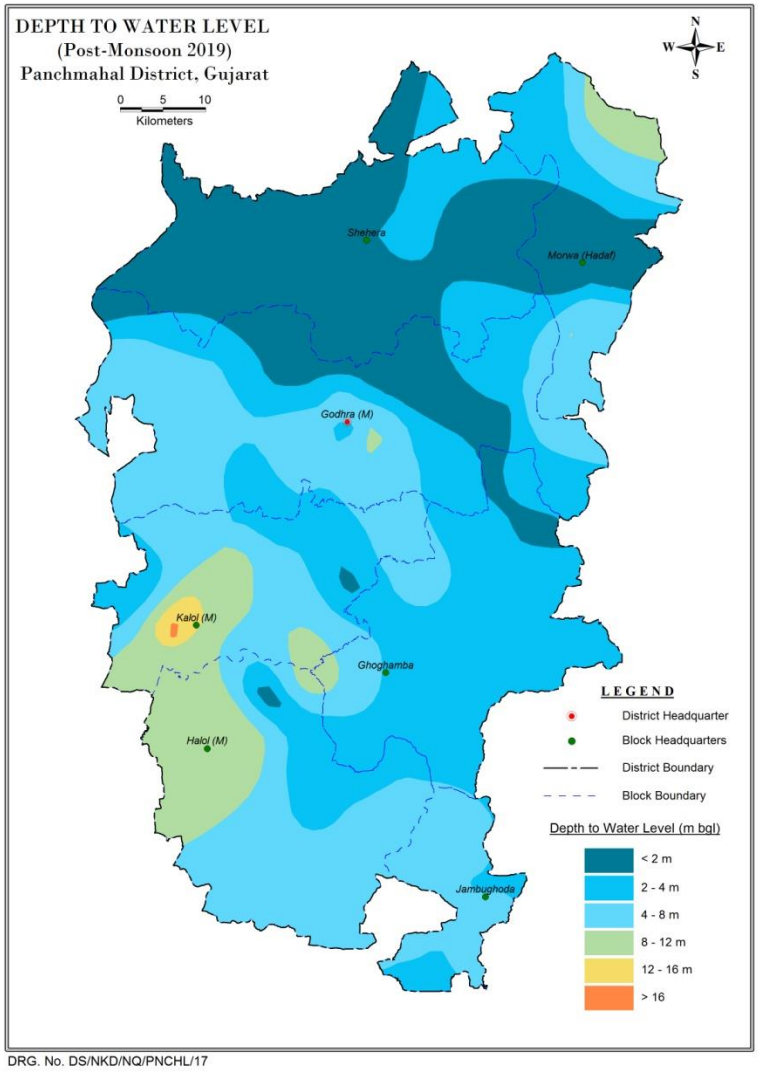


Figure 09: DTW November 2019 map of **Panchmahal District.**

Unconfined Depth to water Table maps of May-2019 & Nov-2019.

The maps showing depth to water table above mean sea level of May-2019 & Nov-2019 is given as figure no 10 & 11.The map reveals that the depth to water table with reference to mean sea level decreases from east to west i.e in general ground water is flowing from East to West direction.

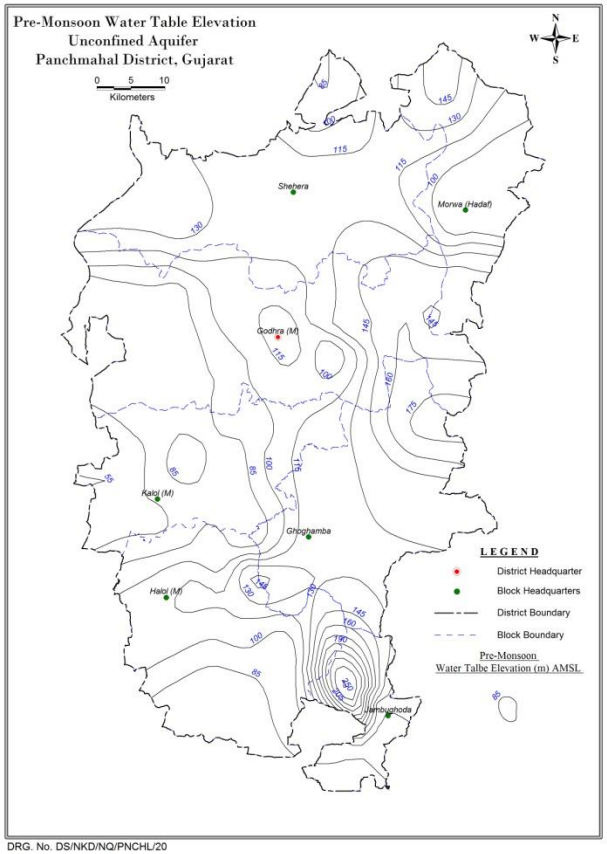


Figure 10: Unconfined Depth to water Table maps of May-2019

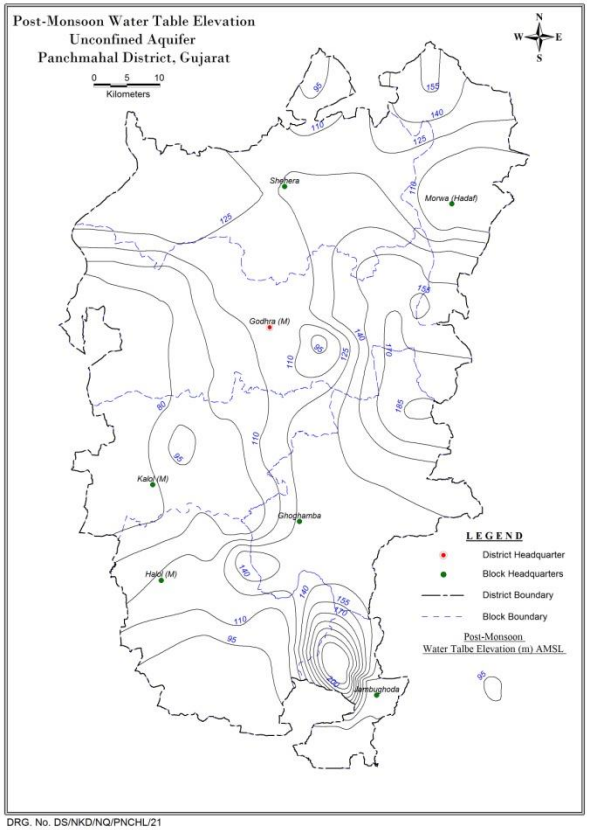


Figure 11: Unconfined Depth to water Table maps of Nov-2019

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

In order to establish the three-dimensional disposition of aquifer system in the area, the existing data of litho logical logs of Exploratory wells studies carried out by CGWB were used to prepare a hydro geological cross section, Fence diagram and 3D Model. The data has been analyzed using Rockworks 16 software and is presented below in the Hydrogeological cross sections A-A' to H-H' and Solid Model of the district showing the depiction of Aquifer Groups up to 200m. Map showing section lines are presented in Fig. 12. The stratigraphic sections depicting in Alluvium area comprising silt, sand, clay, gravel and kankar, unconfined aquifer, occurring up to the depth from 0 to 21 m bgl. In Hard area weathered Aquifer depth of occurrence is from 0 to 25m and fractured aquifer depth of occurrence is from 50 to 100m. Hydrogeological cross sections are placed at Figs 13 (A to H). Fence Diagram and 3D Solid Model of Panchmahal district is depicted in Fig. 14 and 15 respectively.

A total of 30 exploratory wells and piezometers constructed by CGWB. And 23 litho logs are utilized to decipher the subsurface geometry of the aquifer by using Rockworks 16 software prepared hydro geological cross sections, Fence diagram and 3D Model up to the depth of 200 mbgl.

Table No: -08 Data integration

S.No.	Data	Aquifer	Total Data Points	Source	
				CGWB	GWRDC
1	Panel Diagram (3-D)	Combine	23	Expl:30	-
2	Hydrogeological Cross Sections	10 no	23	Expl:30	-
3	Fence/panel Diagrams	1 no	23	Expl:30	-
4	Depth of weathering	1 no	23	Expl:30	-
5	Depth of fracturing	1 no	23	Expl:30	-
7	Depth to Water Level Maps (2019)	Combine	50	17	33
8	Long term water Level Trends	Combine	85	24	61
9	Water quality pre-2019 & post-2019	Combine	44	17	27

Conceptualization of Aquifer system in 2D

Eight hydrogeological cross sections are drawn from North-East to South-West and North-West to South-East directions across the area represented in Figs 13 (A to H).

Litho logical logs of subsurface are correlated based on the position and depth of the geological formations and prepared eight cross sections one fence diagram and one 3D solid model of Panchmahal district.

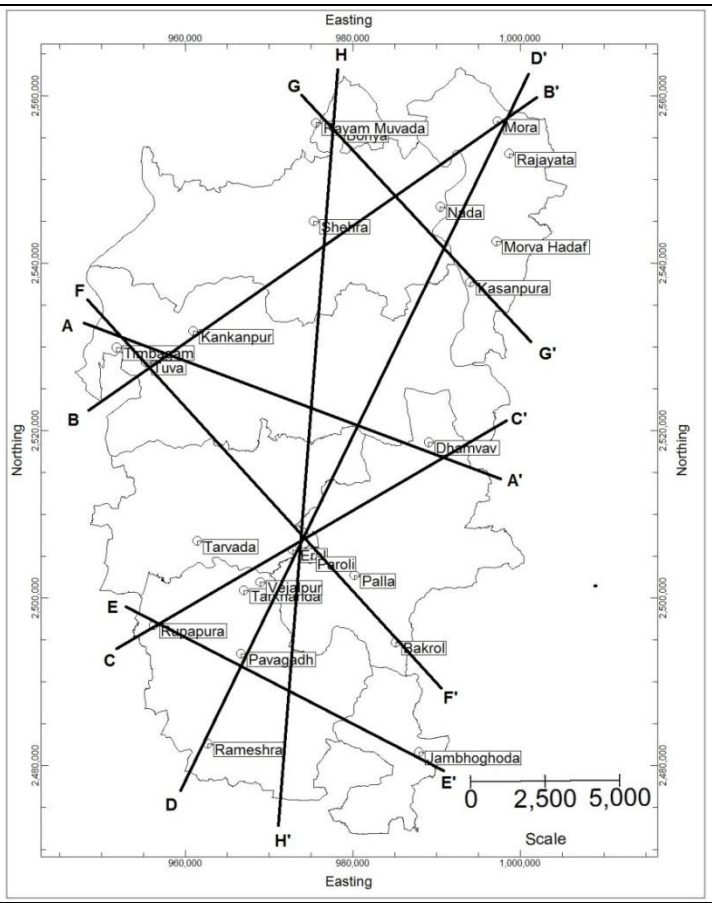
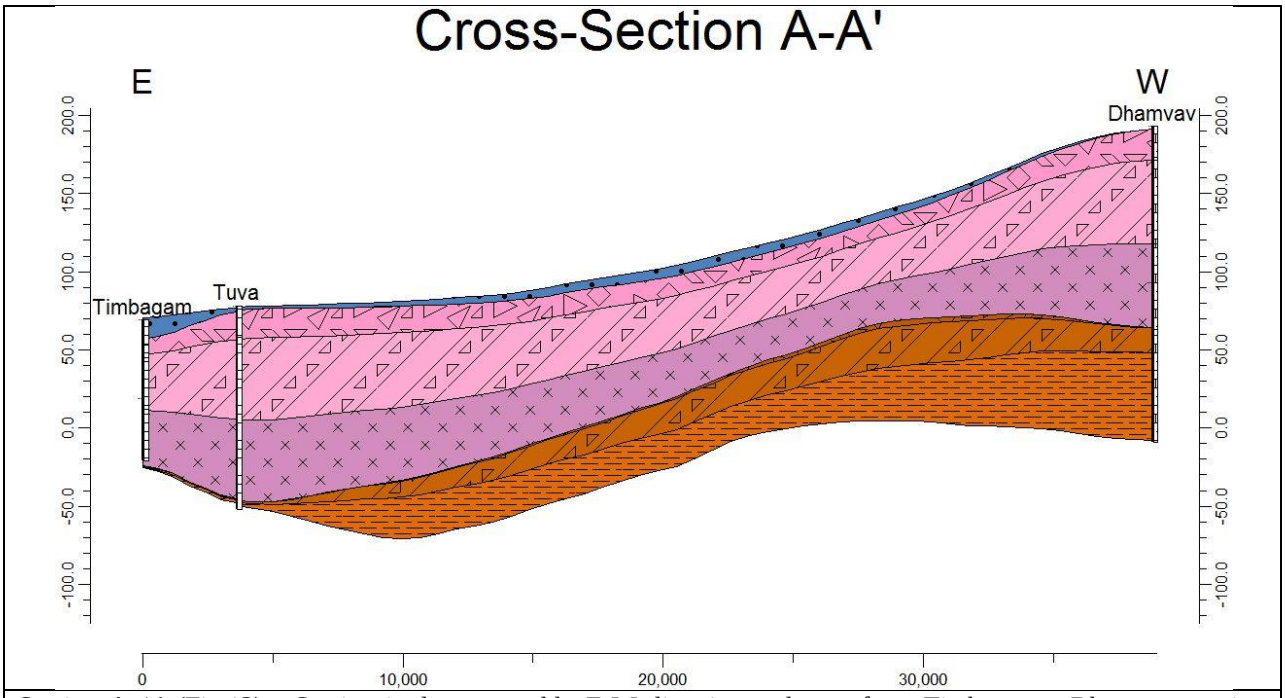
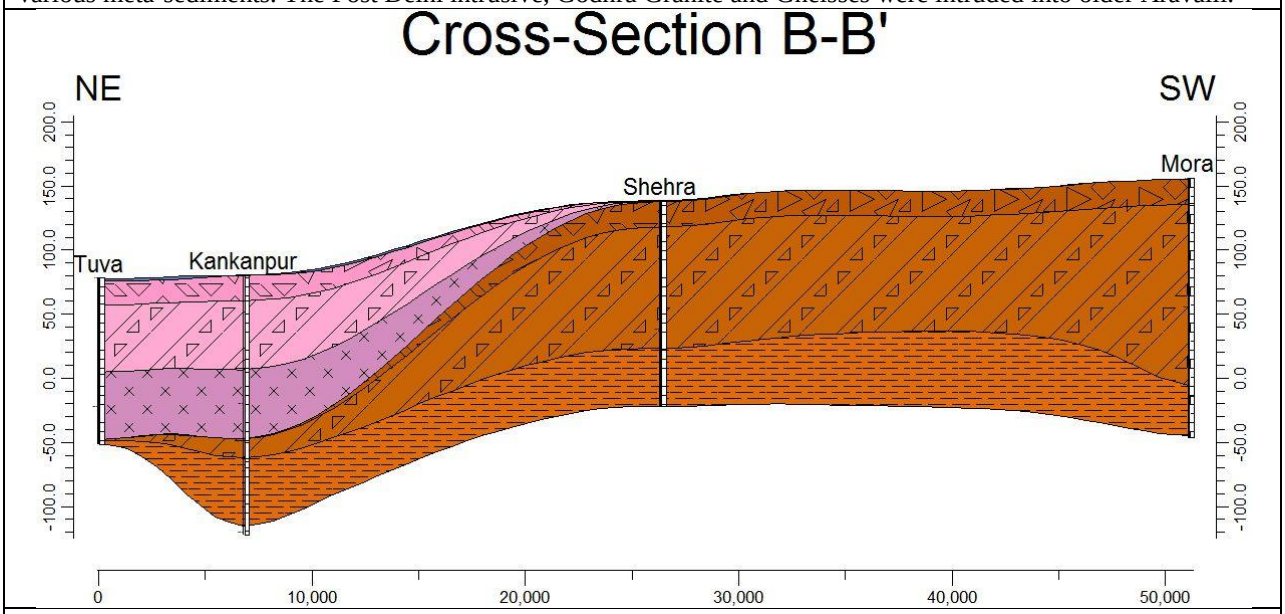


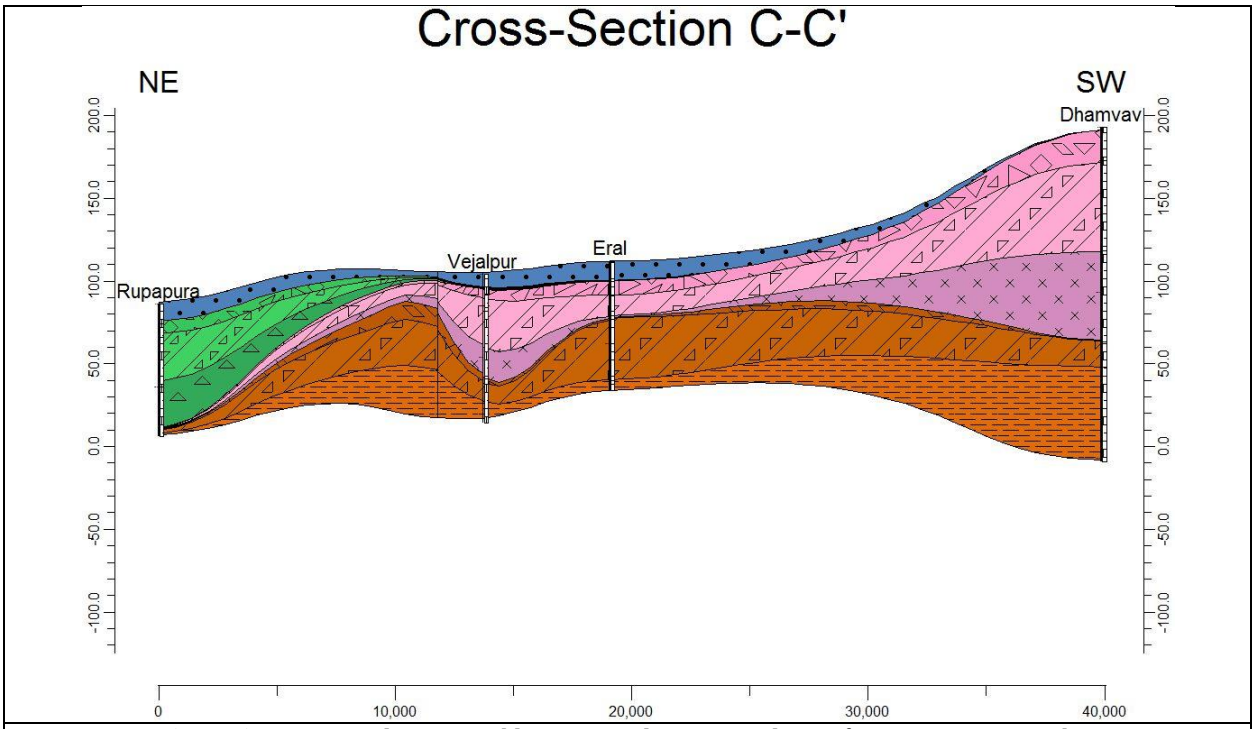
Fig No :12 Map Showing Section Lines



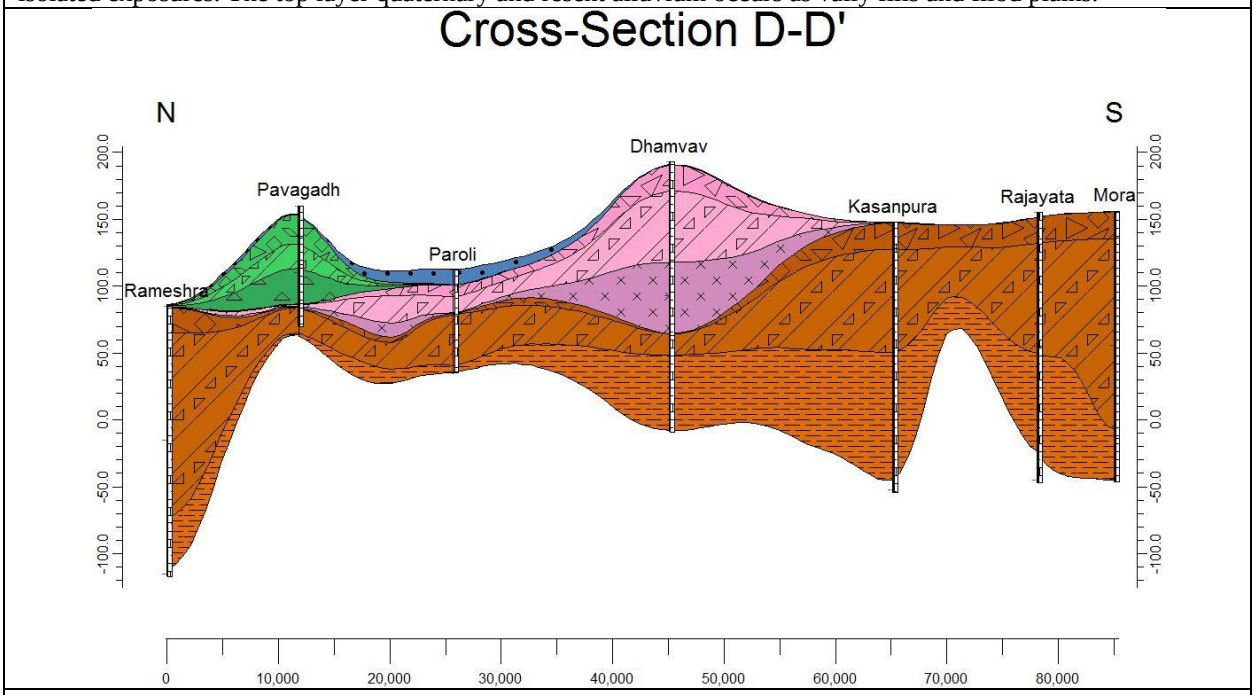
Section A-A' (Fig.13) - Section is drawn roughly E-W direction and start from Timbarva to Dhamvav passing through tuva. Section is represented geologically, the oldest formation in the are is Aravalli Super Group comprises various meta-sediments. The Post Delhi intrusive, Godhra Granite and Gneisses were intruded into older Aravalli.



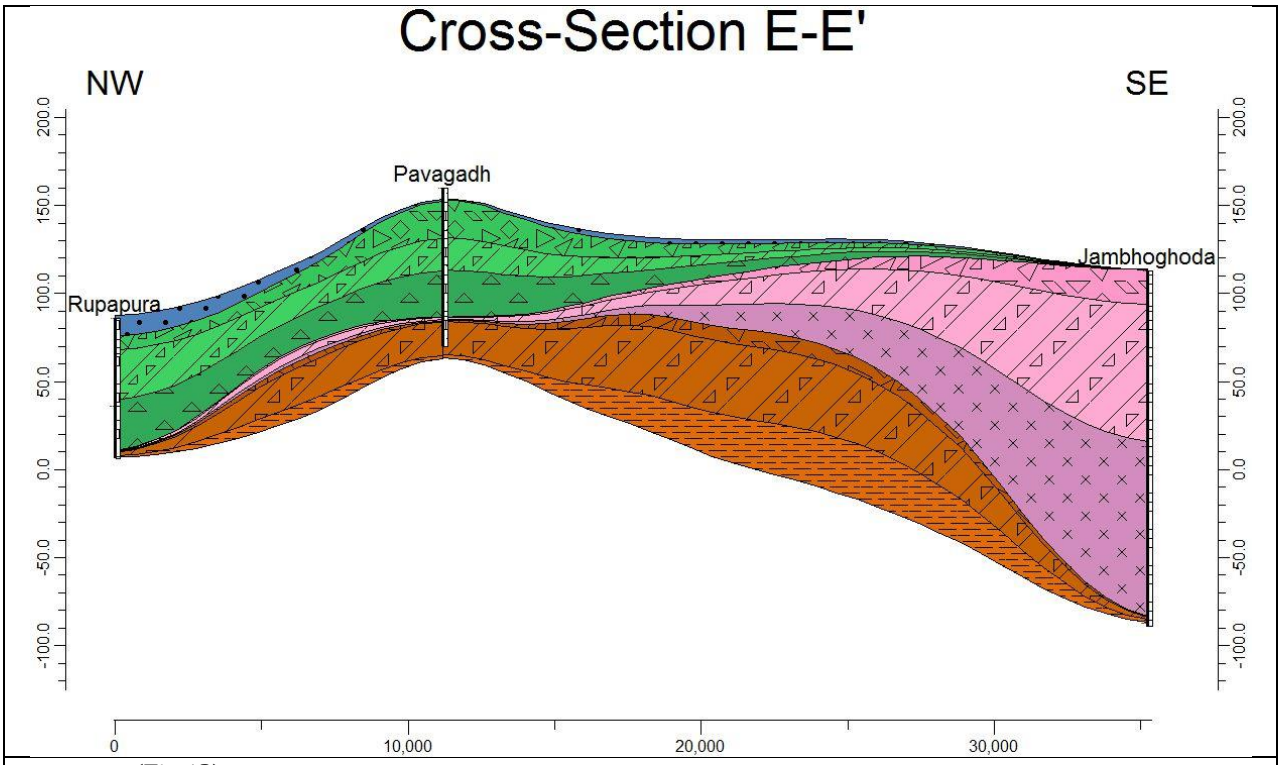
Section B-B' (Fig.13)- Section is drawn roughly NE-SW direction and start from Tuva to Mora passing through Kankanpur and Shehra. Geological formation encountered more or less same as in the section A-A' except variation of thickness and position of out crops.



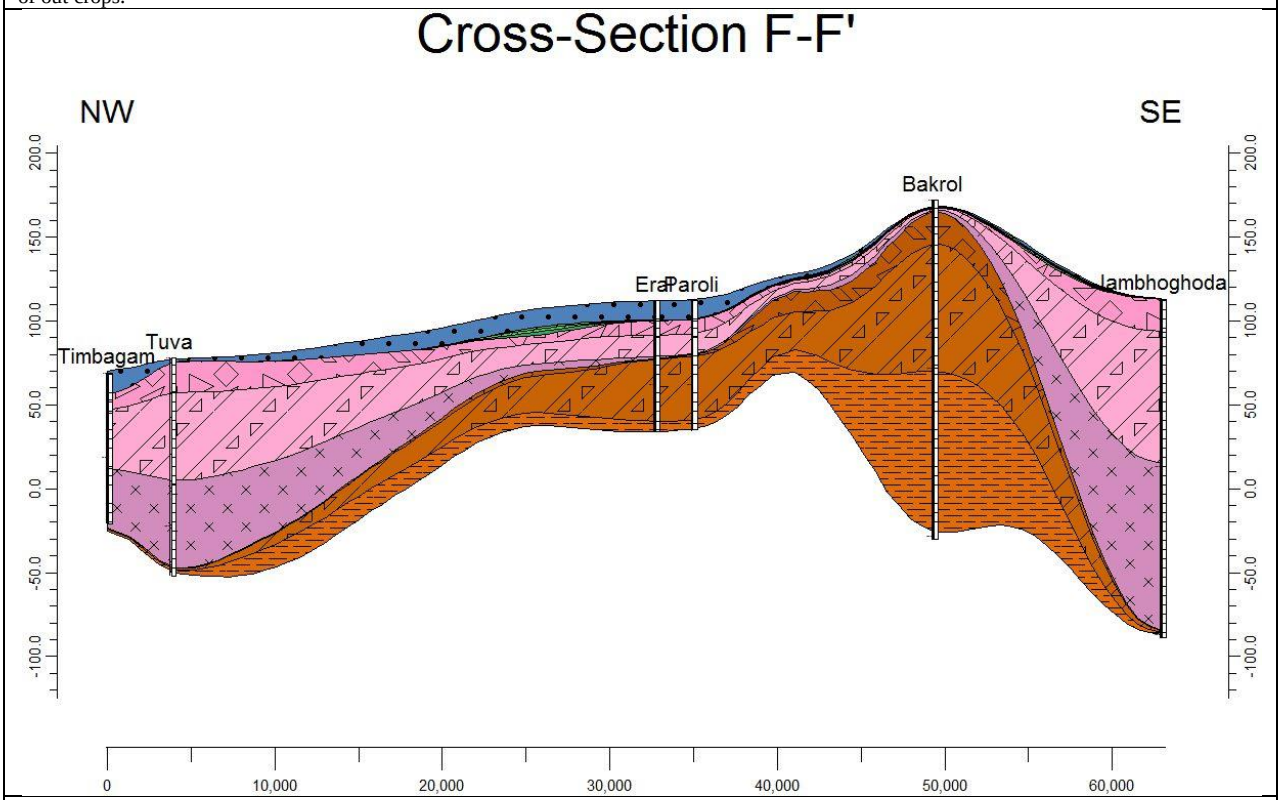
Section C-C’ (Fig.13) Section is drawn roughly NE-SW direction and start from Rupapura to Dhamvav passing through Vejalpur and Eral). Section is represented geologically, the oldest formation in the area is Aravalli Super Group comprises various meta-sediments. The Post Delhi intrusive, Godhra Granite and Gneisses were intruded into older Aravalli in the south west direction. In the North east directions Deccan traps occur as irregular and isolated exposures. The top layer quaternary and resent alluvium occurs as vally fills and fllod plains.



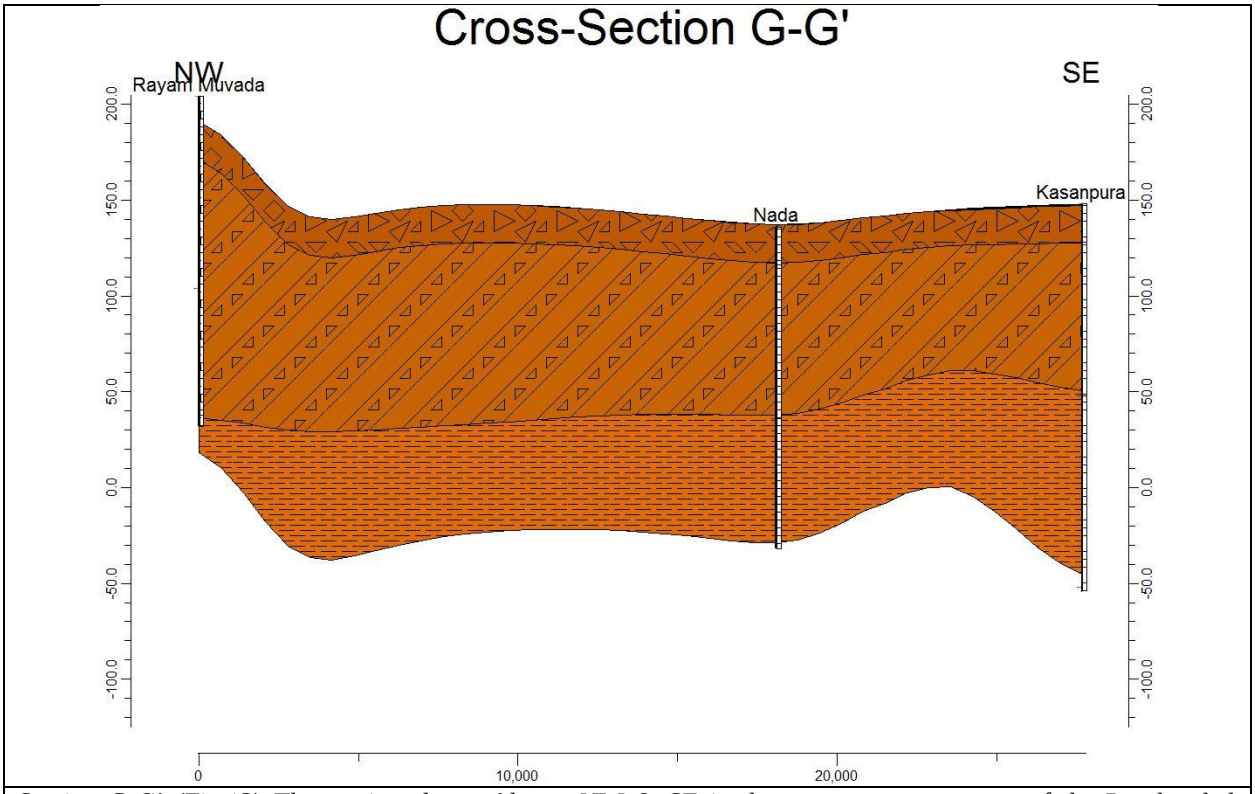
Section D-D’ (Fig.13) section is drawn roughly N-S direction and start from Rameshra to Mora passing through Pavagadh,Paroli,Dhamvav,Kasanpura and Rajayata. Geological formation encountered more or less same as in the section C-C’ except variation of thickness and position of out crops.



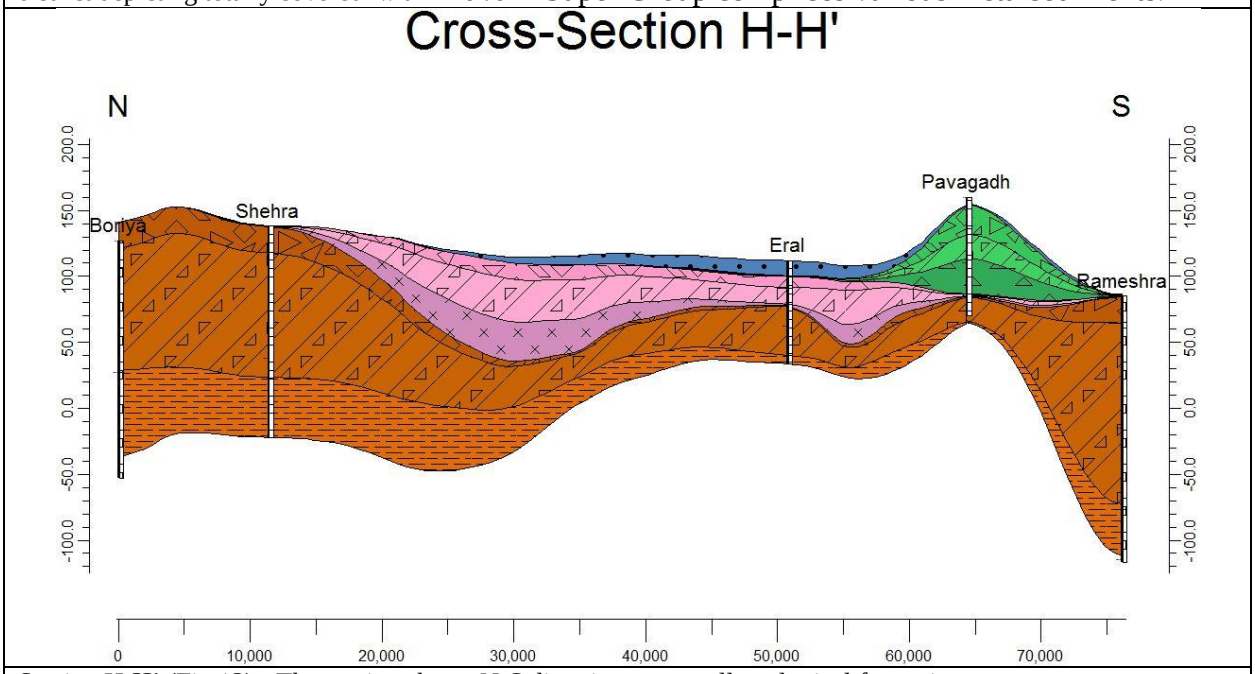
Section E-E' (Fig.13) The section shows trap rock forms the basement in NW and towards SE direction start from Rupapura to Jambhoghoda passing through Pavagadh. Geological formation encountered more or less same as in the section C-C' except variation of thickness and position of out crops.



Section F-F' (Fig.13) The section shows Almost NW & SE direction. Section is represented geologically, the oldest formation in the area is Aravalli Super Group comprises various meta-sediments. The Post Delhi intrusive, Godhra Granite and Gneisses were intruded into older Aravalli in the south west direction. The top layer quaternary and resent alluvium occurs as valley fills and flood plains.



Section G-G' (Fig.13) The section shows Almost NW & SE in the extreme western part of the Panchmahal district depicting totally covered with Aravalli Super Group comprises various meta-sediments.



Section H-H' (Fig.13) - The section shows N-S direction covers all geological formation.

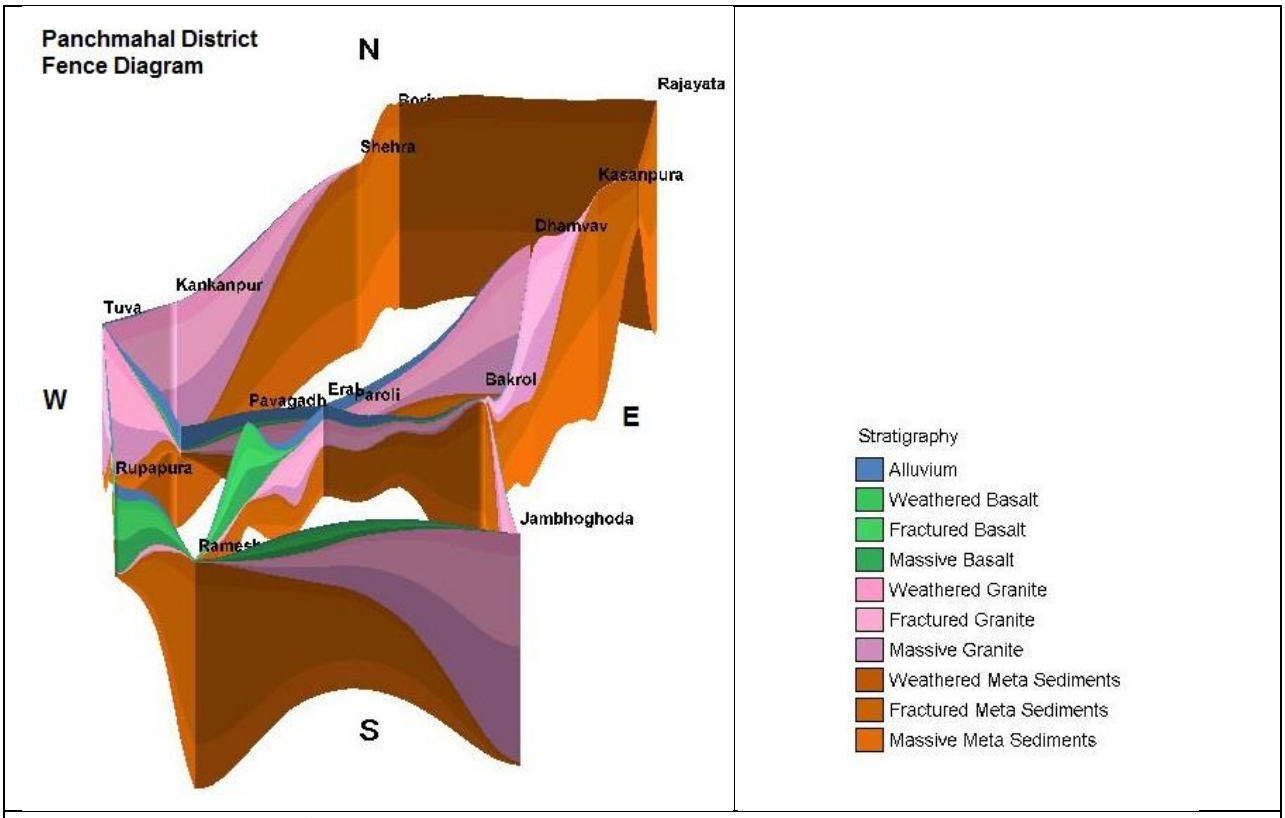


Fig No: 14 PANCHMAHAL DISTRICT FENCE DIAGRAM

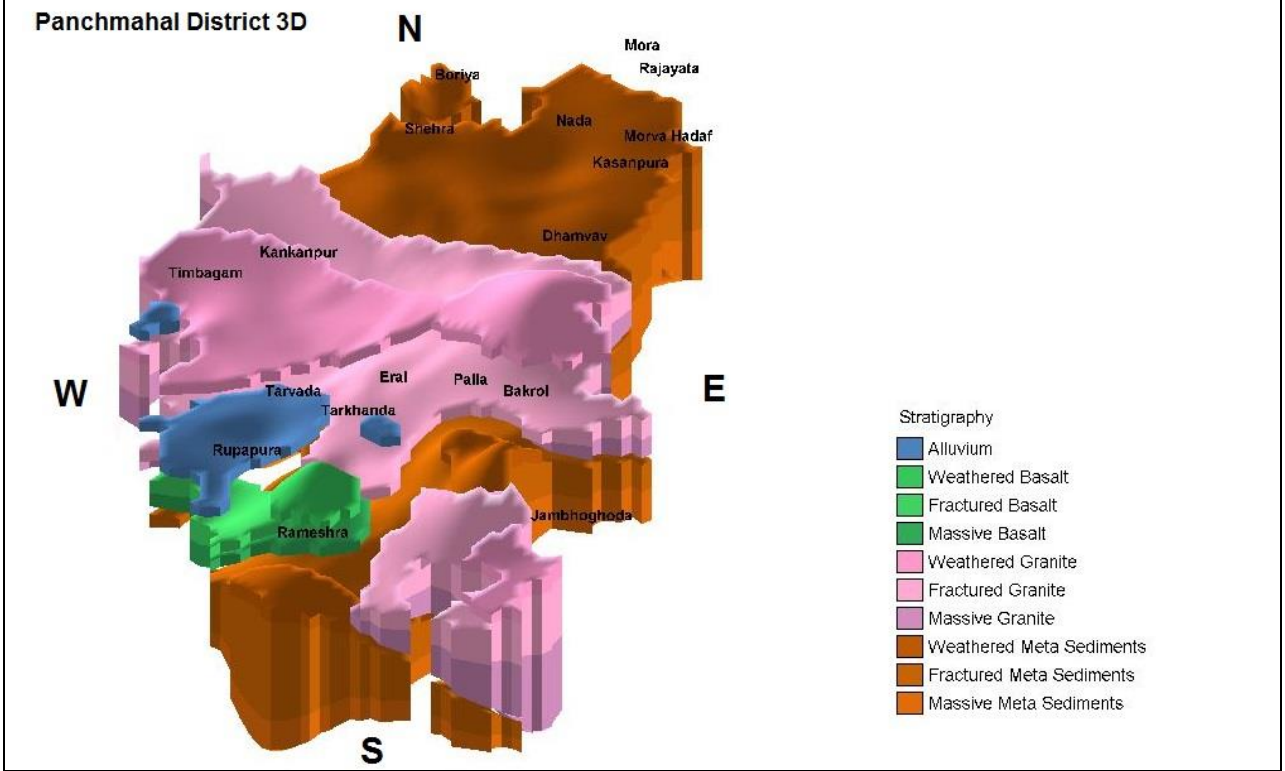


Fig No: 15 PANCHMAHAL DISTRICT 3D AQUIFER DISPOSITION

Finally, the study of these sections revels that the identification and delineating the Aquifers vertically and laterally.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, Godhra Granite and Deccan traps. In soft rock type, it has alluvium. 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.

Aquifer Disposition: In Alluvium area comprising silt, sand, clay, gravel and kankar, unconfined aquifer, occurring up to the depth from 0 to 21 m bgl. In Hard area weathered Aquifer depth of occurrence is from 0 to 25m and fractured aquifer depth of occurrence is from 50 to 100m. The ground water in major part of the district is suitable for domestic, irrigation and industrial purposes.

Aquifer Characterization and Disposition.

On the basis of Hydogeological cross sections the following salient features of aquifer system in the area is summarised below Table No :-09.

Table No-9 Aquifer Characterization and Disposition.

Aquifer Characterisation and Disposition										
Stratigraphy	**Aquifer Nomenclature**	**Lithological**	**Depth of occurrence**	**Thickness**	**Water Level (mbgl)**	**Quality (TDS)**	**Discharge**	**Transmissivity**	**Nature of Aquifer**	**Remarks**
		Characteristics	**Aquifer**	**Range**	**Range**	**Range**	**Range**	**Range**		
			(mbgl)	**(m)**	**(mbgl)**	**Mg/l**	**lps**	**m2/day**		
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
	Fractured Basalt	Basalts & Rhyolite	40 to 54		2 to 16	300 to 2000	1 to 4	0.19 to 1000	**Fractured**	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		3 to 21	300 to 1700	0.1 to 6.3	322 to 1300	**Fractured**	Good Quality

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 10.

Summarised Chemical Data of Panchmahal District.

Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8	310	63	198	0	48	0	0	0.9	15	6	19	0.88	0.39
Max	9.3	3370	668.17	2157	366	720	488	389	200	200	129	510	104.68	1.53
Average	8.6	1312.9	310.2	839.7	128.9	262.4	158.9	75	45.98	63.9	40.5	160.3	16.7	0.90

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

The ground water in major part of the district is suitable for domestic, irrigation and industrial purposes. The Electrical conductance of ground water is generally ranges from 310 to 3370 micromhos/cm at 25°c, for the entire district. Fig No 16 & 17 Shows Electrical conductivity map of Pre & Post monsoon for the year 2019. The chloride concentration in ground water is within 250 ppm in major part of the area. In some isolated alluviul patches chloride values in the range 250 to 488 ppm are seen. Ground water in both Phreatic and confined Aquifers is Potable and fit for domestic, drinking, irrigation and other industrial purposes but higher concentration of Fluoride and Nitrate is observed in shallow aquifer at localised pockets. Fig No 18 & 19 Shows Flouride & Nitrate concentration maps of Pre monsoon for the year 2019.

Panchmahal district has a number of medium and small scale industries set 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. The major key business involved are engineering, 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.

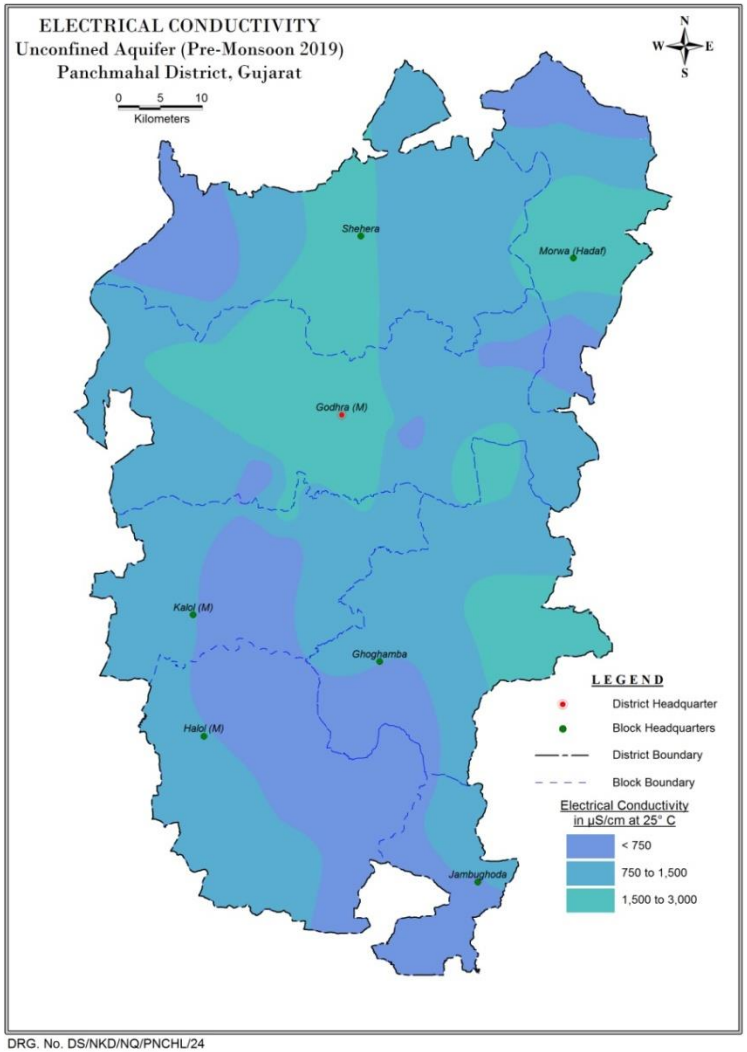


Fig No 16 Shows E C map of Pre monsoon 2019 of Panchmahal

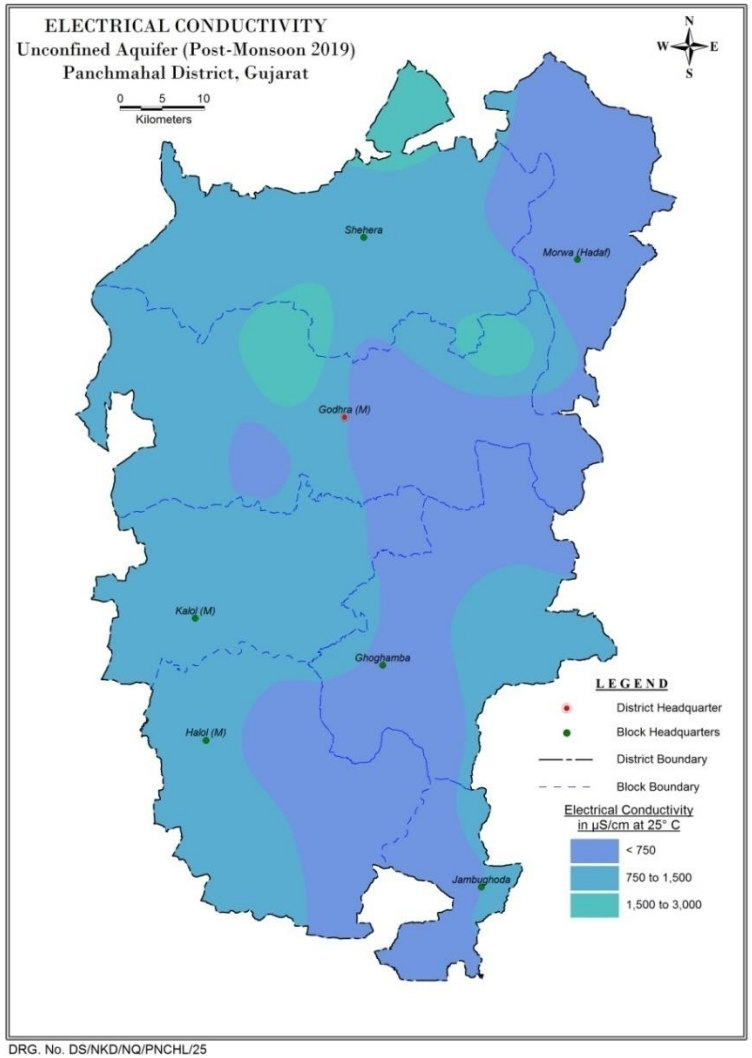


Fig No 17 Shows E C map of Post monsoon 2019 of Panchmahal

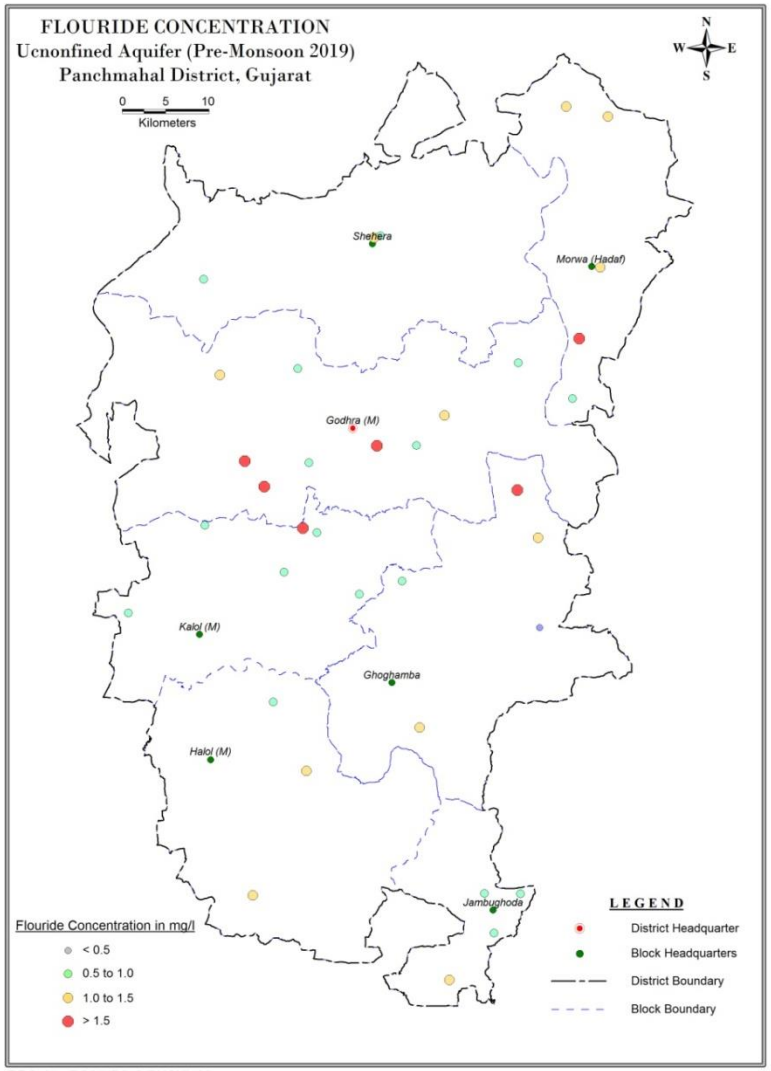


Fig No 18 Shows Flouride map of Pre monsoon 2019 of Panchmahal

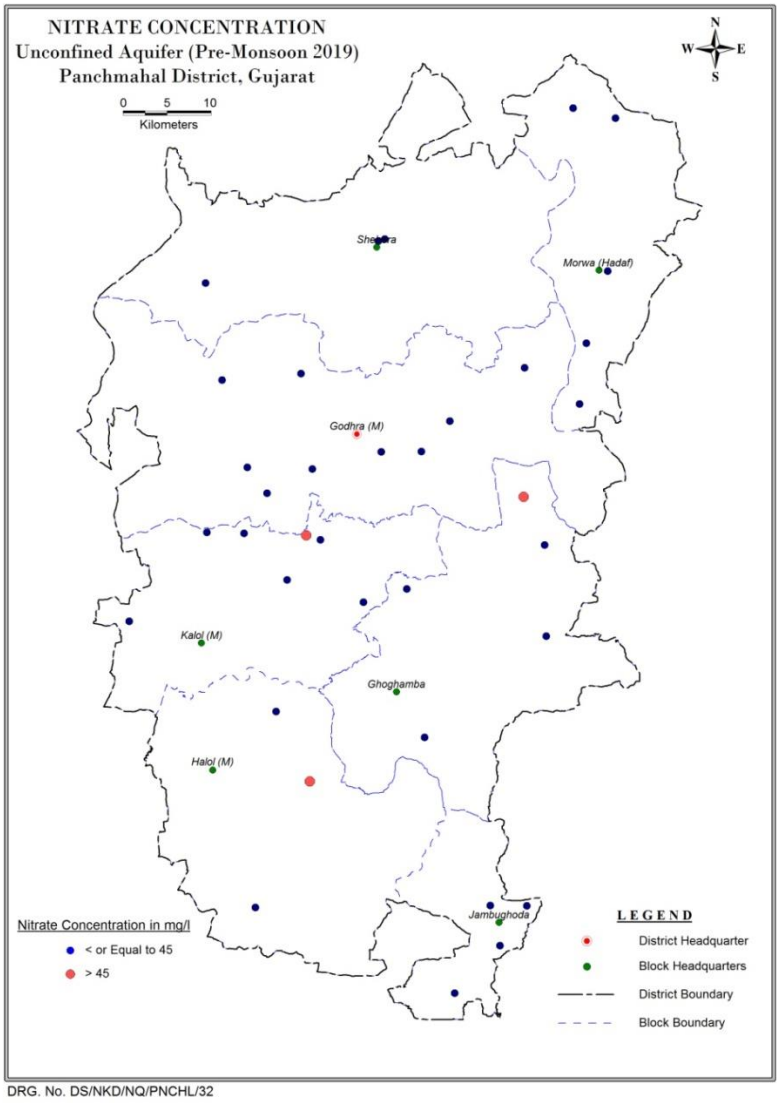


Fig No 19 Shows Nitrate map of Pre monsoon 2019 of Panchmahal

5. GROUND WATER RESOURCES

The ground water resources of the district were calculated as on March 2017 in collaboration with the Government of Gujarat using the methodology suggested by Ground Water Resource Estimation Committee (GEC-15). These resources were computed after reorganization of the districts.

Ground Water Recharge

The Annual Ground Water Recharge varies from 1769.39 ha.m (Jambughoda taluka) to 9646.77ha.m (Godhra Taluka). The Gross Annual Ground Water Recharge in the district is 42268.85 ha.m. The net available recharge after leaving natural discharge from monsoon period varies from 1680.91 ha.m (Jambughoda taluka) to 9164.43 ha.m (Godhra Taluka). The net available recharge in the district is 40155.39 ha.m.

Ground Water Draft

The ground water draft from irrigation and Domestic /Industrial sources is presented in Table: 14. The Existing Gross Ground Water Draft for all uses varies from 679.10 ha.m (Jambughoda taluka) to 2826.20 ha.m (Halol Taluka). The Gross Ground Water Draft for All uses in the district is 14677.42 ha.m.

Level of Ground Water Development & Stage

The stage of ground water development at year 2017, for all the talukas of the Panchmahal district computed range from 27.45 % to 43.53 % and 7 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 36.55%. Taluka wise ground water resources and categorization for each assessment unit is presented in table 11.

Table No-11 Taluka Wise Ground Water Resources, Availability, Utilization and Stage of Ground Water Development of Panchmahal District (2017)																
Sl. No	**Assessment Unit Name**	**Ground Water Recharge(Ham)**				**Total Annual Ground Water (Ham) Recharge**	**Total Natural Discharges (Ham)**	**Annual Extractable Ground Water Recharge (Ham)**	**Current Annual Ground Water Extraction(Ham)**				**Annual GW Allocation for Domestic Use as on 2025**	**Net Ground Water Availability for future use**	**Stage of Ground Water Extraction (%)**	**Categorization**
		Monsoon Season		**Non-monsoon season**					**Irrigation Use**	**Industrial Use**	**Domestic Use**	**Total Extraction**				
		Recharge from Rainfall	**Recharge from Other Sources**	**Rechargefrom Rainfall**	**Recharge from Other Sources**											
1	Ghoghamba	2802.61	2176.74	0	1059.64	6038.99	301.95	5737.04	2132.4	55	310	2497.4	419	3130.64	43.53	Safe
2	Godhra	5280.2	2420.84	0	1945.73	9646.77	482.34	9164.43	1927.2	116	656.62	2699.82	887	6234.23	29.46	Safe
3	Halol	5282.88	994.29	0	1087.82	7364.98	368.25	6996.73	2428.2	60	338	2826.2	456	4052.53	40.39	Safe
4	Jambughoda	62	763.17	0	944.22	1769.39	88.48	1680.91	608.2	10.9	60	679.1	81	980.81	40.4	Safe
5	Kalol	3005.7	1091.81	0	1620.22	5717.73	285.89	5431.84	1961	54	307	2322	415	3001.84	42.75	Safe
6	Morwahadaf	2882.14	828.89	0	903.7	4614.73	230.74	4383.99	1485	47	265	1797	358	2493.99	40.99	Safe
7	Shehra	629.84	3531.2	0	2955.22	7116.26	355.81	6760.45	1392.5	69.4	394	1855.9	532	4766.55	27.45	Safe
		19945.37	**11806.93**	**0**	**10516.55**	**42268.85**	**2113.45**	**40155.39**	**11934.5**	**412.3**	**2330.62**	**14677.42**	**3148**	**24660.59**	**36.55**	Safe

6. GROUND WATER RELATED ISSUES and REASONS FOR ISSUES

Issues

1. **Low Ground water development**

As per the estimate of ground water resources and irrigation potential, there exists a scope for further development of ground water resources in major parts of the district. As per GWRE 2017 total 07 no blocks of Panchmahal district are under safe category. Ground water stage of development ranges from 27.45 % to 43.53 %. Thus, management of ground water resources could be developed/augmentated in a judicious way.

2. **Pollution (Geogenic and Anthropogenic)**

Ground water in both Phreatic and confined Aquifers is Potable and fit for domestic, drinking, irrigation and other industrial purposes but higher concentration of Fluoride and Nitrate is observed in shallow aquifer at localised pockets.

3. **Sustainability**

In Panchmahal district, the main aquifers being hard rock and valley fill sediments alluvium) yields of the wells vary widely. In the hard rocks the yield depends on the thickness of weathered mantle and persistence of jointing, fracturing which is not uniform in nature. In the valley fill sediments preponderance of clay in the alluvium controls yield of the well. However, the yield of the well tapping valley fill sediments is higher and uniform compared to wells tapping hard rock aquifer. The yield from bore wells have reduced over a period of time and some bore wells which used to yield sufficient quantity of water have gone dry due to low rainfall.

Reasons for Issues

Sustainability: Absence of primary porosity, negligible development of secondary porosity, low rainfall, de saturation of weathered zone and urbanization.

Geo-genic pollution (Fluoride): Higher concentration of fluoride in ground water is attributed due to source rock,

7. MANAGEMENT STRATEGIES IN PANCHMAHAL DISTRICT

As per the estimate of ground water resources and irrigation potential, there exists a scope for further development of ground water resources in major parts of the district. As per GWRE 2017 total 07 no blocks of Panchmahal district are under safe category Ground water stage of development ranges from 27.45 % (Shahera) to 43.53 % (Ghoghamba).Thus, management of ground water resources could be developed/augmentated in a judicious way.

In the entire Panchmahal district, there is a scope exists for further ground water development. Large scale artificial recharge schemes may not be feasible due to shallow water level.

Management plan

The uneven distribution of groundwater availability and its utilization indicates that a single management strategy cannot be adopted and requires integrated hydrogeological aspects along with socio-economic conditions to develop appropriate management strategy. The study suggests notable measures for sustainable groundwater management, which involves a combination of various measures given below.

a) Supply side measures
b) Demand side measures

SUPPLY SIDE INTERVENTIONS

ARTIFICIAL RECHARGE TO GROUND WATER AND WATER CONSERVATION PLAN

IDENTIFICATION OF RECHARGE AREA

An area of about 439.03 sq. km has been identified in District Panchmahal of Gujarat State. Various water bearing geological formations occurring in the district have been categorized broadly in two hydrogeological units, namely, alluvial deposits and consolidated rock units of Deccan trap basalt/intrusives, Godhra Granite and Meta Sediments like Schists & Gneiss. The thickness of available unsaturated zone (below 6 m bgl) is computed on basis of Post monsoon (2010-19) decadal average depth to water level map (Fig 20). Based on the decadal average depth to water level of post monsoon period (2010-19) data and long term trend of ground water level (2010-19) four categories were identified as follows.

Area showing declining trend > 0.10 cm / year and water level between 6-9 m bgl.
Area showing declining trend 0 to 0.10 cm / year and water level between 6 -9 m bgl.
Area showing declining trend > 0.10 cm / year and water level between > 9 m bgl.
Area showing declining trend 0 to 0.10 cm / year and water level between > 9 m bgl.

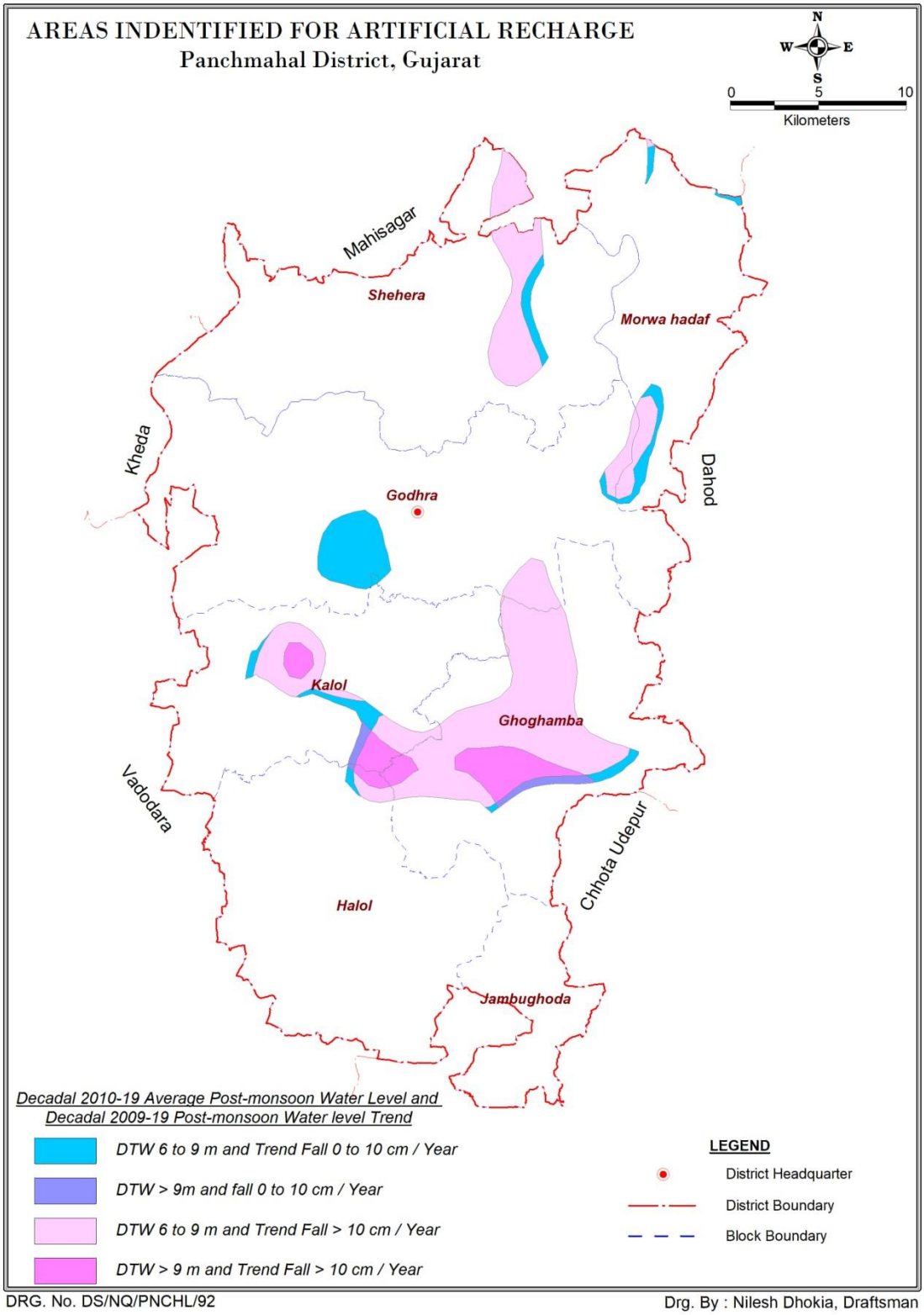


Fig. – 20: Feasible area for Artificial recharge

Table-12 Identification of area feasible for Artificial Recharge in Panchmahal District, Gujarat							
S.No.	**Taluka**	**Aquifer**	**Area(DTW > 9m; Trend 0 to 10cm / year (Sq.km.)**	**Area(DTW > 9m; Trend > 10cm / year (Sq.km.)**	**Area(DTW < 9m; Trend 0to10cm/year (Sq.km.)**	**Area(DTW < 9m; Trend > 10cm / year (Sq.km.)**	**Area feasible for artificial recharge (Sq.km.)**
1	Ghoghamba	Granite & Meta Sediments	6.43	35.57	4.75	157.48	204.23
2	Godhra	Granite & Meta Sediments			38.49	24.05	62.54
3	Halol	Alluvium/basalt/Granite/Meta sediments	0.31	3.67	1.38	5.16	10.53
4	Jambughoda	Granite & Meta Sediments					
5	Kalol	Alluvium/basalt/Granite/Meta sediments	3.10	16.05	9.92	39.37	68.43
6	Morwa hadaf	Meta sediments			11.66	13.54	25.20
7	Shehera	Granite & Meta Sediments			7.91	60.19	68.10
		Total	**9.84**	**55.29**	**74.11**	**299.80**	**439.03**

A total of 439.03 sq. km area spread over the district in the isolated patches having water level & trend as above is computed (Table-12) and same is depicted as suitable areas for artificial recharge.

Table-13 Computation of volume of unsaturated zone available for recharge							
S.No.	Taluka	Aquifer	Volume MCM : DTW > 9 m ; Trend 0 to 10 cm / year	Volume MCM DTW > 9 m ; Trend > 10 cm / year	Volume MCM DTW 6 to 9 m ; Trend 0 to 10 cm / year	Volume MCM DTW 6 to 9 m ; Trend > 10 cm / year	Volume of unsaturated zone available for artificial recharge
		Average Depth unsaturated below 6 m bgl (Excluding clay & impervious hard zones)	6 m	6 m	3 m	3 m	

1	Ghoghamba	Granite & Meta Sediments	38.61	213.43	14.25	472.43	738.72
2	Godhra	Granite & Meta Sediments	0.00	0.00	115.47	72.15	187.63
3	Halol	Alluvium/basalt/Granite/Meta sediments	1.84	22.05	4.15	15.49	43.52
4	Jambughoda	Granite & Meta Sediments	0.00	0.00	0.00	0.00	0.00
5	Kalol	Alluvium/basalt/Granite/Meta sediments	18.57	96.27	29.75	118.11	262.71
6	Morwa hadaf	Meta sediments	0.00	0.00	34.97	40.63	75.59
7	Shehera	Granite & Meta Sediments	0.00	0.00	23.73	180.58	204.31
		Total	**59.01**	**331.76**	**222.32**	**899.40**	**1512.48**

SUB-SURFACE STORAGE SPACE AND WATER REQUIREMENT

Further, while calculating the total volume of unsaturated zone available for recharge, clay & massive non porous intervening zones have been deleted from the total thickness of potential zone for recharge. Average specific yield data of above formations, as per norm of GWRE were considered to compute volume of water required for recharge to saturate dry zones. Storage space volume available in aquifers is 1512.48 MCM. On the basis of specific yield factor of major aquifer system considered, the volume of water required for artificial recharge to fully saturate aquifer (below 6 m bgl) in each talukas areas is around 33.95 MCM (Table 14)

Table-14 Computation of volume of unsaturated zone available for recharge

Sr No	Taluka	Aquifer	Volume of unsaturated zone avilable for artificial recharge MCM	Specific yiled factor	Volume of water required for recharge MCM	Volume of rain water planned for Artificial recharge (MCM)
1	Ghoghamba	Granite & Meta Sediments	738.72	0.02	16.25	
2	Godhra	Granite & Meta Sediments	187.63	0.03	4.69	
3	Halol	Alluvium/basalt/Granite/Meta sediments	43.52	0.03	1.09	
4	Jambughoda	Granite & Meta Sediments	0.00	0.04	0.00	
5	Kalol	Alluvium/basalt/Granite/Meta sediments	262.71	0.02	4.86	
6	Morwa hadaf	Meta sediments	75.59	0.02	1.44	
7	Shehera	Granite & Meta Sediments	204.31	0.03	5.62	
		Total	**1512.48**		**33.95**	

SOURCE WATER AVAILABILITY

The availability of source water, one of the prime requisites of artificial recharge. Gujarat State has been adopted concept of managed aquifer recharge in the state. While planning/finalization of Master plan for Artificial Recharge (2020) to Ground water in Gujarat state it was said that efforts shall be made for supplying surplus water from surface storage for recharging. Also it is expected that under climatic change effect due to change in hydrology more rain fall water may be available. Considering this 15 MCM of surplus surface water is provisioned for artificial recharge in Panchmahal district. 15 MCM of surplus surface water was apportioned with taluka wise and for Panchmahal district 15 MCM of surplus surface water is considered for artificial recharge through 493 no of recharge shafts and 07 no of existing defunct tube wells which can be used as injection wells in Panchmahal district.

Table No 15 Feasibility of Artificial Recharge in Panchmahal District As per master Plan Gujarat 2020.													
Sr No	**District Name**	**Area of District in sqkm**	**Decadal Average (2010-19) Post Monsoon Depth to Water Level (m bgl)**	**Area Feasible for Artificial Recharge**	**Volume of unsaturated zone avilable for recharge (MCM)**	**Volume of Water required for recharge (MCM)**	**Surplus Runoff Availabl e District (As per Master Plan 2020) (MCM**	**Balance Volume of Surplus Local / Distant Sources avilable for recharge (MCM)**	**Additional Percolation Tank Structure Proposed Recharge Capacity @0.14 MCM**	**Additional Check Dam Structure Proposed Recharge Capacity @0.05 MCM**	**PT**	**CD**	**Total Coast (Rs Cores)**
1	**Panchmahal**	3290.57	5.06	439.03	1512.48	33.95	15.00	0.00	As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 15 MCM of surplus surface water is provisioned for artificial recharge through 493 no of recharge shafts and 07 no of existing defunct tube wells which can be used as injection wells in Panchmahal district. Ground water recharge of 1500 ham (through recharge shafts and defunct tube wells) is expected for the district Additional Artificial Recharge Structures are not recommended as Surplus Runoff is not available.				

Ground Water Development Plan

As per GWRE 2017 total 07 no blocks of Panchmahal district are under safe category Ground water stage of development ranges from 27.45 % (Shahera) to 43.53 % (Ghoghamba). To elevate the stage of ground water development to 50% in all blocks, 8591 no Dug wells (20 m depth) and 960 no Bore wells (100m depth) are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 6122 ham which will create 13604.2 Ha additional irrigation potential for the district and same as tabulated below.

Table-16 Water Conservation and Extraction interventions in Panchmahal District of Gujarat State

Sr No	Block	On farm Activities (Area in ha)	Water Use Efficiency (WUE) Measures	No of Farm ponds (30 m x 30m x 1.5 m)	Feasible Extraction structures to elevate the Stage of GW development to 50 % (Soft Rock & Hard Rock)		additional ground water draft(ham) by Extraction structures	Additional Irrigation Potential Created (Ha)
1	Ghoghamba				1070	0	428.00	951.1
2	Godhra				4351	330	2070.4	4600.9
3	Halol				980	190	778	1728.9
4	Jambughoda				395	29	187	415.6
5	Kalol				645	131	453.5	1007.8
6	Morwa Hadaf				850	30	455	1011.1
7	Shahera				300	250	1750	3888.9
	Total				8591.0	960.0	6121.9	13604.2

Creation of irrigation potential on safe development of groundwater.

Based on the additional groundwater availability (GWRE 2017) in the district, created additional irrigation potential area to keep the groundwater development under safe condition (upto 50%). About 13604.2 Ha, additional area may be irrigated by developing stage of groundwater upto 50%.

Demand side intervention

Along with development plan to prevent Over Exploitation, water conservation activities like on farm activities and farm ponds are recommended in the district. By these activities where groundwater extraction can be developed up to 50% i.e., under safe category.

Water use efficiency/Water conservation activities by application of on-farm activities and farm pond:

Table-17 Proposed Artificial recharge and Water Conservation interventions in Panchmahal District of Gujarat State

Sr No	Block	On farm Activities (Area in ha)	No of Farm ponds (30 m x 30m x 1.5 m)	Expected Annual Recharge(Through On farm activities and GW return flow) ham	Conservation from On-farm Activities, & Farm Ponds(ham)
1	Ghoghamba	2042	378	315.48	138.44
2	Godhra	625	705	435.17	237.69
3	Halol	105	580	212.78	204
4	Jambughoda	0	100	48.62	37.06
5	Kalol	684	402	186.31	144.12
6	Morwa Hadaf	252	336	143.4	118.95
7	Shahera	681	525	523.1	176.56
	Total	4389	3026	1864.86	1056.82

4389 Ha area is proposed for on farm activities (Laser leveling/Bench terracing/Contour banding) and 3026 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water. Ground water recharge of 1864.86 ham (through on farm activities and GW return flow) is expected for the district.1056.82 ham saving of ground water through on farm activities & farm ponds activities is expected for the district.

Farm Ponds

A farm pond is a large hole dug out in the earth, usually square or rectangular in shape (Fig. 21), which harvests rainwater and stores it for future use. It has an inlet to regulate inflow and an outlet to discharge excess water. The pond is surrounded by a small bund, which prevents erosion on the banks of the pond. The size and depth depend on the amount of land available, the type of soil, the farmer's water requirements, the cost of excavation, and the possible uses of the excavated earth. Water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

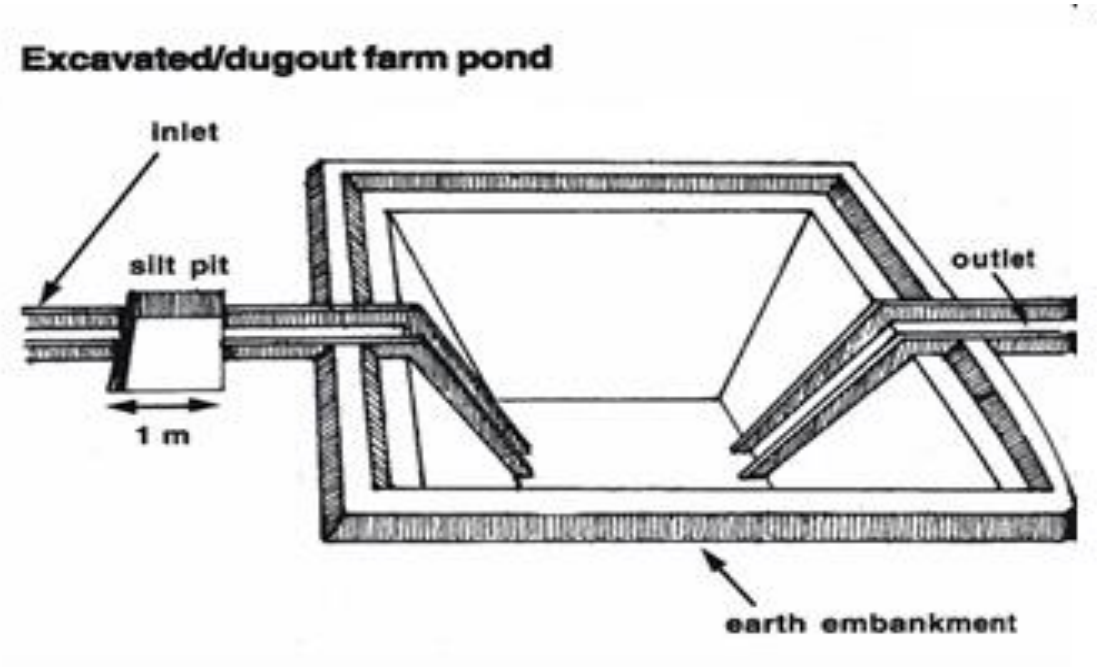


Fig. 21: Thematic diagram of Farm pond

Advantages of Farm Ponds

- They provide water to start growing crops, without waiting for rain to fall.
- They provide irrigation water during dry spells between rainfalls. This increases the yield, the number of crops in one year, and the diversity of crops that can be grown.
- Bunds can be used to raise vegetables and fruit trees, thus supplying the farm household with an additional source of income and of nutritious food.
- Farmers are able to apply adequate farm inputs and perform farming operations at the appropriate time, thus increasing their productivity and their confidence in farming.
- They check soil erosion and minimize siltation of waterways and reservoirs.
- They supplies water for domestic purposes and livestock
- They promote fish rearing.
- They recharge the ground water.
- They improve drainage.
- The excavated earth has a very high value and can be used to enrich soil in the fields, levelling land, and constructing farm roads

It is proposed to construct 3026 farm ponds as per the specification (30 x 30 x 1.5 m). Considering 3 fillings this can accommodate **9.37** MCM of runoff rainfall. Farm ponds can be constructed in the village at feasible location. Dimension of the farm pond depends on land holdings.

Table No-18 Projected Status of Groundwater Resource after implementation of GW Management Plan of Panchmahal District of Gujarat state

Sr No	Taluka	Net G.W. Availability (Ham)	Additional Recharge from Recharge interventions (ham)	Additional Recharge from Return flow of GW Irrigation	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Conservation of Ground water through WUE, on farm activity & farm ponds (ham)	G.W Draft from Extraction structures (ham)	Net GW draft after interventions (ham)	Present stage of G.W. Development (%)	Projected stage of G.W. Development after construction of extraction structures (%)	Projected stage of GW development after construction of extraction structures & implementation of conservation measures(in %)	Projected stage of GW development after construction of extraction structures & implementation of conservation measures & Recharge measures (in %)	Additional Irrigation Potential Created (Ha)
1	Ghoghamba	5737.04	423.20	111.28	6271.52	2497.40	209.00	428.00	2716.40	**43.53**	**50.02**	**44.88**	**43.31**	951.11
2	Godhra	9164.43	419.50	372.67	9956.61	2699.82	246.55	2070.40	4523.67	**29.46**	**50.02**	**47.12**	**45.43**	4600.89
3	Halol	6996.73	232.50	202.28	7431.51	2826.20	184.42	778.00	3419.78	**40.39**	**50.07**	**47.43**	**46.02**	1728.89
4	Jambughoda	1680.91	72.00	48.62	1801.53	679.10	30.98	187.00	835.12	**40.40**	**50.08**	**48.29**	**46.36**	415.56
5	Kalol	5431.84	257.40	117.91	5807.15	2322.00	155.33	453.50	2620.17	**42.75**	**50.01**	**46.64**	**45.12**	1007.78
6	Morwa Hadaf	4383.99	178.10	118.30	4680.39	1797.00	115.40	455.00	2136.60	**40.99**	**50.02**	**47.19**	**45.65**	1011.11
7	Shahera	6760.45	356.10	455.00	7571.55	1855.90	193.30	1750.00	3412.60	**27.45**	**49.97**	**46.85**	**45.07**	3888.89
			1938.80	1426.06	43520.25	14677.42	1134.99	6121.90	19664.33	**37.85**	**50.03**	**46.92**	**45.28**	13604.22

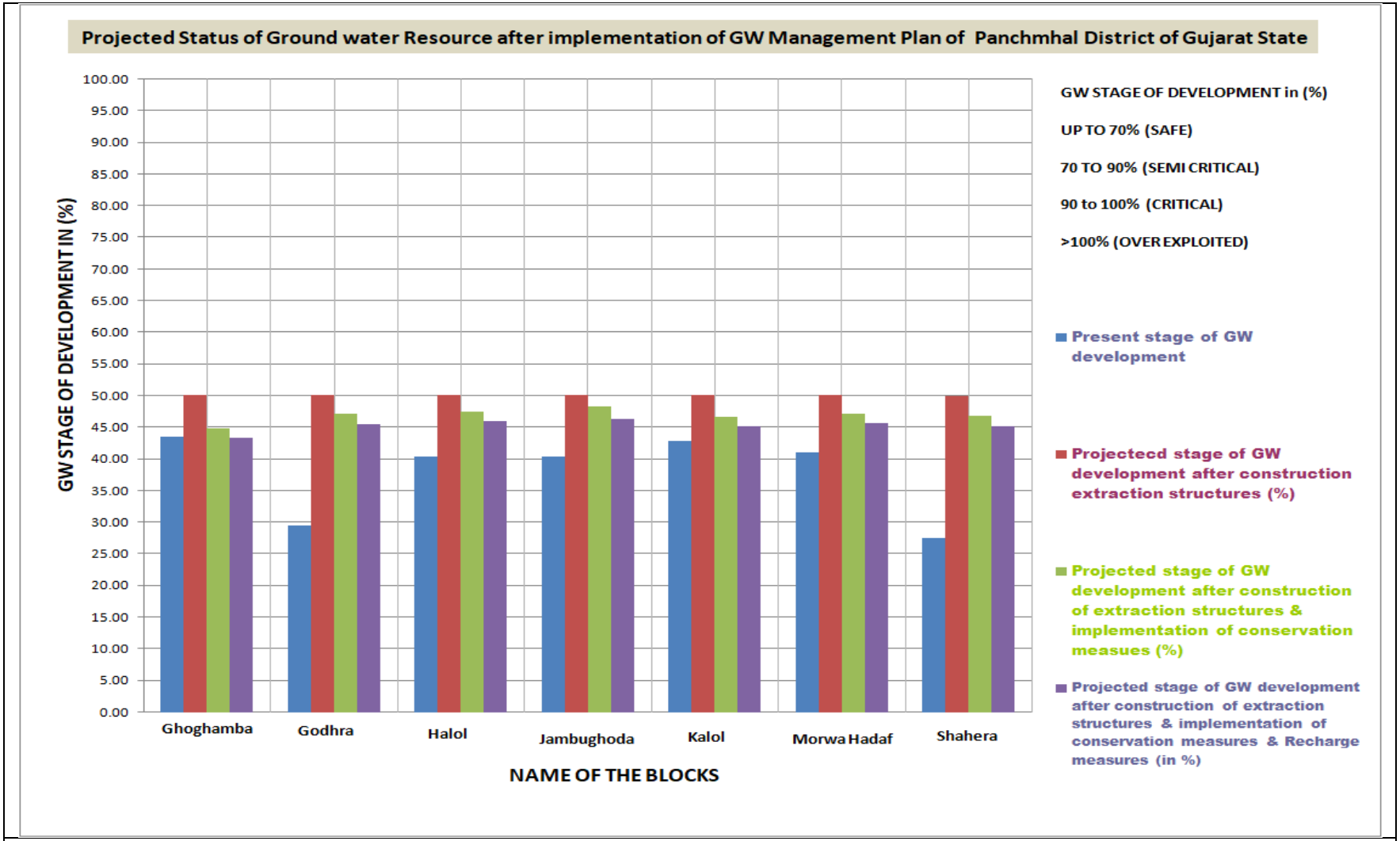


Fig No 22 showing by adopting above management strategies, projected stage of Ground water extraction after creating additional abstraction structures is 50 % for 07 no blocks in Panchmahal district. Projected stage of Ground Water extraction after adopting Artificial Recharge and additional conservation activities is 45.28 % for 07 no blocks in Panchmahal district.

Table- 19 Summary of Interventions, Expected Benefits and Cost Estimates of Panchmahal district of Gujarat State									
Interventions Recommended		**Ghoghamba**	**Godhra**	**Halol**	**Jambughoda**	**Kalol**	**Morwa hadaf**	**Shehera**	**Total**
On-farm Activities (ha)		2042.00	625.00	105.00	0.00	684.00	252.00	681.00	**4389.00**
No of Farm Ponds		378.00	705.00	580.00	100.00	402.00	336.00	525.00	**3026.00**
Feasible Extraction structures to elevate the Stage of GW development to 50% (Soft/Hard rock)	DW	1070.00	4351.00	980.00	395.00	645.00	850.00	300.00	**8591.00**
	BW	0.00	330.00	190.00	29.00	131.00	30.00	250.00	**960.00**
Expected Benefits									**0.00**
Expected Annual Recharge(Through On farm activities and GW return flow) ham		315.48	435.17	212.78	48.62	186.31	143.40	523.10	**1864.86**
Expected Annual Recharge(Recharge Shaft & Defunct Tube wells) ham		219.00	387.00	222.00	72.00	189.00	153.00	288.00	**1530.00**
Conservation from On-farm Activities, WUE Measures & Farm Ponds ham		209.00	246.55	184.42	30.98	155.33	115.40	193.30	**1134.99**
Total Recharge/ Saving (ham)		743.48	1068.72	619.20	151.60	530.64	411.80	1004.40	**4529.85**
Additional Irrigation Potential Created (Ha)		951.11	4600.89	1728.89	415.56	1007.78	1011.11	3888.89	**13604.22**

8. CONCLUSION AND RECOMMENDATIONS

- To elevate the stage of ground water development to 50 % in all blocks, 8591 no Dug wells (20 m depth) and 960 no Bore wells (100m depth) are proposed as feasible extraction structures.

- Artificial recharge structures like recharge shafts and Defunct Tube well are suggested as 15 MCM surplus surface water is provisioned as per the data provided by the State Water Resources Department.

- To prevent Over Exploitation, water conservation activities like On farm activities , farm ponds and Micro irrigation system (Sprinkler/drip) are recommended.

- As a conservation measure, farmers should be encouraged and educated to adopt modern irrigation techniques like drip, sprinkler irrigation etc. to effect minimum withdrawal and maximum utilisation of groundwater.

- The water quality in general is good. However higher EC values and fluoride concentration is observed in isolated pockets. Ground water in such areas may be used after blending with surface water. In areas where ground water has higher concentration of Nitrate is observed, necessary sanitation measures should be adopted.

- If surface water is not available in aforesaid areas with quality issues there water supply tube wells may be constructed tapping deeper aquifer after casing the Phreatic aquifer.

9. Taluka Reports

Aquifer Maps And Management Plan for Talukas

Aquifer Information and Management plan of for Ghoghamba Block of Panchmahal District, Gujarat state.

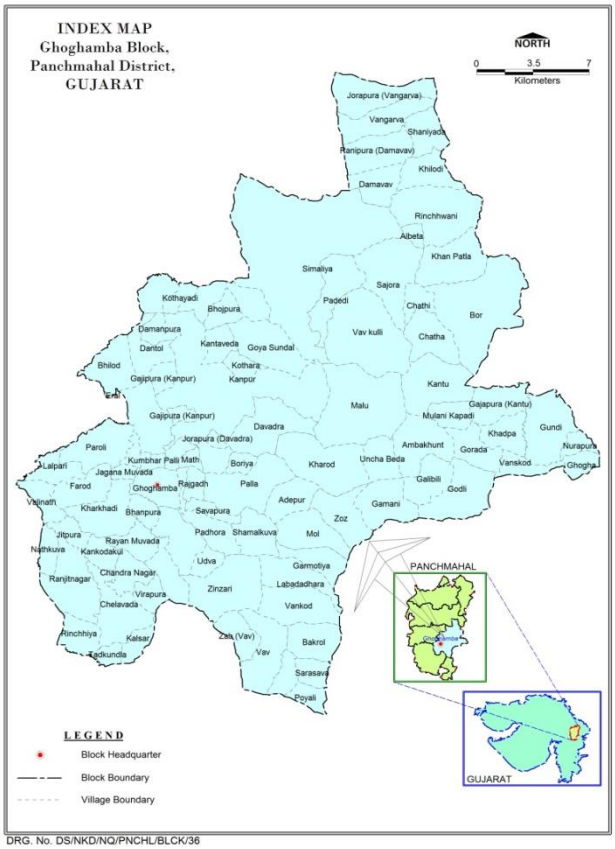
General Information

State Name : Gujarat

District name : Panchmahal

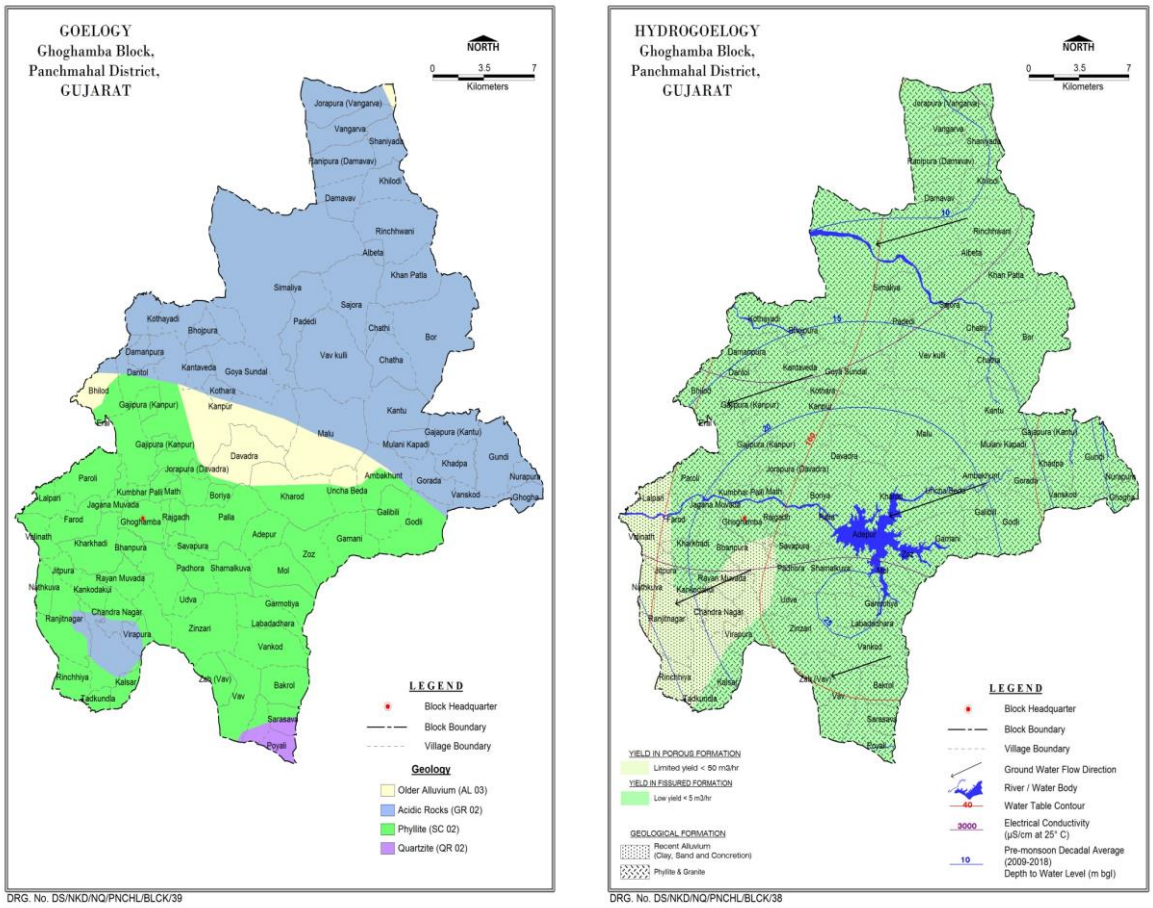
Block Name : Ghoghamba

Location



DRG. No. DS/NKD/NQ/PNCHL/BLCK/36

Salient Features		
Area (Km^2):		465.55
No. of Villages:		101
Population:		1,79,659
Density of Population/Km^2:		385
Net Sown Area in ha		27694
Gross Sown Area in ha		29544
Gross Irrigated Area in ha		7260
Area Irrigated by GW (%):		62.56
Cropping Intensity (%):		106.68
Irrigation Intensity (%):		22.4
Principal crops	Kharif:	Maize, Paddy & Tur
	Rabi:	Wheat,Gram
	Summer:	Bajra,Groundnut & Maize



Geology and Hydrogeology maps of Ghoghamba taluka Panchmahal District.

Geographical Area : 465.55 sq. km.

Basin/Sub-basin : Major Drainages: Goma, Amba & Magarimoti

Principal Aquifer System : Alluvium, Shale, Granite, Schist and Quartzite.

Major Aquifer System : Meta-sediments of Aravalli super group such as Phyllites, quartzite; 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.

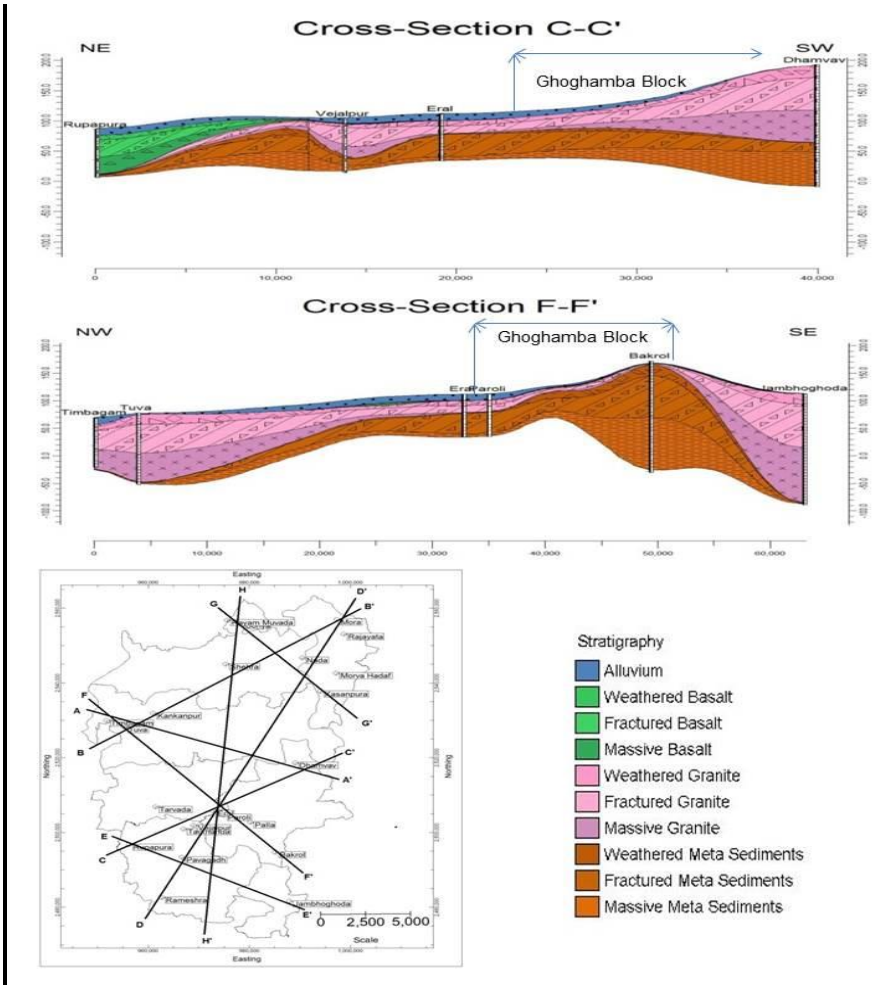
Normal Annual Rainfall : 899 mm

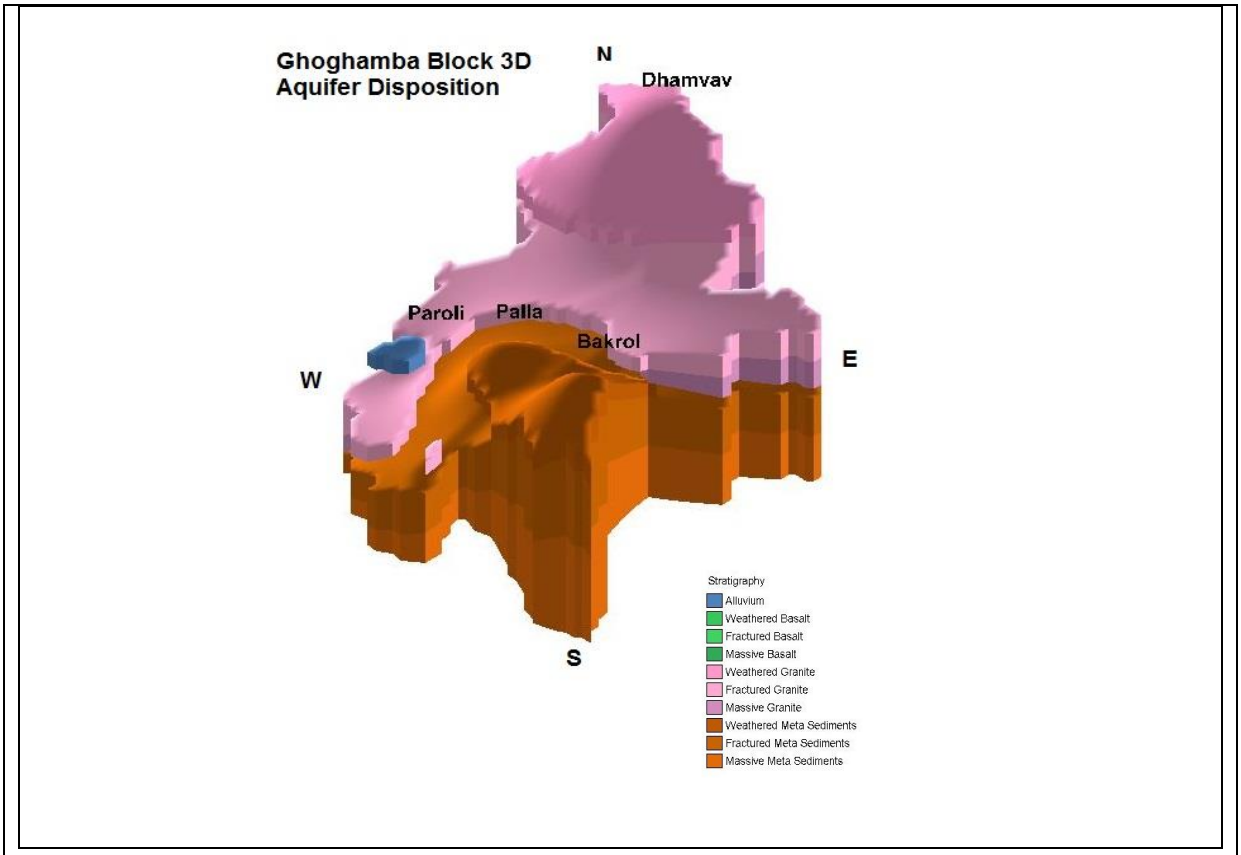
Aquifer Disposition

The Ghoghamba taluka of 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 like Schist, Phyllite and Quartzite. 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.

Aquifer Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Nature of Aquifer
Holocene	Alluvium	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	Phreatic
Upper Proterozoic	Weathered Granite	Granite & Granodiorite	0 to 24	16 to 24	Phreatic
	Fractured Granite	Granite & Granodiorite	55 to 75		Fractured
Lower Proterozoic	Weathered Meta Sediments	Phyllite, mica schist, quartzite	0 to 20	15 to 20	Phreatic
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		Fractured





Status of GW Exploration : Exploratory Wells: 02, Observation Wells: 00

Aquifer Characteristics

Aquifer Characterisation and Disposition										
Stratigraphy	**Aquifer Nomenclature**	**Lithological Characteristics**	**Depth of occurrence Aquifer (mbgl)**	**Thickness Range (m)**	**Water Level (mbgl) Range (mbgl)**	**Quality (TDS) Range Mg/l**	**Discharge Range lps**	**Transmissivity Range m2/day**	**Nature of Aquifer**	**Remarks**
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		3 to 21	300 to 1700	0.1 to 6.3	322 to 1300	**Fractured**	Good Quality

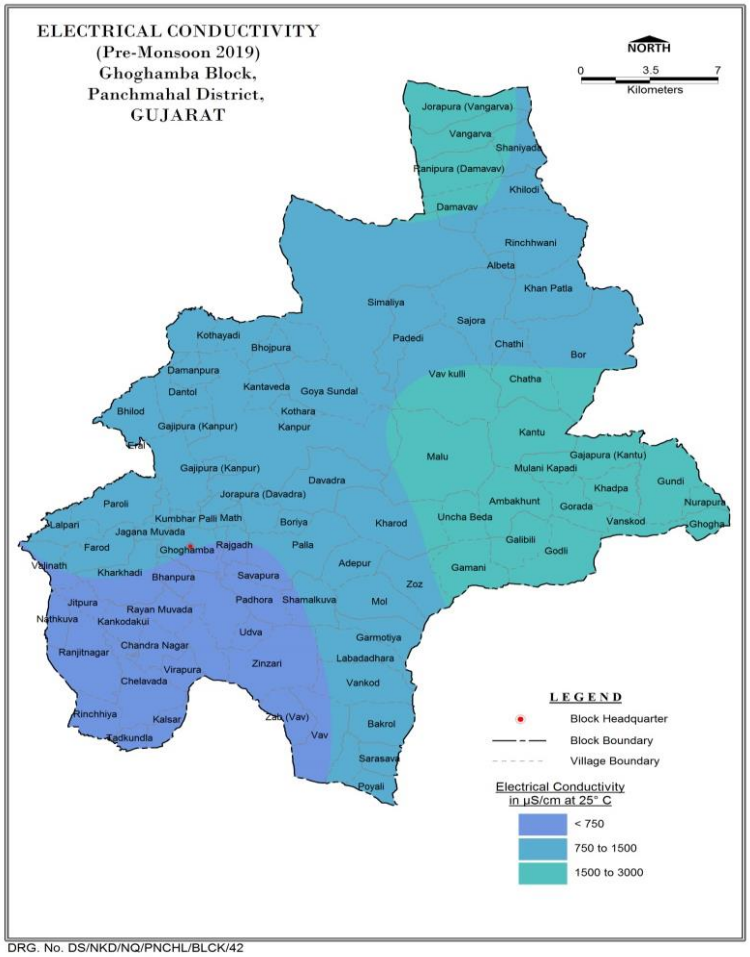
Groundwater Monitoring Status

CGWB- Dug wells : 01, Piezometers :03

GWRDC- Dug wells : 04, Piezometers :05

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 530 to 1820 micromhos/cm at 25°c, for the Ghoghamba taluka.
- Weathered Aquifer and Fractured Aquifer: Potable and fit for domestic, drinking, irrigation and other industrial purposes.



DRG. No. DS/NKD/NQ/PNCHL/BLCK/42

Summarised Chemical Data of Goghamba taluka of Panchmahal District.														
Chemical Parametres	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8.3	530	125	339	12	96	0	0	2.36	30	12	59	1.15	0.46
Max	9.1	1820	525	1160	183	353.8	320	163	45	90	72	216	9.03	1.29
Average	8.7	903.33	249	351.3	90.7	179.7	77.3	43.96	22.64	46.11	32	91.3	3.8	0.97
* All values are in mg/l except pH and EC in µS/cm at 25°C														

Groundwater Resource

- GW Availability 5737.04 ham (Dynamic)
- GW Draft 2497.40 ham
- Stage of GW Development 43.53%
- Total Ground Water resource including both dynamic & in storage for district is 13027.04 ham. (Dynamic:5737.04 ham & In storage: 7290 ham)

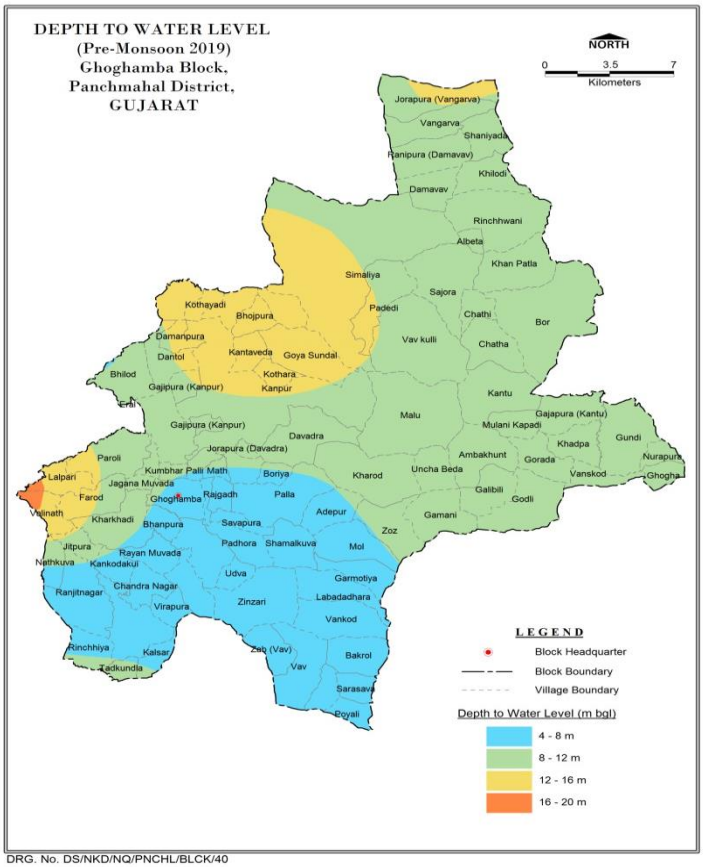
Existing and Future Water Demand

- Present demand for All Usage: 2497.40 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 419.00 ham.
- Net Ground Water availability for future use is 3130.64 ham.

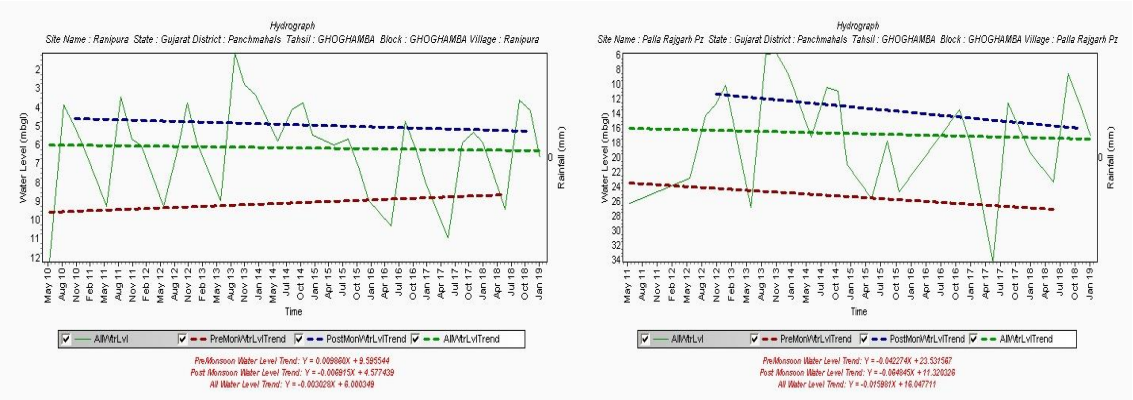
Aquifer Management plan

Groundwater Management Issues

- Low yield and Sustainability of hard rock Aquifers & Non Availability of sufficient Surface Water for Irrigation.
- It is observed that the annual water level trend of all wells showing stabled trend but in pre monsoon season few wells showing feeble declining trend.



DRG. No. DS/NKD/NQ/PNCHL/BLCK/40



Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Ghoghamba taluka is 43.53 %.To elevate the stage of ground water extraction to 50% in Ghoghamba taluka, 1070 no of Dug wells (20 m dpth) and 0.00 no of Bore wells (100 m depth) in Hard rock areas are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 428.00 ham which will create 951.11 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 2.20 MCM of surplus surface water is provisioned for artificial recharge through 72 no of recharge shafts and 01 no of existing defunct tube wells which can be used as injection wells in Ghoghamba taluka of Panchmahal district .Ground water recharge of 219.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  To prevent Over Exploitation water conservation activities in 2042.00 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 378 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.Ground water recharge of 315.48 ham (through on farm activities and GW return flow) is expected for the taluka.209.00 ham saving of ground water through WUE measures & farm ponds activities is expected for the taluka.
- **Outcome**
  By adopting above management strategies, projected stage of Ground water development after creating additional extraction structures is 50 % in the Ghoghamba Block. Projected stage of Ground Water development after additional conservation activities is 43.31 % in the Ghoghamba Block.

Aquifer Information and Management plan of for Godhra Block of Panchmahal District, Gujarat state.

State Name : Gujarat

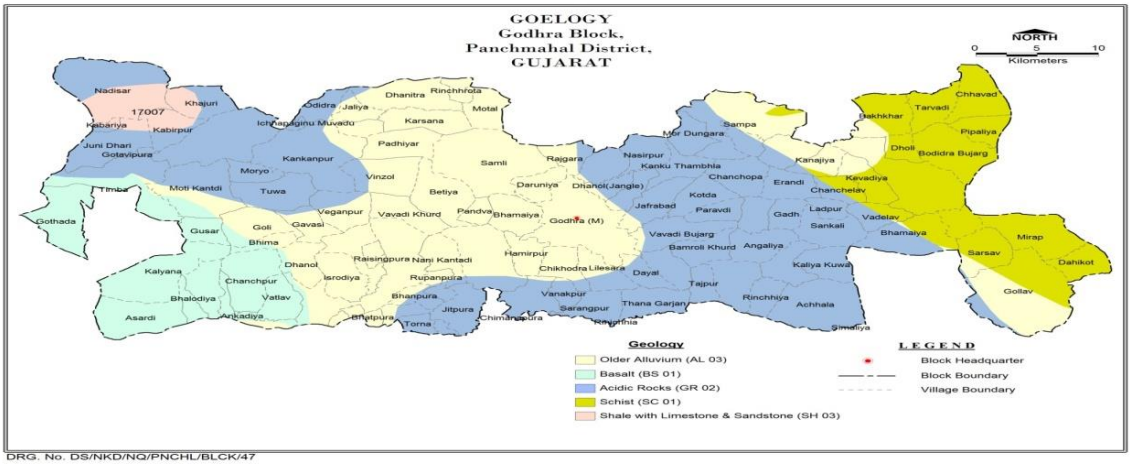
District name : Panchmahal

Block Name : Godhra

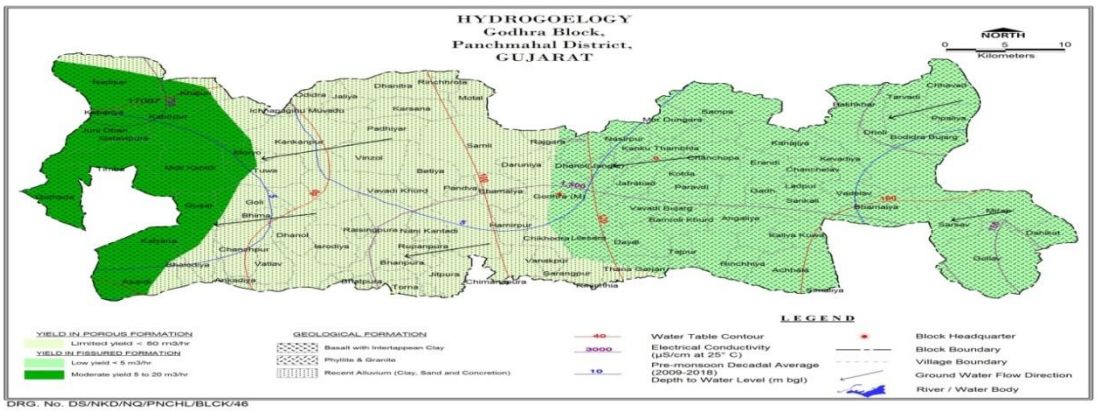
Location

DRG. No. DS/NKD/NQ/PNCHL/BLCK/44

Salient Features		
Area (Km^2):		757.3
No. of Villages:		116
Population:		2,62,491
Density of Population/Km^2:		347
Net Sown Area in ha		43528
Gross Sown Area in ha		46428
Gross Irrigated Area in ha		18936
Area Irrigated by GW (%):		9.56
Cropping Intensity (%):		109.17
Irrigation Intensity (%):		50.73
Principal crops	**Kharif:**	Maize,Paddy & Tur
	Rabi:	Wheat,Gram
	Summer:	Bajra,Groundnut & Maize



DRG. No. DS/NKD/NQ/PNCHL/BLCK/47



Geology and Hydrogeology maps of Godhra taluka Panchmahal District.

Geographical Area :757.30 sq. km.

Basin/Sub-basin : Major Drainages: Mahi,Bapoi,Kun & Misery

Principal Aquifer System : Alluvium, Basalt, Shale, Granite, Schist and Quartzite.

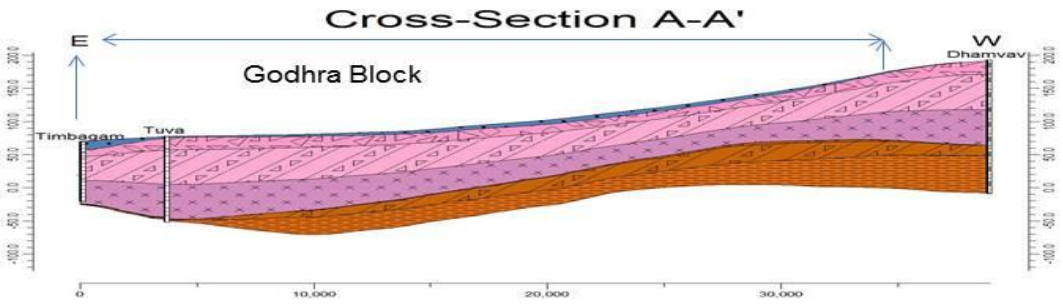
Major Aquifer System : Meta-sediments of Aravalli super group such as Phyllites, quartzite; post Delhi intrusive of Godhra granite and gneiss; Infra-trappean of lameta beds; sandstones and limestone; Deccan trap basalts and alluvium deposit along river channels and valley fills.

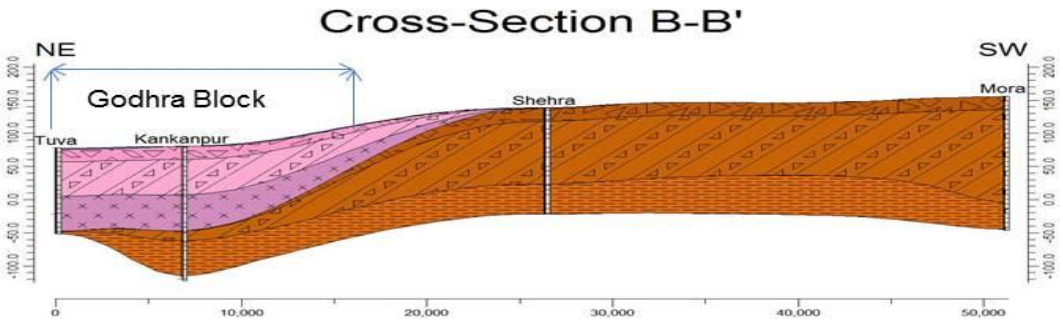
Normal Annual Rainfall : 717 mm

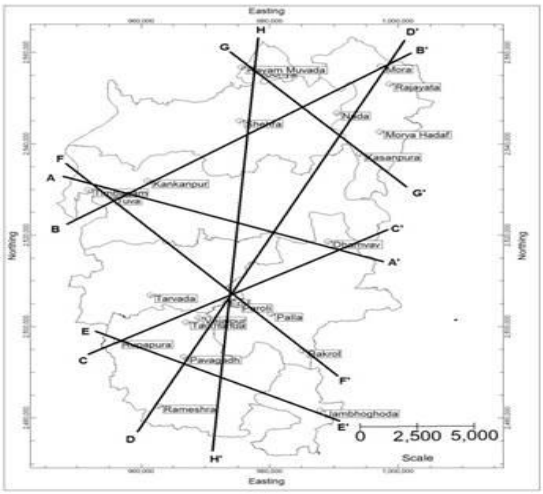
Aquifer Disposition

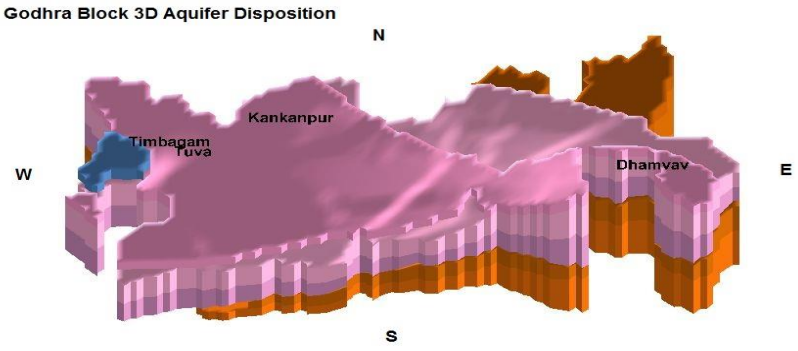
The Godhra taluka of Panchmahal district has two main hydrogeological provinces consisting of hard rock type and soft rock. In the hard rock, it is constituted of Meta sediments and Deccan traps. In soft rock type, it ha alluvium and sandstone. Each terrain has varied hydro-geochemical regime. Groundwater of the distric originates as rainwater that infiltrates through soil into flow system in the underlying geologic material. I Panchmahal district, higher plateau and hill zones of eastern part constitute as recharge areas, which is underlai by granitic rocks and metasediments. The discharge area constitutes alluvium plain in western and south wester part of the district, facing Arabian Sea.

Aquifer Disposition					
Stratigraphy	**Aquifer Nomenclature**	**Lithological**	**Depth of occurrence**	**Thickness**	**Nature of Aquifer**
		Characteristics	**Aquifer (mbgl)**	**Range (m)**	
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	Phreatic
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	Phreatic
	Fractured Basalt	Basalts & Rhyolite	40 to 54		**Fractured**
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	Phreatic
	Fractured Granite	Granite & Granodiorite	55 to 75		**Fractured**
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	Phreatic
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		**Fractured**









Status of GW Exploration : Exploratory Wells: 05, Observation Wells: 00

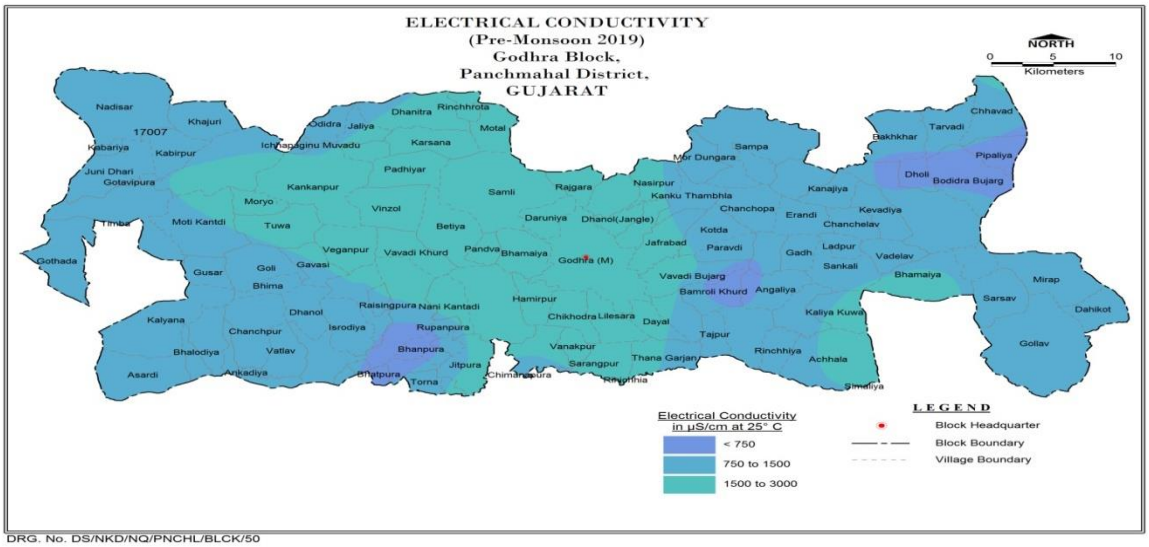
Aquifer Characterisation and Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
	Fractured Basalt	Basalts & Rhyolite	40 to 54		2 to 16	300 to 2000	1 to 4	0.19 to 1000	**Fractured**	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		3 to 21	300 to 1700	0.1 to 6.3	322 to 1300	**Fractured**	Good Quality

Groundwater Monitoring Status : CGWB- Dug wells : 05, Piezometers :02 , GWRDC- Dug wells : 09, Piezometers :06

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 310 to 2800 micromhos/cm at 25°c, for the Godhra taluka.
- Weathered Aquifer and Fractured Aquifer: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Panchmahal district has a number of medium and small scale industries set 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. The major key business involved are engineering, 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.



Summarised Chemical Data of Godhra taluka of Panchmahal District.														
Chemical Parametres	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8.1	310	113	198	0	72	0	0	0.9	25	12	19	1.57	0.56
Max	9	2800	668.17	1792	183	544	488	389	65	100	129	331	15.78	1.25
Average	8.5	1256.4	340.5	503.5	61.9	201.3	179.4	86.3	22.3	50.5	51.5	128.9	5.5	0.89
* All values are in mg/l except pH and EC in µS/cm at 25°C														

Groundwater Resource

- GW Availability 9164.43 ham (Dynamic)
- GW Draft 2699.82 ham
- Stage of GW Development 29.46%
- Total Ground Water resource including both dynamic & in storage for district is 40133.43 ham. (Dynamic:9164.43 ham & In storage: 30969 ham)

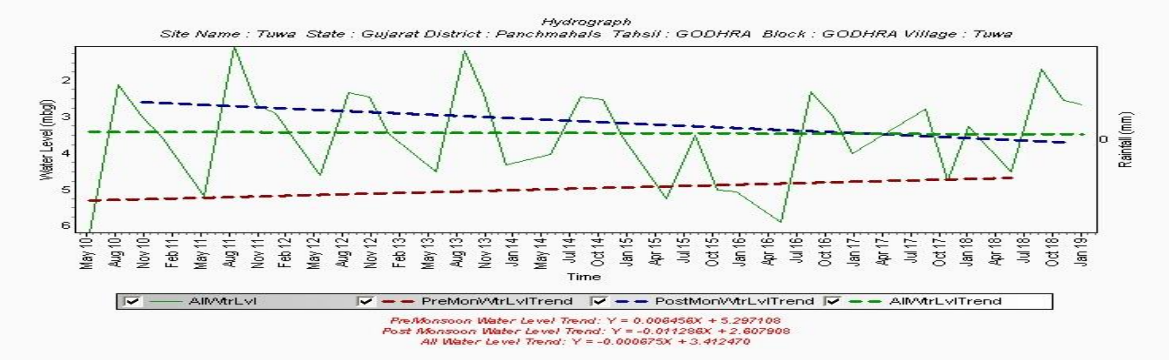
Existing and Future Water Demand

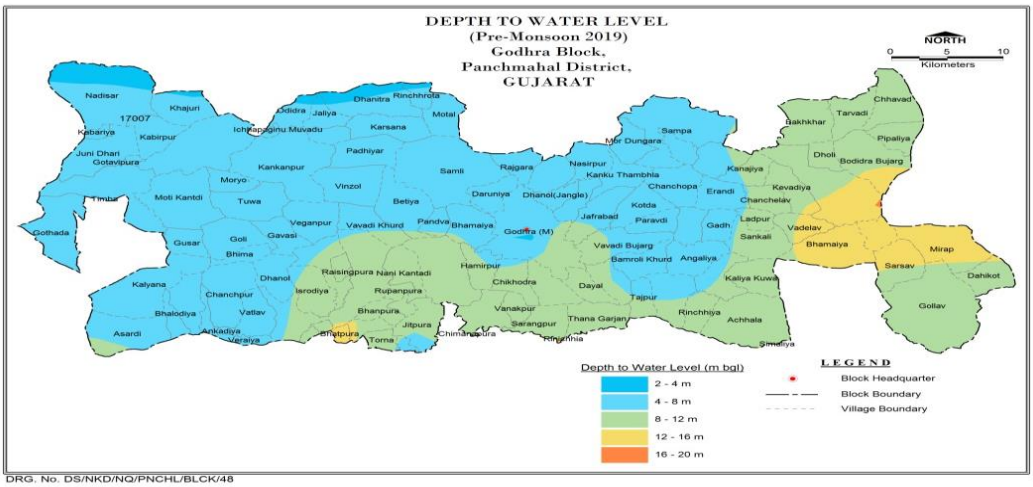
- Present demand for All Usage: 2699.82 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 887.00 ham.
- Net Ground Water availability for future use is 6234.23 ham.

Aquifer Management plan

Groundwater Management Issues

- Low yield and Sustainability of hard rock Aquifers & Non Availability of sufficient Surface Water for Irrigation.
- It is observed that the annual water level trend of all wells showing stabled trend but in pre monsoon season few wells showing feeble declining trend.
- Occurrence of excessive Nitrate in Shallow aquifers at isolated villages.
- Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future





Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Godhra taluka is 29.45 %.To elevate the stage of ground water extraction to 50% in Godhra taluka, 4351 no of Dug wells (20 m dpth) and 330 no of Bore wells (100 m depth) in Hard rock areas are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 2070.00 ham which will create 4600.89 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 3.58 MCM of surplus surface water is provisioned for artificial recharge through 118 no of recharge shafts and 01 no of existing defunct tube wells which can be used as injection wells in Godhra taluka of Panchmahal district .Ground water recharge of 387.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  To prevent Over Exploitation water conservation activities in 625.00 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 705 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.Ground water recharge of 435.17 ham (through on farm activities and GW return flow) is expected for the taluka.246.55 ham saving of ground water through WUE measures & farm ponds activities is expected for the taluka.
- **Outcome**
  By adopting above management strategies, projected stage of Ground water development after creating additional extraction structures is 50 % in the Godhra Block. Projected stage of Ground Water development after additional conservation activities is 45.43 % in the Godhra Block.

Aquifer Information and Management plan of for Halol Block of Panchmahal District, Gujarat state.

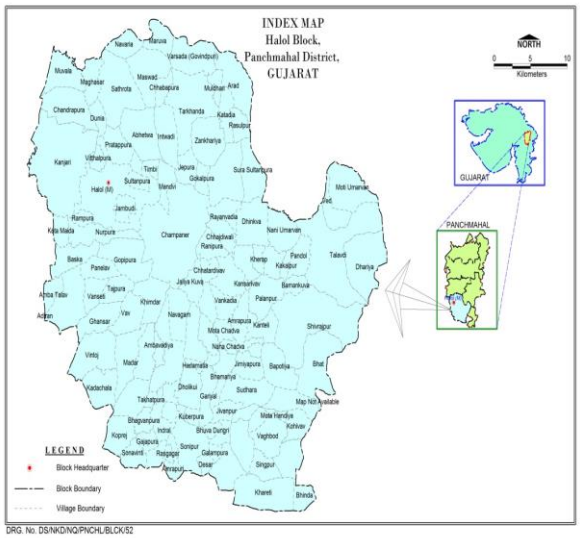
General Information

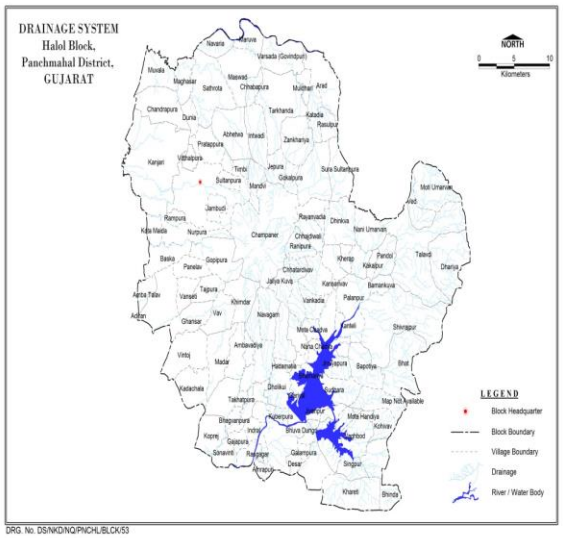
State Name : Gujarat

District name : Panchmahal

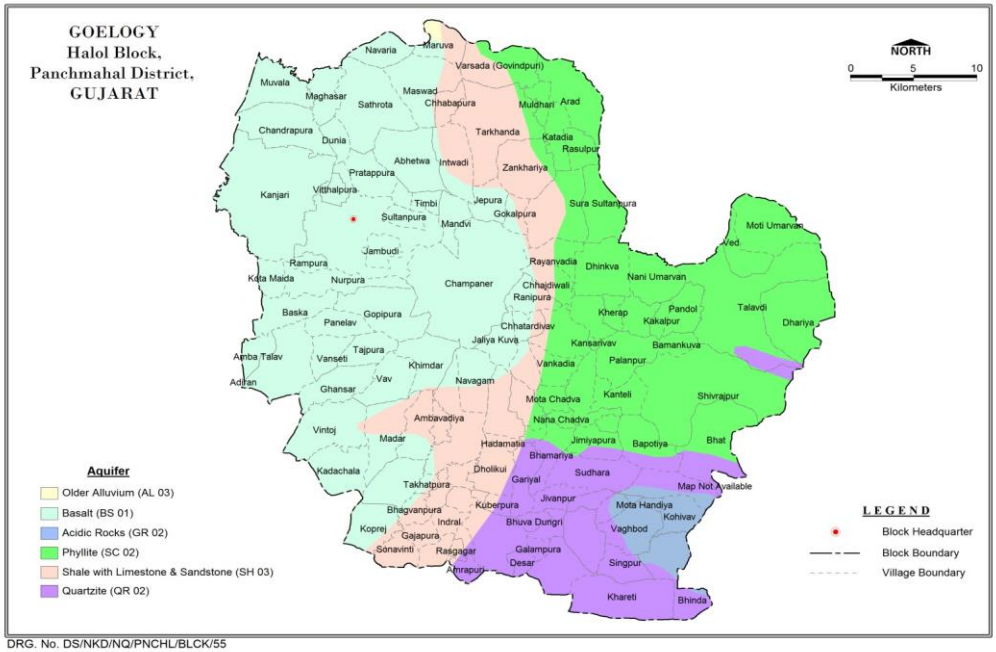
Block Name: Halol

Location

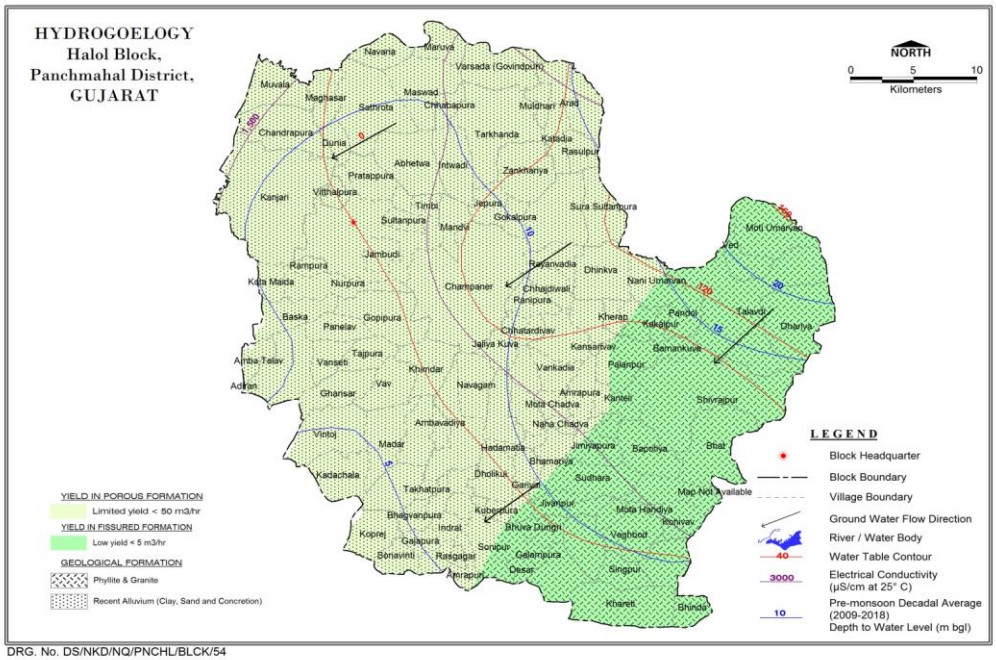




Salient Features		
Area (Km^2):		470.7
No. of Villages:		122
Population:		1,95,300
Density of Population/Km^2:		415
Net Sown Area in ha		25907
Gross Sown Area in ha		28057
Gross Irrigated Area in ha		7499
Area Irrigated by GW (%):		83.82
Cropping Intensity (%):		108.3
Irrigation Intensity (%):		26
Principal crops	Kharif:	Maize, Paddy & Tur
	Rabi:	Wheat, Gram
	Summer:	Bajra,Groundnut & Maize



DRG. No. DS/NKD/NQ/PNCHL/BLCK/55



DRG. No. DS/NKD/NQ/PNCHL/BLCK/54

Geographical Area : 470.70 sq. km.

Basin/Sub-basin : Major Drainages: Dev

Principal Aquifer System: Alluvium, Basalt, Shale, Granite, Schist and Quartzite.

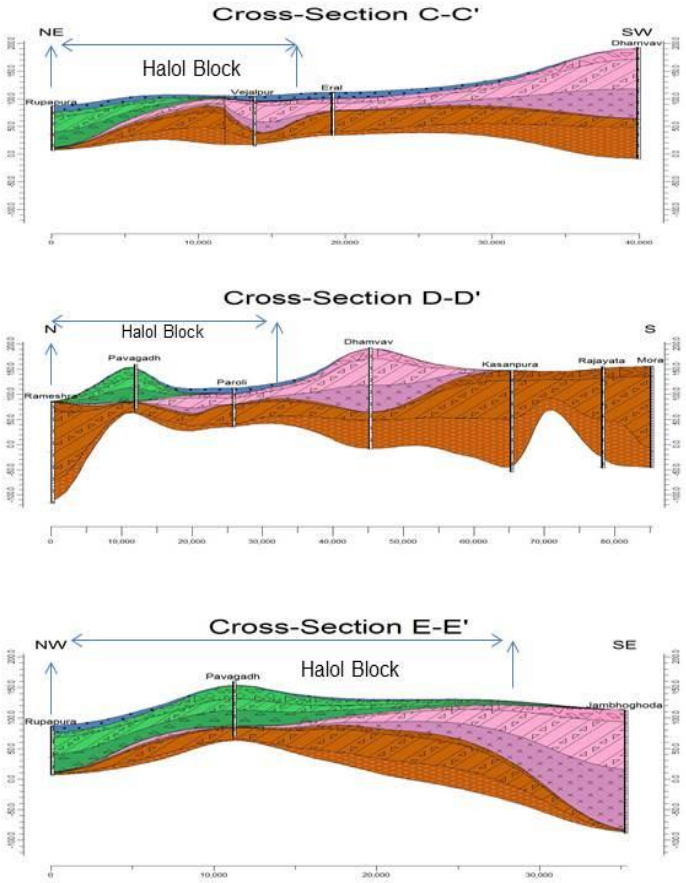
Major Aquifer System : Meta-sediments of Aravalli super group such as Phyllites, quartzite; post Delhi intrusive of Godhra granite and gneiss; Infra-trappean of lameta beds; sandstones and limestone; Deccan trap basalts and alluvium deposit along river channels and valley fills.

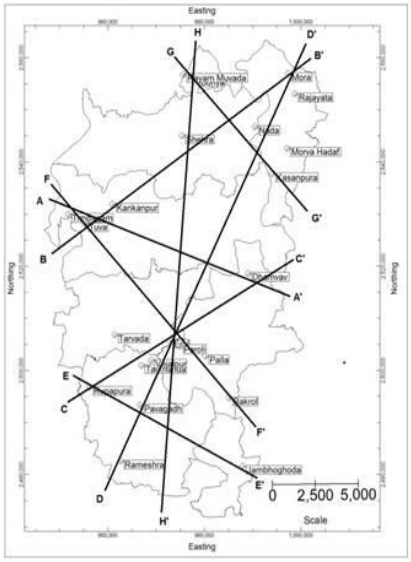
Normal Annual Rainfall : 971.50 mm

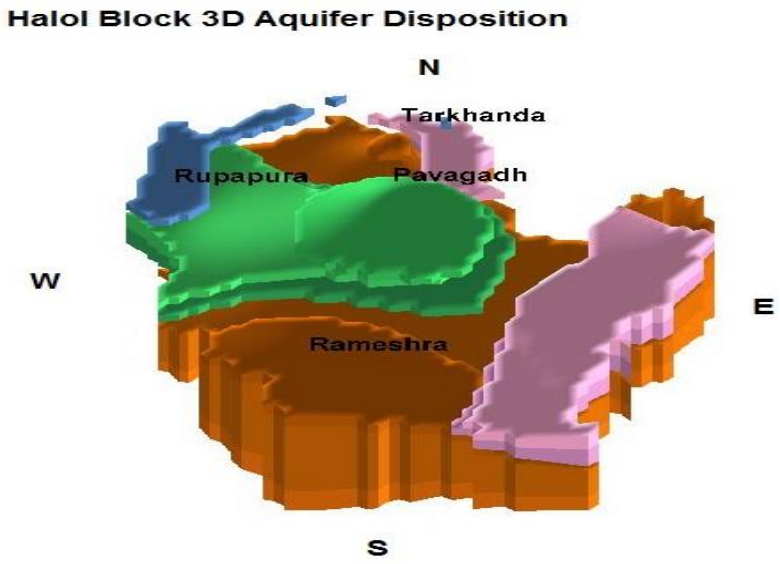
Aquifer Disposition

The Halol taluka of 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.

Aquifer Disposition					
Stratigraphy	**Aquifer Nomenclature**	**Lithological**	**Depth of occurrence**	**Thickness**	**Nature of Aquifer**
		Characteristics	**Aquifer (mbgl)**	**Range (m)**	
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	Phreatic
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	Phreatic
	Fractured Basalt	Basalts & Rhyolite	40 to 54		**Fractured**
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	Phreatic
	Fractured Granite	Granite & Granodiorite	55 to 75		**Fractured**
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	Phreatic
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		**Fractured**







Status of GW Exploration : Exploratory Wells: 11, Observation Wells: 01

Aquifer Characterisation and Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
	Fractured Basalt	Basalts & Rhyolite	40 to 54		2 to 16	300 to 2000	1 to 4	0.19 to 1000	**Fractured**	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		3 to 21	300 to 1700	0.1 to 6.3	322 to 1300	**Fractured**	Good Quality

Groundwater Monitoring Status

CGWB- Dug wells : 03, Piezometers :04

GWRDC- Dug wells : 04, Piezometers :05

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 470 to 3370 micromhos/cm at 25°c, for the Halol taluka.
- Weathered Aquifer and Fractured Aquifer: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Panchmahal district has a number of medium and small scale industries set 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. The major key business involved are engineering, 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.

Summarised Chemical Data of Halol taluka of Panchmahal District.

Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8.30	470.00	138.00	300.00	24.00	72.00	0.00	0.00	15.68	40.00	9.00	40.00	0.88	0.84
Max	8.60	3370.00	575.00	2157.00	366.00	720.00	304.00	30.00	200.00	200.00	42.00	510.00	9.59	1.33
Average	8.52	1128.33	252.33	102.33	147.69	209.73	90.17	14.14	65.11	71.67	17.50	142.17	2.40	1.11

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

Groundwater Resource

- GW Availability 6996.73 ham (Dynamic)
- GW Draft 2826.20 ham
- Stage of GW Development 40.39%
- Total Ground Water resource including both dynamic & in storage for district is 31547.73 ham. (Dynamic:6996.73 ham & In storage: 24551 ham)

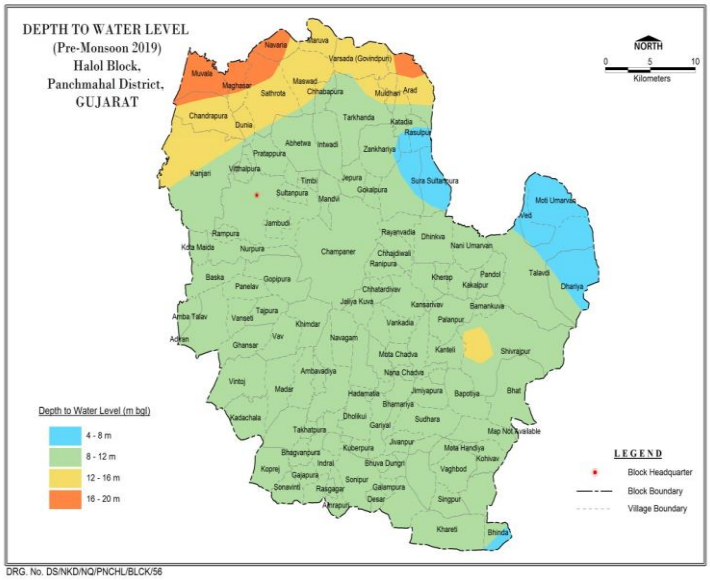
Existing and Future Water Demand

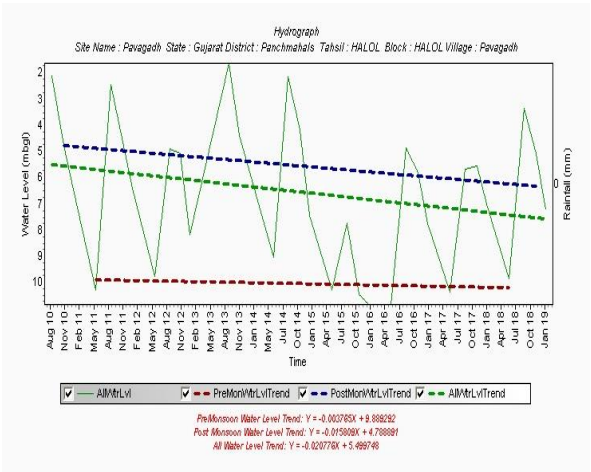
- Present demand for All Usage: 2826.20 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 456.00 ham.
- Net Ground Water availability for future use is 4052.23 ham.

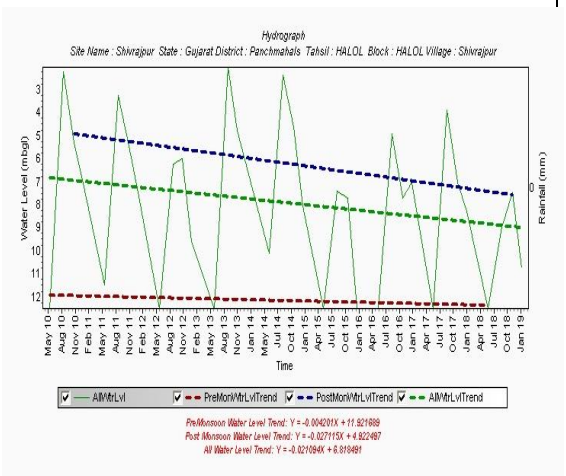
Aquifer Management plan

Groundwater Management Issues

- Low yield and Sustainability of hard rock Aquifers & Non Availability of sufficient Surface Water for Irrigation.
- It is observed that the annual water level trend of all wells showing stabled trend but in pre monsoon season few wells showing feeble declining trend.
- Occurrence of excessive Nitrate in Shallow aquifers at isolated villages.
- Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future







Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Halol taluka is 40.39 %.To elevate the stage of ground water extraction to 50% in Halol taluka, 980 no of Dug wells (20 m dpth) and 190 no of Bore wells (100 m depth) in Hard rock areas are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 778.00 ham which will create 1728.89 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 2.22 MCM of surplus surface water is provisioned for artificial recharge through 73 no of recharge shafts and 01 no of existing defunct tube wells which can be used as injection wells in Halol taluka of Panchmahal district .Ground water recharge of 222.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  To prevent Over Exploitation water conservation activities in 105.00 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 580 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.Ground water recharge of 212.78 ham (through on farm activities and GW return flow) is expected for the taluka.184.42 ham saving of ground water through WUE measures &

farm ponds activities is expected for the taluka.

- **Outcome**
  By adopting above management strategies, projected stage of Ground water development after creating additional extraction structures is 50 % in the Halol Block. Projected stage of Ground Water development after additional conservation activities is 46.02 % in the Halol Block.

Aquifer Information and Management plan of for Jamboghoda Block of Panchmahal District, Gujarat state.

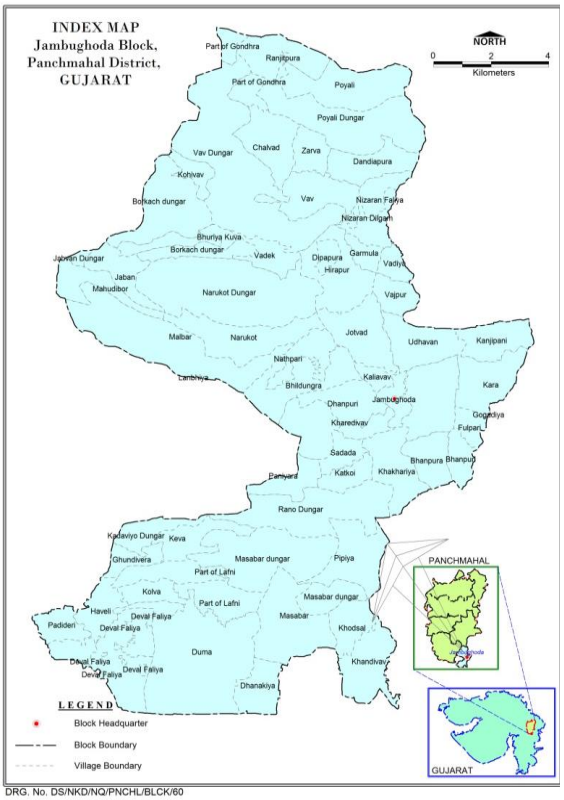
General Information

State Name : Gujarat

District name : Panchmahal

Block Name : Jambughoda

Location

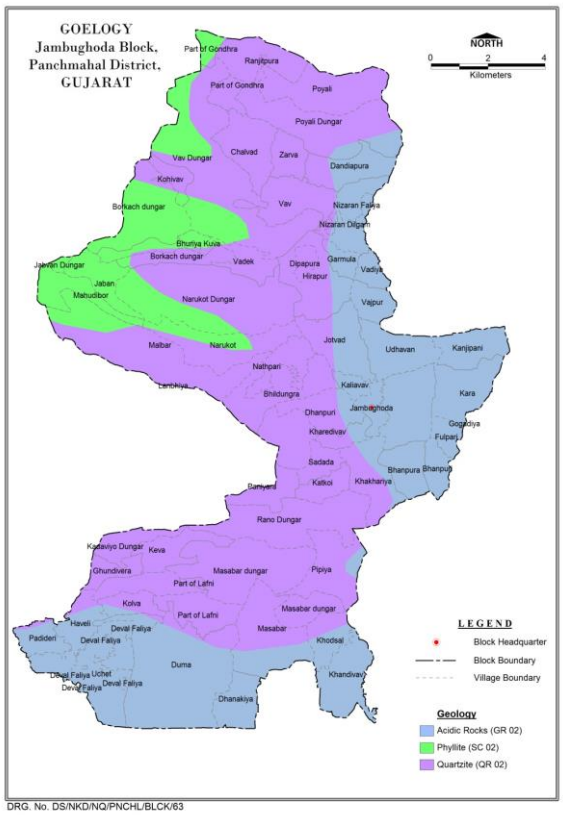


DRG. No. DS/NKD/NQ/PNCHL/BLCK/60

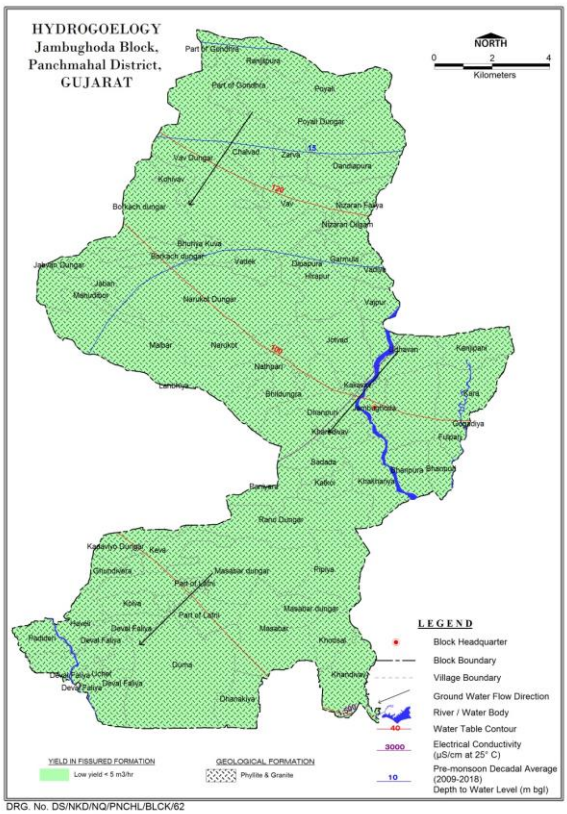
DRG. No. DS/NKD/NQ/PNCHL/BLCK/61

Salient Features	
Area (Km^2):	146.3
No. of Villages:	55
Population:	36,319
Density of Population/Km^2:	248
Net Sown Area in ha	6100
Gross Sown Area in ha	7159
Gross Irrigated Area in ha	6297
Area Irrigated by GW (%):	74.72

Cropping Intensity (%):		117.2
Irrigation Intensity (%):		48.59
Principal crops	**Kharif:**	Maize,Paddy & Tur
	Rabi:	Wheat,Gram
	Summer:	Bajra,Groundnut & Maize



DRG. No. DS/NKD/NQ/PNCHL/BLCK/63



DRG. No. DS/NKD/NQ/PNCHL/BLCK/62

Geographical Area : 146.30 sq. km.

Basin/Sub-basin : Major Drainages: Sorti, Nani Butedi

Principal Aquifer System : Shale, Granite, Schist and Quartzite.

Major Aquifer System: Meta-sediments of Aravalli super group such as Phyllites, quartzite; post Delhi intrusive of Godhra granite and gneiss

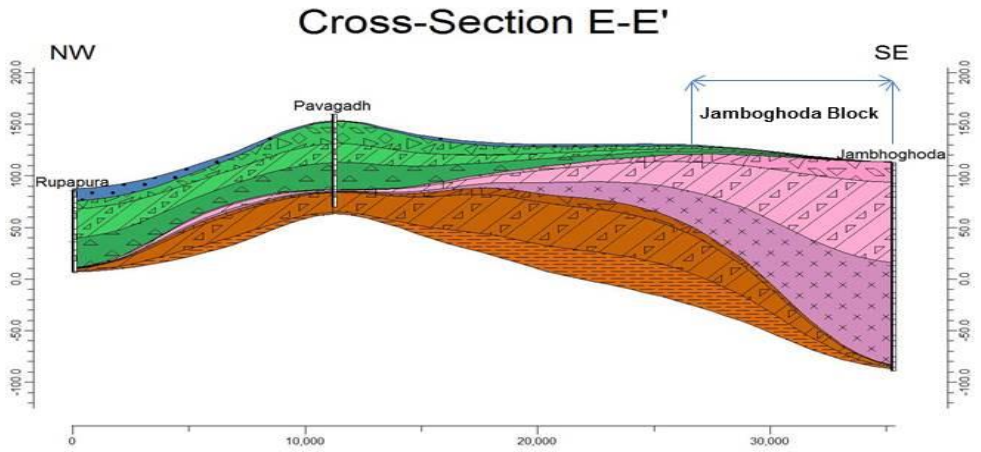
Normal Annual Rainfall : 1054.10 mm

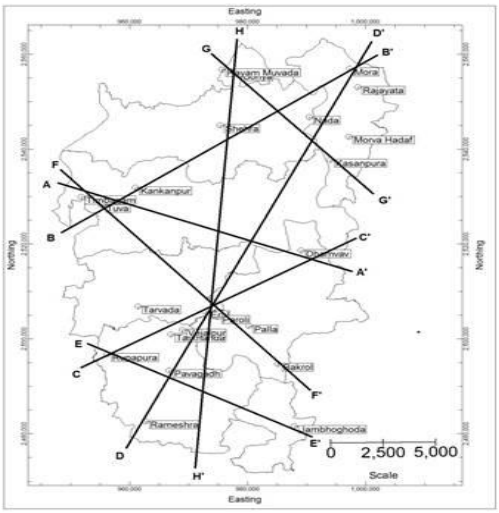
Aquifer Disposition

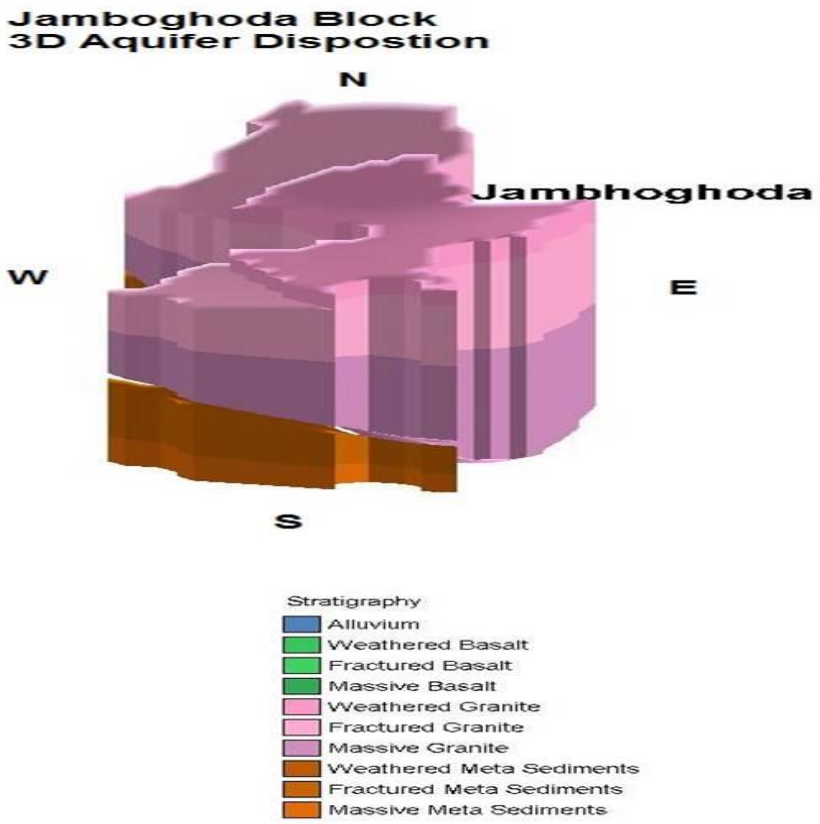
The Panchmahal district has two main hydrogeological provinces consisting of hard rock types and soft rock. In the hard rock, it is constituted of Meta sediments and Deccan traps. In soft rock type, it has alluvium and sandstone. Each terrain has varied hydro-geochemical regime. Groundwater of the district 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.

Aquifer Disposition					
Stratigraphy	**Aquifer Nomenclature**	**Lithological**	**Depth of occurrence**	**Thickness**	**Nature of Aquifer**
		Characteristics	**Aquifer**	**Range**	

			(mbgl)	(m)	
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	Phreatic
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	Phreatic
	Fractured Basalt	Basalts & Rhyolite	40 to 54		**Fractured**
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	Phreatic
	Fractured Granite	Granite & Granodiorite	55 to 75		**Fractured**
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	Phreatic
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		**Fractured**







Status of GW Exploration : Exploratory Wells: 01, Observation Wells: 00

Aquifer Characterisation and Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
	Fractured Basalt	Basalts & Rhyolite	40 to 54		2 to 16	300 to 2000	1 to 4	0.19 to 1000	**Fractured**	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		3 to 21	300 to 1700	0.1 to 6.3	322 to 1300	**Fractured**	Good Quality

Groundwater Monitoring Status
CGWB- Dug wells : 01, Piezometers :00
GWRDC- Dug wells : 04, Piezometers :04

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 410 to 1600 micromhos/cm at 25°c, for the Jambughoda taluka.
- Weathered Aquifer and Fractured Aquifer: Potable and fit for domestic, drinking, irrigation and other industrial purposes.

DRG. No. DS/NKD/NQ/PNCHL/BLCK/66

Summarised Chemical Data of Jambughoda taluka of Panchmahal District.

Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8.10	410.00	113.00	262.00	12.00	48.00	0.00	0.00	15.00	15.00	15.00	31.00	1.96	0.39
Max	8.80	1600.00	425.00	1024.00	292.80	280.00	201.00	62.00	65.00	70.00	63.00	175.00	19.38	1.32
Average	8.54	900.00	245.63	231.00	103.53	165.68	78.88	13.51	30.65	43.75	30.75	92.50	9.00	0.84

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

Groundwater Resource

- GW Availability 1680.91 ham (Dynamic)
- GW Draft 679.10 ham
- Stage of GW Development 40.40%
- Total Ground Water resource including both dynamic & in storage for district is 5471.91 ham. (Dynamic:1680.91 ham & In storage: 3791 ham)

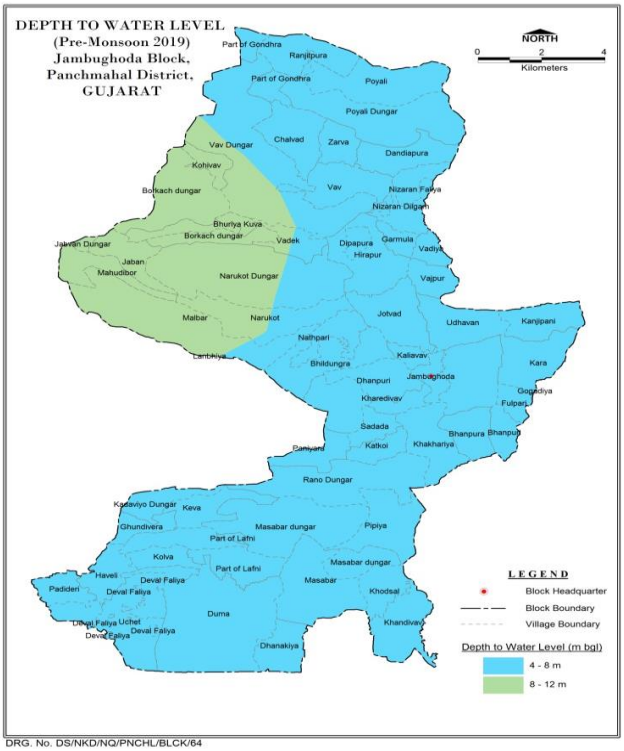
Existing and Future Water Demand

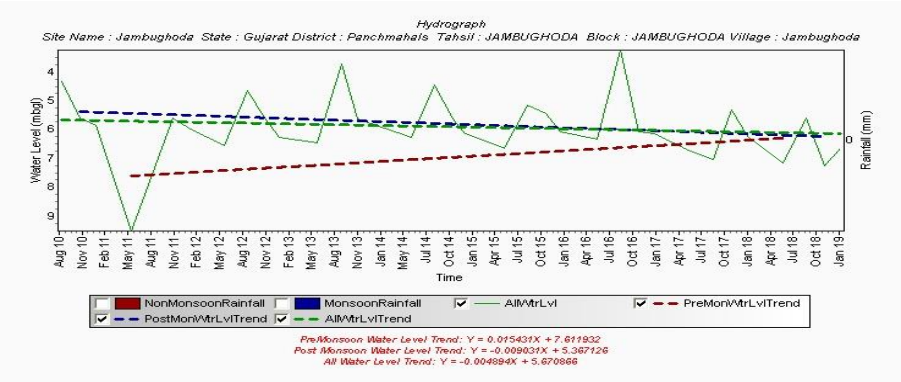
- Present demand for All Usage: 679.10 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 81.00 ham.
- Net Ground Water availability for future use is 980.81 ham.

Aquifer Management plan

Groundwater Management Issues

- Low yield and Sustainability of hard rock Aquifers & Non Availability of sufficient Surface Water for Irrigation.
- It is observed that the annual water level trend of all wells showing stabled trend but in pre monsoon season few wells showing feeble declining trend.
- Occurrence of excessive Nitrate in Shallow aquifers at isolated villages.
- Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future.





Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Jambughoda taluka is 40.40 %.To elevate the stage of ground water extraction to 50% in Jambughoda taluka, 395 no of Dug wells (20 m dpth) and 29 no of Bore wells (100 m depth) in Hard rock areas are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 187.00 ham which will create 415.56 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 0.69 MCM of surplus surface water is provisioned for artificial recharge through 23 no of recharge shafts and 01 no of existing defunct tube wells which can be used as injection wells in Jambughoda taluka of Panchmahal district .Ground water recharge of 72.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  To prevent Over Exploitation water conservation activities in 100 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground

water.Ground water recharge of 48.62 ham (through GW return flow) is expected for the taluka.30.98 ham saving of ground water through WUE measures & farm ponds activities is expected for the taluka.

- **Outcome**

  By adopting above management strategies, projected stage of Ground water development after creating additional extraction structures is 50 % in the Jambughoda Block. Projected stage of Ground Water development after additional conservation activities is 46.36 % in the Jambughoda Block.

Aquifer Information and Management plan of for Kalol Block of Panchmahal District, Gujarat state.

General Information

State Name: Gujarat

District name: Panchmahal

Block Name: Kalol

Location

DRG. No. DS/NKD/NQ/PNCHL/BLCK/68

Salient Features		
Area (Km^2):		398
No. of Villages:		68
Population:		1,63,464
Density of Population/Km^2:		410
Net Sown Area in ha		25458
Gross Sown Area in ha		27993
Gross Irrigated Area in ha		14235
Area Irrigated by GW (%):		75.92
Cropping Intensity (%):		109.96
Irrigation Intensity (%):		45.64
Principal crops	**Kharif:**	Maize,Paddy & Tur
	Rabi:	Wheat,Gram
	Summer:	Bajra,Groundnut & Maize

Geographical Area : 398.00 sq. km.

Basin/Sub-basin : Major Drainages: Goma, Pingli, Kharad, Bapoi & Miseri.

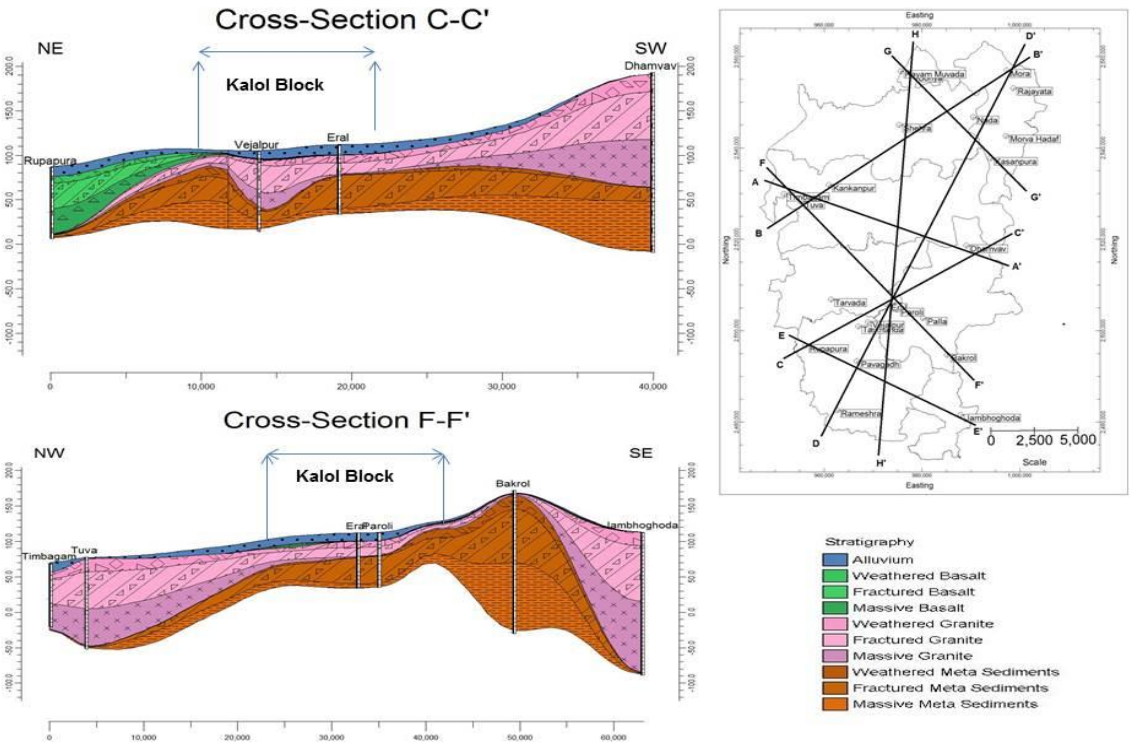
Principal Aquifer System : Alluvium, Basalt, Shale, Granite, Schist and Quartzite.
Major Aquifer System : Meta-sediments of Aravalli super group such as Phyllites, quartzite; post Delhi intrusive of Godhra granite and gneiss; Infra-trappean of lameta beds; sandstones and limestone; Deccan trap basalts and alluvium deposit along river channels and valley fills.
Normal Annual Rainfall : 647.40 mm

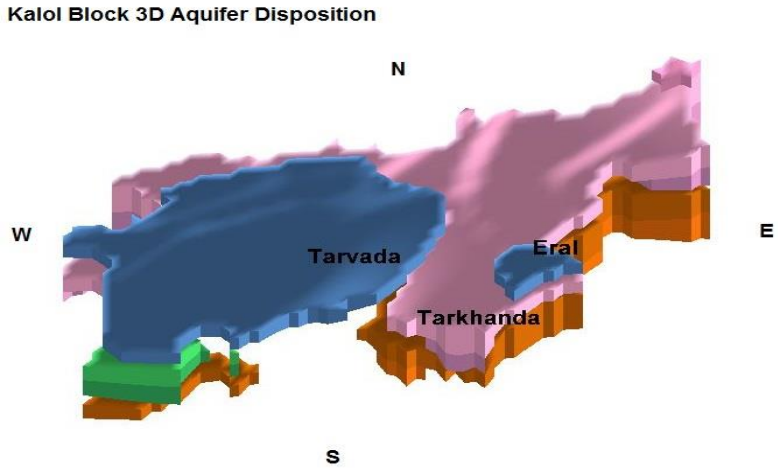
Aquifer Disposition

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.

Aquifer Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Nature of Aquifer
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	Phreatic
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	Phreatic
	Fractured Basalt	Basalts & Rhyolite	40 to 54		**Fractured**
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	Phreatic
	Fractured Granite	Granite & Granodiorite	55 to 75		**Fractured**
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	Phreatic
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		**Fractured**





Status of GW Exploration : Exploratory Wells: 01, Observation Wells: 00

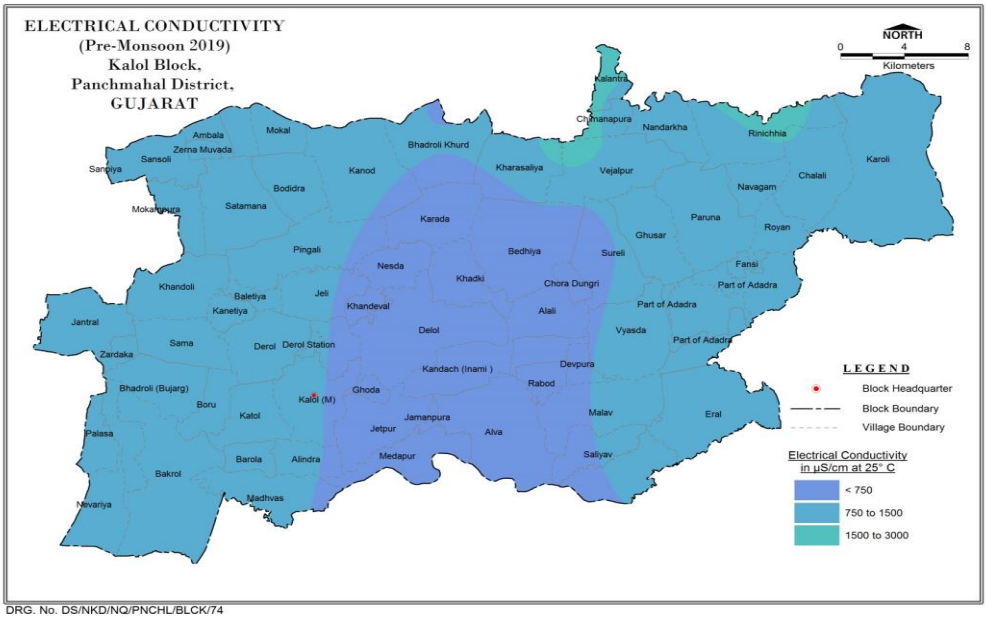
Aquifer Characterisation and Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
	Fractured Basalt	Basalts & Rhyolite	40 to 54		2 to 16	300 to 2000	1 to 4	0.19 to 1000	**Fractured**	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		3 to 21	300 to 1700	0.1 to 6.3	322 to 1300	**Fractured**	Good Quality

Groundwater Monitoring Status : CGWB- Dug wells : 03, Piezometers :01 , GWRDC- Dug wells : 06, Piezometers :01

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 480 to 1280 micromhos/cm at 25°c, for the Kalol taluka.
- Weathered Aquifer and Fractured Aquifer: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Panchmahal district has a number of medium and small scale industries set 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. The major key business involved are engineering, 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.



DRG. No. DS/NKD/NQ/PNCHL/BLCK/74

Summarised Chemical Data of Kalol taluka of Panchmahal District.														
Chemical Parameters	**pH**	**EC**	**TH**	**TDS**	**CO3**	**HCO3**	**Cl**	**SO4**	**NO3**	**Ca**	**Mg**	**Na**	**K**	**F**
Min	8.10	480.00	150.00	307.00	0.00	104.00	40.00	0.00	3.80	25.00	18.00	20.00	2.80	0.63
Max	9.30	1280.00	500.00	819.00	280.60	366.00	200.00	118.00	100.00	100.00	60.00	134.00	13.49	1.26
Average	8.69	944.29	292.71	495.14	64.77	210.00	113.29	29.89	29.13	59.29	34.71	78.71	6.09	0.87
*** All values are in mg/l except pH and EC in µS/cm at 25°C**														

Groundwater Resource

- GW Availability 5431.84 ham (Dynamic)
- GW Draft 2322.00 ham
- Stage of GW Development 42.75%
- Total Ground Water resource including both dynamic & in storage for district is 25421.84 ham. (Dynamic:5431.84 ham & In storage: 19990 ham)

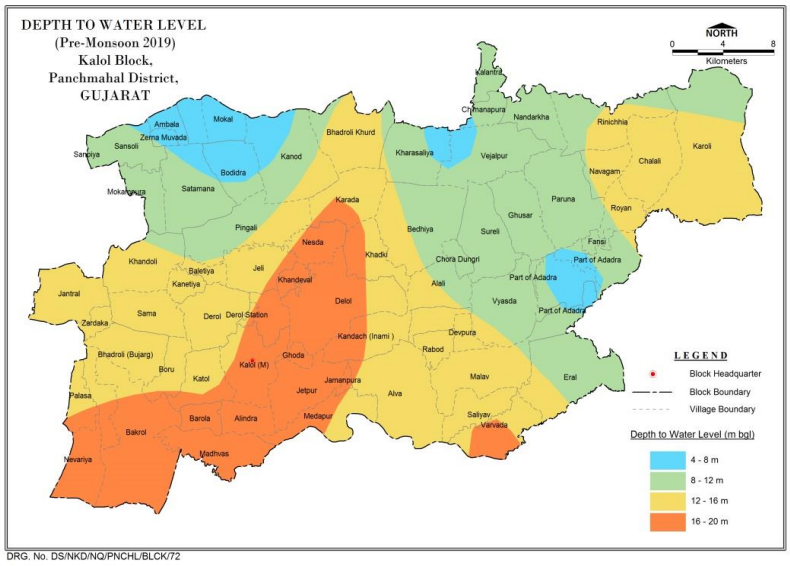
Existing and Future Water Demand

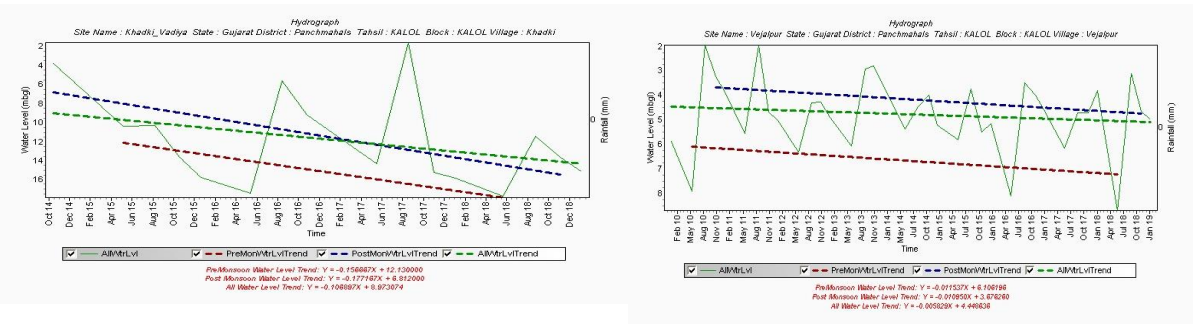
- Present demand for All Usage: 2322.00 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 415.00 ham.
- Net Ground Water availability for future use is 3001.84 ham.

Aquifer Management plan

Groundwater Management Issues

- Low yield and Sustainability of hard rock Aquifers & Non Availability of sufficient Surface Water for Irrigation.
- It is observed that the annual water level trend of all wells showing stabled trend but in pre monsoon season few wells showing feeble declining trend.
- Occurrence of excessive Nitrate in Shallow aquifers at isolated villages.
- Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future.





Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Kalol taluka is 42.74 %.To elevate the stage of ground water extraction to 50% in Kalol taluka, 645 no of Dug wells (20 m dpth) and 131 no of Bore wells (100 m depth) in Hard rock areas are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 453.50 ham which will create 1007.78 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 1.88 MCM of surplus surface water is provisioned for artificial recharge through 62 no of recharge shafts and 01 no of existing defunct tube wells which can be used as injection wells in Kalol taluka of Panchmahal district .Ground water recharge of 189.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  To prevent Over Exploitation water conservation activities in 684 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 402 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.Ground water recharge of 186.31 ham (through on farm activities and GW return flow) is expected for the taluka.155.33 ham saving of ground water through WUE measures & farm ponds activities is expected for the taluka.
- **Outcome**
  By adopting above management strategies, projected stage of Ground water development after creating additional extraction structures is 50 % in the Kalol Block. Projected stage of Ground Water development after additional conservation activities is 45.12 % in the Kalol Block.

Aquifer Information and Management plan of for Morwa (Hadaf) Block of Panchmahal District, Gujarat state.

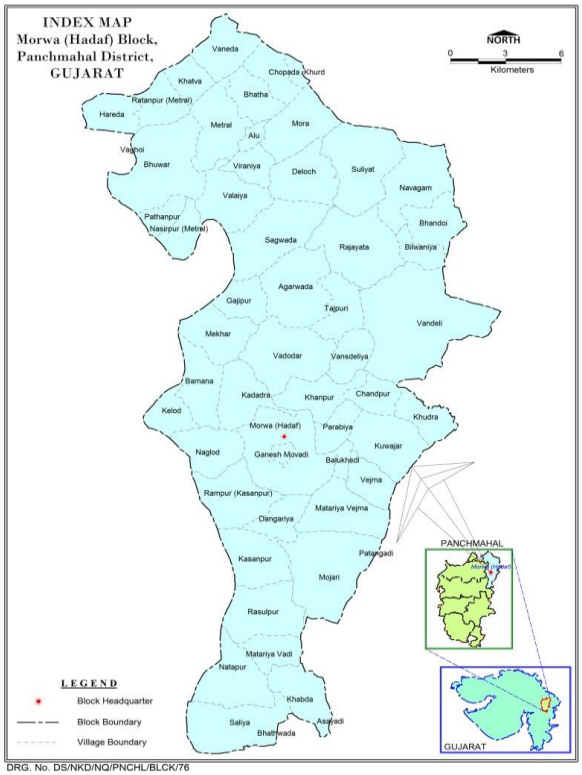
General Information

State Name : Gujarat

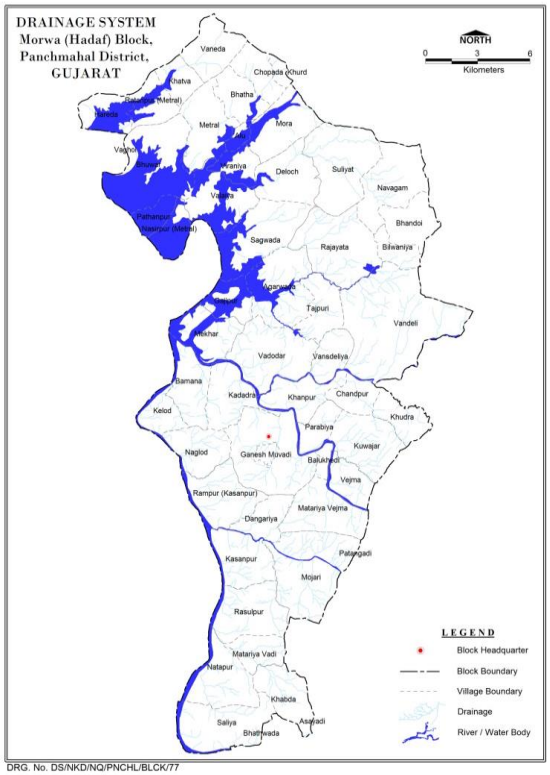
District name : Panchmahal

Block Name : Morwa (Hadaf)

Location



DRG. No. DS/NKD/NQ/PNCHL/BLCK/76



DRG. No. DS/NKD/NQ/PNCHL/BLCK/77

Salient Features		
Area (Km^2):		321.7
No. of Villages:		51
Population:		1,52,751
Density of Population/Km^2:		475
Net Sown Area in ha		19138
Gross Sown Area in ha		23205
Gross Irrigated Area in ha		15935
Area Irrigated by GW (%):		65.48
Cropping Intensity (%):		121.25
Irrigation Intensity (%):		64.72
Principal crops	**Kharif:**	Maize,Paddy & Tur
	Rabi:	Wheat,Gram
	Summer:	Bajra,Groundnut & Maize

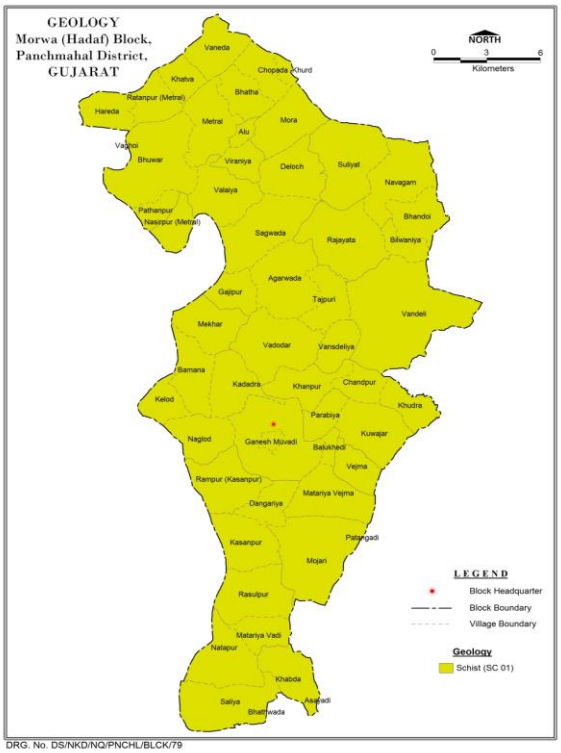
Geographical Area : 321.70 sq. km.

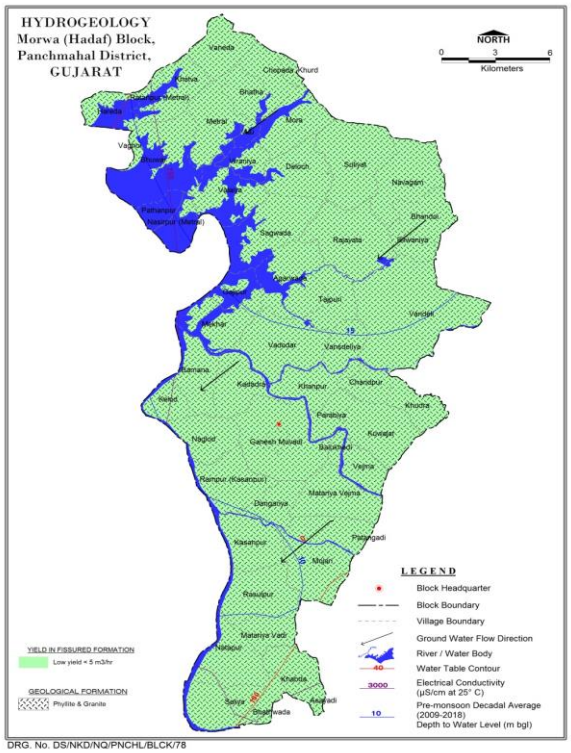
Basin/Sub-basin : Major Drainages: Panam, Hadaf, Kolhari & Kabhutari.

Principal Aquifer System : Schist and Quartzite.

Major Aquifer System : Meta-sediments of Aravalli super group such as Phyllites, quartzite;

Normal Annual Rainfall : 909.70 mm

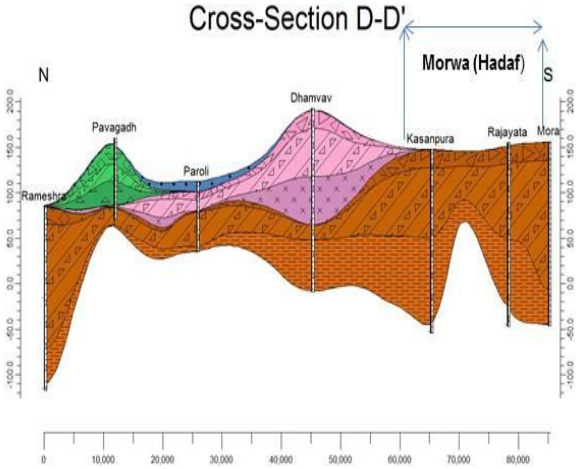


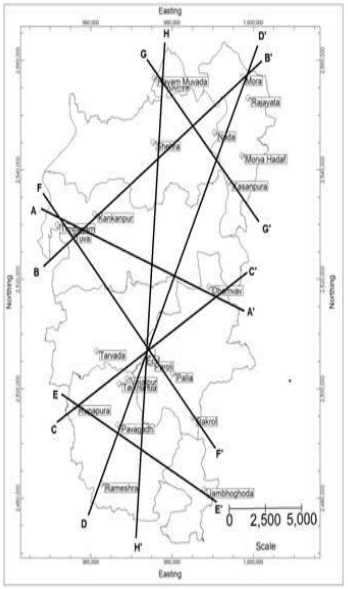


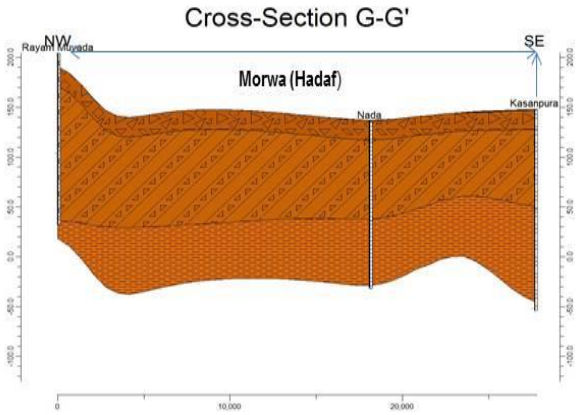
Aquifer Disposition

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.

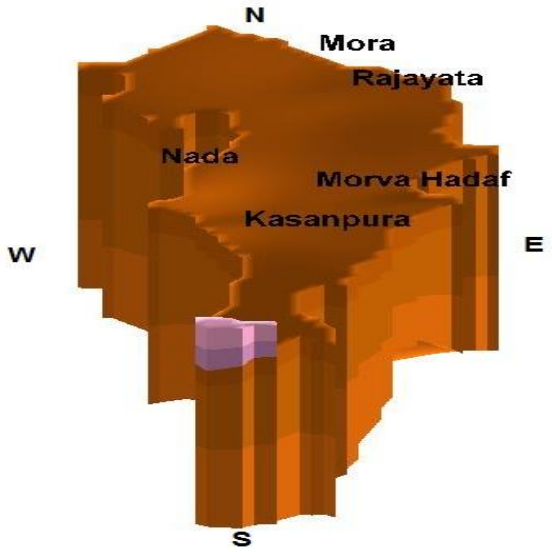
Aquifer Disposition					
Stratigraphy	**Aquifer Nomenclature**	**Lithological Characteristics**	**Depth of occurrence Aquifer (mbgl)**	**Thickness Range (m)**	**Nature of Aquifer**
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	Phreatic
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	Phreatic
	Fractured Basalt	Basalts & Rhyolite	40 to 54		**Fractured**
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	Phreatic
	Fractured Granite	Granite & Granodiorite	55 to 75		**Fractured**
Lower Proterozoic	**Weathered Meta Sediments**	**Phyllite, mica schist, quartzite**	**0 to 20**	**15 to 20**	**Phreatic**
	Fractured Meta sediments	**Phyllite, mica schist, quartzite**	**70 to 100**		**Fractured**







Morwa (Hadaf) Block 3D Aquifer Disposition



Status of GW Exploration : Exploratory Wells: 05, Observation Wells: 00

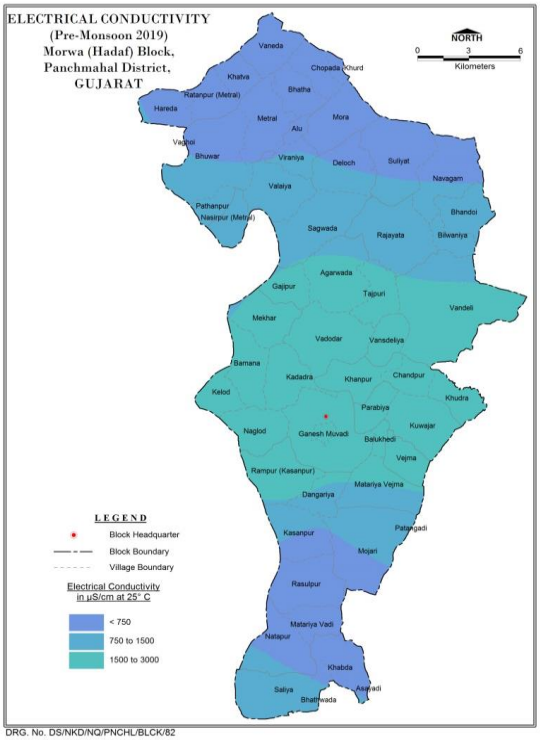
Aquifer Characterisation and Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
	Fractured Basalt	Basalts & Rhyolite	40 to 54		2 to 16	300 to 2000	1 to 4	0.19 to 1000	**Fractured**	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	**Phyllite, mica schist, quartzite**	**0 to 20**	**15 to 20**	**5 to 14**	**400 to 1500**			**Phreatic**	**Good Quality**
	Fractured Meta sediments	**Phyllite, mica schist, quartzite**	**70 to 100**		**3 to 21**	**300 to 1700**	**0.1 to 6.3**	**322 to 1300**	**Fractured**	**Good Quality**

Groundwater Monitoring Status : CGWB- Dug wells : 03, Piezometers :03 **,** GWRDC- Dug wells : 03, Piezometers :04

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 700 to 2260 micromhos/cm at 25°c, for the Morwa (Hadaf) taluka.
- Weathered Aquifer and Fractured Aquifer: Potable and fit for domestic, drinking, irrigation and other industrial purposes.



Summarised Chemical Data of Morwa Hadaf taluka of Panchmahal District.														
Chemical Parameters	**pH**	**EC**	**TH**	**TDS**	**CO3**	**HCO3**	**Cl**	**SO4**	**NO3**	**Ca**	**Mg**	**Na**	**K**	**F**
Min	8	700	138	448	12	104	0	0	3.79	25	15	61	0.95	0.52
Max	9	2260	409.35	1446	231.8	353.8	464	145	70	95	57	297	51.74	1.21
Average	8.4	1215.7	230.05	777.3	107.9	203.8	171.9	27.2	33.1	52.9	34.7	141	18.33	0.89
* **All values are in mg/l except pH and EC in µS/cm at 25°C**														

Groundwater Resource

- GW Availability 4383.99 ham (Dynamic)
- GW Draft 1797.00 ham
- Stage of GW Development 40.99%
- Total Ground Water resource including both dynamic & in storage for district is 12064.99 ham. (Dynamic:4383.99 ham & In storage: 7681 ham)

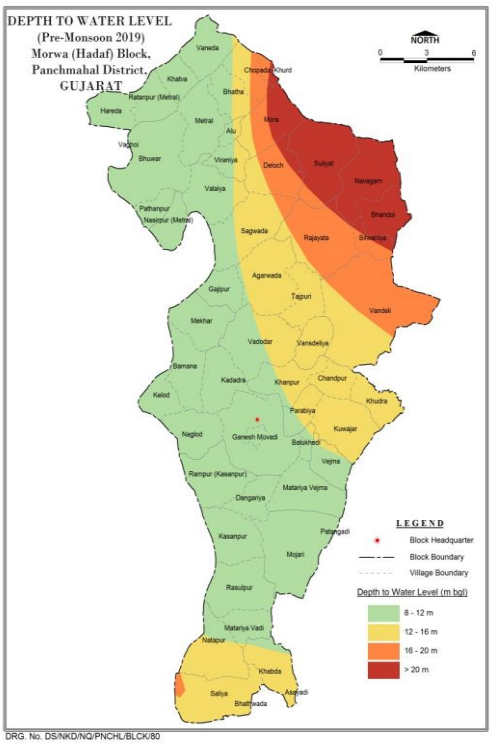
Existing and Future Water Demand

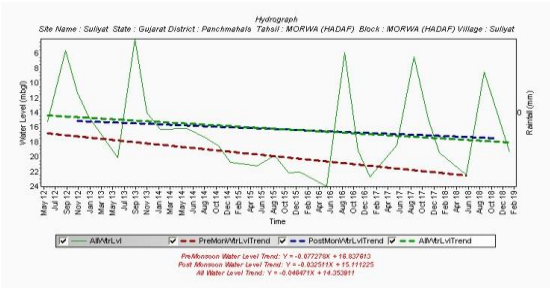
- Present demand for All Usage: 1797.00 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 358.00 ham.
- Net Ground Water availability for future use is 2493.99 ham.

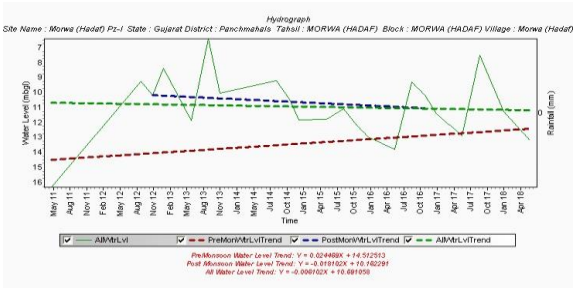
Aquifer Management plan

Groundwater Management Issues

- Low yield and Sustainability of hard rock Aquifers & Non Availability of sufficient Surface Water for Irrigation.
- It is observed that the annual water level trend of all wells showing stabled trend but in pre monsoon season few wells showing feeble declining trend.
- Occurrence of excessive Nitrate in Shallow aquifers at isolated villages.
- Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future.







Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Morwa (Hadaf) taluka is 40.99 %.To elevate the stage of ground water extraction to 50% in Morwa (Hadaf) taluka, 850 no of Dug wells (20 m dpth) and 30 no of Bore wells (100 m depth) in Hard rock areas are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 455.00 ham which will create 1011.11 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 1.52 MCM of surplus surface water is provisioned for artificial recharge through 50 no of recharge shafts and 01 no of existing defunct tube wells which can be used as injection wells in Morwa (Hadaf) taluka of Panchmahal district .Ground water recharge of 153.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  To prevent Over Exploitation water conservation activities in 252 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 336 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.Ground water recharge of 143.40 ham (through on farm activities and GW return flow) is expected for the taluka.115.40 ham saving of ground water through WUE measures & farm ponds activities is expected for the taluka.
- **Outcome**
  By adopting above management strategies, projected stage of Ground water development after creating additional extraction structures is 50 % in the Morwa (Hadaf) Block. Projected stage of Ground Water development after additional conservation activities is 45.65 % in the Morwa (Hadaf) Block.

Aquifer Information and Management plan of for Shahera Block of Panchmahal District, Gujarat state.

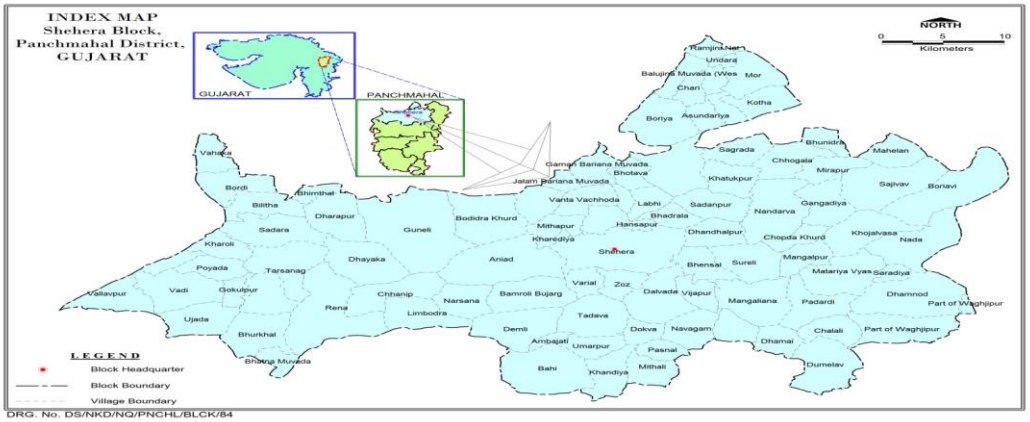
General Information

State Name : Gujarat

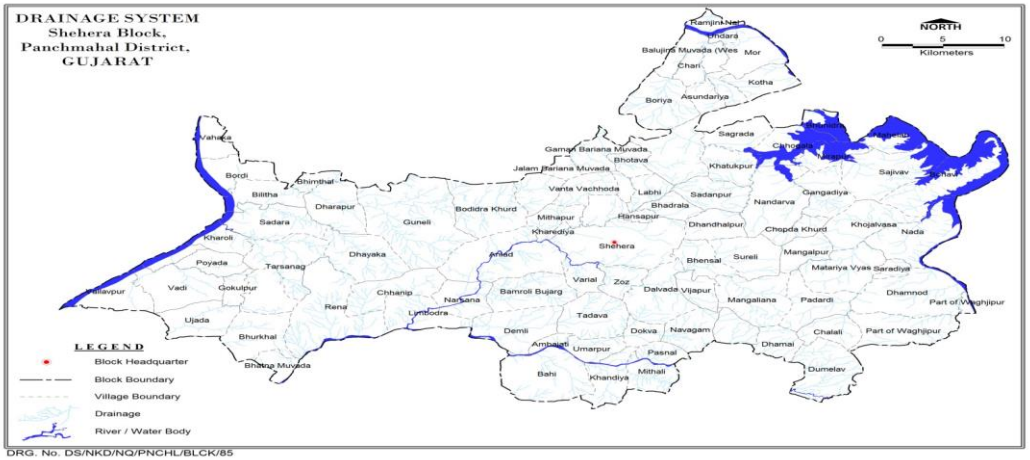
District name : Panchmahal

Block Name : Shahera

Location

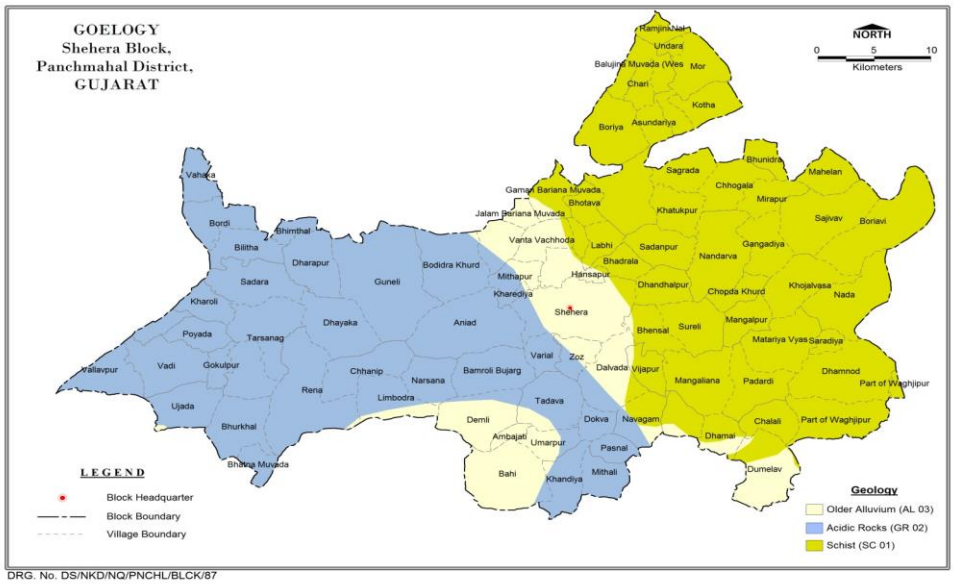


DRG. No. DS/NKD/NQ/PNCHL/BLCK/84



DRG. No. DS/NKD/NQ/PNCHL/BLCK/85

Salient Features		
Area (Km^2):		610.5
No. of Villages:		93
Population:		2,31,324
Density of Population/Km^2:		379
Net Sown Area in ha		29744
Gross Sown Area in ha		30679
Gross Irrigated Area in ha		18524
Area Irrigated by GW (%):		39.47
Cropping Intensity (%):		103.14
Irrigation Intensity (%):		50.6
Principal crops	Kharif:	Maize,Paddy & Tur
	Rabi:	Wheat,Gram
	Summer:	Bajra,Groundnut & Maize



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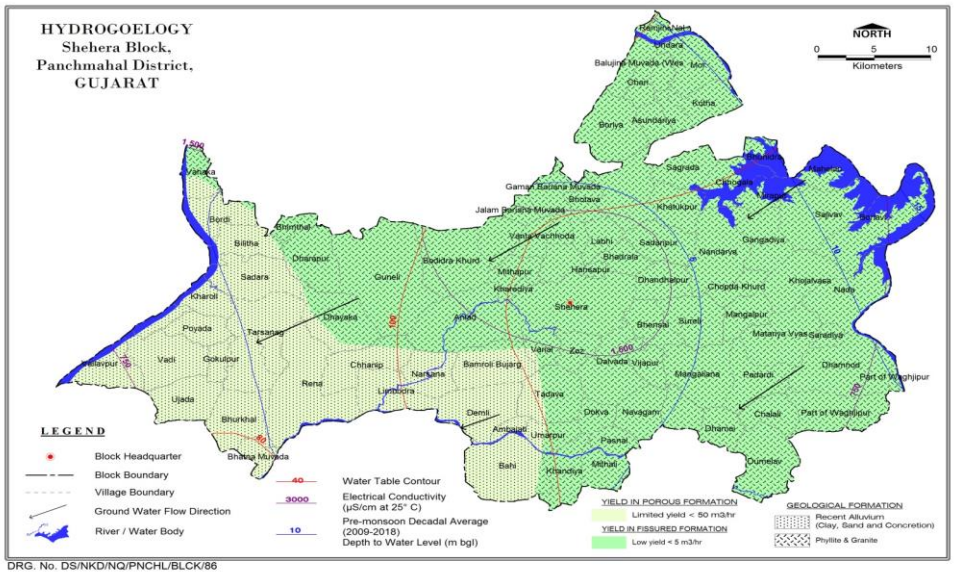


DRG. No. DS/NKD/NQ/PNCHL/BLCK/86

Geographical Area : 610.50 sq. km.

Basin/Sub-basin : Major Drainages: Mahi,Panam,Kun & Chikini

Principal Aquifer System : Alluvium, Basalt, Shale, Granite, Schist and Quartzite.

Major Aquifer System : Meta-sediments of Aravalli super group such as Phyllites, quartzite; 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.

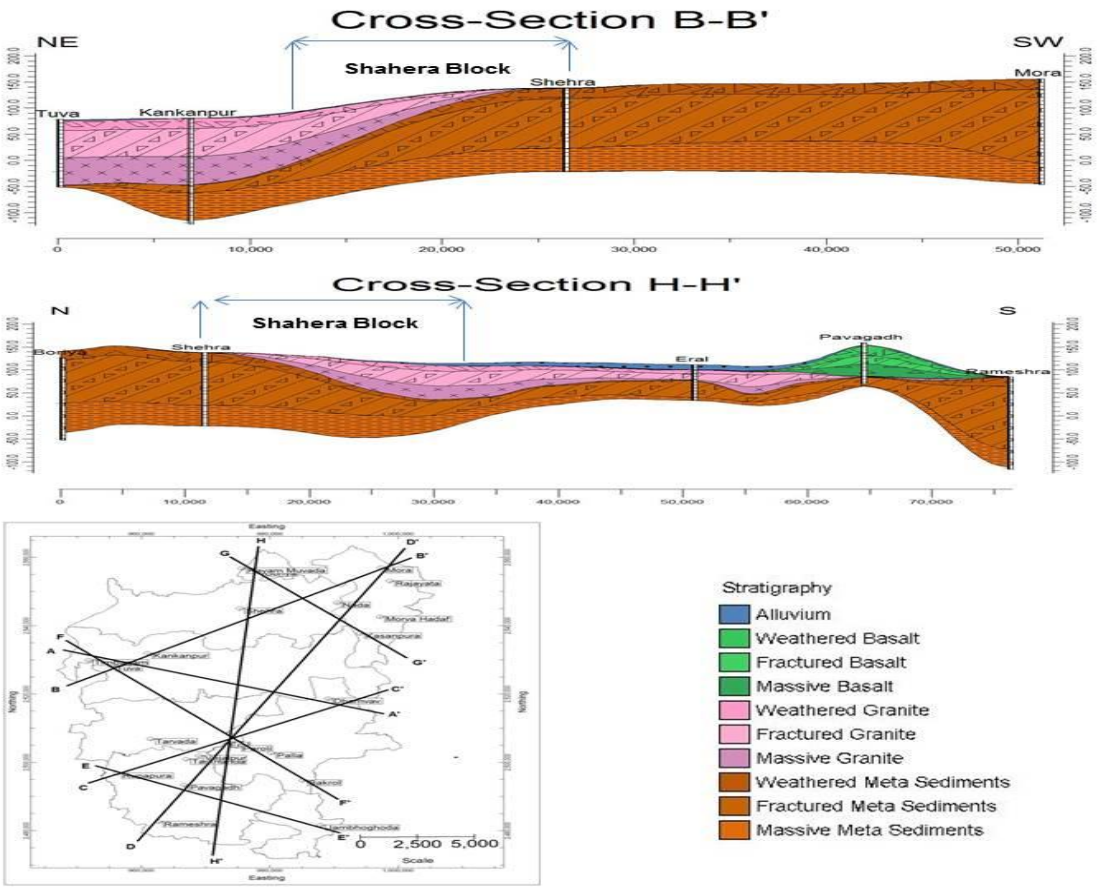
Normal Annual Rainfall : 637.90 mm

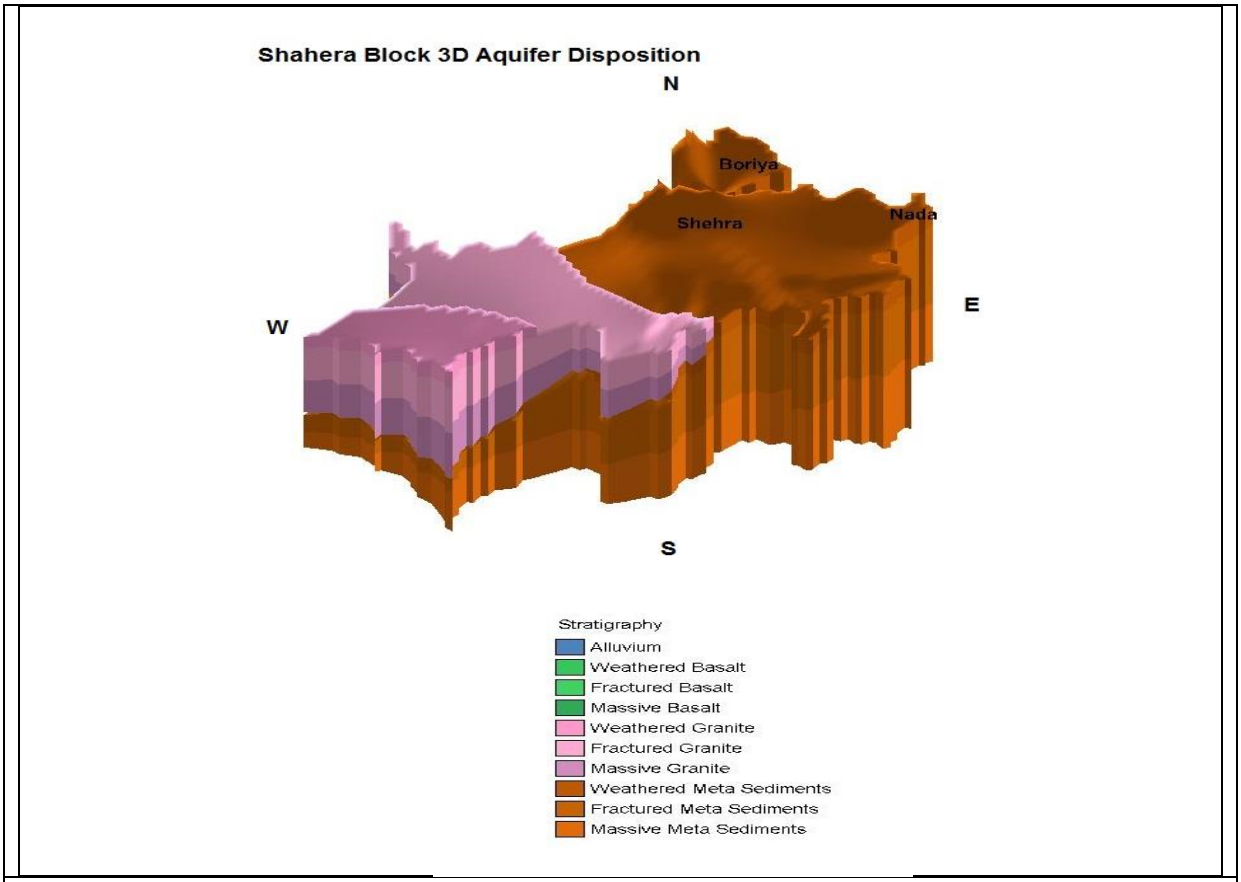
Aquifer Disposition

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.

Aquifer Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Nature of Aquifer
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	Phreatic
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	Phreatic
	Fractured Basalt	Basalts & Rhyolite	40 to 54		**Fractured**
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	Phreatic
	Fractured Granite	Granite & Granodiorite	55 to 75		**Fractured**
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	Phreatic
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		**Fractured**





Status of GW Exploration : Exploratory Wells: 06, Observation Wells: 02

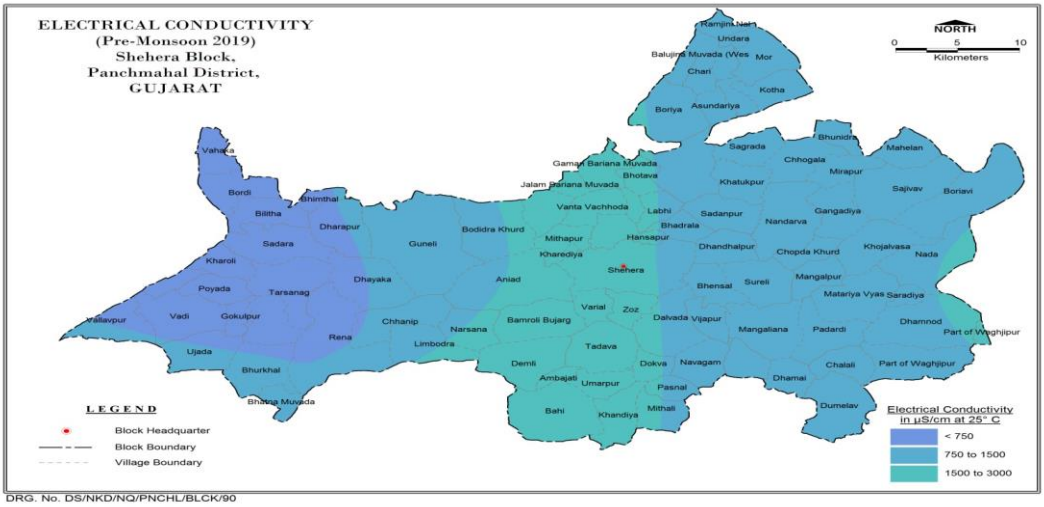
Aquifer Characterisation and Disposition

Stratigraphy	Aquifer Nomenclature	Lithological Characteristics	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Holocene	**Alluvium**	Alluvium - Sand, Kankar and Clay	0 to 21	0 to 21	14 to 16	500 to 600			Phreatic	Good Quality
Cretaceous	**Weathered Basalt**	Basalts & Rhyolite	0 to 24	12 to 24	5 to 10	500 to 600			Phreatic	Good Quality
	Fractured Basalt	Basalts & Rhyolite	40 to 54		2 to 16	300 to 2000	1 to 4	0.19 to 1000	**Fractured**	Good Quality
Upper Proterozoic	**Weathered Granite**	Granite & Granodiorite	0 to 24	16 to 24	5 to 13	400 to 1500			Phreatic	Good Quality
	Fractured Granite	Granite & Granodiorite	55 to 75		3 to 18	250 to 1200	0.5 to 5	239 to 1600	**Fractured**	Good Quality
Lower Proterozoic	**Weathered Meta Sediments**	Phyllite, mica schist, quartzite	0 to 20	15 to 20	5 to 14	400 to 1500			Phreatic	Good Quality
	Fractured Meta sediments	Phyllite, mica schist, quartzite	70 to 100		3 to 21	300 to 1700	0.1 to 6.3	322 to 1300	**Fractured**	Good Quality

Groundwater Monitoring Status : CGWB- Dug wells : 01, Piezometers :03 **,**GWRDC- Dug wells : 03, Piezometers :06

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from360 to 1990 micromhos/cm at 25°c, for the Shahera taluka.
- Weathered Aquifer and Fractured Aquifer: Potable and fit for domestic, drinking, irrigation and other industrial purposes.



Summarised Chemical Data of Shahera taluka of Panchmahal District.

Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8.1	360	63	230	24	80	0	0	2.14	15	6	46	0.98	0.45
Max	9	1990	400	1274	183	480	208	143	55	65	57	305	104.68	1.12
Average	8.6625	877.5	189.25	564.5	105.15	163.7	65.875	29.0325	30.37	39.375	22.875	98.125	24.45625	0.82

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

Groundwater Resource

- GW Availability 6760.45 ham (Dynamic)
- GW Draft 1855.90 ham
- Stage of GW Development 27.45%
- Total Ground Water resource including both dynamic & in storage for district is 26130.45 ham. (Dynamic:6760.45 ham & In storage: 19370 ham)

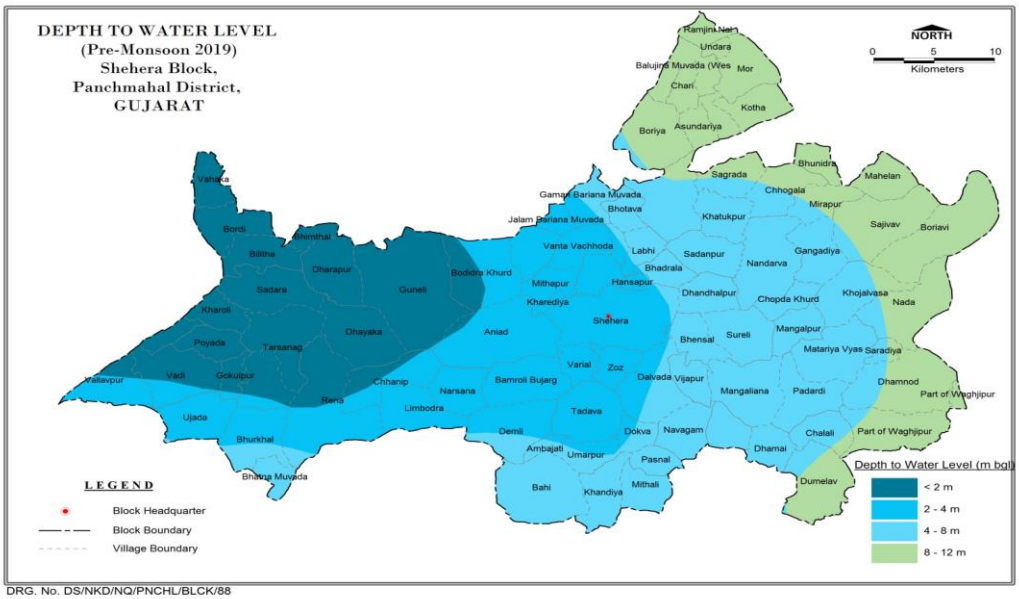
Existing and Future Water Demand

- Present demand for All Usage: 1855.90 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 532.00 ham.
- Net Ground Water availability for future use is 4766.55 ham.

Aquifer Management plan

Groundwater Management Issues

- Low yield and Sustainability of hard rock Aquifers & Non Availability of sufficient Surface Water for Irrigation.
- It is observed that the annual water level trend of all wells showing stabled trend but in pre monsoon season few wells showing feeble declining trend.
- Occurrence of excessive Nitrate in Shallow aquifers at isolated villages.
- Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future.



Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Shehera taluka is 27.45 %.To elevate the stage of ground water extraction to 50% in Shehera taluka, 300 no of Dug wells (20 m dpth) and 250 no of Bore wells (100 m depth) in Hard rock areas are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 1750.00 ham which will create 3888.89 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 2.88 MCM of surplus surface water is provisioned for artificial recharge through 95 no of recharge shafts and 01 no of existing defunct tube wells which can be used as injection wells in Shehera taluka of Panchmahal district .Ground water recharge of 288.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  To prevent Over Exploitation water conservation activities in 681 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 525 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.Ground water recharge of 523.10 ham (through on farm activities and GW return flow) is expected for the taluka.193.30 ham saving of ground water through WUE measures & farm ponds activities is expected for the taluka.
- **Outcome**
  By adopting above management strategies, projected stage of Ground water development after creating additional extraction structures is 50 % in the Shehera Block. Projected stage of Ground Water development after additional conservation activities is 45.07 % in the Shehera Block.

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Annexure 1 Panchmahal Pre Monsoon Water Level_2019 (Un Confined)									
Well No	Well Type	District	Tahsil / Taluk	Village	Latitude	Longitude	Elevation of Ground Level	Water Level	Water Table
CGWB	Dug Well	Panchmahals	Godhra	Godhra_UR1	22.793	73.607	127	6.06	120.94
CGWB	Dug Well	Panchmahals	Godhra	Godhra_UR3	22.78	73.607	123	3.03	119.97
CGWB	Dug Well	Panchmahals	Godhra	Godhra2	22.771	73.633	127	10.59	116.41
CGWB	Dug Well	Panchmahals	Jambughoda	Javan	22.401	73.685	262	8.53	253.47
CGWB	Dug Well	Panchmahals	Kalol	Kalol_UR1	22.6	73.443	83	14.25	68.75
CGWB	Dug Well	Panchmahals	Kalol	Kalol_UR2	22.59	73.451	85	19.47	65.53
CGWB	Dug Well	Panchmahals	Godhra	Khadki Vadiya	22.662	73.5	108	17.2	90.80
CGWB	Dug Well	Panchmahals	Morwa (Hadaf)	Natapur	22.857	73.821	155	8.55	146.45
CGWB	Dug Well	Panchmahals	Halol	pavagadh	22.488	73.556	127	10.23	116.77
CGWB	Dug Well	Panchmahals	Ghoghamba	Ranipurra	22.725	73.758	175	10.88	164.12
CGWB	Dug Well	Panchmahals	Morwa (Hadaf)	Santh Road	22.803	73.793	156	16.67	139.33
CGWB	Dug Well	Panchmahals	Shehera	Shahera	22.954	73.625	126	2.34	123.66
CGWB	Dug Well	Panchmahals	Morwa (Hadaf)	Suliyat	23.062	73.851	150	22.4	127.60
CGWB	Dug Well	Panchmahals	Halol	Tarkhanda	22.546	73.529	103	11.21	91.79
CGWB	Dug Well	Panchmahals	Halol	Timbi 2	22.508	73.508	126	8.35	117.65
CGWB	Dug Well	Panchmahals	Godhra	tuwa	22.804	73.471	83	5.23	77.77
CGWB	Dug Well	Panchmahals	Kalol	Vejalpur	22.696	73.558	105	6.2	98.80

Annexure 2 Panchmahal Post Monsoon Water Level_2019 (Un Confined)										
Well No	Well Type	District	Tahsil / Taluk	Village	Geology	Latitude	Longitude	Elevation of Ground Level	Water Level	Water Table
CGWB	Dug Well	Panchmahals	Godhra	Godhra_UR1		22.793	73.607	127	5.25	121.75
CGWB	Dug Well	Panchmahals	Godhra	Godhra_UR3		22.78	73.607	123	2.15	120.85
CGWB	Dug Well	Panchmahals	Godhra	Godhra2		22.771	73.633	127	8.62	118.38
CGWB	Dug Well	Panchmahals	Jambughoda	Javan		22.401	73.685	262	6.23	255.77
CGWB	Dug Well	Panchmahals	Kalol	Kalol_UR1		22.6	73.443	83	17.49	65.51

CGWB	Dug Well	Panchmahals	Kalol	Kalol_UR2		22.59	73.451	85	10.4	74.60
CGWB	Dug Well	Panchmahals	Godhra	Khadki Vadiya		22.662	73.5	108	9.25	98.75
CGWB	Dug Well	Panchmahals	Morwa (Hadaf)	Natapur		22.857	73.821	155	8.1	146.90
CGWB	Dug Well	Panchmahals	Halol	pavagadh		22.488	73.556	127	3.31	123.69
CGWB	Dug Well	Panchmahals	Ghoghamba	Ranipurra		22.725	73.758	175	2	173.00
CGWB	Dug Well	Panchmahals	Morwa (Hadaf)	Santh Road		22.803	73.793	156	6.25	149.75
CGWB	Dug Well	Panchmahals	Shehera	Shahera		22.954	73.625	126	1.18	124.82
CGWB	Dug Well	Panchmahals	Morwa (Hadaf)	Suliyat		23.062	73.851	150	9.92	140.08
CGWB	Dug Well	Panchmahals	Halol	Tarkhanda		22.546	73.529	103	1.4	101.60
CGWB	Dug Well	Panchmahals	Halol	Timbi 2		22.508	73.508	126	10.19	115.81
CGWB	Dug Well	Panchmahals	Godhra	tuwa		22.804	73.471	83	5	78.00
CGWB	Dug Well	Panchmahals	Kalol	Vejalpur		22.696	73.558	105	2.15	102.85

Annexure 3 Panchmahal Pre Monsoon Water Quality_2019 (Un Confined)										
Well No	Well Type	District	Tahsil / Taluk	Village	Geology	Latitude	Longitude	EC	NO3	F
CGWB	Dug Well	Panchmahals	GODHRA	Chhabanpur		22° 49' 40.8"	73° 36' 46.8"	745	50	1.01
CGWB	Dug Well	Panchmahals	Kalol	Dhanol		22°45'31"	73°30'24"	1482	15	1.69
CGWB	Dug Well	Panchmahals	GODHRA	Godhra UR_1(Temple Campus)		22° 46' 15"	73° 37' 60"	1183	47	1.32
CGWB	Dug Well	Panchmahals	GODHRA	Godhra UR_2(School Camp)		22°46’12.0"	73°37’48.0"	2521	7	1.69
CGWB	Dug Well	Panchmahals	JAMBUGODHA	Javan		22° 24' 3.6"	73° 41' 6"	411	7	0.97
CGWB	Dug Well	Panchmahals	KALOL	Kalol UR_1(Nr School)		22° 36' 0"	73° 26' 34.8"	1697	80	1.34
CGWB	Dug Well	Panchmahals	KALOL	Kalol		22° 35' 24"	73° 27' 3.6"	1489	50	0.89
CGWB	Dug Well	Panchmahals	GODHRA	Khadki Vadiya		22° 39' 43.2"	73° 30' 0"	1297	10	1.65
CGWB	Dug Well	Panchmahals	MORWA (HADAF)	Natapur		22°51’36.0"	73°49’12.0"	583	45	1.61
CGWB	Dug Well	Panchmahals	HALOL	Pavagadh		22°29’24.0"	73°33’36.0"	627	50	1.43
CGWB	Dug Well	Panchmahals	GHOGHAMBA	Ranipura		22°43’48.0"	73°45’36.0"	1960	145	2.2
CGWB	Dug Well	Panchmahals	MORWA (HADAF)	Santroad_1		22° 48' 0"	73° 48' 45"	772	33	1.32
CGWB	Dug Well	Panchmahals	SHEHERA	Shehra		22°56’60.0"	73°37’48.0"	1650	13	1.13
CGWB	Dug Well	Panchmahals	MORWA (HADAF)	Suliyat		23°3’36.0"	73°50’60.0"	652	26	1.38
CGWB	Dug Well	Panchmahals	HALOL	Tarkanda		22°33’0.0"	73°31’48.0"	635	8	0.98
CGWB	Dug Well	Panchmahals	GODHRA	Tuwa		22° 48' 15"	73° 28' 15"	790	5	1.04
CGWB	Dug Well	Panchmahals	KALOL	Vejalpur		22°41’60.0"	73°33’36.0"	1732	46	1.57

Annexure-4 Panchmahal Distrcit Exploration Data													
Sl.	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	79	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	92	7.7	Negigible	Granite	2420	216		
3	Vejalpur (22°33'35" 73°33'30")	Halol	EW-2	1985 - 86	90	90	6.95	0.5	Granite	790	88		
4	Vejalpur (22°33'35" 73°33'30")	Halol	EW-3	1985 - 86	90	90	7.09	0.8	Granite	1620	112		
5	Vejalpur (22°33'35" 73°33'30")	Halol	EW-4	1985 - 86	46	46	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	91	4.13	0.5	Granite	620	72		
7	Vejalpur (22°33'35" 73°33'30")	Halol	EW-6	1985 - 86	90	90	5.96	0.9	Granite	3200	568		
8	Rupapura (22°31'00" 73°26'00")	Halol	OW	1985 - 86	79	79	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	
10	Timbagam (22°49'00" 73°24'00")	Godhra	EW	1987 - 88	90	90	12.48	0.7	Granite	1115	107	0.23	
11	Tarkhanda (22°33'05" 73°32'20")	Halol	EW	1987 - 88	90	90	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	37	23.75	2.1	Phyllites	1290	107	1290	

14	Pavagadh I (22°29'00" 73°32'00")	Halol	EW-1	1987 - 88	90	90	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	90	15.06	0.5	Do	540	28	0.0988	
16	Charia (23°10'00" 73°30'00")	Lunawada	EW	1988 - 89	220	220			Phyllites				
17	Tuwa-I (22°48'00" 73°26'00")	Godhra	EW-1	1988 - 89	90	90	3.3	5	Granite and Pegmatite			1600	
18	Tuwa II (22°48'00" 73°26'00")	Godhra	EW-2	1988 - 89	130	130			Granite and Pegmatite				
19	Kankanpur (22°49'55" 73°29'22")	Godhra	EW	2002 - 03	202.6	202.6			Granite and phyllite				
20	Rameshra (22°23'15" 73°29'30")	Halol	EW	2002 - 03	202	202			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				
22	Mora (23°03'08" 73°50'55")	Morva Hadaf	EW	2002 - 03	202.5	202.5			Phyllite-mica schist				
23	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
24	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
25	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
26	Ucharpi Pz	Lunawada	Pz	2007 -	44.1	44.1	10	1.25	Weath./Fract.	225			41.0 -

	(23°46’42” 72°17’10”)			08					phyllite & phyl.-quart. contact				42.0 : 1.25 lps
27	Kakachiya (23°05'55" 73° 33'30")	Lunawada	EW	2008 - 09	202.7	202.7	>150	-	Schist	1572	341	1053	Dry
28	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
29	Nada (22°57'26" 73°46'50")	Shehra	EW	2008 - 09	168	168	11.65	2.1	Meta-sediments Qtzt/Phyllite	515	21	345	
30	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
31	Boriya (23°02'38" 73°39'56")	Shehra	EW	2008 - 09	180.3	180.3	4.78	5	Qtzt/Phyllite	481	57	322	
32	Boriya (23°02'38" 73°39'56")	Shehra	OW	2008 - 09	178.3	178.3	5.29	6.3	Qtzt/Phyllite	460	50	308	
33	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
34	Dhamavav (22°42'16" 73°45'30")	Godhra	EW	2009 - 10	200.7	200.7	6.06	Negigible	Granite				
35	Kakachiya (23°05'55" 73°33'30")	Lunawada	EW	2009 - 10	202.7	202.7	>150	-	Schist	1572	341	1053	Dry
36	Rajayata (23°00'42" 73°51'45")	Morva Hadaf	EW	2009 - 10	202.7	202.7	8.63	0.5	Quartzite & Phyllites				
37	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
38	Nada (22°57'26" 73°46'50")	Shehra	EW	2009 - 10	168	168	11.65	2.1	Meta-sediments Qtzt/Phyllite	515	21	345	
39	Shehra	Shehra	EW	2009 -	160	115	5.68	2.22	Meta-sediments	1960	284	1313	High F

	(22°56'46" 73°38'00")			10					Mica schist				
40	Boriya (23°02'38" 73°39'56")	Shehra	EW	2009 - 10	180.3	180.3	4.78	5	Qtzt/Phyllite	481	57	322	
41	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	
42	Boriya (23°02'38" 73°39'56")	Shehra	OW	2009 - 10	178.3	178.3	5.29	6.3	Qtzt/Phyllite	460	50	308	
43	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