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

Vadodara District
Gujarat

पश्चिम मध्य क्षेत्र, अहमदाबाद

West Central Region, Ahmedabad

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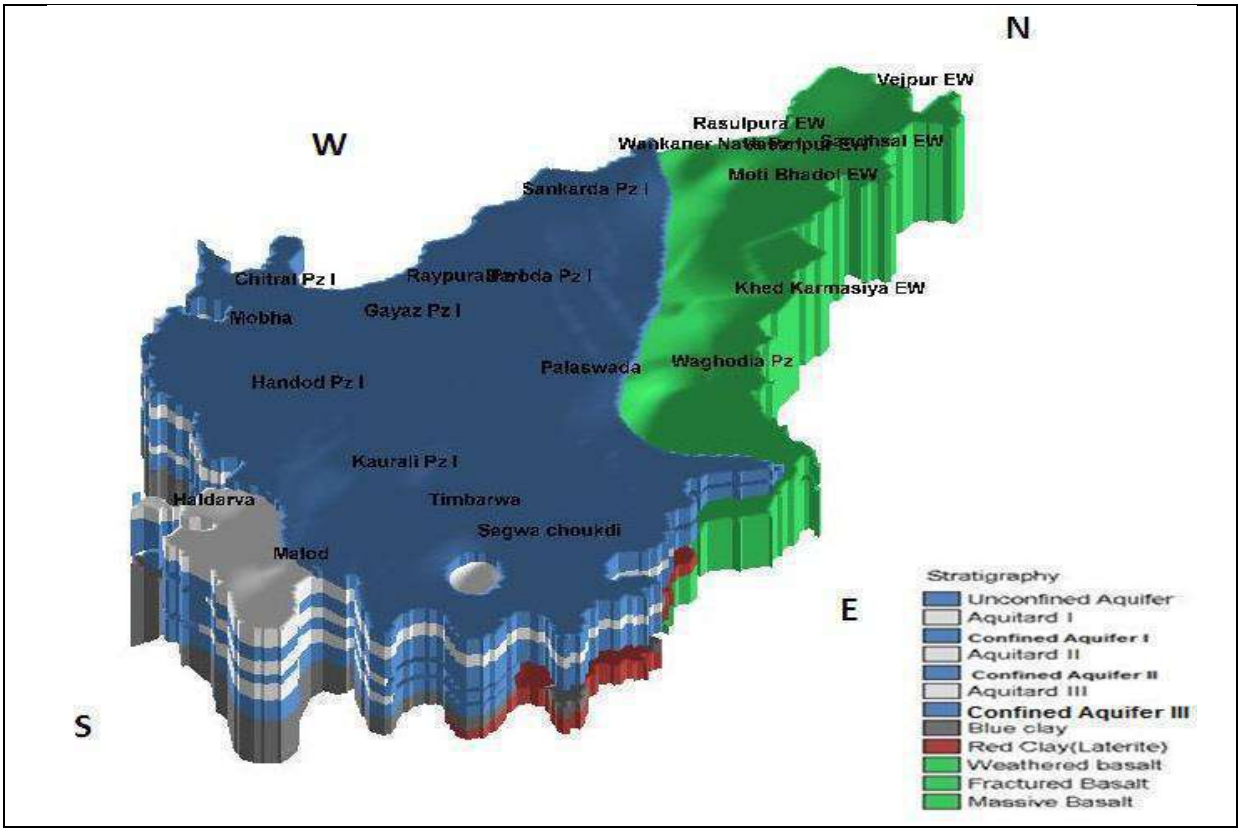
Technical Report Series

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



Government of India

Ministry of Jal Shakti

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West Central RegionAhmedabad

July 2022

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

Contributors' page

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AQUIFER MAP&MANAGEMENT PLAN OF
VADODARA DISTRICT GUJARAT
(4096.10 sq. km)

VADODARA DISTRICT AT GLANCE		
SL No.	Items	Statistics
1	General Information	
	i) Geographical area/Total Reporting area (Sq. Km)	4312/4077
	ii) Administrative Divisions (As on 3/2018) Number of Talukas Number of Villages	 8 656
	iii) Populations (As per 2011 census)	3,093,795
	iv) Average Annual Rainfall (mm)	894
2.	GEOMORPHOLOGY	
	Major Physiographic Units : Undulating plain, ridges, isolated hills& Plateaus	
	Major Drainages: Mahi, Narmada & Dhadar. Tributaries of Mahi (Mesari,Goma,Karad), Tributaries of Dhadar(Jambuva,Viswamitre)& Tributaries of Narmada (Unch,Heran,Dev,Orsang,Karjan,Aswan,Bhukhi)	
3.	LAND USE (Sq. Km)(Directorate of Agriculture Gandhinagar)	
	a) Forest area b) Net area sown c) Cultivable area d) Barren and Uncultivable Land	142 2947 3291 1072
4.	MAJOR SOIL TYPES: Black Soil, alluvial Soil & Hilly Soil.	
5.	TOTAL AREA UNDER FOOD CROPS (Sq km) Rice-147, Wheat-232, Maize-3,Bajra-98	
6.	IRRIGATION BY DIFFERENT SOURCES (Areas in Sq Km and numbers of structures)	
	Dug wells	221/4315
	Shallow Tube wells/ Deep Tube wells	891/5593
	Tanks/Ponds/Water conservation structures	109/129
	Canals	515/7
	Other Sources(Total Pump sets/Check dam/Boribund)	344
	Net Irrigated area (sq. km.) (2014-15)	1953
	Gross Irrigated area (sq. km.) (2014-15)	2080
7.	NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on 31-03-2018) No of Dug Wells No of Piezometers	28 14 14
8.	PREDOMINANT GEOLOGICAL FORMATIONS: Granite, Deccan trap basalt, alluvium and Fluvial marine sediments.	
9.	HYDROGEOLOGY	
	Major Water Bearing Formation: groundwater occurs both as unconfined and confined conditions. Saturated zones of unconsolidated shallow alluvium and weathered zones, shallow depth jointed and fractured rocks forms unconfined aquifers, whereas multilayered aquifer below impervious clay horizons in alluvium formation and interflow zones of basalts, inter-trappean beds, deep seated fracture zones, shear zones in basalts, granites and gneisses give rise to semi confined to confined conditions.	

	Depth to water Level during 2018-19				
	Period	Phreatic Aquifer (DTW)		Semi-confined Aquifer (PZ head)	
		Min	Max	Min	Max
	Pre Monsoon	2.45 (Vejpur)	28.03 (Sankeda)	15.52(Raypura)	42.87(Segwa Chowki II)
	Post Monsoon	0.65 (Amareshwar)	25.02 (Sinor)	13.65(Vadodara)	37.17(Segwa Chowki II)
	Long Term (10 Years) Water Level Trend (2009 to 2018)				
	Trend	Pre-Monsoon		Post- Monsoon	
	Rise (m/Yr)	0.0045 (Sinor) to 1.8004 (Gayaz II)		0.0138 (Saidal) to 1.4796 (Gayaz II)	
	Fall (m/Yr)	0.1102 (Masor) to 0.7992(Sankeda)		0.0132(Chitral Pz I) to 0.3059(Sankeda)	
10.	GROUND WATER EXPLORATION BY CGWB (As on 31-03-2018)				
	No of wells drilled (EW, OW, Pz, SH, Total)			EW :38,OW: 10, PZ:7, SH :0, Total:55	
	Depth Range(m)			50-458	
	Discharge (Liters per minute)			3.50-3334	
11	GROUND WATER QUALITY				
	Presence of chemical constituents (more than permissible limit)			Fluoride and Nitrate at few locations	
	Type of water			In general potable	
12.	DYNAMIC GROUND WATER RESOURCES (As on 2017)				
	Annual Replenishable Ground Water Resources (MCM)			1019.37	
	Net Ground water Availability (MCM)			968.41	
	Projected Demand for Domestic and industrial Uses upto 2025 (MCM)			25.30	
	Stage of Ground Water Development (%)			57.91	
13	GROUND WATER CONTROL AND REGULATION (3/2017)				
	Number of OE Blocks			Nil	
	Number of Critical Blocks			Nil	
	Number of Semi Critical Blocks			01	
	Number of Safe Blocks			07	
	Number of Saline Blocks			Nil	
	No. Of Blocks Notified by CGWA			Nil	
14	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) Decline Ground water levels in Vadodara City v) Demand supply management				

AQUIFER MAP AND MANAGEMENT PLAN
VADODARA DISTRICT

1. 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.

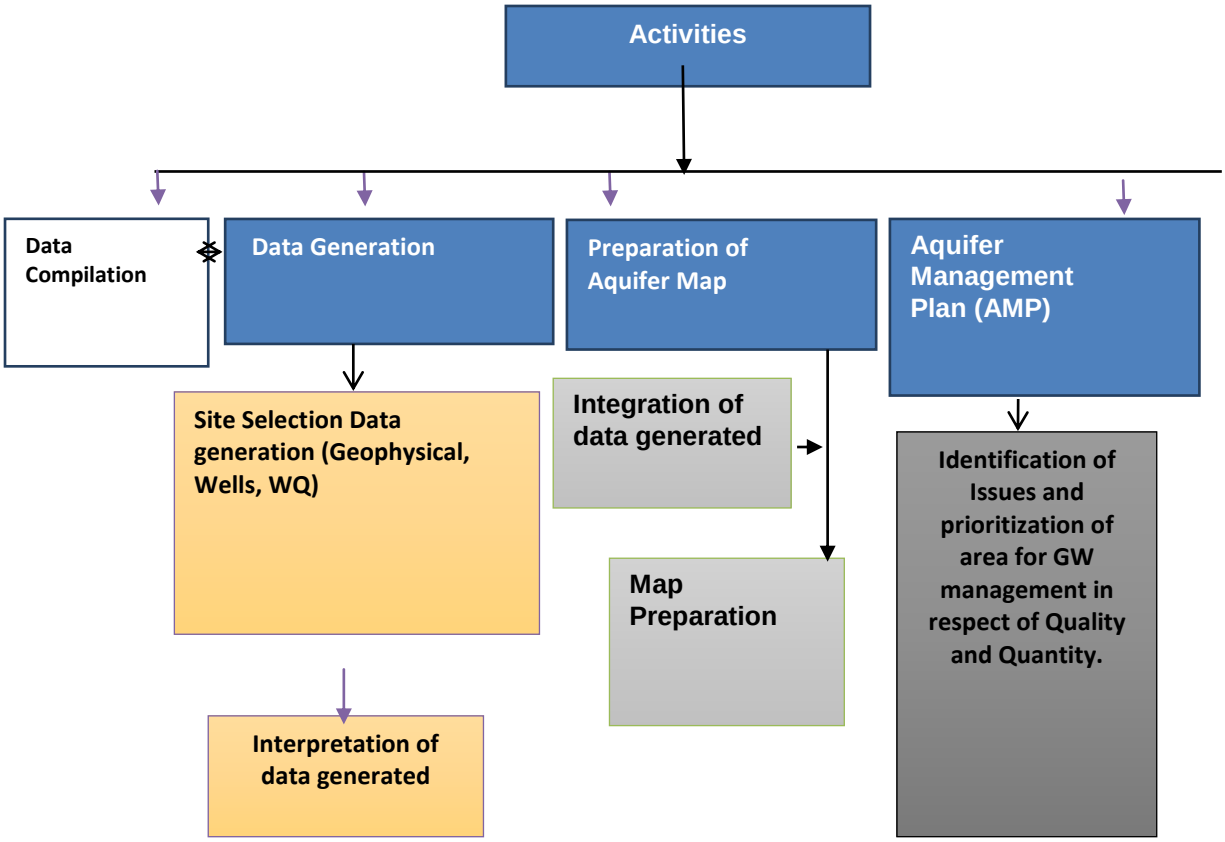
Aquifer Map Preparation:

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

Vadodara district with 4312 Sq km area, is located central part of mainland Gujarat, lies between 21°49'19" and 22°48'37" north latitude and 72°51'05"and 73°35'55" east longitude. It falls in the Survey of India, degree sheets numbered 46B, 46F, & 46G. The district is bounded by Panchmahal district to the north, Anand and Kheda districts to the west, Bharuch and Narmada districts to the south, and Chhota Udaipur to the east. The Mahi River passes through the district. Vadodara city, the district headquarter is about 100 km south of Ahmedabad, is well connected to other parts of the State & Country by network of highways and railway network. (Administrative Map, Fig No. 2).

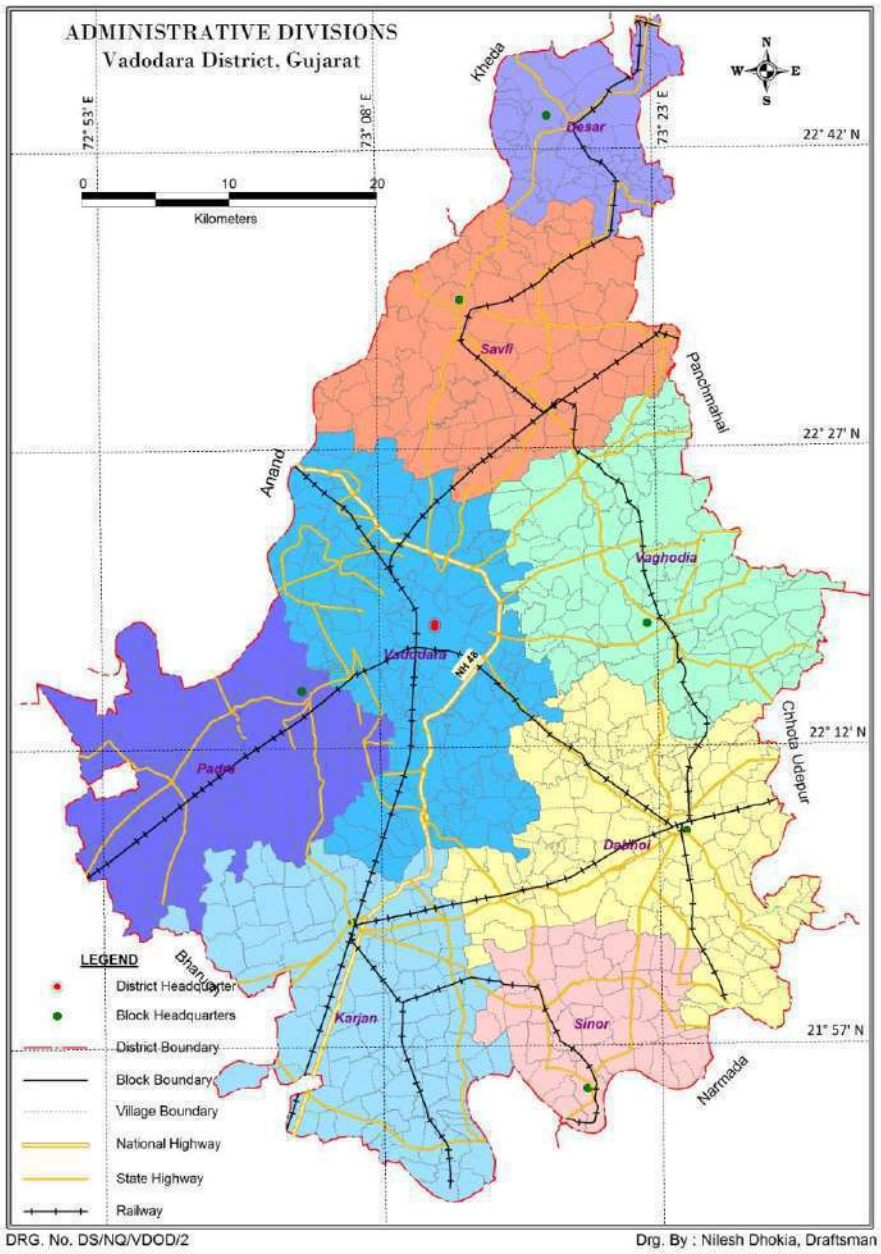


Figure 2. Administrative map of Vadodara district

Vadodara district is divided 8 talukas. Details of the Talukas, their urban & rural areas and numbers of revenue villages & towns etc., are given in Table no: 1

Table: 1 Details of Taluka area & Nos. of Towns & Villages

Sr. No	Taluka	Area (Sq.km)	Urban (Sq.km)	Rural (Sq.km)	No. Town	No. Villages
1	Dabhoi	632.1895	23.82	608.3695	1	118
2	Karjan	601.8724	15.7094	586.163	1	93
3	Padra	534.7288	12.8331	521.8957	1	82
4	Savli	791.9973	0	791.9973	0	137
5	Shinor	292.5048	16.1894	276.3154	1	40
6	Vadodara	693.4307	213.8801	479.5506	9	91
7	Vaghodiya	565.1405	15.0595	550.081	1	95
8	Desar	200.136		262.6275	1	
	Total	4312	297.4915	4077	15	656

Demographic Perticulars

According to the 2011 census Vadodara district has a population of 3,093,795,The district has a population density of 551 inhabitants per square kilometer (1,430/sq mi) .Its population growth rate over the decade 2001-2011 was 14.16%. Vadodara has a sex ratio of 934 females for every 1000 males. It has a literacy rate of 81.21% in 2011, an impressive ten percentage points increase in 10 years.

LAND USE PATTERNS, IRRIGATION & AGRICULTURE

Seasons & Crops Record, Vadodara District -year 2014-15, has been refereed for land use, irrigation & agriculture statistics of the district.

Land Use Patterns

As per *Seasons & Crops Record,* 431200 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 Vadodara District (2014-15)

Sr No	Land Use Classification	Area in Hectare
1	Area Reported for Land Use	431200
2	Forest	14200
3	Total Uncultivable area	48100
4	Culturable Waste	9000
5	Cultivated Area (1 - 2 – 3 – 4)	359900
6	Cultivable Area (5 + 4)	368,900
7	Current Fallow	4300
8	Net Area Sown (5 -7)	355600
9	Area Shown More Than Once	10300
10	Total Cropped Area (8 + 9)	365900
11	Net Area Irrigated	195300
12	Area Irrigated More Than Once	12700
13	Gross Area Irrigated (11 + 12)	208000
Land Use & Season –Crop Record – Vadodara District – Year 2014-15 – 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	9,400	10,900
Canals	48,200	51,500
Total Surface Water	**57,600**	**62,400**
Govt. Tube Wells	84,600	89,100
Pvt. Tube Wells	20,000	22,100
Dug Wells	33,100	34,400
Total Ground Water	**1,37,700**	**1,45,600**
Total Irrigated Area	**1,95,300**	**2,08,000**

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 365,900 hectares of gross area under various crops in the district, out these 208,000 hectares were under irrigated crops

Urban and Industrial area

Vadodara district is one of the most industrially developed areas the state. It has many *Strategic Industries*, such as oil refinery, petrochemical complex, fertilizers, and heavy water project etc., located around areas of Vadodara Taluka. Other important industries are of metal product, rubber& plastic, non- metallic mineral product, pharmaceuticals, engineering & machinery parts etc. Besides these, there are many industrial notified areas in various Taluka areas of the district of which 8 are established and managed by Gujarat Industrial Development Corporation Ltd. (GIDC Ltd).

CLIMATE

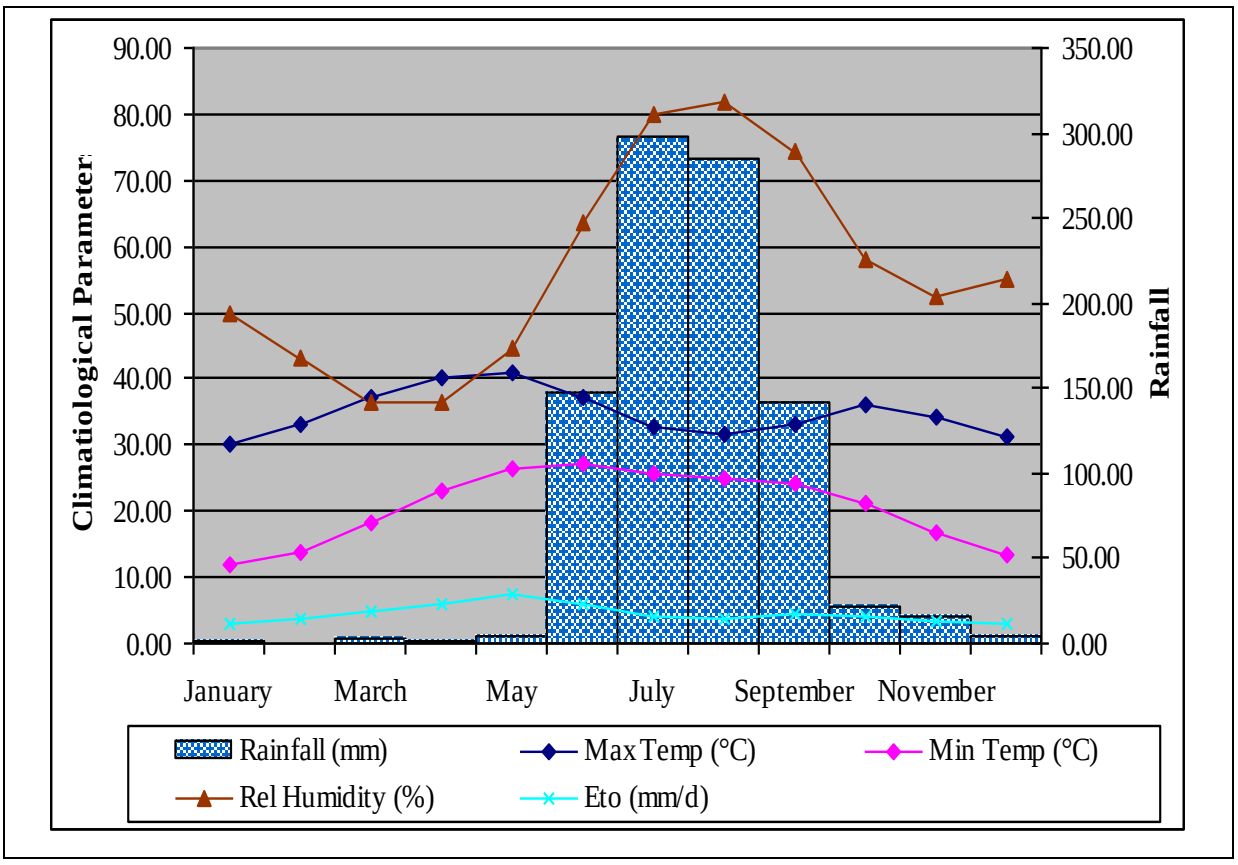
Vadodara district area, in general, being located south of *Tropic of Cancer* and in transition zone of heavy rainfall areas of South Gujarat and arid areas of North Gujarat plains, have sub-tropical climate with moderate humidity. The various season of the year are (a) monsoon - middle of June to October, (b) winter - November to February, and (c) summer – March to June. From March onward the temperature starts rising till it reaches maximum, as high as 41° C in some parts of the district. January is the coldest month of the year.

There is a Indian Meteorological Department (IMD) station located at Baroda (Vadodara), where observation of climatic data is recorded since 1900. Details of this climatological data is given in table No.4 and same is depicted graphically in figure No. 3.

Table No. 4 - Climatological Data of IMD Station –(Baroda) - Vadodara

Month	Max Temp (Deg.C)	Mini Temp (Deg.C)	Humidity (%)	Wind Spd. Kmpd	Sun shine (Hours)	Solar Rad. (MJ/m2/d)	Eto (mm/d)	Rainfall (mm)
January	30.30	12.00	50.00	65.80	9.10	17.23	3.02	1.20
February	33.00	13.80	43.00	67.50	9.70	20.07	3.81	0.60
March	37.10	18.40	36.50	69.10	10.20	23.16	4.88	2.20
April	40.20	22.90	36.50	79.00	10.80	25.75	6.03	0.90
May	40.90	26.50	44.50	143.20	10.90	26.38	7.46	4.40
June	37.10	27.00	63.50	169.50	7.10	20.62	5.97	146.80
July	32.70	25.70	80.00	138.20	4.40	16.51	4.11	297.60
August	31.50	25.00	82.00	116.80	4.50	16.32	3.82	284.70
September	33.20	24.30	74.50	83.90	6.90	18.87	4.28	141.70
October	36.00	21.30	58.00	49.40	9.30	20.24	4.12	22.00
November	34.30	16.70	52.50	49.40	9.40	18.02	3.24	16.20
December	31.20	13.40	55.00	59.20	9.10	16.50	2.83	4.40
Total	-	-	-	-	-	-	-	**922.70**
Average	**34.79**	**20.58**	**56.33**	**90.92**	**8.45**	**19.97**	**4.46**	-

Figure No 3. - Plot of Climatological Data –Vadodara (Baroda) – IMD Station



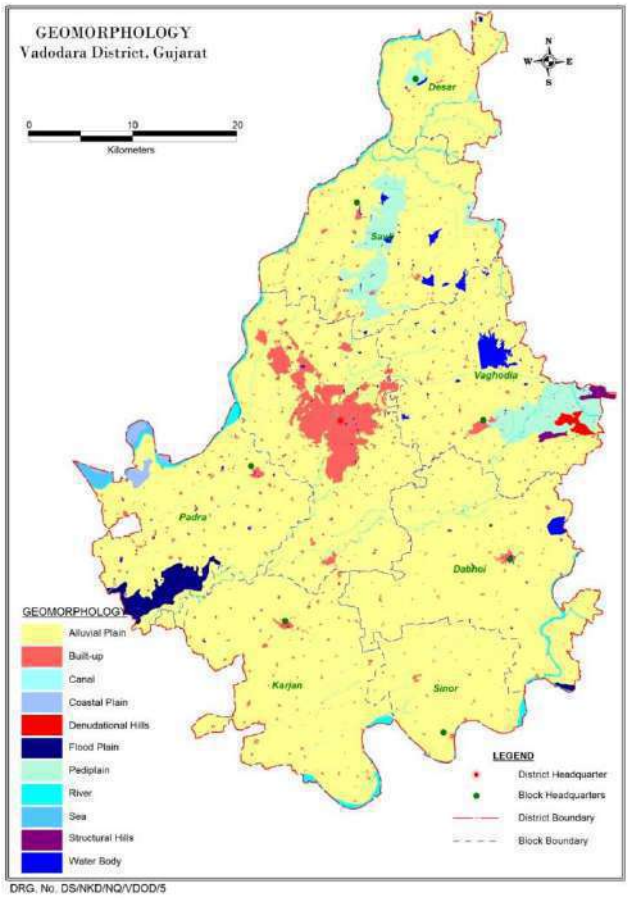
GEOMORPHOLOGY

Physiography

Vadodara district forms a part of the great Gujarat plain. The western & southern part, comprising of Mahi & Narmada *Doab*, is a level plain with gentle undulating terrain have elevation in range of 20 to 80 m amsl.

There are some linear tracts, along Mahi, Viswamitre, Dhadahar and Orsang rivers, have *ravine landforms*, with typical head ward erosional featured gully formation in soft alluvium. The banks of the Mahi has high vertical cliff , 10 to 25 m height, generally on left bank; same way left bank of the Narmada also has high cliff of 10 to 20 m high on right bank. All such features of *Mahi-Narmada Doab*, like ravine features, high cliff along banks and entrenched meandering courses with dry and wide sandy river bed of intermediate independent river systems of the Dhadhar & its tributaries indicate mature river stage and also tectonic uplift of *Doab* portion in *Recent* geological past. Fig No:-4 Geomorphology of Vadodara District.

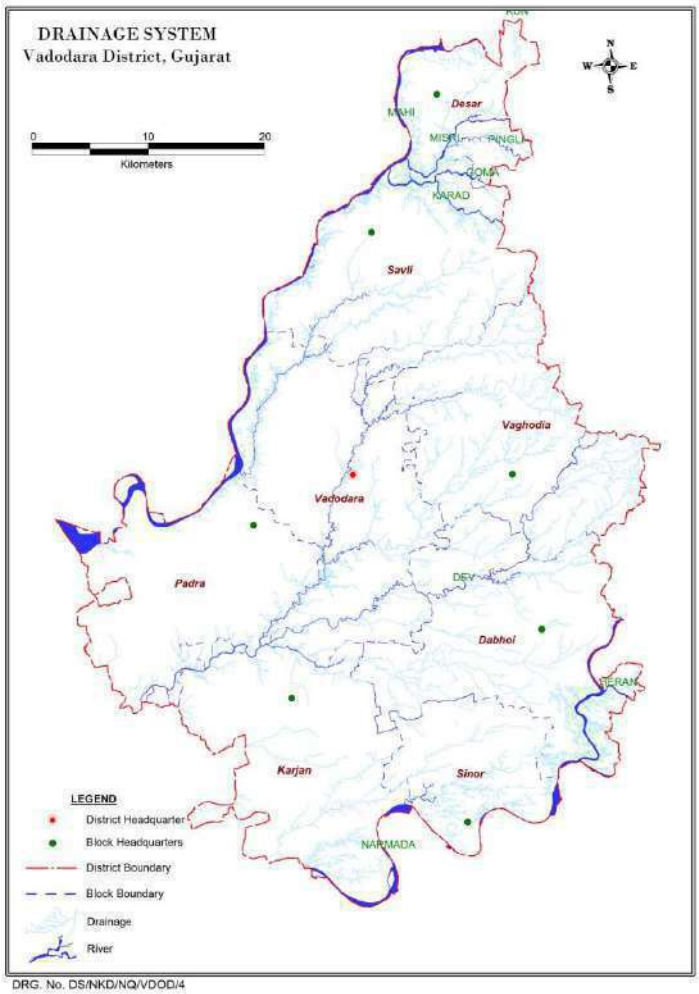
Fig No:-4 Geomorphology of Vadodara District



Drainage

The Narmada and the Mahi are the chief rivers of the district, flow along the northwestern and southern boundary respectively while independent small river system of the Dhadhar with its numerous tributaries flow in south central part of the district. Broadly, the entire district, as a *River Basin* is divided into these three basin, namely the Narmada, the Mahi Basin and the Dhadhar. The Mesari, the Goma and the Karad are the small rivers flowing northwest part of the district, are tributaries of Mahi River, and are part of the Mahi Basin. The Jambuva, the Surya, the Viswamitre and the Dhadhar, which flow through central part of the district and empty into the Gulf of Khambat, are part of the Dhadhar Basin. Fig No:- 5

Fig No:-5 Drainage system of Vadodara district



Soils

The soils of Vadodara district can be broadly classified into three groups. They are black soils, alluvial soils and hilly soils.

HYDROLOGY

Surface Water Resources

Vadodara district has huge potential of Surface Water Resources, but the irrigation potential created through various sources was only 208000 hectare according to Season & Crops Report (2014-15). The district having two major rivers, the Narmada and the Mahi on its borders, besides smaller rives like the Viswamitri, the Orsang, the Heran, the Dadhar etc. Recently, water of the Narmada river have been harnessed by Sardar Sarovar Dam and consequently large part of the district now forms a part of *Narmada Canal Command*. The dam constructed on Mahi at Kadana and Weir at Wanakbori did not produced any direct surface water resources benefit for irrigation in parts of Vadodara district as such Mahi Project command areas falls in neighboring Anand & Kheda district. However, surface water release, from Kadana Dam through Wanakbori weir during lean season; satisfy huge demands of Vadodara City and surrounding many Strategic Industrial Units for their domestic and industrial requirement.

Besides these two major rivers, other rivers of the district such as the Orsang and the Heran do sustain some base flow up to February / March which is being utilized for supplement irrigation at places along their course at suitable places.

Previous studies / Work

- Ground water investigation for augmenting Water supply to Baroda city by Sh V V Rane GSI 1961.
- Ground Water Investigation for proposed Fluorspar beneficiation plant GMDC near Amba Dungar,Baroda District by MM Oza GSI 1964-65.
- Hydrogeological investigation for Ground water potential of Mahi basin near Vasad by Soil survey Organisation.
- Systematic Hydrogeological survey in 46f & 46J in Vadodara district by P R Gupte CGWB 1986-87.
- Systematic Hydrogeological survey and Exploration in Vadodara district by A K Jain CGWB 1986-87.
- Ground water exploration work in parts of Vadodara district by B N Warke CGWB 1988-89.
- Hydrogeological Conditions, Ground Water Resources & Development Potential of Vadodara Dsitrict, Gujarat by Prakash R Gupte CGWB in 2010.

2. GEOLOGY AND HYDROGEOLOGY

STRATIGRAPHIC SET UP

The rocks of the Vadodara district shows an age from Proterozoic to Recent but a striking feature of the district stratigraphy is the total absence of Paleozoic, and the development of only the uppermost Mesozoic rocks. The south westerly extended Precambrian basement of Peninsular India, the oldest rocks of Proterozoic age, are exposed in eastern and north eastern part of the district. Post Cretaceous sediments & major volcanic rocks rest over this south westerly extended Precambrian basement. Post Cretaceous sediments, Infratrappean and Intratrappean are exposed as scattered inliers while younger volcanic rocks unit as Deccan trap is well represented and so are the Tertiary and Quaternary, though the Tertiary records are not complete and fully exposed. The stratigraphic outline of the district is given in table no. 5.

Table No. 5 Stratigraphic outline of the Vadodara District

Continental sediments – fluvio-marine, fluvial and aeolian	Quaternary
Marine and fluvio-marine sediments	Tertiary
……Unconformity…….	
Basalts of the Deccan Trap with associated differentiates and intrusive bodies	Upper Cretaceous to Lower Eocene
……Unconformity…….	
Marine, fluvio-marine and fluvial sediments	Cretaceous
……Unconformity…….	
Crystalline rocks -Metasediments associated with granite, gneiss and other mafic rocks	Precambrian (Aravalli)

HYDROGEOLOGY

OCCURRENCE & DISTRIBUTION OF GROUNDWATER

In Vadodara district area, groundwater occurs both as unconfined and confined conditions. Saturated zones of unconsolidated shallow alluvium and weathered zones forms unconfined aquifers, whereas multilayered aquifer below impervious clay horizons in alluvium formation and interflow zones of basalts, inter-trappean beds, deep seated fracture zones, shear zones in basalts give rise to semi confined to confined conditions.

In major part of the district, multilayered alluvium deposits form aquifer system in central, south-central and western half of the district. The weathered basalts, granite, gneiss etc., covered by soil / *muram* and the valley fill & piedmont deposits forms potential aquifer in the vicinity of rivers and on vast undulating plains adjacent to hilly terrain but their regional continuity and extent are limited due to heterogeneous nature of deposits with limited thickness and as such rarely exceed a few square kilometers.

In major part of the district, multilayered alluvium deposits form aquifer system in central, south central and western part of the district. In alluvium part so many exploratory wells has been drilled and the depth rage is 50 to 400 mbgl.And yield of this Aquifer having 3 to 20 lps.In hard rock basaltic terrain exploratory wells depth ranges between 50 to 450 mbgl and yield having 0.23 to 11 lps.

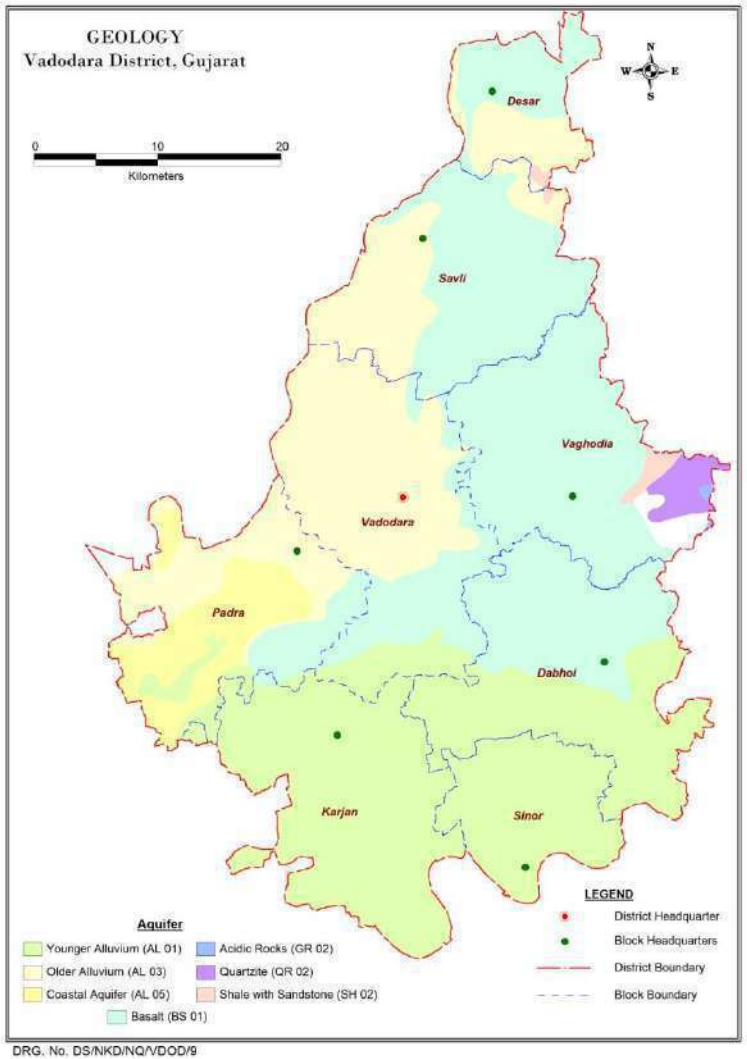


Fig No-6 Geology map of Vadodara

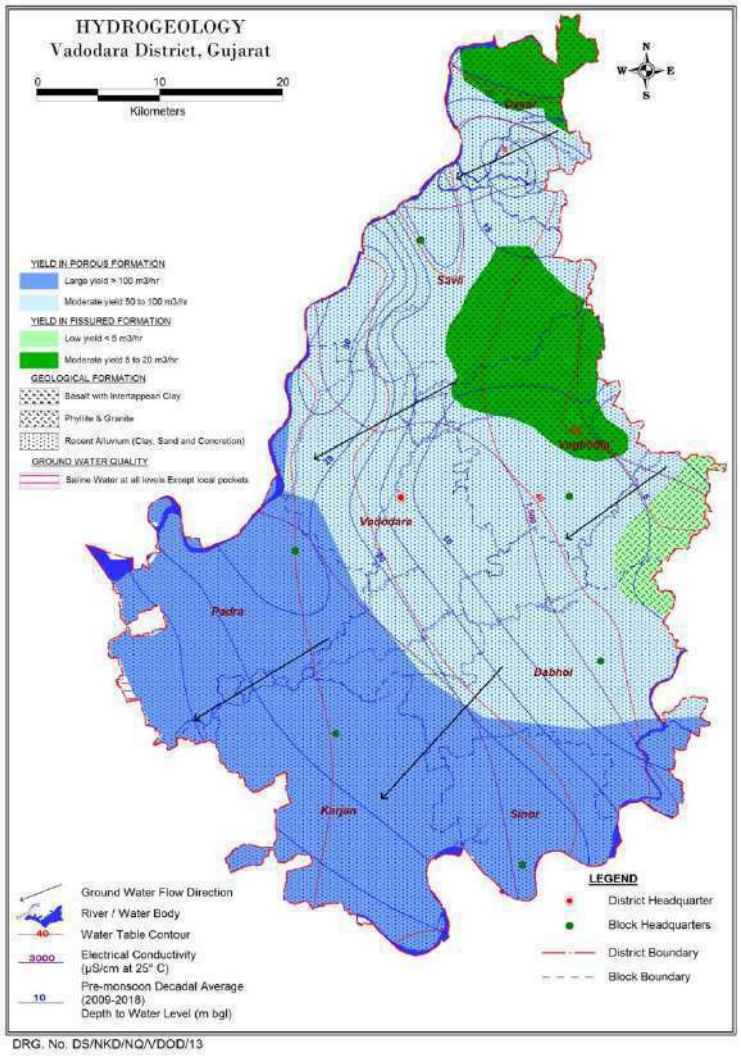


Fig No-7 Hydrogeology map of Vadodara

SUBSURFACE GEOLOGY

Exploration Details

The boreholes drilled by CGWB and erstwhile ETO, as a part of Ground Water Exploration work in various parts of Vadodara district have revealed the sub surface geological formation in the district. ETO have drilled few boreholes in parts of the district and adjoining Bharuch & Kheda during under various program. Then CGWB have drilled 14 Boreholes in 'Outfall Area of Narmada Project' (1972-1978) in parts of Vadodara district & Bharuch district. Then under piezometer construction program, few bore holes were drilled in parts of Padara, Karjan, Dabhoi, Vadodara & Savli Taluka areas during 1988 -90.

On the basis of their Litholog and geophysical log data various sub surface geological cross sections were prepared during project studies and exploration programme. The exploration programme of Narmada project revealed that in Northeastern part of Mahi-Narmada-Daob the Tertiary formations encountered at shallow depth range between 13 to 45 mbgl, whereas in the western part of Narmada-Mahi and Daob the tertiaries are overlie by Jambusar formation of Pleistocene age. While the thickness of alluvium increases towards west in Narmada-Mahi Daob.It further reduces in North eastern sector 13 to 45 m in near Almgir,Atkot,Chatral and Palaswada.In western part of the district the depth of tertiary increases to 70 m at Tentalo,85 m at padre and 150 at vagra (Bharuch).

GROUND WATER STRUCTURES

Vadodara district area has varied ground water extraction structures, appropriate to different hydrogeological units and necessity. Various types of dug wells (DW) are common to both alluvial / soft rock areas and also in hard rock areas. In unconsolidated formation the depth of dug well is few meter to more than 25 m; while in hard rock areas, generally their depth depends upon weathering zone, through which they have curbing and below it have naked zone. With declining water levels along with rapid development, bore well of 30 to 90 m depth are drilled at bottom of dried up dug well section and such well are termed as *dug cum bore well (DCB well),* are common in both unconsolidated & consolidated formation of the district. In consolidated rock units, especially in Deccan Trap areas, horizontal bores at the bottom of the well, with gentle gradient towards well are common. Large dia, collector type wells, generally for regional water supply or for industrial uses are common in sandy beds of Mahi and Orsang rivers. To meet large demands bore well / tube wells are common structures. There are shallow bore wells up to 60 to 80 m depth both in consolidated and unconsolidated areas. Such bore well, in hard rock areas are drilled for hand pump and also for irrigation purposes. In unconsolidated arrears, in areas of Quaternary alluvial deposits having deep aquifer, deep tube wells up to 200 m depth are common.

GROUNDWATER REGIME MONITORING

Ground water regime monitoring is the basic component of groundwater management and it is carried out in parts of Vadodara 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 14 Dug wells and 14 piezometers as part of the NHS from CGWB and there are 18 Dug wells and 28 piezometers from GWRDC Ltd. The following maps have been generated to understand the behaviour of ground water regime.

1. Phreatic or Unconfined Aquifer
   - Depth to Water Level Pre monsoon May 2019.
   - Depth to Water Level Post monsoon November2019.
2. Phreatic Depth to water Table maps of May-2019 & Nov-2019.
3. Confined Aquifer (Confined I)
   - Depth to piezometric surface Pre monsoon May 2019.
   - Depth to piezometric surface Post monsoon November2019.

Depth to Water Level Pre monsoon (May 2019)

The figure 08 shows depth to water level map of Vadodara district, prepared on the basis of NHS data of May 2019. In major part of the district, the water level ranged in between 2 to 20m, southern part of the Sinor, Karjan and central part of Padra taluka has the water level range in between 20 to 40m. On the northern part of Desar and Eastren part of Vagodia taluka also range in between 2 to 5 m bgl of water level. On the central part of Vadodara,vagodia and south eastern part of Daboi water level range in between 10 to 15m bgl. (Figure 08: DTW May 2019 map of Vadodara 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 20 m bgl while eastern part of the Vagodiya taluka, northren part of Desar and have water level ranges of 2 to5 m. southern part of the Sinor, Karjan and central part of Padra taluka has the water level range in between 20 to 40m.(Figure 09: DTW November 2019 map of Vadodara district.)

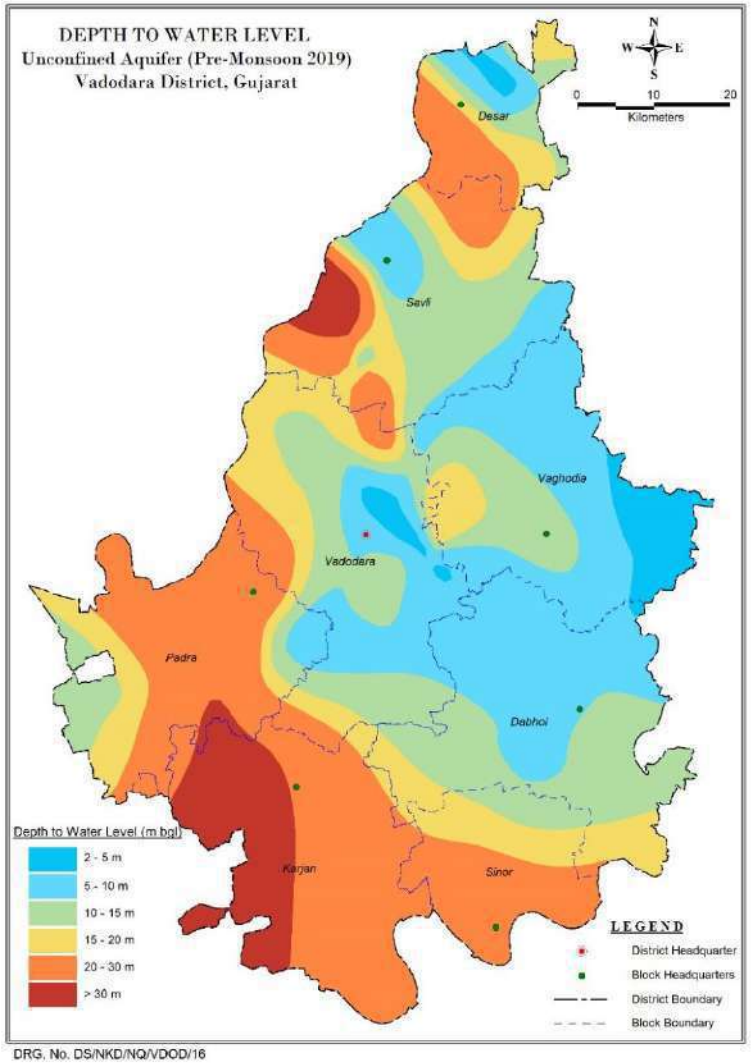


Figure 08: DTW May 2019 map of Vadodara district.

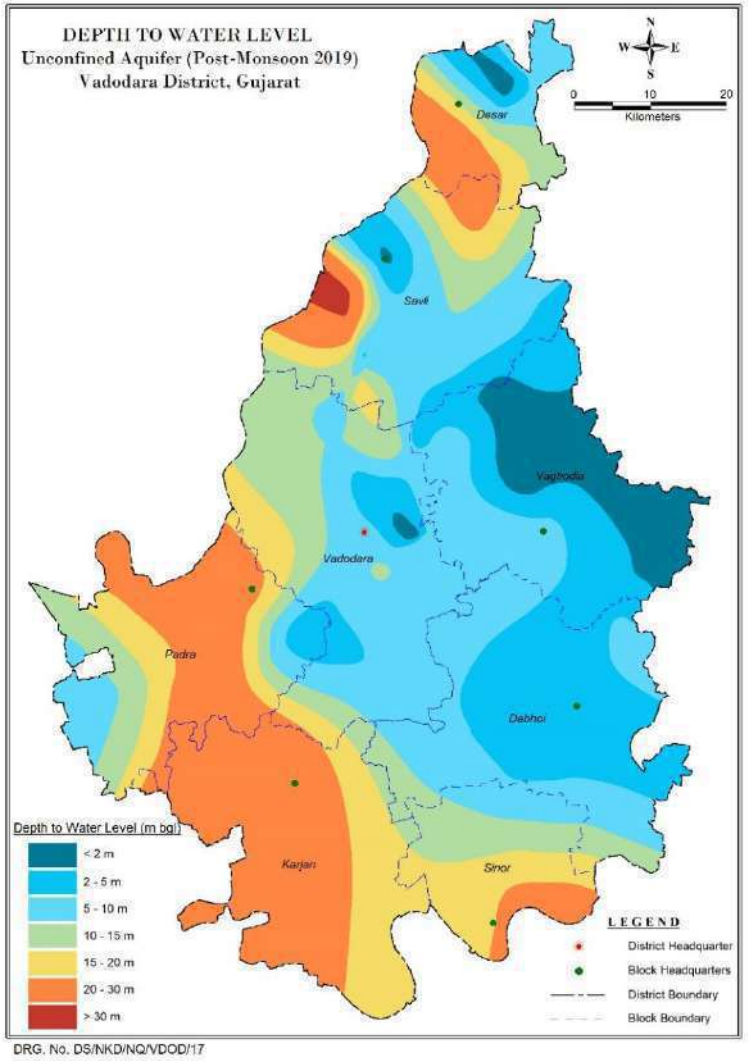


Figure 09: DTW November 2019 map of Vadodara district.

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.

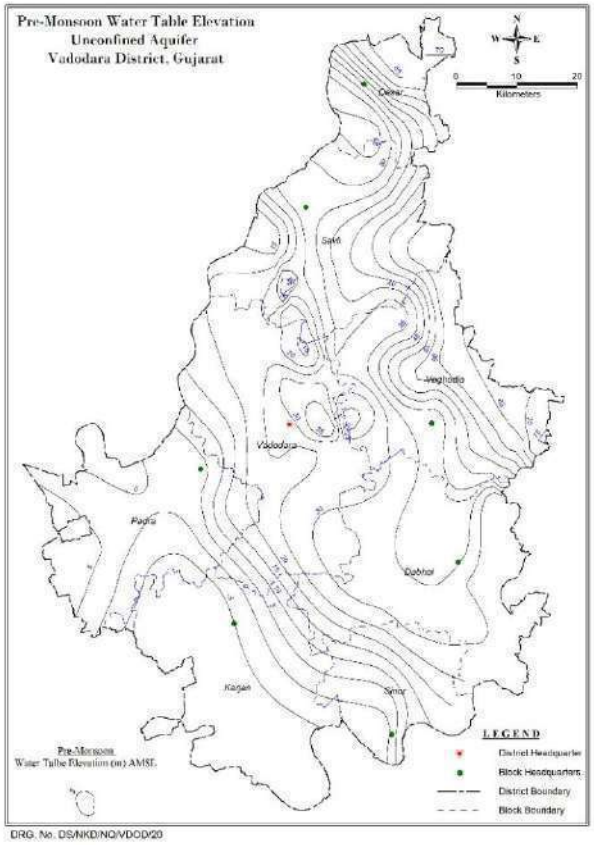


Figure 10: Unconfined Depth to water Table maps of May-2019

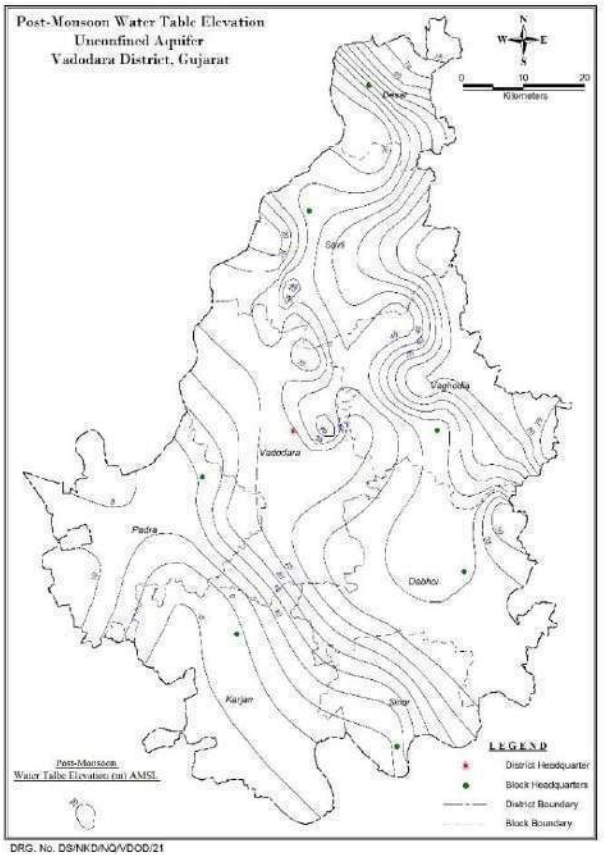
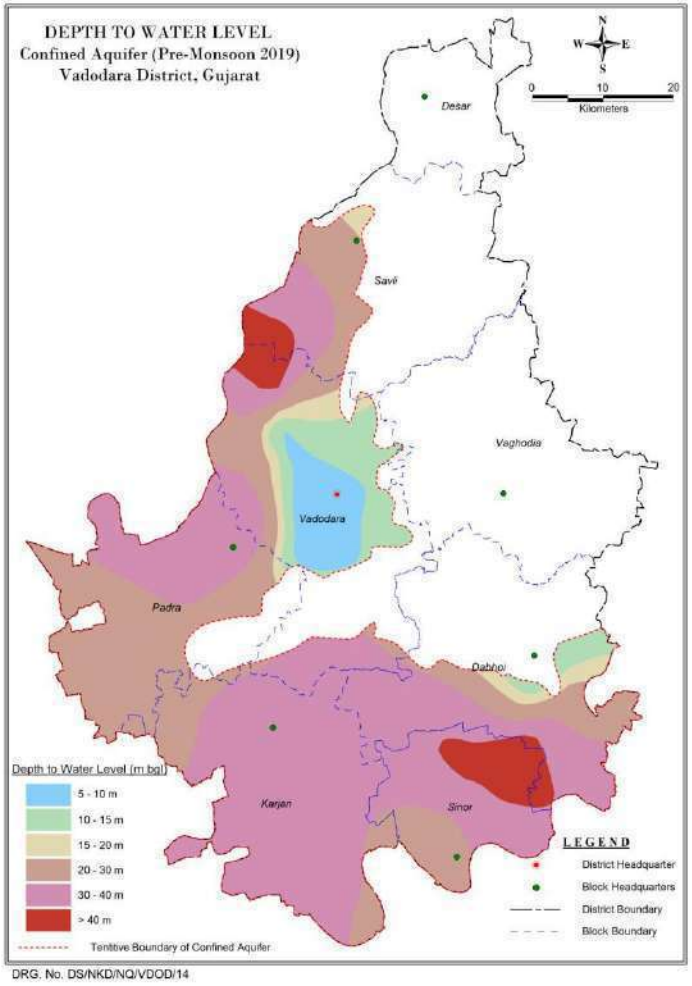
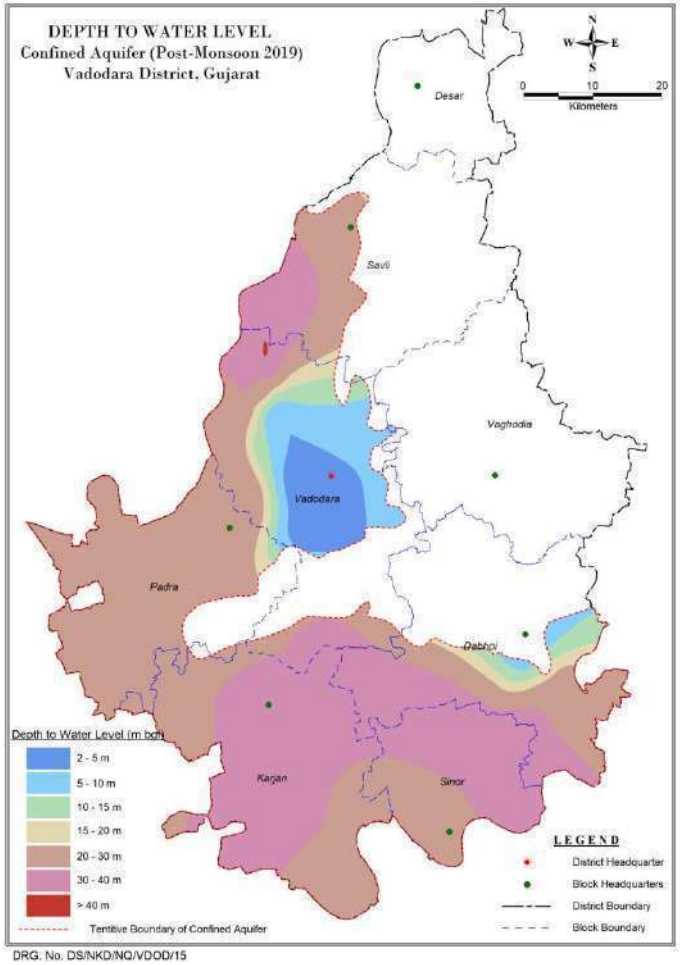


Figure 11: Unconfined Depth to water Table maps of Nov-2019

Figure 12-Depth to piezometric surface Pre monsoon May 2019 (Confined I).	Figure 13-Depth to piezometric surface Post monsoon November2019 (Confined I).
	
Majority of the deep water levels during this season are in the range of 30-40 m covering 50% of the area of confined I Aquifer, followed by 20 - 30 m bgl (30%). Shallow water level ranges 5-15 m bgl (15%) are followed by water levels < 5 m.bgl occupy 5% of the area in northern part of Vadodara taluka.More than 40 m waterlevel occurred in isolated.	Majority of the deep water levels during this season are in the range of 20-30 m covering 50% of the area, followed by 05 -20 m bgl (30%). Shallow water level ranges 2-15 m bgl (15%) are followed by water levels < 2 m.bgl occupy 5% of the area in central part of Vadodar taluka . In Karjan & Sinor WL ranges 30-40 mbgl.

Depth to Piezometric Surface:

Piezometric surface in the district ranges from 40 m a MSL to 10 m bMSL. In perusal of map (Fig.14) Two ground water trough are observed. In the Easter boundary the groundwater trough to the depth of 5 m bMSL is extending fro Padar taluka Sinor taluka and also in adjoining district. Groundwater flow direction in the eastern part is from East to West. One prominent ground water trough to a depth of 5 m b MSL in the most part of Karjan taluka is observed and extendin to the adjoining taluka of Vadodara and Dabhoi.

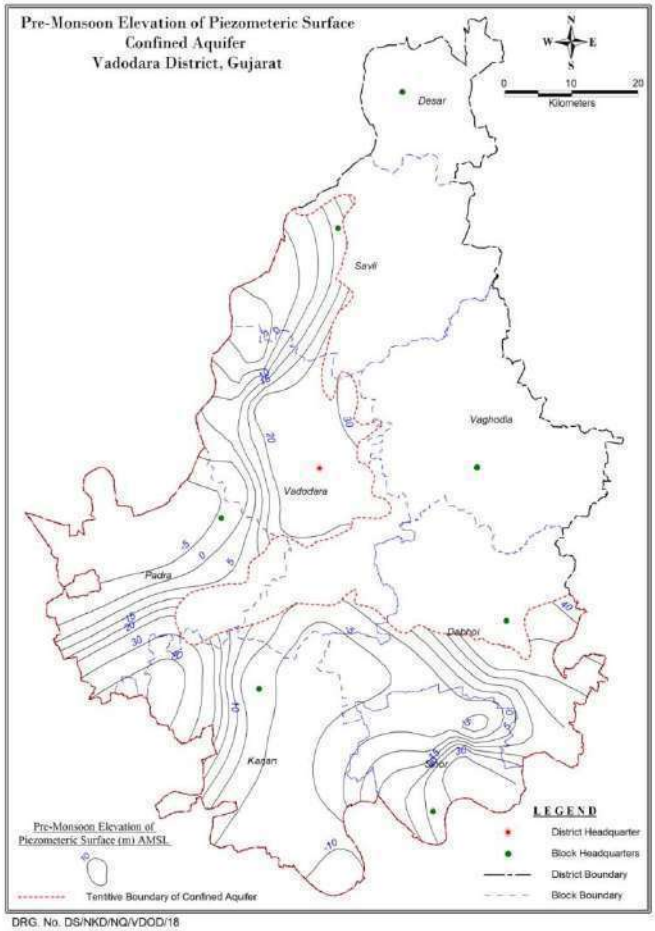


Fig.14 Depth to piezometric surface in m MSL in May 2019.

Water Level Trend (2009 - 2018)

From the analysis of the water level trend of the Vadodara district from 2011 to 2020, it is observed that, during year, the water level has a rise of 0.0086 m/yr (Panwad) to 0.83 m/yr (Vadodara-I) and also has a fall of 0.0024 m/yr (Pavi) to 1.489 m/yr (Sankheda). Details of rise and fall during the year 2011 and 2020 is given in the Table 6 and selected hydrographs are shown in Fig.15 (A to K).

Table: 6 Groundwater trends in m/year for the period of 2011 to 2020 in the district of Vadodara

Sr no	Location	PreMonsoon			PostMonsoon			Annual		
		Data Points	Rise	Fall	Data Points	Rise	Fall	Data Points	Rise	Fall
1	Sinor	9	-	0.0272	9	-	0.4271	35	-	0.2546
2	Kaprali	6	-	0.2611	6	-	0.0073	23	-	-
3	Segwa chowki I	9	-	0.1571	9	-	0.4654	35	-	0.285
4	Segwa chouki ii	6	-	1.5749	10	-	0.269	32	-	0.5152
5	Moti chikhali	10	-	0.2915	10	-	0.0631	37	-	0.1206
6	Sengpur	9	-	0.0907	10	-	0.0212	39	-	0.0327
7	Saidivasana	9	0.0037	-	10	0.0702	-	39	0.0586	-
8	Vagudan	8	0.0168	-	10	-	0.0302	34	-	0.0791
9	Waghach	5	-	-	6	-	0.4542	20	-	-
10	Handod1	7	0.2824	-	6	0.263	-	27	0.1599	-
11	Devat (thadgam)	9	-	0.1595	9	0.0837	-	36	0.0267	-
12	Baladgam	9	0.1079	-	9	-	0.1987	36	-	0.148
13	Masor	7	-	0.0652	9	-	0.2586	31	-	0.0783
14	Kosindra Pz-I	7	-	0.0619	9	-	0.0894	28	-	0.0905
15	Tokri	6	-	0.0409	6	0.0832	-	24	0.1397	-
16	Vega	10	-	0.1523	10	-	0.0467	38	-	0.063
17	Vadshala Pzi	6	0.5797	-	5	-	-	21	-	-
18	Chitral Pz-I	9	-	1.2072	10	0.2929	-	39	-	0.6377
19	Chitral PZ_II	6	0.1431	-	7	0.4629	-	25	0.1988	-
20	Chavaria	9	0.2443	-	8	-	0.0533	32	-	0.0679
21	Bhindol	8	0.0163	-	7	0.0126	-	33	-	0.0247
22	Panwad	9	0.7633	-	10	-	0.1601	39	0.0086	-
23	Govindpura	10	-	0.22	10	-	0.0962	39	-	0.1176
24	Amreshwar	9	0.1625	-	8	-	0.0483	31	0.1065	-
25	Ghayaj ii	8	0.4977	-	10	0.3239	-	38	0.2892	-
26	Alladpur	9	-	0.2235	9	-	0.3512	36	-	0.2885
27	Pitha	9	-	0.1208	10	0.2129	-	39	0.1617	-
28	Vadtalav Pz	10	-	0.4796	9	0.6861	-	33	0.4258	-
29	Vadodara_ONGC	6	0.4393	-	6	-	0.2582	18	-	-
30	Bodeli	8	-	0.9257	8	-	0.3005	30	-	0.4108
31	Patiyapura	10	-	0.0453	10	0.0202	-	40	0.0587	-
32	Raypura i	9	-	0.3472	9	-	1.4507	35	-	0.5914

33	Saidal	10	0.1278	-	8	-	0.0116	34	0.0509	-
34	Vadodara_Kevada Bag	6	0.6899	-	5	-	-	17	-	-
35	Vadodara I	10	0.6467	-	10	1.2655	-	39	0.8297	-
36	Vadodara Ii	10	0.0797	-	10	-	0.7653	38	-	0.3237
37	Chhota udepur	10	-	0.3641	10	-	0.1053	37	-	0.2142
38	Pavi	10	-	0.0718	9	0.0308	-	38	-	0.0024
39	Vadodara_Sama	3	-	-	2	-	-	9	-	-
40	Waghodia Pz	10	-	0.1831	6	-	0.095	30	-	0.0823
41	Ghamodi	9	-	0.0515	10	0.147	-	39	0.1231	-
42	Ferkuva	10	0.0812	-	10	0.2478	-	40	0.2182	-
43	Asala	8	-	0.2406	10	0.4657	-	38	0.214	-
44	Chella Karamsiya Pz	9	0.1534	-	8	0.0974	-	33	0.1547	-
45	Chisadia	7	-	-	6	0.4902	-	26	0.3543	-
46	Karamasiya	9	-	0.326	7	0.1544	-	31	-	0.2706
47	Sankarda	10	-	0.7447	8	0.6856	-	32	-	0.2983
48	Sankarda1	7	1.3122	-	3	-	-	18	-	-
49	Jojh	9	-	0.0373	10	0.0471	-	39	0.0113	-
50	Tundav	10	0.5141	-	10	0.3875	-	40	0.3938	-
51	Juna samalya	9	-	0.2881	9	0.0032	-	37	0.0985	-
52	Kevadi	10	-	0.0583	10	-	0.1069	40	-	0.0058
53	Sankheda	8	-	1.5964	4	-	-	25	-	1.4888
54	Chhaliyar	10	-	0.5922	9	-	0.5507	36	-	0.6468
55	Vejpur2	10	0.0094	-	10	0.1349	-	39	0.0922	-
	Minimum		0.0037	0.0272		0.0032	0.0073		0.0086	0.0024
	Maximum		1.312	1.596		1.266	1.451		0.83	1.489

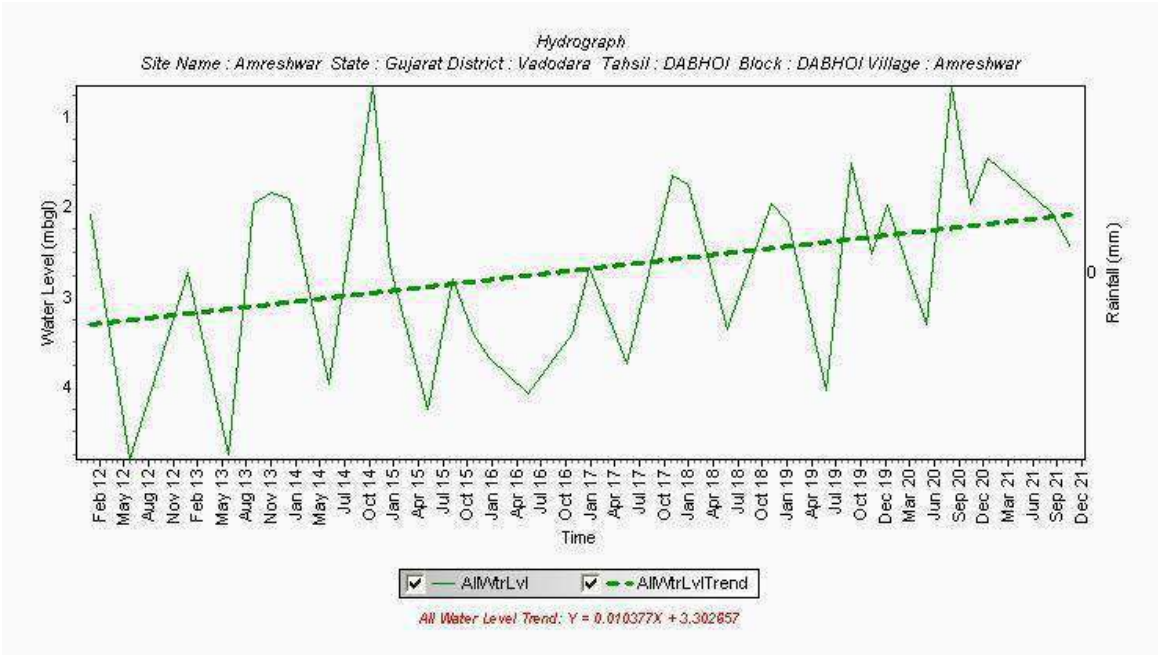
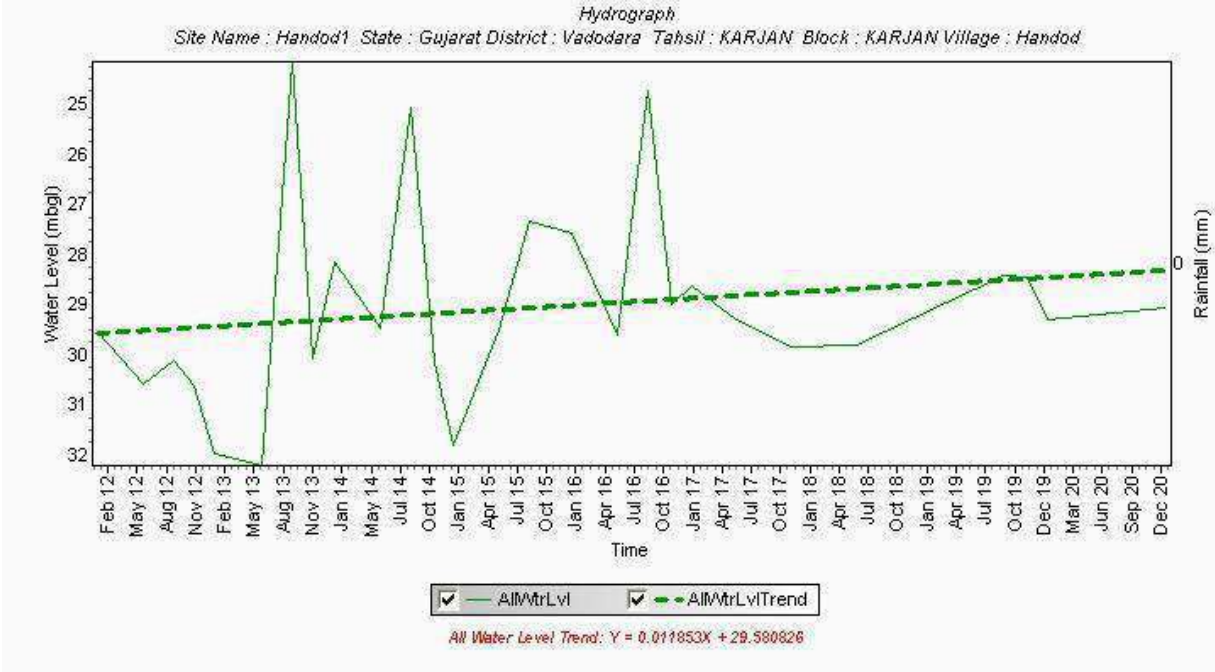


Fig.15 (A) Hydrograph at Amreshwar site observed rising trends 0.0103 m/month



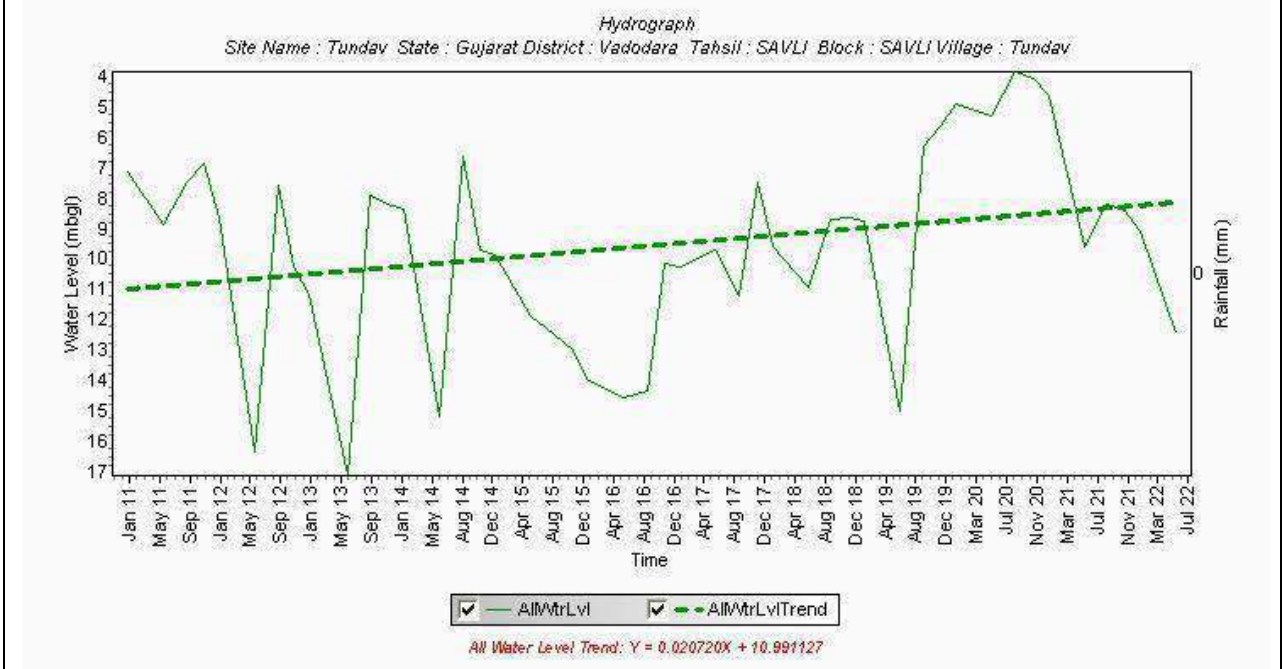
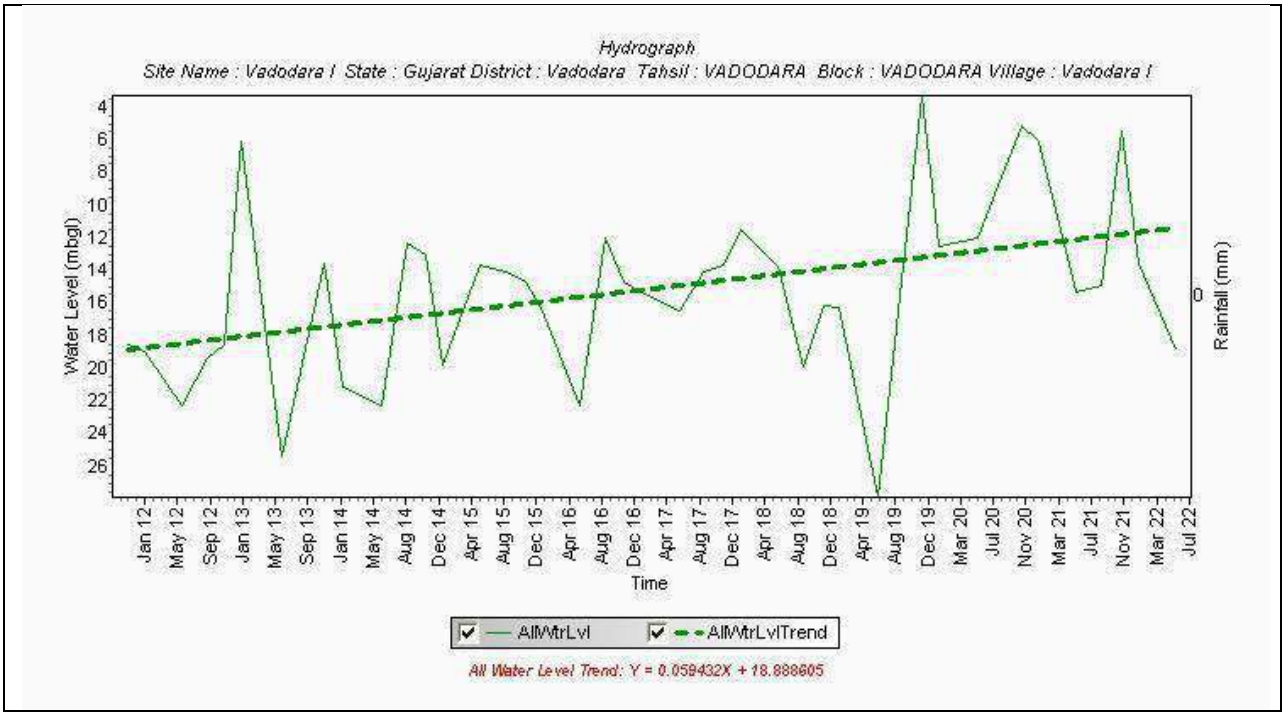


Fig.15 (B & C) Rising trends at Handod and Tundav observed 0.0118 m/month and 0.02072 m/month respectively.



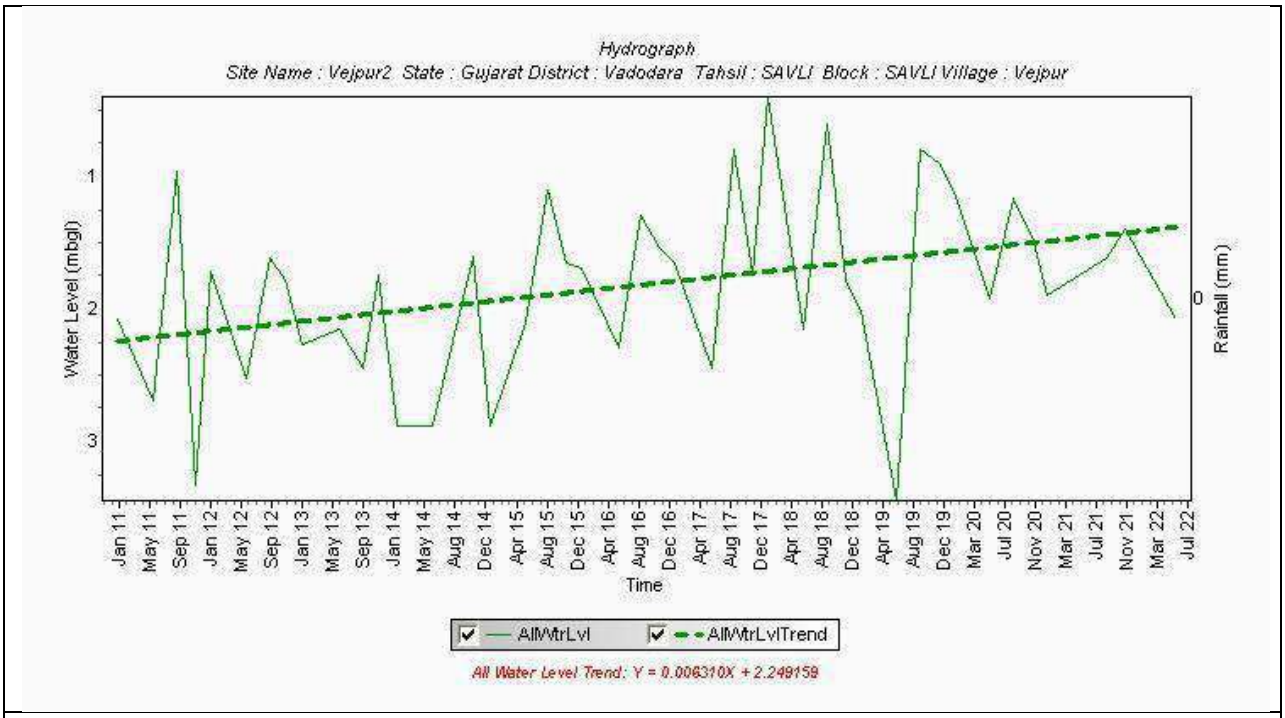
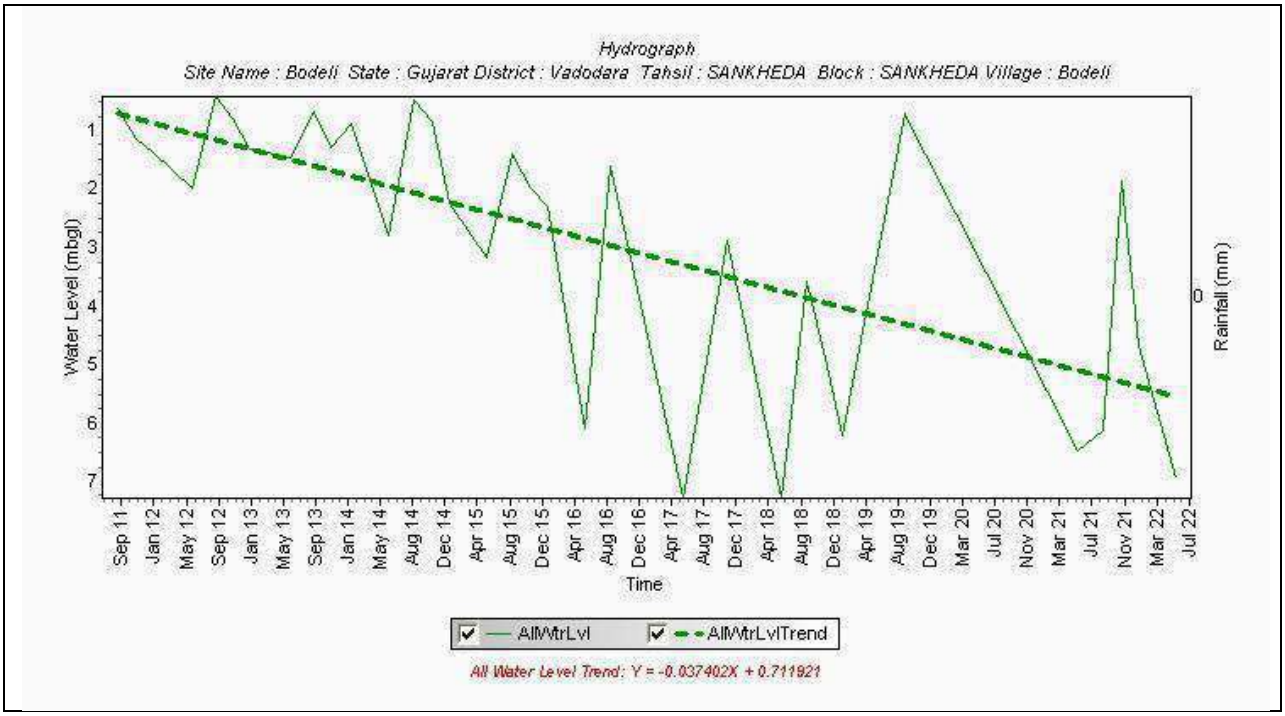


Fig.15 (D& E) Rising trends at Vadodara-I and Vejpur observed 0.059 m/month and 0.0063 m/month respectively.



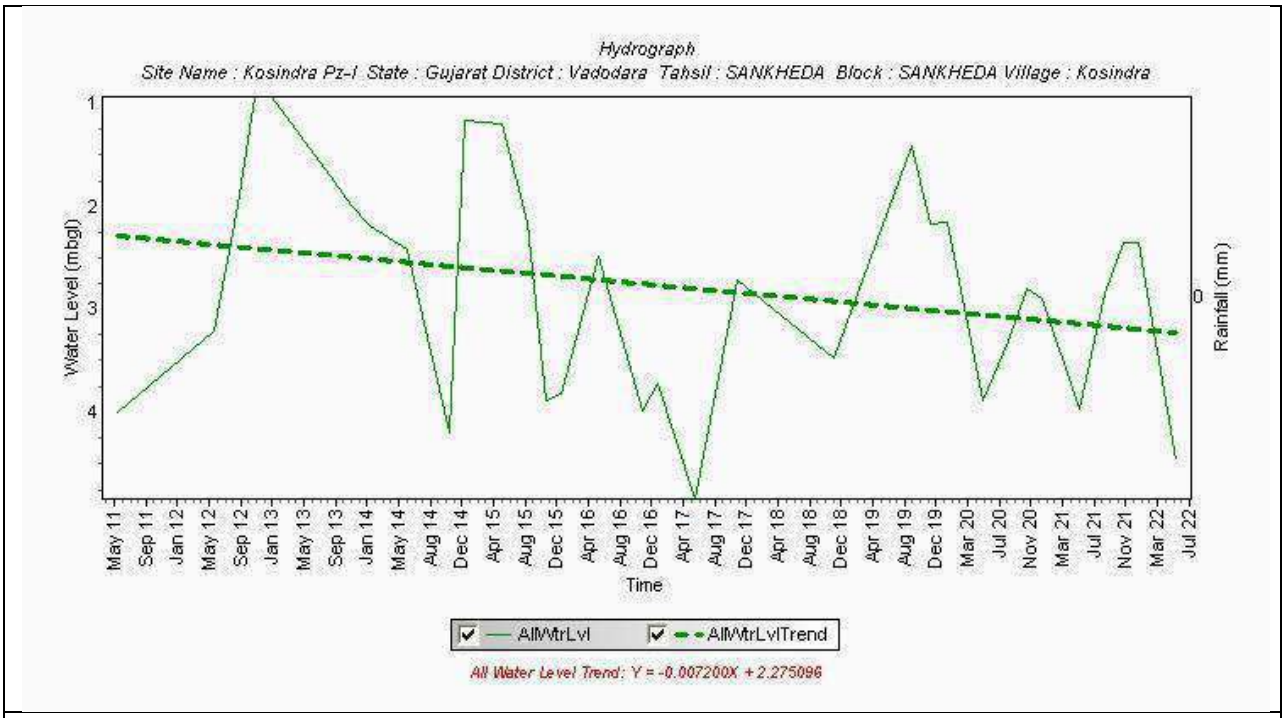
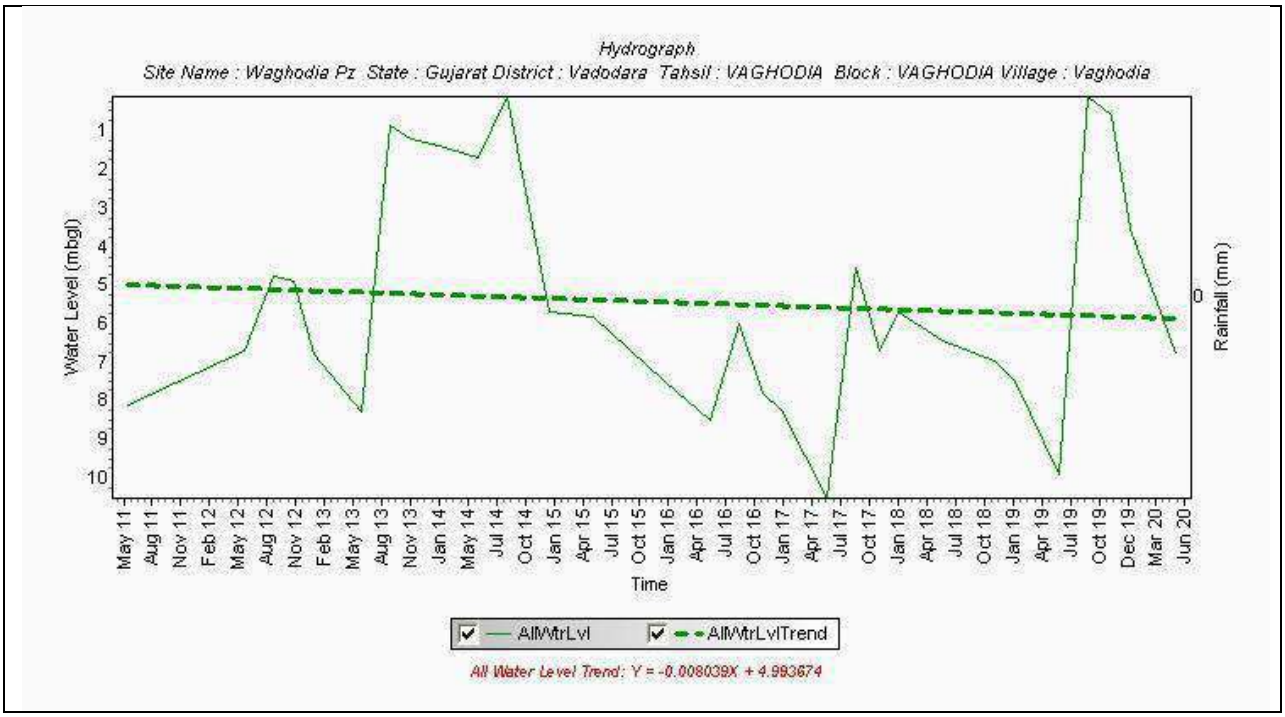


Fig.15 (F & G) Falling trends at Bodeli and Kosindra observed 0.0374 m/month and 0.0072 m/month respectively.

Fig.15 (H & I) Falling trends at Sankheda and Segwa Choukdi observed 0.06029 m/month and 0.0459 m/month respectively.



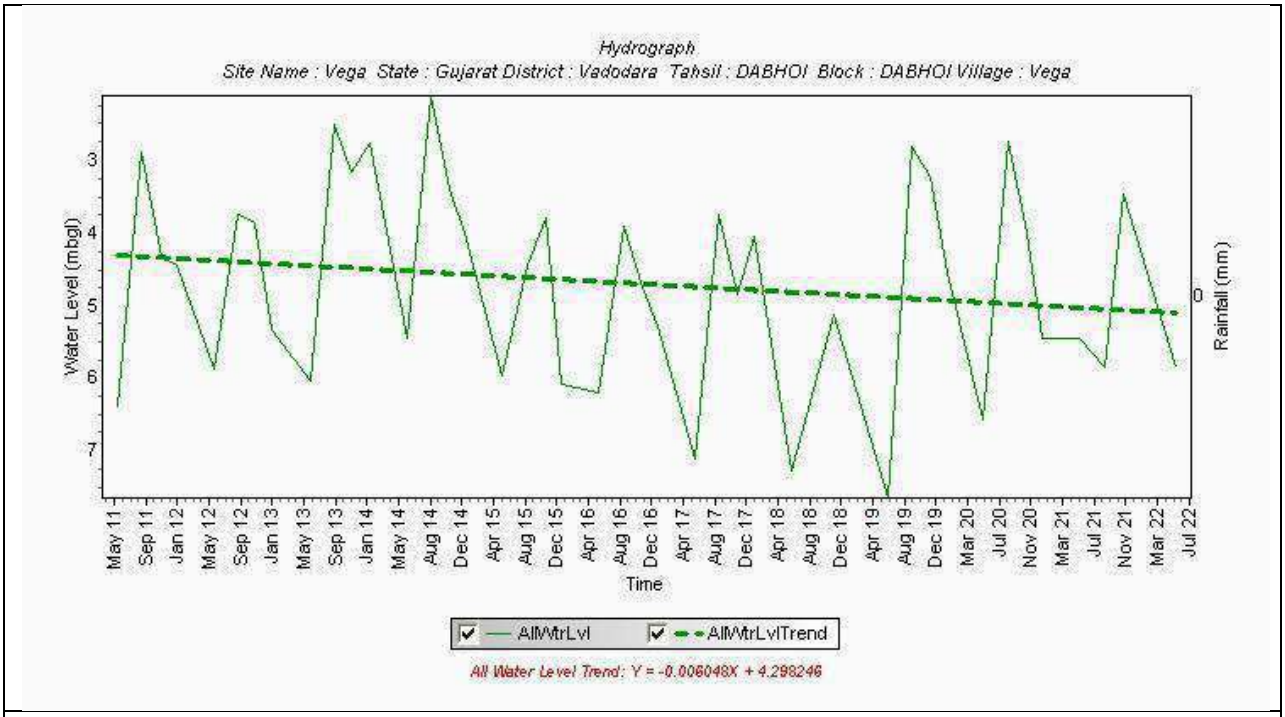


Fig.15 (J & K) Falling trends at Waghodia and Vega observed 0.008 m/month and 0.0060 m/month respectively.

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 and Electrical logs of Exploratory wells studies carried out by CGWB and state Ground water Departments (GWRDC & GWSSB) 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 L-L' and Solid Model of the district showing the depiction of Aquifer Groups and Aquitard up to 300m. Map showing section lines are presented in Fig. 16. The stratigraphic sections depicting unconfined aquifer, Confined Aquifer I, II and III for alluvium and weathered aquifer & fractured aquifer for Hard rock are placed at Figs 17 (A to L). Fence Diagram and 3D Solid Model of Vadodara district is depicted in Fig. 18 and 19, respectively.

A total of 55 exploratory wells and piezometers constructed by CGWB. And 35 litho logs and Electrical 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 300 mbgl.

Table No: - 7 Data integration

S.No.	Data	Aquifer	Total Data Points	Source	
				CGWB	GWRDC
1	Panel Diagram (3-D)	Combine	35	Expl:55	-
2	Hydrogeological Cross Sections	12 no	35	Expl:55	-
3	Fence/panel Diagrams	1 no	35	Expl:55	-
4	Depth of weathering	1 no	7	Expl:55	-
5	Depth of fracturing	1 no	7	Expl:55	-
7	Depth to Water Level Maps (2019)	Combine	65	27	38
8	Long term water	Combine	34	16	18
9	Water quality pre-2019 & post-2019	Combine	50	4	46

Conceptualization of Aquifer system in 2D

Twelve hydrogeological cross sections are drawn from North-East to South-West and North-West to South-East directions across the area represented in Figs 17 (A to L)

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

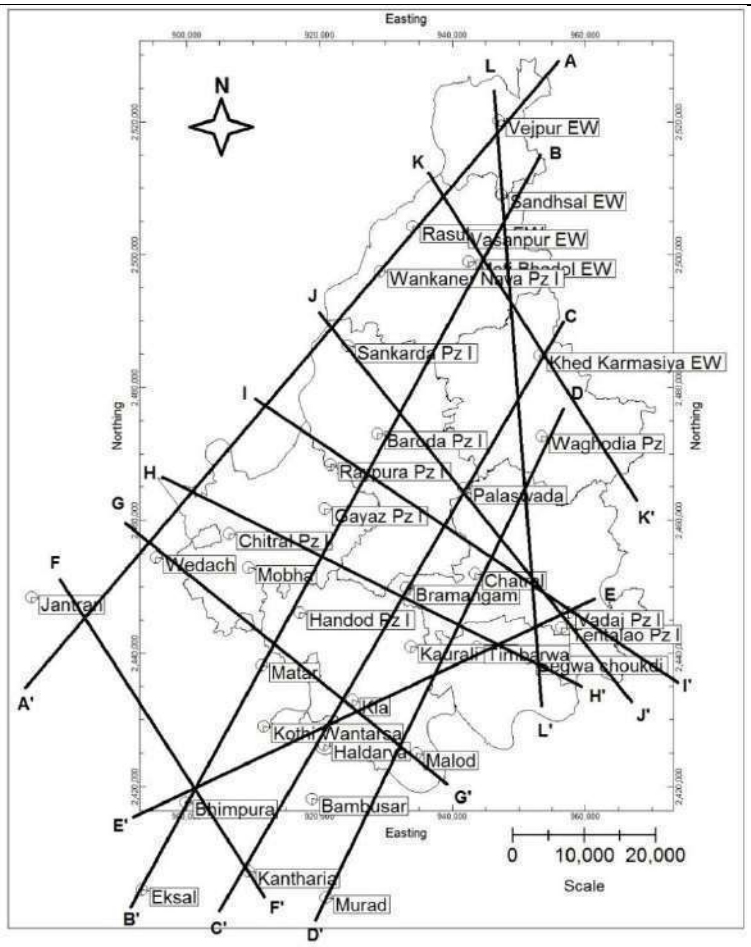
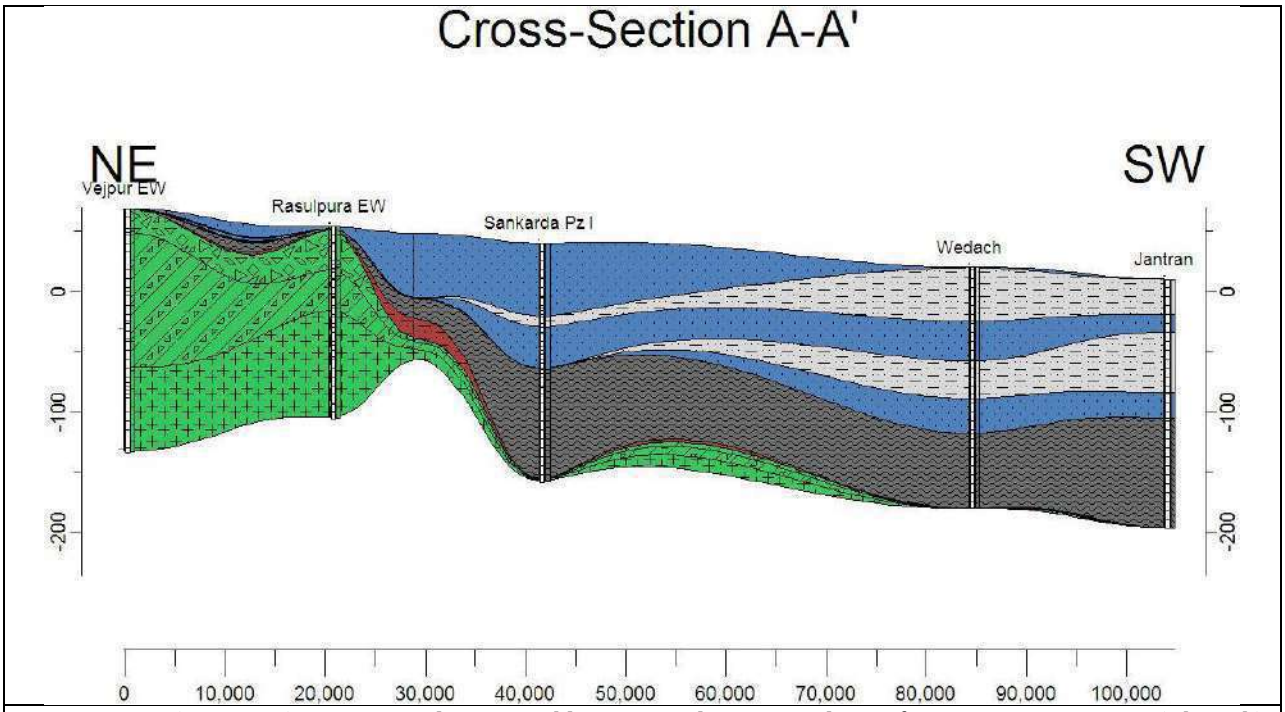
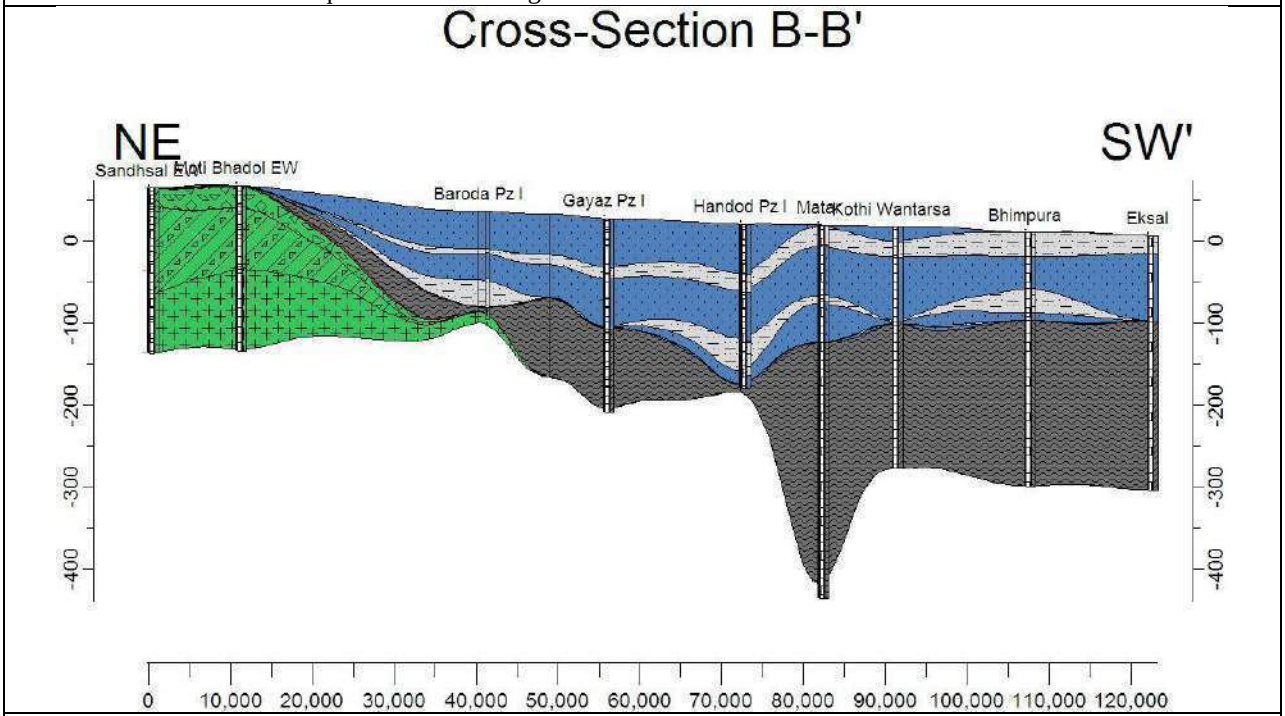


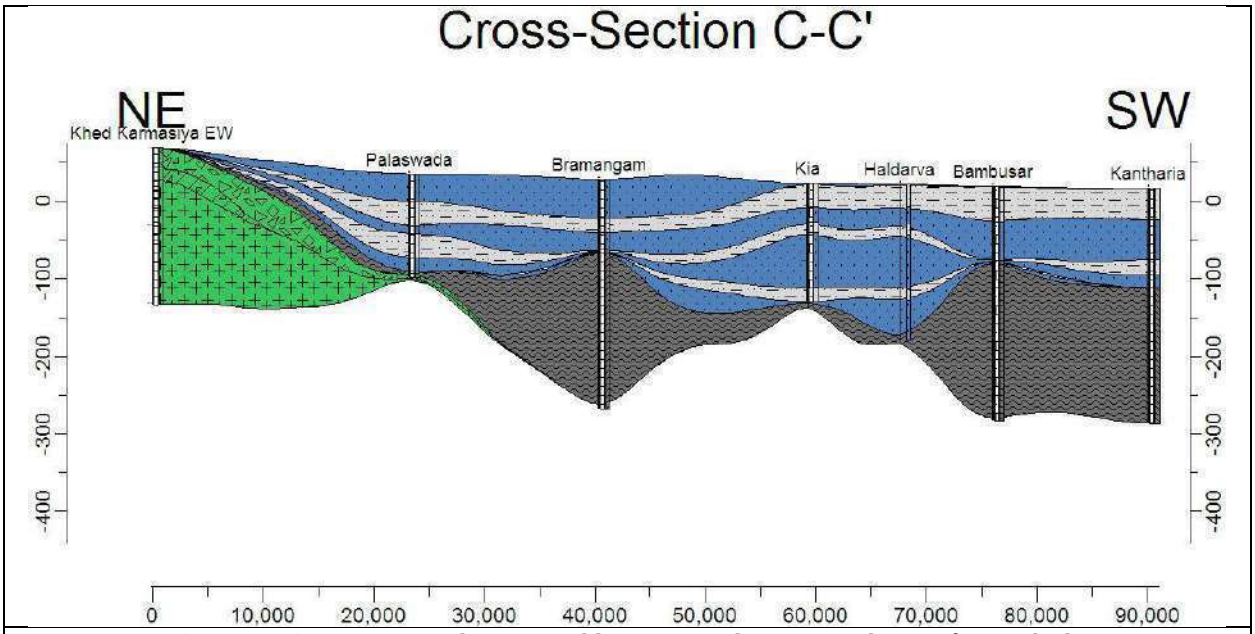
Fig No :14 Map Showing Section Lines



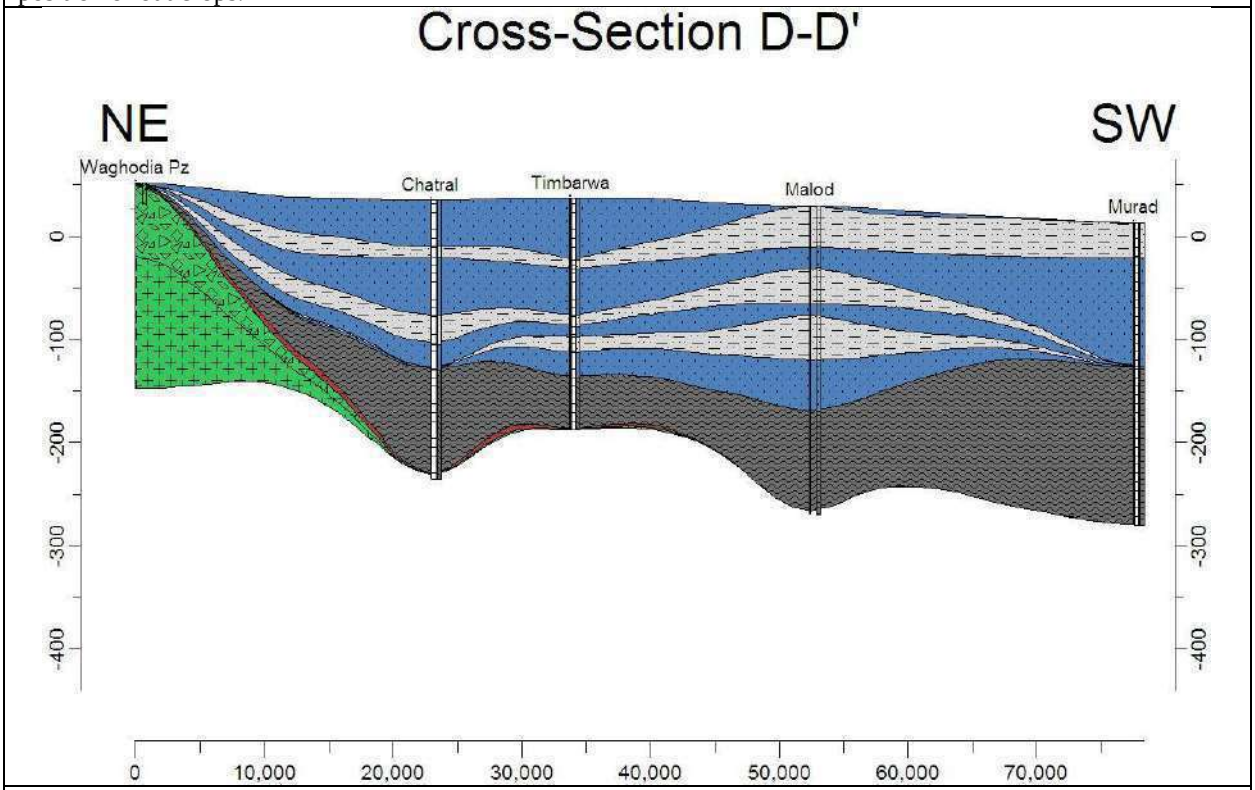
Section A-A' (Fig. 17-A)- Section is drawn roughly NE-SW direction and start from Vejpur to Jantran (Bharuch) passing through Rasulpura, Sankarda and Wedach(Bharuch). Section is represented geologically, In north-eastern part of the district, basalt (weathered & Fractured Basalt) forms the major aquifer. In remaining south-western part of the district, multilayered alluvium deposits forms the aquifer system. The aquifers are of phreatic and confined in nature. Blue clay (Tertiary) is the marker horizon between quaternary and tertiary aquifer systems. At Wedach and Jantran of Bharuch district aquitard occurred at ground level.



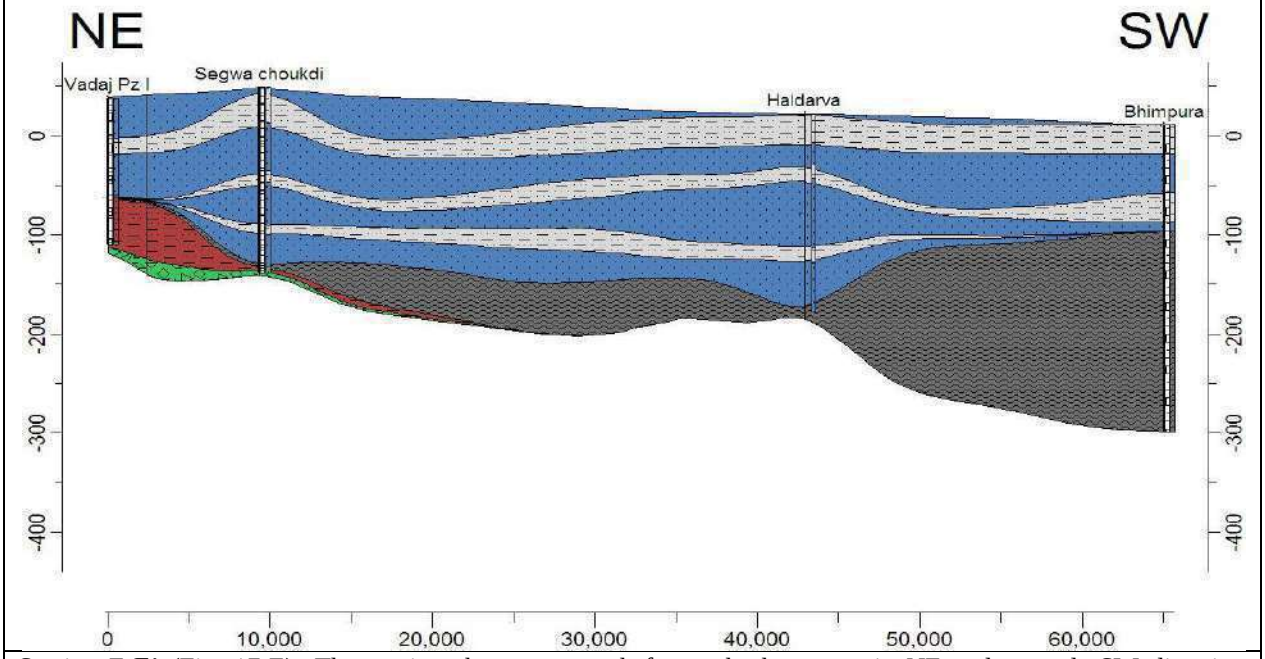
Section B-B' (Fig. 17-B)- Section is drawn roughly NE-SW direction and start from Sndhsal to Eskal (Bharuch) passing through Moti Bhadol, Baroda, Gayaz, Handod, and Bhimpura (Bharuch). Geological formation encountered more or less same as in the section A-A' except variation of thickness and position of out crops.



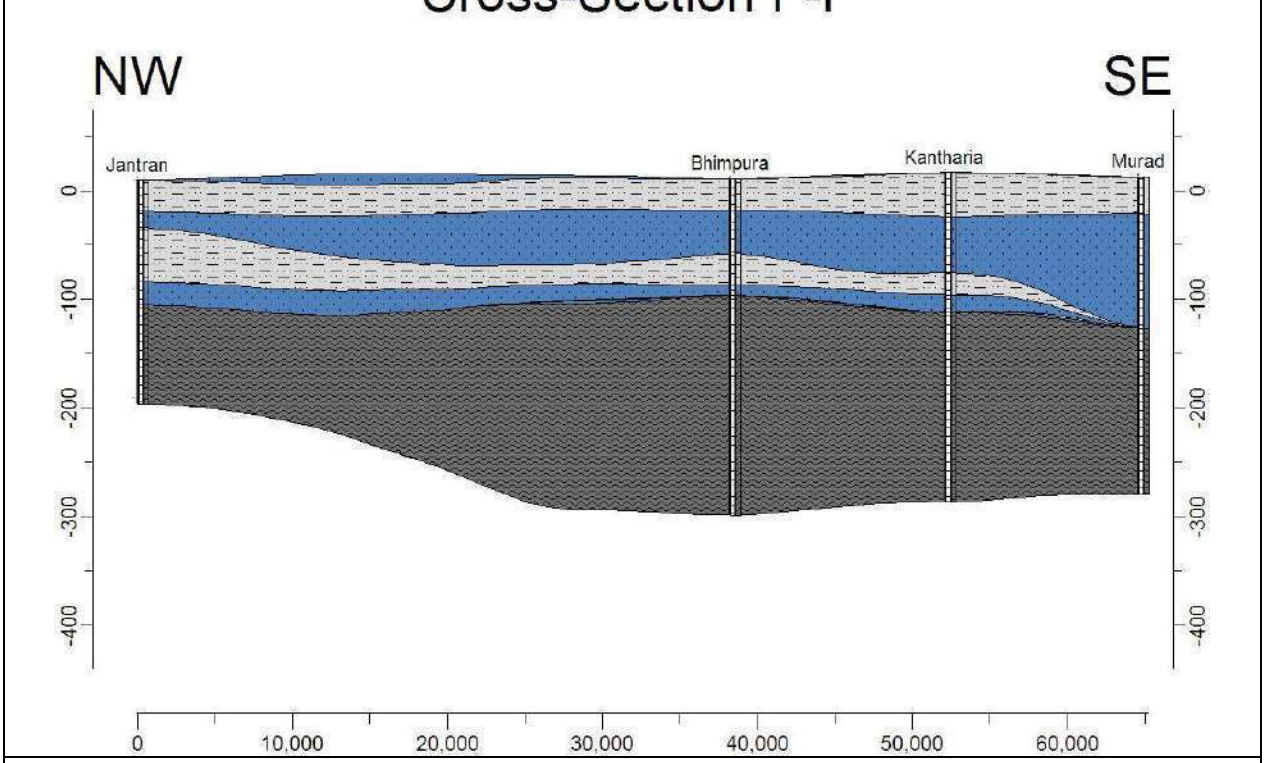
Section C-C' (Fig. 17-C)- Section is drawn roughly NE-SW direction and start from Khed Karmasiya to Kanthariya (Bharuch) passing through Palaswada,Bramangam,Kia,Haldarva and Bambusar (Bharuch). Geological formation encountered more or less same as in the section A-A' except variation of thickness and position of out crops.



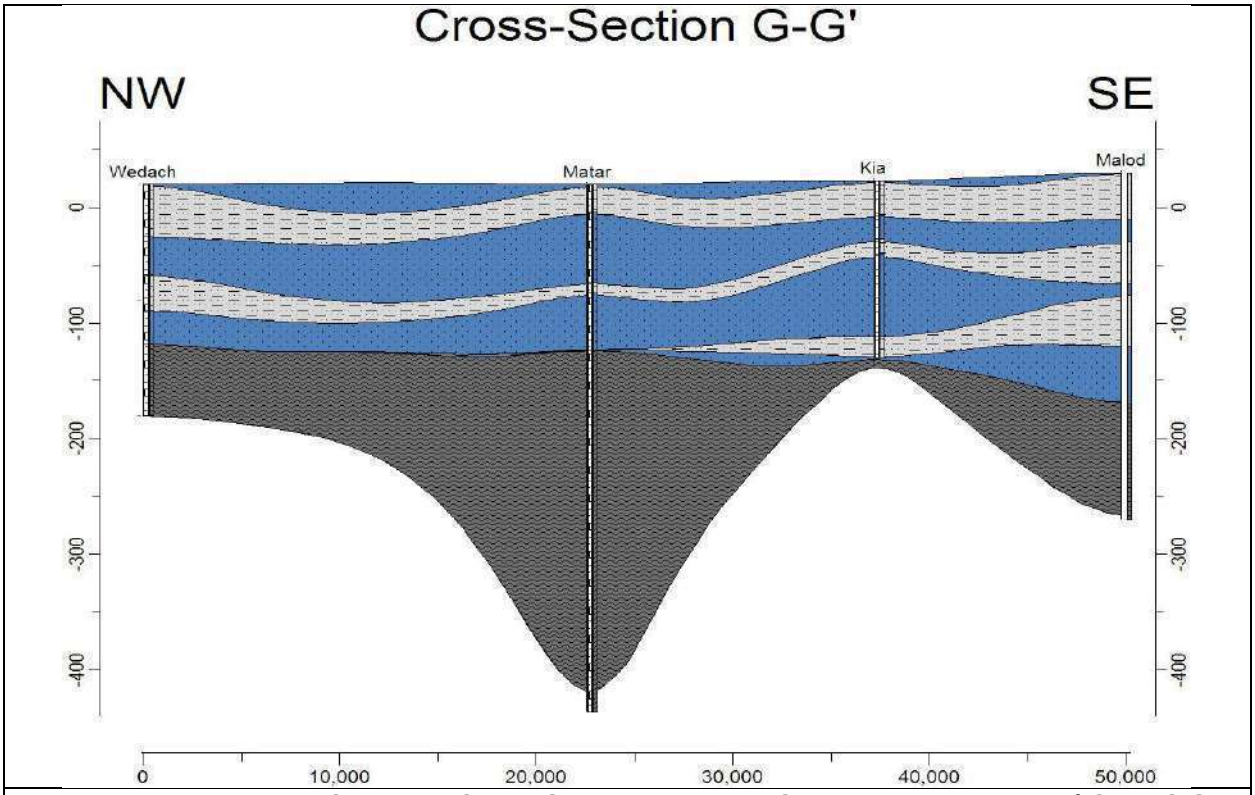
Section D-D' (Fig. 17-D)- section is drawn roughly NE-SW direction and start from Waghodia to Murad (Bharuch) passing through Chatral, Timbarva and Malod (Bharuch). Geological formation encountered more or less same as in the section A-A' except variation of thickness and position of out crops.



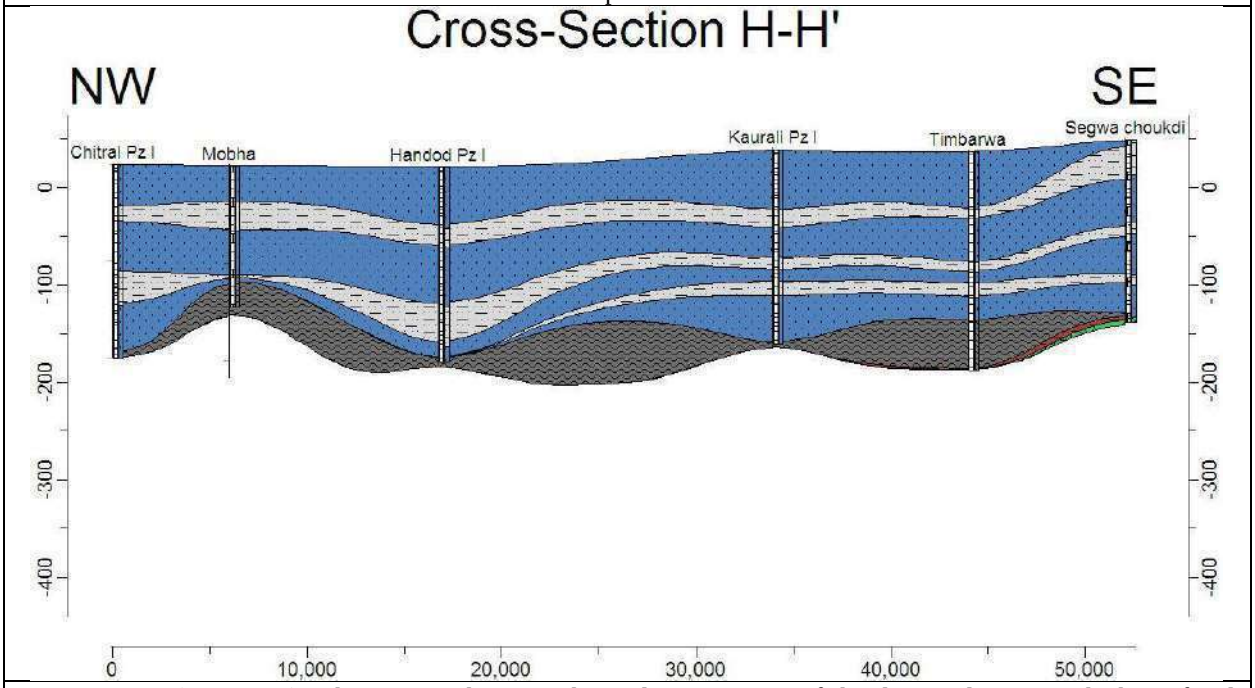
Section E-E' (Fig. 17-E)- The section shows trap rock forms the basement in NE and towards SW direction subsurface geological formations comprise alternating layers of sand and clay etc. It is also seen that the thickness blue clay increases as one moves from north-east to south –west part of the area.



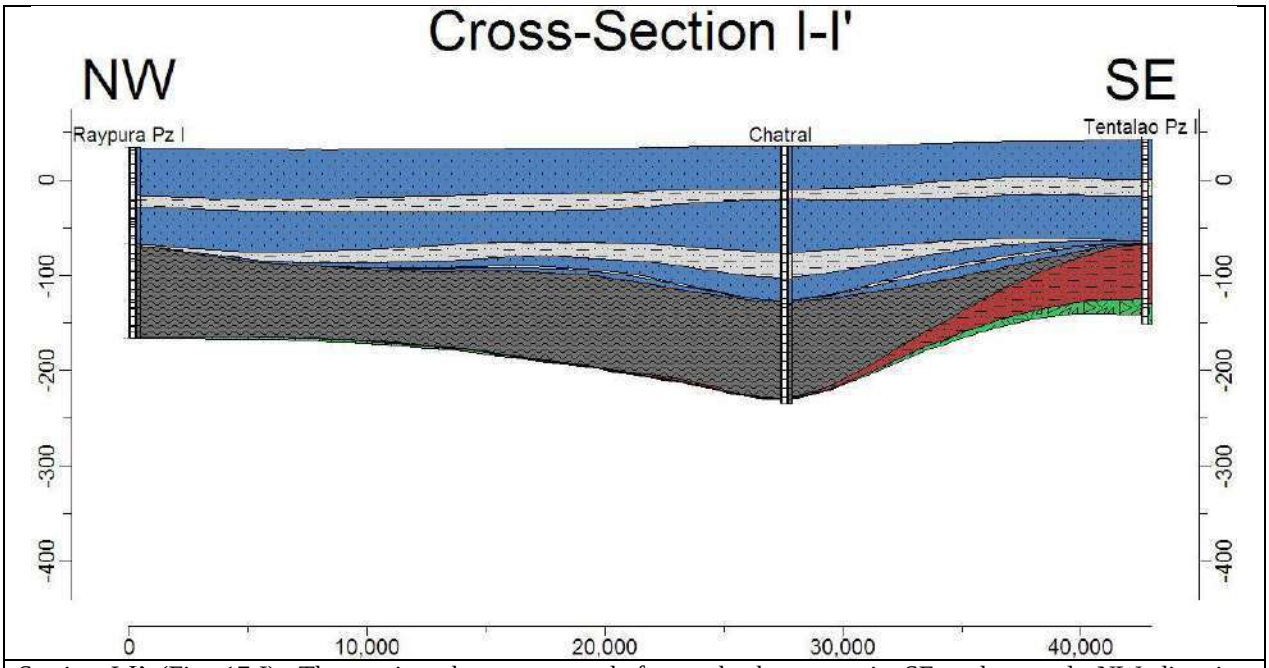
Section F-F' (Fig. 17-F)- The section shows Almost NW & SE in the extreme western part of the Bharuch district depicting continues thick aquitard occurred at ground level. It is also seen that the thickness blue clay increases as one moves from north-west to south –east part of the area.



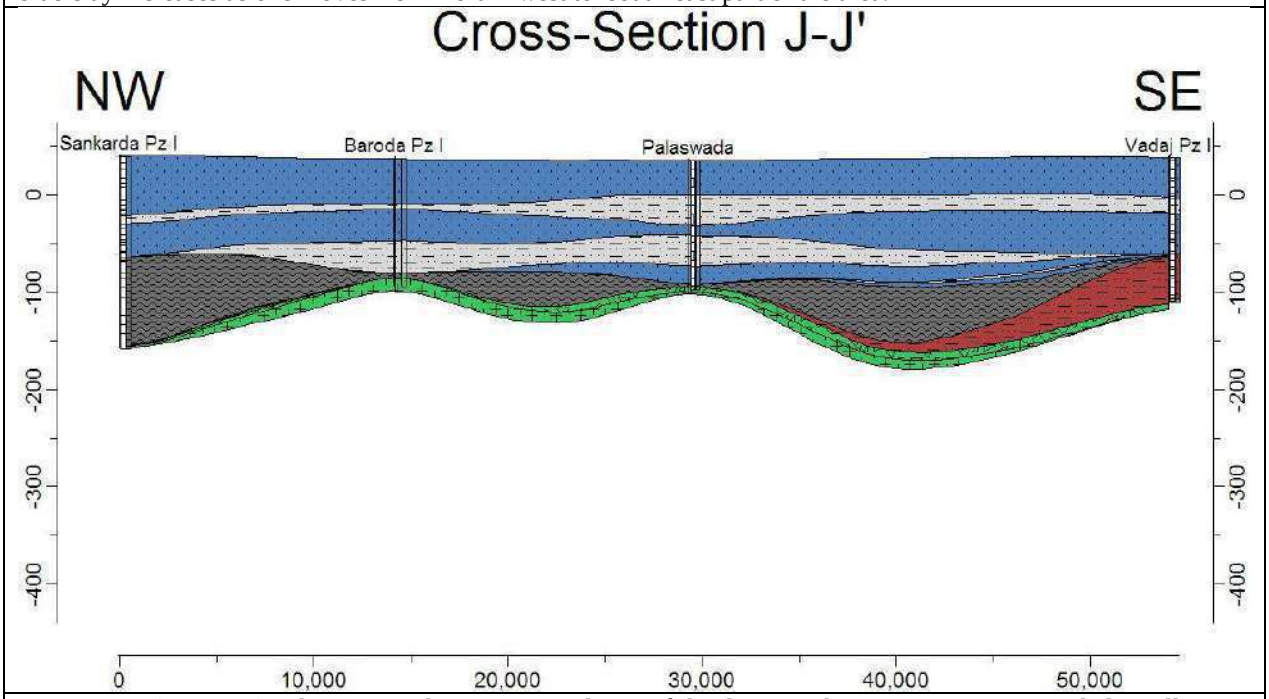
Section G-G' (Fig. 17-G)- The section shows Almost NW & SE in the extreme western part of the Vadodara district depicting continues thick aquitard occurred at ground level. It is also seen that the thickness blue clay increases as one moves from north-west to south –east part of the area.



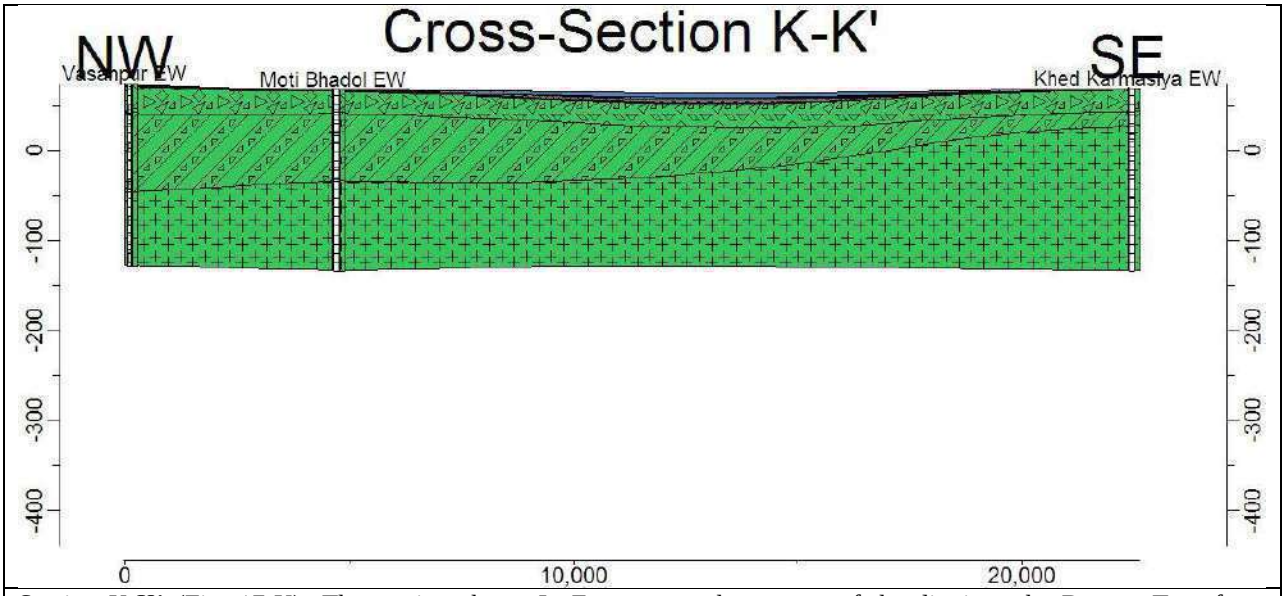
Section H-H' (Fig. 17-H)- The section shows in the mid Eastern part of the district depicting Thick confined Aquifer I, II and III separated by thin Aquitards and below tertiary sediments (Blue Clay).



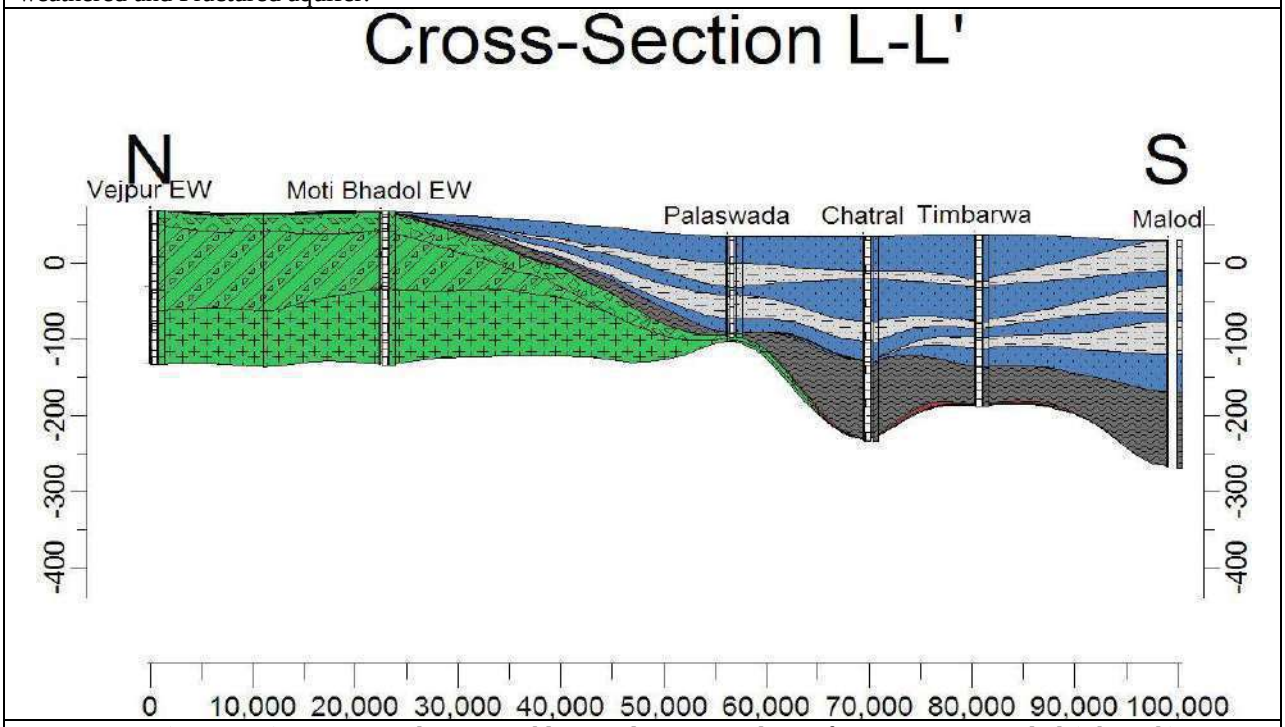
Section I-I' (Fig. 17-I)- The section shows trap rock forms the basement in SE and towards NW direction subsurface geological formations comprise alternating layers of sand and clay etc. It is also seen that the thickness blue clay increases as one moves from north –west to south-east part of the area.



Section J-J' (Fig. 17-J)- The section shows In central part of the district , the Deccan Trap occurs below alluvium and tertiary sediments at various depth.



Section K-K' (Fig. 17-K)- The section shows In Extreme northern part of the district , the Deccan Trap form weathered and Fractured aquifer.



Section L-L' (Fig. 17-L)- Section is drawn roughly N-S direction and start from Vejpur to Malod (Bharuch) passing through Moti Bhadol, palaswada,Chatral and Timbarva. Geological formation encountered more or less same as in the section A-A' except variation of thickness and position of out crops.

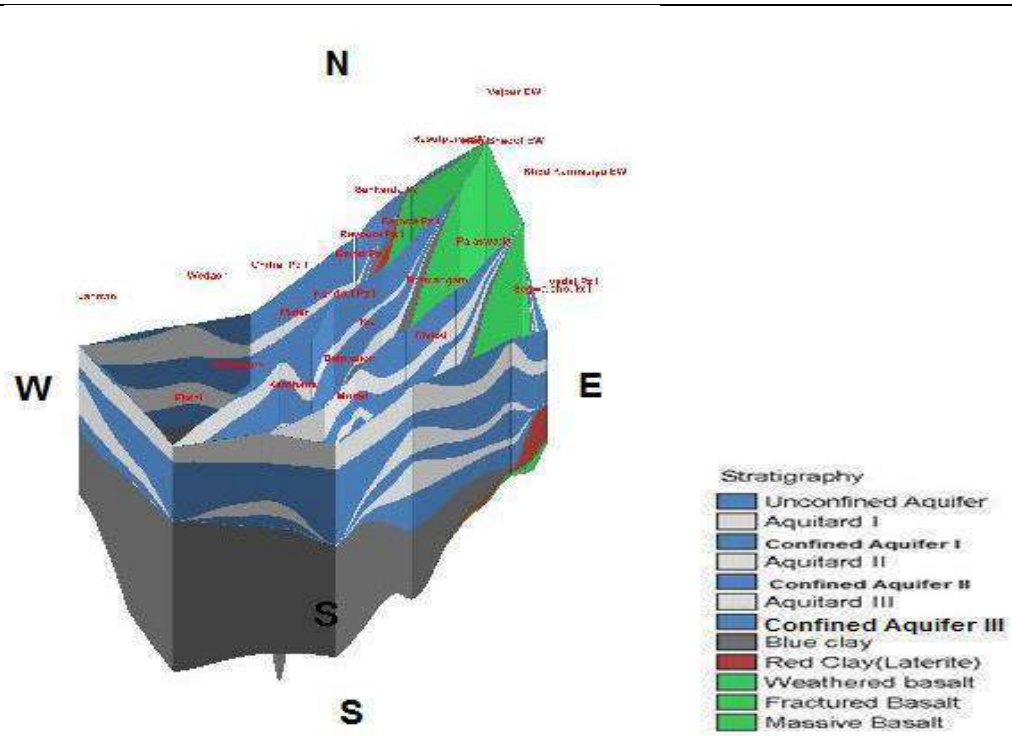


Fig No: 18 VADODARA DISTRICT FENCE DIAGRAM

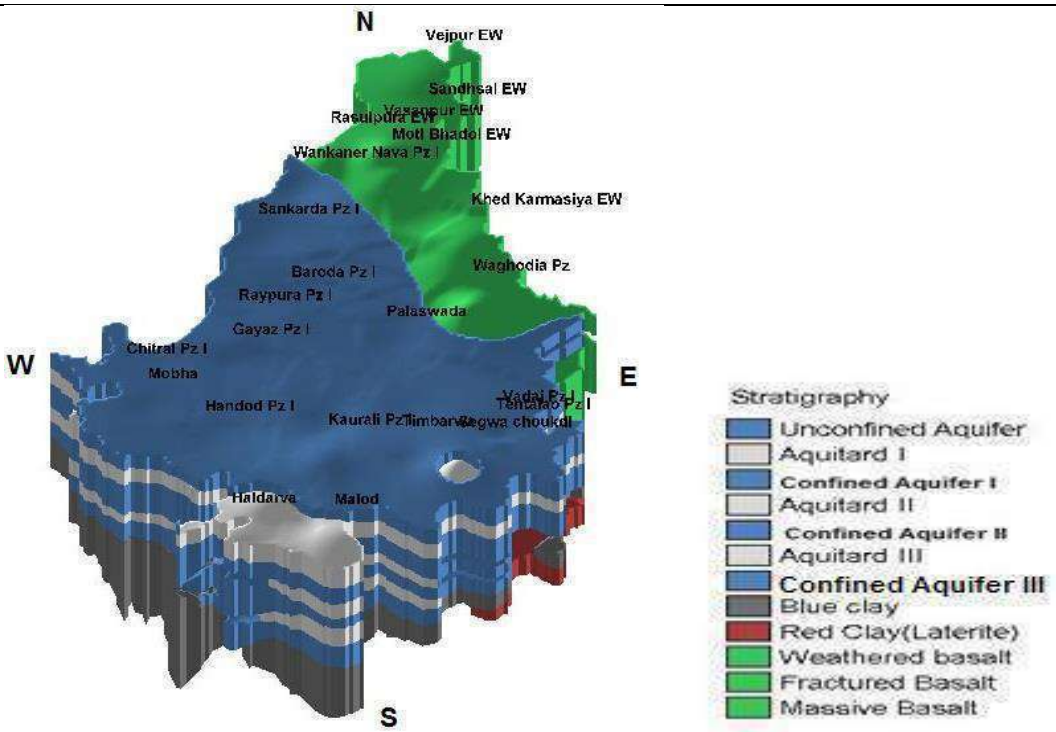


Fig No: 19 VADODARA DISTRICT 3D AQUIFER DISPOSITION

Finally, the study of these sections revels that the identification and delineating the Aquifers vertically and laterally. The Aquifers are regionally developed in entire district of Vadodara.

Aquifer Disposition: The Alluvium area comprises of silt, sand, clay, gravel and kankar forms unconfined aquifer, occurring up to the depth from 0 to 60m bgl. Confined aquifer I occurs between the depth ranges of 70 to 100 m bgl, whereas confined aquifer II occurs in the depth range of 110-130 m bgl and confined aquifer III occurs in the depth range between 150-200 m bgl. The average thickness of the aquifers varies as given below.

- Unconfined aquifer: 35 to 60 m
- Confined Aquifer I : 10 to 30 m
- Confined Aquifer II: 10 to 20 m
- Confined Aquifer III : 25 to 50 m

The Hard rock area is characterized by Basaltic formation with weathered depth up to 25 m whereas fractured basalt exists from 35 to 100m.E.C of ground water varies from less than 700µS/cm to more than 4000µS/cm for both phreatic and confined Aquifers in the district. Ground water having more than 3000µS/cm is observed in areas where tertiary formation is at depth. The ground water quality is good in hard rock terrain (Basalt).

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 :-08

Aquifer Characterisation and Disposition

Stratigraphy	Formation	Aquifer Nomenclature	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
Quaternary	Alluvium	**Unconfined Aquifer**	0 to 60	35 to 60	3 to 38	470 to 2890	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from less than 700µS/cm to more than 4000µS/cm in the district
		Confined Aquifer I	70 to 100	10 to 30	5 to 50	360 to 5370	1.2 to 60	38 to 2665	Confined	
		Confined Aquifer II	110 to 130	10 to 20	18 to 37		4 to 20	602 to2616	Confined	
Tertiary	Alluvium	**Confined Aquifer III**	150 to 200	25 to 50	24 to 37		6 to 34	2616 to 4622	Confined	Ground water having more than 3000µS/cm is observed in areas where tertiary formation is at depth.
Upper Cretaceous to Lower Eocene	Basalt	**Weathered Basalt**	0 to 25	0 to 25	3 to 17	337 to 1980	0.5 to 5		Weathered Aquifer	Good Quality
		Fractured Basalt	35 to 100		9 to 14	1000 to 2120	0.2 to 7		Fractured Aquifer	Good Quality

4. HYDROCHEMISTRY

The Vadodara district has main two hydrogeological provinces, Deccan trap and Alluvium areas. Each terrain also have varied hydrological regime. Ground water in both Phreatic and confined Aquifers is Potable and fit for domestic, drinking, irrigation and other industrial purposes but higher values of EC and concentration of Fluoride and Nitrate is observed in shallow aquifer at localized pockets. During the course of NHS water samples are collected periodically from National Hydrograph Stations in the district. The Gujarat Water resources and Development Corporation (GWRDC) Ltd., Govt. of Gujarat is also monitoring ground water quality of tube wells. On the basis of chemical analysis of such water samples hydrochemistry of shallow and deeper aquifers are describe as follows.

QUALITY OF SHALLOW GROUND WATER

Generally in hard rock and alluvium areas of entire district overall quality is potable and fit for domestic, drinking, irrigation and other industrial purposes, whereas eastern part in alluvium area quality varies widely, have high EC values. E.C. of ground water varies from less than 700 µS /cm to more than 4000 µS/cm in the district. In some localized pockets of alluvium area, overlying Deccan trap rocks, in parts of Vaghodiya, Vadodara & Dabhoi taluka areas also have high EC groundwater. In areas of consolidated formations – hard rock areas and also along Mahi river alluvium zone, ground water with EC less than 2000 µS /cm are observed.

Based on the analytical results of about NHS water samples distributed throughout the district, collected during pre monsoon may 2019.The various chemical parameters of phreatic aquifer tabulated in table No.9.Map depicting areal distribution of electrical conductance measures of dissolved ions, in phreatic aquifer is prepared and given as figure No.20

Table 09: Summarised chemical data of Vadodara district

Chemical Parameter	Min	Max	Average	Chemical Parameter	Min	Max	Average
pH	7.97	8.64	8.24	F	0.37	2.88	1.04
EC	794	4394	1993	Alk	240	640	399
TDS	531	2942	1335	Ca	20	240	80
CO_3	0	144	34	Mg	24	180	78

HCO_3	195	683	419	TH	150	1350	524
Cl	35	815	307	Na	40	489	224
NO_3	7	120	31	K	1.3	71	18.5
SO_4	4.4	438	140	Fe	0	1.45	0.06
*All values are in mg/l except pH and EC in µS/cm at 25°C							

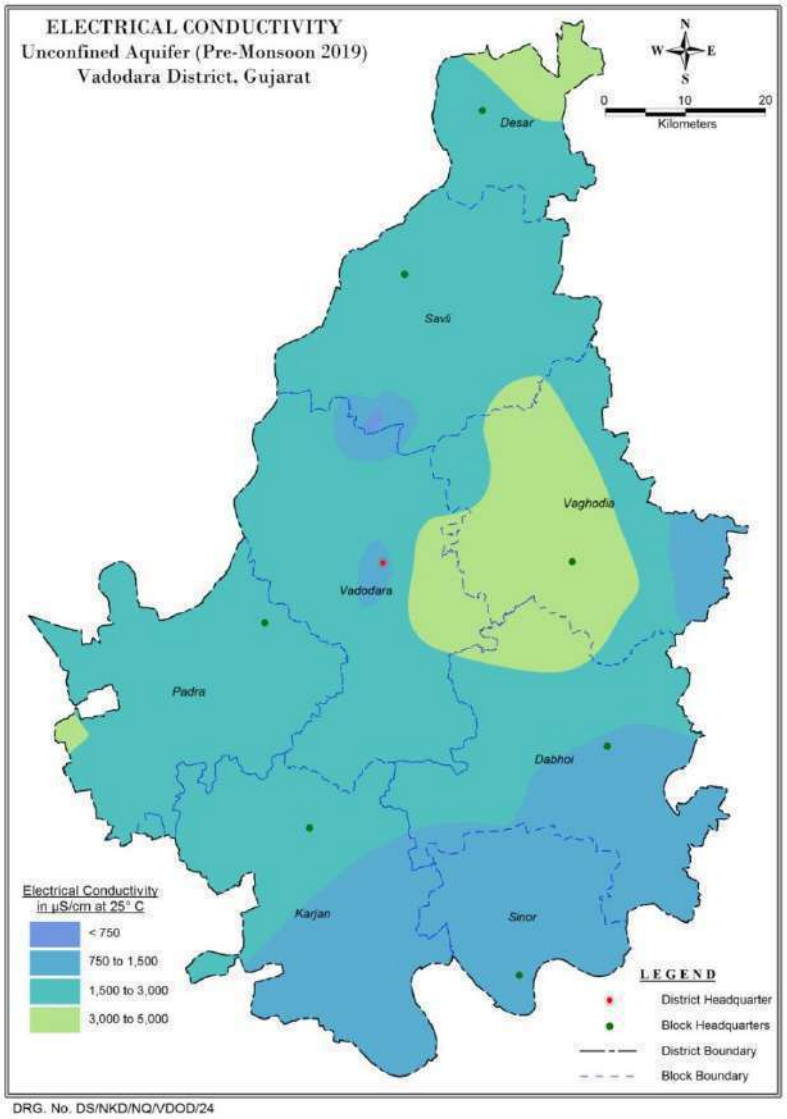


Fig No:-20 Electrical Conducivity Phreatic Aquifer

QUALITY OF DEEP GROUND WATER

The quality of ground water in the confined aquifer has been determined by analysis of water samples collected during various surveys. Study of exploratory boreholes geophysical logs also reveals the nature of formation water quality at various depths. Plot of electrical conductance of deep aquifer water samples shows that in major part of confined aquifer zones, ground water is within range of 3000 µS / cm range. More than 3000 µs / cm are observed in areas where Tertiary formation is at depth. Deterioration of ground water quality is observed at localized pockets where the tertiary formation is at depth.

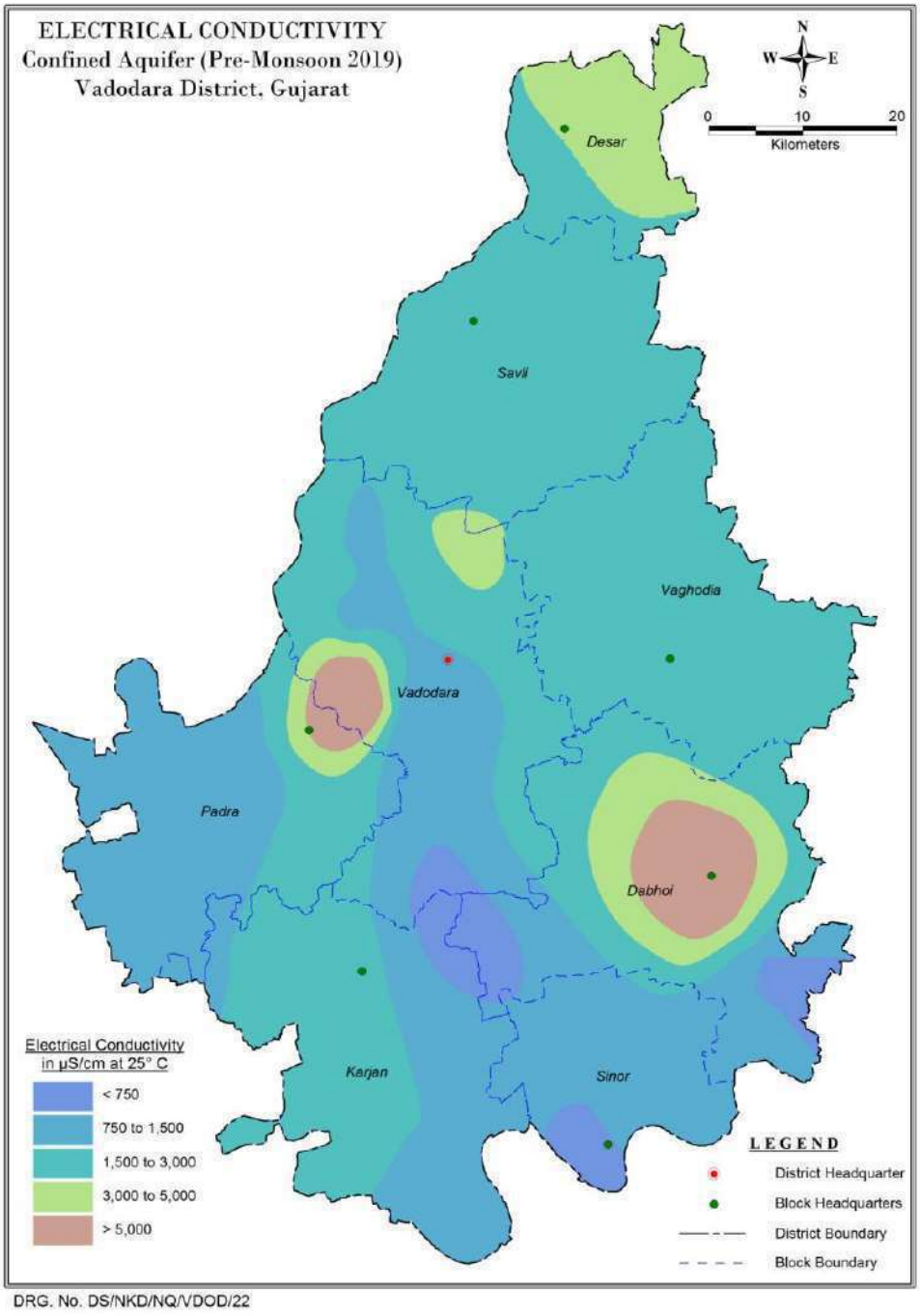


Fig No:-21 Electrical Conducivity Confined Aquifer I

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 4057.63 ha.m (Desar taluka) to 18734.32 ha.m (Dabhoi Taluka). The Gross Annual Ground Water Recharge in the district is 101937.97 ha.m. The net available recharge after leaving natural discharge from monsoon period varies from 3854.75 ha.m (Desar Taluka) to 17797.60 ha.m (Dabhoi Taluka). The net available recharge in the district is 96841.08ha.m.

Ground Water Draft

The ground water draft from irrigation and Domestic /Industrial sources is presented in Table: 10. The Existing Gross Ground Water Draft for all uses varies from 1921.41ha.m (Desar taluka) to 12136.00 ha.m (Vadodara Taluka). The Gross Ground Water Draft for All uses in the district is 56076.76 ha.m.

Level of Ground Water Development & Stage

The stage of ground water development at year 2017, for all the talukas of the Vadodara district computed range from 17.05% to 78.11% and 7 units of assessment (talukas) have been categorized as *Safe and one taluka in semi critical stage,* 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 57.91%. Taluka wise ground water resources and categorization for each assessment unit is presented in table 10.

Table No:-10 Taluka Wise Ground Water Resources, Availability, Utilization and Stage of Ground Water Development (2017) District : Vadodara

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	Recharge from Rainfall	Recharge from Other Sources											
1	**Dabhoi**	12022.39	1953.30	0.00	4758.62	18734.32	936.72	17797.60	11103.00	44.46	251.92	11399.38	332.00	6318.14	64.05	Safe
2	**Desar**	109.20	1327.19	0.00	2621.24	4057.63	202.88	3854.75	1749.00	25.86	146.55	1921.41	193.00	1886.89	49.85	Safe
3	**Karjan**	12154.22	757.83	0.00	1821.23	14733.27	736.66	13996.61	8750.50	41.27	233.87	9025.64	308.00	4896.83	64.48	Safe
4	**Padra**	13499.72	1339.32	0.00	1386.28	16225.32	811.27	15414.05	8434.00	65.49	371.08	8870.57	489.00	6425.57	57.55	Safe
5	**Savli**	3555.21	2571.97	0.00	3943.22	10070.40	503.52	9566.88	4876.50	62.80	355.88	5295.18	469.00	4158.58	55.35	Safe
6	**Sinor**	7854.97	1148.09	0.00	815.07	9818.13	490.91	9327.22	5386.00	16.12	91.33	5493.44	120.00	3805.11	58.90	Safe
7	**Vadodara**	13640.53	1462.79	0.00	1250.74	16354.06	817.70	15536.36	10582.00	233.00	1321.00	12136.00	343.00	4378.36	78.11	Semi critical
8	**Vaghodia**	5591.75	1814.40	0.00	4538.70	11944.85	597.24	11347.61	1689.00	36.92	209.21	1935.14	276.00	9345.69	17.05	Safe
		68427.99	**12374.88**	**0.00**	**21135.10**	**101937.97**	**5096.90**	**96841.08**	**52570.00**	**525.91**	**2980.84**	**56076.76**	**2530.00**	**41215.16**	**57.91**	

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 Vadodara district are under safe category and one block i.e. Vadodara is under Semi critical category. Ground water stage of development ranges from 17.05 % (Vaghodiya) to 78.11 % (Vadodara). 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 values of EC and concentration of Fluoride and Nitrate is observed in shallow aquifer at localized pockets.

3. **Sustainability**

In northern part of the district, basalt (weathered & Fractured Basalt) forms the major aquifer. Low yield (<2 lps) occurs in ~20 % of area covering entire district. 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.

4. **Decline water levels in Vadodara City**

The long term groundwater regime monitoring studies through NHS reveal an overall declining trend in major parts of the Vadodara City. The decline in range is 0.002 to 0.15 m /year.

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,

Decline water levels in Vadodara City: Over-extraction, Urbanization and limited artificial measures etc.

7. MANAGEMENT STRATEGIES IN VADODARA 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 Vadodara district are under safe category and one block i.e. Vadodara is under Semi critical catogory.Ground water stage of development ranges from 17.05 % (Vaghodiya) to 78.11 % (Vadodara).. Thus, management of ground water resources could be developed/augmentated in a judicious way.

In the entire Vadodara 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 1225.11 sq. km has been identified in District Vadodara 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. 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 22). 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.

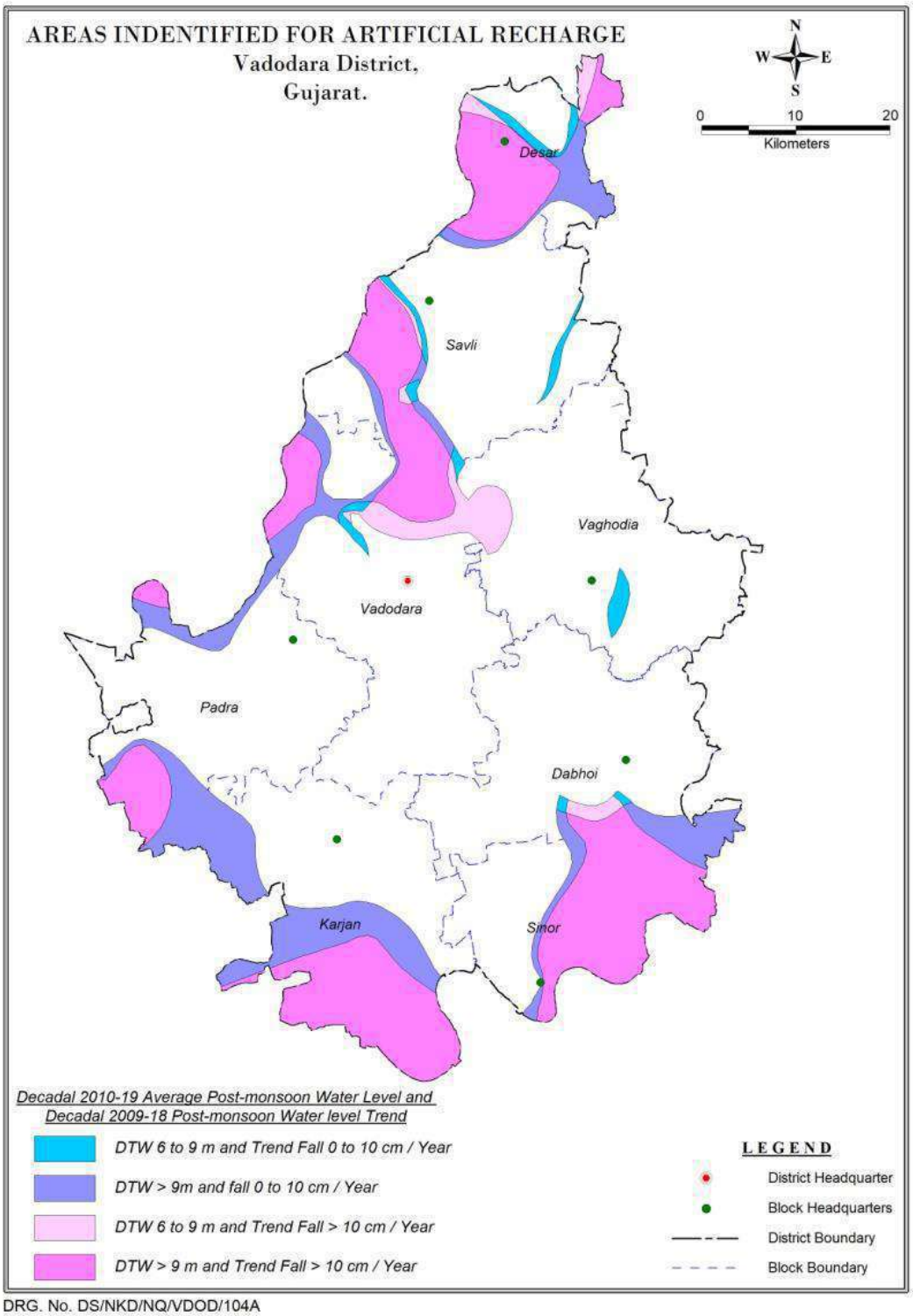


Fig. – 22: Feasible area for Artificial recharge

Table -11 : Identification of suitable area for Artificial Recharge in Vadodara District							
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	Dabhoi	Alluvium	63.89	211.30	2.99	9.19	287.37
2	Desar	Basalt		15.39	11.37	13.79	40.55
3	Karjan	Alluvium		172.38			172.38
4	Padra	Alluvium	180.80	56.07			236.87
5	Savli	Basalt	91.94	235.11	17.77	38.73	383.55
6	Sinor	Alluvium					
7	Vadodara	Alluvium	28.64	35.14	6.35	24.26	94.40
8	Vaghodia	Basalt			9.99		9.99
	Total		365.27	725.39	48.48	85.96	1225.11

A total of 1225.11 sq. km area spread over the district in the isolated patches having water level & trend as above is computed (Table 11) and same is depicted as suitable areas for artificial recharge.

Table-12 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 (MCM)**
		Average Depth unsaturated below 6 m bgl (Excluding clay & impervious hard zones)	**6 m**	**6 m**	**3 m**	**3 m**	
1	Dabhoi	Alluvium	383.36	1267.81	8.97	27.56	1687.70
2	Desar	Basalt	0.00	92.31	34.12	41.37	167.80
3	Karjan	Alluvium	0.00	1034.28	0.00	0.00	1034.28
4	Padra	Alluvium	1084.82	336.43	0.00	0.00	1421.25
5	Savli	Basalt	551.63	1410.65	53.32	116.18	2131.78
6	Sinor	Alluvium	0.00	0.00	0.00	0.00	0.00
7	Vadodara	Alluvium	171.84	210.86	19.06	72.78	474.54
8	Vaghodia	Basalt	0.00	0.00	29.98	0.00	29.98
	Total		2191.65	4352.35	145.45	257.88	6947.33

7.1.1.2 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 6947.33 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 425.47 MCM (Table 13)

Table-13 Computation of volume of unsaturated zone available for recharge

Sr No	Taluka	Aquifer	Volume of unsaturated zone available for artificial recharge MCM	Specific yield factor	Volume of water required for recharge MCM	Volume of rain water planned for Artificial recharge (MCM)
1	Dabhoi	Alluvium	1687.70	0.05	84.38	
2	Desar	Basalt	167.80	0.02	3.36	
3	Karjan	Alluvium	1034.28	0.09	93.08	
4	Padra	Alluvium	1421.25	0.07	99.49	
5	Savli	Basalt	2131.78	0.05	106.59	
6	Sinor	Alluvium	0.00	0	0.00	
7	Vadodara	Alluvium	474.54	0.08	37.96	
8	Vaghodia	Basalt	29.98	0.02	0.60	
	Total		6947.33		425.47	

7.1.1.3 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 20 MCM of surplus surface water is provisioned for artificial recharge in Vadodara district. 20 MCM of surplus surface water was apportioned with taluka wise and for vadodara district 20 MCM of surplus surface water is considered for artificial recharge through 558 no of recharge shafts and 109 no of existing defunct tube wells which can be used as injection wells in Vadodara district.

To assures local drinking water supply, mainly in events of drought or scarcity and when water table in urban centers has started receding at an alarming rate, there is an urgent need for ground water augmentation. The suitable method for artificial recharge in urban area is to arrest the rainwater from roof tops and store or recharge the same through injection wells/shafts. As per 2011 census 31 urban centers have been identified where the population exceeds 1 Lakh (Masteplan AR Gujarat 2020). There are about 20, 65,771 people resides in the Vadodara City urban area of the Vadodara district. There are about 4, 59,509 number urban households are present in Vadodara city and considering about 25% houses are suitable for harvesting and considering 40 sq. as typical house hold roof top area the total area available for harvesting (90% of total roof top) has been estimated to be 41,35,581 sq. m. The source water available for harvesting has been taken as 60% of normal rainfall in the Vadodara City urban centre after making allowance for storm rain etc., thus, the total source water available for harvesting has been estimated as 2.10 MCM/yr. The Average cost of making the roof top harvesting arrangements for storing it at surface and recharging to ground water is @ Rs. 20,000/- per house. Thus, the cost of roof top harvesting for 1, 14,877 Number of houses of the Vadodara city is estimated as Rs. 229.75 crores.

Table No: 14 Feasibility of Artificial Recharge in Vadodara 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 Available 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	**Vadodara**	4096.10	13.76	1225.11	6947.33	425.47	20.00	0.00	As per Master plan 2020 for Artificial Recharge to Ground Water in Gujarat state, 20 MCM of surplus surface water is provisioned for artificial recharge through 558 no of recharge shafts and 109 no of existing defunct tube wells which can be used as injection wells in Vadodara district. Ground water recharge of 2000 ham (through recharge shafts and defunct tube wells) is expected for the district. Additional Artificial Recharge Structures are not recommended; Surplus Runoff is not available.				

Table 15: Rooftop Rainwater harvesting plan for Vadodara district							
District Name	Town having population > 1 lakh	Urban Population (Census 2011)	Urban Household Number (Census 2011)	Area for RWH @ 25% of houshold @ 90 % suitable area of avg 40 sqm area / household (sqm)	Average Rinfall of the District 2009-18 (mm)	Volume of Rainwater Harvestable (MCM)	Cost of RWH @ Rs 20,000 / household (in cores)
Vadodara	1	20, 65,771	4, 59,509	41,35,581	845.00	2.10	229.75

Ground Water Development Plan

As per GWRE 2017 total 07 no blocks of Vadodara district are under safe category and one block i.e. Vadodara is under Semi critical catogory.Ground water stage of development ranges from 17.05 % (Vaghodiya) to 78.11 % (Vadodara). To elevate the stage of ground water development to 65% in all blocks except in Vadodara taluka, 4343 no dug wells (20 m depth) in Hard rock and 1693 no Tube wells (60 to 70 m depth) in alluvium area are proposed as feasible extraction structures. But in Vadodara block only water conservation measures like Micro irrigation system (3830 Ha), Farm ponds (1070 No) and on farm activities (1052 Ha) are proposed. The extraction structures will result in additional ground water draft of 9533.5 ham which will create 19067 Ha additional irrigation potential for the district and same as tabulated below.

Table-16 Water Conservation and Extraction interventions in Vadodara 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 65% (Soft Rock & Hard Rock)		additional ground water draft(ham) by Extraction structures	Additional Irrigation Potential Created (Ha)
					Dug welll	Tubewell/ Bore well		
1	Sinor				0	203	609	1218
2	Padra				0	421	1230	2460
3	Savli				400	296	988	1976
4	Karjan				0	31	77.5	155
5	Dabhoi				0	73	182.5	365
6	Vadodara	1052	3830	1070	0	0	0	0
7	Vaghodiya				3400	614	5821	11642
8	Desar				543	55	625.5	1251
	Total				4343	1693	9533.5	19067

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 65%). About 19067 Ha, additional area may be irrigated by developing stage of groundwater upto 65%.

Demand side intervention

Along with development plan to prevent Over Exploitation, water conservation activities like on farm activities, farm ponds and Micro irrigation system (Sprinkler/drip) are recommended in the district. By these activities where groundwater extraction can be developed inbetween 61.29% to 70.00% ie under safe category.

Water use efficiency/Water conservation activities by application of on-farm activities, farm pond and Micro irrigation system:

Table-17 Proposed Artificial recharge and Water Conservation interventions in Vadodara 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)	Expected Annual Recharge(Through On farm activities and GW return flow) ham	Conservation from On-farm Activities, WUE Measures & Farm Ponds(ham)
1	Sinor	0.00	837	623	204.9	318.57
2	Padra	2368	1607	915	359.9	642.99
3	Savli	3835	501	562	482.3	441.02
4	Karjan	1724	1436	635	180.15	498.34
5	Dabhoi	2874	2003	870	305.65	713.70
6	Vadodara	944	3830	1070	94.4	953.21
7	Vaghodiya	100	178	1210	592.1	406.59
8	Desar	405	301	186	103.05	123.03
	Total	12251.09	10693	6071	2322.45	4097.45

12251 Ha area is proposed for on farm activities (Laser leveling/Bench terracing/Contour banding) and 6071 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.10693 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in Vadodara district. Ground water recharge of 2620.75 ham (through on farm activities and GW return flow) is expected for

the district. 4097.45 ham saving of ground water through WUE measures & 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. 23), 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.

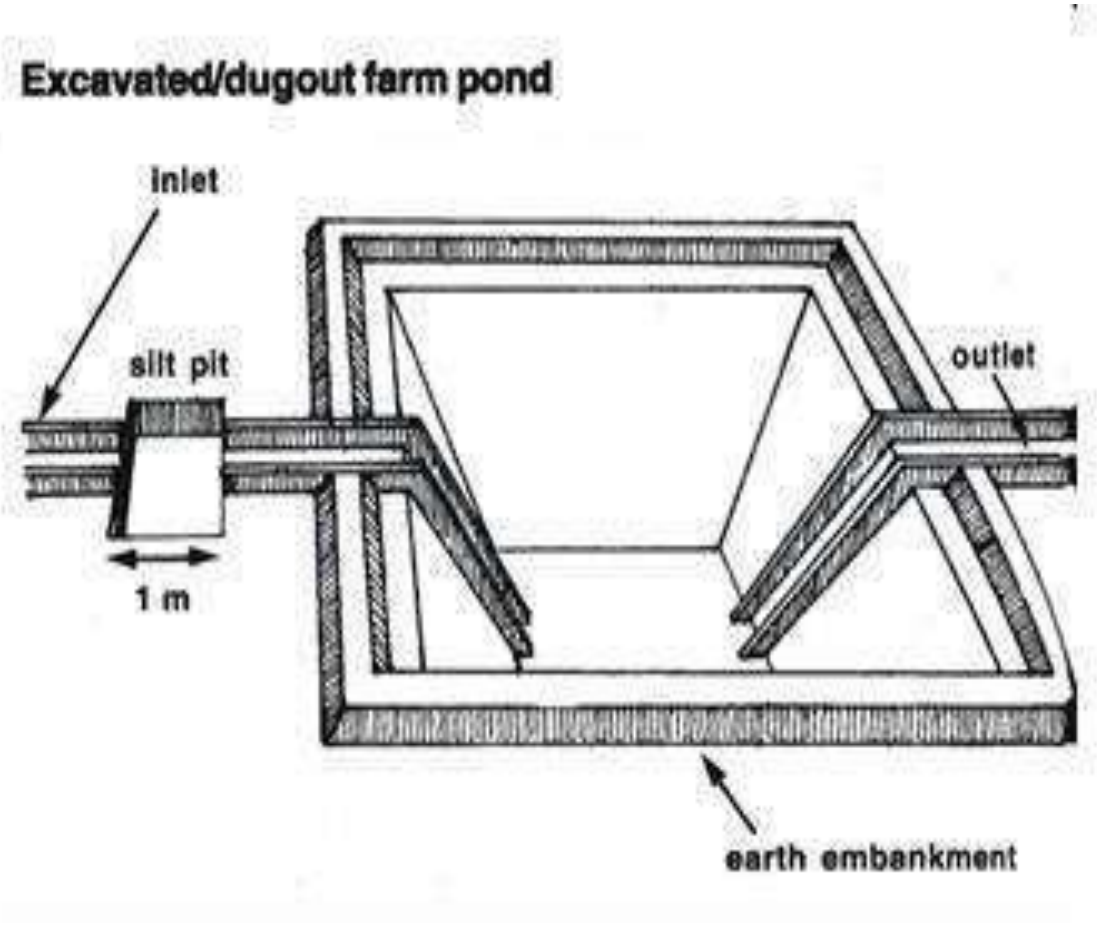


Fig. 23: Thematic diagram of Farm pond

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 6071 farm ponds as per the specification (30 x 30 x 1.5 m). Considering 3 fillings this can accommodate **18.80** 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 Vadodara 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	Sinor	9327.22	144.00	60.90	9532.12	5493.44	318.57	609.00	5783.87	58.90	65.00	61.61	60.68	1218.00
2	Padra	15414.05	483.90	123.00	16020.95	8870.57	642.99	1230.00	9457.58	57.55	65.01	59.96	59.03	2460.00
3	Savli	9566.88	662.50	98.80	10328.18	5295.18	441.02	988.00	5842.16	55.35	65.01	58.14	56.57	1976.00
4	Karjan	13996.61	466.40	7.75	14470.76	9025.64	498.34	77.50	8604.80	64.48	65.00	60.70	59.46	155.00
5	Dabhoi	17797.60	593.40	18.25	18409.25	11399.38	713.70	182.50	10868.18	64.05	65.01	60.03	59.04	365.00
6	Vadodara	15536.36	421.40	0.00	15957.76	12136.00	953.21	0.00	11182.79	78.11	78.11	71.54	70.08	0.00
7	Vaghodiya	11347.61	286.00	582.10	12215.71	1935.14	406.59	5821.00	7349.55	17.05	65.02	61.56	60.16	11642.00
8	Desar	3854.75	154.50	62.55	4071.80	1921.41	123.03	625.50	2423.88	49.85	65.02	61.24	59.53	1251.00
			3212.10	953.35	101006.53	56076.76	4097.45	9533.50	61512.81	55.67	66.65	61.85	60.57	19067.00

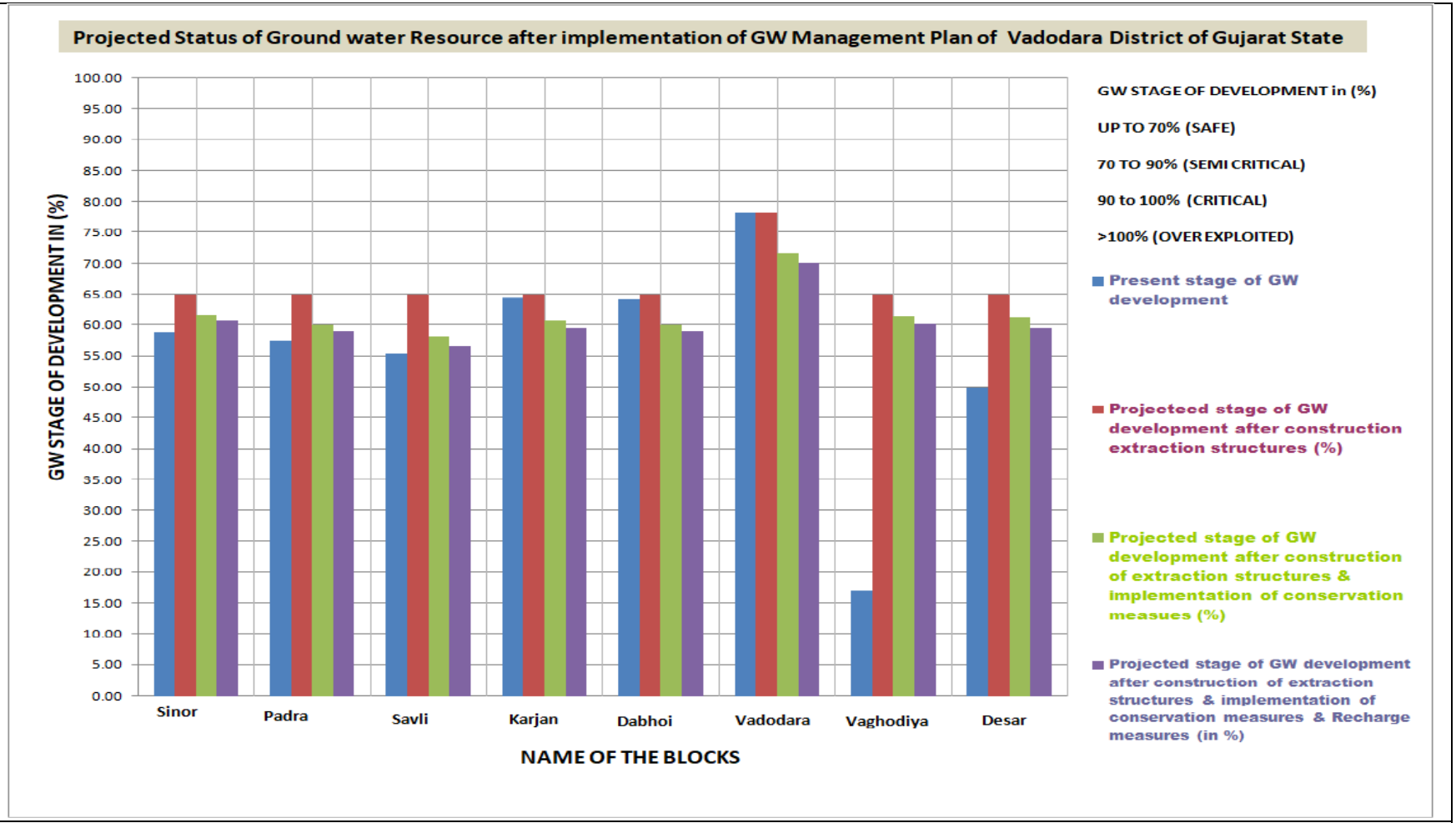


Fig No 24 Shows by adopting above management strategies, projected stage of Ground water extraction after creating additional abstraction structures is 65 % for 07 no blocks in Vadodara district. Projected stage of Ground Water extraction after adopting Artificial Recharge and additional conservation activities is 60 % for 07 no blocks in Vadodara district. However in Vadodara block the stage of ground water extraction is 70% after adopting conservation measures.

Table- 18 Summary of Interventions, Expected Benefits and Cost Estimates of Vadodara district of Gujarat State										
Interventions Recommended		**Sinor**	**Padra**	**Savli**	**Karjan**	**Dabhoi**	**Vadodara**	**Vaghodiya**	**Desar**	**Total**
On-farm Activities (ha)		0	2368	3835	1724	2874	944	100	405	12250
Water Use Efficiency (WUE) Measures (ha)		837	1607	501	1436	2003	3830	178	301	10693
No of Farm Ponds		623	915	562	635	870	1070	1210	186	6071
RTRWH Structures (Per household @ 20000/-)		0	0	0	0	0	114877	0	0	229.75
Feasible Extraction structures to elevate the Stage of GW development to 65% (Soft/Hard rock)	DW	0	0	400	0	0	0	3400	543	4343
	TW/BW	203	421	296	31	73	0	614	55	1693
Expected Benefits										
Expected Annual Recharge(Through On farm activities and GW return flow) ham		204.9	359.9	482.3	180.15	305.65	94.4	592.1	103.05	2322.45
Expected Annual Recharge(Recharge Shaft & Defunct Tube wells) ham		142.82	261.03	276.85	293.89	308.88	327.14	276.12	113.28	2000.00
Conservation from On-farm Activities, WUE Measures & Farm Ponds ham		318.6	642.99	441.02	498.34	713.7	953.21	406.59	123.03	4097.45
Total Recharge/ Saving (ham)		666.29	1263.92	1200.17	972.38	1328.23	1374.75	1274.81	339.36	8419.90
Additional Irrigation Potential Created (Ha)		1218	2460	1976	155	365	0	11642	1251	19067

8. CONCLUSION AND RECOMMENDATIONS

- Artificial recharge structures like recharge shafts (558 no) and Defunct Tube wells (109 no) are suggested as 20 MCM surplus surface water is provisioned as per the data provided by the State Water Resources Department.

- To elevate the stage of ground water development to 65% in Vadodara district except Vadodara block, 4343 no Dug wells (20 m depth) in Hard rock and 1693 no Tube wells (60 to 70 m depth) in alluvium area are proposed as feasible extraction structures.

- 19067 Hectare land may additionally irrigated on 65% of groundwater development and observing all intervention proposed.

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

- 12250 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 6071 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.

- 10693 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in Vadodara district.

- Ground water recharge of 2322.45ham (through on farm activities and GW return flow) is expected for the district.

- 4097.45ham saving of ground water through WUE measures & farm ponds activities is expected for the district.

- 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 Information and Management plan of for Dabhoi Block of Vadodara District, Gujarat state.

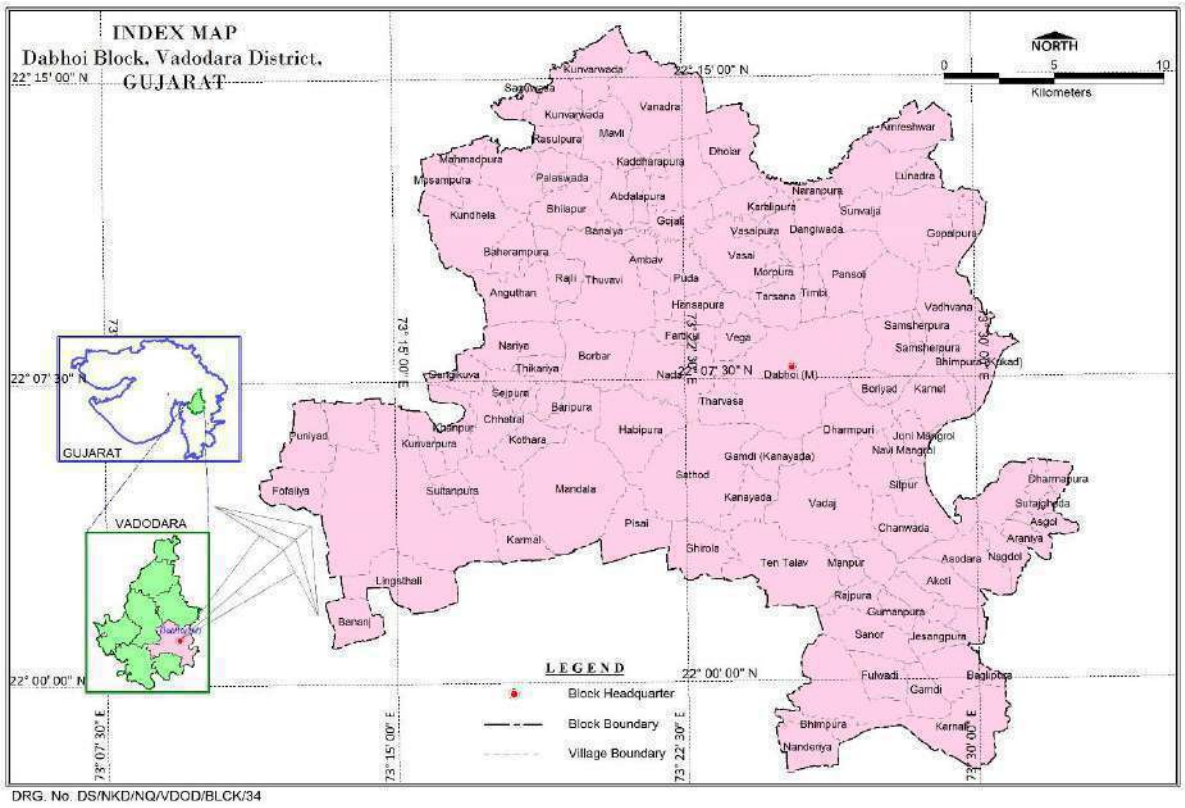
General Information

State Name : Gujarat

District name : Vadodara

Block name : Dabhoi

Location



Salient Features		
Area (Km^2):		632.6
No of Talukas		1
No. of Villages:		118
Population:		1,83,009
Density of Population/Km^2:		289
Net Sown Area in ha		29963
Gross Sown Area in ha		33019
Gross Irrigated Area in ha		26569
Area Irrigated by GW (%):		50.7
Cropping Intensity (%):		110.2
Irrigation Intensity (%):		60
crops	Kharif:	Paddy,Tobacco,Bajra,Banana,Castor,Vegetables,Cotton & Pigeon p
	Rabi:	Wheat,Potato,Tobacco,Mustard,Vegetables,Gram & Forage
	Summer:	Bajra, Paddy,Vegetables,Green Gram & Ground nut

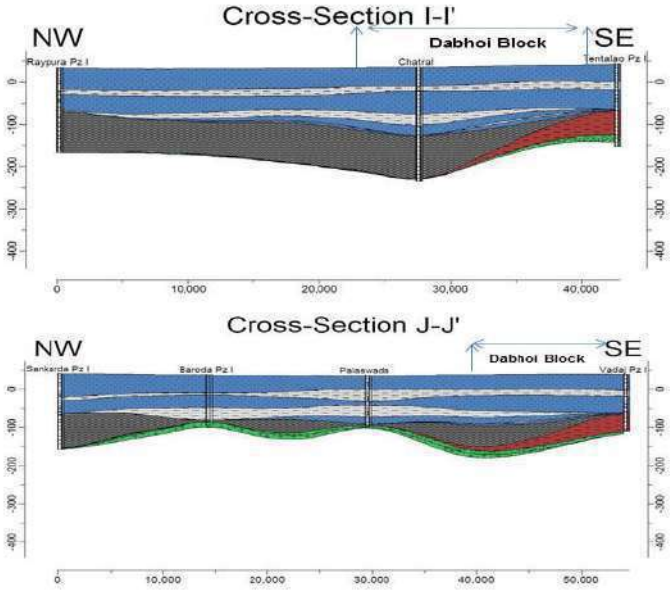
Geographical Area ; 632.60 sq. km.

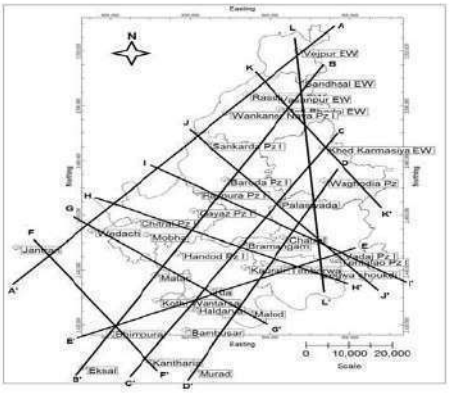
Basin/Sub-basin : Major Drainages: Narmada & Tributaries of Narmada (Heran,Dev,Orsang,)

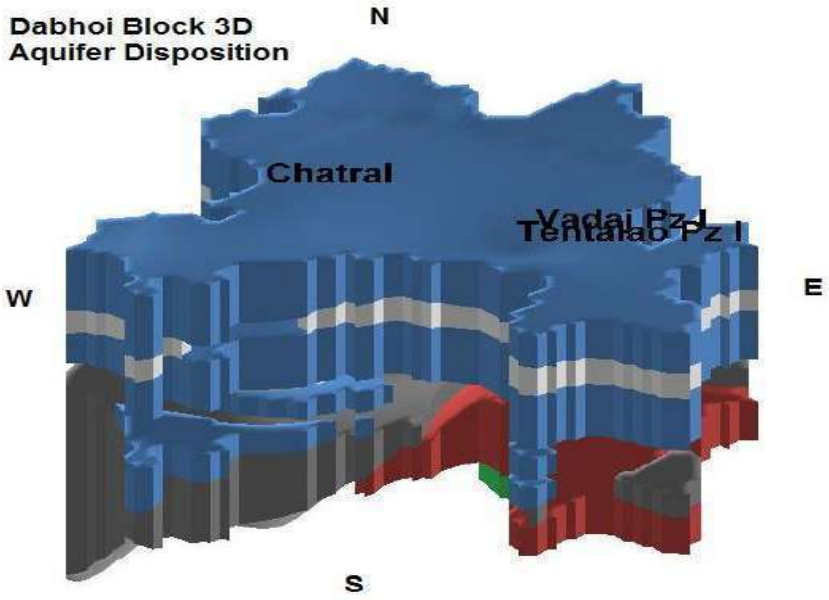
Principal Aquifer System: Alluvium, Basalt.
Major Aquifer System : Deccan traps basalt, alluvium and Fluvial marine sediments.
Normal Annual Rainfall : 769 mm

Aquifer Disposition

- Unconfined Aquifer Depth of occurrence 0 to 45 mbgl.
- Confined Aquifer I depth of occurrence 60 to 110 mbgl.
- Confined Aquifer II depth of occurrence 140 to 165 mbgl.







Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence	Thickness	Water Level (mbgl)	Quality (TDS)	Discharge	Transmissivity	Nature of Aquifer	Remarks
			Aquifer	Range	Range	Range	Range	Range		
			(mbgl)	(m)	(mbgl)	Mg/l	lps	m2/day		
Quaternary	Alluvium	Unconfined Aquifer	0 to 45	35 to 45	3 to 38	820 to 1330	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from 740µS/cm to more than 8000µS/cm in the Dabhoi taluka
		Confined Aquifer I	60 to 110	10 to 30	5 to 50	460 to 5370	1.2 to 60	38 to 2665	Confined	
		Confined Aquifer II	140 to 165	10 to 20	18 to 37		4 to 20	602 to2616	Confined	

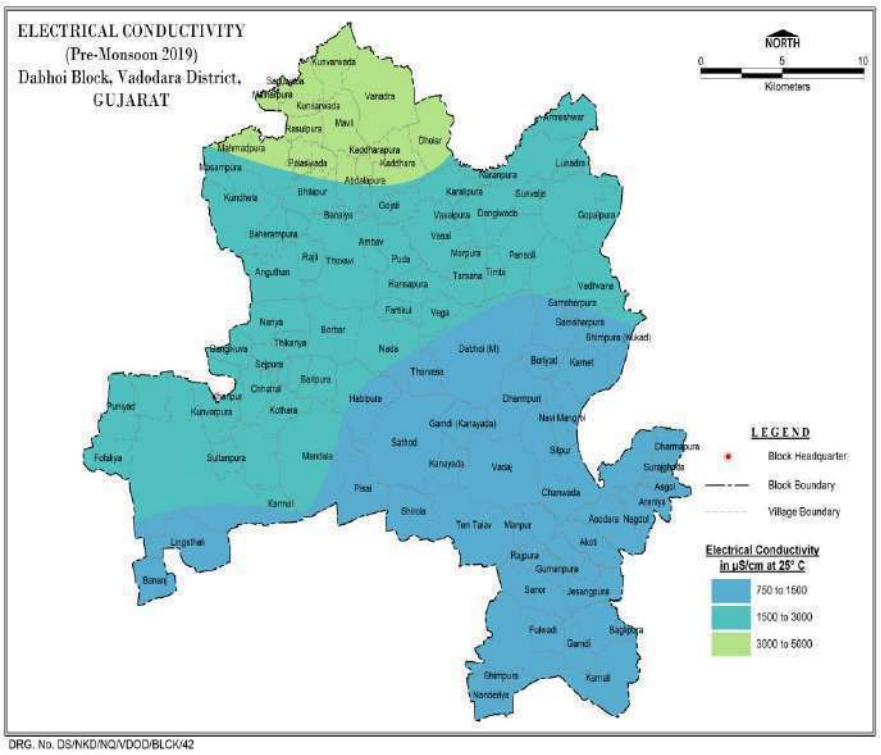
Groundwater Monitoring Status

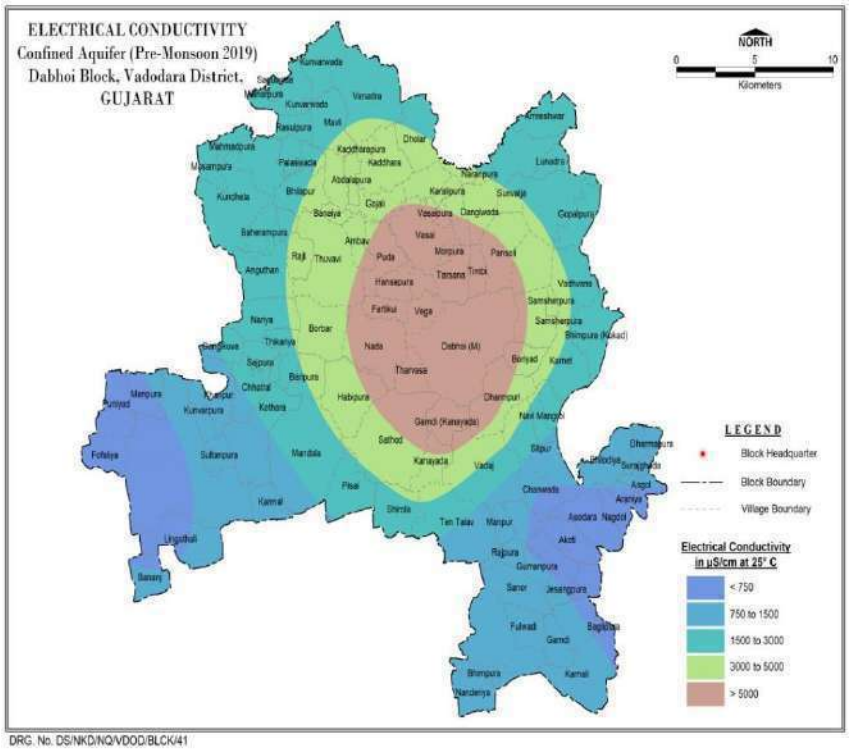
CGWB- Dug wells : 02, Piezometers :01

GWRDC- Dug wells : 04, Piezometers :04

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 740 to 8520 micromhos/cm at 25°c, for the Dabhoi taluka.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Groundwater having more than 5000 µs / cm is observed in proper Dabhoi village area where Tertiary formation is at depth.





Summarised Chemical Data of Dabhoi taluka of Vadodara District.

Chemical Parametres	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	2.5	740	175	460	0	0	128	0	0	30	24	87	3.26	0.45
Max	9	8520	3125	5370	36	427	960	2775	14	900	210	518	55.25	1.25
Average	7.9	2446	704.7	1570.9	18.7	292.8	363.8	410.11	4.04	161.56	72.2	229.7	15.1	0.89

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

Groundwater Resource

- GW Availability 17797.60ham (Dynamic)
- GW Draft 11399.38 ham
- Stage of GW Development 64.05%
- Total Ground Water resource including both dynamic & in storage for district is 121387 ham. (Dynamic:17797.60ham & In storage: 103590 ham)

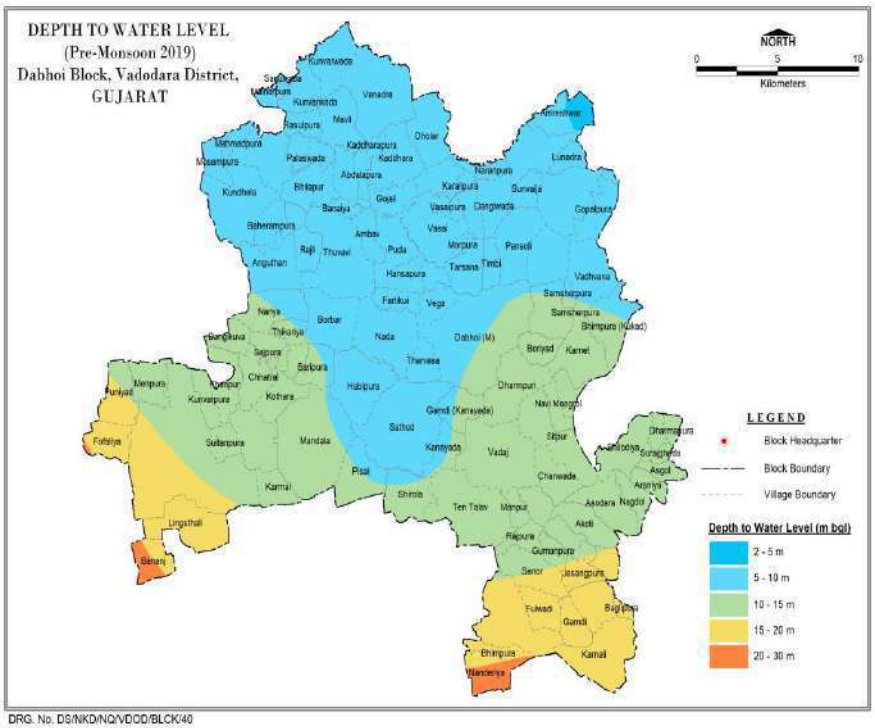
Existing and Future Water Demand

- Present demand for All Usage: 11399.38 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 332.00 ham.
- Net Ground Water availability for future use is 6318.14 ham.

Aquifer Management plan

Groundwater Management Issues

- After commencement of Narmada Canal based irrigation, little rising trend is observed in long term water level analysis (last 10 years) of Phreatic Aquifer.
- It is observed that in pre monsoon season few wells of confined Aquifer showing feeble declining trend.
- Groundwater having more than 5000 µs / cm is observed in proper Dabhoi village area where Tertiary formation is at depth.



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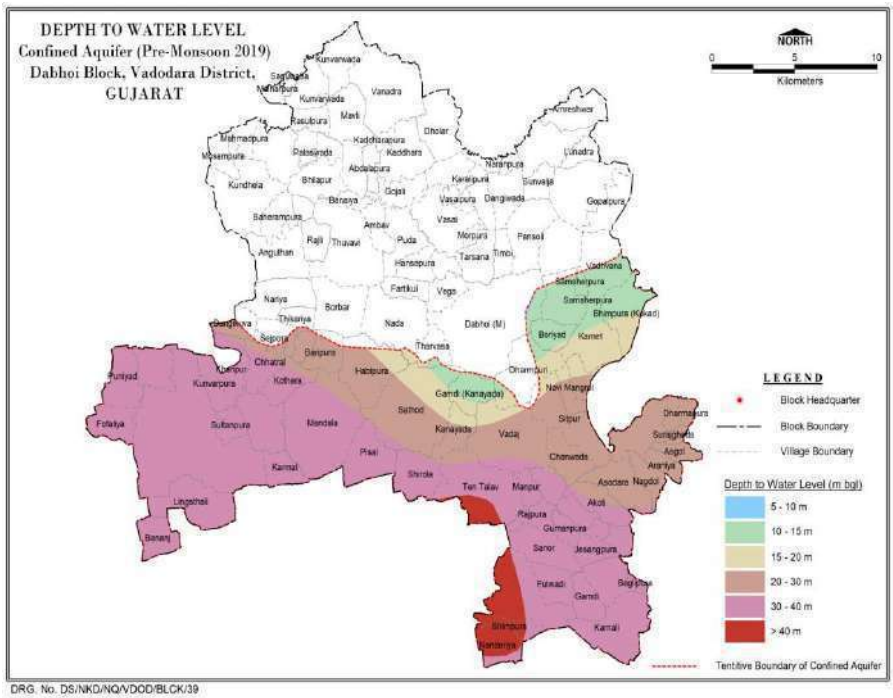

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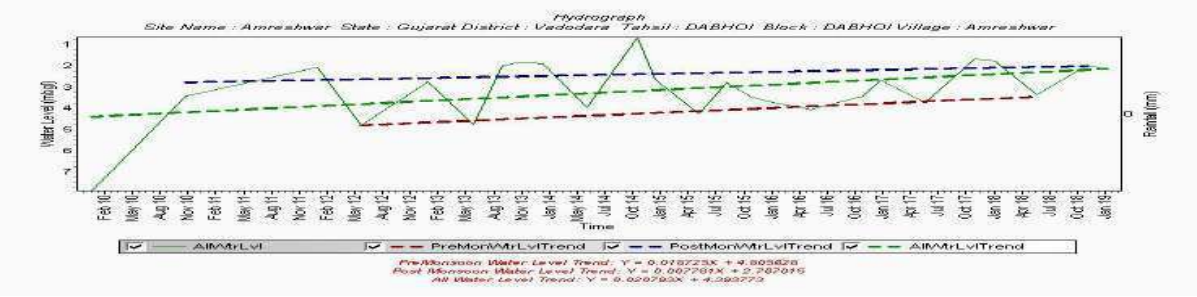


Groundwater Management Plan

- **Ground water development plan**
  The stage of ground water extraction of Dabhoi taluka is 64.05 %.To elevate the stage of ground water extraction to 65% in Dabhoi taluka, 73 no Tube wells (60 to 70 m depth) in alluvium area are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 182.50 ham which will create 365.00 Ha additional irrigation potential for the taluka.
- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 3.08 MCM of surplus surface water is provisioned for artificial recharge through 86 no of recharge shafts and 16 no of existing defunct tube wells which can be used as injection wells in Dabhoi taluka of Vadodara district .Ground water recharge of 306.00 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 2874 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 870 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.2003 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in taluka .Ground water recharge of 305.65 ham (through on farm activities and GW return flow) is expected for the taluka.308.88 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 65 % in the Dabhoi Block. Projected stage of Ground Water development after additional conservation activities is 59.04 % in the Dabhoi Block.

Aquifer Information and Management plan of for Desar Block of Vadodara District, Gujarat state.

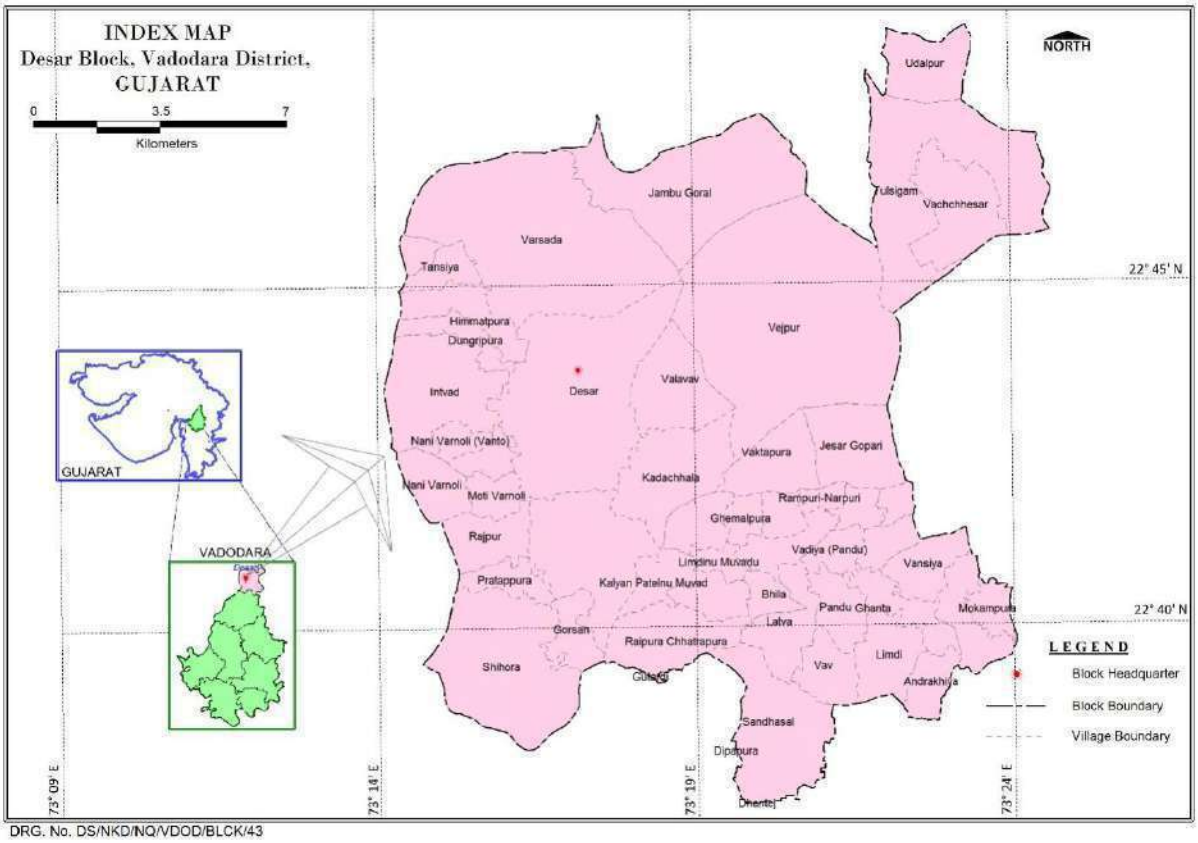
General Information

State Name : Gujarat

District name : Vadodara

Block name :Desar

Location



DRG. No. DS/NKD/NQ/VDOD/BLCK/43

Salient Features		
Area (Km^2):		232
No of Talukas		1
No. of Villages:		49
Net Sown Area in ha		16995
Gross Sown Area in ha		17913
Gross Irrigated Area in ha		8173
Cropping Intensity (%):		105.4
Irrigation Intensity (%):		33.95
Principal crops	Kharif:	Paddy,Tobacco,Bajra,Banana,Castor,Vegetables,Cotton & Pigeon pea
	Rabi:	Wheat,Potato,Tobacco,Mustard,Vegetables,Gram & Forage
	Summer:	Bajra, Paddy,Vegetables,Green Gram & Ground nut

Basin/Sub-basin:Major Drainages: Mahi & Tributaries of Mahi(Mesari,Pingli,Goma and Kun)

Major Aquifer System: Deccan traps basalt.

Normal Annual Rainfall: 837 mm

Aquifer Disposition

- Weathered Aquifer depth of occurrence 0 to 35mbgl.
- Fractured Aquifer depth of occurrence 35 to 130 mbgl.
- Massive Basalt 130 to 200 mbgl.

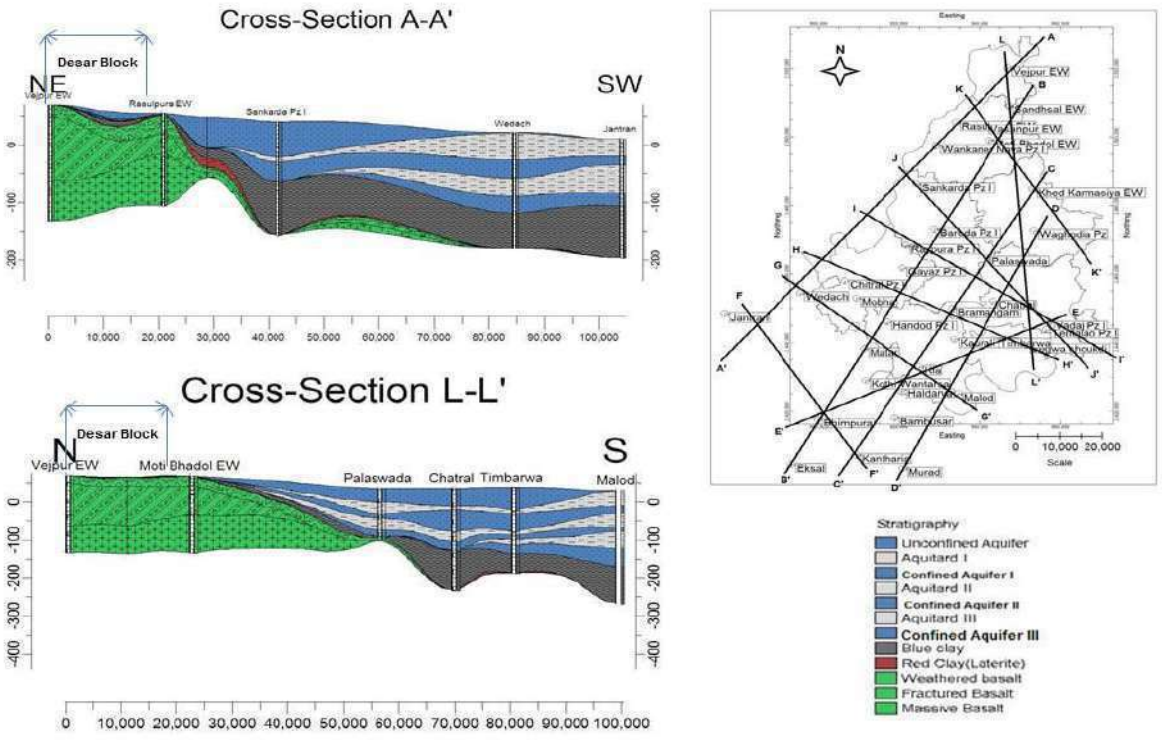


Plate-3

Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence	Thickness	Water Level (mbgl)	Quality (TDS)	Discharge	Transmissivity	Nature of Aquifer	Remarks
			Aquifer	Range	Range	Range	Range	Range		
			(mbgl)	(m)	(mbgl)	Mg/l	lps	m2/day		
Upper Cretaceous to Lower Eocene	Basalt	Weathered Basalt	0 to 35	0 to 35	3 to 30	1980			Phreatic	Good Quality
	Basalt	Fractured Basalt	35 to 130		9 to 14	1950	0.2 to 7		Fractured	Good Quality

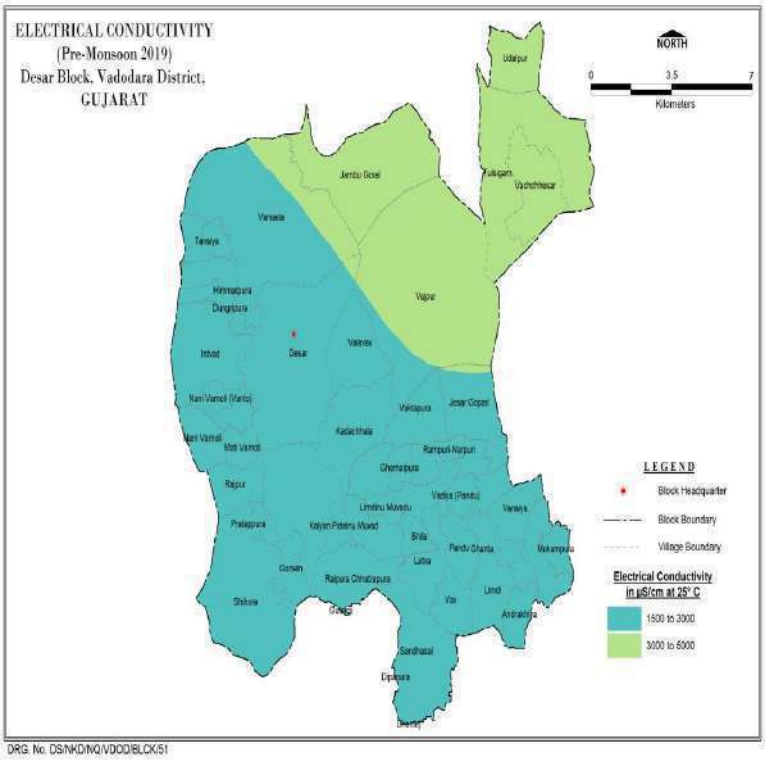
Groundwater Monitoring Status

CGWB- Dug wells : 00, Piezometers :00

GWRDC- Dug wells : 01, Piezometers :01

Groundwater Quality

- In Desar taluka having only one monitored Dug well and one piezometer the Electrical conductance of ground water is generally ranges from 1950 to 1980 micromhos/cm at 25°c.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.



Summarised Chemical Data of Desar taluka of Vadodara District.														
Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Dug well	8.7	3120	600	1980	24	488	640	176	9.88	150	54	442	0	0.59
Piezometer	8.9	3060	688	1950	36	427	560	311	1.37	160	69	385	4	1.58
* All values are in mg/l except pH and EC in µS/cm at 25°C														

Groundwater Resource

- GW Availability 3854.75 ham (Dynamic)
- GW Draft 1921.41 ham
- Stage of GW Development 49.85 %

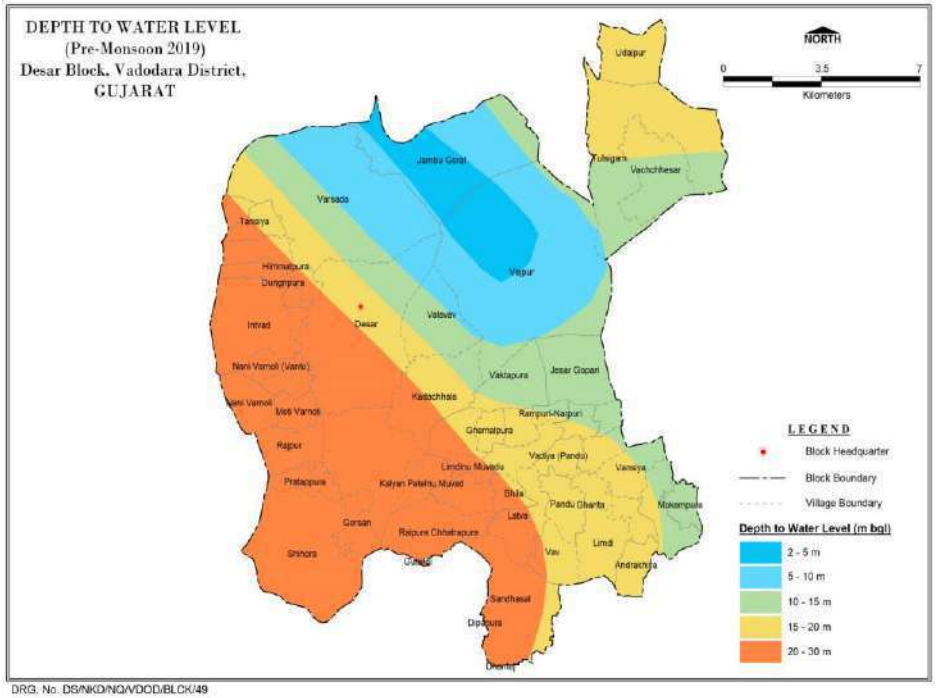
Existing and Future Water Demand

- Present demand for All Usage: 1921.41 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 193.00 ham.
- Net Ground Water availability for future use is 1886.89 ham.

Aquifer Management plan

Groundwater Management Issues

- Feeble declining trend is observed in long term water level analysis of fractured aquifer.



Groundwater Management Plan

- **Ground water development plan**

  The stage of ground water extraction of Desar taluka is 49.85 %. To elevate the stage of ground water development to 65% in Desar block, 543 no of Dug wells (20 m depth) and 55 no Tube wells (70m depth) are proposed as feasible extraction structures.The extraction structures will result in additional ground water draft of 625.50 ham which will create 1251 Ha additional irrigation potential for the Desar Block.

- **Supply side Management Plan**

  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 1.13 MCM of surplus surface water is provisioned for artificial recharge through 32 no of recharge shafts and 06 no of existing defunct tube wells which can be used as injection wells in Desar taluka of Vadodara district .Ground water recharge of 114.00 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 405 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 186 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.301 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in taluka .Ground water recharge of 103.05 ham (through on farm activities and GW return flow) is expected for the taluka.123.03 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 65 % in the Desar Block. Projected stage of Ground Water development after additional conservation activities is 59.53 % in the Desar Block.

Aquifer Information and Management plan of for Karjan Block of Vadodara District, Gujarat state.

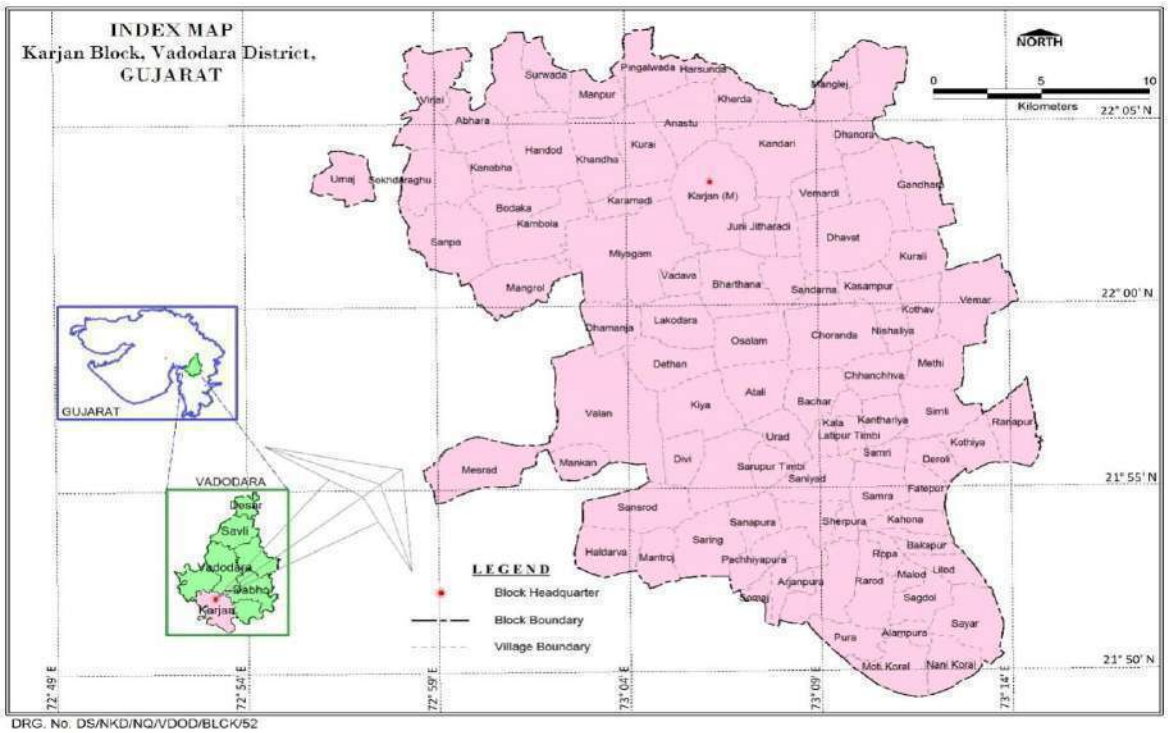
General Information

State Name : Gujarat

District name : Vadodara

Block name: Karjan

Location



DRG. No. DS/NKD/NQ/VDOD/BLCK/52

Geographical Area : 601.90 sq. km.

Basin/Sub-basin :Major Drainages: Narmada & Tributaries of Narmada (Dev)

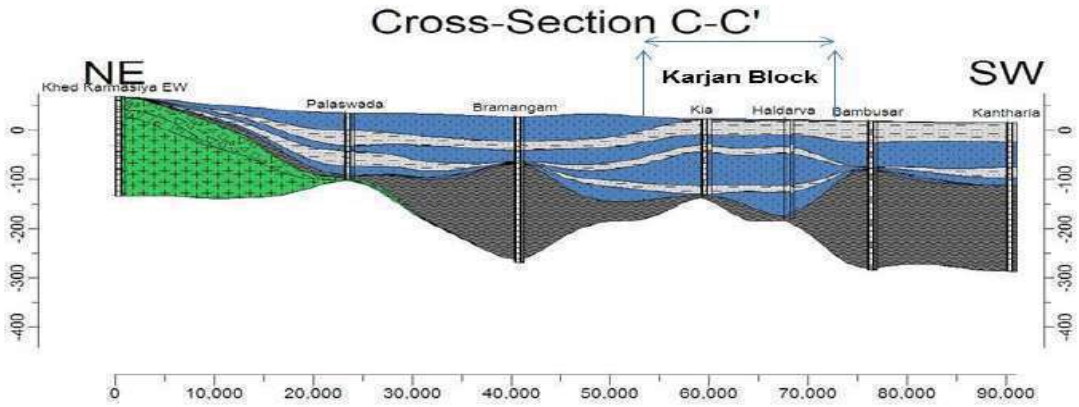
Principal Aquifer System : Quaternary Alluvium,

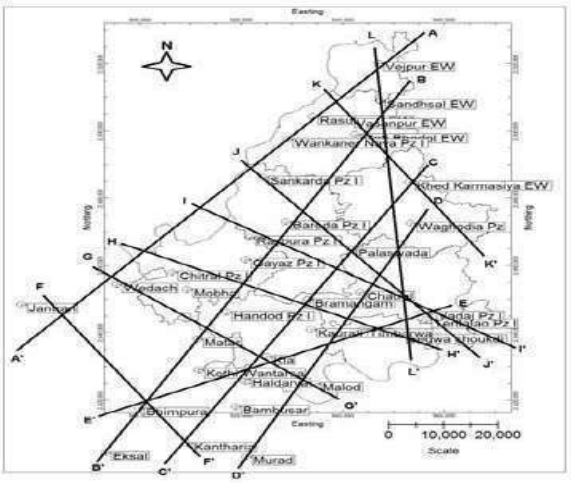
Major Aquifer System : Alluvium and Fluvial marine sediments.

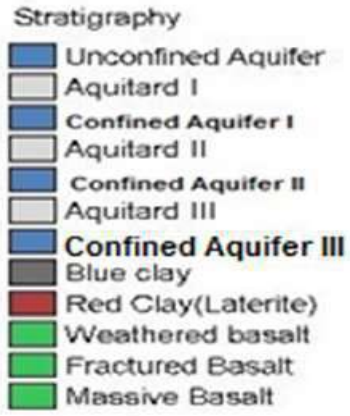
Normal Annual Rainfall : 871 mm

Aquifer Disposition

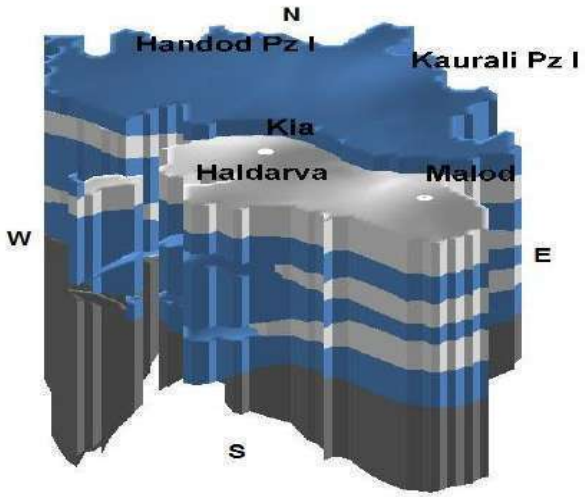
- Unconfined Aquifer Depth of occurrence 0 to 65 mbgl.
- Confined Aquifer I depth of occurrence 80 to 110 mbgl.
- Confined Aquifer II depth of occurrence 123 to 135 mbgl.
- Confined Aquifer III depth of occurrence 150 to 200 mbgl.







Karjan Block 3D Aquifer Disposition



Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence	Thickness	Water Level (mbgl)	Quality (TDS)	Discharge	Transmissivity	Nature of Aquifer	Remarks
			Aquifer	Range	Range	Range	Range	Range		
			(mbgl)	(m)	(mbgl)	Mg/l	lps	m2/day		
Quaternary	Alluvium	Unconfined Aquifer	0 to 62	35 to 60	3 to 38	360 to 1150	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from 530 µS/cm to 1800 µS/cm in the Karjan Taluka.
		Confined Aquifer I	80 to 110	10 to 30	5 to 50		1.2 to 60	38 to 2665	Confined	
		Confined Aquifer II	123 to 135	10 to 20	18 to 37		4 to 20	602 to2616	Confined	
Tertiary	Alluvium	Confined Aquifer III	150 to 200	25 to 50	24 to 37		6 to 34	2616 to 4622	Confined	Ground water having more than 3000µS/cm is observed in areas where tertiary formation is at depth.

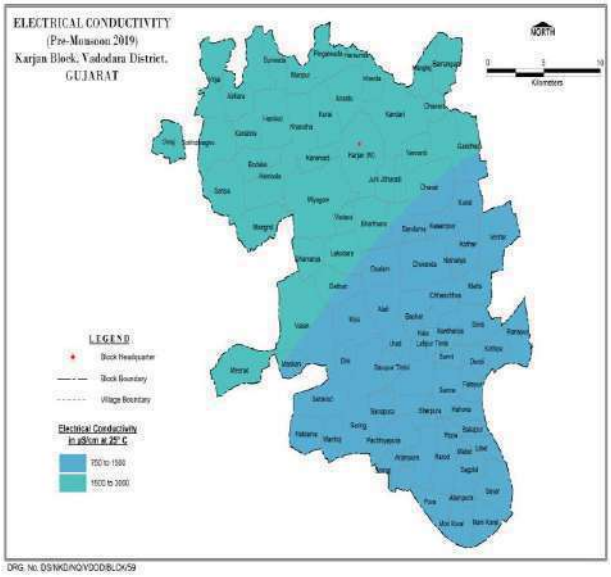
Groundwater Monitoring Status

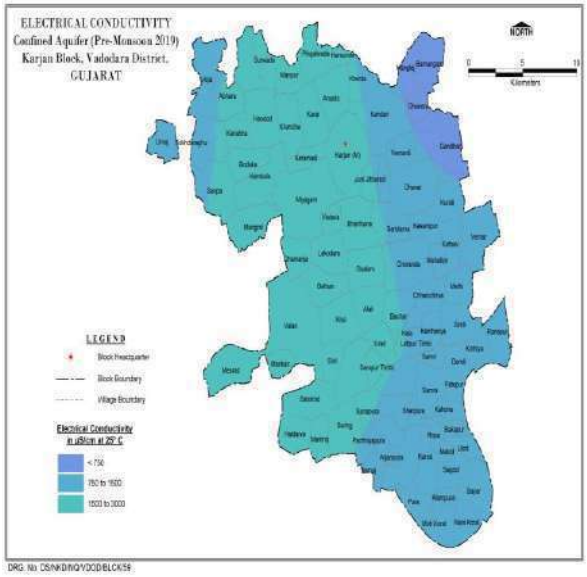
CGWB- Dug wells : 00, Piezometers :01

GWRDC- Dug wells : 01, Piezometers :05

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 530 to 1800 micromhos/cm at 25°c, for the Karjan taluka.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.





Summarised Chemical Data of Karjan taluka of Vadodara District.														
Chemical Parameters	**pH**	**EC**	**TH**	**TDS**	**CO3**	**HCO3**	**Cl**	**SO4**	**NO3**	**Ca**	**Mg**	**Na**	**K**	**F**
Min	7.7	530	113	360	0	146.4	104	0	1.02	25	12	66	5.5	0.2
Max	9	1800	400	1150	36	244	360	271	1.54	85	45	257	12.32	1.24
Average	8.32	1232	247.6	796	14.4	202.52	236.8	85.4	1.268	53	27.6	164.8	7.684	0.676
*** All values are in mg/l except pH and EC in µS/cm at 25°C**														

Groundwater Resource

- GW Availability 13996.61ham (Dynamic)
- GW Draft 9025.64 ham
- Stage of GW Development 64.48%
- Total Ground Water resource including both dynamic & in storage for district is 110300.61ham. (Dynamic:13996.61ham & In storage: 96304 ham)

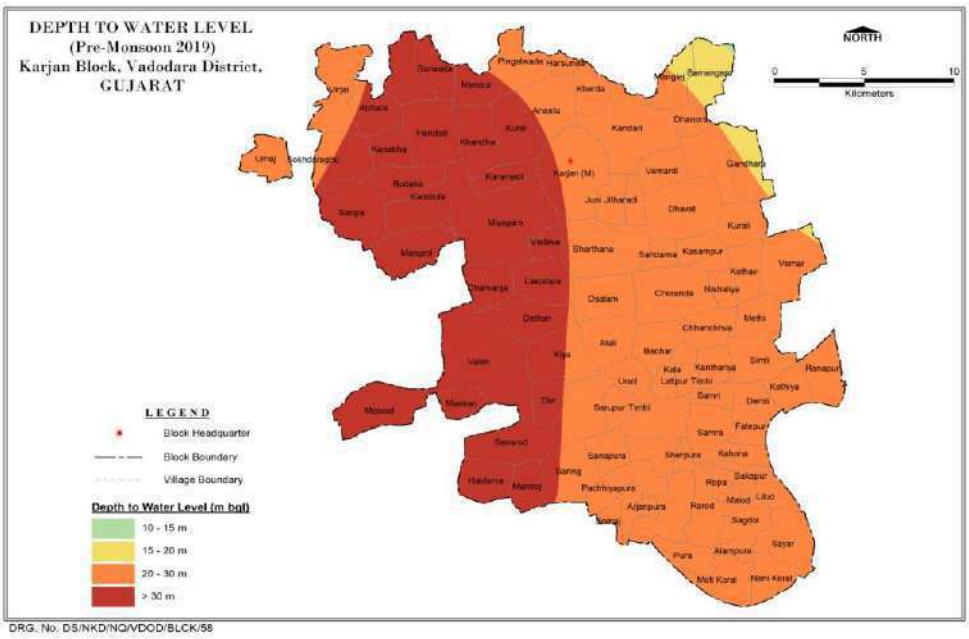
Existing and Future Water Demand

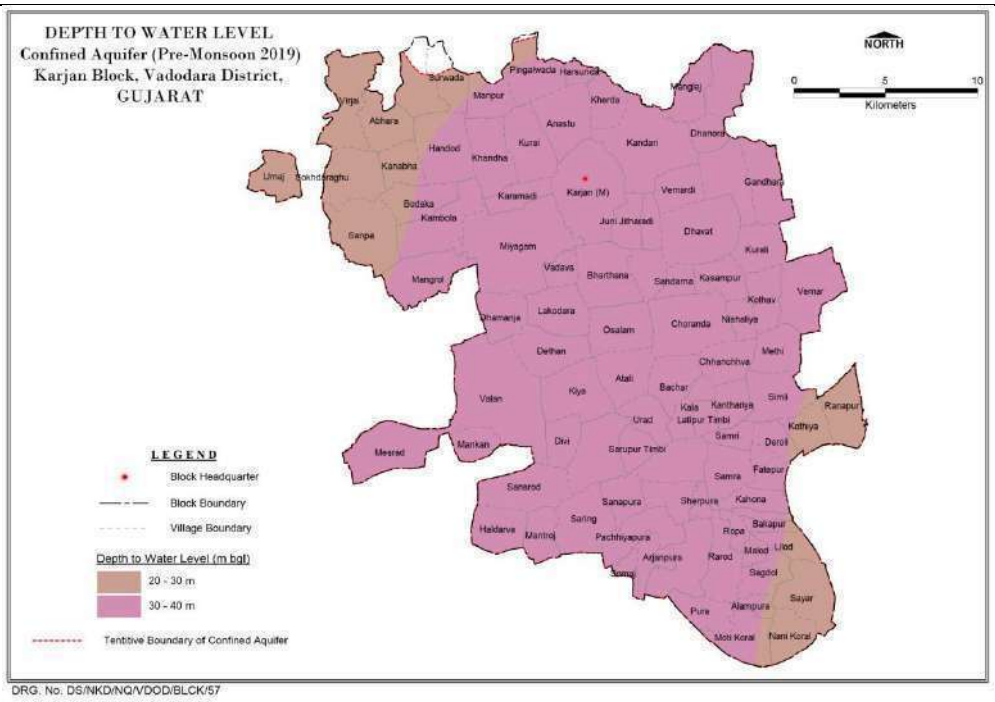
- Present demand for All Usage: 9025.64 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 308.00 ham.
- Net Ground Water availability for future use is 4896.83 ham.

Aquifer Management plan

Groundwater Management Issues

- 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.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.





Groundwater Management Plan

- **Ground water development plan**

  The stage of ground water extraction of Karjan taluka is 64.48 %.To elevate the stage of ground water extraction to 65.00% in Karjan taluka, 31 no Tube wells (60 to 70 m depth) in alluvium area are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 77.50 ham which will create 155 Ha additional irrigation potential for the taluka.

- **Supply side Management Plan**

  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 2.93 MCM of surplus surface water is provisioned for artificial recharge through 80 no of recharge shafts and 18 no of existing defunct tube wells which can be used as injection wells in Karjan taluka of Vadodara district .Ground water recharge of 294.00 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 1724 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 635 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.1436 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in taluka .Ground water recharge of 180.15 ham (through on farm activities and GW return flow) is expected for the taluka.498.34 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 65 % in the Karjan Block. Projected stage of Ground Water development after additional conservation activities is 59.46 % in the Karjan Block.

Aquifer Information and Management plan of for Padra Block of Vadodara District, Gujarat state.

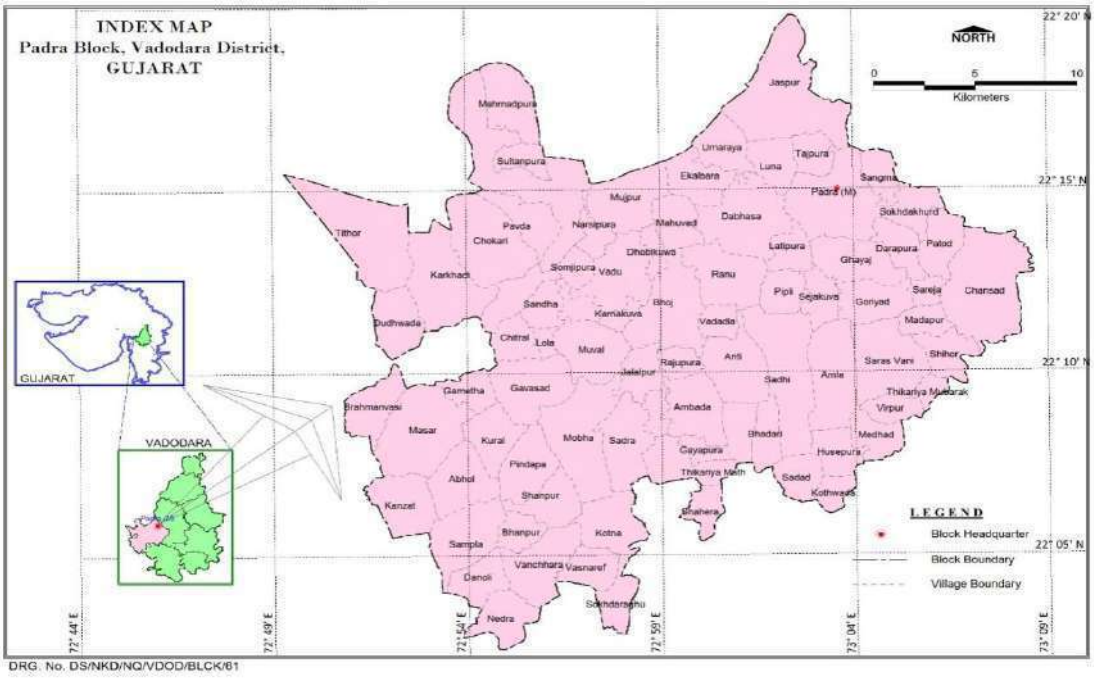
General Information

State Name : Gujarat

District name : Vadodara

Block name : Padra

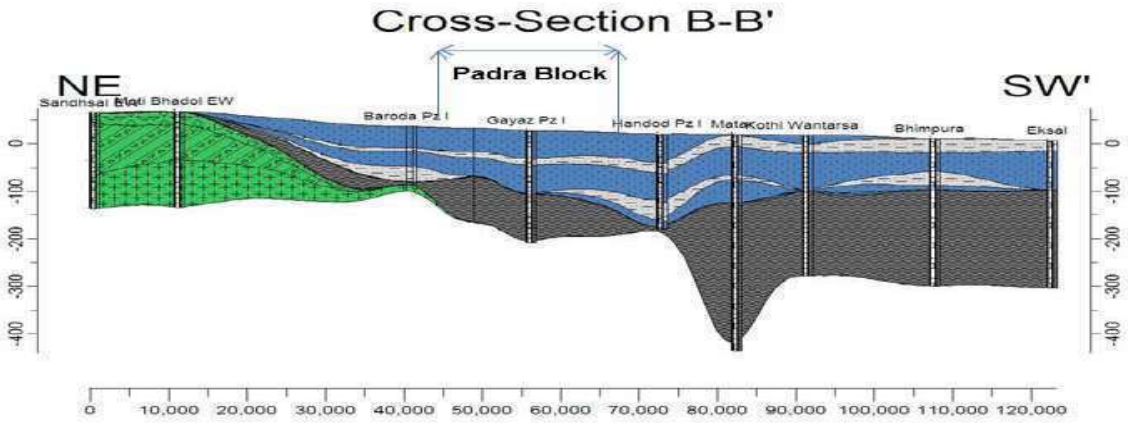
Location

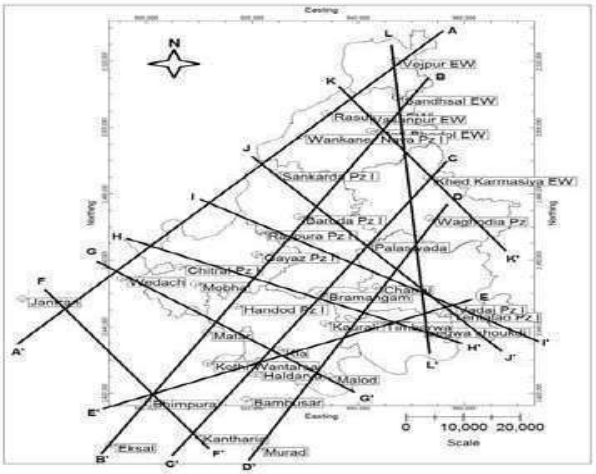


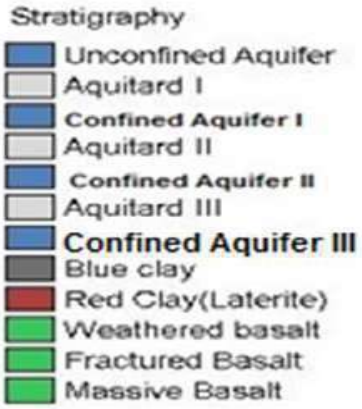
Salient Features		
Area (Km^2):		534.6
No of Talukas		1
No. of Villages:		83
Population:		250,155
Density of Population/Km^2:		468
Net Sown Area in ha		40587
Gross Sown Area in ha		41234
Gross Irrigated Area in ha		27294
Area Irrigated by GW (%):		86.04
Cropping Intensity (%):		101.59
Irrigation Intensity (%):		50
Principal crops	Kharif:	Paddy,Tobacco,Bajra,Banana,Castor,Vegetables,Cotton & Pigeon pea
	Rabi:	Wheat,Potato,Tobacco,Mustard,Vegetables,Gram & Forage
	Summer:	Bajra, Paddy,Vegetables,Green Gram & Ground nut

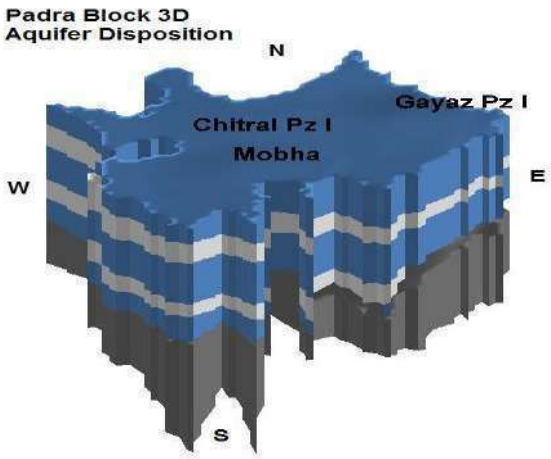
Geographical Area : 534.60 sq. km.
Basin/Sub-basin : Major Drainages: Mahi **&** Tributaries of Mahi (Dev)
Principal Aquifer System : Quaternary Alluvium
Major Aquifer System : Alluvium and Fluvial marine sediments.
Normal Annual Rainfall : 769 mm
Aquifer Disposition

- Unconfined Aquifer Depth of occurrence 0 to 60 mbgl.
- Confined Aquifer I depth of occurrence 74 to 110 mbgl.
- Confined Aquifer II depth of occurrence 135 to 165 mbgl.







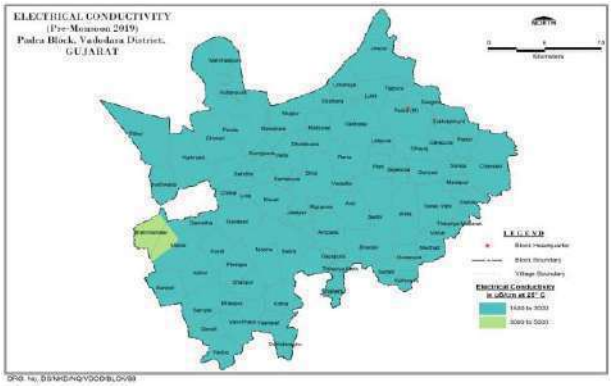


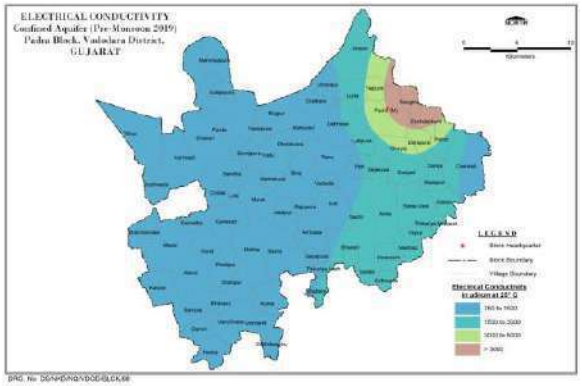
Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence Aquifer (mbgl)	Thickness Range (m)	Water Level (mbgl) Range (mbgl)	Quality (TDS) Range Mg/l	Discharge Range lps	Transmissivity Range m2/day	Nature of Aquifer	Remarks
Quaternary	Alluvium	Unconfined Aquifer	0 to 60	35 to 60	3 to 38	1240 to 1950	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from 830 µS/cm to 3130 µS/cm in the Padra Taluka.
		Confined Aquifer I	74 to 110	10 to 30	5 to 50	550 to 1220	1.2 to 60	38 to 2665	Confined	
		Confined Aquifer II	135 to 165	10 to 20	18 to 37		4 to 20	602 to2616	Confined	

Groundwater Monitoring Status
CGWB- Dug wells : 02, Piezometers :03
GWRDC- Dug wells : 02, Piezometers :02

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 830 to 3130 micromhos/cm at 25°c, for the Padra taluka.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.





Summarised Chemical Data of Padra taluka of Vadodara District.														
Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8.1	830	188	550	0	207.4	144	0	0.41	10	18	102	1	0.51
Max	9	3130	488	1950	48	940	744	207	9.25	100	66	493	215.2	1.27
Average	8.5	2036.8	334.8	1312.8	19.8	451.4	351.4	99.6	5.6	55.4	47.2	287.6	45.4	0.88
* **All values are in mg/l except pH and EC in µS/cm at 25°C**														

Groundwater Resource

- GW Availability 15414.05 ham (Dynamic)
- GW Draft 8870.57 ham
- Stage of GW Development 57.55 %
- Total Ground Water resource including both dynamic & in storage for district is 128112.05 ham. (Dynamic:15414.05 ham & In storage: 112698 ham)

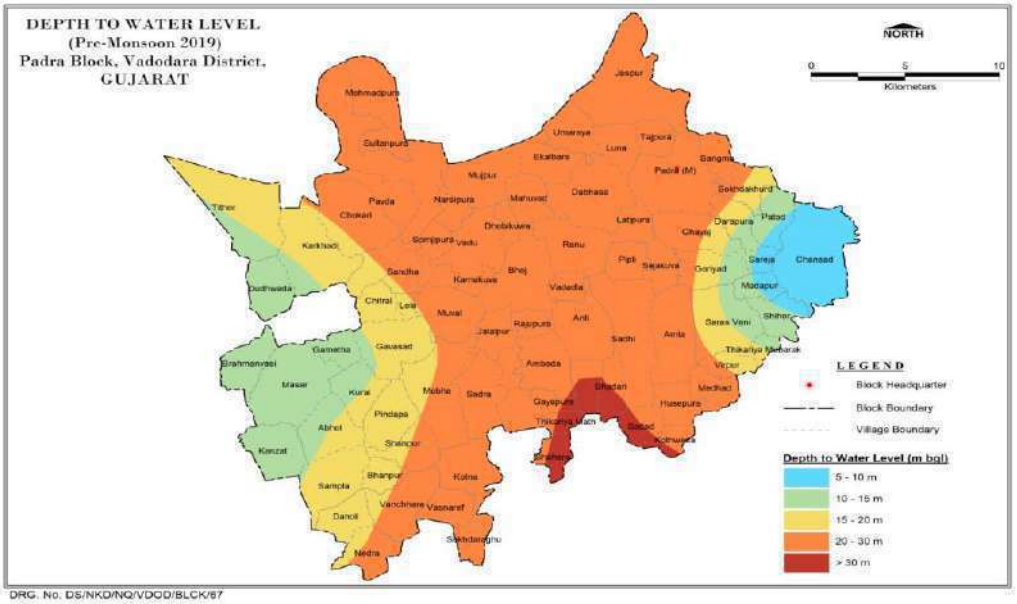
Existing and Future Water Demand

- Present demand for All Usage: 8870.57 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 489.00 ham.
- Net Ground Water availability for future use is 6425.57 ham.

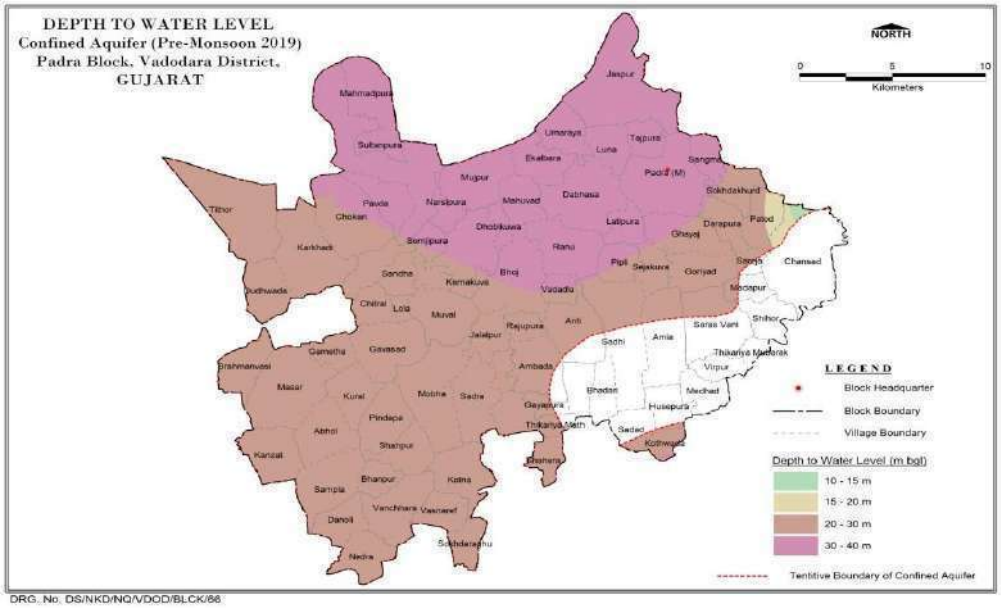
Aquifer Management plan

Groundwater Management Issues

- After commencement of Narmada Canal based irrigation, little rising trend is observed in long term water level analysis (last 10 years) of both Phreatic and Confined Aquifers.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.



DRG. No. DS/NKD/NQ/VDOD/BLCK/87



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

Groundwater Management Plan

- **Ground water development plan**

  The stage of ground water extraction of Padra taluka is 57.55 %.To elevate the stage of ground water extraction to 65% in Padra taluka, 421 no Tube wells (60 to 70 m depth) in alluvium area are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 1230.00 ham which will create 2460.00 Ha additional irrigation potential for the taluka.

- **Supply side Management Plan**

  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 2.61 MCM of surplus surface water is provisioned for artificial recharge through 73 no of recharge shafts and 14 no of existing defunct tube wells which can be used as injection wells in Padra taluka of Vadodara district .Ground water recharge of 247.00 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 2368 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 915 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.1607 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in taluka .Ground water recharge of 359.9 ham (through on farm activities and GW return flow) is expected for the taluka.642.99 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 65.00 % in the Padra Block. Projected stage of Ground Water development after additional conservation activities is 59 % in the Padra Block.

Aquifer Information and Management plan of for Savli Block of Vadodara District, Gujarat state.

General Information

State Name : Gujarat

District name : Vadodara

Block name : Savli

Location

DRG. No. DS/NKD/NQ/VDOD/BLCK/70

Salient Features		
Area (Km^2):		567
No of Talukas		1
No. of Villages:		137
Population:		237,929
Density of Population/Km^2:		420
Net Sown Area in ha		40233
Gross Sown Area in ha		69286
Gross Irrigated Area in ha		33854
Area Irrigated by GW (%):		55.5
Cropping Intensity (%):		172.21
Irrigation Intensity (%):		62.43
Principal crops	Kharif:	Paddy,Tobacco,Bajra,Banana,Castor,Vegetables,Cotton & Pigeon pea
	Rabi:	Wheat,Potato,Tobacco,Mustard,Vegetables,Gram & Forage
	Summer	Bajra, Paddy,Vegetables,Green Gram & Ground nut

Geographical Area : 567.00 sq. km.

Basin/Sub-basin : Major Drainages: Mahi **&** Tributaries of Mahi (Goma,Karad and Viswamitri)

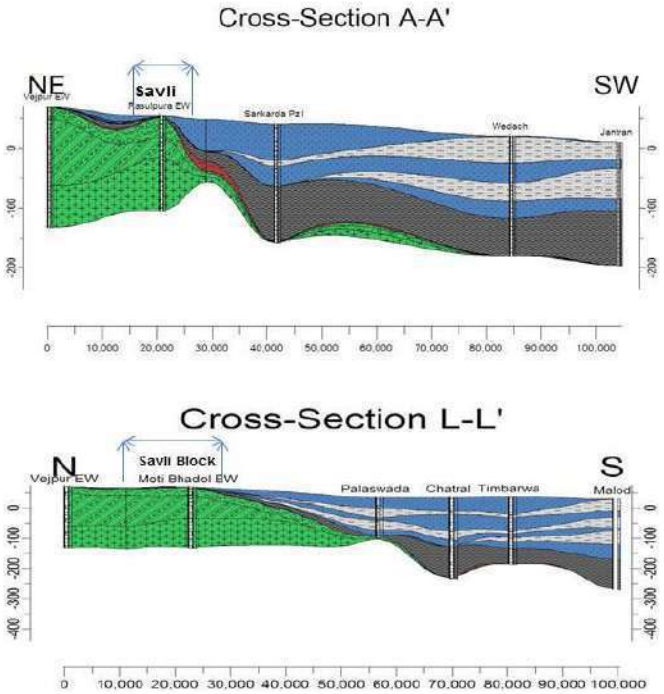
Principal Aquifer System : Alluvium and Basalt.

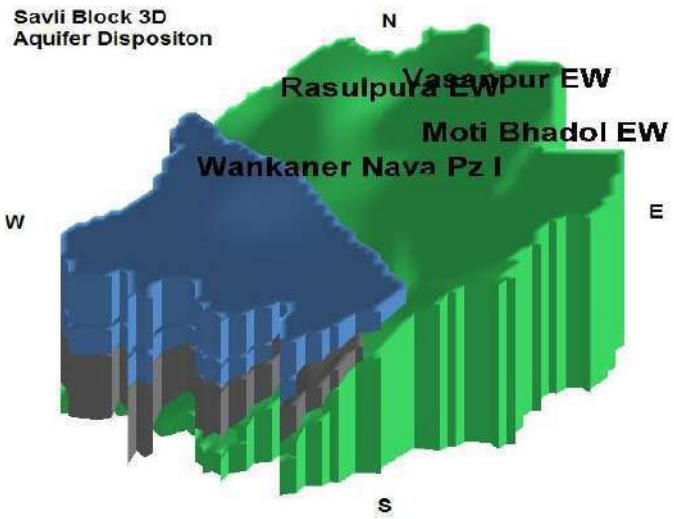
Major Aquifer System : Deccan traps basalt, alluvium and Fluvial marine sediments.

Normal Annual Rainfall : 837 mm

Aquifer Disposition

- Weathered aquifer depth of occurrence 0 to 30 mbgl.
- Fractured Aquifer depth of occurrence 40 to 120 mbgl.
- Phreatic aquifer depth of occurrence 0 to 61 mbgl.
- Confined Aquifer I depth of occurrence 70 to 105 mbgl.





Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence	Thickness	Water Level (mbgl)	Quality (TDS)	Discharge	Transmissivity	Nature of Aquifer	Remarks
			Aquifer	Range	Range	Range	Range	Range		
			(mbgl)	(m)	(mbgl)	Mg/l	lps	m2/day		
Quaternary	Alluvium	Unconfined Aquifer	0 to 61	25to 40	3 to 38	470 to 1337	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from less than 710µS/cm to more than 2010 µS/cm in the Savli taluka
		Confined Aquifer I	70 to 105	10 to 30	5 to 50		1.2 to 60	38 to 2665	Confined	
Upper Cretaceous to Lower Eocene	Basalt	Weathered Basalt	0 to 30	0 to 20	3 to 17				Phreatic	
	Basalt	Fractured Basalt	40 to 120		9 to 14		0.2 to 7		Fractured	

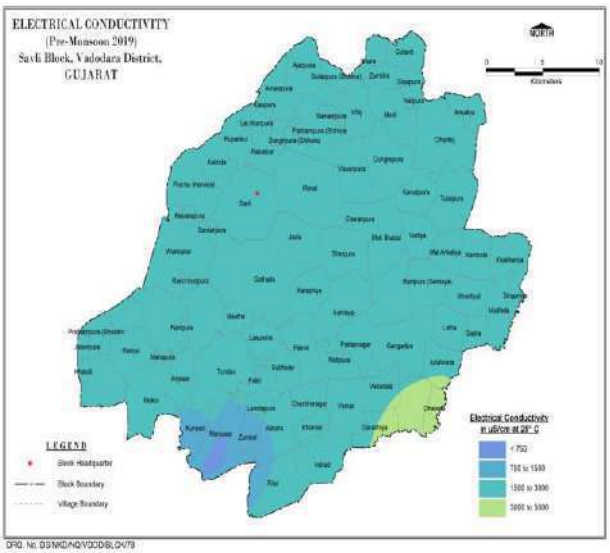
Groundwater Monitoring Status

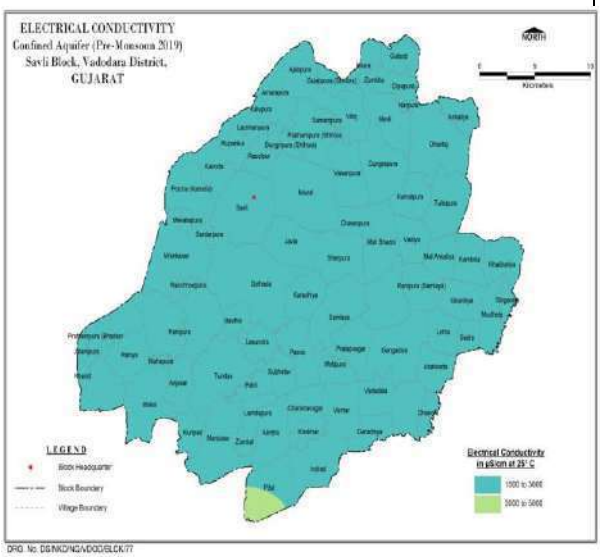
CGWB- Dug wells : 05, Piezometers :01

GWRDC- Dug wells : 04, Piezometers :01

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 710 to 2010 micromhos/cm at 25°c, for the Savli taluka.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Occurrence of excessive Nitrate in Shallow aquifers at isolated villages.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.





Summarised Chemical Data of Savli taluka of Vadodara District.														
Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	2.80	710.00	113.00	470.00	0.00	0.00	152.00	0.00	0.00	30.00	9.00	97.00	3.09	0.45
Max	8.80	2010.00	510.00	1337.00	24.00	403.00	344.00	353.00	92.00	100.00	75.00	230.00	102.20	1.45
Average	7.50	1736.86	404.71	1131.14	8.57	266.77	294.71	184.43	22.87	75.71	51.86	193.00	33.77	1.00
* All values are in mg/l except pH and EC in µS/cm at 25°C														

Groundwater Resource

- GW Availability 9566.88 ham (Dynamic)
- GW Draft 5295.18 ham
- Stage of GW Development 55.35 %
- Total Ground Water resource including both dynamic & in storage for Savli Taluka is 60571.88 ham. (Dynamic:9566.88 ham & In storage: 51005 ham)

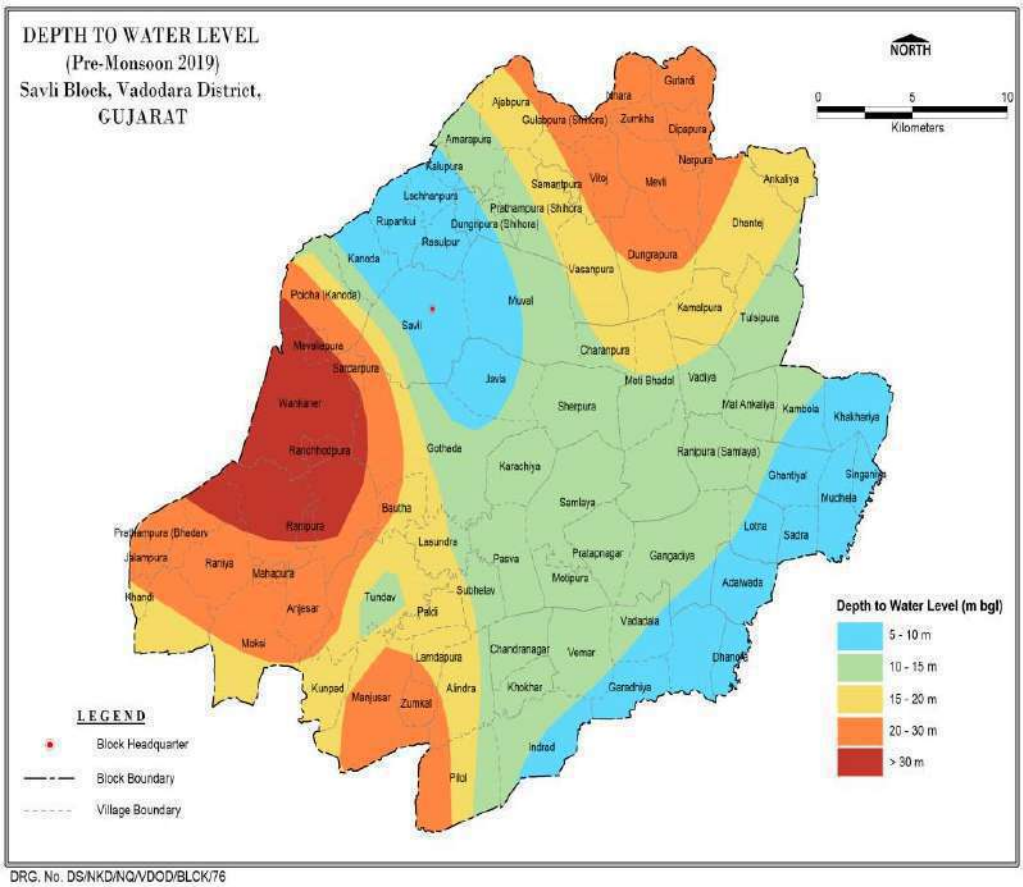
Existing and Future Water Demand

- Present demand for All Usage: 5295.18 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 469.00 ham.
- Net Ground Water availability for future use is 4158.58 ham.

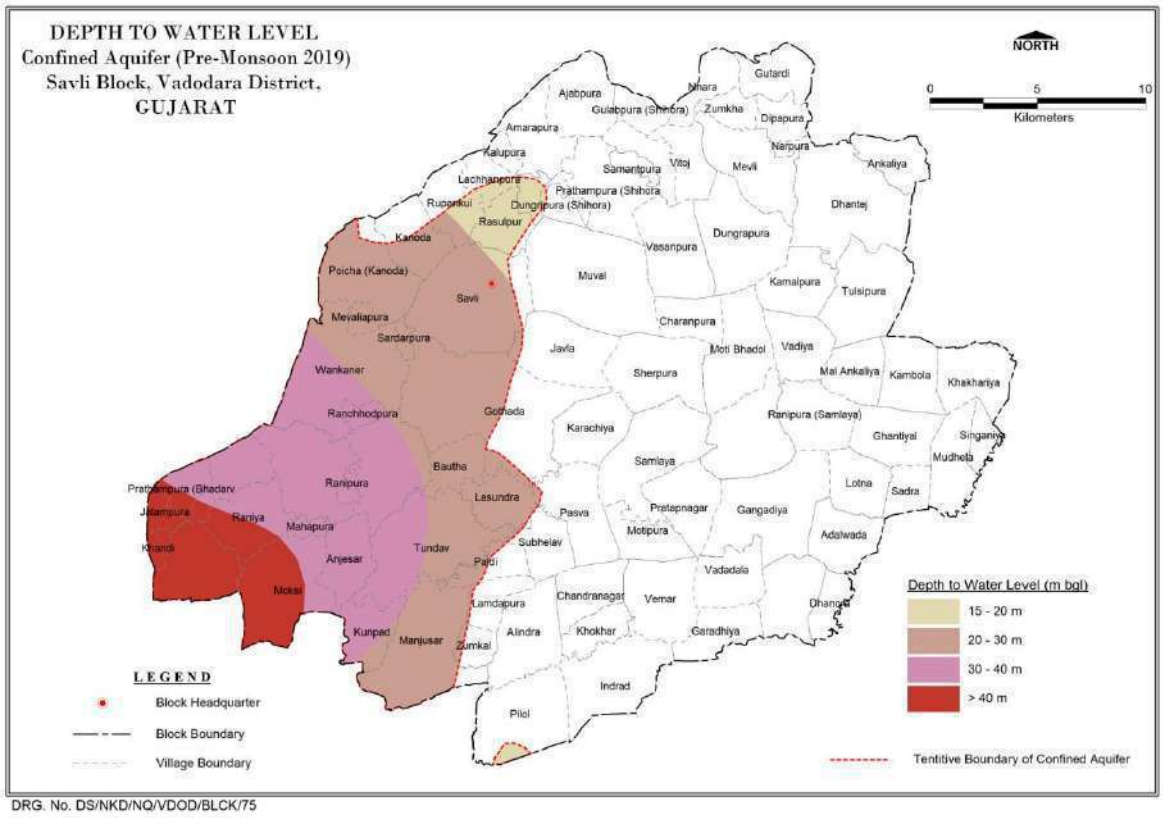
Aquifer Management plan

Groundwater Management Issues

- After commencement of Narmada Canal based irrigation, little rising trend is observed in long term water level analysis (last 10 years) of Phreatic Aquifer.
- Feeble declining trend is observed in long term water level analysis of Confined Aquifer I.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.



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



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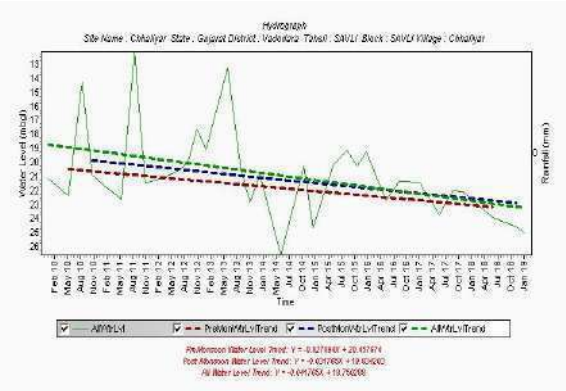


Groundwater Management Plan

- **Ground water development plan**

  The stage of ground water extraction of Savli taluka is 55.35 %.To elevate the stage of ground water development to 65% in Savli block, 400 no of Dug wells (20 m depth) and 296 no Tube wells (70m depth) are proposed as feasible extraction structures.The extraction structures will result in additional ground water draft of 988 ham which will create 1976 Ha additional irrigation potential for the Savli Block.

- **Supply side Management Plan**

  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 2.76 MCM of surplus surface water is provisioned for artificial recharge through 78 no of recharge shafts and 15 no of existing defunct tube wells which can be used as injection wells in Savli taluka

of Vadodara district .Ground water recharge of 279.00 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 3835.00 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 562 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.501 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in taluka .Ground water recharge of 482.3 ham (through on farm activities and GW return flow) is expected for the taluka.441.02 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 65 % in the Savli Block. Projected stage of Ground Water development after additional conservation activities is 56.57 % in the Savli Block.

Aquifer Information and Management plan of for Sinor Block of Vadodara District, Gujarat state.

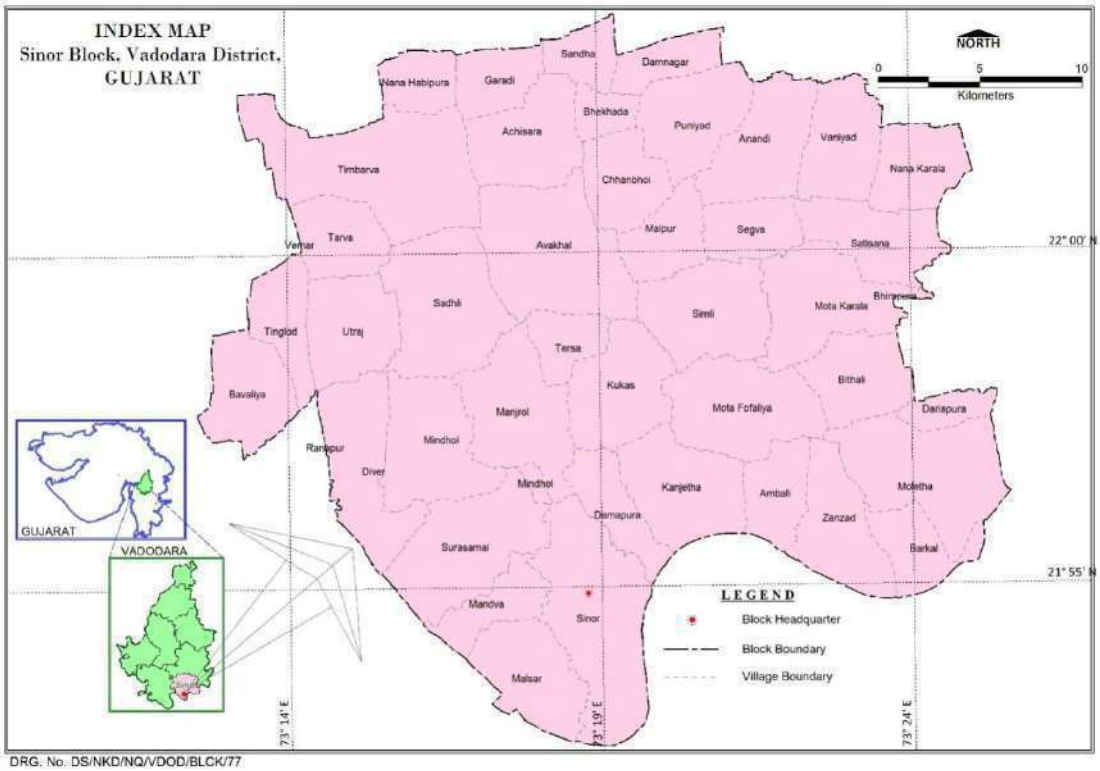
General Information

State Name: Gujarat

District name : Vadodara

Block name : Sinor

Location



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

Salient Features		
Area (Km^2):		292.5
No of Talukas		1
No. of Villages:		41
Population:		69,094
Density of Population/Km^2:		236.21
Net Sown Area in ha		13878
Gross Sown Area in ha		23237
Gross Irrigated Area in ha		21637
Area Irrigated by GW (%):		79
Cropping Intensity (%):		167.44
Irrigation Intensity (%):		83
Principal crops	Kharif:	Paddy,Tobacco,Bajra,Banana,Castor,Vegetables,Cotton & Pigeon pea
	Rabi:	Wheat,Potato,Tobacco,Mustard,Vegetables,Gram & Forage
	Summer:	Bajra, Paddy,Vegetables,Green Gram & Ground nut

Geographical Area :292.50 sq. km.

Basin/Sub-basin : Major Drainages: Narmada

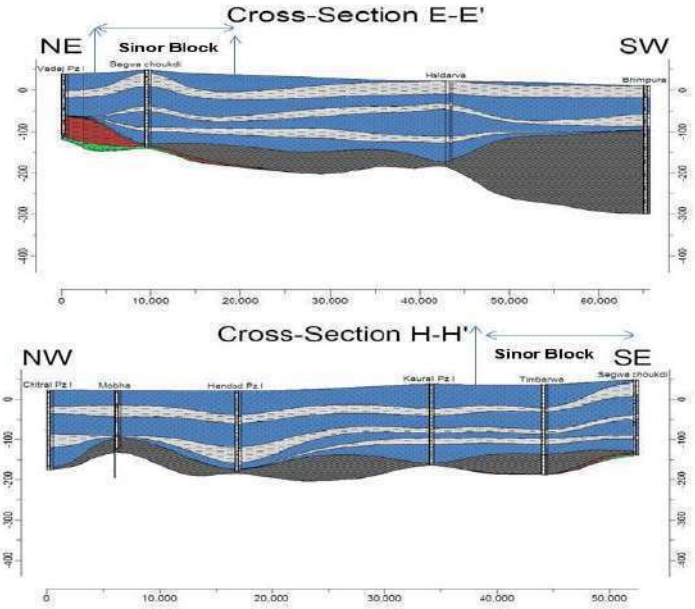
Principal Aquifer System : Quaternary Alluvium

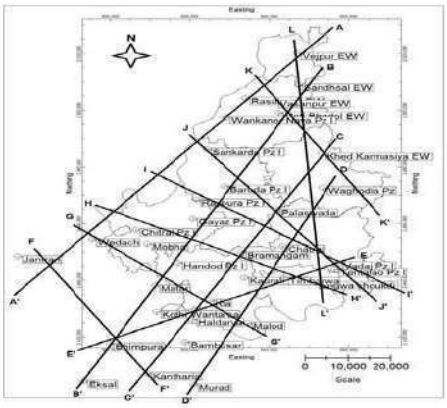
Major Aquifer System : Alluvium and Fluvial marine sediments.

Normal Annual Rainfall :769 mm

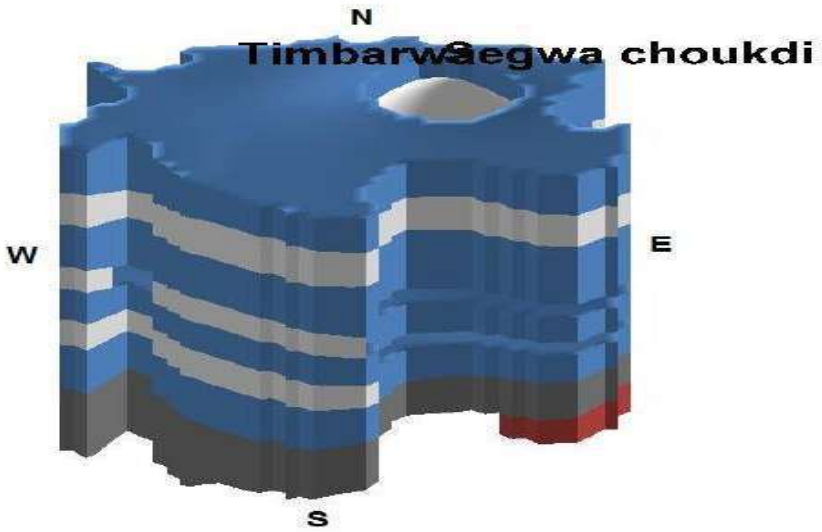
Aquifer Disposition

- Unconfined Aquifer Depth of occurrence 0 to 60 mbgl.
- Confined Aquifer I depth of occurrence 70 to 114 mbgl.
- Confined Aquifer II depth of occurrence 124 to 135 mbgl.
- Confined Aquifer III depth of occurrence 150 to 174 mbgl.





Sinor Block 3D Aquifer Disposition



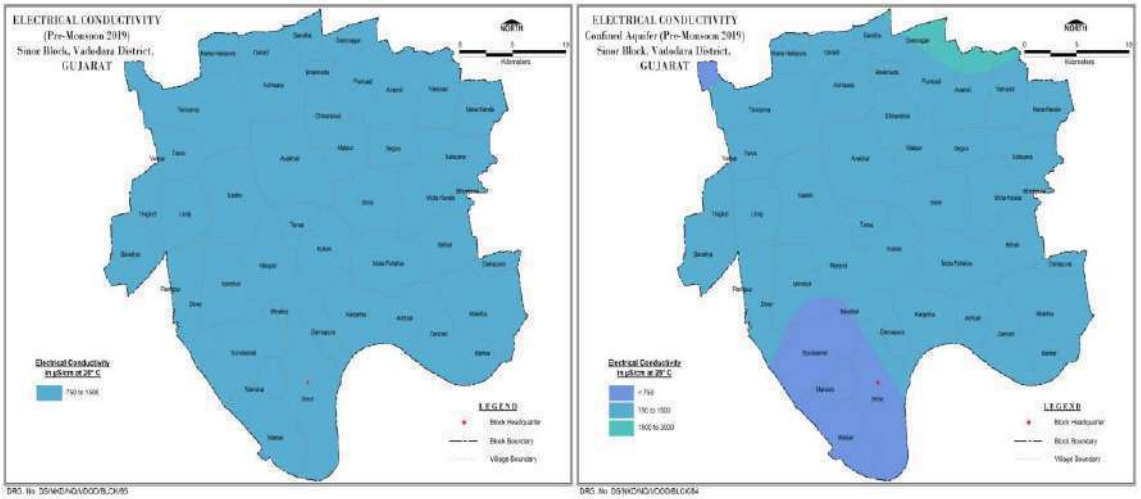
Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence	Thickness	Water Level (mbgl)	Quality (TDS)	Discharge	Transmissivity	Nature of Aquifer	Remarks
			Aquifer	Range	Range	Range	Range	Range		
			(mbgl)	(m)	(mbgl)	Mg/l	lps	m2/day		
Quaternary	Alluvium	Unconfined Aquifer	0 to 60	35 to 60	3 to 38	470 to 650	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from 730 µS/cm to 970 µS/cm in the Sinor Taluka.
		Confined Aquifer I	70 to 114	10 to 30	5 to 50		1.2 to 60	38 to 2665	Confined	
		Confined Aquifer II	124 to 135	10 to 15	18 to 37		4 to 20	602 to2616	Confined	
Tertiary	Alluvium	Confined Aquifer III	150 to 174	25 to 30	24 to 37		6 to 34	2616 to 4622	Confined	Ground water having more than 3000µS/cm is observed in areas where tertiary formation is at depth.

Groundwater Monitoring Status

CGWB- Dug wells : 01, Piezometers :02
GWRDC- Dug wells : 01, Piezometers :03

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 730 to 970 micromhos/cm at 25°c, for the Sinor taluka.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.



Summarised Chemical Data of Sinor taluka of Vadodara District.														
Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	8.50	730.00	150.00	470.00	12.00	146.40	72.00	0.00	0.88	35.00	15.00	45.00	2.21	0.40
Max	8.80	970.00	375.00	650.00	24.00	280.60	200.00	107.00	5.85	100.00	39.00	131.00	9.65	0.65
Average	8.60	882.50	259.50	575.00	18.00	222.65	148.00	26.75	3.75	61.25	25.50	89.50	5.56	0.47

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

Groundwater Resource

- GW Availability 9327.22ham (Dynamic)
- GW Draft 5493.44 ham
- Stage of GW Development 58.90 %
- Total Ground Water resource including both dynamic & in storage for district is 62562.22 ham. (Dynamic:9327.22 ham & In storage: 53235 ham)

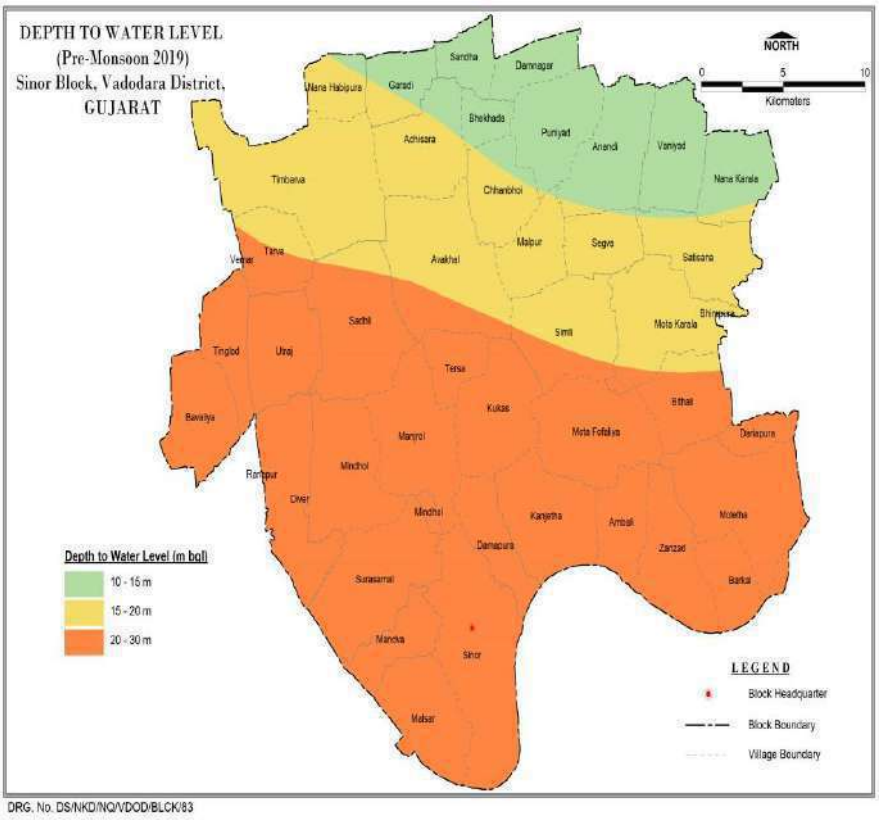
Existing and Future Water Demand

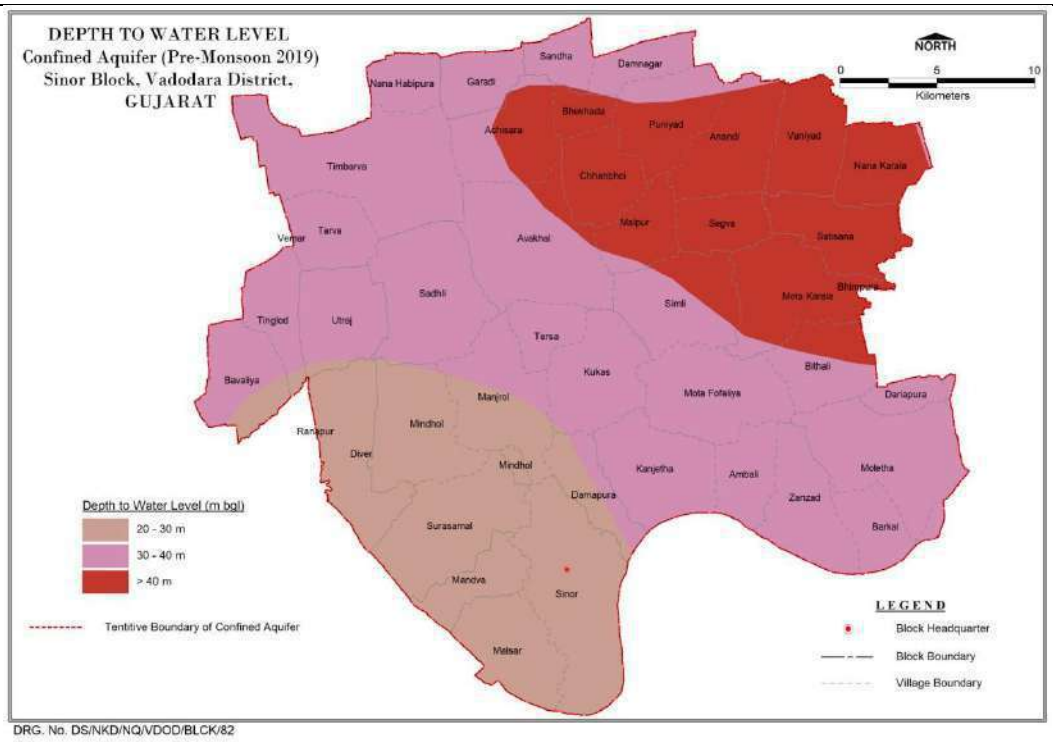
- Present demand for All Usage: 5493.44 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 120.00 ham.
- Net Ground Water availability for future use is 3805.11 ham.

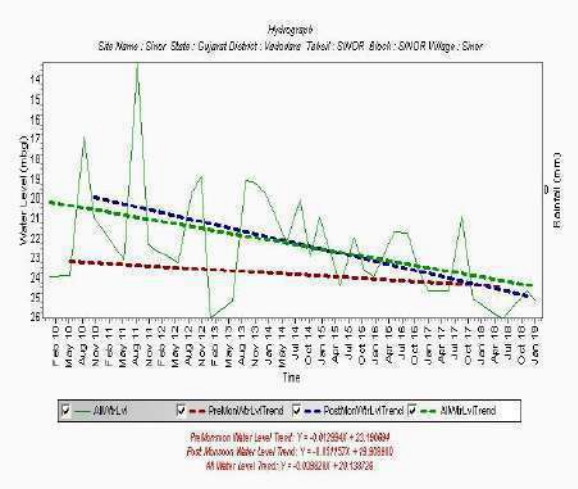
Aquifer Management plan

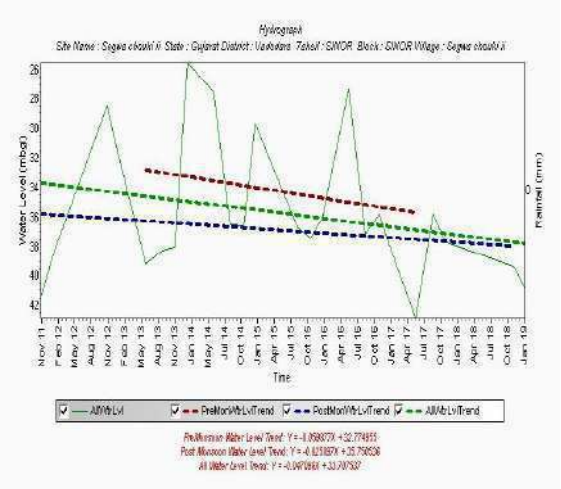
Groundwater Management Issues

- After commencement of Narmada Canal based irrigation, little rising trend is observed in long term water level analysis (last 10 years) of Phreatic Aquifer.
- Feeble declining trend is observed in long term water level analysis of Confined Aquifer I.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.









Groundwater Management Plan

- **Ground water development plan**

  The stage of ground water extraction of Sinor taluka is 58.90 %.To elevate the stage of ground water extraction to 65% in Sinor taluka, 203 no Tube wells (60 to 70 m depth) in alluvium area are proposed as feasible extraction structures. The extraction structures will result in additional ground water draft of 609.00 ham which will create 1218 Ha additional irrigation potential for the taluka.

- **Supply side Management Plan**

  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 1.42 MCM of surplus surface water is provisioned for artificial recharge through 40 no of recharge shafts and 08 no of existing defunct tube wells which can be used as injection wells in Sinor taluka

of Vadodara district .Ground water recharge of 144.00 ham (through recharge shafts and defunct tube wells) is expected for the taluka.

- **Demand side management Plan**

  To prevent Over Exploitation water conservation activities 623 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.837 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in taluka .Ground water recharge of 204.9 ham (GW return flow) is expected for the taluka.318.6 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 65 % in the Sinor Block. Projected stage of Ground Water development after additional conservation activities is 60 % in the Sinor Block.

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

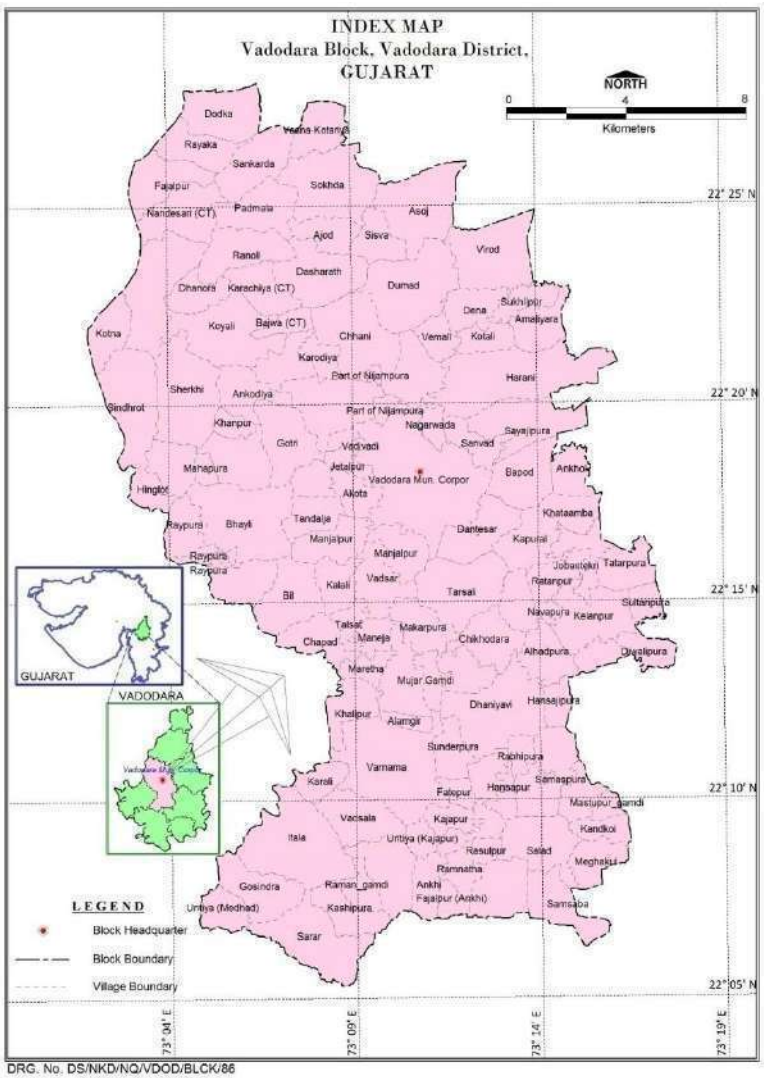
General Information

State Name : Gujarat

District name : Vadodara

Block name : Vadodara

Location



Salient Features	
Area (Km^2):	670
No of Talukas	1
No. of Villages:	82
Population:	2,71,670
Density of Population/Km^2:	405.47
Net Sown Area in ha	36595
Gross Sown Area in ha	52488
Gross Irrigated Area in ha	43798
Area Irrigated by GW (%):	41.27
Cropping Intensity (%):	143.43

Irrigation Intensity (%):		57
Principal crops	Kharif:	Paddy,Tobacco,Bajra,Banana,Castor,Vegetables,Cotton & Pigeon pea
	Rabi:	Wheat,Potato,Tobacco,Mustard,Vegetables,Gram & Forage
	Summer:	Bajra, Paddy,Vegetables,Green Gram & Ground nut

Geographical Area : 670.00 sq. km.

Basin/Sub-basin : Major Drainages: Mahi & Tributaries of Mahi (Vishwamitri)

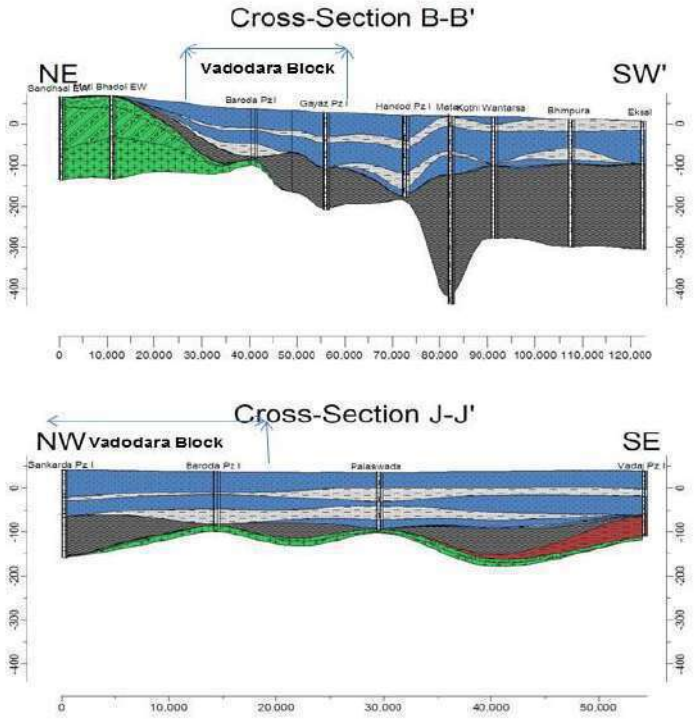
Principal Aquifer System : Alluvium

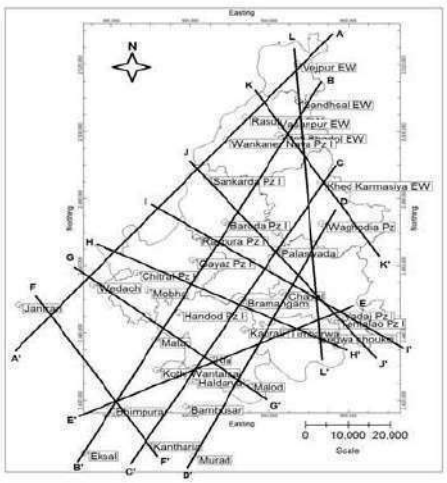
Major Aquifer System : Alluvium and Fluvial marine sediments.

Normal Annual Rainfall : 1039 mm

Aquifer Disposition

- Unconfined Aquifer Depth of occurrence 0 to 46 mbgl.
- Confined Aquifer I depth of occurrence 60 to 100 mbgl.
- Confined Aquifer II depth of occurrence 115 to 130 mbgl.





Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	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
Quaternary	Alluvium	Unconfined Aquifer	0 to 46	35 to 60	3 to 38	550 to 2830	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from less than 760 µS/cm to more than 8790 µS/cm in the Vadodara taluka.
		Confined Aquifer I	60 to 100	10 to 30	5 to 50	520 to 5630	1.2 to 60	38 to 2665	Confined	
		Confined Aquifer II	115 to 130	10 to 20	18 to 37		4 to 20	602 to2616	Confined	

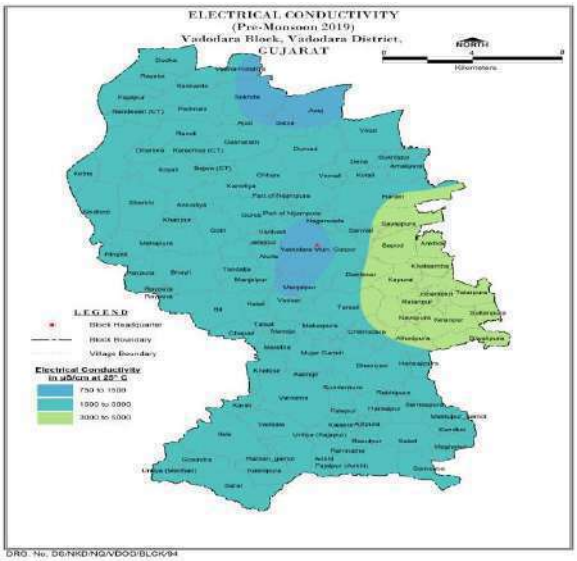
Groundwater Monitoring Status

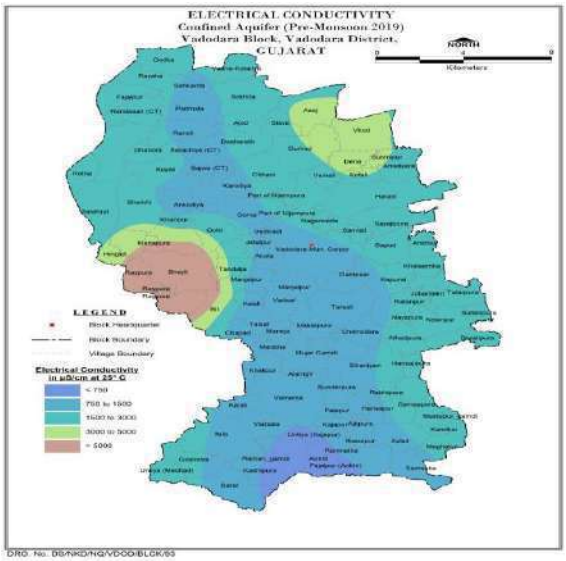
CGWB- Dug wells : 05, Piezometers :04

GWRDC- Dug wells : 05, Piezometers :09

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 760 to 8790 micromhos/cm at 25°c, for the Vadodara taluka.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Groundwater having TDS more than 4000 ppm, and Nitrate >66 ppm is observed in localised pockets due to rapid urbanization, industrial growth nearby the Vadodara city may leads to increase in the ground water pollution level.
- Due to uncontrolled chemical wastes dumping nearby the industries, industrial effluent mixed with sewage and runoff water has arguably turned the local river Vishwamitri into big sewer, which ultimately leads to contaminate the ground water after leaching.





Summarised Chemical Data of Vadodara taluka of Vadodara District.														
Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	7.60	760.00	175.00	520.00	0.00	183.00	104.00	0.00	1.12	25.00	18.00	70.00	2.25	0.13
Max	8.90	8790.00	1875.00	5630.00	36.00	1220.00	1600.00	1030.00	66.00	325.00	255.00	1156.00	28.98	1.41
Average	8.20	2459.00	426.40	1582.73	9.60	400.99	487.00	168.47	8.73	88.47	49.27	363.13	8.05	0.86
* All values are in mg/l except pH and EC in µS/cm at 25°C														

Groundwater Resource

- GW Availability 15536.36 ham (Dynamic)
- GW Draft 12136.00 ham
- Stage of GW Development 78.11%
- Total Ground Water resource including both dynamic & in storage for taluka is 151211.36 ham. (Dynamic:15536.36ham & In storage: 135675 ham)

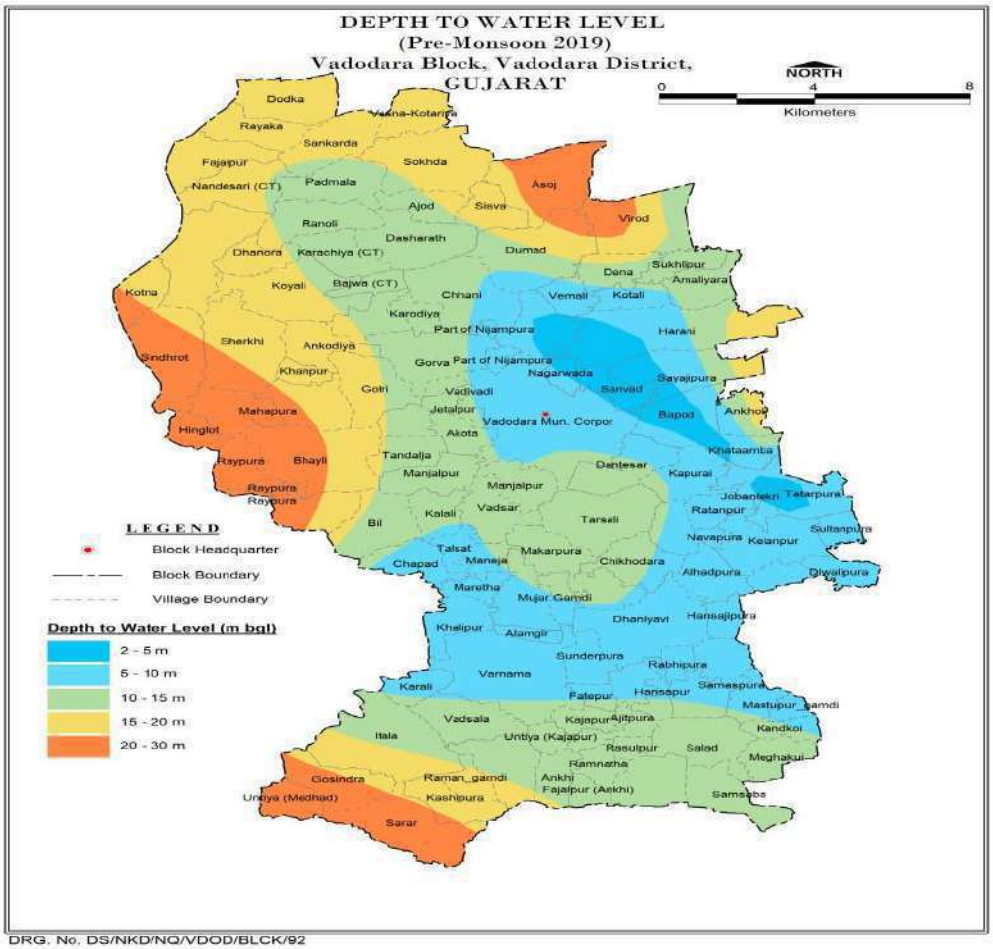
Existing and Future Water Demand

- Present demand for All Usage: 12136.00 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 343.00 ham.
- Net Ground Water availability for future use is 4378.36 ham.

Aquifer Management plan

Groundwater Management Issues

- The long term groundwater regime monitoring studies through NHS reveal an overall declining trend in major parts of the Vadodara taluka. The decline in range is 0.002 to 0.15 m /year.
- But in some areas after commencement of Narmada Canal based irrigation, little rising trend is observed in long term water level analysis (last 10 years) of both Phreatic and Confined Aquifers.
- Groundwater having TDS more than 4000 ppm, and Nitrate >66 ppm is observed in localised pockets due to rapid urbanization, industrial growth nearby the Vadodara city may leads to increase in the ground water pollution level.



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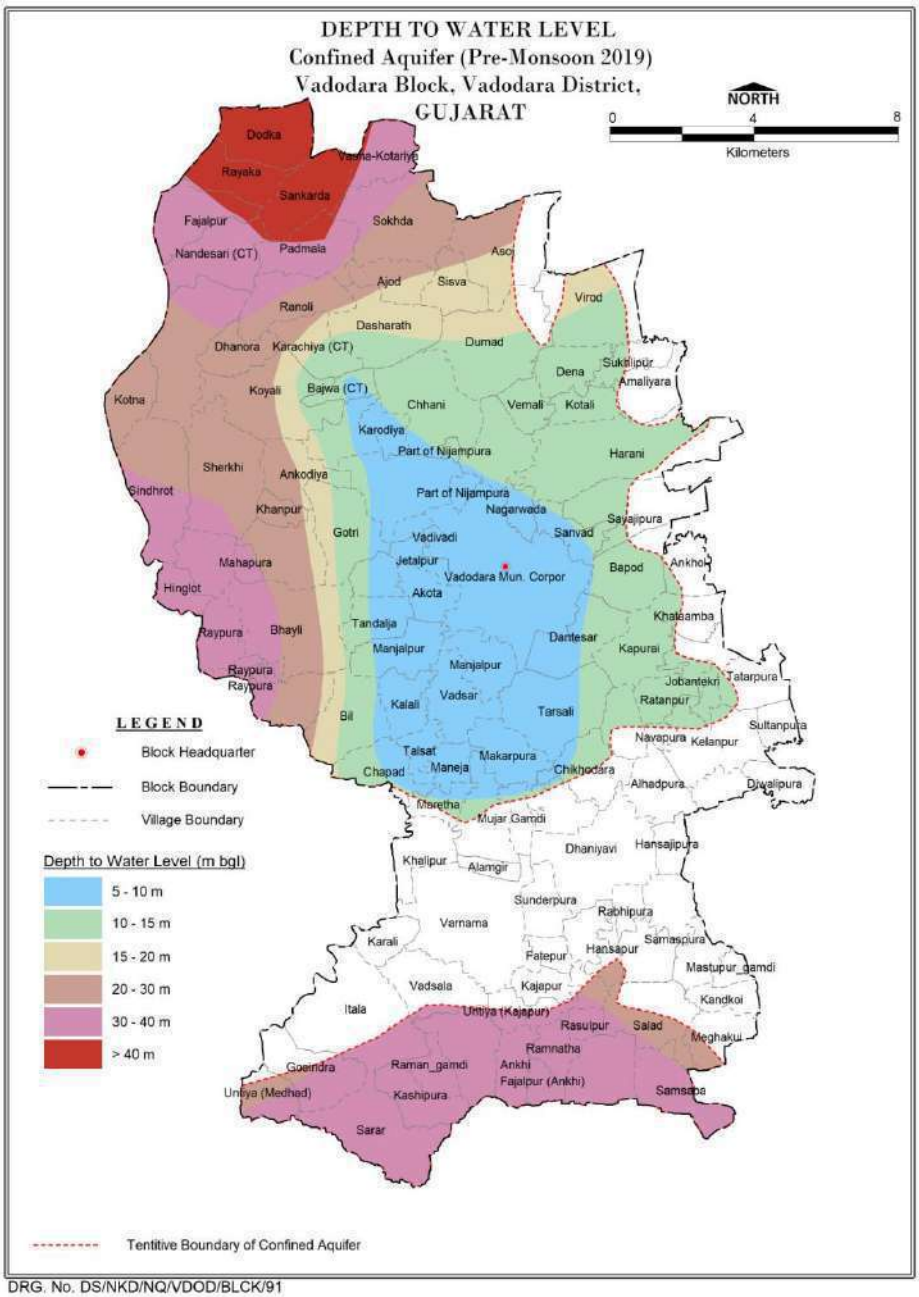

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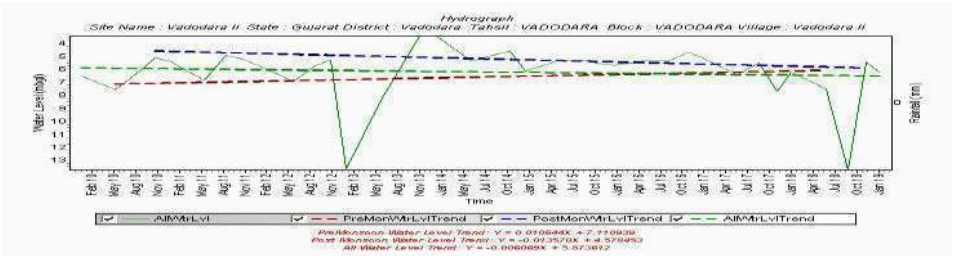
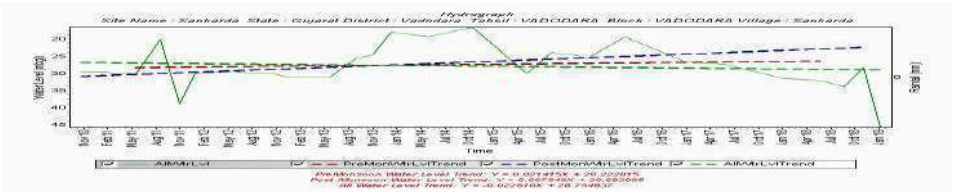




Groundwater Management Plan

- **Supply side Management Plan**
  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 3.27 MCM of surplus surface water is provisioned for artificial recharge through 92 no of recharge shafts and 17 no of existing defunct tube wells which can be used as injection wells in Vadodara taluka of Vadodara district .Ground water recharge of 105.20 ham (through recharge shafts and defunct tube wells) is expected for the taluka.
- **Demand side management Plan**
  944 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 1070 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.3830 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in Vadodara taluka.Ground water recharge of 94.4 ham (through on farm activities and GW return flow) is expected for the Vadodara taluka.953.21 ham saving of ground water through WUE measures & farm ponds activities is expected for the Vadodara taluka.
- **Outcome**
  Projected stage of Ground Water development after additional conservation activities is 70 % (Safe category) in the Vadodara Block.

Aquifer Information and Management plan of for Vaghodia Block of Vadodara District, Gujarat state.

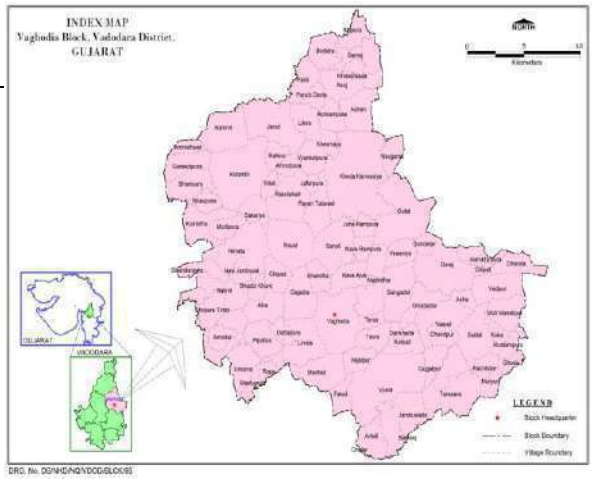
General Information

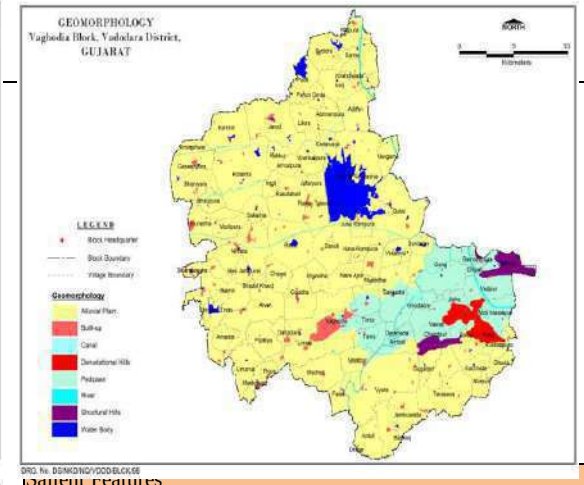
State Name : Gujarat

District name : Vadodara

Block name : Vaghodia

Location





Salient Features		
Area (Km^2):		565.5
No of Talukas		1
No. of Villages:		96
Population:		1,33,240
Density of Population/Km^2:		235.61
Net Sown Area in ha		40861
Gross Sown Area in ha		44564
Gross Irrigated Area in ha		14924
Area Irrigated by GW (%):		6.71
Cropping Intensity (%):		109.06
Irrigation Intensity (%):		27.63
Principal crops	Kharif:	Paddy,Tobacco,Bajra,Banana,Castor,Vegetables,Cotton & Pigeon pea
	Rabi:	Wheat,Potato,Tobacco,Mustard,Vegetables,Gram & Forage
	Summer:	Bajra, Paddy,Vegetables,Green Gram & Ground nut

Geographical Area : 565.50 sq. km.

Basin/Sub-basin : Major Drainages: Vishwamitri and Dev.

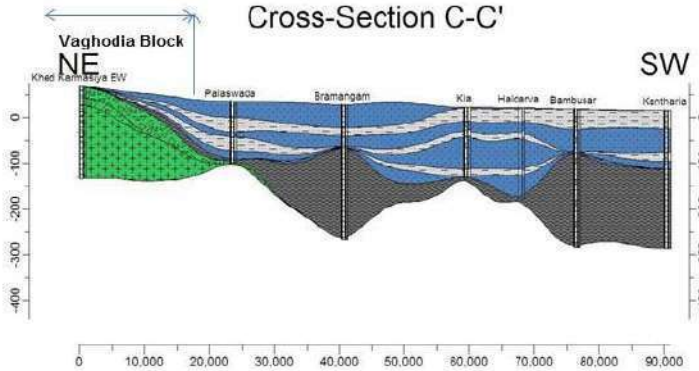
Principal Aquifer System : Alluvium and Basalt.

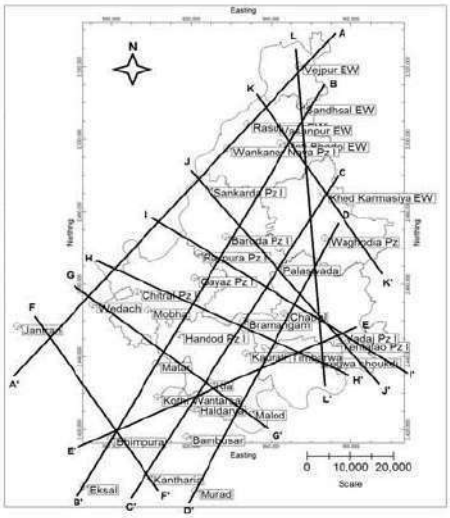
Major Aquifer System : Deccan traps basalt, alluvium and Fluvial marine sediments.

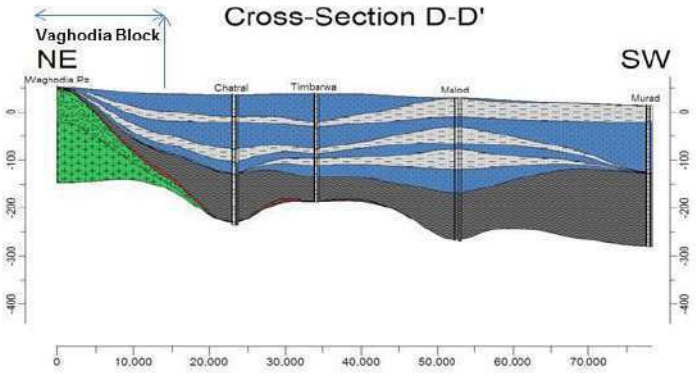
Normal Annual Rainfall :739 mm

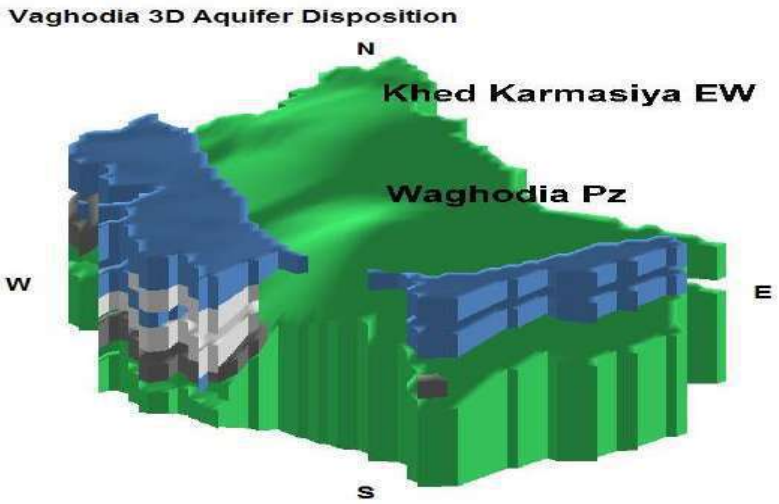
Aquifer Disposition

- Weathered aquifer depth of occurrence 0 to 20 mbgl.
- Fractured Aquifer depth of occurrence 35 to 70 mbgl.
- Phreatic aquifer depth of occurrence 0 to 45 mbgl.
- Confined Aquifer I depth of occurrence 60 to 112 mbgl.
- Confine Aquifer II depth of occurrence 140 to 165 mbgl.









Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence	Thickness	Water Level (mbgl)	Quality (TDS)	Discharge	Transmissivity	Nature of Aquifer	Remarks
			Aquifer	Range	Range	Range	Range	Range		
			(mbgl)	(m)	(mbgl)	Mg/l	lps	m2/day		
Quaternary	Alluvium	Unconfined Aquifer	0 to 45	25to 40	3 to 38	530 to 2890	2 to 50	1.67 to 1067	Phreatic	E.C of ground water varies from less than 830µS/cm to more than 4460 µS/cm in the Vaghodia taluka
		Confined Aquifer I	60to 112	10 to 30	5 to 50		1.2 to 60	38 to 2665	Confined	
		Confined Aquifer II	140 to 165	10 to 20	18 to 37		4 to 20	602 to2616	Confined	
Upper Cretaceous to Lower Eocene	Basalt	Weathered Basalt	0 to 20	0 to 20	3 to 17				Phreatic	
	Basalt	Fractured Basalt	35 to 70		9 to 14		0.2 to 7		Fractured	

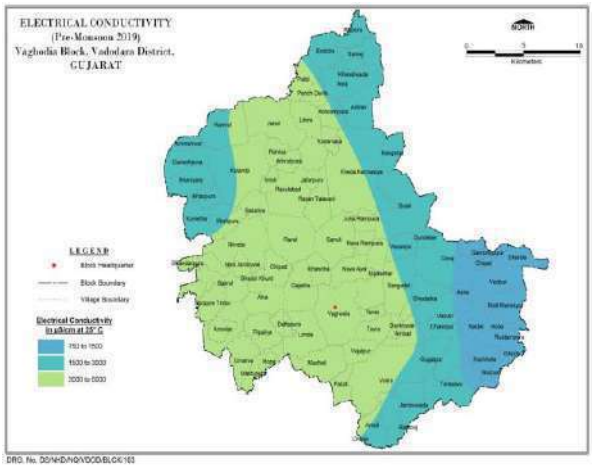
Groundwater Monitoring Status

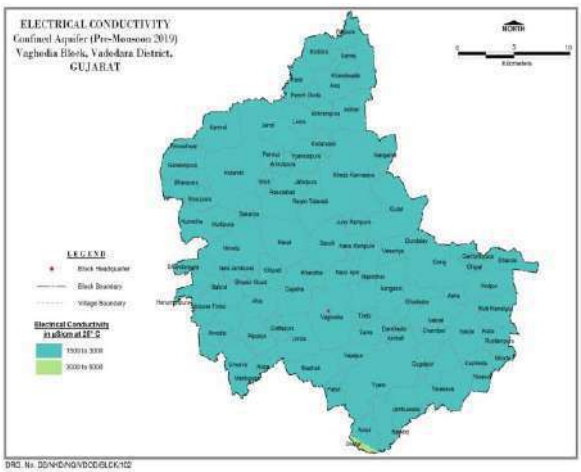
CGWB- Dug wells : 04, Piezometers :00

GWRDC- Dug wells : 05, Piezometers :03

Groundwater Quality

- The Electrical conductance of ground water is generally ranges from 830 to 4460 micromhos/cm at 25°c, for the Vaghodia taluka.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Occurrence of excessive Fluoride in Shallow aquifers at isolated villages.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.





Summarised Chemical Data of Vaghodiya taluka of Vadodara District.														
Chemical Parameters	pH	EC	TH	TDS	CO3	HCO3	Cl	SO4	NO3	Ca	Mg	Na	K	F
Min	7.2	830	188	530	0	195.2	160	0	0.66	15	27	104	1.58	0.2
Max	8.9	4460	3363	2890	36	927	1184	3020	6.23	615	438	2539	350.25	1.66
Average	8.4	2621.9	876.875	1742.5	18.0	506.3	482.0	587.3	2.8	148.1	121.5	613.375	50.28375	0.95875

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

Groundwater Resource

- GW Availability 11347.61 ham (Dynamic)
- GW Draft 1935.14 ham
- Stage of GW Development 17.05 %
- Total Ground Water resource including both dynamic & in storage for Vaghodia is 31185.61 ham. (Dynamic:11347.61ham & In storage: 19838 ham)

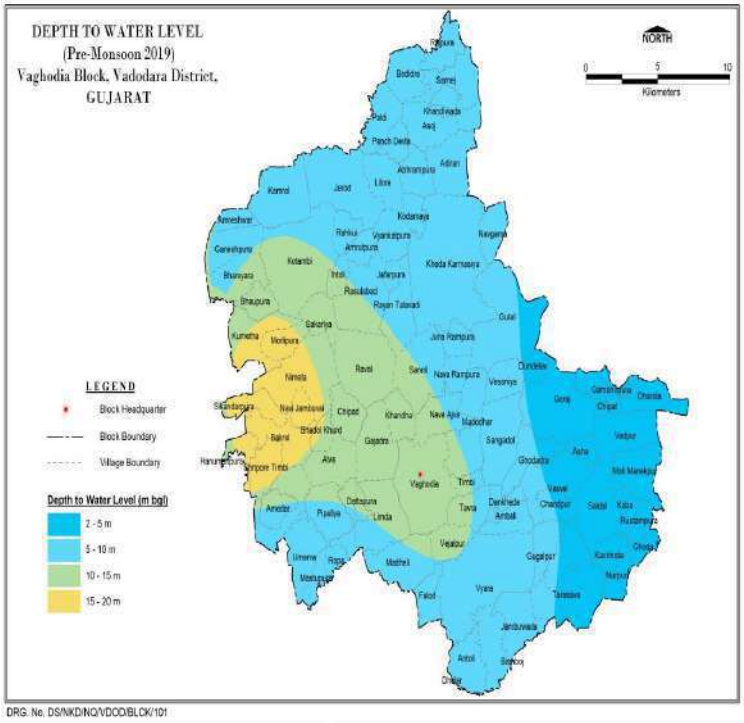
Existing and Future Water Demand

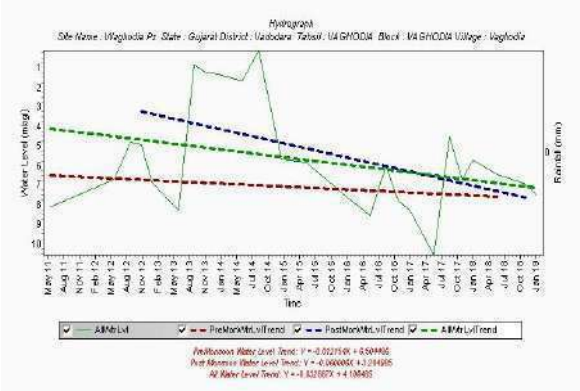
- Present demand for All Usage: 1935.14 ham.
- Annual Ground Water allocation for Domestic use as on 2025 is 276.00 ham.
- Net Ground Water availability for future use is 9345.69 ham.

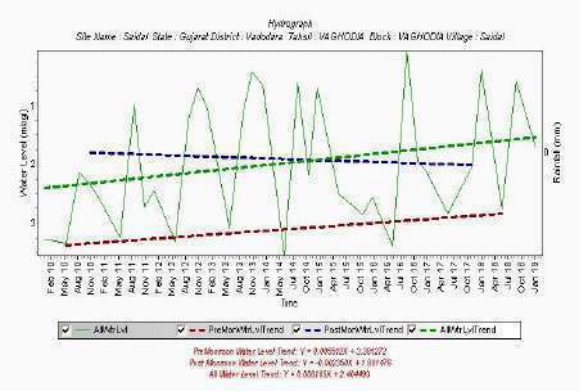
Aquifer Management plan

Groundwater Management Issues

- After commencement of Narmada Canal based irrigation, little rising trend is observed in long term water level analysis (last 10 years) of Phreatic Aquifer.
- Feeble declining trend is observed in long term water level analysis of Confined Aquifer I.
- Groundwater having more than 3000 µs / cm is observed in localised villages' where Tertiary formation is at depth.







Groundwater Management Plan

- **Ground water development plan**

  The stage of ground water extraction of Vaghodia taluka is 17.05 %.To elevate the stage of ground water development to 65% in Vaghodia block,3400 no of Dug wells (20 m depth) and 614 no Tube wells (70m depth) are proposed as feasible extraction structures.The extraction structures will result in additional ground water draft of 5821.00 ham which will create 11642.00Ha additional irrigation potential for the Vaghodia Block.

- **Supply side Management Plan**

  As per Masterplan 2020 for Artificial Recharge to Ground Water in Gujarat state, 2.76 MCM of surplus surface water is provisioned for artificial recharge through 77 no of recharge shafts and 15 no of existing defunct tube wells which can be used as injection wells in Vaghodia taluka of Vadodara district .Ground water recharge of 276.00 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 100.00 Ha area is proposed for on farm activities (Laser levelling/Bench terracing/Contour banding) and 1210 no of farm ponds are recommended which will serve dual purpose of irrigation and recharge to ground water.178 Ha area is proposed for Micro irrigation system (Sprinkler/drip) in taluka .Ground water recharge of 592.1 ham (through on farm activities and GW return flow) is expected for the taluka.406.59 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 65 % in the Vaghodia Block. Projected stage of Ground Water development after additional conservation activities is 60.16 % in the Vaghodia Block.

Aquifer Information and Management plan of for Vadodara City of Vadodara District, Gujarat state.

General Information

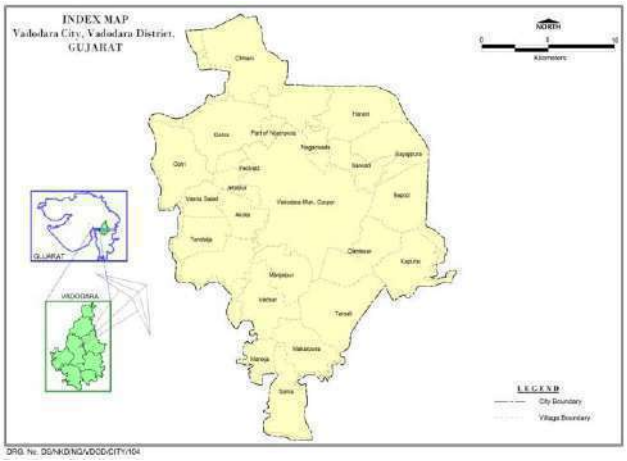
State Name : Gujarat

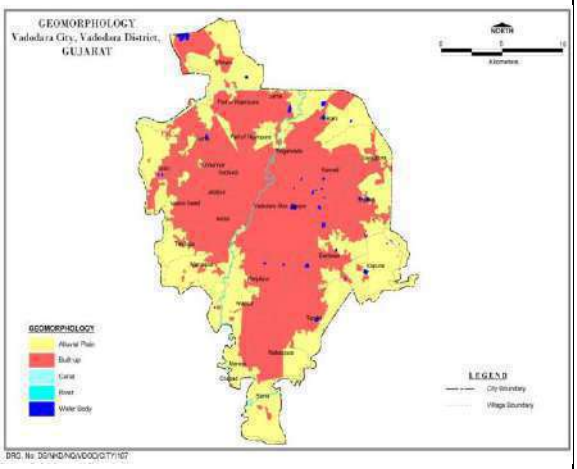
District name : Vadodara

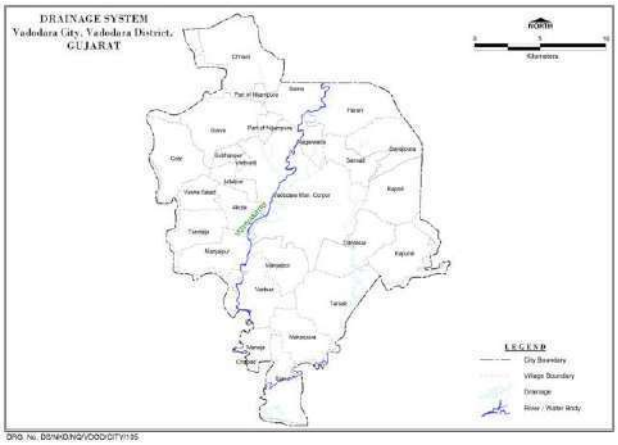
Block name : Vadodara

City Name : Vadodara

Location







Salient Features of Vadodara City	
Area (Km^2):	156.6
Population (Census 2011)	20,65,771
Density of Population/Km^2:	13191
Urban House hold Number (Census 2011)	4,59,509
Altitude(MASL)	35.5
Present Scenario of Water Supply Scheme of Vadodara City (Source Vadodara Municipal Corporation)	
Ajwa/Nimeta (Dam)	145 MLD
Radial Collector Well	250 MLD
Tube Wells (46 tube wells in City and 23 tube wells in River mahi)	25 MLD
Khanpur	37 MLD
Total	457 MLD
Per Capita supply	210 lpcd

Geographical Area : 156.6 sq. km.

Basin/Sub-basin : Major Drainages: Mahi & Tributaries of Mahi (Vishwamitri)

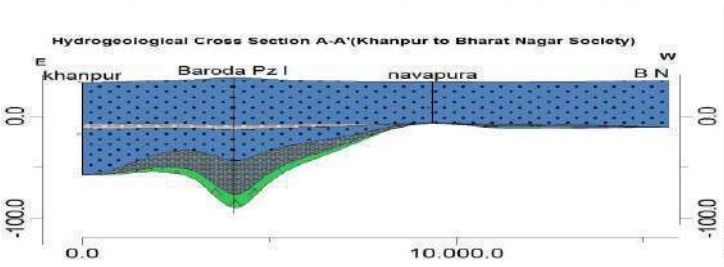
Principal Aquifer System : Quaternary Alluvium

Major Aquifer System : Alluvium and Fluvial marine sediments.

Normal Annual Rainfall : 845 mm

Aquifer Disposition

- Unconfined Aquifer Depth of occurrence 0 to 40 mbgl.
- Confined Aquifer I depth of occurrence 51 to 83 mbgl.


Hydrogeological Cross Section A-A'(Khanpur to Bharat Nagar Society)
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W
khanpur
Baroda Pz I
navapura
B N
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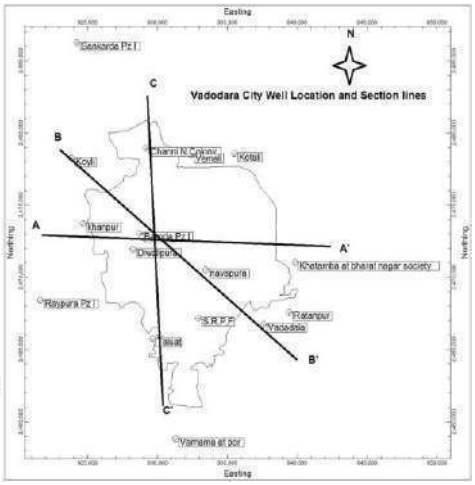
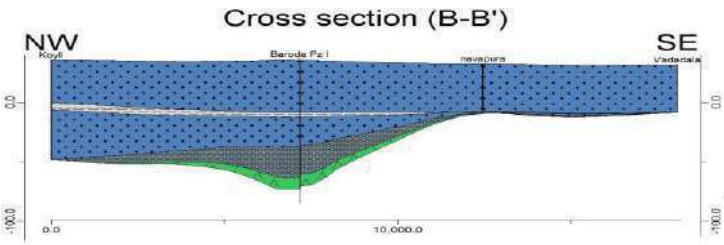

Vadodara City Well Location and Section lines
N
A
A'
B
B'
C
C'
Khanpur
Navapura
Varnama at por


Cross section (B-B')
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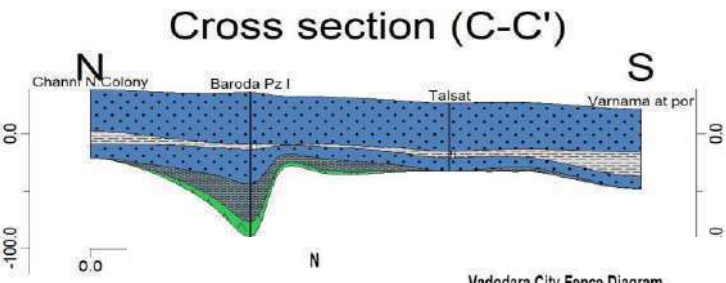
Cross section (C-C')
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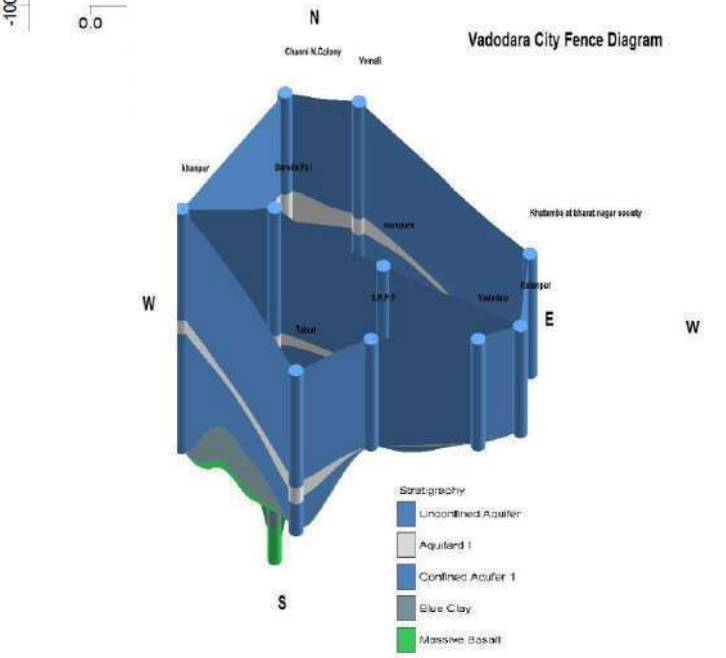
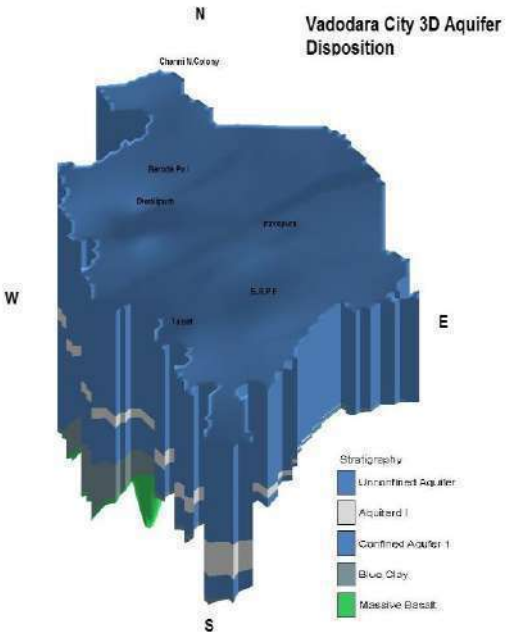
Stratigraphy
Unconfined Aquifer
Aquitard I
Confined Aqufer 1
Blue Clay
Massive Basalt


Vadodara City Fence Diagram
N
W
E
S
Stratigraphy
Unconfined Aquifer
Aquitard I
Confined Aqufer 1
Blue Clay
Massive Basalt


Vadodara City 3D Aquifer Disposition
N
W
E
S
Stratigraphy
Unconfined Aquifer
Aquitard I
Confined Aqufer 1
Blue Clay
Massive Basalt

Aquifer Characterisation and Disposition										
Stratigraphy	Formation	Aquifer Nomenclature	Depth of occurrence	Thickness	Water Level (mbgl)	Quality (TDS)	Discharge	Transmissivity	Nature of Aquifer	Remarks
			Aquifer	Range	Range	Range	Range	Range		
			(mbgl)	(m)	(mbgl)	Mg/l	lps	m2/day		
Quaternary	Alluvium	Unconfined Aquifer	0 to 40	35 to 40	5 to 28	392 to 4490	2 to 50	1.67 to 1067	Phreatic	Ground water TDS varies from 392 to 4490 in the Vadodara City.
		Confined Aquifer I	51 to 83	10 to 20	5 to 35	360 to 5370	1.2 to 60	38 to 2665	Confined	

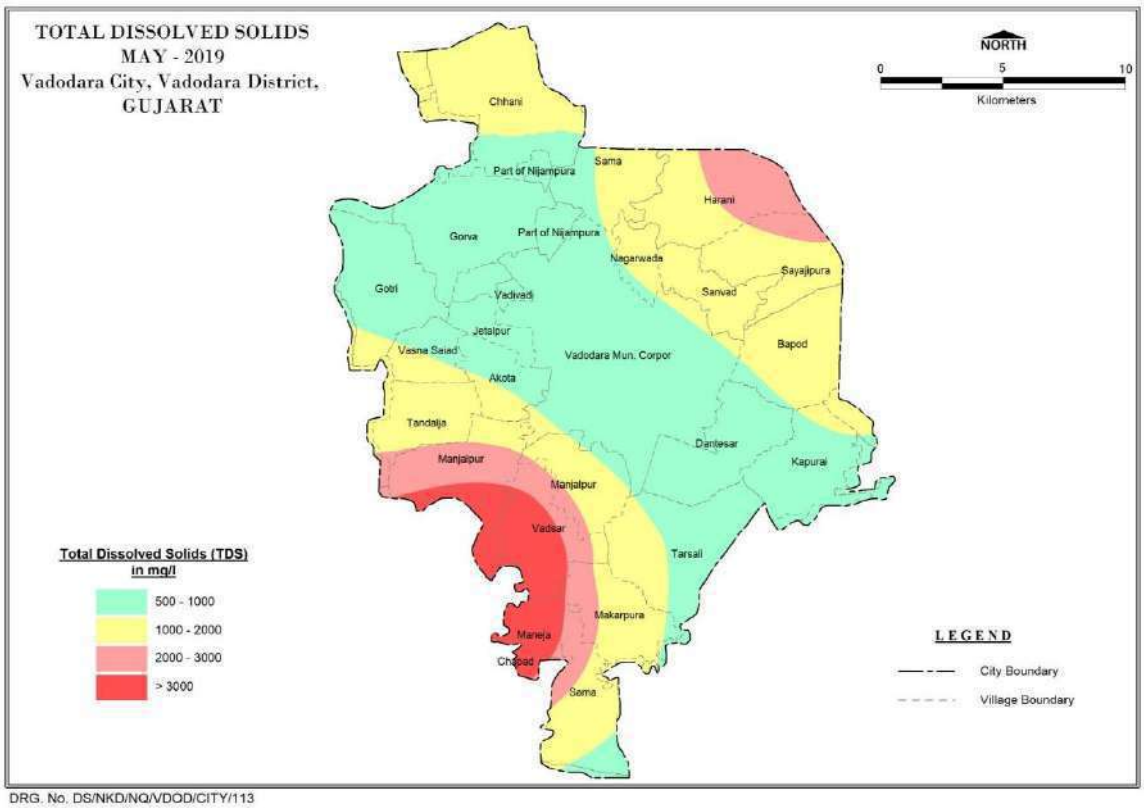
Groundwater Monitoring Status

CGWB- Dug wells : 03, Piezometers :02

GWRDC- Dug wells : 02, Piezometers :02

Groundwater Quality

- The TDS of ground water is generally ranges from 392 to 4490 ppm for the Vadodara City.
- Phreatic and confined Aquifers: Potable and fit for domestic, drinking, irrigation and other industrial purposes.
- Groundwater having TDS more than 4000 ppm, Nitrate >90 ppm and Fluoride having more than 2.1 ppm is observed in localised pockets due to rapid urbanization, industrial growth nearby the Vadodara city may leads to increase in the ground water pollution level.
- Due to uncontrolled chemical wastes dumping nearby the industries, industrial effluent mixed with sewage and runoff water has arguably turned the local river Vishwamitri into big sewer, which ultimately leads to contaminate the ground water after leaching.



Vadodara City Water Quality Data						
	Chemical Parameters					
	TDS	**Total Hard.**	**Cl**	**No3**	**F**	**Alk**
Min	392	104	68	0.8	0.22	208
Max	4490	976	2052	91.11	2.06	667
Average	1030	313	301	21	1	391

Groundwater Resource (City-Vadodara GWRE 2017)

- GW Availability 3487.00 ham (Dynamic)
- GW Draft 3181.00 ham
- Stage of GW Development 91.24 %

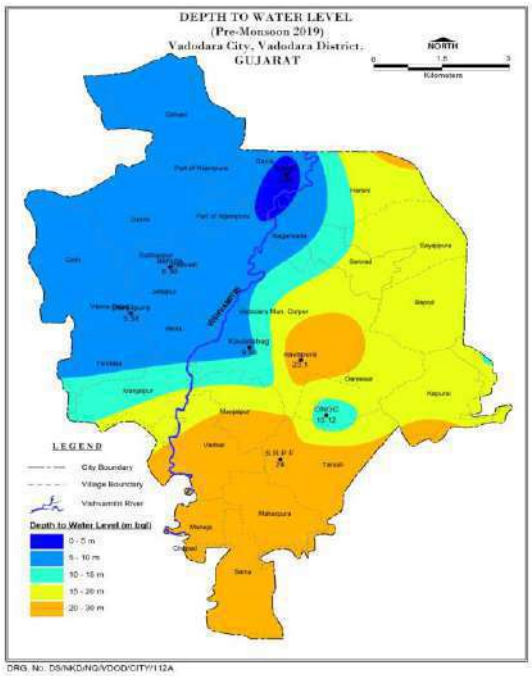
Existing and Future Water Demand (City-Vadodara GWRE 2017)

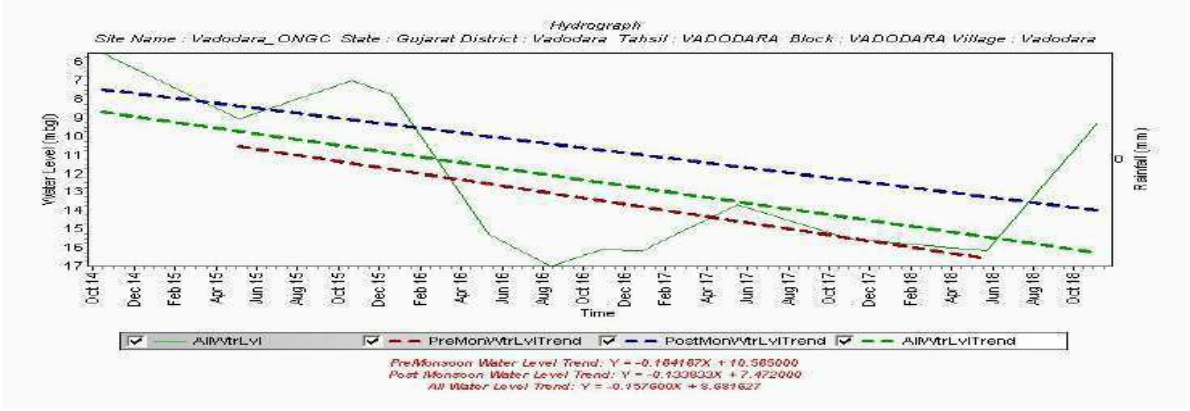
- Present demand for All Usage: 3181.00 ham.
- Projected demand for domestic and Industrial uses up to 2025 is 6699.00 ham.
- Net Ground Water availability for future use is 00.00 ham.

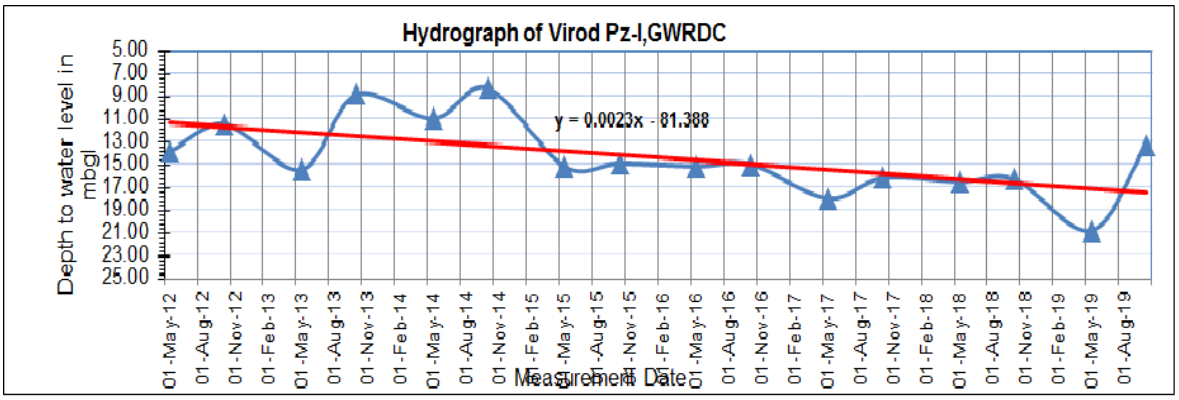
Aquifer Management plan

Groundwater Management Issues

- The long term groundwater regime monitoring studies through NHS reveal an overall declining trend in major parts of the Vadodara City. The decline in range is 0.002 to 0.15 m /year.
- Groundwater having TDS more than 4000 ppm, Nitrate >90 ppm and Fluoride having more than 2.1 ppm is observed in localised pockets due to rapid urbanization, industrial growth nearby the Vadodara city may leads to increase in the ground water pollution level.







Groundwater Management Plan

There are about 20, 65,771 people resides in the Vadodara City urban area of the Vadodara district. There are about 4, 59,509 number urban households are present in Vadodara city and considering about 25% houses are suitable for harvesting and considering 40 sq. as typical house hold roof top area the total area available for harvesting (90% of total roof top) has been estimated to be 41,35,581 sq. m. The source water available for harvesting has been taken as 60% of normal rainfall in the Vadodara City urban centre after making allowance for storm rain etc., Thus, the total source water available for harvesting has been estimated as 2.10 MCM/yr. The Average cost of making the roof top harvesting arrangements for storing it at surface and recharging to ground water is @ Rs. 20,000/- per house. Thus, the cost of roof top harvesting for 1, 14,877 Number of houses of the Vadodara city is estimated as Rs. 229.75 crores.

AR & Conservation Possibilities

Ground water resources in the Vadodara City should be augmented by through Roof Top Rain Water Recharge structure and it would lead to saving 2.10 MCM of ground water and improve stage of ground water of Vadodara city from critical (91.24%) to Semi Critical category (86.05%).

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8. Narmada Water Resources, Water supply &Kalpsar Department, Govt. Of Gujarat, Gandhinagar.

And several other unpublished reports of CGWB and Govt websites**.**

Annexure 1 Vadodara Pre Monsoon Water Level_2019 (Un Confined)										
Well No	Well Type	Tahsil / Taluk	Village	Geology	Latitude	Longitude	Elevation of Ground Level	date	Water Level	Water Table
CGWB	Dug Well	Dabhoi	Amareshwar		22.228	73.483	51.00	01-May-19	4.04	46.96
CGWB	Dug Well	Savli	Juna Samlaya		22.504	73.283	59.00	01-May-19	14.02	44.98
CGWB	Dug Well	Vadodara	kevdabag		22.29	73.19	36.00	01-May-19	9.55	26.45
CGWB	Dug Well	Padra	Masor		22.13	72.9	21.00	01-May-19	14.2	6.80
CGWB	Dug Well	Vadodara	Vadodara_ONGC		22.269	73.213	37.00	01-May-19	13.12	23.88
CGWB	Dug Well	Vaghodia	Patiyapura		22.275	73.442	60.00	01-May-19	9.42	50.58
CGWB	Dug Well	Vaghodia	Saidal		22.283	73.503	66.00	01-May-19	3.05	62.95
CGWB	Dug Well	Vadodara	Sama		22.343	73.201	37.00	01-May-19	3.96	33.04
CGWB	Dug Well	Savli	Tundav		22.483	73.203	45.00	01-May-19	15.03	29.97
CGWB	Dug Well	Dabhoi	Vega		22.159	73.413	47.00	01-May-19	7.66	39.34
CGWB	Dug Well	Savli	Vejpur2		22.747	73.356	71.00	01-May-19	3.45	67.55
CGWB	Dug Well	Savli	Sankeda		22.539	73.175	50.00	01-May-19	37.9	12.10
CGWB	Dug Well	Sinor	Sinor		21°54'45"	73°20'30"	36.00	01-May-19	26	10.00
CGWB	Dug Well	Vadodara	Vadodara Ii		22.305	73.272	36.00	01-May-19	8.36	27.64
CGWB	Dug Well	Vaghodia	Chella Karamsiya Pz		22.397	73.432	70.00	01-May-19	5.12	64.88
CGWB	Dug Well	Vaghodia	Waghodia Pz		22.364	73.377	66.00	01-May-19	9.92	56.08
CGWB	Tube Well	Vadodara	Virod		22°23'37"	73°13'38"	35.00	01-May-19	20.80	14.20
CGWB	Tube Well	Dabhoi	Lunadra		22°12'29"	73°28'37"	32.50	01-May-19	6.60	25.90
CGWB	Tube Well	Vadodara	Shankarpura		22°16'32"	73°16'13"	31.72	01-May-19	4.70	27.02
CGWB	Tube Well	Vaghodia	Bhaniyara		22°23'20"	73°16'06"	45.12	01-May-19	13.10	32.02
CGWB	Tube Well	Padra	Ghayaj ii		22.233	73.054	31.00	01-May-19	29.53	1.47
CGW	Tube	Karjan	Handod2		22.074	73.046	23.00	01-	32.22	-9.22

B	Well							May -19		
CGWB	Tube Well	Vadodara	Vadodara I		22.305	73.272	36.00	01-May -19	27.92	8.08
CGWB	Tube Well	Savli	Chaliyar		22.667	73.317	51.00	01-May -19	27.38	23.62

Annexure 2 Vadodara Post Monsoon Water Level_2019 (Un Confined)										
Well No	Well Type	Tahsil / Taluk	Village	Geology	Latitude	Longitude	Elevation of Ground Level	date	Water Level	Water Table
CGWB	Dug Well	Dabhoi	Amareshwar		22.228	73.483	51	01-Oct -19	2.52	48.48
CGWB	Dug Well	Savli	Juna Samlaya		22.504	73.283	59	01-Oct -19	9.3	49.70
CGWB	Dug Well	Vadodara	kevdabag		22.29	73.19	36	01-Oct -19	8.65	27.35
CGWB	Dug Well	Padra	Masor		22.13	72.9	21	01-Oct -19	8.25	12.75
CGWB	Dug Well	Vadodara	Vadodara_ONGC		22.269	73.213	37	01-Oct -19	10.21	26.79
CGWB	Dug Well	Vaghodia	Patiyapura		22.275	73.442	60	01-Oct -19	3.72	56.28
CGWB	Dug Well	Vaghodia	Saidal		22.283	73.503	66	01-Oct -19	1.3	64.70
CGWB	Dug Well	Vadodara	Sama		22.343	73.201	37	01-Oct -19	2.54	34.46
CGWB	Dug Well	Savli	Tundav		22.483	73.203	45	01-Oct -19	5.6	39.40
CGWB	Dug Well	Dabhoi	Vega		22.159	73.413	47	01-Oct -19	3.22	43.78
CGWB	Dug Well	Savli	Vejpur2		22.747	73.356	71	01-Oct -19	0.9	70.10
CGWB	Dug Well	Savli	Sankeda		22.539	73.175	50	01-Oct -19	32.25	17.75
CGWB	Dug Well	Sinor	Sinor		21°54'45"	73°20'30"	36	01-Oct -19	24.21	11.79
CGWB	Dug Well	Vadodara	Vadodara Ii		22.305	73.272	36	01-Oct -19	3.27	32.73
CGWB	Dug Well	Vaghodia	Chella Karamsiya Pz		22.397	73.432	70	01-Oct -19	1.4	68.60
CGWB	Dug Well	Vaghodia	Waghodia Pz		22.364	73.377	66	01-Oct -19	0.57	65.43
CGWB	Tube Well	Vadodara	Virod	ALV	22°23'37"	73°13'38"	35.00	01-Oct -19	13.30	21.70
CGWB	Tube Well	Dabhoi	Lunadra	ALV	22°12'29"	73°28'37"	32.50	01-Oct -19	5.50	27.00

CGWB	Tube Well	Vaghodia	Bhaniyara	ALV	22°23'20"	73°16'06"	45.12	01-Oct-19	7.20	37.92
CGWB	Tube Well	Padra	Ghayaj ii		22.233	73.054	31.00	01-Oct-19	22.53	8.47
CGWB	Tube Well	Karjan	Handod2		22.074	73.046	23.00	01-Oct-19	28.45	-5.45
CGWB	Tube Well	Vadodara	Vadodara I		22.305	73.272	36.00	01-Oct-19	11.86	24.14
CGWB	Tube Well	Savli	Chaliyar		22.667	73.317	51.00	01-Oct-19	24.85	26.15

Annexure 3 Vadodara Pre Monsoon Water Level_2019 (Confined I)

Well No	Well Type	Tahsil / Taluk	Village	Geology	Latitude	Longitude	Elevation of Ground Level	date	Piezometric Head	Elevation of Piezometrict Surface
CGWB	Tube Well	Padra	Chitral Pz-I		22.182	72.946	22.00	01-May-19	27.09	-5.09
CGWB	Tube Well	Vadodara	Raypura i		22.282	73.09	32.00	01-May-19	36.42	-4.42
CGWB	Tube Well	Vadodara	Sankarda		22.439	73.122	40.00	01-May-19	48.72	-8.72
CGWB	Tube Well	Sinor	Segwa chouki ii		22.008	73.383	43.00	01-May-19	50	-7.00

Annexure 4 Vadodara Post Monsoon Water Level_2019 (Confined I)

Well No	Well Type	Tahsil / Taluk	Village	Geology	Latitude	Longitude	Elevation of Ground Level	date	Piezometric Head	Elevation of Piezometric Surface
CGWB	Tube Well	Padra	Chitral Pz-I		22.182	72.946	22.00	01-Oct-19	22.52	-0.52
CGWB	Tube Well	Vadodara	Raypura i		22.282	73.09	32.00	01-Oct-19	28.3	3.70
CGWB	Tube Well	Vadodara	Sankarda		22.439	73.122	40.00	01-Oct-19	40.78	-0.78
CGWB	Tube Well	Sinor	Segwa chouki ii		22.008	73.383	43.00	01-Oct-19	38.56	4.44

Annexure 5 Vadodara Pre Monsoon Water Quality_2019 (Un Confined)

Well No	Well Type	Tahsil / Taluk	Village	Geology	Latitude	Longitude	Sampling Date	EC	NO3	F
CGWB	Dug Well	DABHOI	Amreshwar		22°13'48.0"	73°28'48.0"	May-01-2019	1714.00	14.00	0.66
CGWB	Dug Well	SAVLI	Juna samalya		22°13'48.0"	73°16'48.0"	May-01-2019	1762.00	47.00	1.39
CGWB	Dug Well	Vadodara City	Kevada Bag		22°13'48.0"	73.19	May-01-2019	1285.00	66.00	0.97
CGWB	Dug Well	PADRA	Masor		22°13'48.0"	72°54'36.0"	May-01-2019	2394.00	8.00	0.65

CGWB	Dug Well	SAVLI	Tundav		22°13’48.0"	73°12’0.0"	May-01-2019	1996.00	92.00	1.11

Annexure-6 Vadodara Distrcit Exploration Data												
Sr No.	Village	Latitude	Agency	Basin	Depth	Zones Tested		SWL	Date	Disch.	Trans.(AT)	Remarks
	Well type	Longitude	Project	Geology	Drilled	Zones Tapped				(lpm)	(m2/day)	
	Taluka	Toposheet	Year	Aquifer	Constr.	Zones Encountered				Drawdown	Perm.	
						From (m)	To (m)	(m)		(m)	(m/day)	
1	2	3	4	5	6	8	9	10	11	12	12	14
1	Maletha (BH-I)	21°56'45";	CGWB NP	Narmada	301.78	170.76	200	33.06	20-05-74	-	-	
	EW	72°25'45	6		203	170.76	200			-	-	
	Sinor	46C/05	1974-1975									
2	Kurai (BH-I)	22°04'15"	CGWB NP	Narmada	283.77	59.74	65.23	18.04	28-10-72	2074	2616	
	EW	73°05'15"	6		127.05	76.81	81.69			2.4	49.7	
	Karjan	46F/04	1972-1973			83.52	87.56					
						91.68	110.04					
						113.7	124.01					
						76.8	109.72					
						113.38	123.74					
						162.76	180.18					
3	Nisaria (BH-I)	22°59'31"	CGWB NP	Narmada	370.09	191.11	196.11	-		-	-	
	EW	73°71'45"	6		252	206.79	213			-	-	
	Karjan	46F/04	1976-1977			242	249					
4	Nisaria	22°59'31"	CGWB NP	Narmada	148.34	94	112	-		-	-	
	EW-2	73°71'45"	6		146.5	136	145			-	-	
	Karjan	46F/04	1976-1977									
5	Nisaria	22°59'31"	CGWB NP	Narmada	114	93.5	115.53	30.49	31-05-77	3334	3086.4	
	EW-3	73°71'45"	6		115.53					6.53	154.32	
	Karjan	46F/04	1976-1977									
6	Nisaria	22°59'31"	CGWB NP	Narmada	256.2	173.55	185	28.59	20-01-77	3292	4622	
	EW-4	73°71'45"	6		253.2	187	189			-	130	

	Karjan	46F/04	1976-1977			191	202					
						206	210.5					
						213	215					
						220	222					
						233	237					
						242	251					
7	Nisaria	22°59'31"	CGWB NP	Narmada	244.12	176.5	182.04	-		-	-	
	EW-5	73°71'45"	6		241.82	194.54	200.68			-	-	
	Karjan	46F/04	1976-1977			232.68	238.82					
8	Nisaria	22°59'31"	CGWB NP	Narmada	112.18			-		-	-	Assly. pulled
	EW-6	73°71'45"	6		-					-	-	out
	Karjan	46F/04	1976-1977									
9	Nisaria	22°59'31	CGWB NP	Narmada	115.7			-		-	-	Assly. pulled
	EW-7	73°71'45	6		-					-	-	out.
	Karjan	46F/04	1976-1977									
10	Malod (BH-I)	21°52'30"	CGWB NP	Narmada	383.24	40	55	27.82	12-06-76	1261	2655.6	
	EW	73°12'15"	6		57	50	60			4.89	176.9	
	Karjan	46G/01	1976-1976			96	106					
11	Kia	21°57'00"	CGWB NP	Narmada	458			-		-	-	
	EW-1	73°06'45"	6		-					-	-	
	Karjan	46G/01	1973-1974									
12	Kia	21°57'00"	CGWB NP	Narmada	153.31	63.85	82.53	23.75	23-04-74	2669	7620	
	EW-2	73°06'45"	6		48.08					3.95	405.6	
	Karjan	46G/01	1973-1974									
13	Bramangaon	22°06'00"	CGWB NP	Narmada	296.84	69	73	25.9	/05/1976	-	-	
	EW-1	73°11'45"	6		93	75	79			-	-	
	Karjan	46F/04	1975-1976			84	90					
14	Bramangaon	22°06'00"	CGWB NP	Narmada	49.1	33	45	24.62	27-02-77	160	-	

	EW-2	73°11'45"	6		47					0.76	-	
	Karjan	46F/04	1975-1976									
15	Timbarwa	22°01'00"	CGWB NP	Narmada	225.22	69.7	79.6	30.5	26-03-74	2444	1932	
	EW	73°17'45"	6		177.73	85.95	98			3.51	29.04	
	Karjan	46F/08	1974-1975			104.75	114.85					
						124.73	134.86					
						140.86	154.86					
						146.78	174.53					
						70	80					
						115	125					
16	Mobha	22°08"00"	CGWB NP	Narmada	218.23	66.2	82.2	19.31	01-07-74	2890	1952.64	
	EW	72°58'00"	6		85.2	23	36			4.47	162.72	
	Padra	46B/16	1974-1975			66	82					
						101	112					
17	Sarsauni	22°10'30"	CGWB NP	Narmada	196.4	112	122	-		-	-	Assly pulled
	EW	72°05'30"	6		122					-	-	out
	Padra	46B/04	1975-1976									
18	Sarsauni	22°10'30"	CGWB NP	Narmada	80.9	42	48	-		-	-	
	EW-2	72°05'30"	6		75	55	68			-	-	
	Padra	46B/04	1975-1976			70	75					
19	Sarsauni	22°10'30"	CGWB NP	Narmada	39.5	30	35	-		-	-	
	EW-3	72°05'30"	6		35					-	-	
	Padra	46B/04	1975-1976									
20	Sarsauni	22°10'30"	CGWB NP	Narmada	196.4	47.5	53	20.38	11-02-75	3334	1267.2	
	EW-4	72°05'30"	6		82.5	62	65			8.55	90.48	
	Padra	46B/04	1975-1976			74	79.5					
21	Alamgir	22°12'00"	CGWB NP	Narmada	235	54	64	-		-	-	
	EW	73°11'30"	6		-					-	-	
	Vadodara	46F/04	1974-1975									

22	Chatral	22°07'00"	CGWB NP	Narmada	270.3	140	162.92	25.54	06-11-74	-	-	
	EW	73°17'45"	6		165.37	55	65			-	-	
	Dabhoi	46F/08	1975-1976			92	98					
						106	112					
						140	150					
23	Chatral	22°07'00"	CGWB NP	Narmada	90.23	60	76	31.07	15-03-76	1250	1065.6	
	EW-2	73°17'45"	6		78					5.84	66.48	
	Dabhoi	46F/08	1975-1976									
24	Akotadra	22°09'45"	CGWB NP	Narmada	53.65	26	41.5	9.18	07-12-75	162	8.47	
	EW	73°27'45"	6		43.5					15.38	0.55	
	Dabhoi	46F/08	1975-1976									
25	Palaswada	22°14'00"	CGWB NP	Narmada	133	18.28	25.9	14.48	12-10-74	768	-	Trap at 128m.
	EW	73°17'00"	6		-	30.48	35.96			0.84	-	
	Dabhoi	46F/08	1972-1973			30.48	35.96					
						67	71.32					
						75	77.4					
						109.73	128.02					
26	Tentalao	23°25'15"	CGWB NP	Narmada	195	60.32	72.42	28.1	15-06-74	1128	38.88	
	EW	73°25'15"	6		111	81.51	87.95			18.44	1.3	
	Dabhoi	46E/07	1974-1975			97.25	109					
27	Segwa Chokdi	22°01'00"	CGWB PZP		187.38	36	40	36.68	16-10-86	300	602	
	Pz-1	73°23'00"	101	Alluvium	162	42	49			3.52	-	
	Sinor	46F/08	1986-1987			51	54					
						59	64					
						94	103					
						127	139					
						152	161					
28	Segwa Chokdi	22°01'00"	CGWB PZP		90	36	40	38.69	14-11-86	220	-	
	Pz-2	73°23'00"	101	Alluvium	86	42	49			0.31	-	

	Sinor	46F/08	1986-1987			51	54					
						59	64					
						66	84					
29	Haldarwa	21°54'00"	CGWB PZP		200.5	149	155	24.98	24-12-86	378	-	
	Pz-1	73°04'45"	101	Alluvium	198	174	180			3	-	
	Karjan	46G/01	1986-1987			188	194					
30	Haldarwa	21°54'00"	CGWB PZP		137	45	48	22.54	08-01-87	288	189	
	Pz-2	73°04'45"	101	Alluvium	137	62	65			1.71	-	
	Karjan	46G/01	1986-1987			123	135					
31	Ghayaj	22°13'00	CGWB PZP		136.15	74	84	33.4	17-12-90	750	-	
	Pz-1	73°05'25	101	Alluvium	130	100	113			0.4	-	
	Padra	46F/04	1990-1991			123	129					
32	Ghayaj	22°13'00	CGWB PZP		45	20	35	33.8	25-12-90	-	-	
	Pz-2	73°05'25	101	Alluvium	36					-	-	
	Padra	46F/04	1990-1991									
33	Raypura	22°16'55"	CGWB PZP		200	46	50	41.05	16-02-91	751	-	
	Pz-1	73°05'25	101	Alluvium	95	55	59			-	-	
	Vadodara	46F/03	1990-1991			62	65					
						69	79					
						85	94					
34	Raypura	22°16'55"	CGWB PZP		50	25	31	41.79	24-02-91	-	-	
	Pz-2	73°05'25	101	Alluvium	44	33	43			-	-	
	Vadodara	46F/03	1990-1991									
35	Kurali	22°01'23"	CGWB PZP		200	80	84	37.3	08-04-91	856	-	
	Pz-1	73°12'15"	101	Alluvium	171	87	111			-	-	
	Karjan	46F/04	1990-1991			123	135					
						150	170					
36	Kurali	22°01'23"	CGWB PZP		65	39	57	44.8	20-04-91	-	-	
	Pz-2	73°12'15"	101	Alluvium	58					-	-	
	Karjan	46F/04	1991-1992									

37	Vadaj	22°04 25	CGW B PZP		147.6			35.17	04-01-95	138	224.46	
	Pz	73°28 35	101	Alluvium	96					0.3	-	
	Dabhoi	46F/08	1994-1995									
38	Handod	22°04 25	CGW B PZP		200	98	104	2.15	06-03-95	240	-	
	Pz-1	73°02 45	101	Alluvium	145	110	116			-	-	
	Karjan	46F/04	1994-1995			120	134					
						140	143					
39	Handod	22°04 25	CGW B PZP		200	185	195	-		-	-	
	Pz-2	73°02 45	101	Alluvium	197					-	-	
	Karjan	46F/04	1994-1995									
40	Handod	22°04 25	CGW B PZP		51	32	40	27.1	24-03-95	114	-	
	Pz-3	73°02 45	101	Alluvium	-	42	49			-	-	
	Karjan	46F/04	1994-1995									
41	Sakarda	22°26'00'	CGW B PZP		200	71	72	36.53	08-06-94	72	-	
	Pz-1	73°7'20"	101	Alluvium	-	80	83			7.4	-	
	Vadodara	46F/03	1994-1995			93	97					
42	Sakarda	22°26'00'	CGW B PZP		60.6	30	36	37.62	25-06-94	-	-	
	Pz-2	73°7'20"	101	Alluvium	-	39	42			-	-	
	Vadodara	46F/03	1994-1995			45	51					
43	Vankaner	22°32'20"	CGW B PZP		101	37	43	40.75	25-06-94	-	-	
	Pz-1	73°10'36"	101	Alluvium	-					-	-	
	Savli	46F/02	1994-1995									
44	Vankaner	22°32'20"	CGW B PZP		70	46	54	46.9	20-10-94	34	-	
	Pz-2	73°10'36"	101	Alluvium	-					0.1	-	
	Savli	46F/02	1994-1995									
45	Chitral	22°10'55"	CGW B PZP		200	95	104	29.7	03-05-95	180	135	
	Pz-1	72°56'45"	101	Alluvium	106					0.64	-	
	Padra	46B/16	1995-1996									
46	Chitral	22°10'55"	CGW B PZP		50	37	43	28.65	01-06-95	36	79	

	Pz-2	72°56'45"	101	Alluvium	45					0.67	-	
	Padra	46B/16	1995-1996									
47	Ganthial	23°14'00"	CGWB	Basalt	202.6			23.3	15-05-03	12		
	EW	72°43'20"								38.24		
	Savli		2003-04									
48	Khed Karmasiay	22°25'09"		Basalt	159.9			19.27	28-05-03	210		
	EW - I	73°24'30"								3.43		
	Vaghoriya		2003-04									
49	Khed Karmasiay	22°25'09"		Basalt	159.9				06-06-03			
	OW	73°24'30"										
	Vaghoriya		2003-04									
50	Moti Bhadol	22°32'30"		Basalt	201.6			(Dry)	24-09-03			
	EW	73°18'30"										
	Savli		2003-04									
51	Rasulpur	22°35'54"		Basalt	159.9			7.1	10-10-03	438		
	EW - I	73°13'30"								10.45		
	Savli		2003-04									
52	Rasulpur	22°35'54"		Basalt	56.2			8.48	17-10-03	420		
	EW - II	73°13'30"								8.62		
	Savli		2003-04									
53	Rasulpur	22°35'54"		Basalt	196.5			7.75	20-10-03	660		
	EW - III	73°13'30"										
	Savli		2003-04									
54	Vasanpur	22°34'50"		Basalt	202.6			26.9	10-11-03	210		
	EW- I	73°17'28"								10.45		
	Savli		2003-04									
55	Vasanpur	22°34'50"		Basalt	202.6			27.12	19-11-03	438		
	OW	73°17'28"								1.83		

	Savli		2003-04									
56	Sandhsal	22°38'18"		SST / Basalt	202.6			10.4	30-11-03	210		
	EW - I	73°21'30"								17.95		
	Savli		2003-04									
57	Sandhsal	22°38'18"		SST / Basalt	147.7			10.16	08-12-03	420		
	EW - I	73°21'30"								15.54		
	Savli		2003-04									
58	Vejpur	22°44'15"		Basalt	202.6			6.78	19-12-03	690		
	EW - I	73°21'15"								2.29		
	Savli		2003-04									