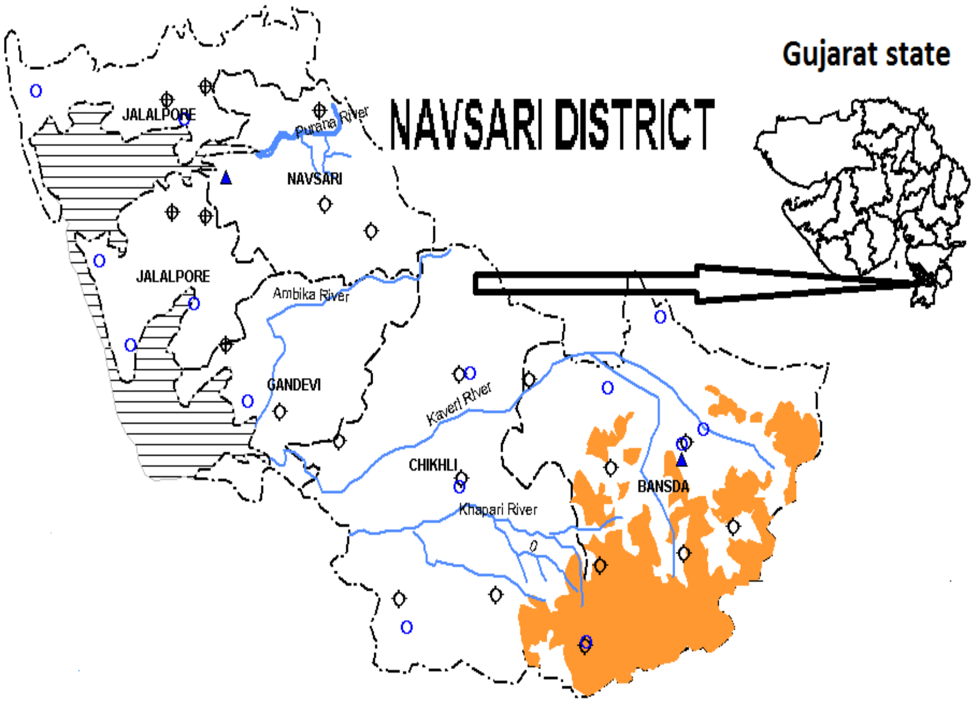
Government of India
Ministry Of Water Resources
Central Ground Water Board

DISTRICT GROUND WATER BROCHURE
NAVSARI DISTRICT
GUJARAT STATE



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DECEMBER-2013

DISTRICT AT A GLANCE-NAVSARI DISTRICT

Sl No.	Items	Statistics
1	GENERAL INFORMATION	
	i) Geographical area as per state territory/as per village papers (Sq. Km) **ii) Administrative Divisions (As on 3/2012)** **Number of Talukas** **Number of Villages/Towns** **iii) Populations (As on 2011 census)** **iv) Average Annual Rainfall of district (mm)**	2210 5 374/9 1330711 1909
2.	GEOMORPHOLOGY	
	Major Physiographic Units: High relief area- western ghats, North-south ridges (flat topped, step like & dissected) Piedmont zone-(foot hill zone), alluvial plain & coastal plain (Barren and sand strips, Bordering alluvial plain, mud flats). Deccan trap basalt plateau & dissected hill of Deccan traps.	
	Major Drainages: Ambica, Purna, Kaveri and Khapri and their tributaries.	
3.	LAND USE (Sq. Km) (2011-12)	
	a) Forest area **b) Net area sown** **c) Cropped area**	277 1363 1511
4.	MAJOR SOIL TYPES: **Black clayey to loam soil (Black cotton soil), silt caly loam to clay loam soils, Light greyish to yellowish brown soil, clay loam to sandy loam, Dark gray to black coastal soil (clay loam to silty loam, saline-alkaline soil).**	
5.	PRINCIPAL CROPS **Rice, Jowar, Bajra, Wheat, Maize and other Pulses.**	
6.	IRRIGATION BY DIFFERENT SOURCES (2006-07) (Areas and numbers of structures)	
	Dugwells **Tube wells/Borewells Public** **Tube wells/Borewells Private** **Canals** **Other Sources** **Net Irrigated area** **Gross Irrigated area**	9263 235 **169** 552 (Sq. Km) -- 839 (Sq. Km) 973 (Sq. Km)
7.	NUMBERS OF GROUND WATER MONITORING WELLS **OF CGWB (As on 31-03-2012)** **No of Dug Wells** **No of Piezometers**	 16 2
8.	PREDOMINANT GEOLOGICAL FORMATIONS **Quarternary alluvium (coastal) and Deccan trap basalt (Age upper cretaceous to Lower Eocene).**	
9.	HYDROGEOLOGY	
	➢ **Major Water Bearing Formation- Basalt & Sand layers.** ➢ **Pre-monsoon depth to water level (may 2012) 2.74 mbgl (at Chinam) to 25.80mbgl (Navsari)** ➢ **Post- monsoon depth to water level (November 2012) 1.05 mbgl (at Khedgam) to 21.69 mbgl (Navsari) 18.65 mbgl at Navsari** ➢ **Long term water level trend in 10 yrs premonsoon (may 2003-may 2012) Rise (0.0023m/yr at Dandi to 0.129 m/yr at Amrama.) and decline 0.059m/yr at Anklas to 0.1.040 m/yr at Hanumanbari.)** ➢ **Long term water level trend in 10 yrs post monsoon (Nov./2003-Nov./2012) Rise range 0.0049m/yr at Ubrat to 0.2831 m/yr at Kantavel. Fall range to 0.123 m/yr at Gandevi to 0.459m/yr at Anklas.**	

10.	GROUND WATER EXPLORATION BY CGWB (As on 31-03-2012)			
	No of wellsdrilled (EW, OW, Pz, SH, Total)	EW	OW	PZ
		23	01	05
	Depth Range(m)	52-200m		
	Discharge (Litres per minute)	18-2744		
	Storativity (S)	-		
	Transmissivity (m^2/day)	0.26-2261		
	Specific capacity lps/m of dd	145-1006		
11	GROUND WATER QUALITY (3/2012)			
	Presence of chemical constituents more than permissible limit) **Ground water is unfit for irrigation & drinking water but potable from east to central part of the district.**	EC >3000 toward Coast		
	In general water quality is potable but saline in coastal area.			
12.	DYNAMIC GROUND WATER RESOURCES (2009)- in ha m			
	Annual Replenisible Ground Water Resources	46893.49		
	Net Annual Ground Water Recharge	44548.82		
	Projected Demand for Domestic and industrial Uses upto 2025	3117.00		
	Stage of Ground Water Development of district	57.73%		
13	AWARENESS AND TRAINING ACTIVITY			
	Mass Awareness Programmes organized	NO		
	Date	NA		
	Place	NA		
	No of Participants	NA		
	Water Management Training Programmes organized (3/07)	NO		
	Date	NA		
	Place	NA		
	No of Participants	NA		
14	EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING(31/3/2012)	NO		
	Projects completed by CGWB (No & Amount spent)	NA		
	Projects under technical guidance of CGWB (Numbers)	NA		
15	GROUND WATER CONTROL AND REGULATION (3/2007)	NO		
	Number of OE Talukas	NIl		
	Number of Critical Talukas	NIL		
	Number of Semi-Critical Talukas:	NIL		
	Number of Talukas notified	NO		

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MAJOR GROUND WATER ISSUES

- **i) Excess run-off due to rugged topography in eastern part.**
- **ii) In the higher plateau areas, storage tank can be constructed for domestic purpose since other sources would not be feasible**
- **iii) Conjunctive use of Surface and ground water.**
- **iv) Ground water demand and supply is to be matched**
- **v) Proper development and management of ground water**
- **vi) Rain water harvesting is to be adopted for recharge to ground water to augment the ground water resource by methods such as gully plugging, small, check dams and bhandaras.**
- **vii) Water conservation is to be propagated for optimum use of water**
- **viii) Salinity in coastal part of area**

DISTRICT GROUND WATER BROCHURE
NAVSARI DISTRICT, GUJARAT

1.0 INTRODUCTION

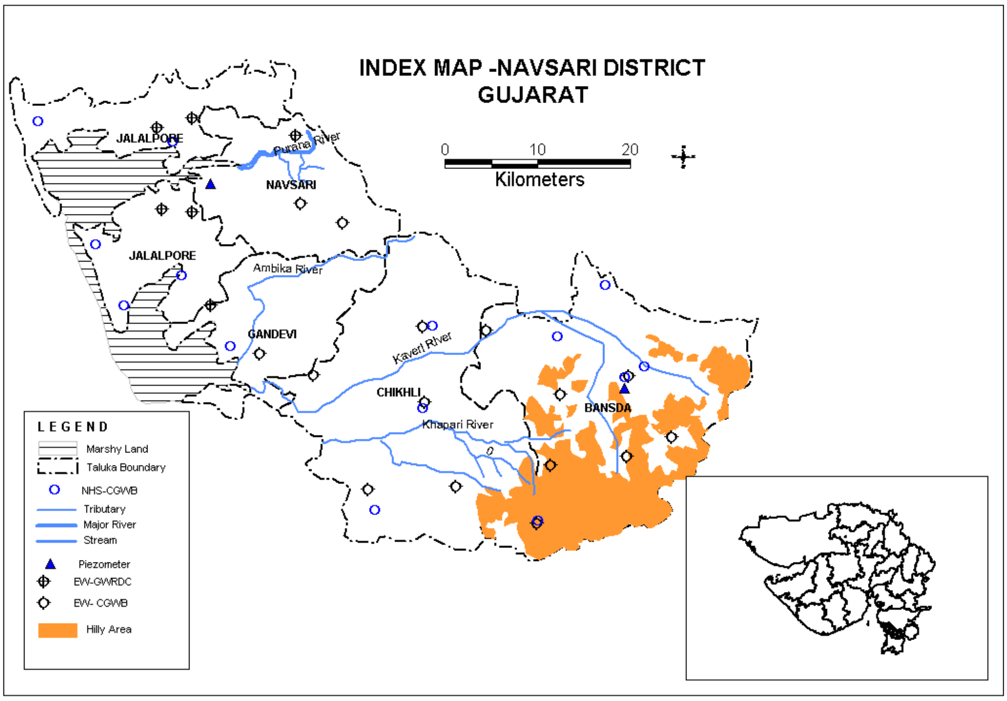
Navsari district is situated in the southern part of Gujarat State. It is one of the most important districts in Gujarat State bifurcated from Valsad districtIt lies between Latitude 20°32' & 21°05' North and Longitude 72°42' & 73°30' East and falls in Survey of India Toposheet Nos 46C, 46D, 46G& 46H. It is bounded by Surat district in the north, Dangs district in the east , Valsad district in the South and Arabian sea in the west. Navsari district has a geographical area of about 2210.97 sq. km. The geographical areas of different talukas is given in table- 1.

Table:- 1 Geographical Area

S. No	Taluka	Geographical Area (Sq. Km.)
1	Bansda	599.34
2	Chikhli	574.61
3	Gandevi	294.75
4	Jalalpore	492.82
5	Navsari	249.45
	Total	**2210.97**

The district comprises of five Talukas, i.e., Navsari, Jalalpore, Gandevi, Chikli, and Bansda. The administrative divisions of the district have been reconstituted recently by dividing Valsad district into two district such as Navsari in the north and Valsad in the south . There are 374 villages and 09 towns in the district. Index Map shows administrative boundies, drainage, topography, and ground water structures (Figure-1)

Figure-1



The drainage in the district is controlled by the topography and the lineaments. The major rivers draining the district are Purna, Ambika, Kaveri and Khapar and their tributaries. The rivers are ephemeral toward hilly area toward east and gradually tends to become perennial toward west. All the river basin are east-westward stretching basins The river originates from Sahayadri hills and flow toward west.

The drainage Pattern is mainly detritic and drainage density is fine. Radial pattern are locally developed around the hills. In piedmonts drainage density is courser and sub-parallel and are characterised by broad stream course. In alluvial terrain the drainage density is characteristically course and sub-parallel to parallel

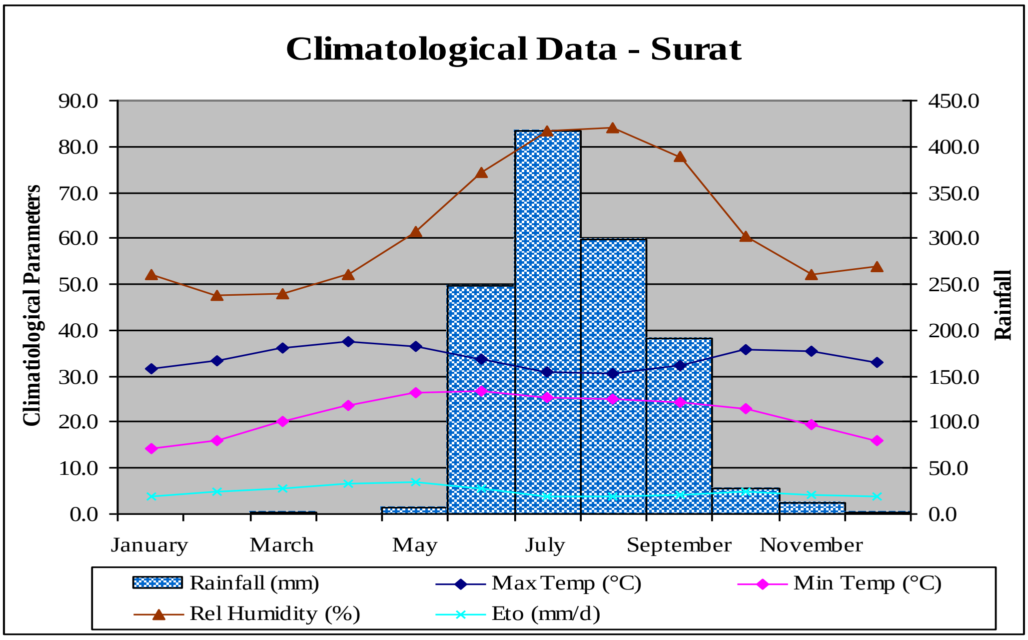
Systematic hydrogeological surveys were carried out by S/ Shri P.C. Rai and Kailash Chander during the year 1976-77. During 1977-78 systematic hydrogeological surveys were carried out by Shri G S Mittal Jr. Hydrogeologist. Shri K. Balakrishan (1993-94 &1994-95) carried out reappraisal hydrogeological surveys in Auranga, Ambika, Purna and Mindhola river basin of Gujarat State. Ground water exploration was carried out during 1993-94 &9 94-95

2.0 Rainfall & Climate

District receive rainfall mainly from Southwest monsoon . The rainfall is confined between June to October months. Long term normal rainfall (1951-80) for the Surat IMD station is about 1210 mm as such there is no meteorological station in the district and nearest IMD stations are located at Surat and Valsad. As such The Surat IMD station is more representative of climatological conditions for the Navsari district, therefore, the climatological data of Surat IMD station is taken into consideration for discussion. Taluka wise rainfall data is given in Annexure-I

General climate of the district is sub-tropical and is characterised by three well-defined seasons, i.e. summer - from April to June, monsoon - from July to September, and winter - from October to March. Mean maximum daily temperatures range from 30° to 37°C and mean minimum daily temperatures from 14 to 26 °C. April and May are the hottest months when the temperatures may exceed 44°C. The winters are generally pleasant with minimum temperatures around 09°C., however, at times temperatures may further drop down. The relative humidity is highest in the early morning, which reduces as the day advances. In the monsoon season the humidity is high reaching up to 84%, during winters it may drop down to 47%. Light winds, mainly from southern and south-western directions blow during summer. In winter light winds blow from north-west and north-east. During monsoon however, moderate to heavy wind prevail from south and south-western directions. Mean wind speed ranges from 108 km/d during winters to more than 220 km/d during summer and monsoon. Potential Evapo-transpiration (PET) has been calculated from other climatological data using Penman method. The PET is maximum during summer months. It ranges from 3.9 mm/d during December to 6.9 mm/d during May. The average monthly PET is about 4.8 mm/d.

Figure-2



3.0 GEOMORPHOLOGY AND SOIL TYPES

3.1 Physiography

Navsari district is situated in the southern part of the state. Four physiographic units have been established in the area.

1) High Relief Zone
2) Piedmont Zone.
3) Alluvial Plain.
4) Coastal Plain.

High Relief Zone

The High relief zones are observed in the eastern part of the district which forms part of Sahayadri hills (Western Ghat). The general disposition are in the North-South direction. The ridges are flat topped and step like in its disposition. They are dissected by all rivers flowing east to west. The valleys are narrow and have plenty of detrital materials.

Piedmont Zone

The unit is located in the eastern part of area adjacent to foot hills. The unit is characterised by assorted clastic sediments and gradually graded into alluviual plain toward west. The plains are extensively cultivated.

Alluvial Plain

The central and western parts are covered by extensive alluvial plains formed the different geomorphic processes. The general slope is gentle toward west. It has low moderate infiltration characteristic. It forms the recharge zone in the east and discharge zone in the west.

Coastal Plain

This unit includes barren and sandy strips bordering the alluvial plain. The areas are subjected the frequent submergence during rainy season resulting the water logging conditions. Mudflats are characteristic geomorphic units in these areas.

The present physiographic set-up is combined result of diversified lithology (Deccan tap and Alluvium).

3.2 Soil Type

The soils derived their characteristics from the basaltic rocks as parts of the district. The basaltic lava flows are covered by black clayey to loamy soil. It is in general ranges in thickness up to one meter. The colour of the soil turns brown due to high iron content at places. In the piedmont slope area the soil is shallow to moderately deep, moderate to severely eroded and non calcareous in nature. The texture is silt clay loam to clay loams. The clay content varies from 30 to 60%. The water holding capacity of the soil is moderate. In the midland and flood plain areas, the soil is deep to very deep, light greyish to yellowish brown in colour. The texture is fine clay loam to sandy loam. The clay content varies from 25 to 60%. In coastal region the soil is deep to very deep dark grey to black colour. The texture is clay loam to silty loam. The area is affected by tide as well as leaching of salts from up land forming saline alkali soils. The content of clay in this is high and permeability is low (mud flats).

4.0 GROUND WATER SCENERIO

4.1 Hydrogeology

The hydrogeological frame work of the area is essentially governed by geological setting, distribution of rainfall fall and facilities of circulation and movement of water through inter connected primary and secondary porosity of the geological units forming the aquifers. The Hydrogeological Map of the district is given in Plate-IV

4.1.1 Aquifer System

Based on the geological formation the area can be divided broadly into two hydrogeological units:

Deccan Trap (Fissure Formations):
Alluvium (Porous Formation) :

Deccan Trap:

Deccan trap basalt occupies a major part of the district and comprises of basaltic lava flows and numerous cross cuttings of dykes of basaltic and doleritic composition . The porosity subsequently are developed by weathering, fracturing and faulting in the basaltic rocks . In lava flows the vesicles are formed by escaping of gases which results the upper part of the lava flow porous and these vesicles seldom are interconnected to allow any flow of ground water.

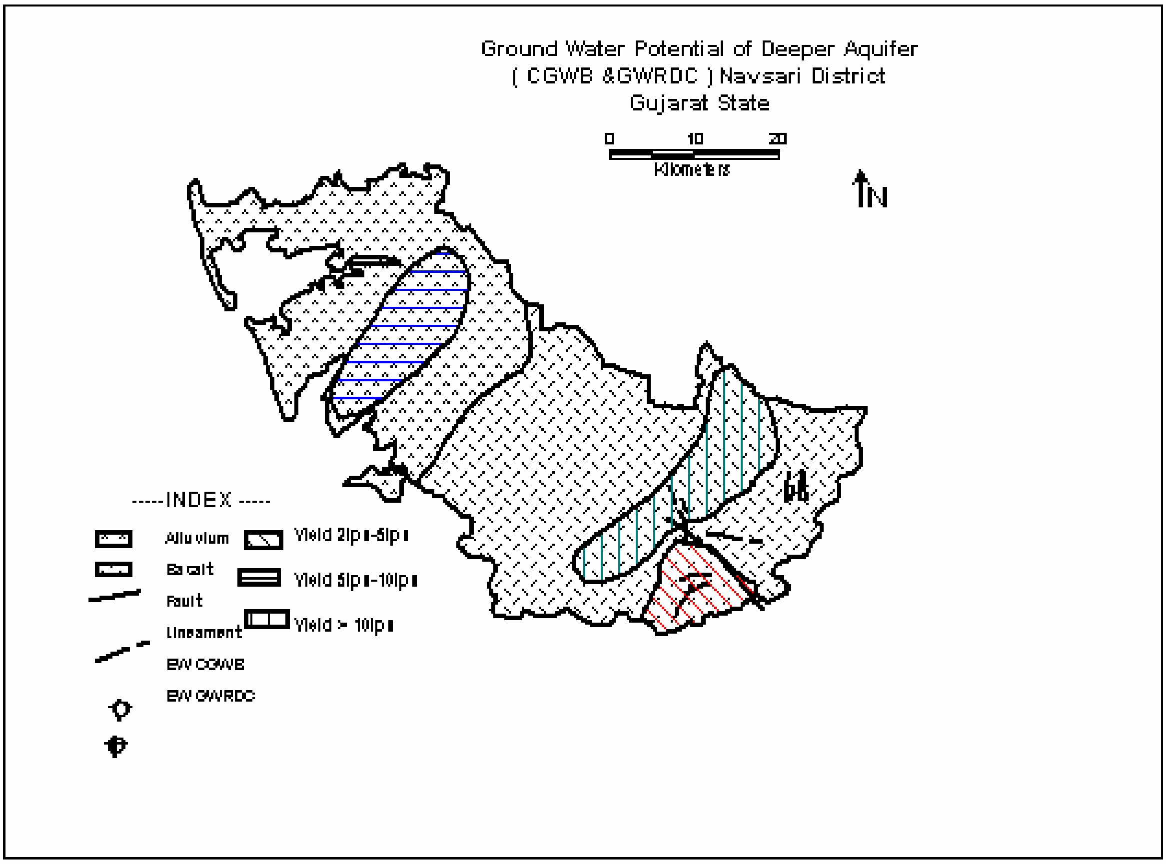
The phreatic aquifers are formed by weathered of basalt. The depth of weathering varies from surface to about 15 meters below ground level. It also varies from place to place depending upon the geomorphology of the area. The deeply weathered zones form good area for storage and movement of ground water. The second type of aquifer found in the area is fractured well jointed and faulted basalts. The fractured developed at the time cooling of lava flows which unique to each flow units and by the later tectonic activity deepest water bearing fracture zones encountered in each basin by exploratory drilling is as follows ;

1. Ambika Basin Wangan EW depth 192m. (20°41’55”; 73°24’45”)
2. Purna Basin Gunkhadi EW depth 181m. (21°02’36”; 73°35’32”)

The aquifer formed by later tectonic activities support shallow and deep aquifer system. Combination of weathering and fracturing can enhance the hydrogeological parameters of the aquifers.

The third type of aquifer is formed by paleoweathering weathering. Significant time lapse has taken in between successive lava flows. During this period weathering takes placed may reach to a considerable depth. The ground water yield potential is shown in figure-3

Figure-3



The weathering causes development of porosity, permeability and inter connection of vesicles. Each individual flow is amygdaloidal / vesicular zones in its upper part and massive at the bottom which covers amygdaloidal zone of the older lava flows. The massive zone acts as aquiclude if not fractured. The vesicular and massive zone of successive lava flows forms multiple aquifer system. Massive zones also acts as confining layer. The deep aquifers are recharged by some deep fracture system. There are twelve lava flows are encountered in the bore hole drilled down the depth of 200m ranging in thickness from 6m to 35m. The ground water exploration carried out in the district revealed that yield of wells drilled in Deccan trap area ranges between 42 lpm (Wankel 20°45’47”; 73°10’51”) to 300lpm (Pipalkhed 20°40’15”; 73°16’30”) whereas the Co-efficient of transmissivity ranges between 10 m^2/day (Unai 20°50’47”; 73°20’20”) to 31.64 m^2/day (Pipalkhed 20°40’15”; 73°16’30”).

Alluvium:

This consists of gravel, sand, silt clay and kankar. The ground water occurs mainly under unconfined conditions but at places semi-confined conditions are also observed. The occurrence and movement of ground water in alluvium is controlled by primary porosity (interstitial pore spaces) of the alluvial material. The ground water exploration carried out in the district revealed that yield of wells drilled in alluvial area ranges between

78lpm (Devisar 20°46'30"; 73°59'10") to 2744 lpm (Ethan) whereas the Co-efficient of transmissivity ranges between 300 m^2/day (Kothavasan) to 2261 m^2/day (Ethan).

4.1.2 Behaviour of Water Levels

The behaviour of water levels was studied based on the water level data collected from the National Network of Hydrograph Stations (NNHS) located in the district. There are a total number of 18 monitoring stations in the district which include 16 open wells and 02 piezometers..

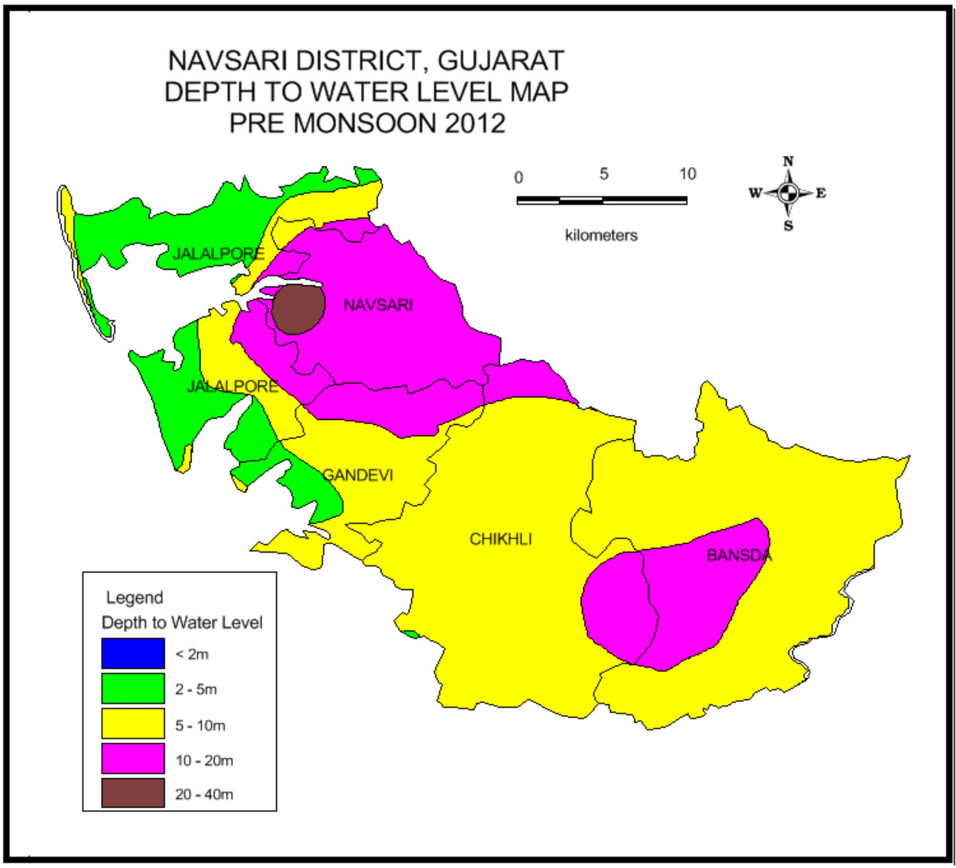
The seasonal fluctuation in water levels were calculated between May and November 2012. Historical data on water levels were used for preparing the hydrograph as well as for computing long term trends.

4.1.3 Depth to Water Level

The maps depicting the depth to water level have been prepared based on water level data for May 2012 and November 2012 collected from NNHS. During pre-monsoon period (May 2012) the depth to water level in the district ranges between less than 4 m bgl and more than 10m bgl. Minimum water level during May 2012 was observed at Chinam (2.74 m bgl) and the Maximum water level was recorded at Navsari (25.80) m bgl in the district.

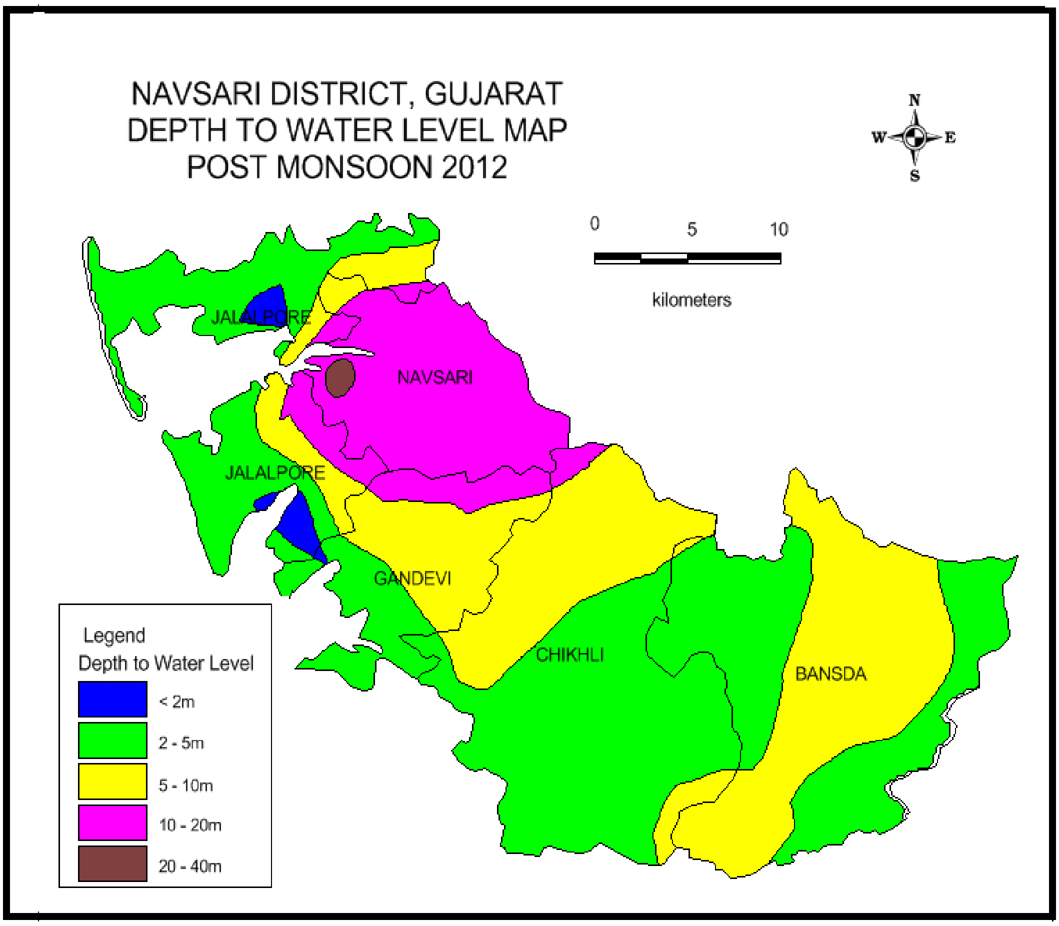
Spatially, the depth to water levels (May-2012) in the major parts of the district ranges between 5 and 10 m bgl. Depth to water level between 2 to 5m is seen in north-western part of the district. There are two significant pockets where the water level ranging between 10 to 20m is also seen (Figure -4). There is no area where water level less than 2m is seen.

Figure-4



During post monsoon period (November 2012) the depth to water level in the district ranges between less than 3m bgl and more than 20m bgl . Minimum water level during May 2012 was observed at Khedgam (1.05 m bgl) and the Maximum water level was recorded at Navsari (21.69) m bgl in the district. Spatially, the depth to water levels in the major parts of the district lie between 2 and 5 m bgl. Depth to water level ranging between 5 to 10 m is found in two isolated patches. The depth to water level between 10 to 20m is found in north-western part of the district. Further there is a small pocket where water level of more than 20m is also seen (Figure-5).

Figure-5

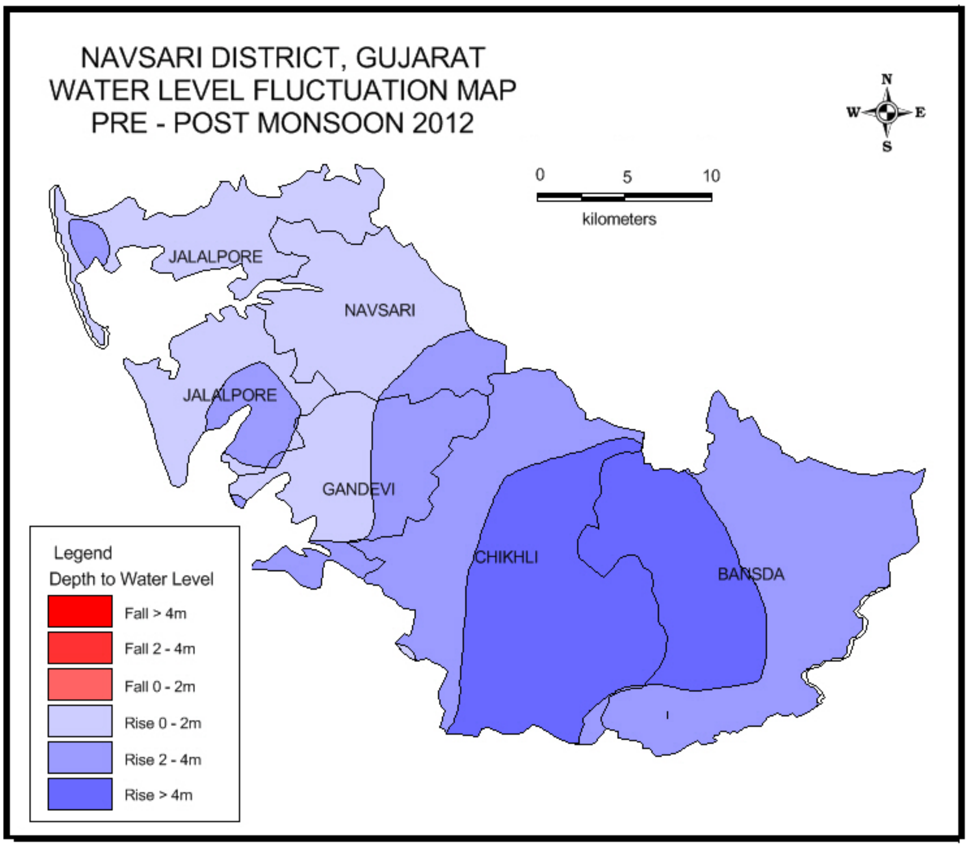


4.1.4 Rise And Fall In Water Levels.

Rise and fall in water levels between May 2012 and November 2012 has been shown in Figure -6. The whole shows the rise of water level of different ranges. Nearly 40% of the are in north-western part of the district shows the rise of water level up to 2m. Whereas the eastern part of the area shows the rise of water level of ranging between 2 to 4m. There is a significant pocket in south-western part of the district which shows the rise of water level for more than 4m.

c

Figure-6



4.1.5 Change in Ground Water Scenario over the years

Long term water level data is available for 17 NNHS since 2003 and data was analysed for the period between January 2003 to November 2012 and water level trend for various period (pre-monsoon and post-monsoon period trend) is shown in table -II

Pre-monsoon water level trend shows that 41% of the hydrograph stations indicate a rise of water level ranging from 0.0023 m/year (Dandi) to 0.129 m/year (Abrama) where as 59% of the hydrograph stations indicate a decline of water level ranging from 0.059 m/year (Anklas) to 1.0400 m/year (Hanumanbari) . During post- monsoon period water level trend shows that only 76% of the hydrograph stations indicate a rise of water level ranging from 0.0049 m/year (Ubrat) to 0.2831 m/year (Kantavel) where as 24% of the hydrograph stations indicate a decline of water level ranging from 0.123 m/year (Gandevi) to 0.459m/year (Anklash) as table-II

Table –I1 Ground Water Level Trend of Navsari district (Period 1st Jan. 2003 to 30th Nov-2012)

Tahsil/ Taluk	Location	Well No	Rise (m/yr)	Fall (m/yr)	Data Points	Rise (m/yr)	Fall (m/yr)	Data Points
			Pre-Monsoon			**Post Monsoon**		
Chikhali	Abrama	46D1D05	0.129	-	18	0.1212	-	20
	Rankuva	46H1B03	0.0257	-	19	0.1619	-	18
	Hond	46H2A01	-	0.1216	16	-	0.1760	12
	Kaliyari	46H2A03	-	0.1075	19	0.1707	-	20
	Khergam	46H2A04	0.0277	-	20	0.062	-	20
Gandevi	Sari-khurd	46D1D06	0.0162	-	20	-	0.123	20
Navsari	Chinam	46D1D03	0.0564	-	19	0.0339	-	20
	Dandi	46D1D02	0.0023	-	20	0.0850	-	19
	Navsari	46D1D01	-	0.1374	16	-	0.3069	16
	Onjal	46D1D04	0.0234	-	13	0.1849	-	13
	Onjal	46D1D04A	-	0.2336	7	0.0306	-	6
	Ubhrat	46C4C02	-	0.1079	19	0.0049	-	18
Vansada	Hanumanbari	46H1B01	-	1.0400	12	0.0110	-	10
	Kantasvel	46H1B05	-	0.1261	18	0.2831	-	19
	Pipalkhed	46H2B01	-	0.6845	17	0.0913	-	20
	Unai	46H1B02	-	0.2058	18	-	0.459	17
	Anklas	46H2B03	-	0.059	18	0.0471	-	20
Percentage of Rise/ Fall			**41.18**	**58.82**		**76.47**	**23.53**	

4.2 Ground Water Resources

The Ground Water Resources and Irrigation Potential of the district were calculated as on March 2009 in collaboration with the Government of Gujarat using the methodology suggested by “Ground Water Estimation Committee (GEC-97). These resources were computed after reorganisation of the districts. The ground water resources for different Talukas of the district are given in the table –III and VI.

4.2.1 Ground Water Recharge

The annual ground water recharge varies from 5894.20 ha m. in Bansda Taluka to 13149.02 ha m. in Gandevi Taluka and total gross recharge for the district is 46893.49 ha m. The net available recharge, after leaving natural discharge for non monsoon period varies from 5599.49 (Bansda) to 12491.70 ha m. (Gandevi), the recharge for district is 44548.82 ha m.

4.2.2 Ground Water Draft

The table -III also shows the Draft from Irrigation and Domestic/Industrial sources. The gross draft in the district is 25719.70 ha m. and varies from 3203.50 ha m. (Bansda) to 7943.0 ha m. (Gandevi).

4.2.3 Ground Water Balance for Irrigation

The irrigation potential available for future use for ground water has been computed leaving the ground water projected for allocation for the domestic and industrial requirements (Next 25 years) for all the talukas (Table IV) below. The ground water available for future irrigation varies from 2249.99 ha m. in Bansda Taluka to 4325.57 ha m. in Gandevi Taluka and total of the same for the district is 17936.12 ha m.

4.2.4 Level of Ground Water Development & Stage

The level of Ground Water Development varies from 50.90% (Navsari Taluka) to 63.67% (Gandevi Taluka) and overall Level of Development for the district is 57.73%. and , therefore, these have been categorised as “Safe”. The overall category of the district is also “Safe” (figure-7).

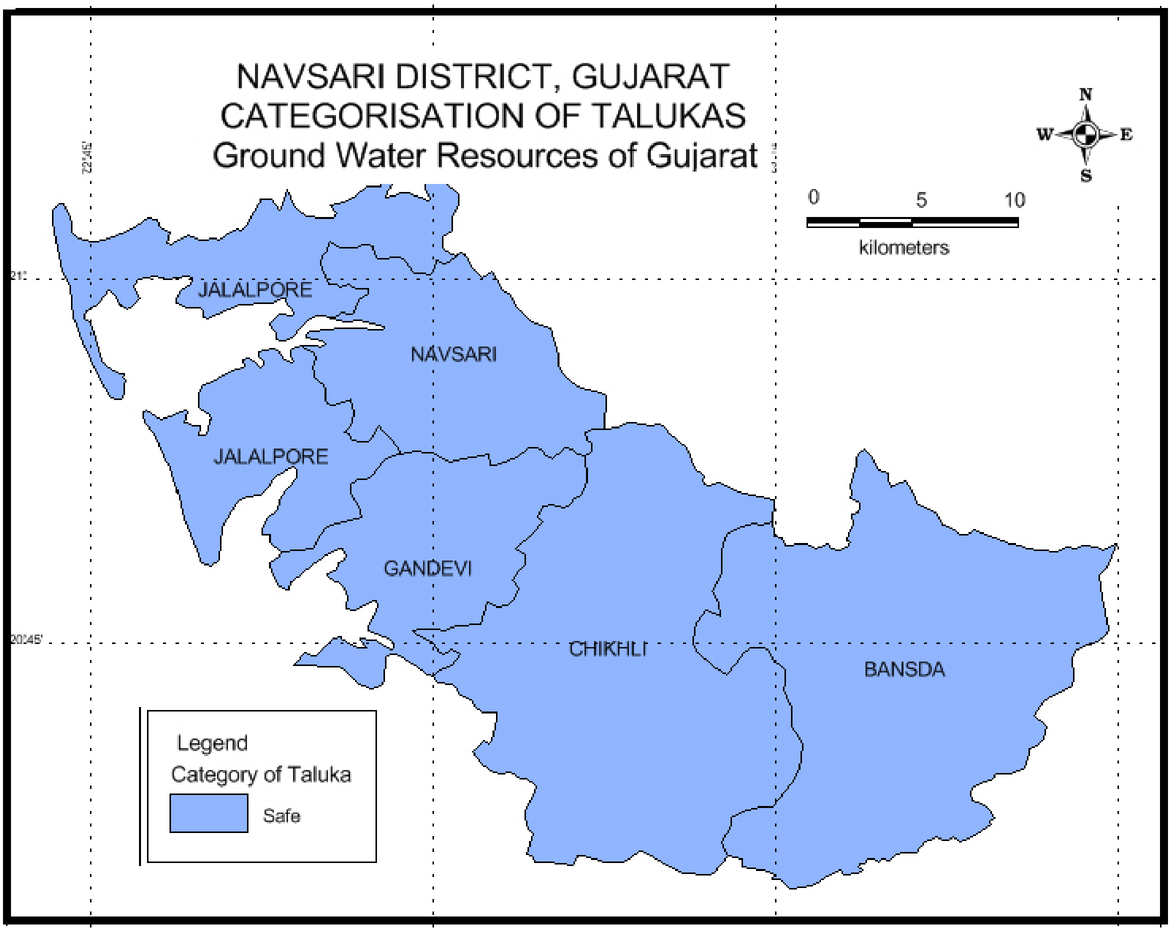
Table :-III Ground Water Resources Potentials as on 2009

S. No.	Taluka	Annual Ground Water Recharge	Natural Discharge During Non-Monsoon	Net Annual Available Ground Water (3-4)	Existing Draft for Domestic and industrial Water Supply	Ground Water Draft for Irrigation	Existing Gross Draft For All Uses (6+7)
		(Ha m)	(Ha m)	(Ha m)	(Ha m)	(Ha m)	(Ha m)
1	2	3	4	5	6	7	8
1	Bansda	5894.20	294.71	5599.49	364.00	2839.50	3203.50
2	Chikhli	9767.75	488.39	9279.37	497.00	4918.80	5415.80
3	Gandevi	13149.02	657.45	12491.57	530.00	7423.00	7953.00
4	Jalalpore	8879.44	443.97	8435.47	435.00	4262.40	4697.40
5	Navsari	9203.08	460.15	8742.92	398.00	4052.00	4450.00
6	**Total**	**46893.49**	**2344.67**	**44548.82**	**2224.00**	**23495.70**	**25719.70**

Table :-IV Stage of Ground Water Development

S. No.	Taluka	Net Annual Available Ground Water	Allocation for Domestic and Industrial Requirement (Next 25 Years)	Net Ground Water Availability for future Irrigation	Level of Ground Water Development	Stage of Development
		(Ha m)	**(Ha m)**	**(Ha m)**	**(%)**	
		9	**10**	**11**	**12**	**13**
1	Bansda	5599.49	510.00	2249.99	57.21	Safe
2	Chikhli	9279.37	697.00	3663.57	58.36	Safe
3	Gandevi	12491.57	743.00	4325.57	63.67	Safe
4	Jalalpore	8435.47	609.00	3564.07	55.69	Safe
5	Navsari	8742.92	558.00	4132.92	50.90	Safe
	Total	**44548.82**	**3117.00**	**17936.12**	**57.73**	**Safe**

Figure-7



4.3 Ground Water Quality

4.3.1 Quality of Shallow Ground Water

The quality of ground water in the shallow aquifer has been studied based on the chemical analysis of water samples collected from NHS during May 2012 and May 2012. It is noticed that the ground water is relatively more saline in near coastal part of district. Statistical analysis of these are presented in table -V

Table :-V Statistical Analysis of Chemical Constituents (Shallow Aquifer)

Constituent	Number	Min	Max	Average
pH	11	7.82	8.76	8.26
EC	11	650.00	3235.00	1489.64
TDS	11	435.50	2167.45	998.06
CO3	11	0.00	48.00	7.64
HCO3	11	183.00	939.00	396.00
Cl	11	64.00	540.00	242.64
NO3	11	2.00	36.00	14.64
SO4	11	7.60	184.34	74.79
F	11	0.00	0.92	0.37
Alk	11	150.00	769.67	337.32
Ca	11	28.00	84.00	56.00
Mg	11	29.00	68.00	45.27
TH	11	250.00	480.00	326.36
Na	11	37.00	397.00	176.64
K	11	0.10	476.00	57.42
Fe	11	0.12	12.00	1.79
SAR	11	0.90	10.32	4.24

4.3.2 Quality of Water from Deeper Aquifers

The quality of ground water for the deeper Alluvial and Basaltic aquifers is available form the Exploratory wells drilled by CGWB and GWRDC during ground water exploration in Navsari district. Statistical Analysis of Chemical Constituents (Deeper Aquifers) is in the table below:-

Table :-VI Statistical Analysis of Chemical Constituents (Deeper Aquifers)

	Alluvium			Hard Rock		
Constituent	**Number**	**Min**	**Max**	**Number**	**Min**	**Max**
EC (µS/cm)	06	936	2402	09	417	1978
Cl (mg/l)	06	48	616	09	21	655

Alluvial Areas

The ground water quality data for deeper alluvial aquifers is available for six exploratory wells. The EC values range between 936 µS/cm at Ethan EW to 2402 µS/cm at Kothasan. The Chloride values range from 48 mg/l at Telada to 3564 mg/l at Kothasan.

Basalt Areas

The ground water quality data for the basaltic areas of Navsari district are available for 09 exploratory wells. The electrical conductivity ranges from 417 µS/cm (Khudvel) to 1978 µS/cm at Wankel.

The chloride concentration was within desirable limit (250 mg/l) in 21 samples whereas it was within maximum permissible limit of 1000 ppm in all samples.

5.0 Ground Water Management Strategy

5.1 Ground Water Development

1. Primary sources of irrigation in the district are dug wells and canals. No area is irrigated by the canals and tanks/ponds. In 2002-2003, 9218 dug wells were being used for irrigation. As reported by the agricultural department of Govt. of Gujarat, there are five tube wells in the district. Primary means of lifting the ground water is oil engines (7117) and electrical motors (9402).

2. All the geological formations occurring in the district form the aquifer, however, the Deccan Trap are the most extensive aquifers in the district. Alluvium forms a potential but limited aquifer in the central parts. Deccan trap basalt occupies a major part of the district and forms the most important aquifer system. It generally forms a poor aquifer due to compactness and poor primary porosity. However, the upper weathered parts, which at places are up to 30 m thick, form good aquifer in the district. At deeper levels, the secondary porosity developed as a result of tectonic activities, in the form of joints, and fractures, shear zones, form repository of ground water at many places. Amygdaloidal horizons within basalt also form potential aquifers at places.

3. The exploratory drilling decipher the depth of the district up to the depth of 202mbgl. High discharge encountered from shallow depth to as deep as 199 meters mbgl The water table condition occurs up to 20 meters and below that it is semi confined to confined condition. The discharge of wells drilled in Deccan trap area ranges between less than 1 lps to 5 lps whereas the Co-efficient of transmissivity ranges between 10 m^2/day to 31.64 m^2/day. The weathered fractured basalt and fractured amygdaloidal basalt are generally yielding high discharge. The flow contacts are generally yielding water but the discharge is poor. The water bearing zones are generally thin, which are less than one meter in thickness. In alluvial area, the depth of pilot holes drilled ranges from 52m to 200metres bgl and tube wells constructed ranges from 37m to 70 mbgl. The ground water exploration carried out in the district revealed that yield of wells drilled in alluvial area ranges between 78lpm to 2744 lpm (Plate-VI) whereas the Co-efficient of transmissivity ranges between 300 m^2/day to 2261 m^2/day.

4. From the study of NHS it is revealed that the depth to water level during pre-monsoon period May 2012) in the district ranges between less than 4 m bgl and more than 10m bgl. Where as during post monsoon period (November 2012) the depth to water level in the district ranges between less than 3m bgl and more than 18m bgl . Long term water level data shows that during pre-monsoon water level trend shows that 47% of the hydrograph stations indicate a rise of water level ranging from 0.008 m/year to 0.149 m/year where as 53% of the hydrograph stations indicate a decline of water level ranging from 0.020 m/year to 0.532m/year. During post- monsoon period water level trend shows that only 24% of the hydrograph stations indicate a rise of water level ranging from 0.004 m/year to 0.0149 m/year where as 76% of the hydrograph stations indicate a decline of water level ranging from 0.023 m/year to 0.430m/year. The over all trend of water level for all the data indicates that the rise ranges between 0.004m/year and 0.126 m/year whereas decline range between 0.10m/year and

0.610 m/year. Nearly 47% of hydrograph stations show rising trend of water level where as 53% of the hydrograph stations show declining trend.

5. The level of Ground Water Development varies from 38.8% (Gandevi Taluka) to 52.28% (Chikhli Taluka) and overall Level of Development for the district is 47.17%. and , therefore, these have been categorised as "Safe". The overall category of the district is also "Safe". The irrigation potential available for future use for ground water has been computed leaving the ground water projected for allocation for the domestic and industrial requirements (Next 25 years) for all the talukas The ground water available for future irrigation varies from 2416 ha m. in Bansda Taluka to 6820 ha m. in Gandevi Taluka and total of the same for the district is 24545 ha m.

5.2 Water Conservation & Artificial Recharge

1. The western part of the basin is under canal command area and the use of ground water has been restricted , especially in Purna basin. Large quantum of water is available in western side of Purna basin which needs to be harvested by construction of ground water structures for irrigation. Beside the ground water level in canal command area is generally within the depth of five meters below ground level and at places water logging conditions are noticed. Therefore, it is suggested that conjunctive use of surface water and ground water be adopted in canal command area. Some of the measures which can be adopted are (a) area within the canal command where water cannot be supplied be identified and farmers may be encourage to construct irrigation wells in such areas.
2. The water availability in canals may be restricted in such a manner that it should become necessary to use ground water also especially in summer. These measures would increase the utilization of ground water resources, prevents the problems arising due to water logging, minimize wasteful sub surface out flow and create space for aquifer replenishment during monsoon period.
3. In the eastern part of the basins, in the Deccan trap area, the yield of wells are comparatively poor. Since the rain fall in these part is generally high, suitable measures to augment the ground water resource may be adopted. Such measures could be contour bunding, gully plugging, small, check dams and bhandaras.
4. The surplus ground water potential may be utilized by construction of different ground water exploitation structures in favorable areas. Favorable locations for ground water structure are valley floors, valley fill area, large plateaus, amphitheatrical valleys meeting point of two or more nalas. Also where there is convergence of valley lines or where the drainage from different dimensions in the surrounding region tunned into a narrow catchment, the area can be favourable site for ground water structure.
5. In the higher plateau areas, rain water harvesting structures associated with storage tank can be constructed for domestic purpose since other sources would not be feasible .

6.0 Ground Water Related Problems

1. Beside the ground water level in canal command area is generally within the depth of five meters below ground level and at places water logging conditions are noticed. Therefore, it is suggested that conjunctive use of surface water and ground water be adopted in canal command area. Some of the measures which can be adopted are (a) area within the canal command where water cannot be supplied be identified and farmers may be encourage to construct irrigation wells in such areas.
2. In western part of the area , the quality of deep aquifer may be studied in detail. The ground water pollution by industries may also be studied in detail because of rapid increase of industrialisation in western part of the district in recent years.

7.0 Recommendations

1. The western part of the basin is under canal command area and the use of ground water has been restricted , especially in Purna basin. Large quantum of water is available in western side of Purna basin which needs to be harvested by construction of ground water structures for irrigation. Beside the ground water level in canal command area is generally within the depth of five meters below ground level and at places water logging conditions are noticed. Therefore, it is suggested that conjunctive use of surface water and ground water be adopted in canal command area. Some of the measures which can be adopted are (a) area within the canal command where water cannot be supplied be identified and farmers may be encourage to construct irrigation wells in such areas.
2. The water availability in canals may be restricted in such a manner that it should become necessary to use ground water also especially in summer. These measures would increase the utilization of ground water resources, prevents the problems arising due to water logging, minimize wasteful sub surface out flow and create space for aquifer replenishment during monsoon period.
3. In the eastern part of the basins, in the Deccan trap area, the yield of wells are comparatively poor. Since the rain fall in these part is generally high, suitable measures to augment the ground water resource may be adopted. Such measures could be contour buding, gully plugging, small, check dams and bhandaras.
4. In the Deccan tarp area, the wells which are partially penetrated the aquifer i.e. only the top portion of weathered or vesicular basalt, could be deepened down to underlying massive basalt.
5. For large scale ground water development programme, The entire basins should be divided into as many water sheds as possible and ground water resources of each water shed should be evaluated separately to minimize errors on account of heterogenety to basaltic aquifer.
6. The surplus ground water potential may be utilized by construction of different ground water exploitation structures in favourable areas. Favourable locations for ground water structure are valley floors, valley fill area, large plateaus, amphitheatrical valleys meeting point of two or more nalas. Also where there is convergence of valley lines or where the drainage from different dimensions in the surrounding region tunned into a narrow catchment, the area can be favourable site for ground water structure.
7. In hilly area for domestic purpose only shallow bore wells should be constructed and hand pumps may installed for extraction of water .
8. For deep bore wells detailed geophysical investigation is suggested because of the heterogenous nature of aquifer in basalt area.
9. The depth of 20metre and diameter of 4 metre is recommended for bottom of wells may of well to around 30metres. Lateral bores also enhance yield of wells.
10. No spacing is required in case of dug wells with discharge of less than 2 LPS. However, a distance of 200m for dug well/DCB with discharge of 2 to 5 Lps and 300 to 500m for shallow bore wells with a discharge of 5 to 10 Lps is recommended.
11. In the higher plateau areas, storage tank can be constructed for domestic purpose since other sources would not be feasible .
12. In western part of the area , the quality of deep aquifer may be studied in detail. The ground water pollution by industries may also be studied in detail because of rapid increase of industrialisation in western part of the district in recent years.

Annexure-I

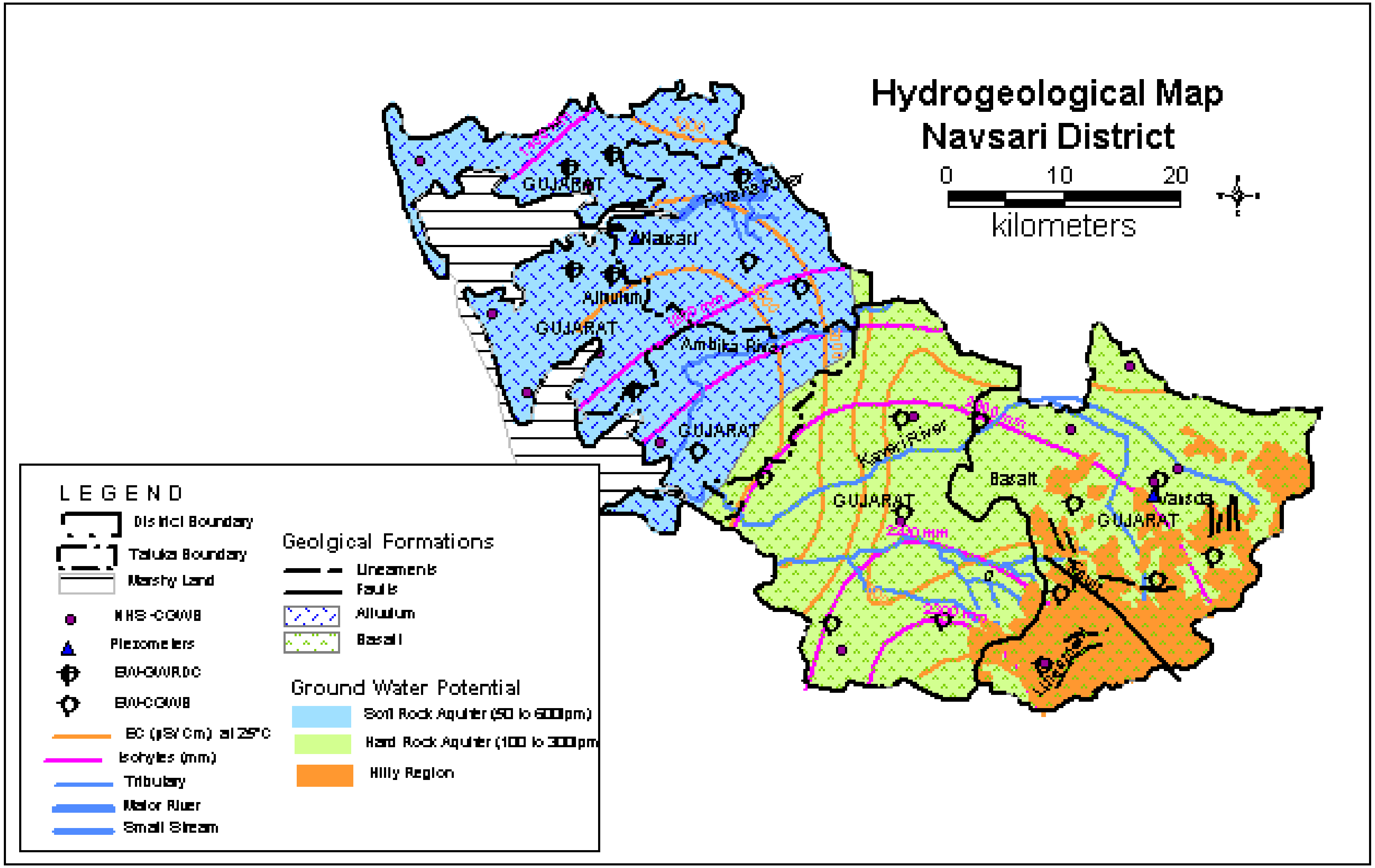
Taluka wise Rain Fall Data of Navsari District (mm.)

Year	Chikhali	Gandevi	Navsari	Vansada	Jalalpore
1974	1021	1402	833	1258	-
1975	2002	2516	1608	1969	-
1976	2920	3607	2376	3465	-
1977	2272	2629	1594	2298	-
1978	1567	1531	1143	1642	-
1979	1903	2082	1829	1486	-
1980	1862	2261	1360	1623	-
1981	2323	2636	1477	2392	-
1982	1356	1372	1048	1641	-
1983	2098	2390	1761	2134	-
1984	2075	1686	1606	1938	-
1985	1974	1510	1098	1597	-
1986	1511	1659	1140	1386	-
1987	1213	1019	762	1032	-
1988	2816	2379	2058	2397	-
1989	2360	1256	1115	1563	-
1990	1839	1150	1294	1728	-
1991	1571	919	879	1304	-
1992	2031	1678	1756	1957	-
1993	2509	1422	1369	2590	-
1994	4101	1241	2131	3047	-
1995	1470	1087	1199	1338	-
1996	1788	1243	1119	2368	-
1997	1968	1027	1060	1587	-
1998	2401	1645	1547	1960	1524
1999	1781	1517	973	2117	1041
2000	1685	1575	1250	1301	1194
2001	1842	2033	2012	1601	1799
2002	1288	1485	1393	1589	1082
2003	2063	2985	2932	1876	2426

Table :- Statistical Analysis of Rainfall Data (1974-2003)

Station	No. Of Years	Average Rainfall	St. Dev.	CV	Mini.	Year	Maxi.	Year
		(mm)	(mm)	%	(mm)		(mm)	
Chikhli	29	1987.0	596.93	30.04	1021	1974	4101	1994
Gandevi	29	1764.73	652.22	36.96	919	1991	3607	1976
Navsari	29	1457.20	491.71	33.74	762	1987	2932	2003
Vansda	29	1872.80	543.34	29.01	1032	1987	3465	1976
Jalalpore	06	1511.00	534.00	35.34	1041	1999	2426	2003

Plate-I


Hydrogeological Map
Navsari District
0
10
20
kilometers
GUJARAT
Naksari
Alluvium
Ambika River
Kaveri River
Basalt
Vansda
L E G E N D
District Boundary
Taluka Boundary
Marshy Land
NHS-CGWB
Piezometers
EW-GWRDC
EW-CGWB
EC (µS/Cm) at 25°C
Isohyets (mm)
Tributary
Major River
Small Stream
Geolgical Formations
Lineaments
Faults
Alluvium
Basalt
Ground Water Potential
Soft Rock Aquifer (50 to 600lpm)
Hard Rock Aquifer (100 to 300lpm
Hilly Region