Draft Report

केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report on

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN

Kavthe Mahankal and Miraj Talukas, Sangli District, Maharashtra

(Part-I)

मध्य क्षेत्र, नागपुर

Central Region, Nagpur

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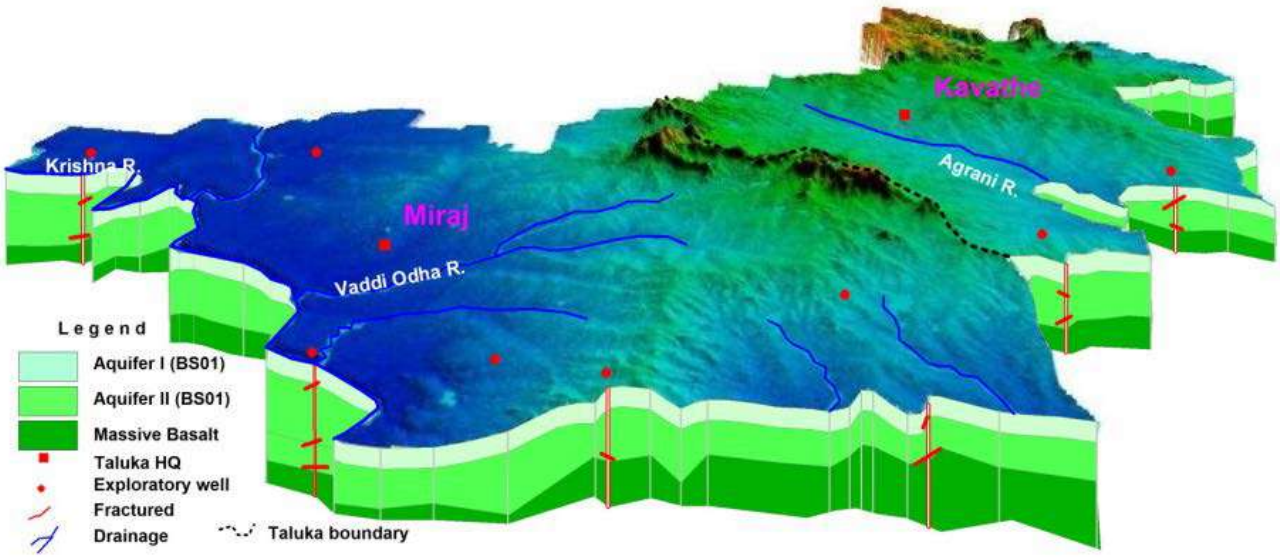
केन्द्रीय भूमिजल बोर्ड
CENTRAL GROUND WATER BOARD

जल बचत जल संचय

AQUIFER MAPS AND GROUND WATER MANAGEMENT PLANS FOR KAVTHE MAHANKAL AND MIRAJ TALUKAS, SANGLI DISTRICT, MAHARASHTRA



मध्य क्षेत्र, नागपुर
CENTRAL REGION, NAGPUR
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AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN FOR KAVTHE MAHANKAL AND MIRAJ TALUKAS, SANGLI DISTRICT, MAHARASHTRA

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AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN FOR KAVTHE MAHANKAL AND MIRAJ TALUKAS, SANGLI DISTRICT, MAHARASHTRA

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AQUIFER MAPS AND GROUND WATER MANAGEMENT PLAN FOR KAVTHE MAHANKAL AND MIRAJ TALUKAS, SANGLI DISTRICT, MAHARASHTRA

1 INTRODUCTION

In XII five year plan, National Aquifer Mapping (NAQUIM) had been taken up by CGWB to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. The NAQUIM has been prioritised to study Over-exploited, Critical and Semi-Critical talukas as well as the other stress areas recommended by the State Govt. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

The vagaries of rainfall, inherent heterogeneity & unsustainable nature of hard rock aquifers, over exploitation of once copious alluvial aquifers, lack of regulation mechanism has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "**traditional groundwater development concept**" to "**modern groundwater management concept**".

Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide the **"Road Map"** for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation. The aquifer maps and management plans will be shared with the Administration of Kavthe Mahankal and Miraj Talukas, Sangli District, Maharastra for its effective implementation.

1.1 Objective and Scope

Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan. The activities under NAQUIM are aimed at:

- identifying the aquifer geometry,
- aquifer characteristics and their yield potential
- quality of water occurring at various depths,
- aquifer wise assessment of ground water resources
- preparation of aquifer maps and
- Formulate ground water management plan.

This clear demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The

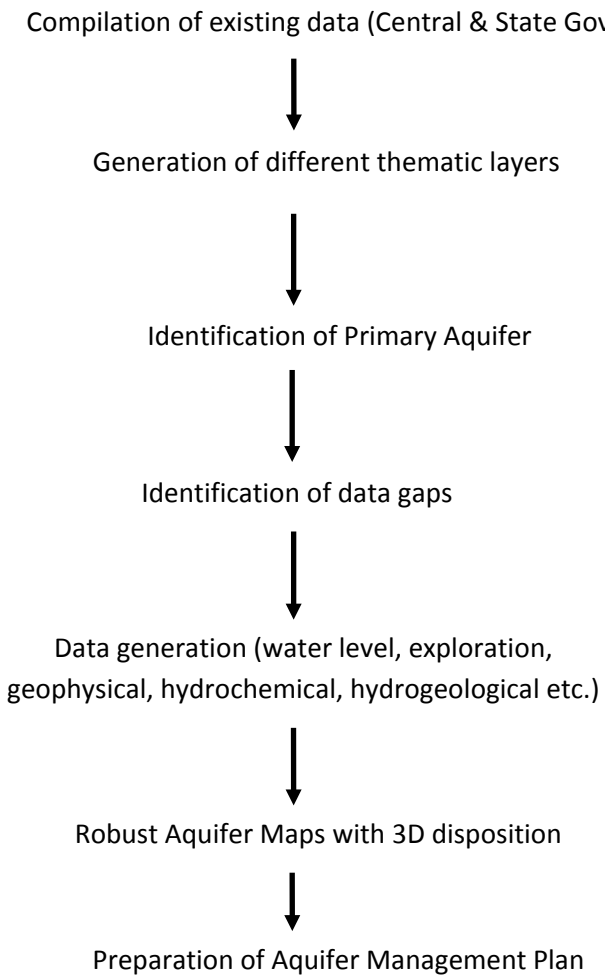
robust and implementable ground water management plan will provide a **"Road Map"** to systematically manage the ground water resources for equitable distribution across the spectrum.

Kavthe Mahankal and Miraj Talukas, of Sangli District, Maharastra are spread over an area of 749.53 and 954.06 sq.km respectively and have been entirely covered during the Annual Action Plan of 2016-17.

1.2 Approach and Methodology

The ongoing activities of NAQUIM include toposheet wise micro-level hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200 / 300 meters.

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilisation for preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:



1.3 Study area

Keeping in view the current demand and supply and futuristic requirement of water, Central Ground Water Board has taken up the National Aquifer Mapping Programme (NAQUIM) in

India during XII five year plan (2012-17). An area of 1703.59 sq. km. was selected for NAQUIM activities during the year 2016-17 in Kavthe Mahankal and Miraj Talukas, Sangli District, Maharastra. The index map of the study area is presented in **Fig.1.1.**

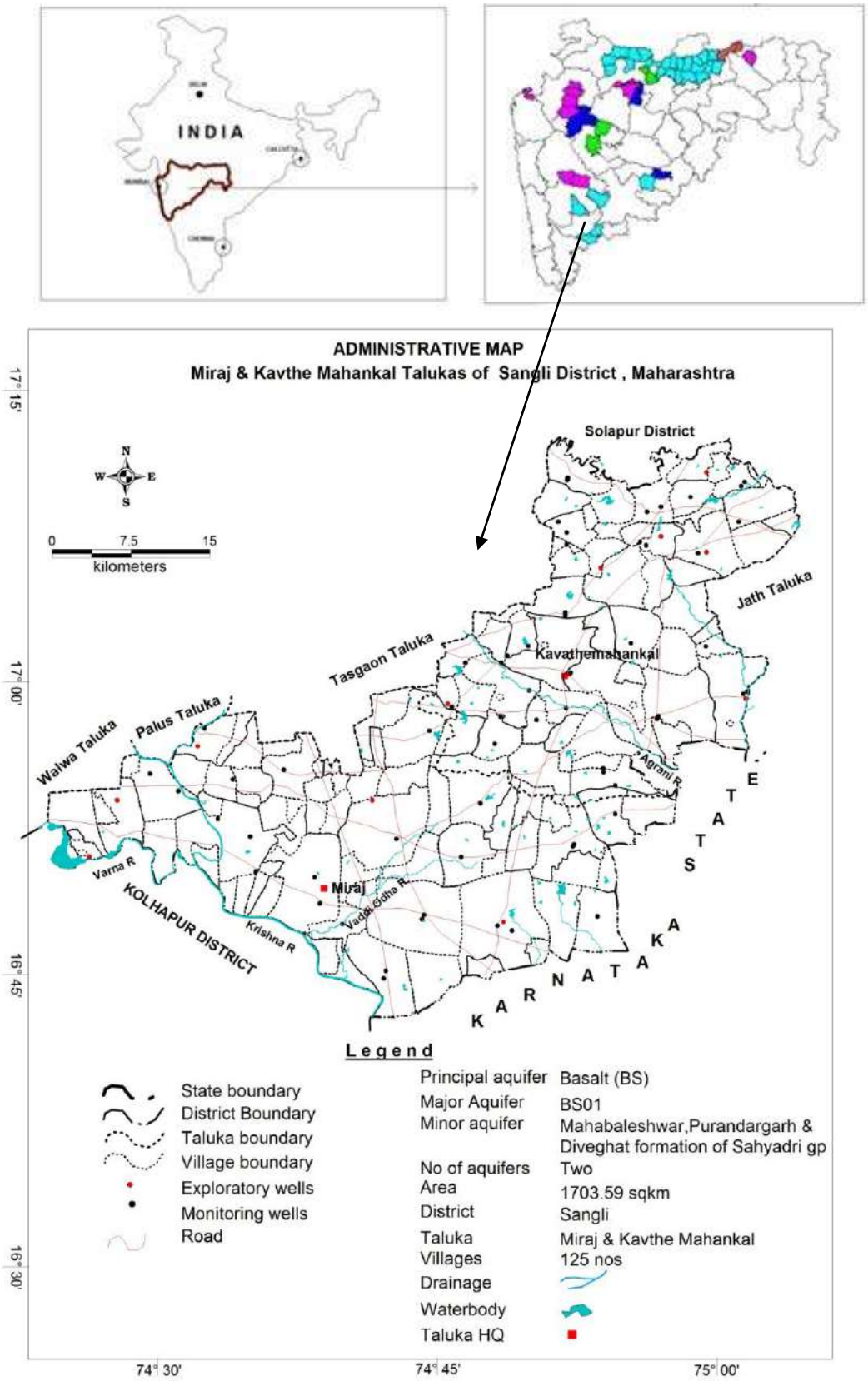


Fig. 1.1: Index map,

These talukas are categorized as Critical/Semi-Critical, as per Ground Water Resources Estimation carried out by CGWB and GSDA as on March 2013.

1.4 Data Adequacy and Data Gap Analysis:

The available data of the Exploratory wells drilled by Central Ground Water Board, Central Region, Nagpur, Geophysical Survey carried out in the area, Ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analysed for adequacy of the same for the aquifer mapping studies. The locations of existing exploratory wells and ground water monitoring wells which are also used as ground water quality sampling locations are shown in **Fig. 1.2**. In addition to these, the data on ground water monitoring stations and ground water quality stations of the State Govt. (GSDA) was also utilised for data adequacy and data gap analysis. The data adequacy and data gap analysis was carried out for each of the quadrant of falling in the study area mainly in respect of following primary and essential data requirements:

- Exploratory Wells
- Geophysical Surveys
- Ground Water M onitoring and
- Ground Water Q uality

After taking into consideration, the available data of Ground Water Exploration, Geophysical survey, Ground Water Monitoring and Ground Water Quality, the data adequacy is compiled and the summarised details of required, existing and data gap of Exploratory wells, Ground Water monitoring and Ground water quality stations is given below **(Table 1.1)** and discussed in detail.

Table – 1.1: Data Adequacy and Data Gap Analysis

Taluka	EXPLORATORY DATA			GEOPHYSICAL DATA			GW MONITORING DATA (AQI)			GW MONITORING DATA (AQII)			GW QUALITY DATA (AQI)			GW QUALITY DATA (AQII)		
	Req.	Exist.	Gap	Req.	Exist	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap
Kavthe Mahankal	10	8	2	33	0	33	11	24	13	10	8	2	11	24	13	10	8	2
Mira j	7	5	2	42	0	42	14	18	8	7	5	2	14	18	8	7	5	2
	17	**13**	**4**	**75**	**0**	**75**	**25**	**42**	**21**	**17**	**13**	**4**	**25**	**42**	**21**	**17**	**13**	**4**

1.5 Data Gap Identification

The data adequacy as discussed in the above table 1.1, data gap exist in exploration, water level and quality have been achieved during data generation and only data gap exists in Geophysical Survey (VES). Exploratory Wells, Ground Water Level Monitoring and Ground Water Quality, there is no data gap. Location of existing exploratory wells GW level monitoring stations are presented in **Fig. 1.2**.

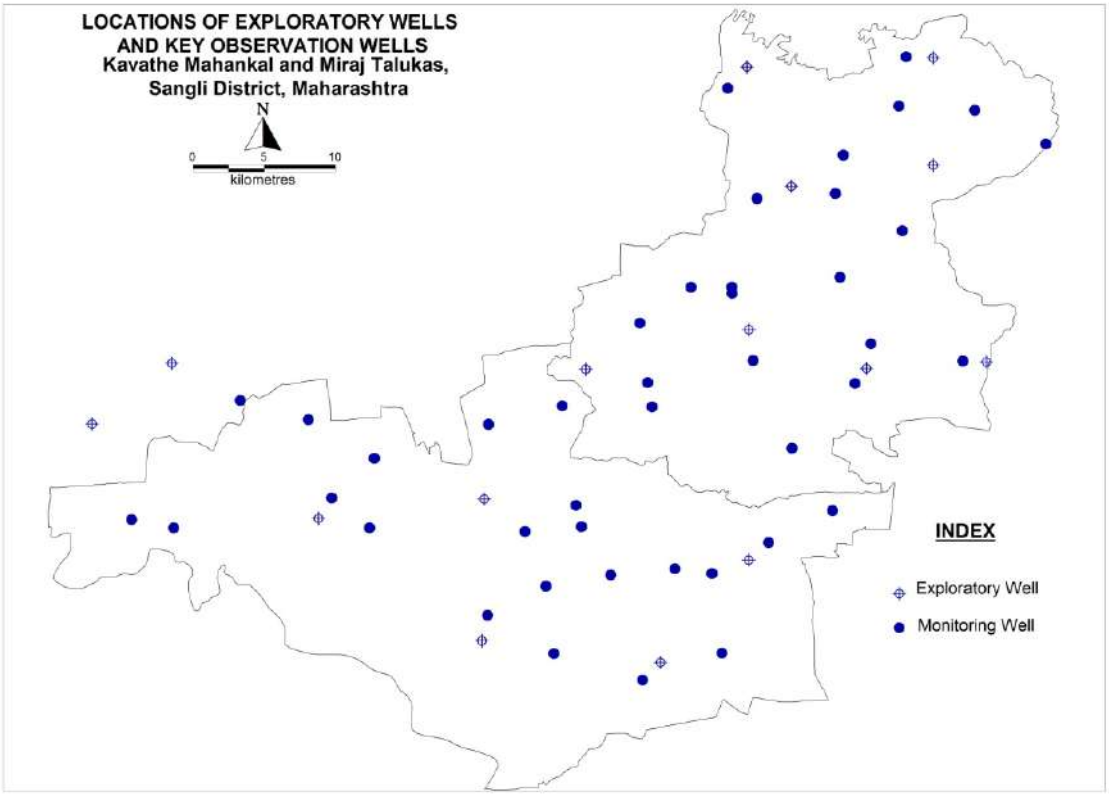


Fig 1.2: Locations of Existing Exploratory Wells and Ground Water Monitoring Wells.

1.6 Climate and Rainfall

The area experiences the sub-tropical to tropical temperate monsoon climate with a hot summer and general dryness throughout the year except during the south-west monsoon season. The climate of the area is characterised by three distinct seasons: summer, monsoon and winter. Typical summer months are from February to May, with maximum temperatures ranging from 30 to 40 °C. The warmest month is May. The monsoon lasts from June to end of September, with moderate rainfall. Winter months are October to January. The average wind speed recorded is 7.4 km/h.

Rainfall data of rain gauge stations located at taluka headquarters of Kavthe Mahankal and Miraj have been collected from available sources and are subjected to various types of statistical analysis to understand the characteristic of the rainfall. The annual rainfall data for the period 2007 to 2016 is presented in Table-1.2.

The perusal of data indicates that in Kavthe Mahankal Taluka, the minimum rainfall of 312.5 mm was received in the year 2012, whereas maximum rainfall of 628.8 mm was received in the year 2016 while in Miraj Taluka, the minimum rainfall of 433.6 mm was received in the year 2008, whereas maximum rainfall of 823 mm was received in the year 2009. The average annual rainfall for the decade was found to be 493 mm and 624.66 mm in Kavthe Mahankal and Miraj Talukas respectively and it is presented in Fig- 1.3. Annual Normal Rainfall and Rainfall during 2016 are shown in **Fig.1.3** and **Fig. 1.4** respectively. The figure indicates that the rainfall is increasing from east to west and is maximum (>600 mm) in the western part.

Table 1.2: Annual Rainfall Data - 2007-2016 (mm)

Taluka	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	**Average**
Kavthe Mahankal	511.2	463	608.1	584.5	403.5	312.5	404.3	574.2	445.2	628.8	493.53
Miraj	622.8	433.6	823	757.6	522.8	642	523.6	664.6	508.8	747.8	624.66

The analysis of long term rainfall data pertaining to the period 1998-2016 has also been carried out for Kavthe Mahankal and Miraj Talukas, Sangli District (**Annexure-I**) and the probability of occurrence of normal annual rainfall has been studied over the study area. It was observed that the distribution of rainfall is more or less uniform over the area. The rains usually start in the second week of June and last till the end of September. The intensity of rainfall is the highest in July. It is observed that the

- The chance of receiving normal annual rainfall varies from 58 to 68%.
- The coefficient of variation of annual rainfall from normal varies from 27 to29%.
- The percentage probability of receiving excess rainfall (i.e. 25% or more in excess of the normal) is around 16% i.e. once in 6 to 7 years.
- The probability of occurrence of moderate drought is around 11 to 16%, i.e. one drought in every 7 to 9 years.

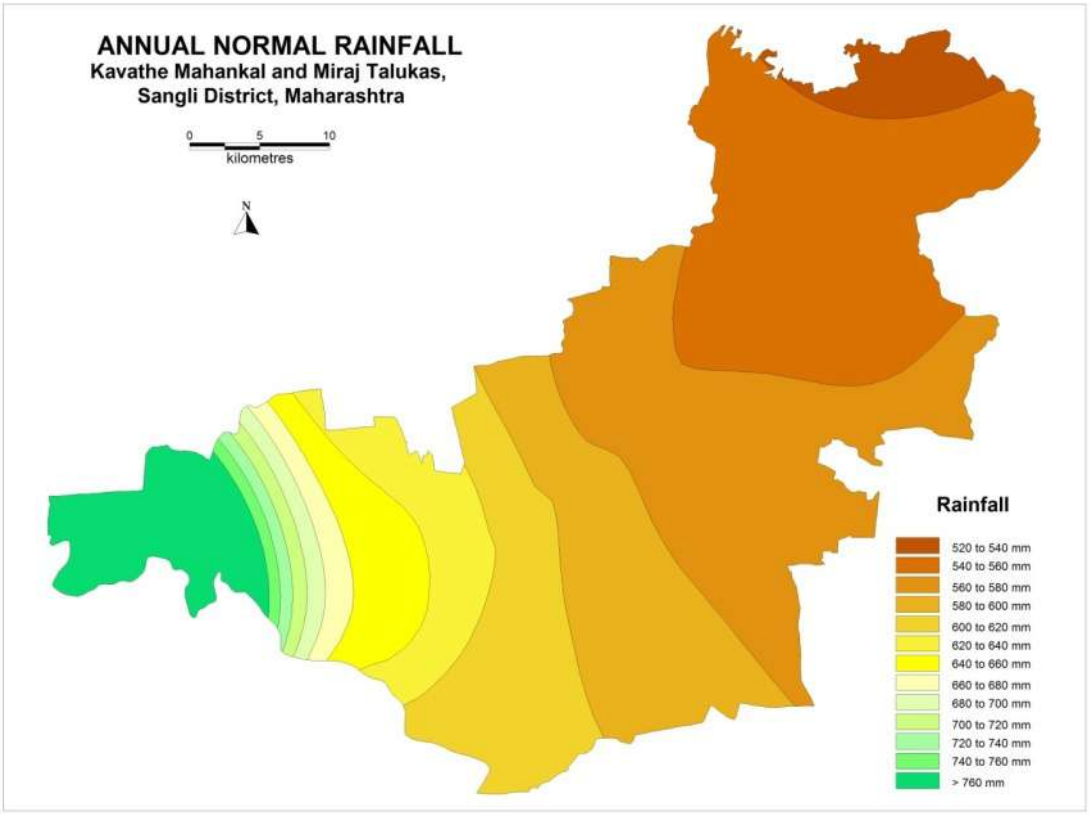


Fig. 1.3 Annual Normal Rainfall

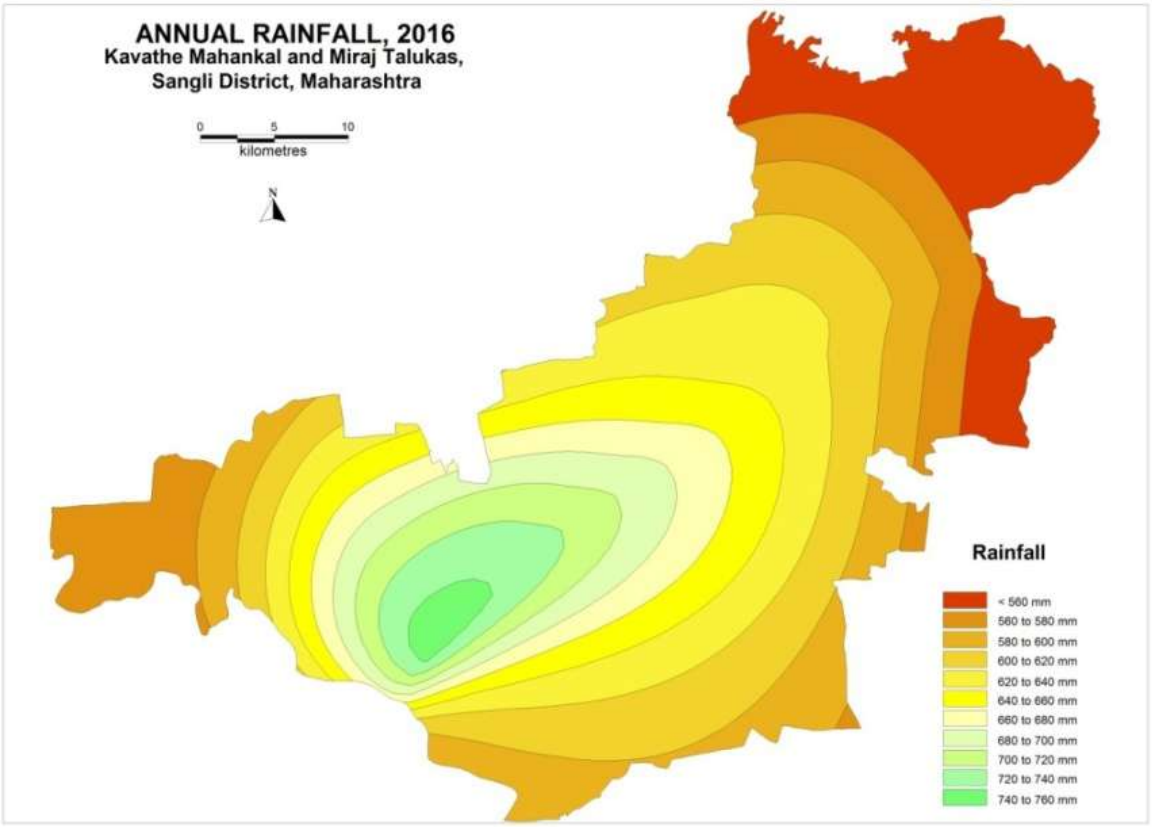


Fig. 1.4 Rainfall (2016)

The short term rainfall analysis for the period 2006-2015 infdicates that average rainfall of Kavthe Manhakal and Miraj talukas are 494.97 and 433.6 mm respectively, whereas the long term rainfall data for 20 years (1998-2016) for both these talukas was also analysed and it indicates that normal rainfall of Kavthe Manhakal and Miraj talukas are 520.3 mm and 584.8 mm respectively **.** The current rainfall (2015) for these two talukas was 445 mm (14% deficient) and 508 mm (13% deficient). From the decadal rainfall trend analysis from 2006 to 2015 it's observed that, both the stations have significant falling rainfall trend . In Last five years, four year rain fall are showing decline trend in the range of 10% to 40 % from normal rainfall (Table 1.3). Thus indicating that both these talukas are experiencing low and declining rainfall with frequent droughts.

Table 1.3 Rainfall data of last five year.

YEAR	Kavthe Mahankal			Miraj		
	ANNUAL	DEP %	CATEGORY	ANNUAL	DEP%	CATEGORY
2011	403.5	-22	NORMAL	522.8	-11	NORMAL
2012	312.5	-40	MODERATE	642	10	NORMAL
2013	404.3	-22	NORMAL	523.6	-10	NORMAL
2014	574.2	10	NORMAL	664.6	14	NORMAL
2015	445.2	-14	NORMAL	508.8	-13	NORMAL

1.7 Physiography

The Kavthe Mahankal and Miraj Talukas, Sangli District has hilly terrain especially towards the south-East where it is surrounded by ranges of Sahyadri Mountains (Western Ghats). The terrain is intersected by the River Krishna and its three tributaries. The river Krishna rises in the western Ghat and outflows from the area to the neighbouring Karnataka and Andhra State and finally discharges itself in the bay of Bengal.

The area can be broadly divided into three physiographic units i.e., Older Flood Plain (513-560 mamsl), Region of Denudational origin (550-600 mamsl), Middle Level Plateau (600-900 mamsl), High Level Plateau (>900 mamsl). The western part of the area is occupied by hills, the central part by hillocks and the eastern part by nearly plain terrain with few isolated mounds, dissected by valleys of Krishna River and other tributaries like Agrani River Varna River and Vaddi odha. The height of the hillocks vary between 100 to 150 m above the ground level. The minimum elevation in the area is 560 m above mean sea level and the maximum being 780 m above mean sea level. The physiography of the area is shown in **Fig. 1.5**

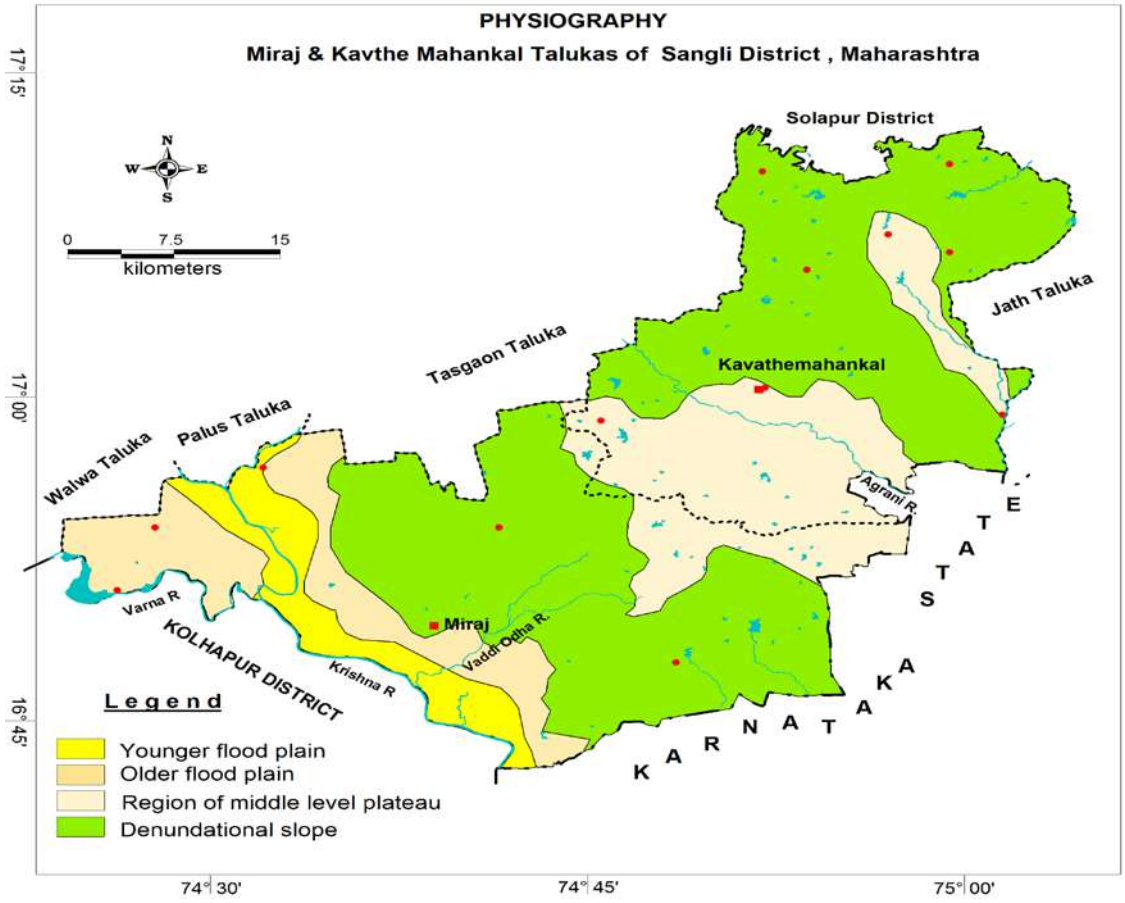


Fig.1.5: Physiography

1.8 Geomorphology

Geomorphologically, the Kavthe Mahankal and Miraj Talukas, of Sangli District forms part of Deccan Plateau. The analysis of geomorphological data and thematic map collected from MRSAC, Nagpur reveals that almost entire area forms the Upper Plateau-Highly Dissected (HDP), which can be broadly divided in to nine units depending on extent of weathering and thickness of soil cover viz. Plateau Undissected (PLU) with less than 1m weathering, Plateau Slightly Dissected (PLS) with less than 1m weathering, Plateau Moderately Dissected (PLM), Plateau Highly Dissected (PLH), Plateau slightly Weathered (PLWS), Plateau Weathered (PLWS) with 1-2m weathering and Escarpment Slope (ES), Butte (B)and Mesa (M). The geomorphology of the area is shown in **Fig. 1.6.**

1.9 Land Use, Agriculture, Irrigation and Cropping Pattern

Agriculture is the prominent land use aspects in Kavthe Mahankal and Miraj Talukas, and forms 81.46% of total area. North Eastern part of study area is undulating and hilly where mostly cereals are grown, whereas the major agricultural activity is restricted in the southern and central part corresponding with the valley part. The spatial distribution of land use is presented in **Fig. 1.7** The agricultural distribution of crops shows that cereals like Ragi, Wheat, Jowar, Maize and Small Millets etc., being grown in 789.08 sq.km area of Kavthe Mahankal and Miraj Talukas whereas pulses like tur, gram, udid, moong, val etc., being grown in 193.92 sq.km., the cash crop predominantly sugarcane is also cultivated in 148.1 sq.km. The Taluka wise break up of Land Use, Agriculture and Irrigation is given in Table-1.2.

The surface water based irrigation caters to the major area i.e., 244.53 sq.km. (18 % of cultivable area), out of which 180.26 sq.km is due to Krishna –Koyana canal command irrigation project whereas minor irrigation schemes like Mhaisal , Tembhu and Takari are able to irrigate 64.27 sq.km. area. The ground water development in the area is high and the same is also reflected in the irrigated area which is about 95.16 sq.km (7% of cultivable area). There are 9294 dugwells in the Miraj taluka and 7100 dugwells in the Kavthemahankal taluka

Table 1.4: Land use and cropping pattern

Name of the Taluka	Cultivable	Forest	Agricultural Land Break up					GW irrigated	SW irrigated
			Paddy	Cereals	Pulses	Sugarcane	Grapes		
Miraj	806.35	10.79	9.6	439.1	123.85	138	9.1	71.2	180.26
Kavthemahanka	581.02	9.24	0	349.98	70.07	10.1	2.15	23.96	64.27
Total	1387.37	20.03	9.6	789.08	193.92	148.1	11.25	95.16	244.53

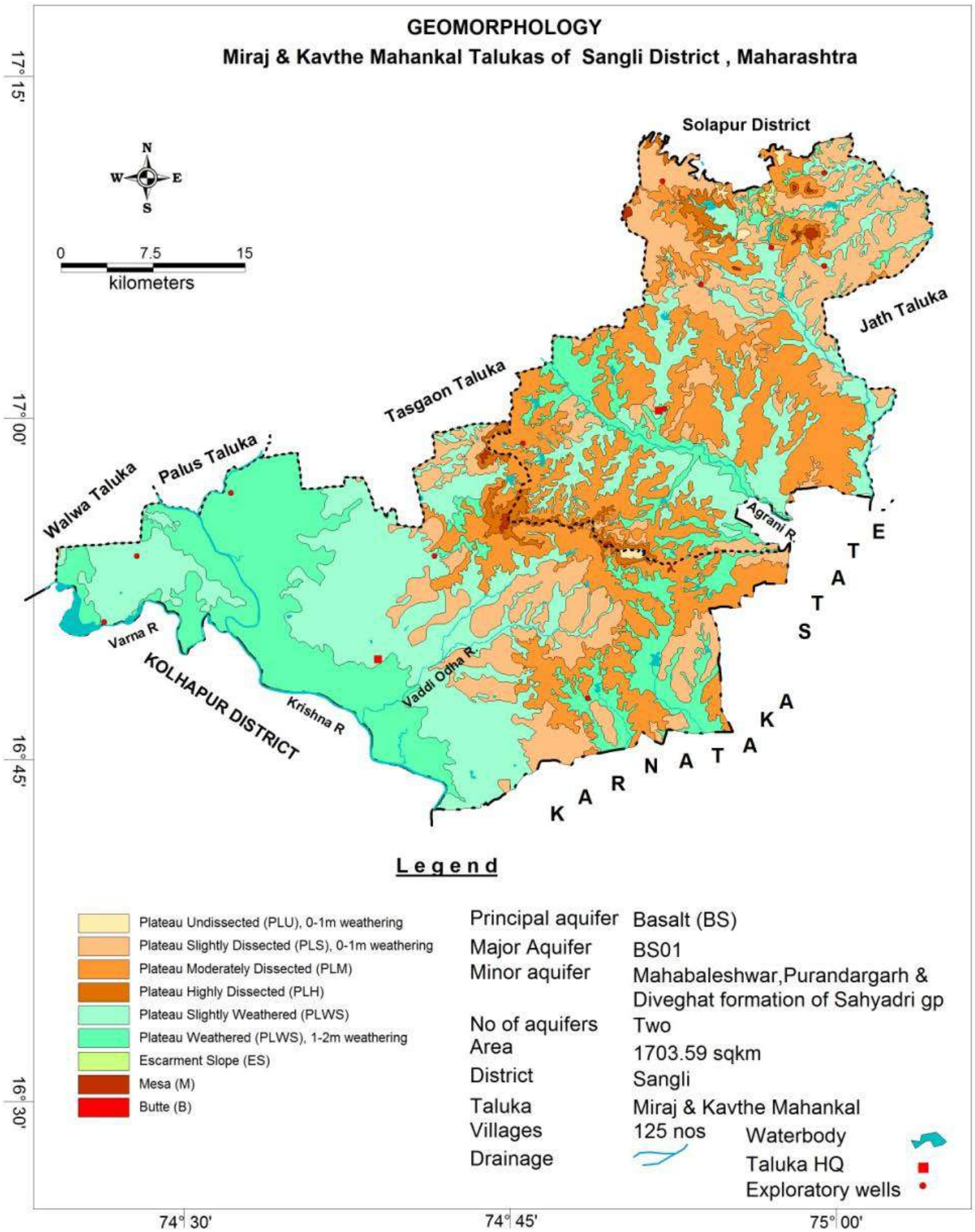


Fig.1.6: Geomorphology

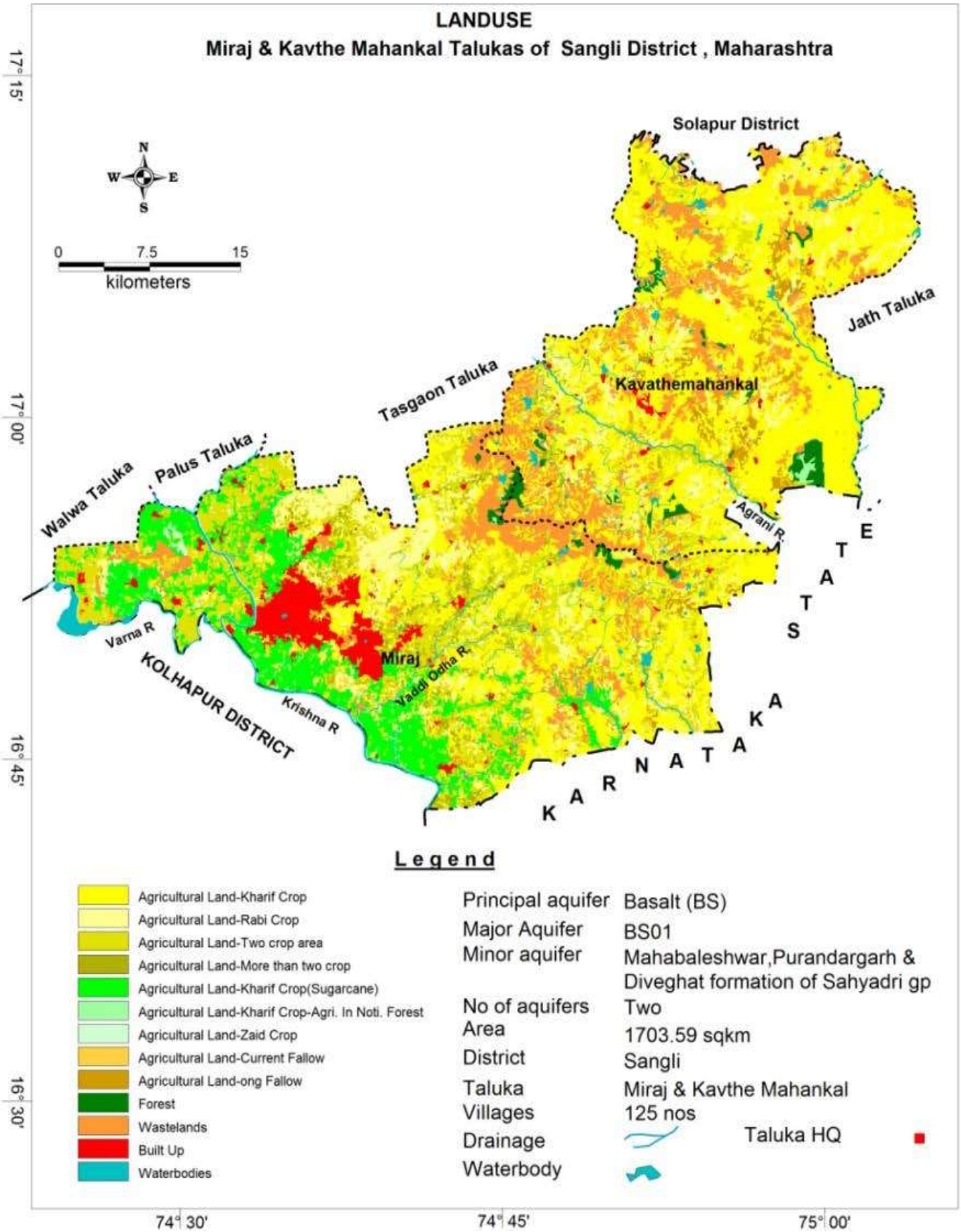


Fig.1.7: Land Use

1.10 Soil

The soil data and the thematic map of the area available with the MRSAC, Nagpur has been collected and analysed. It has been observed that the major part of the area is occupied by clayey soil and clayey loam, especially around the drainage lines, followed by sandy loam. Gravelly sandy clay type of soils occupies mainly the high hill slopes and barren wastelands of the area. The thematic map on the soil distribution in the study area is shown in **Fig. 1.8,** and taluka wise soil are presented in **table 1.5**

Table 1.5: Taluka wise soil

Taluka	Area (SQkm)	Texture and depth
Kavthe Mahankal	0.791969	Clayey-Shallow (10 to 25 cm)
Kavthe Mahankal	67.6481	Clayey-Moderately deep (25 to 50 cm)
Kavthe Mahankal	56.8542	Clayey-Deep (50 to 100 cm)
Kavthe Mahankal	164.309	Clayey-Very deep (> 100 cm)
Kavthe Mahankal	15.4944	Clay loam-Moderately deep (25 to 50 cm)
Kavthe Mahankal	0.868064	Clay loam-Deep (50 to 100 cm)
Kavthe Mahankal	21.9541	Sandy clay loam-Very deep (> 100 cm)
Kavthe Mahankal	35.4623	Gravelly sandy loam-Shallow to very shallow (< 25 cm)
Kavthe Mahankal	45.709	Gravelly sandy loam-Very shallow (< 10 cm)
Kavthe Mahankal	270.611	Gravelly sandy loam-Shallow (10 to 25 cm)
Kavthe Mahankal	8.58888	Gravelly sandy clay loam-Very shallow (< 10 cm)
Kavthe Mahankal	20.8324	Gravelly sandy clay loam-Shallow (10 to 25 cm)
Kavthe Mahankal	9.67972	Gravelly clay loam-Moderately deep (25 to 50 cm)
Kavthe Mahankal	10.2152	Waterbody Mask-Waterbody Mask
Kavthe Mahankal	6.76066	Habitation Mask-Habitation Mask
Miraj	1.65266	Clayey-Shallow (10 to 25 cm)
Miraj	196.18	Clayey-Moderately deep (25 to 50 cm)
Miraj	87.9772	Clayey-Deep (50 to 100 cm)
Miraj	436.22	Clayey-Very deep (> 100 cm)
Miraj	13.2588	Clay loam-Moderately deep (25 to 50 cm)
Miraj	0.41665	Gravelly sandy loam-Very shallow (< 10 cm)
Miraj	97.2921	Gravelly sandy loam-Shallow (10 to 25 cm)
Miraj	18.755	Gravelly sandy clay loam-Very shallow (< 10 cm)
Miraj	12.4863	Gravelly clay loam-Moderately deep (25 to 50 cm)
Miraj	11.3888	Waterbody Mask-Waterbody Mask
Miraj	52.027	Habitation Mask-Habitation Mask

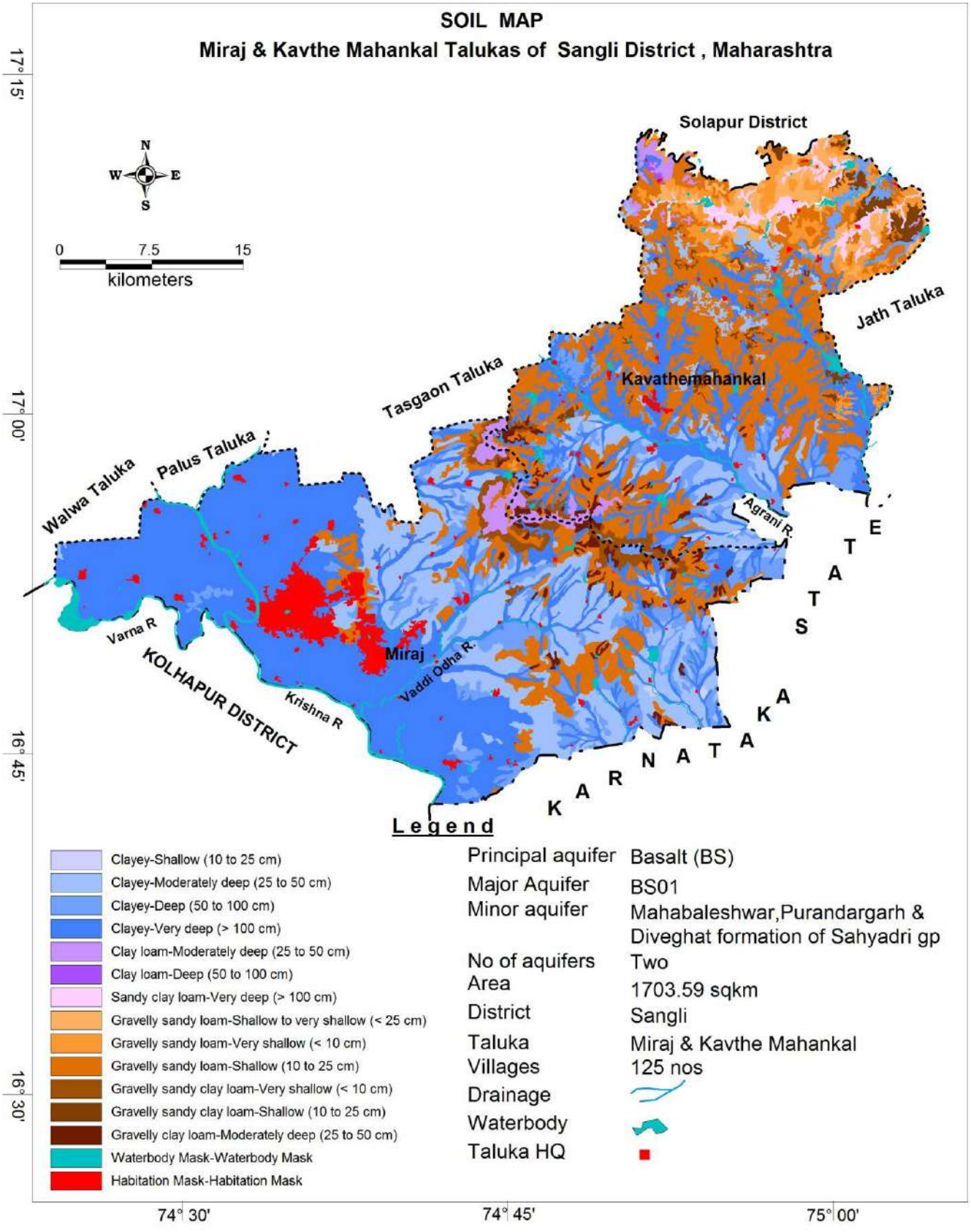

SOIL MAP
Miraj & Kavthe Mahankal Talukas of Sangli District , Maharashtra
Solapur District
Jath Taluka
Tasgaon Taluka
Kavathemahankal
Palus Taluka
Walwa Taluka
Agrani R.
Varna R
Miraj
Vaddi Odha R.
Krishna R
KOLHAPUR DISTRICT
MAHARASHTRA
KARNATAKA STATE
N
S
E
W
0
7.5
15
kilometers
17° 15'
17° 00'
16° 45'
16° 30'
74° 30'
74° 45'
75° 00'
Legend
Clayey-Shallow (10 to 25 cm)
Clayey-Moderately deep (25 to 50 cm)
Clayey-Deep (50 to 100 cm)
Clayey-Very deep (> 100 cm)
Clay loam-Moderately deep (25 to 50 cm)
Clay loam-Deep (50 to 100 cm)
Sandy clay loam-Very deep (> 100 cm)
Gravelly sandy loam-Shallow to very shallow (< 25 cm)
Gravelly sandy loam-Very shallow (< 10 cm)
Gravelly sandy loam-Shallow (10 to 25 cm)
Gravelly sandy clay loam-Very shallow (< 10 cm)
Gravelly sandy clay loam-Shallow (10 to 25 cm)
Gravelly clay loam-Moderately deep (25 to 50 cm)
Waterbody Mask-Waterbody Mask
Habitation Mask-Habitation Mask
Principal aquifer Basalt (BS)
Major Aquifer BS01
Minor aquifer Mahabaleshwar,Purandargarh & Diveghat formation of Sahyadri gp
No of aquifers Two
Area 1703.59 sqkm
District Sangli
Taluka Miraj & Kavthe Mahankal
Villages 125 nos
Drainage
Waterbody
Taluka HQ

Fig.1.8: Soil

1.11 Hydrology and Drainage

The Kavthe Mahankal and Miraj Talukas, of Sangli District lies in the middle of the undulating watershed of the Krishna River, which forms the southern border of study area. The towns of Sangali and Miraj lie on the north bank of the river. The major river of the area is Krishna which flows in NW-SE direction. The major tributaries of Krishna River are Varna River, Vaddi odha and Agrani river. The drainage and hydrology map of the Kavthe Mahankal and Miraj Talukas of Sangli District is shown in **Fig. 1.9**. and watershed map in **Fig 1.10** ,detail of water shed are presented in **Table 1.6**

Table 1.6: Detail of water shed

Region	Basin	Catchment	Subcatchment	Watershed	Sub Water shed	Area
Bay of Benga	Krishna	Main Krishna above confl. With Bhima	Main upper most Krishna and Yerla	Kapur	KR-35	11.4992
			LB Krishna upto confl. With Yerla near Sangli	Agran	KR-51	158.624
			LB Krishna upto confl. With Yerla near Sangli	Agran	KR-36	54.124
			Main upper most Krishna and Yerla	Krishna	KR-41	25.5542
			LB Krishna upto confl. With Yerla near Sangli	LB Krishna	KR-50	375.786
			LB Krishna upto confl. With Yerla near Sangli	Agran	KR-39	192.833
			Panchganga Varna	Varna	KR-48	87.1077
			LB Krishna upto confl. With Yerla near Sangli	Agran	KR-37	209.901
			LB Krishna upto confl. With Yerla near Sangli	LB Krishna	KR-40	238.006
			LB Krishna upto confl. With Yerla near Sangli	Agran	KR-38	133.13
		Upper Bhima above confl. with Sina	RB Bhima Sina to Man	Debucha	BM-115	71.8407
			RB Bhima Sina to Man	Bsalven K	BM-116	59.4212
			RB Bhima Sina to Man	Bsalven K	BM-117	47.5003

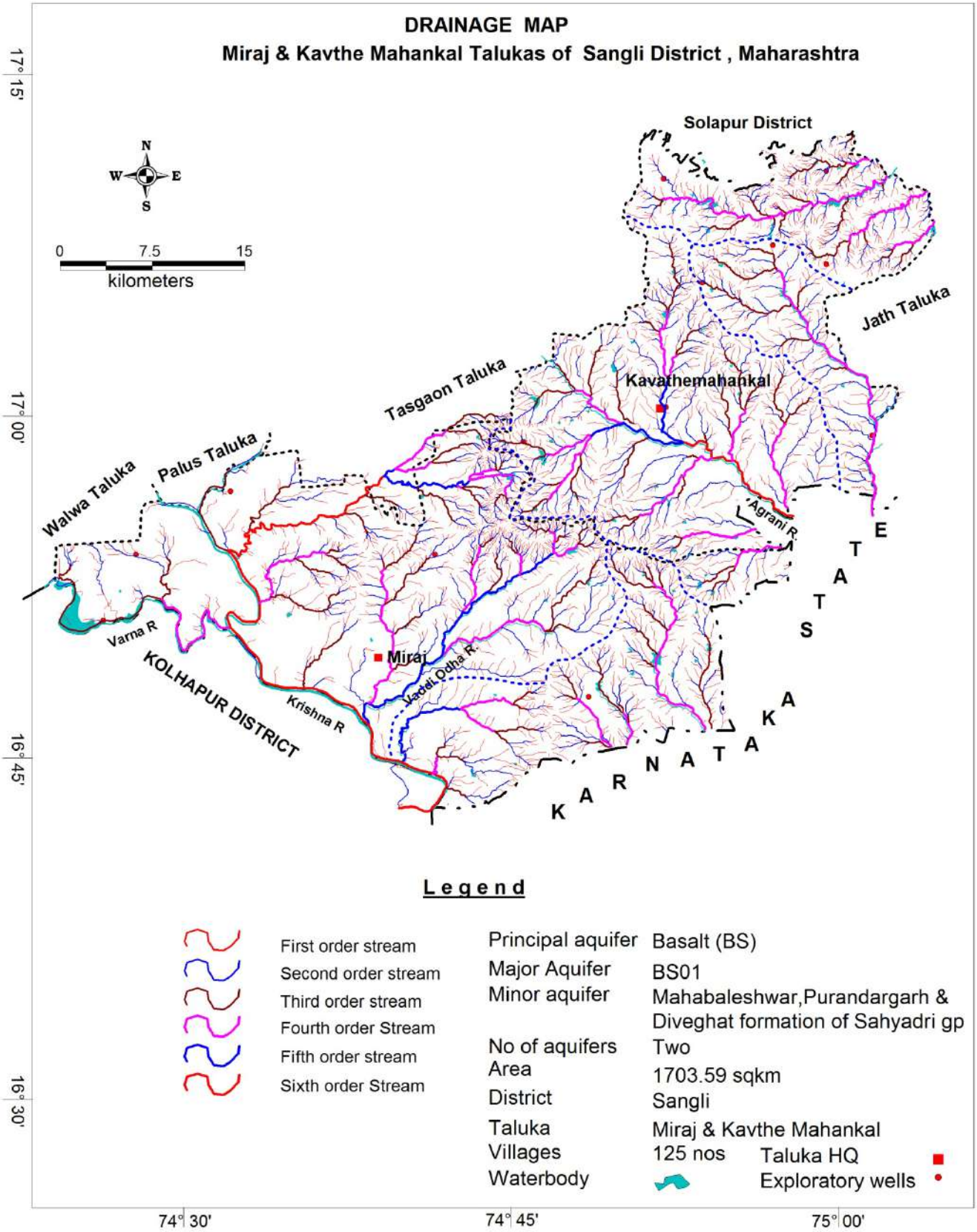


Fig.1.9: Drainage

The study area has one medium and 17 minor irrigation project and it caters to the irrigation and drinking water requirements of Kavthe Mahankal and Miraj Talukas, of Sangli District.

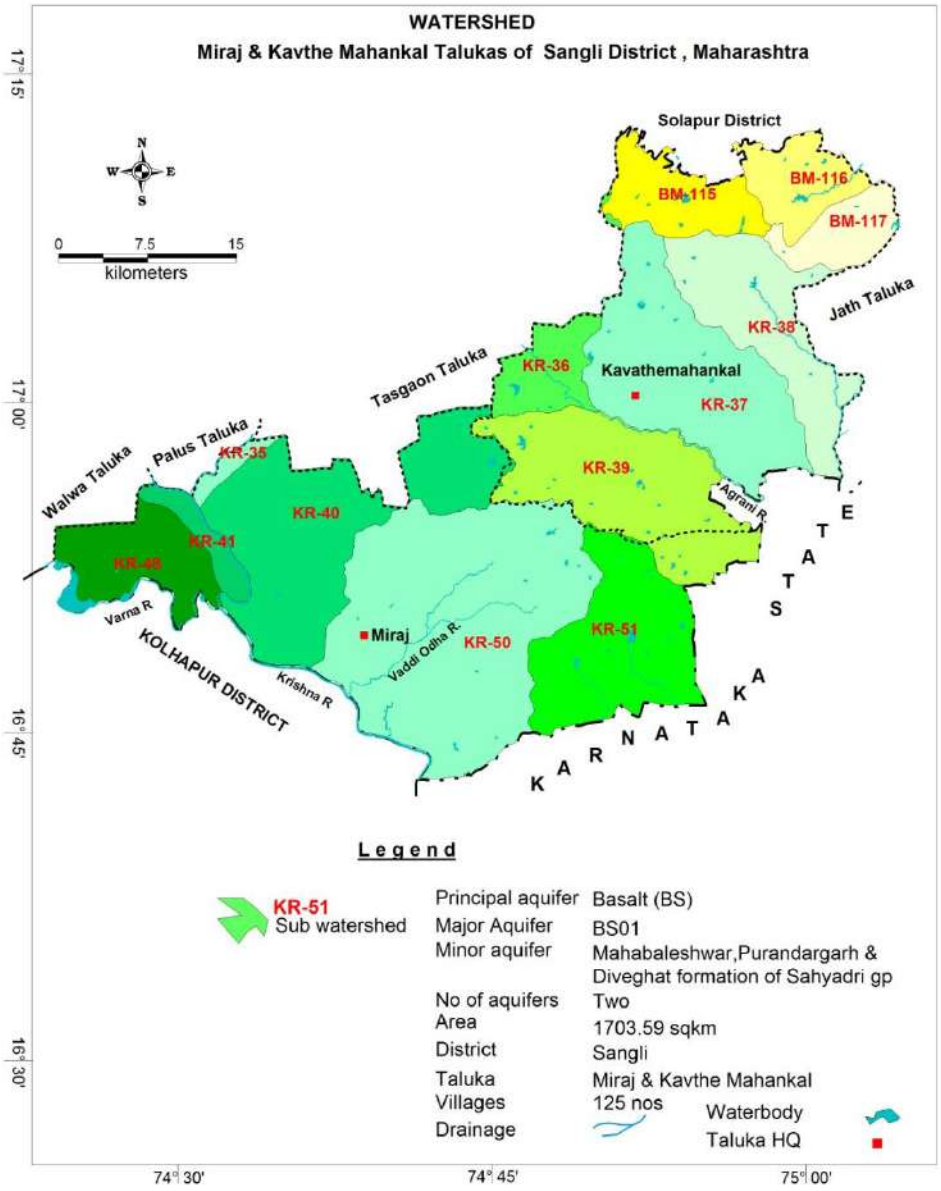


Fig 1.10 Watershed map

1.12 Prevailing Water Conservation and Recharge Practices

The study area has the rainfall in the range of 500 to 600 mm, hence the need for water conservation and artificial recharge is felt much by the people as well as the District administration. However as per the data available percolation tanks /check dams are the most preferred water conservation structures in the study area. At present, in the study area of the Sangli District administration has constructed about 196 percolation tanks (PT) (145 in Kavthe Mahankal and 51 in Miraj taluka) and 39 check dams (CD) (30 in Kavthe Mahankal and 9 in Miraj taluka) spread across the study area.

2 DATA COLLECTION AND GENERATION

The primary data such as water levels, quality and lithological inputs were available with CGWB as well as GSDA, Govt. of Maharashtra has been collected and utilised as baseline data. However, the ancillary data such as numbers of ground water abstraction structures, irrigation facilities, rainfall etc., have been collected from the various State Govt. Departments and compiled and validated so as to remove the discrepancies and make it utilisable on GIS platform.

2.1 Data Collection and Compilation

The data collection and compilation for various components was carried out as given below.

i. Hydrogeological Data – Current and historical water levels along with water level trend data of 18 and 24 monitoring wells in Miraj and Kavthe Mahankal talukas respectively representing Aquifer-I. The water levels of 5 and 8 exploratory wells in Miraj and Kavthe Mahankal talukas respectively representing Aquifer-II were also collected and compiled.

ii. Hydrochemical Data - Ground water quality data of 33 monitoring wells each in Miraj and Kavthe Mahankal talukas representing Aquifer-I of CGWB and data of 10 and 8 exploratory wells in Miraj and Kavthemahankal talukas respectively representing Aquifer-II were also collected and compiled.

iii. Exploratory Drilling – Ground water exploration data of CGWB of 10 exploratory wells and 3 observation wells in Kavthe Mahankal taluka and 7 exploratory wells in Miraj Taluka.

iv. Geophysical Data – No Geophysical Surveys were carried out Miraj and Kavthe Mahankal talukas.

v. Hydrology Data – Data on various irrigation projects, their utilisation status, number of ground water abstraction structures and area irrigated from Irrigation Department were compiled.

vi. Hydrometeorological Data - Long term rainfall data for each of the Talukas from IMD and Dept. of Agriculture were complied.

vii. Water Conservation Structures – Numbers, type and storage potential of water conservation structures prevailing in the area from Dept. of Agriculture, ZP, Social forestry etc. were complied.

viii. Cropping Pattern Data – Data on prevailing cropping pattern from Agriculture Dept. were complied.

2.2 Data Generation

After taking into consideration, the data available with CGWB on Ground Water Exploration, Geophysical survey, Ground Water Monitoring Wells (GWMW) and Ground Water Quality, the data adequacy was compiled and it indicated that exploratory drilling is required at 4 locations, ground water monitoring wells are required at 21 locations for water level and water quality sampling. The requirement, availability and gap of major data inputs i.e., exploratory wells, geophysical data, GWMW and ground water

quality data are detailed in the **Table 2.1**. Based on Data Gap Analysis, all the necessary data was generated except VES as discussed below.

Table – 2.1: Data Adequacy and Data Gap Analysis

Taluka	EXPLORATORY DATA			GEOPHYSICAL DATA			GW MONITORING DATA (AQI)			GW MONITORING DATA (AQII)			GW QUALITY DATA (AQI)			GW QUALITY DATA (AQII)		
	Req.	Exist.	Gap	Req.	Exist	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap	Req.	Exist.	Gap
Kavthe	10	8	2	33	0	33	11	24	13	10	8	2	11	24	13	10	8	2
Mira	7	5	2	42	0	42	14	18	8	7	5	2	14	18	8	7	5	2
	17	**13**	**4**	**75**	**0**	**75**	**25**	**42**	**21**	**17**	**13**	**4**	**25**	**42**	**21**	**17**	**13**	**4**

2.2.1 Ground Water Exploration

As seen from **Table-2.1**, exploratory drilling was required at 4 locations i.e., Ranjani, Belanki, Bolvad and Madhavnagar. The drilling at these four sites was done down to 200 m depth by deploying DTH/LMP-87/77 to assess the lithological disposition of shallow aquifer (Aquifer-I) and deeper aquifer (Aquifer-II). The deep aquifers are encountered in depth of 38.0-41.10, 146.00-148.00, however their yield was negligible, whereas the water level was recorded in only well i.e., Mandoni (43.6 mbgl). The locations of exploratory wells are shown in **Fig. 2.1**. The details of exploratory and observation wells are given in **Annexure-III.**

2.2.2 Ground Water Monitoring Wells

As observed from Table-2.1, GWMW's were required at 21 locations and correspondingly 21 key observation wells (KOW) were established in addition to the existing GWMW to assess the ground water scenario of shallow aquifer (Aquifer-I) of the area. The depth of these dug well varies from 5.0 to 17.3 mbgl. The pre monsoon depth to water level (May 2016) in these wells varies from 0.5 (Shindewadi) and 13.40 m bgl (Khanderajuri). The post monsoon depth to water level (Nov. 2015) in the dug well varies from 0.4 (Sawalwadi) and 10.52 m bgl (Ranjani). In general field EC of dug well zone was in the range of 462 to 2250 µmhos/cm. The locations of KOW's are shown in **Fig. 2.1**. and **Annexure IVa**.

2.2.3 Ground Water Quality

Water quality stations were required at 21 locations and correspondingly 21 key observation wells (KOW) were established (**Fig. 2.1**) in addition to the existing GWMW to assess the ground water quality of shallow aquifer (Aquifer-I) of area. Assess the ground water quality of shallow aquifer (Aquifer-I) of area 33 locations for Aquifer-I and 33 for Aquifer-II were monitored. The details of chemical analysis for Aquifer-I and Aquifer-II are given in **Annexure-VII and VIII.**

2.2.4 Micro Level Hydrogeological Data Acquisition

In addition to the KOW's, micro level hydrogeological data was also required at 43 locations as per data gap analysis for deciphering the sub-surface lithological disposition, water level scenario and other hydrogeological inputs such as weathered thickness etc., of shallow aquifer (Aquifer-I). Thus against the requirement of 43 well, 43 dug wells were inventoried for micro level data acquisition. The details of dug wells inventoried for micro level data acquisition are given in **Annexure-V**. The locations of micro level hydrogeological data acquisition wells are shown in **Fig. 2.2**.

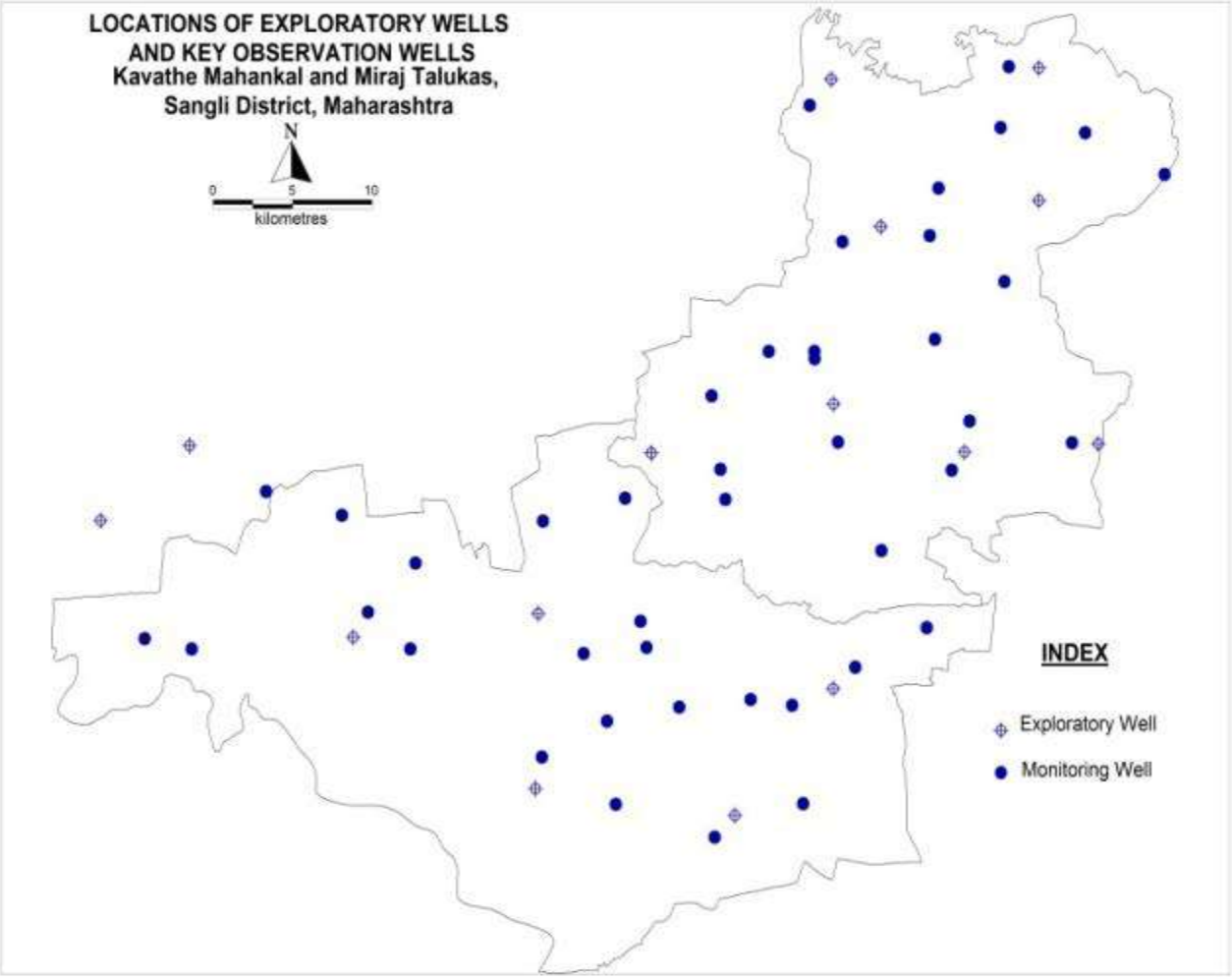


Fig 2.1 Location Exploration and Monitoring wells

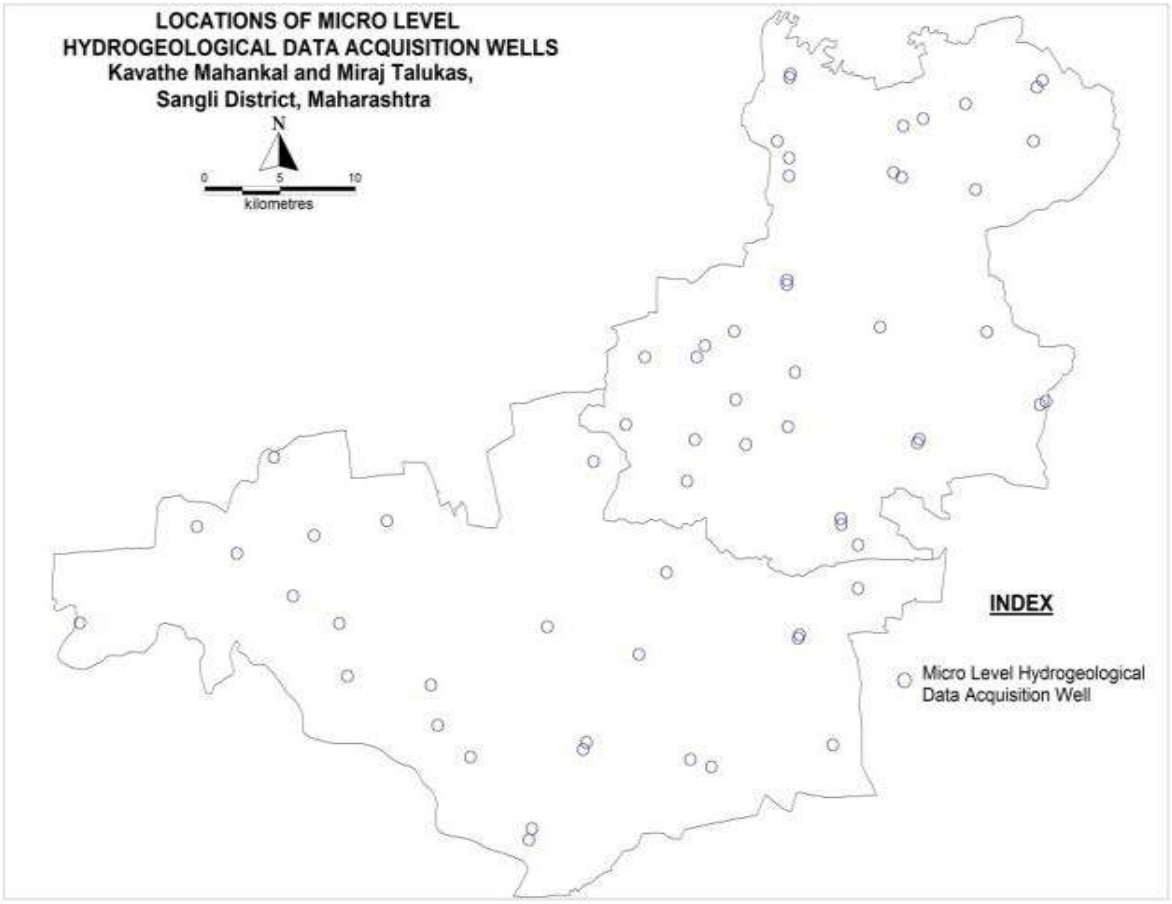


Fig 2.2 Location of micro level hydrogeological data acquisition wells

2.2.5 Soil Infiltration Tests

To estimate the actual rate of infiltration of various soil cover and their impact on recharge to ground water, two nos infiltration tests have been conducted at Kavthe Mahankal and Savali on different soil types and the location of these sites are shown in (**Fig. 2.3**). The data has been analyzed and the salient features of the infiltration tests are presented in **Table 2.2**, whereas the detailed data of the soil infiltration test is presented in **Annexure-II** and the plots of soil infiltration tests are presented in **Fig. 2.4**. The duration of the test is around 150 minutes, the depth of total water infiltration varies from 15 cm to 26.4 cm and the final infiltration rate in the area ranged from 1.20 cm/hr at Savali for the brownish black clayey soil type to 6.3 cm/hr at Kavthe mahankal for sandy black cotton soil type.

Table 2.2: Salient Features of Infiltration Tests

S. No.	Village	Date	Soil Type	Duration (min)	Water Level (cm agl)	Total Precipitation (cm	Final Infiltration Rate (cm/hr)
1.	Kavthe mahankal	22-03-2017	Black cotton soil	158	12.00	26.4	6.3
2.	Savali	21-03-2017	Brownish black , clayey	155	15.00	15.0	1.20

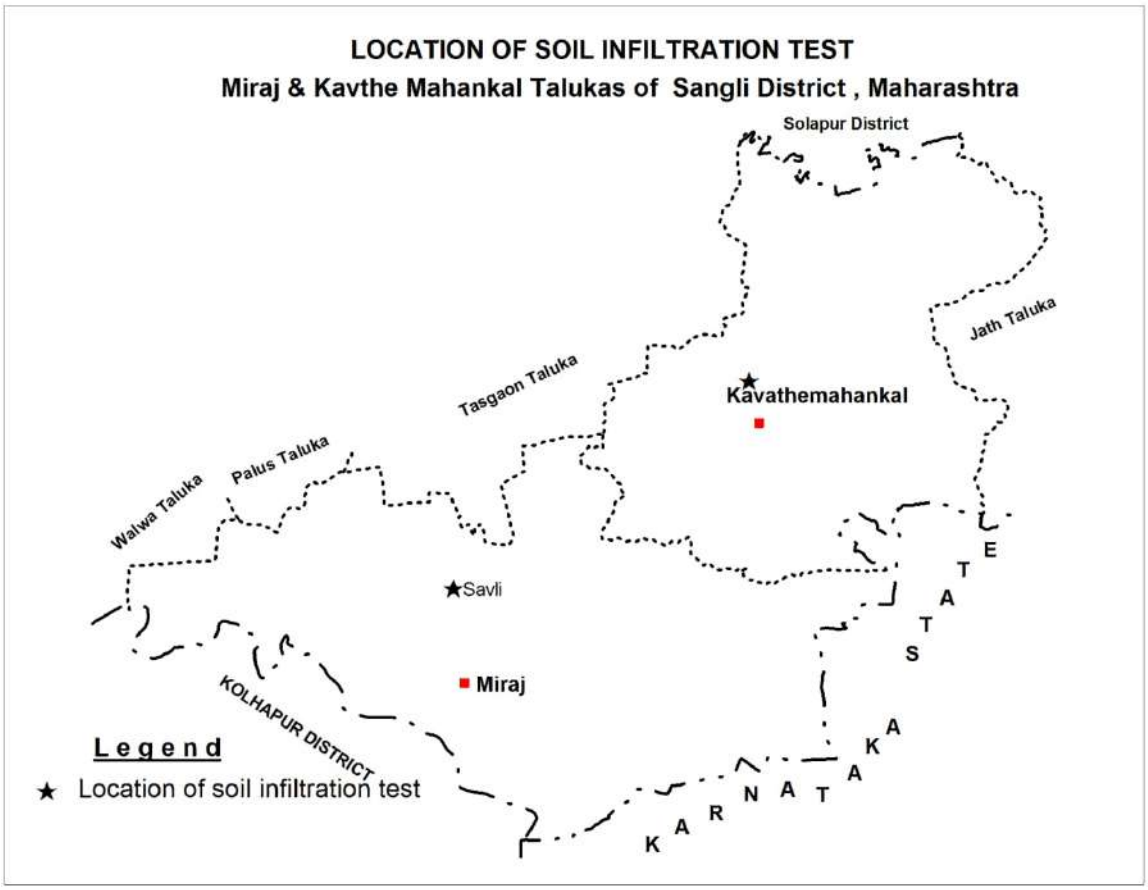
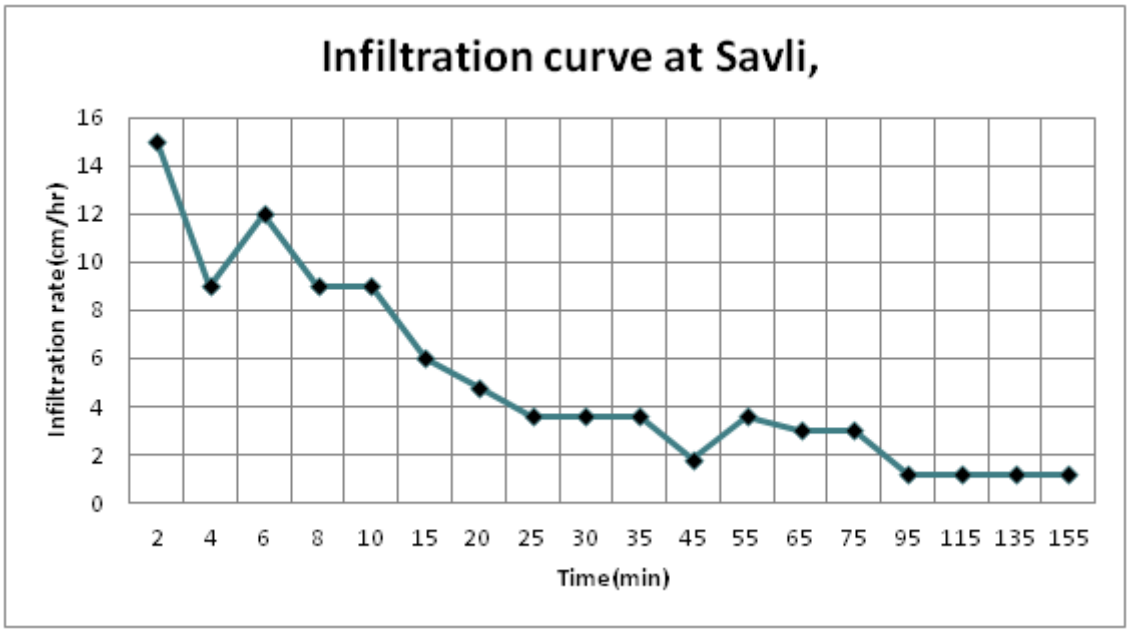


Fig.2.3: Locations of Soil Infiltration Tests



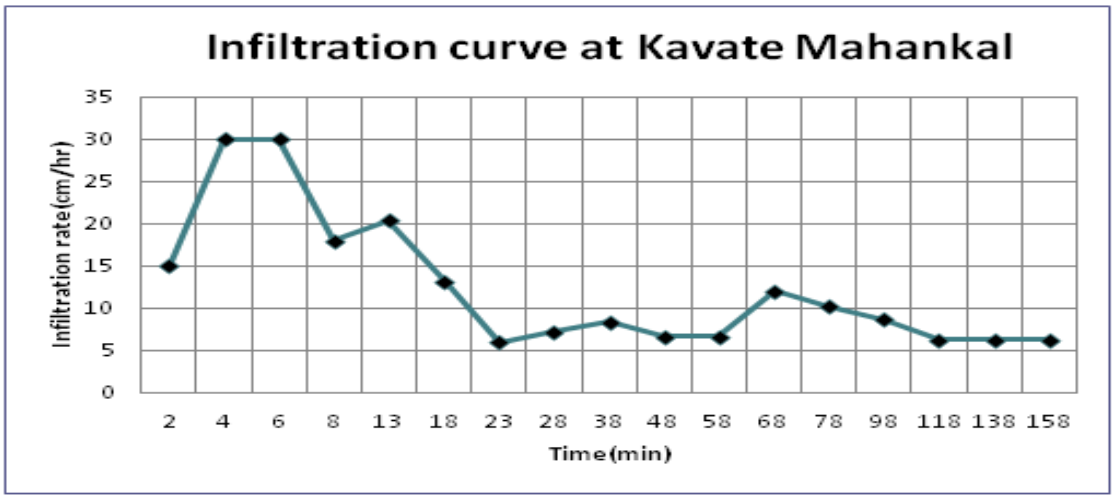


Fig.2.4: Soil Infiltration Plots for Savali and Kavthemahankal.

2.2.6 Thematic Layers

The following 5 thematic layers were also generated on GIS platform which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

- Drainage
- Geomorphology
- Soil
- Land Use – Land Cover
- Geology and Structure

The thematic layers such as drainage, geomorphology, soil, land use-land cover have been described in Chapter – I. The geology of the area is presented in **Fig. 2.5**. Geology and Basltic flow in **fig 2.6,** the area occupied is mainly comprised of Deccan Traps with inter-trappean beds of Upper Cretaceous- Lower Eocene age. Alluvium is occupied along the Krishna River. The generalized geological sequence occurring in the study area is given in **Table 2.3**. The area exposes a thick succession of basaltic lava flows of cretaceous to Eocene age. These lava flows are of 'aa' type and pahoehoe in nature. The flows have been intruded by a number of basic and intermediate dykes. The flows are intruded by dykes of dolerite and basalt.

Table 2.3:**Generalized Geological sequence of Kavthemahankal and Miraj taluka.**

Geologic Period	Age in million years	Stratigraphic unit	Lithology
Recent to Sub-Recent	-	River Alluvium	Sand, silt and clay.
Eocene to upper Cretaceous	30-60	Deccan traps	Basalt hard, massive, vesicular, amygdaloidal varieties with inter- trappean.

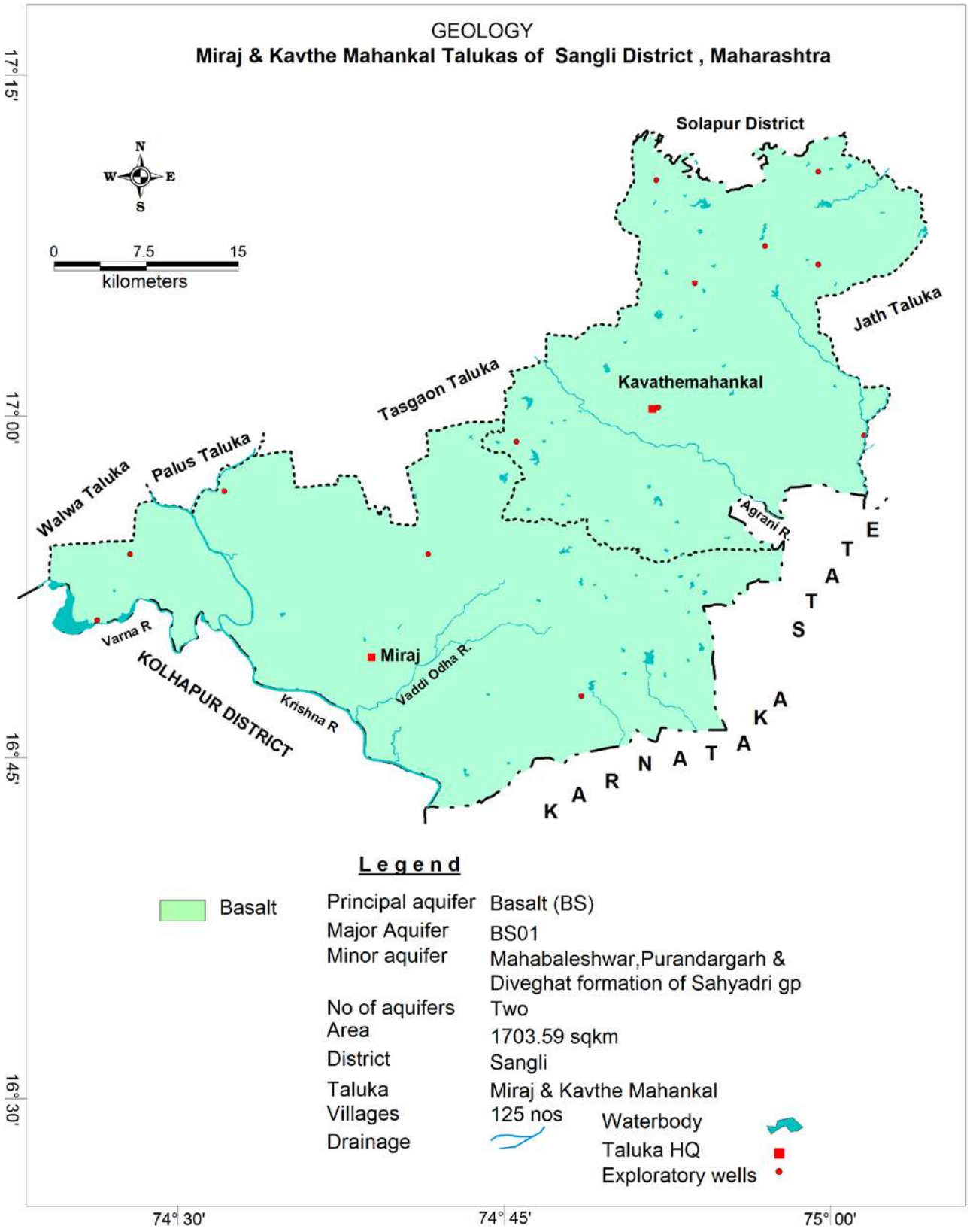


Fig 2.5 Geology of the area

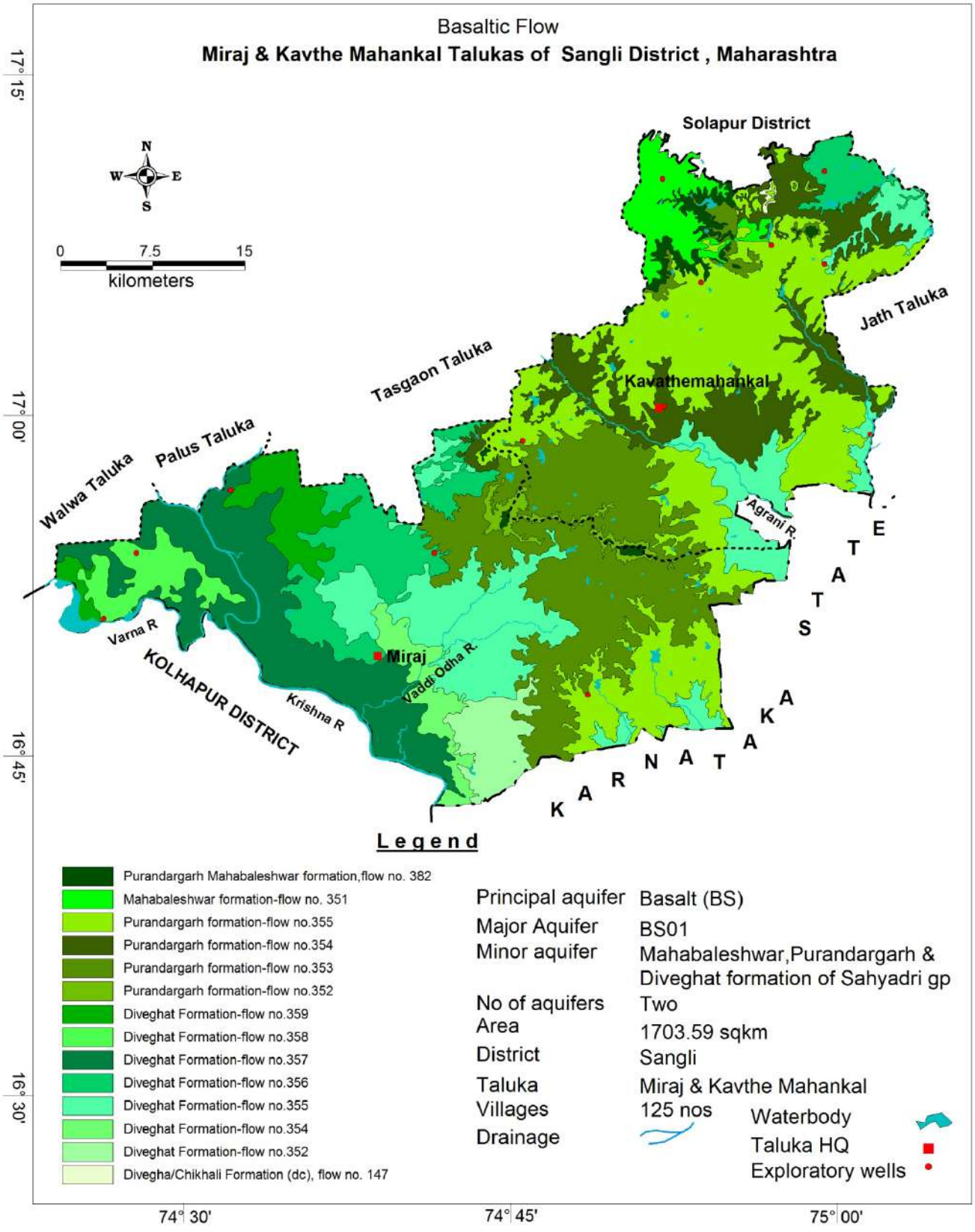


Fig 2.6 Basaltic Flow

3. DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

The data collected and generated on various parameters viz., water levels, water quality, exploration, aquifer parameters, geophysical, hydrology, hydrometeorology, irrigation, thematic layers was interpreted and integrated. Based on this the various aquifer characteristic maps on hydrogeology, aquifer wise water level scenario both current and long term scenarios, aquifer wise ground water quality, 2-D and 3-D sub surface disposition of aquifers by drawing fence and lithological sections, aquifer wise yield potential, aquifer wise resources, aquifer maps were generated and as discussed in details.

3.1 Hydrogeology

Hydrogeologically, the area occupied is mainly comprised of Deccan Traps with inter-trappean beds of Upper Cretaceous- Lower Eocene age (**Fig. 3.1**). The Lava pile exposed within the altitude of 560 to 780 mamsl, consists of 14 basalt flows of 'aa'/pahoehoe type occupying major part of the area. Each flow comprise of 3 units namely top vesicular basalt followed by fractured/massive basalt followed by massive basalt. Alluvium is occupied along the Krishna River.

The yield of wells is function of the permeability and transmissivity of aquifer encountered and varies with location, diameter and depth etc. The basaltic lava flows are massive and fine grained with negligible primary porosity and transmissivity, however their yields are enhanced mainly due to the presence of secondary porosity developed due to the fractures and jointing. Also weathered zones of about 5-12 m thickness have developed in plains and depressions. Thus the weathered, jointed and fractured zones of vesicular and massive units of a flow constitute the main water bearing horizons. However, these zones are not continuous and uniformly developed laterally as well as vertically and this factor plays an important role in the success and failure of wells in the area. There are three types of ground water structures in the area i.e. dugwells, borewells and dug cum borewells (DCB) and dugwells with near horizontal bores within fractured basalt. Their yield characteristics are described below.

Ground water occurs in unconfined state in shallow aquifer encountered between 8 and 32 m depth and tapped by dugwells, water levels are ranging from 0.5 – 13.4 m bgl and the yield of dugwells in basalt varies from 10 to 100 m^3/day. However, dugwells located in favourable area in basalt can yield 100 to 250 m^3/day. Ground water is predominantly used for irrigation, as it is the major ground water utilising sector in these intense sugarcane, grape, pomegranate and other cashcrop growing talukas.

State government has drilled large number of borewells fitted with hand pumps and electric motors for rural drinking water purposes in the area. Yields of borewells range from 500 to 3000 lph. The ground water development in these talukas is mostly through dugwells.

Ground water occurs under phreatic/ unconfined to semi-confined conditions in basalts. Ground water occurs in unconfined state in shallow Aquifer-I tapped by dugwells of 5.6 to 28 m depth, water levels are ranging from 0.5 to 13.4 m bgl during pre-monsoon and 0.4 to 10.52 during post-monsoon. Yield varies from 10 to 100 m^3/day. The deeper Aquifer-II is also present which is being tapped by borewells and it ranges from 20 to 152 m bgl, whereas the water level ranges from 9.2 to 53.2 m bgl during pre-monsoon and 5.3 to 31.0 during post-monsoon. For deeper Aquifer-II, 17 exploratory wells (10 in Kavthe Mahankal and 7 in Miraj taluka) have been drilled and studied

Limited yields of upto 1 lps are observed in a horse shoe shaped patch occurring along north, central and southern parts, whereas moderate yields of 1 to 3 lps are being observed in limited areas in western parts and high yields of 3 to 5 lps are present in north western and south eastern parts of the Kavthe Mahankal and Miraj Talukas, Sangli District.

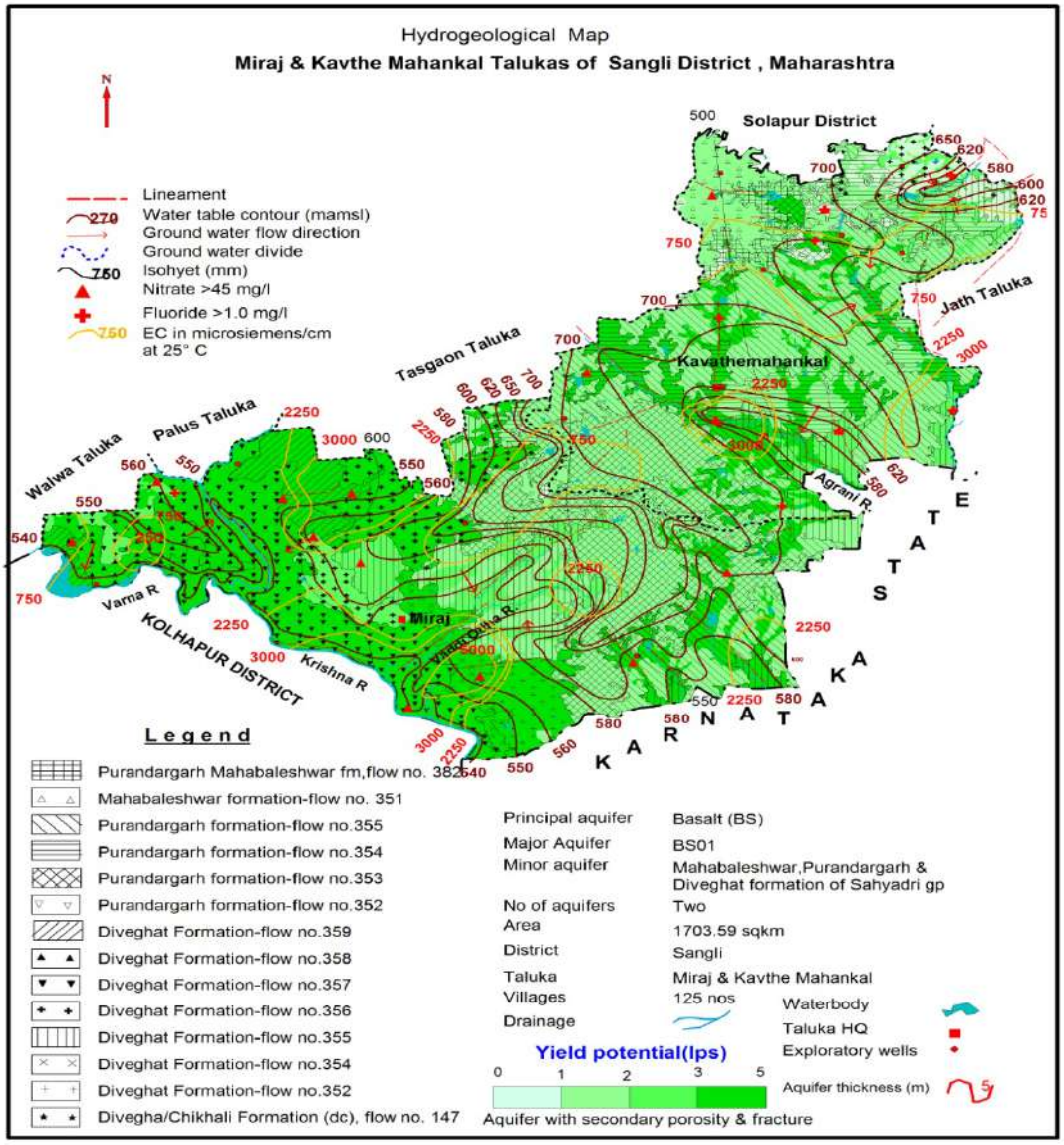


Fig. 3.1: Hydrogeology

3.1.1 Water Level Scenario – Aquifer-I (Shallow Aquifer)

The present depth to water level scenario of shallow aquifer was generated by utilizing water level data of 60 monitoring wells representing shallow aquifer.

The **premonsoon** depth to water levels during May 2016 ranged between 0.5 (Shindewadi) and 13.40 m bgl (Khanderajuri). The shallow water levels within 5 m bgl are observed mainly along the major drainages, whereas water levels between 5 and 10 m bgl are observed in major part. The deeper water levels of more than 10 m bgl are observed in limited areas in the central part of the study area covering west to east elongated patch adjacent to the water divide boundary of Agrani River and Krishna River.

The **postmonsoon** depth to water levels during Nov. 2016 ranged between 0.4 (Sawalwadi) and 10.52 m bgl (Ranjani). The shallow water levels within 3 m bgl are observed in major parts (88%) of the area. Moderate water levels of 3 to 5 m bgl are observed as isolated patches over entire Kavthe Mahankal and Miraj Talukas, Sangli District. The pre-monsoon and postmonsoon water level data is presented as **Annexure-IVa**, whereas depth to water level map is given in **Fig.3.2 and Fig. 3.3**.

The water level measured during pre and post monsoon period (2016) was used to compute the seasonal fluctuation. The analysis of water level fluctuation data indicates that 11.47% wells show fall in water levels while the remaining 88.53% wells show rise in water levels. The minimum water level fluctuation was observed at Nagaj (-9.53m , fall) while maximum water level fluctuation was observed at Khanderajuri (11.9m . rise). The water level fluctuations were grouped under three categories i.e., less, moderate and high and the % of wells in each category was analysed (**Table-3.1**).

Table-3.1: Analysis of Water Level Fluctuation

S. No.	Category	Fluctuation Range	% of Wells
1.	Less water level fluctuation	0 to 4 m	55.73%
2.	Moderate water level fluctuation	4 to 8 m	26.2%
3.	High water level fluctuation	>8 m	6.55%

The analysis indicates that majority of the wells (55.73%) are falling in less fluctuation range indicating good aquifer storage, whereas moderate water level fluctuation are

observed in 26.2% wells and high water level fluctuation were observed in 6.55 % wells. The seasonal fluctuation map is presented as **Fig. 3.4**, the perusal of map indicates that fluctuation of upto 4 m is observed in major part of the area, whereas higher fluctuation of more than 4 m is observed in hilly areas and low potential areas.

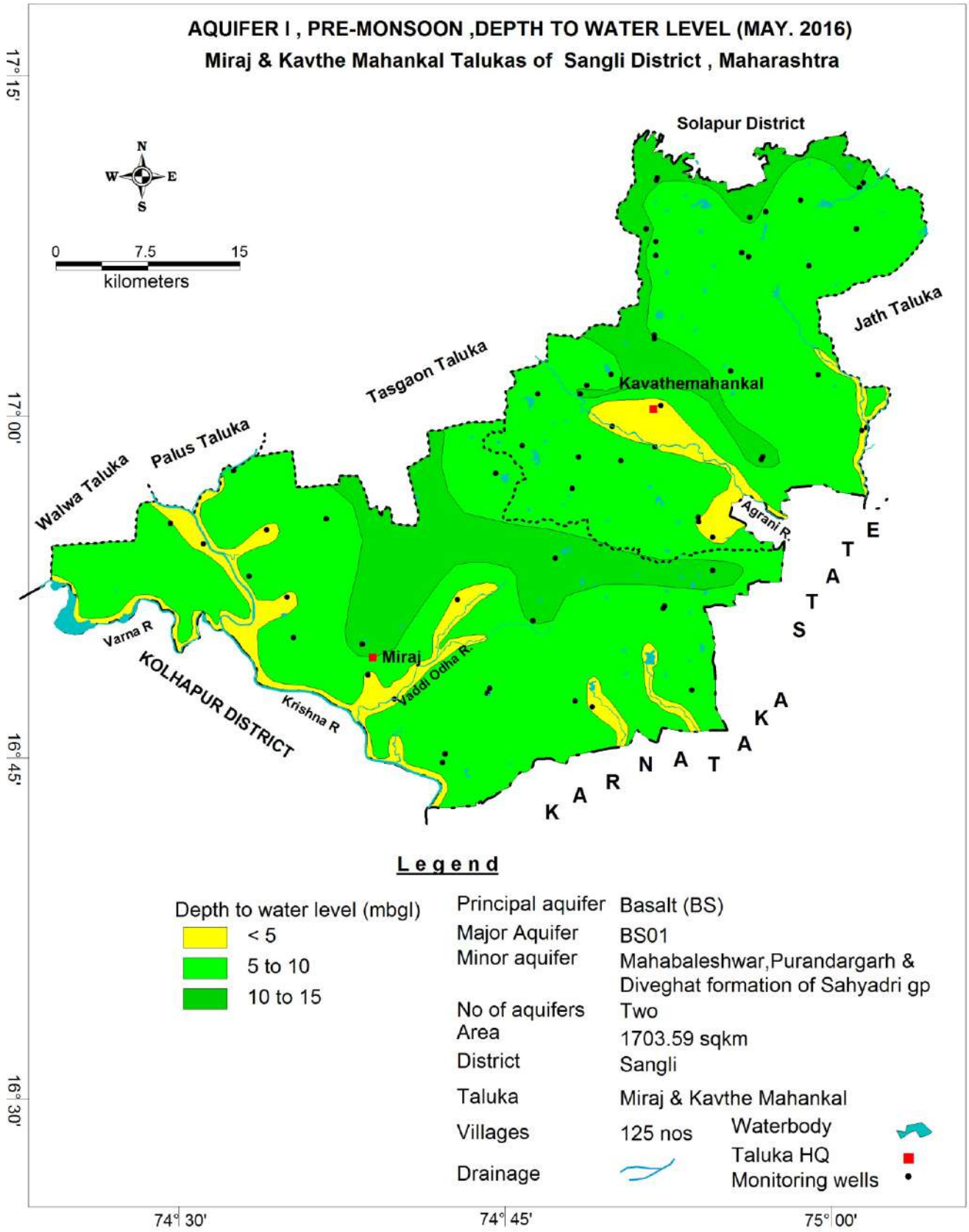


Fig 3.2 Premonsoon depth to water level

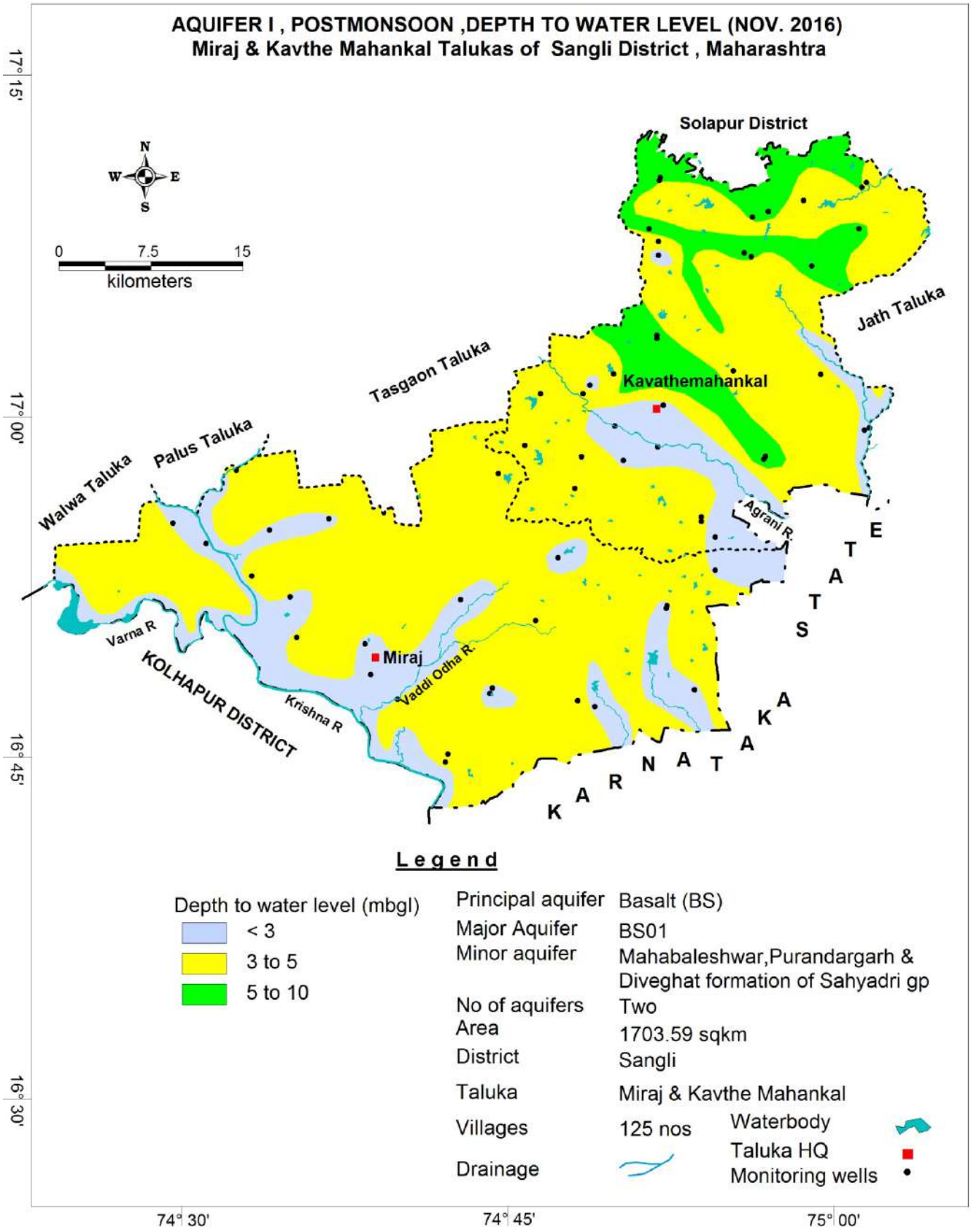


Fig3.3 :Postmonsoon depth to water level

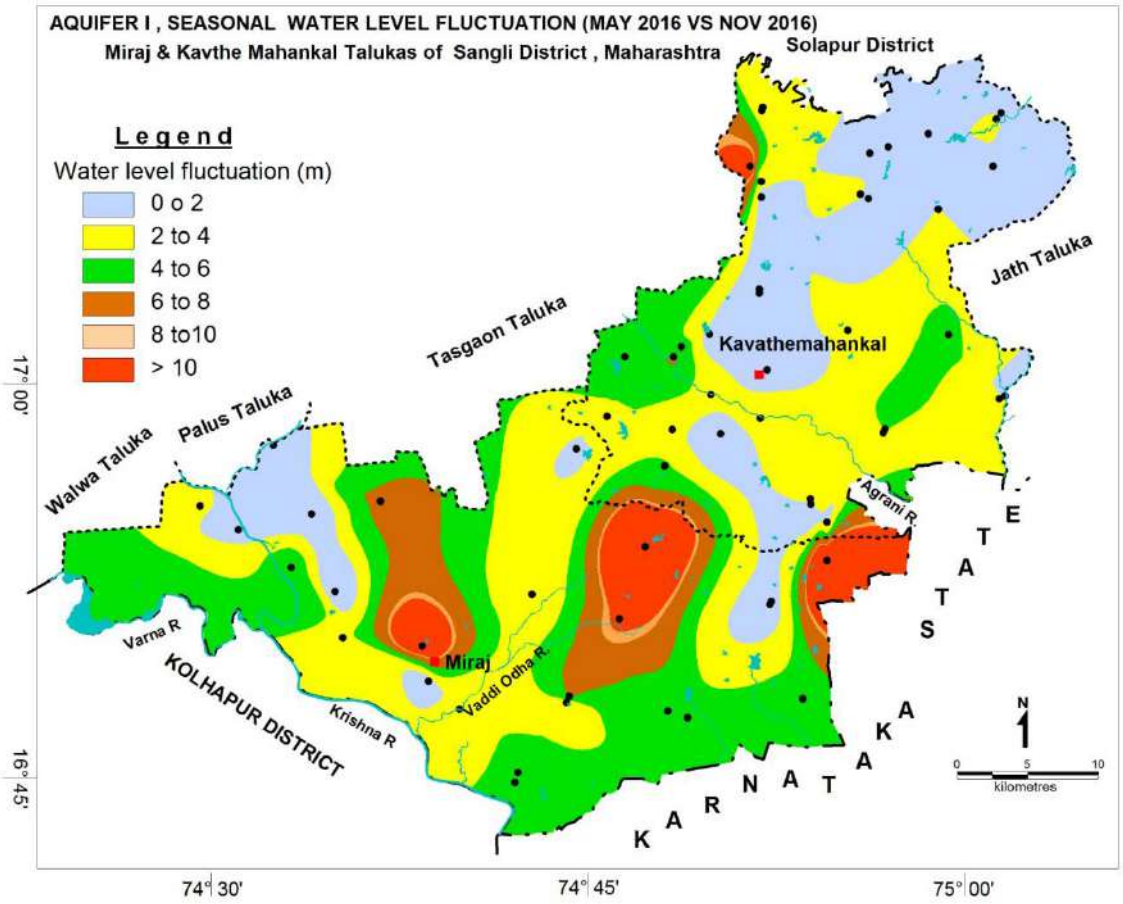


Fig 3.4 : Water level fluctuation

i. Ground Water Flow

The water table elevation map for premonsoon period (May 2016) was also prepared (**Fig.3.5**) to understand the ground water flow directions. The water table elevation ranges from 540 m amsl to 700 m amsl ,in a groundwater regime, equipotential lines, the line joining points of equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the Water table elevation, ground water flow directions are demarcated (**Fig. 3.5**). It has been observed that

1. The area under study, Krishna river is the only perennial river, while its tributaries are seasonal emanating from the hilly terrain and constitute the drainage system in the area. The drainage pattern is mainly dendritic, sub dendritic to sub parallel. The

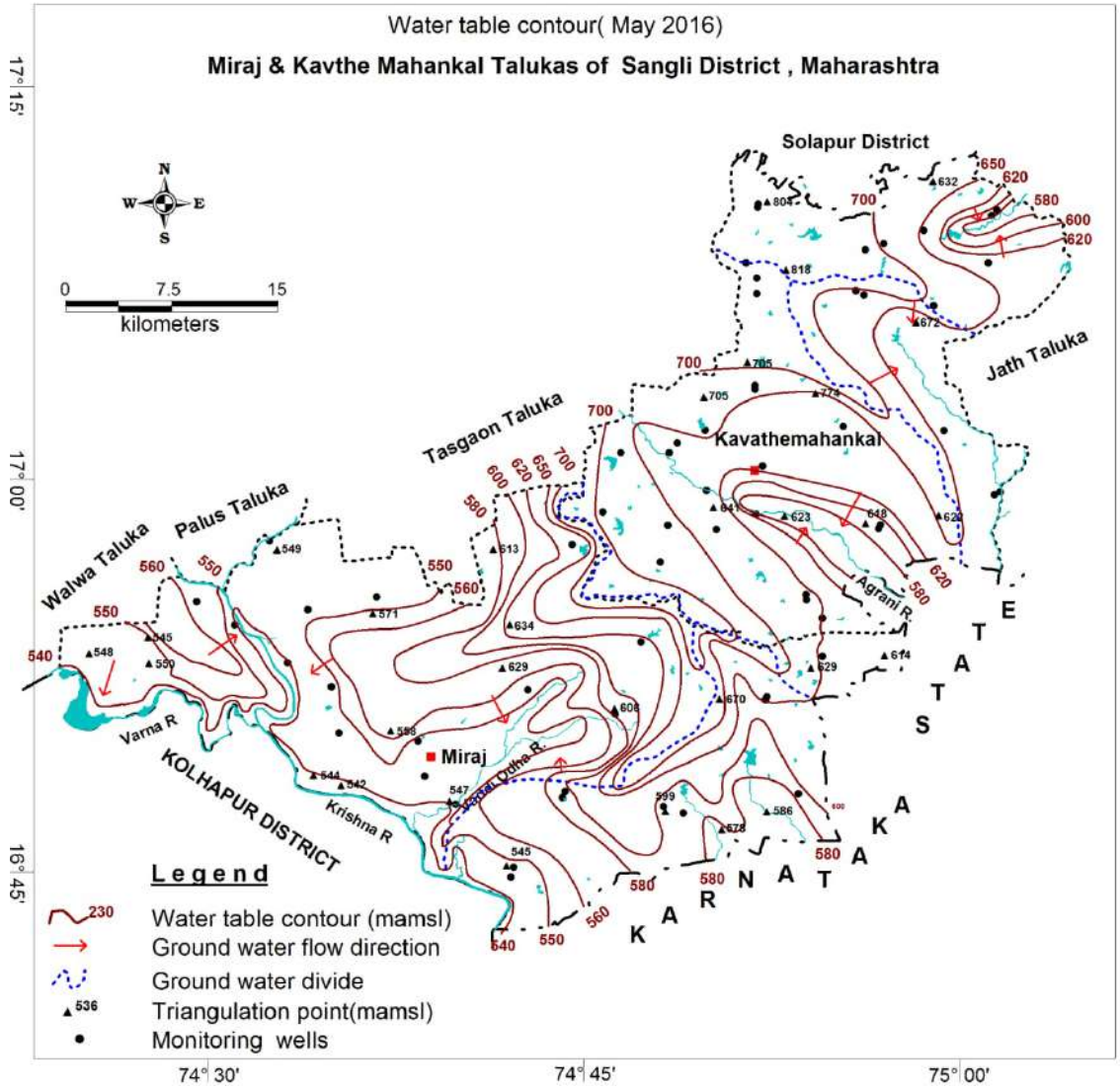


Fig. 3.5: Ground water table contour,Miraj and Kavthe Mahankal Talukas

ordering of the stream is upto 6th order. Overall direction of surface water drainage is from northwest to southeast.

2. The water table varies from 540 m amsl near the confluence of Krishna rivers in southeastern part of the area in Miraj Taluka to about 700 m amsl north-western part of the area in Kavthe Mahankal Taluka.
3. The ground water movement is mainly controlled by the elevation and topography of the area. The overall ground water movement in the area is from southwest, towards Krishna river. The ground water divide almost follows the surface water divide. This indicates the topographic control for the ground water movement. However, close to reservoirs and tanks/ponds (talavs) of the study area, the ground water movement is controlled by artificial recharge to ground water

ii. Depth to Water Level Trend (2007-16)

In order to study long term behavior of the water levels and also the effect of various developmental activities with time, the data for the period 2007-16 have been computed and analyzed. The long term water level data of 25 wells has been utilised.

In the study area, pre monsoon rise in water levels trend has been recorded at 5 stations and it ranges between 0.01 m/year (Dudhebhavi,Kavthe Mahankal) to 0.18 m/year (Desing,Kavthe Mahankal) while falling trend was observed in 20 stations varing from -0.003 (Kokale,Kavthe Mahankal) to -0.59 m/year (Ranjani,Kavthe Mahankal). In pre monsoon the falling water level trend has been observed in almost entire area of Kavthe Mahankal and Miraj while small patches of rising trend has been observed isolated patches. (**Fig 3.6**)

In the study area, post monsoon rise in water levels trend has been recorded at 07 stations and it ranges between 0.04 m/year (Kavalapur,Miraj) to 0.15 m/year (Hingangaon ,Kaavathe Manahkal) while falling trend was observed in 18 stations varing from -0.05 m/year (Dudhebhavi,Kavthe Mahankal) to -0.52 (Bedag,Miraj). The decadal post monsoon water level trend is presented in **Fig 3.7**.

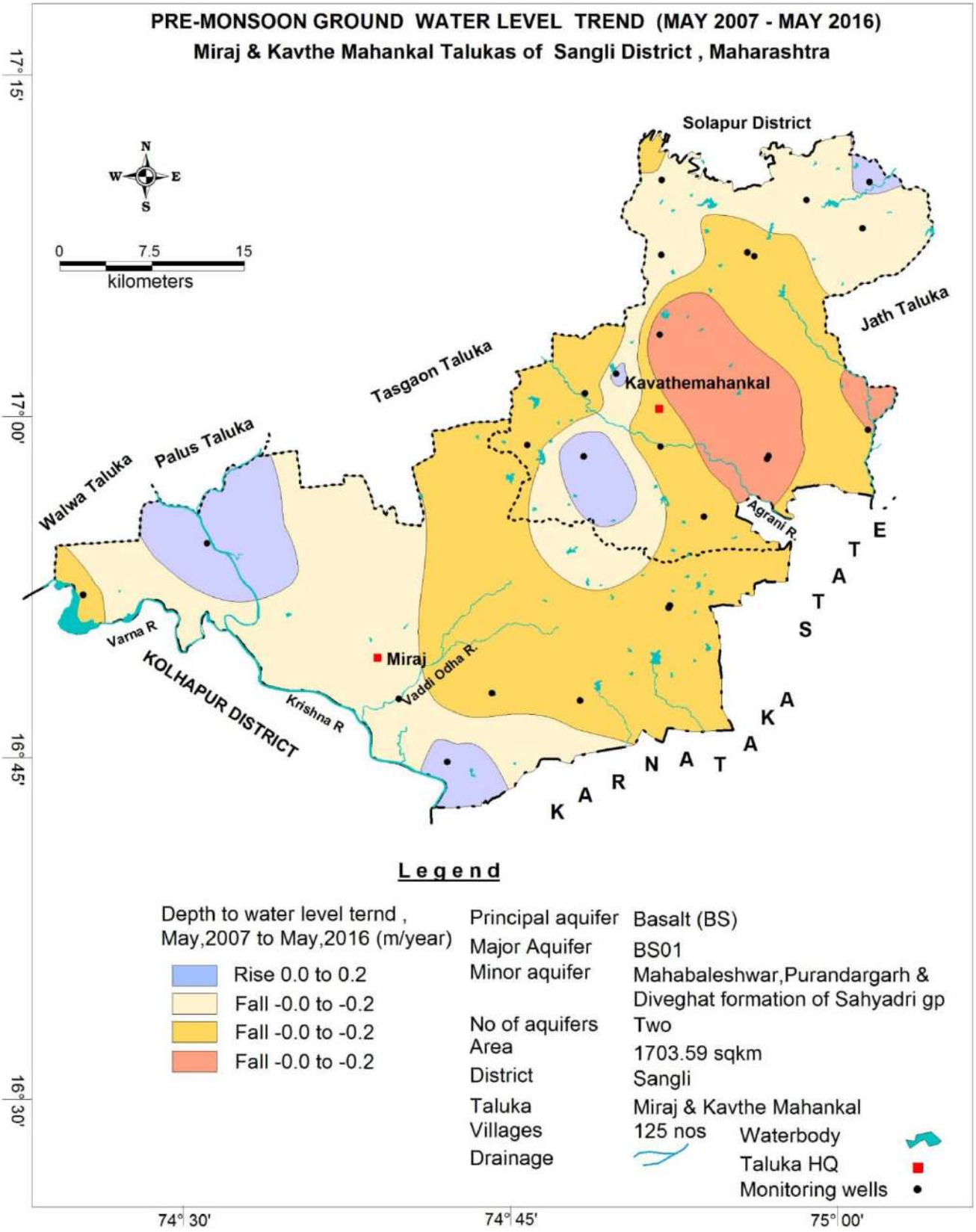


Fig 3.6 Premonsoon ground water level trend

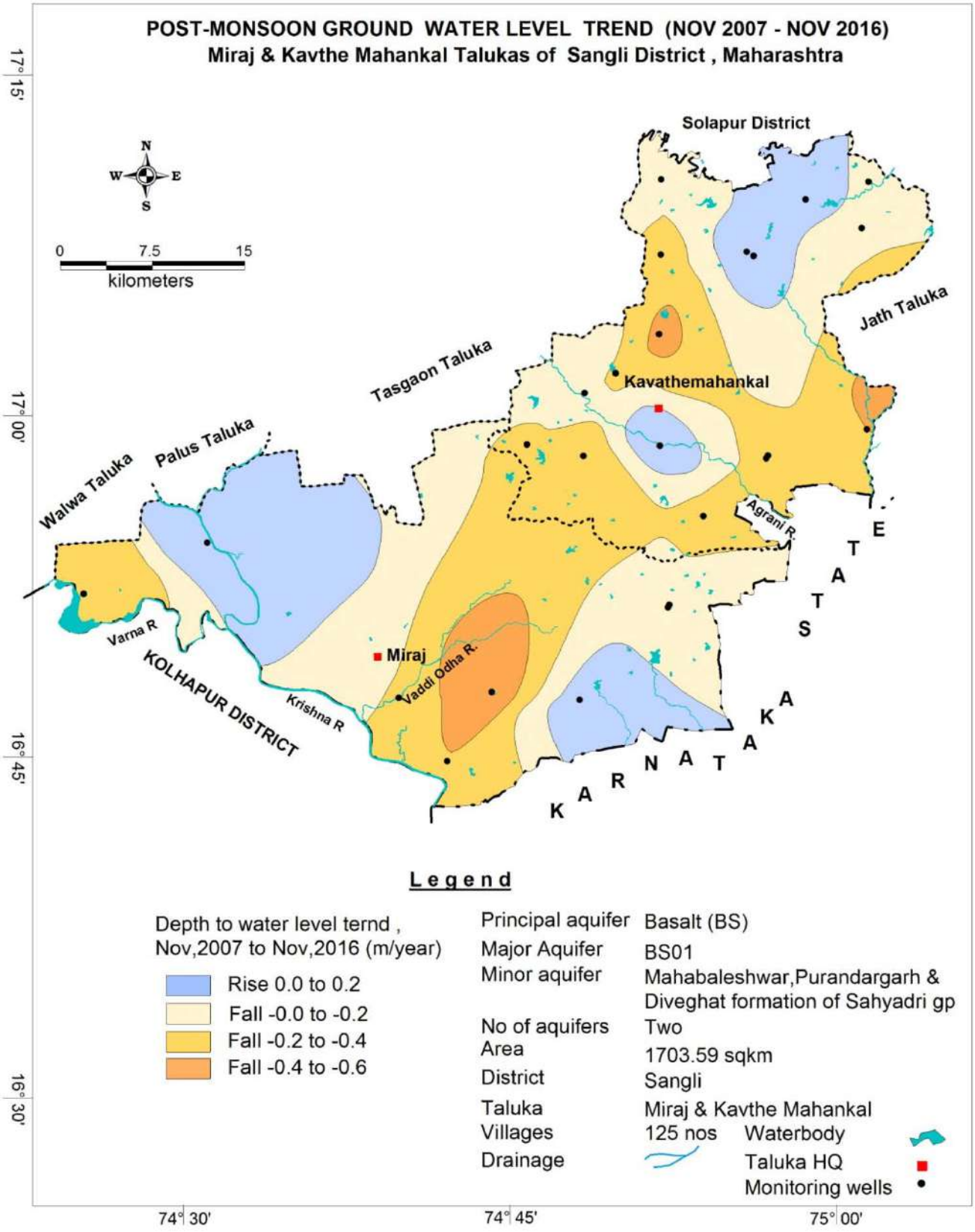


Fig 3.7 Postmonsoon ground water level trend

iii. Water Level Scenario – Aquifer-II (Deeper Aquifer)

The depth to water level scenario of deeper aquifer was generated by utilizing water level data of 20 exploratory/observation wells representing deeper aquifer.

The **premonsoon** depth to water levels ranged between 9.2 (Ghatnandre) and 53.20 m bgl (Alkud (m)). The shallow water levels within 10 m bgl are observed mainly in eastern part, north south elongated patch extending from Shelkewadi in the north to Arag in the south represents the water level in the range of 20 to 30 m bgl, whereas in major part of the area covering western part of the study area the deeper water levels ranging between 30 and 40 m bgl is observed. The pre-monsoon and post monsoon water level data is presented as **Annexure-VI**, whereas depths to water level maps are given in **Fig.3.8 and Fig.3.9**

The **postmonsoon** depth to water levels ranged between 5.3 (Kokale) and 31.00 m bgl (Kalambi). The spatial distribution of water levels shows that the areas with moderately deeper water levels of 10 to 20 m bgl during premonsoon have migrated to shallow water levels within 10 m bgl in major parts of the area during post monsoon, thereby indicating adequate ground water recharge even in deeper aquifer due to monsoon rainfall. Whereas the area of deeper water level (>20 m bgl) are occurring in the same regions, but their spatial extent / area coverage has reduced due to the monsoon rainfall recharge

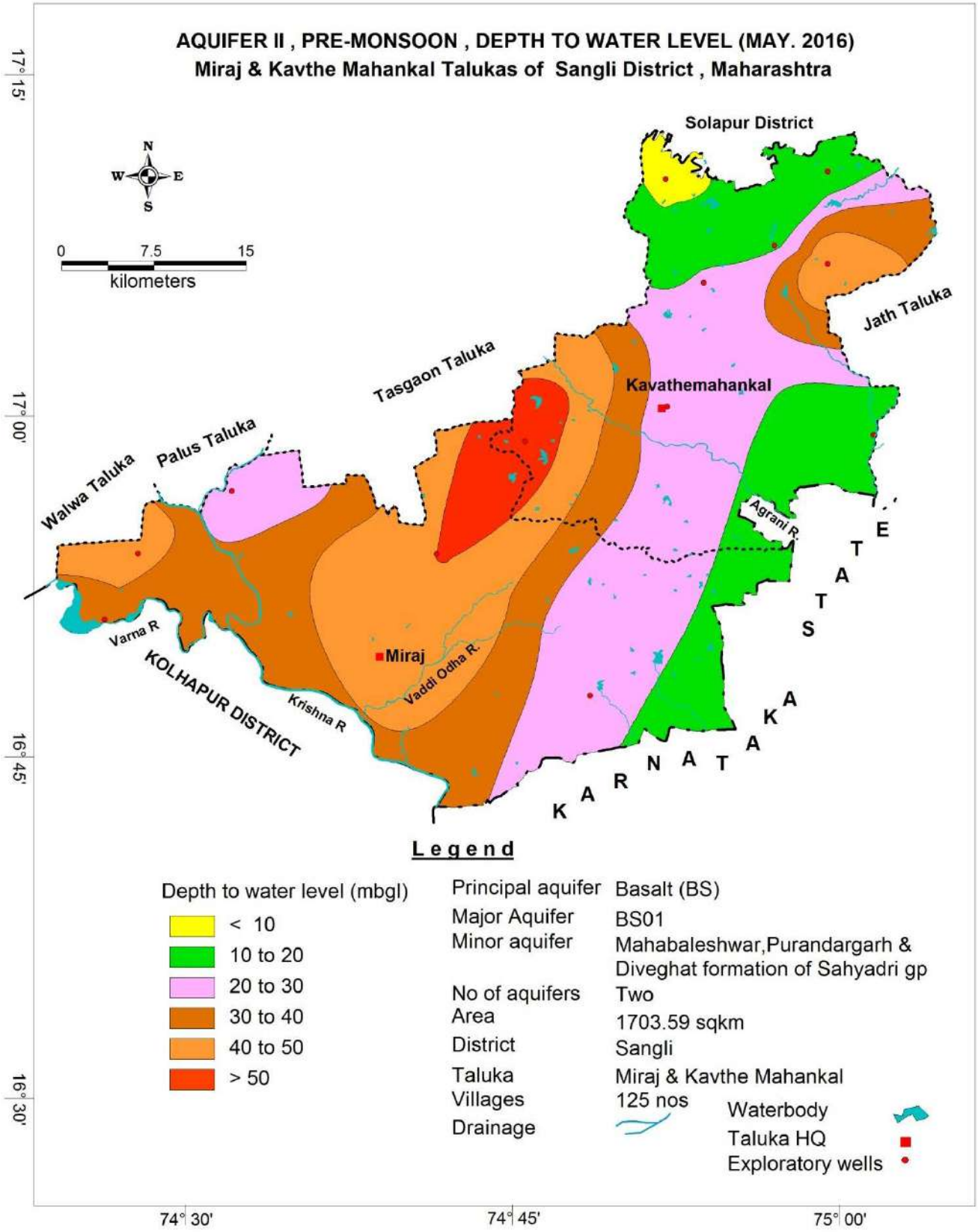


Fig 3.8 Aquifer II,Premonsoon depth to water level

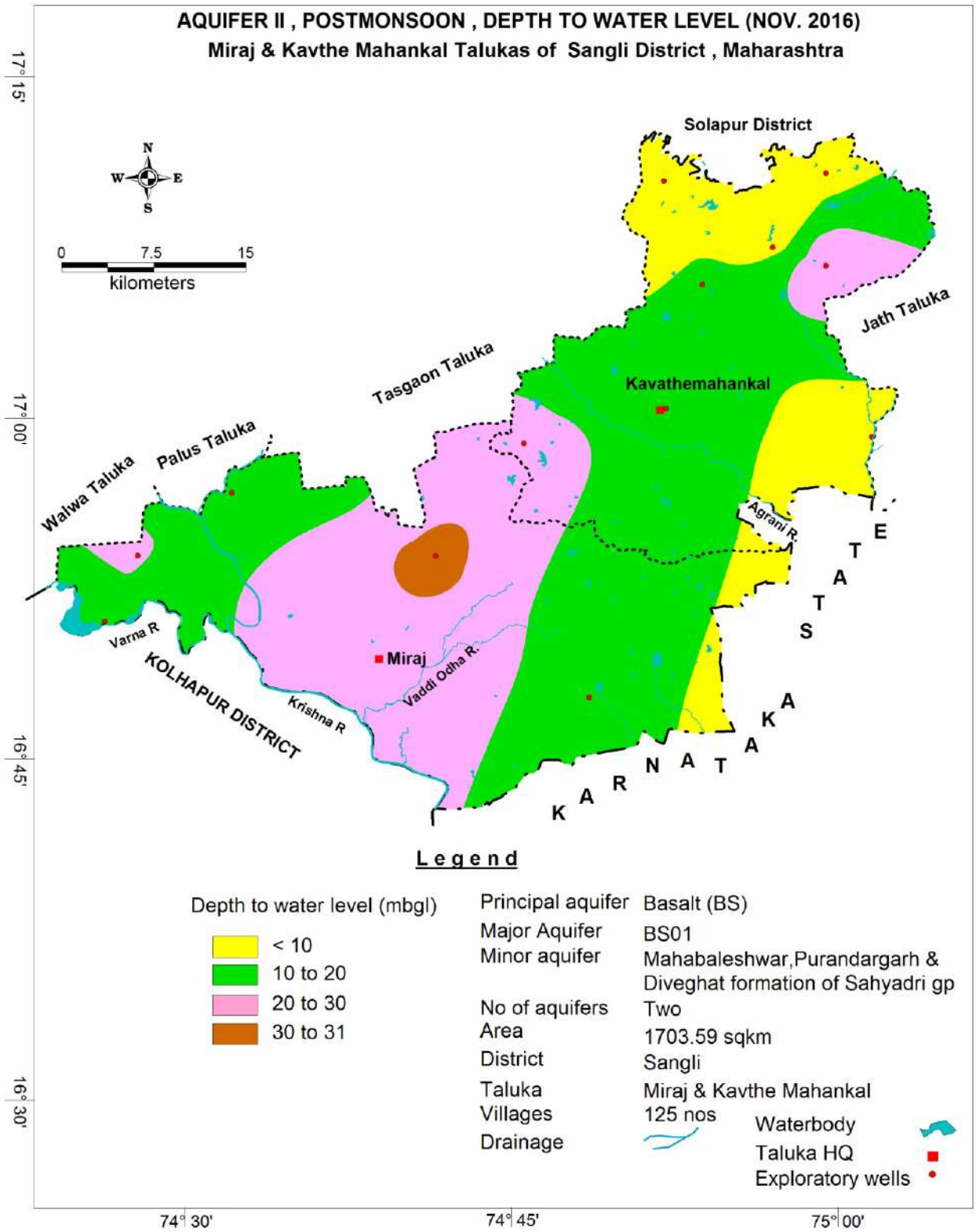


Fig 3.9 Aquifer II,Postmonsoon depth to water level

3.2 Ground Water Quality

The suitability of ground water for drinking/irrigation/industrial purposes is determined keeping in view the effects of various chemical constituents present in water on the growth of human being, animals, various plants and also on industrial requirement. Though many ions are very essential for the growth of plants and human body but when present in excess, have an adverse effect on health and growth. For assessment of ground water quality, samples from 66 KOW's (shallow dug wells representing phreatic aquifer) have been collected during pre-monsoon. Similarly for Aquifer – II, the ground water quality data of 18 exploratory/observation wells drilled during earlier exploration and current exploratory drilling activities were utilised. The ground water samples were analysed for major chemical constituents. The aquifer wise ranges of different chemical constituents present in ground water are given in **Table 3.2.**The details of water quality analysis of Aquifer I and II are given in **Annexure VII and VIII**.

Study of the Table3.2, it is observed that in case of Aquifer-I, the maximum values of all the parameters(except calcium and total hardness) are within permissible range of BIS indicating that the ground water is suitable for drinking purpose. In case of Aquifer-II, it is observed that TDS, Total Hardness, Calcium and Magnesium are above permissible limit at some places

Table 3.2: Aquifer wise ranges of chemical constituents

Constituents	BIS standards for drinking water	Aquifer - I (Shallow aquifer)			Aquifer-II (Deeper Aquifer)		
		Min	Max	No. of samples above MPL	Min	Max	No. of samples above MPL
pH	6.5-8.5	7.1	8.2	Nil	7.1	8.2	Nil
EC	-	164	7500	Nil	372	6270	-
TDS	500-2000	105	4800	7	238	4012	3
TH	300-600	100	2500	15	120	1580	3
Calcium	75-200	16	1569	16	72	836	10
Magnesium	30-100	0	290	7	4.86	181	Nil
Sodium	-	22.1	535	-	38	360	-
Potassium	-	0.1	73.8	-	120	360	-
Carbonate	-	0	21	-	0	0.56	-
Bi-	-	99.75	1015	-	119.4	439.2	-

carbonate					1		
Chloride	250-1000	33	1979	2	60	800	Nil
Nitrate	45	2.22	230	13	0.5	33	Nil
Sulphate	200-400	1	1450	6	1	1450	2
Fluoride	1-1.5	0.09	1.53	1	NA	NA	NA

Note- All values except EC (µS/cm @ 25°C) and pH are in mg/L.

The iso-conductivity map of Aquifer I and II has been prepared and presented as **Fig. 3.10 and 3.11**. In case of Aquifer-I and II, it is observed that major area is having EC up to 2250 µS/cm, whereas in few isolated patches it is >2250 µS/cm.

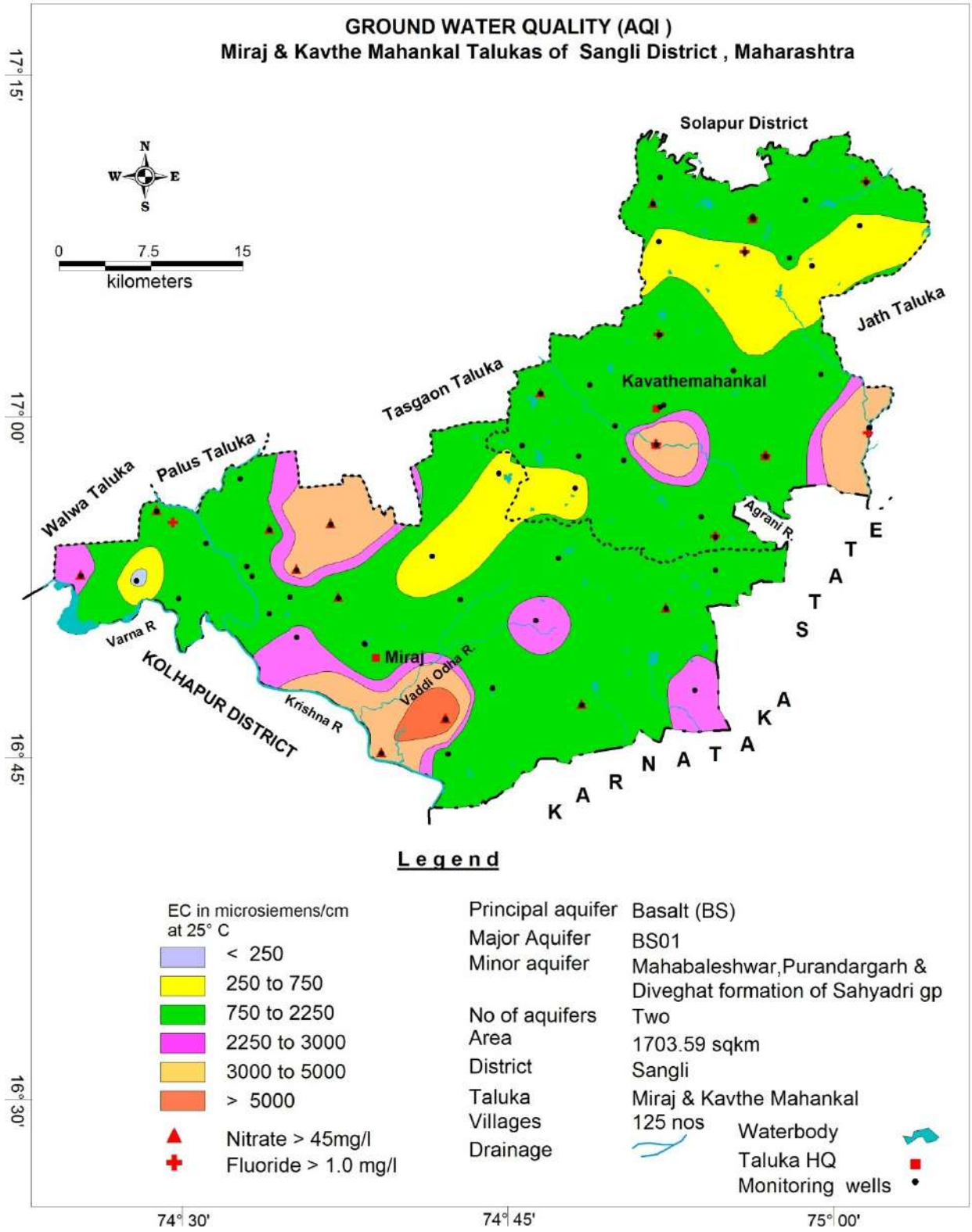


Fig 3.10 Ground water quality aquifer I

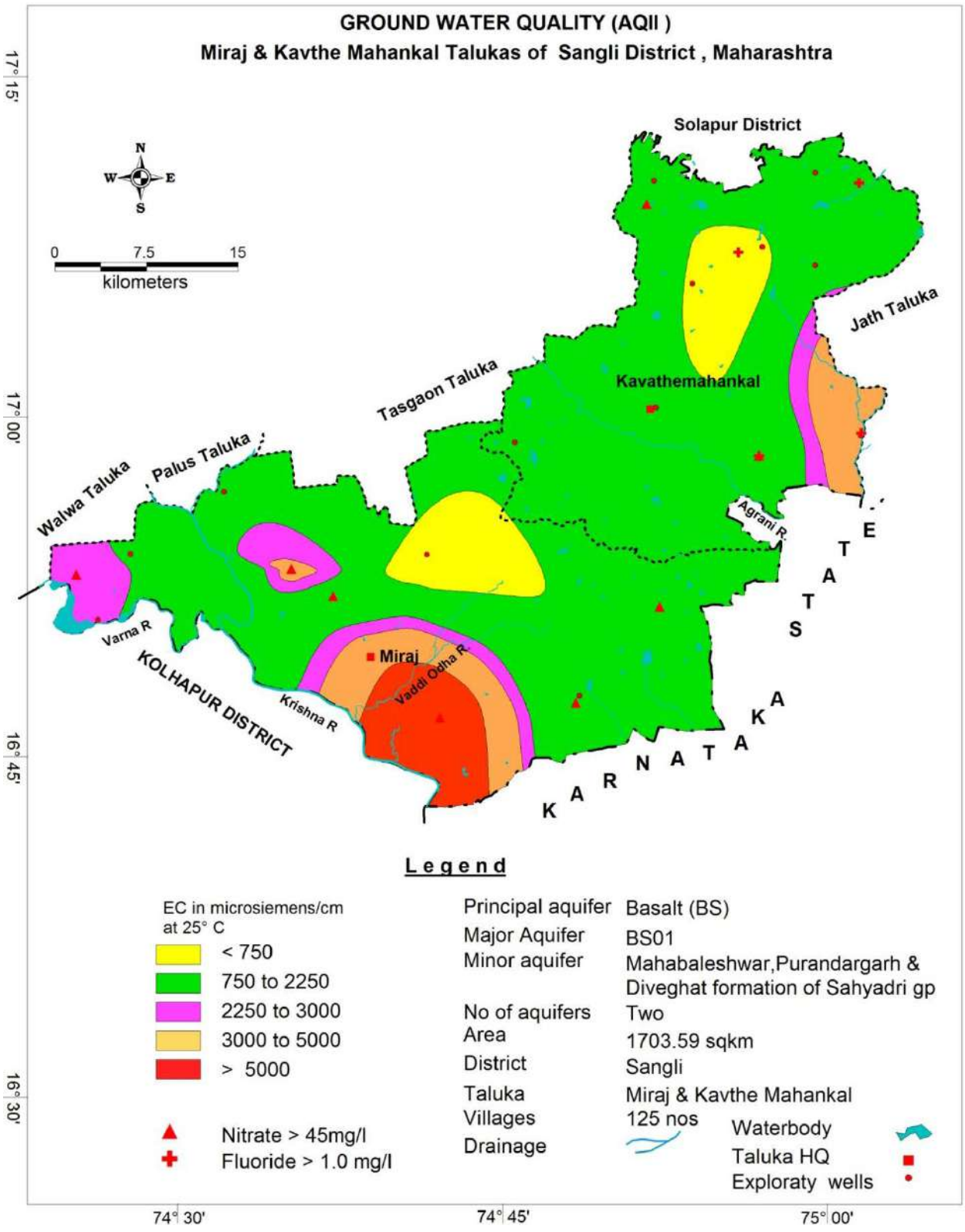


Fig 3.11 Ground waterquality Aquifer II

3-D and 2-D Aquifer Disposition

The data generated from ground water monitoring wells, micro level hydrogeological inventories, exploratory and observation wells, various thematic layers was utilized to decipher the aquifer disposition of the area. This particularly includes the information on

geometry of aquifers and hydrogeological information of these aquifers. In the area, Deccan Trap Basalt is the only formation and within it two aquifer systems has been deciphered as listed below:

Deccan Trap Basalt –

b. **Aquifer – I (Shallow Aquifer): 8 to 32m**
c. **Aquifer – II (Deeper Aquifer): 20 to 152 m**

The fence diagram indicating the disposition of various aquifers is presented in **Fig.3.12** and the 3-D representation is presented in **Fig. 3.13.** The disposition of Aquifer-I and Aquifer-II followed by massive basalt can be observed in the Fence.

The 2-D map showing spatial disposition and vertical extent of **Aquifer-I and Aquifer-II** indicating its depth of occurrence and fractured rock thickness has been generated and shown in **Fig 3.14 and** Fig.**3.15.** The perusal of 2-D disposition of **Aquifer-I map** indicates in major part the shallow aquifer is observed up to 15 m depth and thickness of the aquifer is

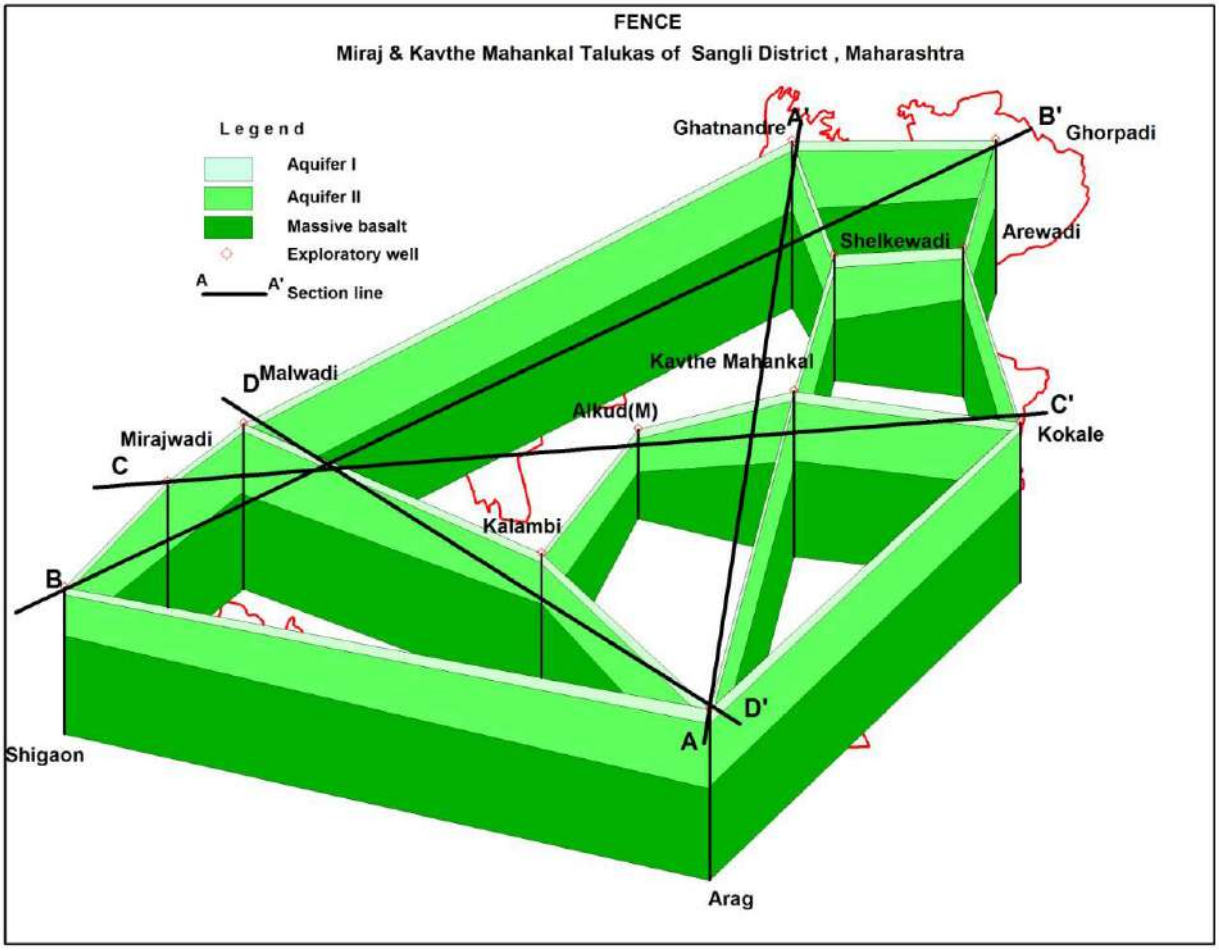


Fig.3.12: Fence diadram

upto 10 m. In south central part of the study area around vaddi odha the maximum depth observed is up to (32 m) and thickness (upto 16 m), which implies that this part is having good ground water potential.

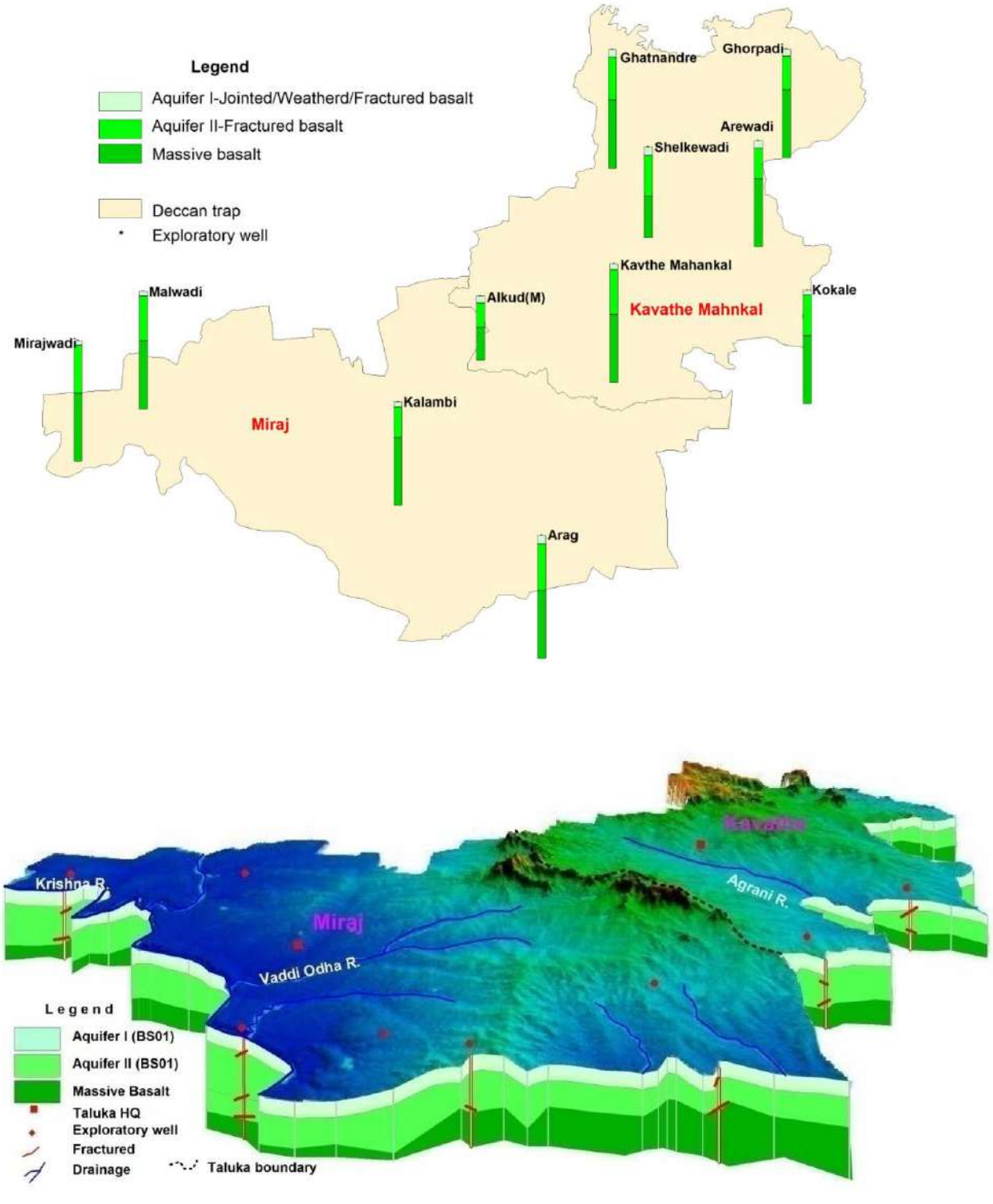


Fig.3.13: 3-D disposition of Aquifers

The perusal of 2-D disposition of **Aquifer-II map Fig-3.15** indicates in major part the deeper aquifer is observed upto 152 m depth and the thickness of fractured rock is limited to 6 to 9 m. In north south central strip the maximum depth of Aquifer -II is upto 80 to 100 m, however even in this 100 m depth, the thickness of fractured rock is limited to 1 to 3 m. Thus the water bearing zones in Aquifer-II are limited in the area and the borewell construction is not feasible in the areas except when located in the potential areas

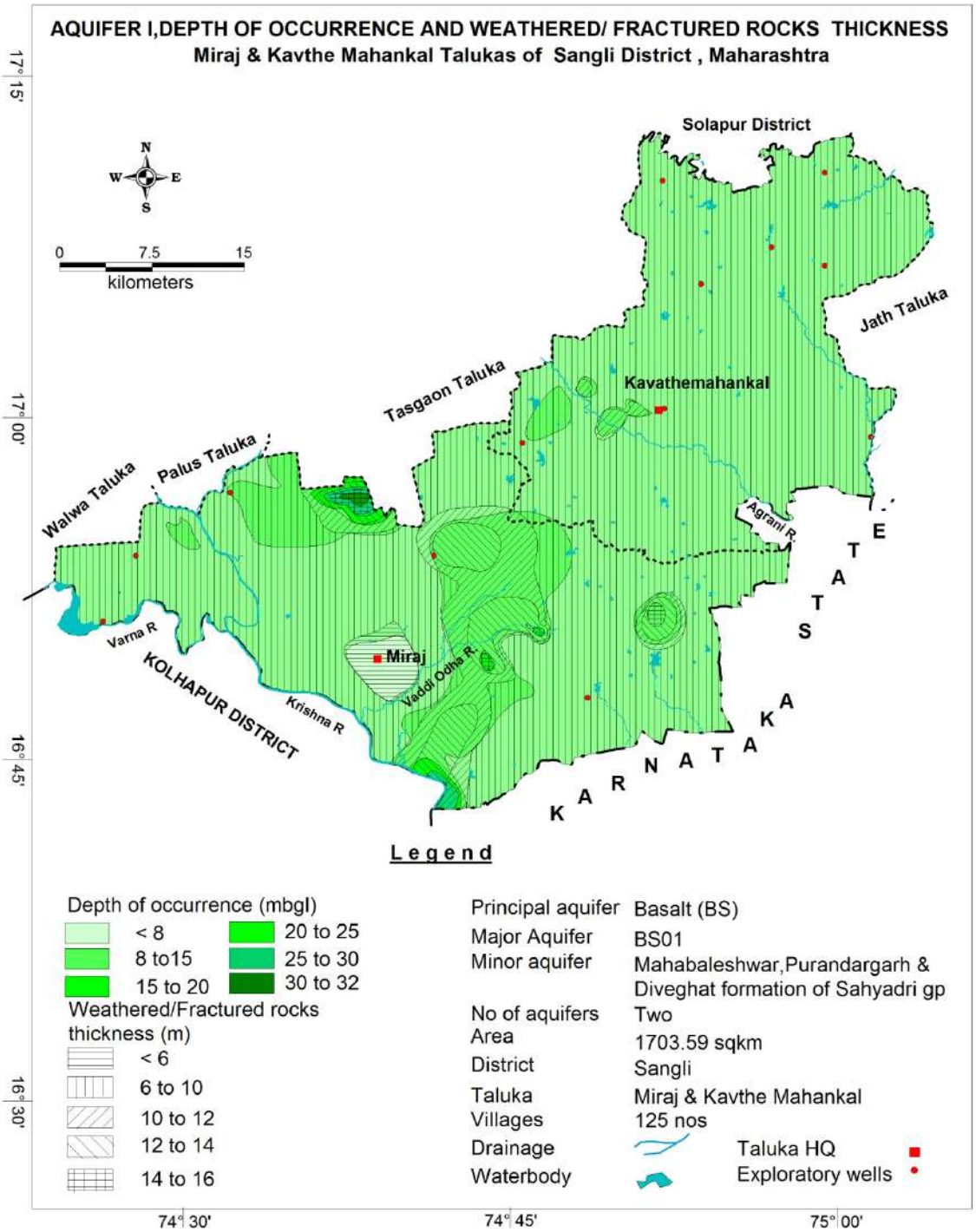


Fig.3.14: Aquifers-I , Depth of occurrence and weathered/fractured rock thickness

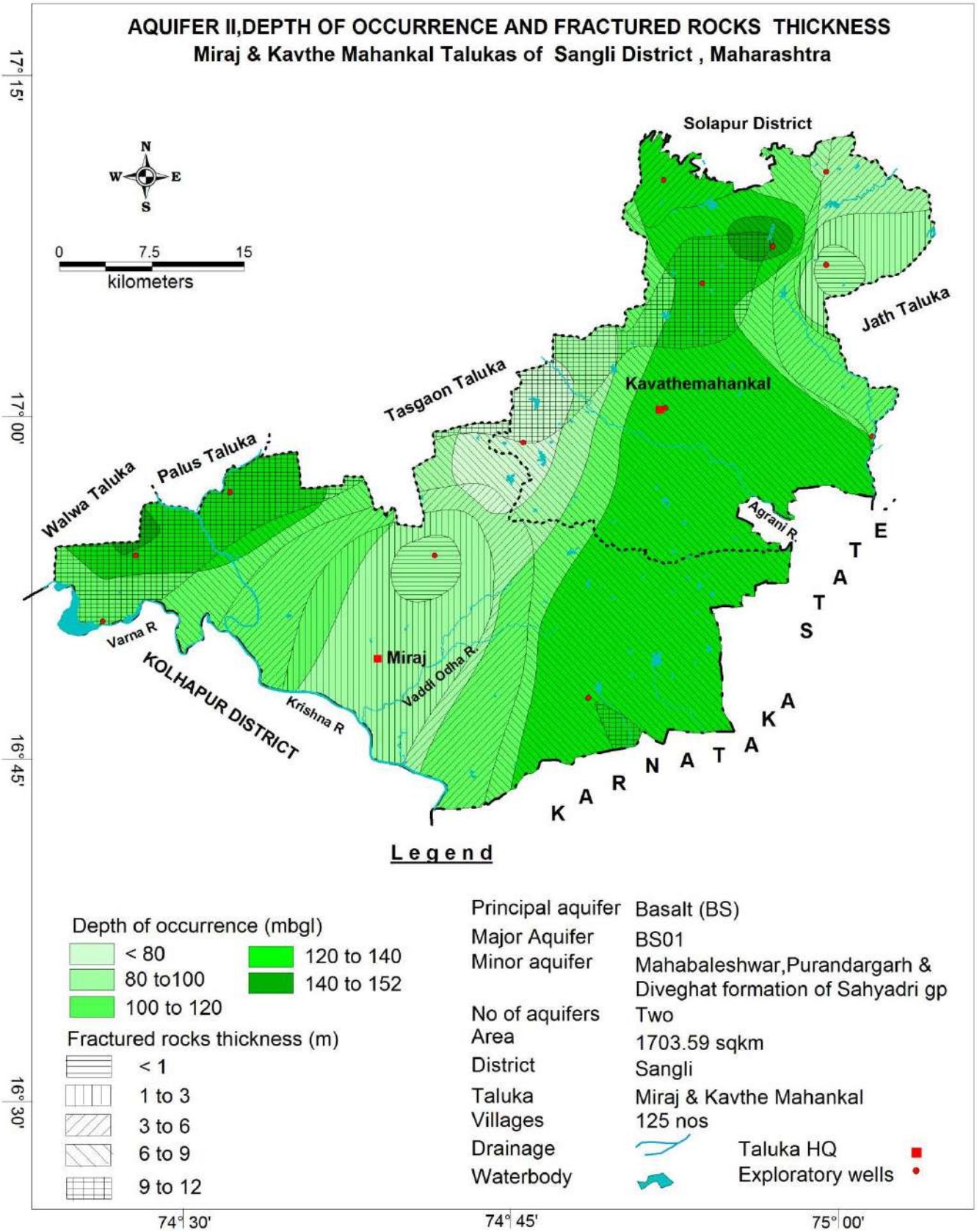


Fig.3.15: Aquifers-II , Depth of occurrence and fractured rock thickness

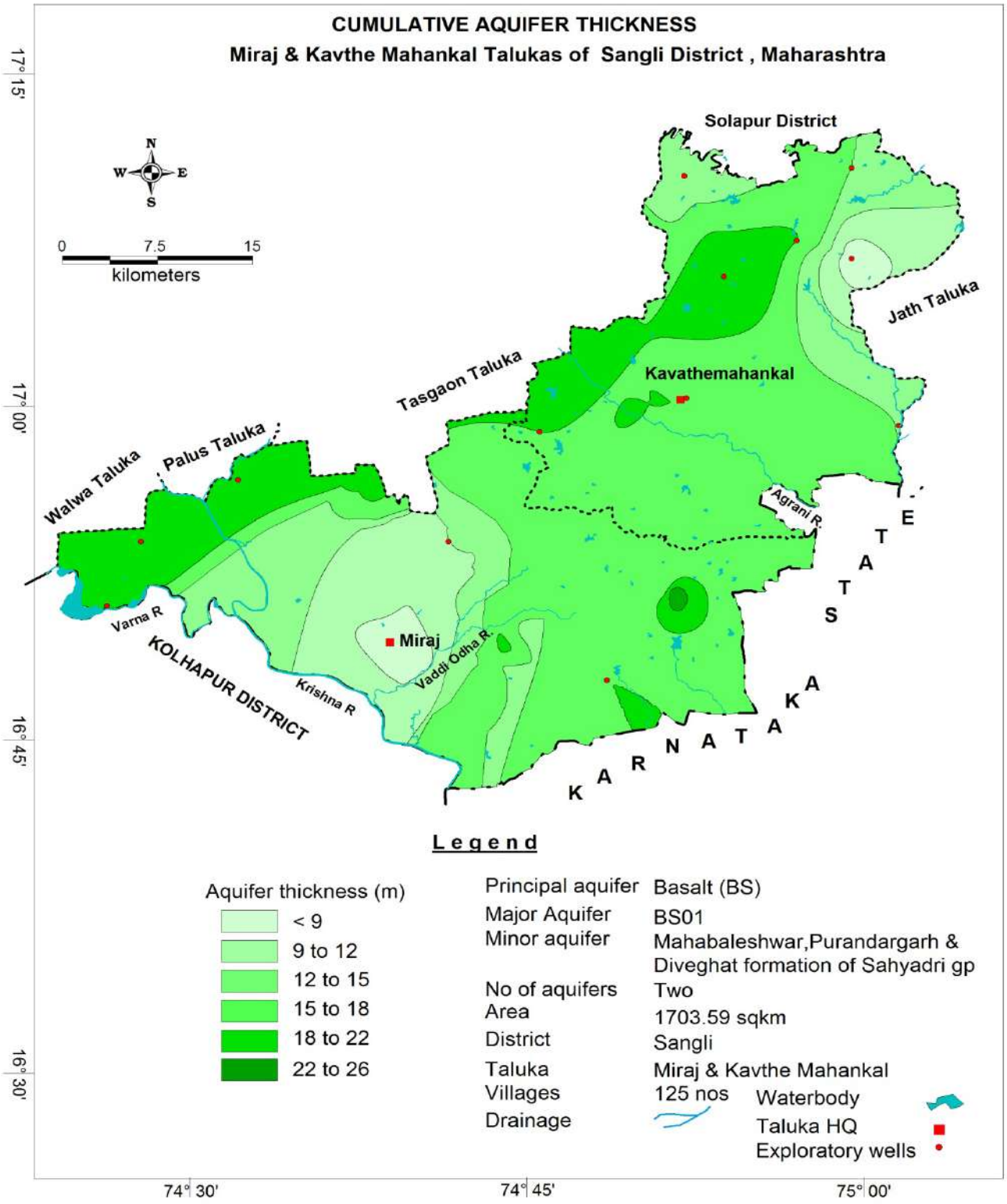


Fig.3.16: Cumulative aquifer thickness

The cumulative thickness map of Aquifer-I and II is prepared and presented as **Fig-3.16** the study of this map reveals that In the north eastern parts the cumulative depth of Aquifer-I and II is shallow, whereas in southern and centrally elongated parts, the cumulative thickness of Aquifer-I and II is higher indicating potential areas of ground water.

3.2.1 Hydrogeological Cross Sections

Based on ground water exploration a sub-surface lithological section has been prepared to know the lithological continuity and its extent. The aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' represents South –North direction (across both Miraj and Kavthe Mahankal Talukas), B-B' represents southwest- northeast direction (across both Miraj and Kavthe Mahankal Talukas), C-C' representing West to East direction (across both Miraj and Kavthe Mahankal Talukas) and D-D' representing northwest to southeast direction (across Miraj Taluka), as marked in Fig. 3.12. The sections are shown in Fig 3.20 to 3.23 .

3.2.1.1 Hydrogeological cross section A-A'

Section A-A' (**Fig.3.17**) represents South –North direction and data of 4 exploratory wells i.e., Arag, Kavthemahankal, Shelkewadi and Ghatnandre has been utilised. It can be clearly seen from the section that as we move from South to North direction i.e., from Arag to Ghatnandre, the thickness of Aquifer-I (shallow aquifer) is decreasing. On the contrary, the thickness of Aquifer-II (Deeper aquifer) is increasing. The maximum depth of Aquifer-II is ranging from 98.9 m bgl at Ghatnandre to 139 m bgl at Kavthemahankal, whereas maximum number of fracture zones (3 no.'s) were encountered at Shelkewadi at 68.4 m,101.9 m and 120.0 m depth which yielded a high discharge of 33.63 lps. The water levels of Aquifer-I and Aquifer-II has also been depicted in the section and a close observation of water level indicates that the water table of Aquifer-II is just below the Aquifer-I.

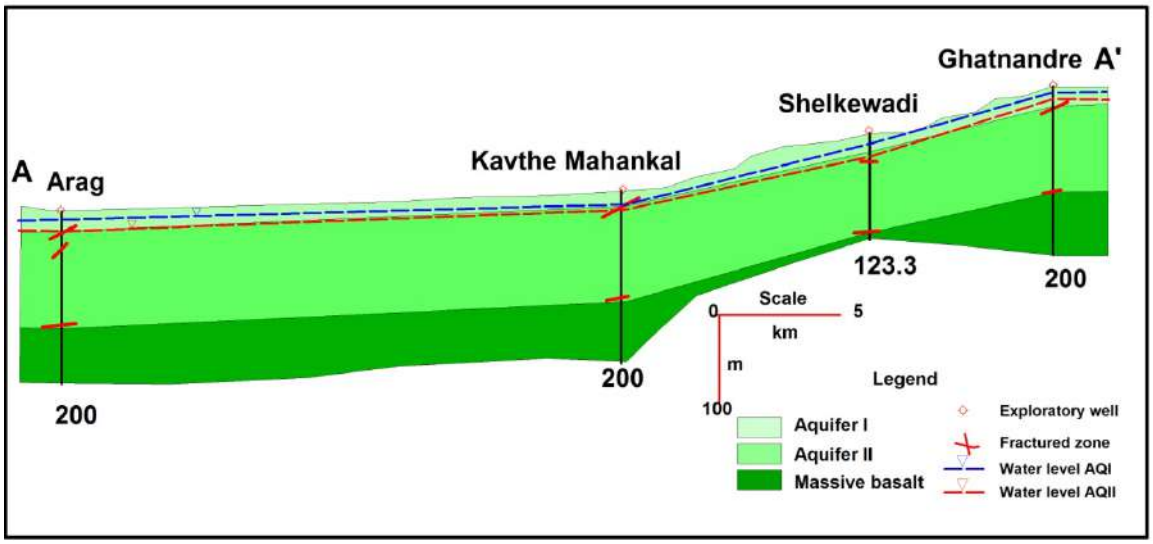


Fig.3.17: Hydrogeological Cross Section A-A'

3.2.1.2 Hydrogeological Cross Section B-B'

Hydrogeological cross section B-B' (**Fig.3.18**) represents southwest- northeast direction and data of 3 exploratory wells i.e., Shigaon, Shelkewadi and Ghorpadi has been

utilised. In this section as we move from southwest to northeast direction, i.e., from Shigaon to Ghorpadii, the thickness of Aquifer-I (shallow aquifer) is increasing. On the contrary, the thickness of Aquifer-II (Deeper aquifer) is decreasing. The maximum depth of Aquifer-II is ranging from 68.4 m bgl at Kavthemahankal to 172 m bgl at Ghorpadii, whereas the maximum discharge of 6 lps have been observed at Ghorpadi. The water levels of Aquifer-I and Aquifer-II has also been depicted in the section and a close observation of water level indicates that the water table of Aquifer-II is just below the Aquifer-I .

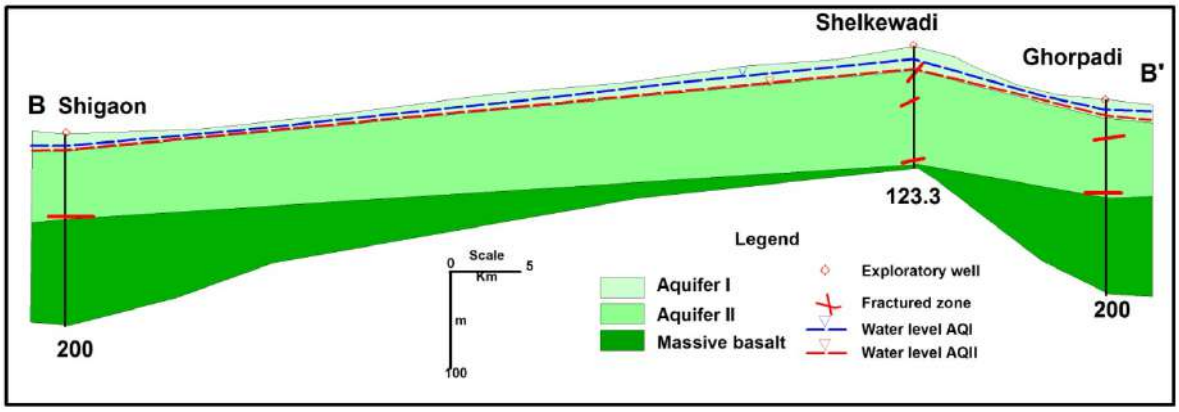


Fig.3.18: Hydrogeological Cross Section B-B'

3.2.1.3 Hydrogeological Cross Section C-C'

Hydrogeological cross section C-C' (**Fig.3.19**) represents West to East direction and data of 4 exploratory wells i.e., Mirajwadi, Alkud, Kavaathemahankal and Kokale has been utilised. In this section as we move from West to East direction, i.e., from Mirajwadi to Kokale , the thickness of Aquifer-I (shallow aquifer) is increasing. On the contrary, the thickness of Aquifer-II (Deeper aquifer) is decreasing. The maximum depth of Aquifer-II is ranging from 53.0 m bgl at Alkudi to 142 m bgl at Mirajwadi, whereas the maximum discharge of 3 lps have been observed at Alkud. The water levels of Aquifer-I and Aquifer-II has also been depicted in the section and a close observation of water level indicates that the water table of Aquifer-II is just below the Aquifer-I in the eastern part of the section while in the western part it is far below the Aquifer-I.

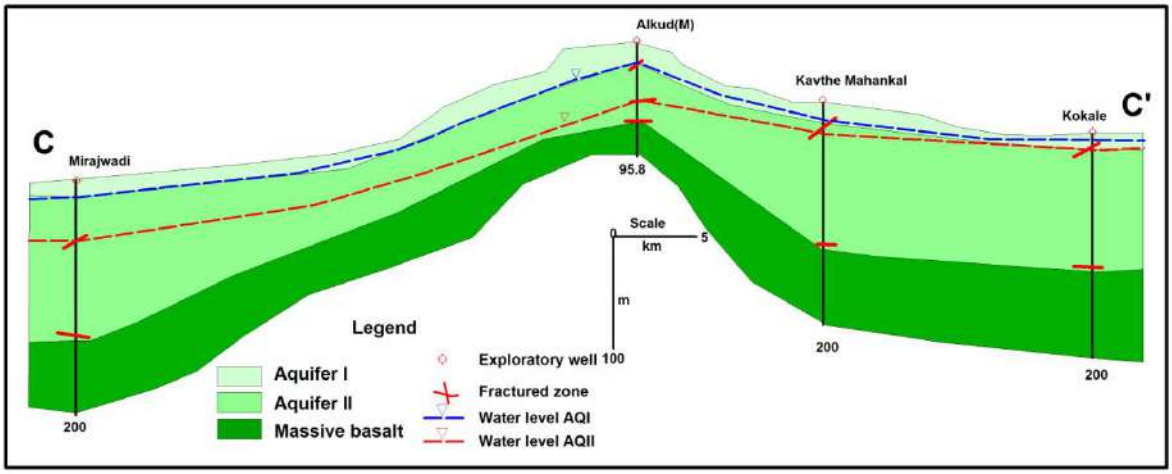


Fig.3.19: Hydrogeological Cross Section C-C'

3.2.1.4 Hydrogeological Cross Section D-D'

Hydrogeological cross section C-D (**Fig.3.20**) represents northwest to southeast direction and data of 3 exploratory wells i.e., Malwadi, Kalambi and Arag has been utilised. In this section as we move from northwest to southeast direction, i.e., from Malwadi to Arag, the thickness of Aquifer-I (shallow aquifer) is increasing. On the contrary, the thickness of Aquifer-II (Deeper aquifer) is decreasing. The maximum depth of Aquifer-II is ranging from 132 m bgl at Malwadi to 172 m bgl at Arag, whereas the maximum discharge of 0.78 lps have been observed at Arag. The water levels of Aquifer-I and Aquifer-II has also been depicted in the section and a close observation of water level indicates that the water table of Aquifer-II is just below the Aquifer-I.

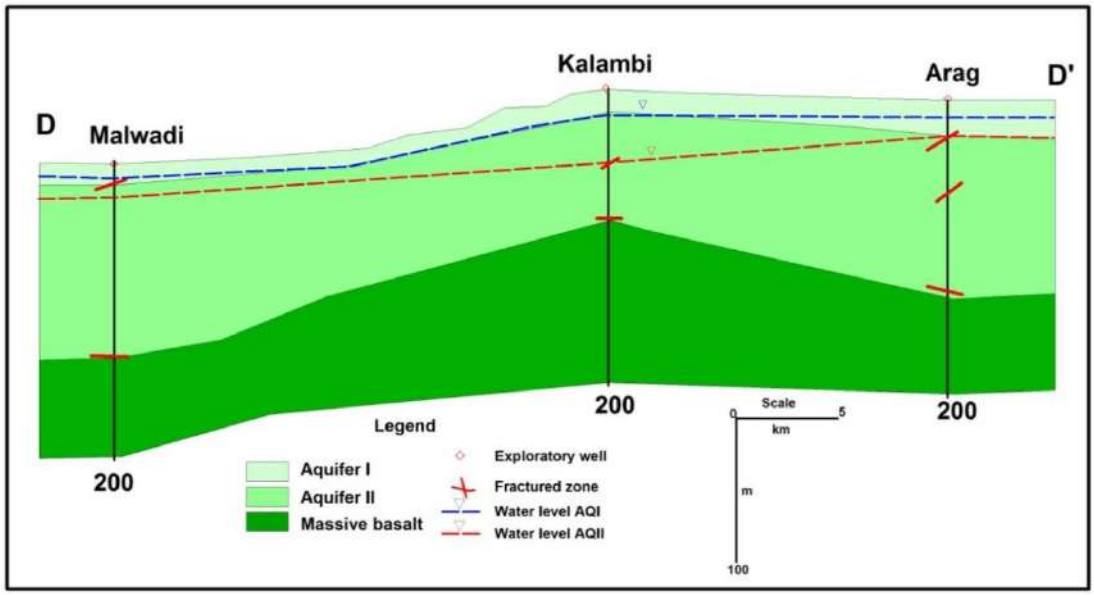


Fig.3.20: Hydrogeological Cross Section D-D'

3.3 Aquifer Characteristics

Basalt forms the main aquifer of the area and comprises two distinct units viz, upper vesicular unit and lower massive unit. The massive basalt is hard, compact and does not have primary porosity and hence impermeable. Weathering, jointing and fracturing induces secondary porosity in massive unit of basalt. In vesicular basalt, when vesicles are interconnected constitutes good primary porosity and when the vesicles are filled/ partly filled the porosity is limited. Ground water occurs under phreatic/ unconfined to semi-confined conditions in basalts.

Based on extensive analysis of historical data, micro level hydrogeological survey data generated and ground water exploration carried out in the Kavthe Mahankal and Miraj Talukas, of Sangli District, the following two types of aquifers can be demarcated and the details are given below in Table-3.3.

Aquifer I - Unconfined aquifer occurs in Deccan trap basalt is exposed in major parts of the Kavthe Mahankal and Miraj Talukas, Sangli District except where dykes are observed. This aquifer generally occurs down to the depth of 8 to 32 m bgl and within this the weathered and fractured rock thickness is ranging from 6 to 18 m, whereas the water levels are ranging from 0.5 to 14.5 m bgl. The dugwells tapping this aquifer can sustain pumping for 1 to 2 hours and these are the more feasible structures in the area.

Aquifer-II – semi –confined to confined aquifer occurs in the depth range of 20 to 152 m bgl, however the actual water bearing zones i.e., fractured rock thickness is limited to 0.50 to 12.0 m, whereas the water levels are ranging from 9.2 to 53.2 m bgl. The borewells tapping this aquifer can sustain pumping for 0.50 to 3 hours. The maps showing yield potential of Aquifer-I and Aquifer-II are presented in **Fig 3.21** and **Fig.3.22.**

Table-3.3: Aquifer Characteristics

Type of Aquifer	Formation	Depth range (mbgl)	SWL (mbgl)	Fracture/ weathered Zones encountered (m bgl)	Fractured/ weathered rocks Thickness (m)	Yield (m3/day)	Sustai-nability	Aquifer parameter (Transmissivity - m2/day)	Sy/S	Suitability for drinking/ irrigation
Aquifer-I	Deccan Trap-Weathered/ Fractured Basalt	8 - 32	0.5-14.5	Upto 32	6 to 18	10 to 100 m3/day	1 to 2 Hours	10.03-62.81	0.019-0.028	Yes , suitable for both
Aquifer-II	Jointed/ Fractured Basalt	20-152	9.2-53.2	20 to 152	0.5 to 12	Upto 3 lps	0.5 to 3 hours	5.85-177	1.30 x 10-4. 5.31 x 10-4	Yes, suitable for both, except High EC

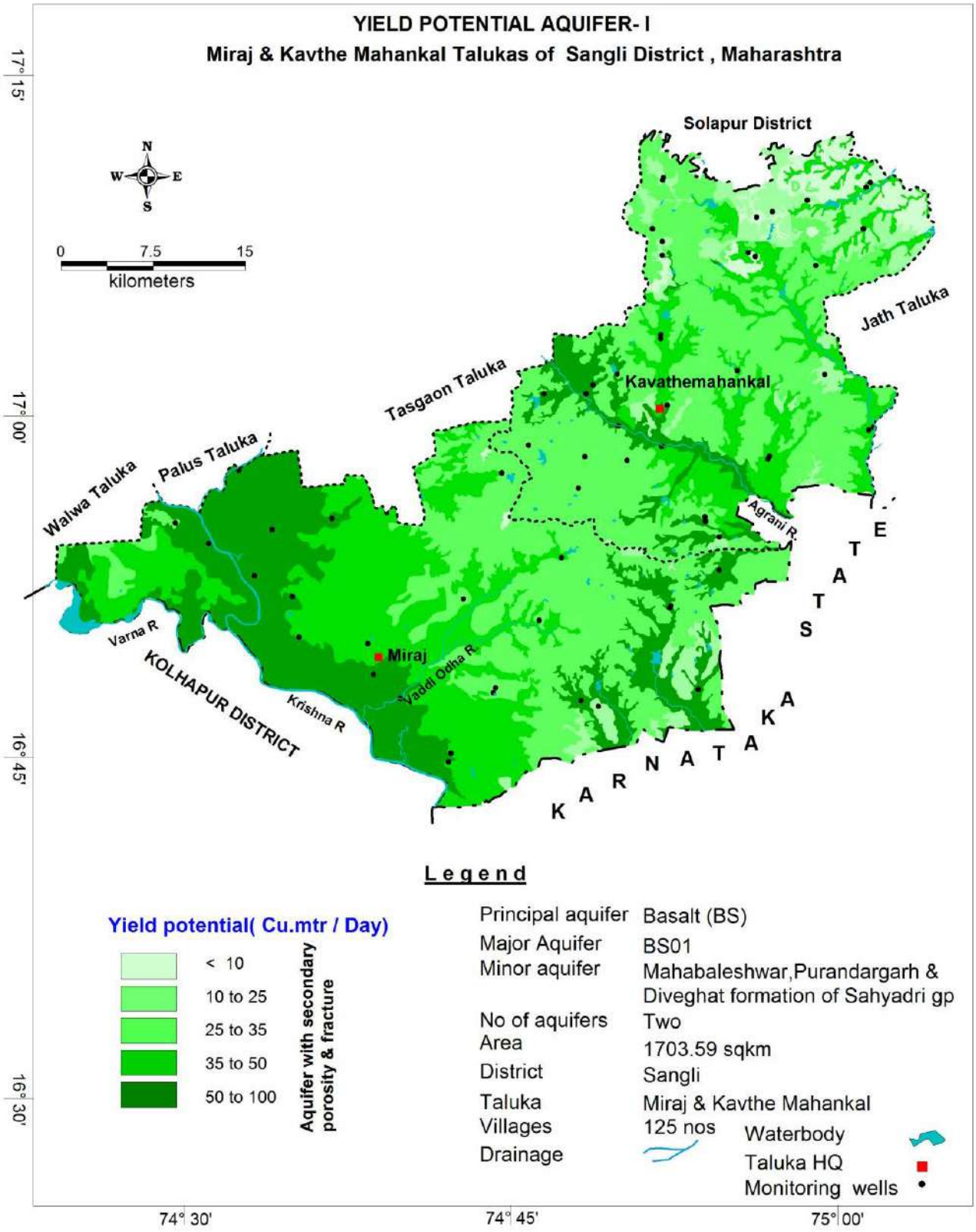


Fig.3.21: Yield Potential of Aquifer I

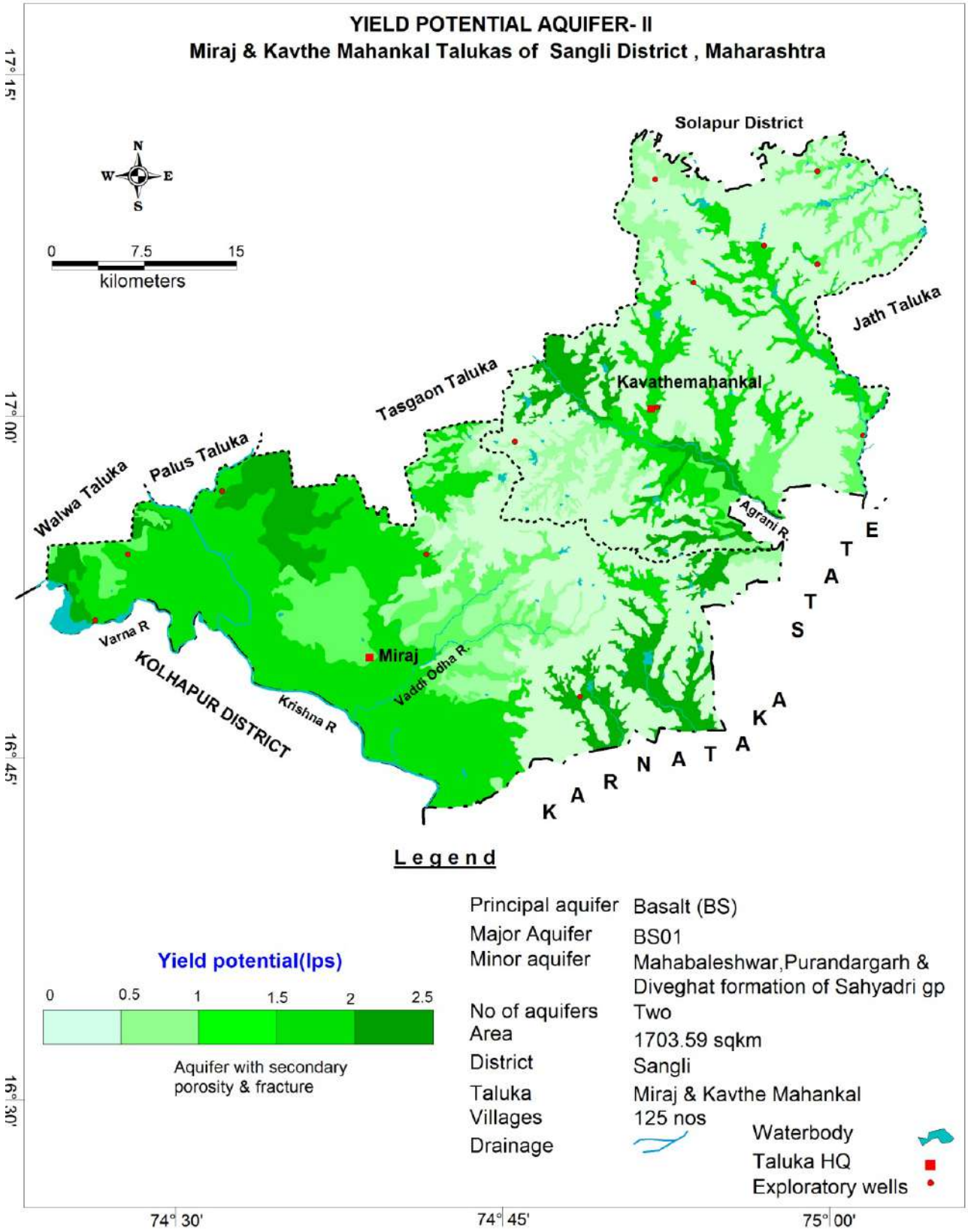


Fig.3.22: **Yield Potential of Aquifer Ii**

The perusal of **Fig. 3.21** indicates that in major parts the yield potential of Aquifer-I is < 50 m3/day. The north south patch extending from

Ashta in the north to Arag in the south, forming western parts of the study area having good/higher yield potential ranging from 50 to > 100 m3/day. Small areas along Agarani river also show moderate to good yield potential. These areas seem to be feasible for dug well construction.

The perusal of **Fig. 3.22** indicates that in major parts the yield potential of Aquifer-II is low within 1 lps particularly the area extending from Ghorpadi in north to Miraj in the south. The north south patch extending from Ashta in the north to Arag in the south, forming western parts of the study area exhibit moderate to good ground water potential of 2 to 3 lps. In remaining areas moderate ground water potential of 1 to 2 lps is noticed.

Along with yield potential, the aquifer parameters viz., transmissivity and specific yield / storativity also form an important aquifer characteristic and provide valuable input on sustainability of the aquifers. The transmissivity of Aquifer-I ranges from 10.03 to 62.81 m^2/day thus indicating vide variation, whereas the specific yield ranges from 0.019-0.028 i.e., 1.9% to 2.8% which is within the norms of 2% to 3% for basaltic aquifers indicating that the yields of the wells in the area are better than the borewells. The transmissivity of Aquifer-II ranges from 5.85-177 m^2/day.

4. GROUND WATER RESOURCES

The ground water resources have been assessed for two types of aquifer existing in the area i.e., Aquifer-I and Aquifer-II. The details of the assessment are discussed below.

4.1 Ground Water Resources – Aquifer-I

The ground water resource assessment has been carried out for command and non-command areas separately after excluding the hilly areas and the salient features of the resources are given in **Table 4.1, 4.2** and **4.3**.and the map depicting the distribution of ground water resources and categorisation of the talukas is presented in **Fig 4.1**.

As per Table-4.1, out of the total geographical area of 170359 ha, recharge worthy areas accounts to 155215.24 ha which includes 7416.07 ha in command areas and 147799.17 ha in non-command areas, whereas 368 ha area is not worthy for recharge on account of its hilly nature.

Table-4.1: Ground Water Recharge Worthy Areas for Resource Estimation

Assessment Unit (Taluka)	Predominant Formation	Total Geographical Area (ha)	Hilly Area (ha)	Ground Water Recharge Worthy Area	
				Command area (ha)	Non-command area (ha)
Kavthe Mahankal	Hardrock (Basalt)	74953.00	0.00	3647.00	71306.00
Miraj Taluka	Hardrock (Basalt)	95406.00	368.00	3769.07	76493.17

4.1.1 Recharge Component

During the monsoon season, the rainfall recharge is the main recharge parameter, which is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying groundwater level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. Monsoon recharge can be expressed as:-

$R = h \times Sy \times A + DG$

where,

h = rise in water level in the monsoon season, Sy = specific yield

A = area for computation of recharge, DG = gross ground water draft

The monsoon ground water recharge has two components- rainfall recharge and recharge from other sources. The other sources of groundwater recharge during monsoon

season include seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, and water conservation structures.

During the non-monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-monsoon recharge.

The season wise assessment of recharge from various components such as rainfall and other sources was done and presented in Table-4.2 and **Fig.4.1**. During monsoon season the recharge from rainfall contributes maximum component (11479.82 ham) and recharge from other sources is 2681.15 ham, whereas during non-monsoon season, recharge from rainfall is 583.87 while the recharge from other sources is 7976.94 ham. The total annual ground water recharge is 22721.19 ham and net ground water availability after natural discharge is estimated as 21475.23 ham.

Table-4.2: Recharge Components evaluated for Resource Estimation

Assessment Unit (Taluka)	Command / Non-Command / Total	Recharge from rainfall during monsoon season (ham)	Recharge from other sources during monsoon season (ham)	Recharge from rainfall during non-monsoon season (ham)	Recharge from other sources during non-monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Provision for Natural Discharges (ham)	Net Annual Ground Water Availability (ham)
Kavthe Mahankal	Command	248.10	292.47	8.43	1232.32	1781.32	112.62	1668.70
	Non Command	4822.59	929.67	192.13	1931.31	7875.70	393.79	7481.92
	Total	5070.69	1222.14	200.57	3163.63	9657.02	506.41	9150.62
Miraj	Command	270.38	705.78	16.96	2365.56	3358.69	254.29	3104.40
	Non Command	6138.75	753.23	365.75	2447.75	9705.48	485.27	9220.21
	Total	6409.13	1459.02	382.71	4813.31	13064.17	739.56	12324.61

The utilisation of available ground water resources for various purposes for the study area is provided in Table-4.3 and **Fig.4.2**. The annual gross draft for all uses is estimated at 20570.49 ham with domestic and industrial sector having a draft of 720.15 ham. The annual draft for irrigation use is estimated as 19850.34 ham. The allocation for domestic & industrial requirement supply up to next 25 years is about 1039.66 ham and ground water available for future irrigation is 2130.02 ham. The stage of ground water development is alarming i.e., 98.1% (critical) in Kavthemahankal taluka and 94.07%(Semi-critical) in Miraj taluka.

Table- 4.3: Draft and Stage of GW Development in the study area

Assessment Unit (Taluka)	Command / Non-Command / Total	Net Annual Ground Water Availability (ham)	Existing Gross Ground Water Draft for irrigation (ham)	Existing Gross Ground Water Draft for domestic and industrial water supply (ham)	Existing Gross Ground Water Draft for All uses (ham)	Provision for domestic and industrial requirement supply to 2025 (ham)	Net Ground Water Availability for future irrigation development (ham)	Stage of Ground Water Development (%)	Category
Kavthe Mahankal	Command	1668.70	2850.88	137.41	2988.29				
	Non Command	7481.92	5666.71	321.44	5988.15				
	Total	9150.62	8517.59	458.85	8976.44	623.83	694.00	98.10	**Critical**
Miraj	Command	3104.40	2198.35	167.67	2366.02				
	Non Command	9220.21	9134.40	93.63	9228.03				
	Total	12324.61	11332.75	261.30	11594.1	415.83	1436.02	94.07	**Semi Critical**

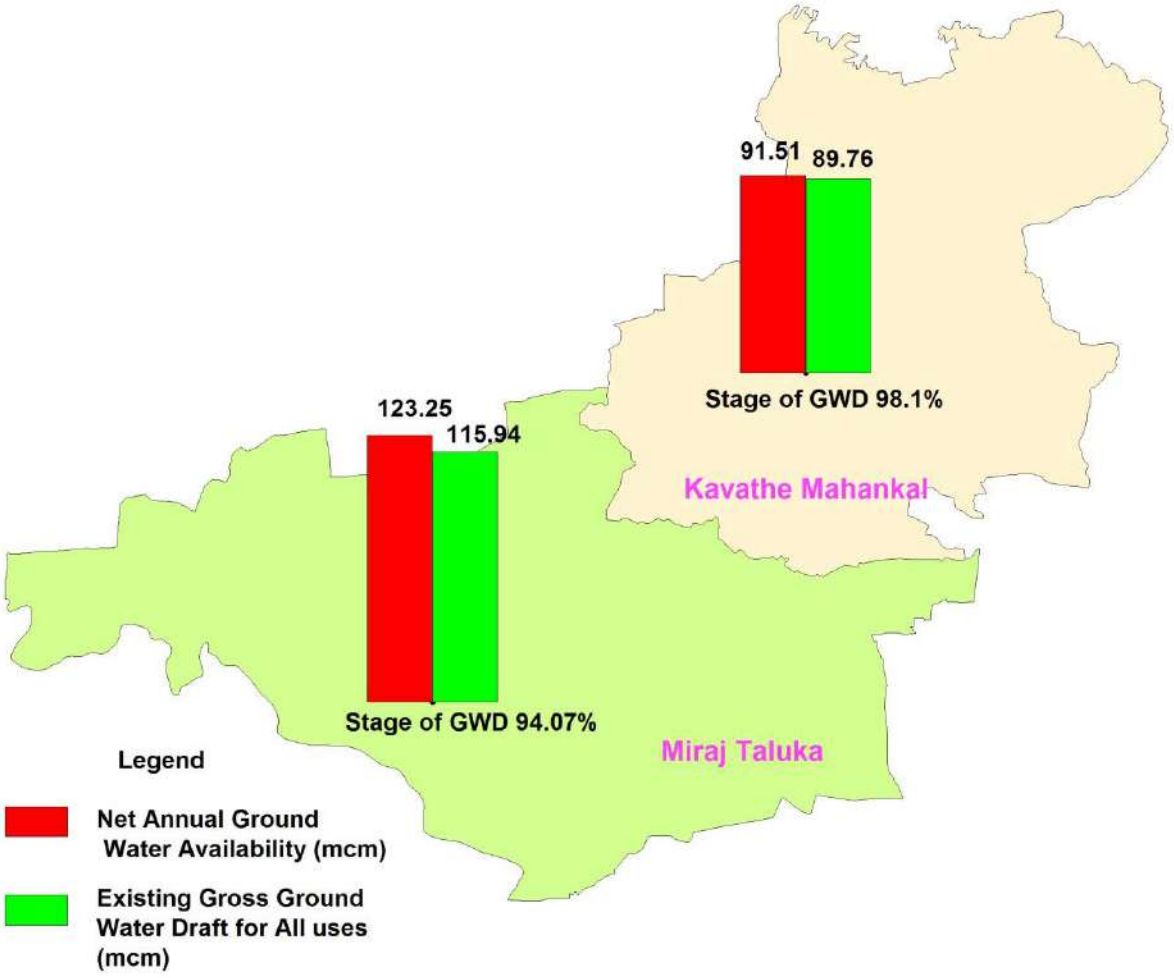


Fig.4.1: Ground Water Resources

1.1.1 In-storage groundwater resources

The fresh In-storage groundwater resources in aquifer-I, of the Miraj and Kavthe Mahankal talukas, below the pre-monsoon water level are estimated 0.7846 mcm , whereas saline in-storage resources are 0.0 mcm . Including the components of Dynamic (214.76 mcm) and In-storage ground water resources (0.7846 mcm), the total fresh resources of the study area has been estimated as 215.54 mcm. **Table 4.4**

Table 4.4: In-storage groundwater resources

Name of Administrative Unit	Type of rock formation	Total Geographical Area	Total area considered for resource calculation (ha)	Thickness of the Productive Zone below Pre monsoon WL (m)	Average Specific Yield (fraction)	Fresh Water	Brackish/ Saline Water
Kavthe Mahankal	Hardrock	74953.00	8939.70	1.08	0.0080	76.72	0.00
Miraj	Hardrock	95406.00	200.00	1.30	0.0067	1.74	0.00
						78.46	

4.2 Ground Water Resources – Aquifer-II

The ground water resource of the Aquifer –II was also assessed to have the correct quantification of resources so that proper management strategy can be framed. To assess these resources, the area was divided into various different polygons based on the fractured zones / thickness of aquifer –I occurring below water level in that particular polygon, then the storativity value for the nearest exploratory well was taken into consideration. By applying the formula of deeper ground water resource estimation as given by CHQ during the static ground water resources was utilised i.e.,

GWR = Area x Thickness of aquifer x Storativity

By applying above formula, the ground water resource of Aquifer-II was estimated as 35.7 MCM and are presented below in **Table- 4.5**.

Table- 4.5: Ground Water Resources of Aquifer-II.

Taluka	Mean Fractured Rock Thickness (m)	Area (Sq km)	Pz headmeter above confining layer	Sy	S	Resource above confining layer	Resource of fractured rocks	Total Resource (MCM)
Kavthe Mahankal	4.5	0.644545	55	0.004	0.0001307	0.004633	0.011602	0.016235
Kavthe Mahankal	0.75	13.1409	35	0.004	0.0000403	0.018535	0.039423	0.057958
Kavthe Mahankal	4.5	32.2527	36	0.004	0.000531	0.616543	0.580549	1.197091
Kavthe Mahankal	2	48.2349	40	0.004	0.0000403	0.077755	0.385879	0.463634
Kavthe Mahankal	4.5	89.0478	25	0.004	0.0000403	0.089716	1.60286	1.692576
Kavthe Mahankal	10.5	122.682	45	0.002	0.0000403	0.222484	2.576322	2.798806
Kavthe Mahankal	7.5	431.475	55	0.001	0.0000403	0.956364	3.236063	4.192427
Miraj	10.5	4.6968	35	0.004	0.000531	0.08729	0.197266	0.284556
Miraj	10.5	7.79294	36	0.004	0.0000403	0.011306	0.327303	0.338609
Miraj	0.75	24.2084	40	0.004	0.0000403	0.039024	0.072625	0.111649
Miraj	7.5	57.6947	25	0.004	0.000531	0.765897	1.730841	2.496738
Miraj	10.5	122.616	45	0.002	0.0000403	0.222364	2.574936	2.7973
Miraj	4.5	192.609	55	0.004	0.0000403	0.426918	3.466962	3.89388
Miraj	2	198.123	35	0.004	0.000531	3.682116	1.584984	5.2671
Miraj	7.5	320.956	36	0.004	0.0000403	0.465643	9.62868	10.09432
						7.686588		**35.70288**

5 GROUND WATER RELATED ISSUES

The Kavthemahankal and Miraj talukas are part of famous 'Sugarcane and Horticulture belt' of Maharashtra. On one hand, ground water development has been drastically raised, while, on the other side, the area receives very low rainfall, construction of water conservation structures by various government agencies & NGOs, micro irrigation practices adopted by the farmers etc. Hence, although the stage of ground water development is high i.e., upto 94.07% and 98.1 % respectively, and the talukas are categorized as semi-critical and Critical, because of rise in water levels in certain areas. Though the farmers of the area have adapted large scale micro irrigation techniques, however limited ground water availability has stunted the increase in irrigation potential. The major issues affecting the areas are discussed below

5.1 Over Exploitation of Ground Water

As such, Kavthe Mahankal and Miraj Talukas, Sangli Districtis having major issue that is high ground water development. At present the overall stage of ground water development is around 94.07% and 98.1% in Miraj and Kavthe Mahankal Talukas respectively. The stage of ground water development has increased over the period of time from 2008 to 2013 from 90.05% to 94.07% in Miraj taluka and from 93.72% to 98.1% in Kavthe mahankal taluka **(Fig 5.1).** The main reason for ground water excessive draft is for irrigation purpose. in Miraj taluka the draft has increased from 9564.01 MCM in 2008 to 11594.05 MCM in 2013 while in Kavthe mahankal the draft has increased from 7969.99 MCM in 2008 to 8976.44 MCM in 2013 **(Fig 5.2)** . Also, the gap between the availability of ground water and draft is reducing over the period from 2008 to 2013. This provides very limited scope for ground water development particularly in irrigation sector.

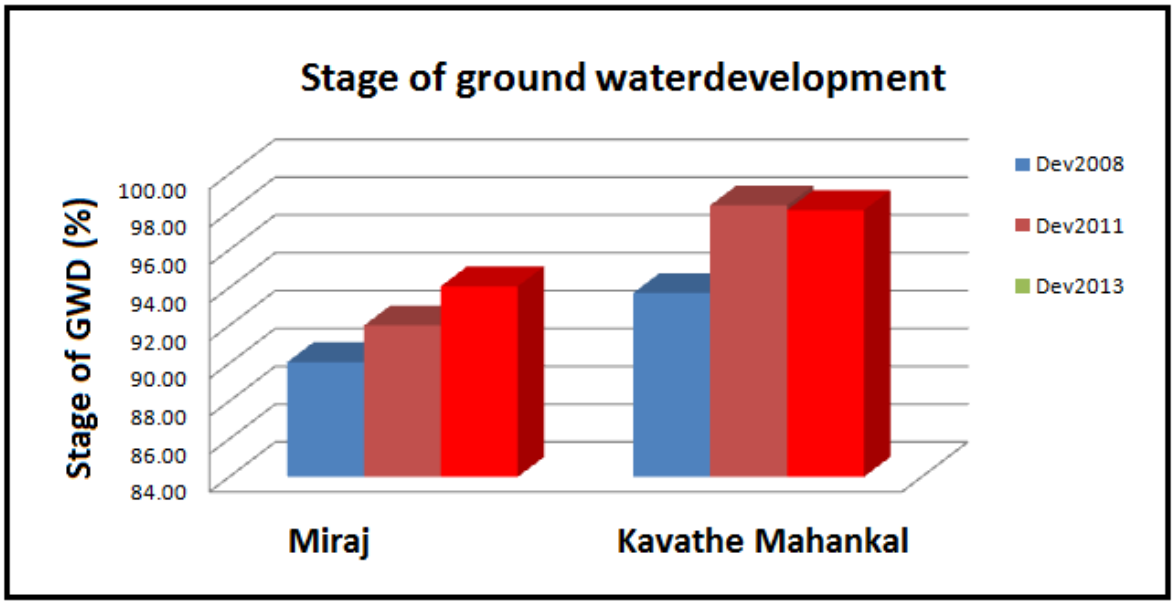


Fig 5.1 Change in stage of ground water development

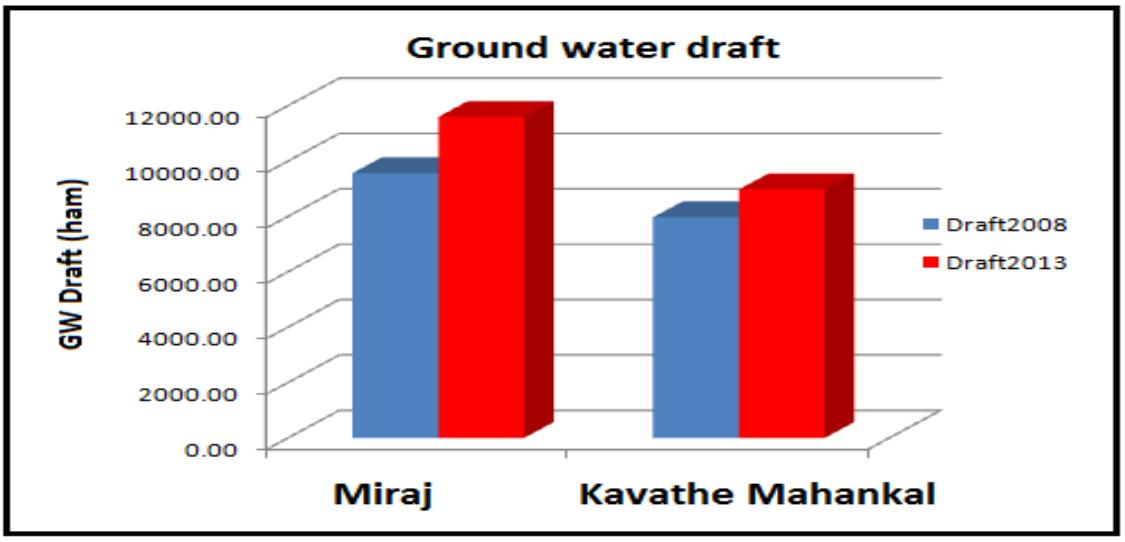


Fig 5.2: Change of ground water draft

5.2 Declining Water Levels

The ground water exploitation has resulted in declining of water levels over the period of time. At present, the pre monsoon declining water level trend of more than 0.2m/year has been observed in about 879Sq.km. (56.6% of area) and the post monsoon declining water level trend of more than 0.2m/year has been observed in about 666 Sq.km. (42.85% of area) (**Fig 5.3 & Fig 5.4**).

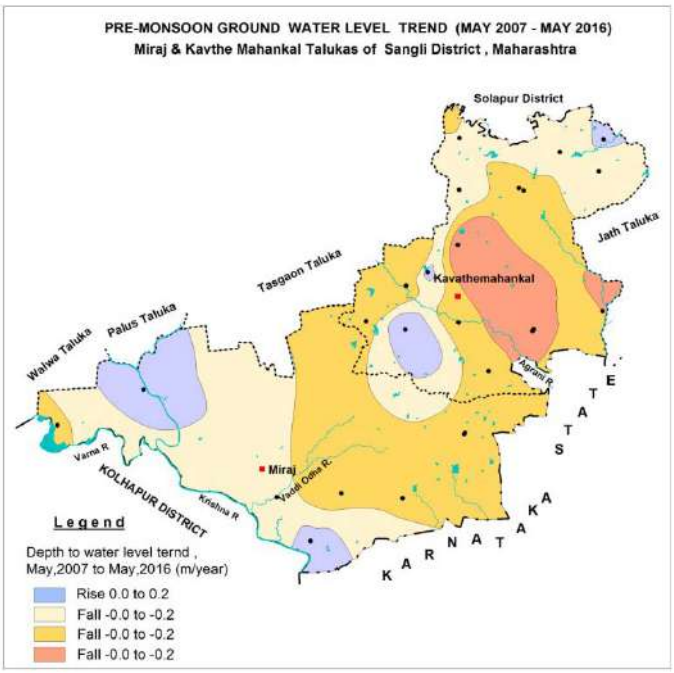


Fig 5.3 Premonsoon Fall @.0.2/year 879 Sqkm

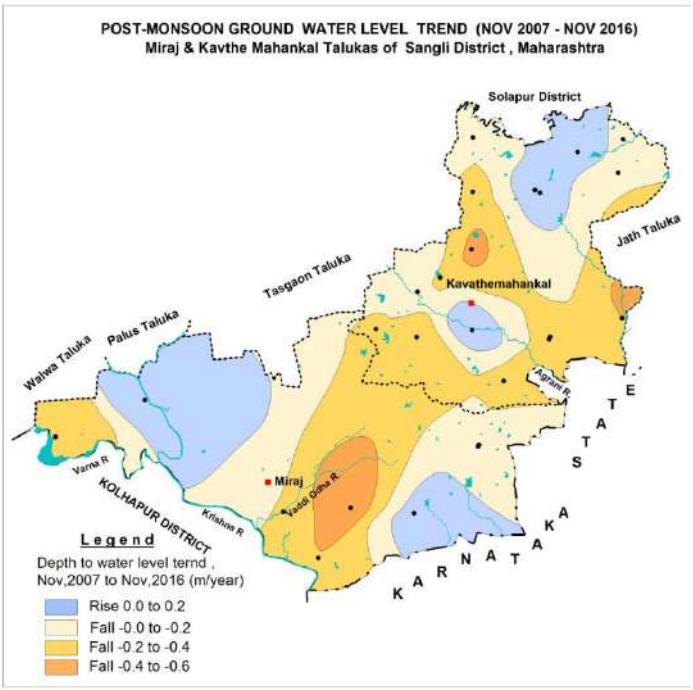


Fig 5.4 Postmonsoon Fall @.0.2/year 666 Sqkm

5.3 Low Rainfall and Droughts

The short term rainfall analysis for the period 2006-2015 infdicates that average rainfall of Kavthe Manhakal and Miraj talukas are 494.97 and 433.6 mm respectively, whereas the long term rainfall data for 20 years (1998-2016) for both these talukas was also analysed and it indicates that normal rainfall of Kavthe Manhakal and Miraj talukas are 520.3 mm and 584.8 mm respectively**.** The current rainfall (2015) for these 2 talukas was 445 mm (14% deficient) and 508 mm (13% deficient). From the decadal rainfall trend analysis from 2006 to 2015 it's observed that, both the stations have significant falling rainfall trend . In Last five years ,four year rain fall are showing decline trend in the range of 10% to 40 % from normal rainfall **(Table 5.1).** Thus indicating that both these talukas are experiencing low and declining rainfall with frequent droughts.

Table 5.1 Rainfall data of last five year.

YEAR	Kavthe Mahankal			Miraj		
	ANNUAL	DEP %	CATEGORY	ANNUAL	DEP%	CATEGORY

2011	403.5	-22	NORMAL	522.8	-11	NORMAL
2012	312.5	-40	MODERATE	642	10	NORMAL
2013	404.3	-22	NORMAL	523.6	-10	NORMAL
2014	574.2	10	NORMAL	664.6	14	NORMAL
2015	445.2	-14	NORMAL	508.8	-13	NORMAL

5.4 Low Ground Water Potential / Limited Aquifer Thickness / Sustainability

Low ground water potential areas have been identified in 1100 sq.km. covering northern part of Miraj Taluka and almost entire Kavthemahankal taluka mostly due to restricted depth of weathering in Aquifer-I and limited aquifer thickness of Aquifer-II as seen in Fig. 3.14 and Fig 3.15 and yield potential maps are prented in fig5.5 and 5.6. Sustainability of both the aquifers is limited and the wells normally sustain pumping of 0.5 to 3 hours.

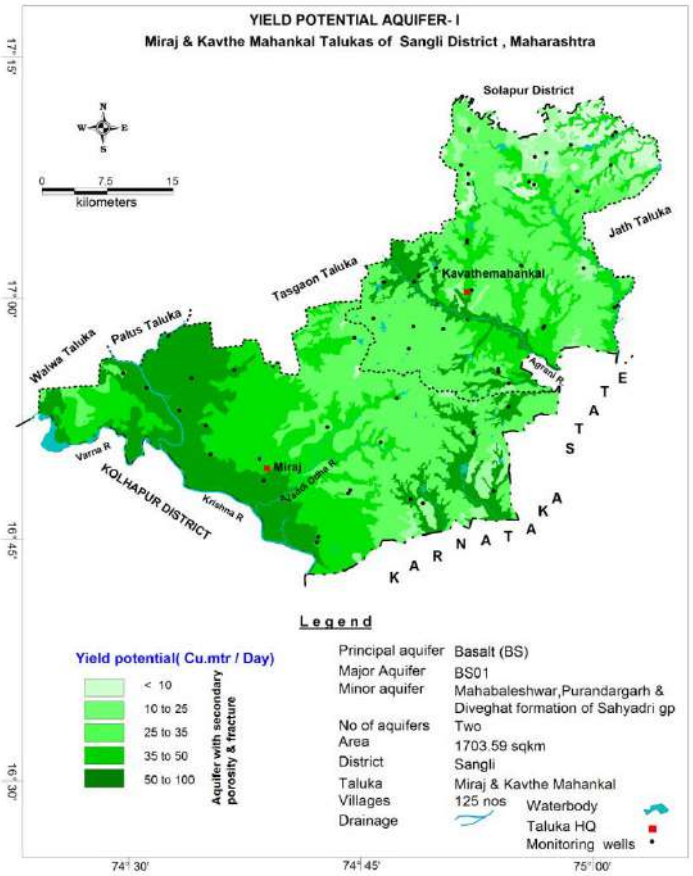


Fig 5.5 Yield potential of Aquifer I

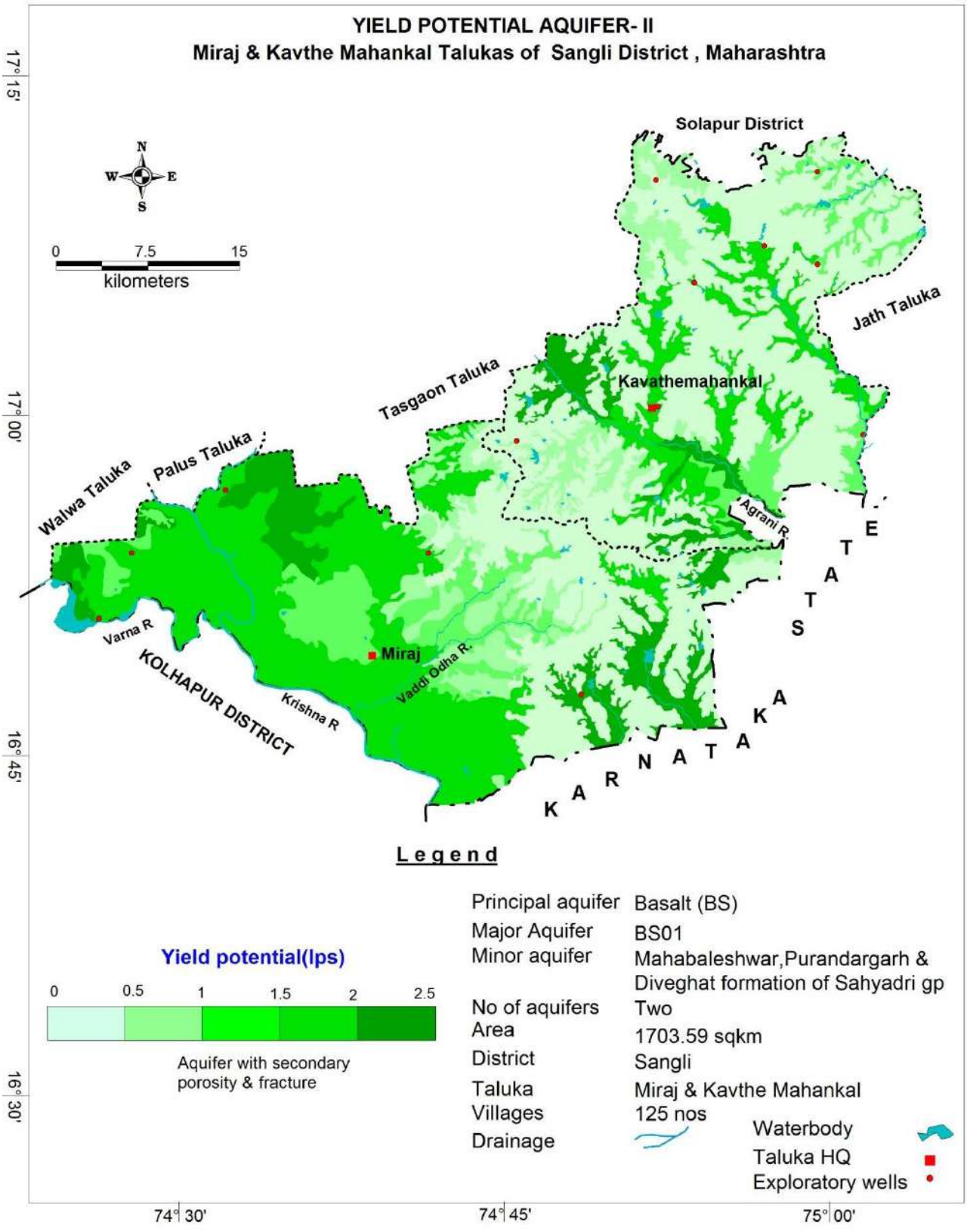


Fig 5.6 Yield potential of Aquifer II

6 STRATEGIES

A through study was carried out based on data gap analysis, data generated in-house, data acquired from State Govt. departments and maps procured from MRSAC, an integrated approach was adopted while preparing aquifer management plan of Miraj and Kavthe Manhakal talukas of Sanghli district, categorised as Semi Critical/ Critical blocks. Based on geomorphology, soil, land use, field data and lithological layers generated, following management plan is prepared. The detailed aquifer management plan for Miraj and Kavthe Manhakal talukas of Sanghli district is presented in **Table 6.1**.

6.1 Aquifer Management Plan for Kavthe Manhakal Taluka

The geographical area of Kavthe Manhakal Taluka is 745 sq. km., as per ground water resources estimation 2013, the stage of ground water development is **98.1 %** and categorised as critical. The annual ground water resource available is 91.51 MCM and the gross ground water draft for all uses is 89.76 MCM including 85.18 MCM for irrigation and 4.59 MCM for domestic sector. The major issues identified in Kavthe Manhakal Taluka are high stage of ground water development, low rainfall,decline of water level,exploitation of ground water and limited aquifer potential.

The agricultural demand from ground water and surface water is 85.18 mcm and 41.77 MCM respectively. Whereas, the domestic demand for ground water and surface water is 4.59 and 1.15 MCM. The agricultural supply from ground water and surface water is 85.18 mcm and 41.77 MCM respectively. Whereas, the domestic supply for ground water and surface water is 4.59 and 1.15 MCM. Hence, there is no Demand-Supply gap. To bring the stage of ground water development upto 70 % it is estimated that about 36.72 MCM of water is required.

Supply side interventions proposed to tackle above said major issues through rainwater harvesting and artificial recharge. The volume of unsaturated zone available in Kavthe Manhakal taluka is worked out as 986.26 MCM. The volume of water required for recharge the area is 26.31 MCM. The surface surplus non-committed runoff availability is 12.08 MCM. Therefore, the surface runoff of 12.08 MCM is considered for planning. For this, a total of 48 percolation tank and 83 Check dams are required as recharge measures. The volume of water expected to be conserved/recharged @75% efficiency is 7.2 MCM through Percolation tank and 1.87 MCM through Check dams. The cost estimate for 48 percolation tank and 83 check dams are Rs. 72 and Rs. 24.9 crore respectively. The location of artificial recharge structures proposed are given in **Annexure IX** and shown in **Fig 6.1.**

The rainwater harvesting in urban areas can be adopted in 25% of the household with 50 Sq. m roof area. A total of 0.29 MCM potential can be generated by taking 80% runoff coefficient. The estimated cost for rainwater harvesting through rooftop is calculated as Rs.19.47 crore. Hence, this technique is not economically viable and therefore it is not recommended.

Overall total volume of water expected to be recharged or conserved by artificial recharge is 9.07 MCM with a cost estimate of Rs. 96.9 crore, excluding roof top rain water harvesting which is not economically viable.

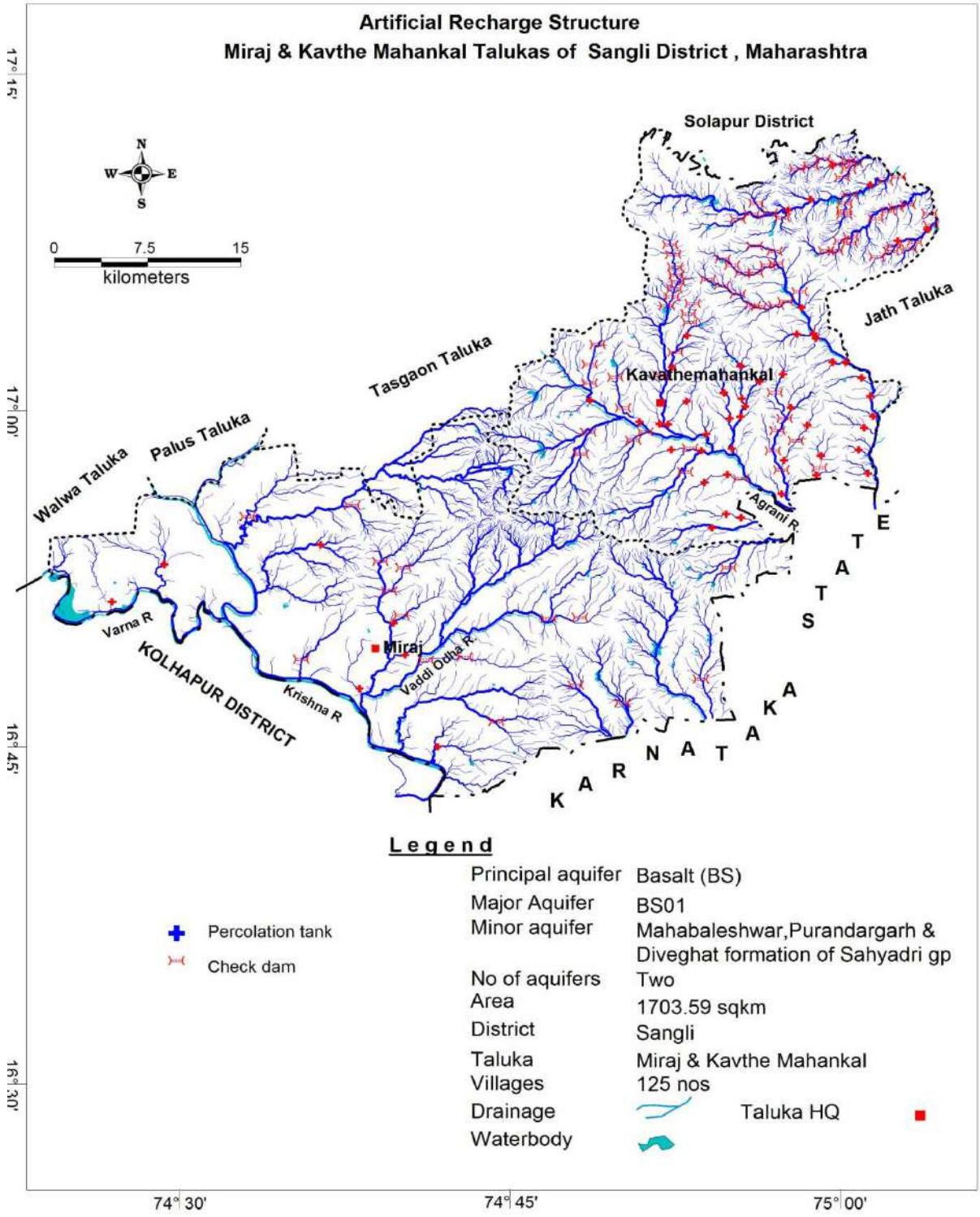


Fig 6.1 Location of Artificial recharges structures

Demand side interventions such as change in cropping pattern has not been proposed. About 70% of sugarcane crop area (i.e. 15 Sq km) is proposed to be covered under Drip i.e., about 10.5 sq km. Due to which about 5.99 MCM water is expected to be saved (water req for Surface Flooding 2.45 m., Drip 1.87 = saving 0.57 m). The expenditure of Rs. 15.57 Crore is expected considering Rs. 60,000/- per acre, towards the implementation of micro-irrigation in Kavthe Manhakal Taluka.

About 90% of Cotton crop area (i.e. 5.5 Sq km) is proposed to be covered under Drip i.e., about 4.95 sq km. Due to which about 1.49 MCM water is expected to be saved (water req for Surface Flooding 0.8 m., Drip 0.5 = saving 0.3 m). The expenditure of Rs. 3.06 Crore is expected considering Rs. 25,000/- per acre, towards the implementation of micro-irrigation in Kavthe Manhakal Taluka.

About 75% of sugarcane crop area (i.e. 70 Sq km) is proposed to be covered under Drip i.e., about 52.5 sq km. Due to which about 21.00 MCM water is expected to be saved (water req for Surface Flooding 0.9 m., Drip 0.5 = saving 0.4 m). The expenditure of Rs. 32.43 Crore is expected considering Rs. 25,000/- per acre, towards the implementation of micro-irrigation in Kavthe Manhakal Taluka.

Thus, following benefits are expected after implementation of above said Aquifer Management Plan in Baramati Taluka.

1. Additional ground water resources available after implementing above measures is 37.54 MCM which would bring the stage of ground water development from 98.1 % to 70 % i.e. about 28.1 % reduction in the stage of ground water development with estimated expenditure of Rs. 147.96 crore.
2. About 126 ha additional area will be covered under assured irrigation
3. Apart from this, it is proposed to impose ground water regulatory measures like banning the bore well drilling down to 60 m bgl for irrigation purpose.

6.2 Aquifer Management Plan for Miraj Taluka

The geographical area of Miraj Taluka is 809 sq. km., as per ground water resources estimation 2013, the stage of ground water development is **94.07 %** and categorised as semi-critical. The annual ground water resource available is 123.25 MCM and the gross ground water draft for all uses is 115.94 MCM including 113.32 MCM for irrigation and 2.61 MCM for domestic sector. The major issues identified in Miraj Taluka are high stage of ground water development, exploitation of ground water, limited aquifer potential, decline of water level and water scarcity during lean period.

The agricultural demand from ground water and surface water is 113.32 and 117.17 MCM respectively. Whereas, the domestic demand for ground water and surface water is 2.61 and 0.65 MCM. The agricultural supply from ground water and surface water is 113.32 and 117.17 MCM respectively. Whereas, the domestic supply for ground water and surface water is 2.61 and 0.65 MCM. Hence, there is no Demand-Supply gap. To bring the stage of ground water development upto 70 % it is estimated that about 42.38 MCM of water is required.

Supply side interventions proposed to tackle above said major issues through rainwater harvesting and artificial recharge. The volume of unsaturated granular zone available in Miraj taluka is worked out as 152.3 MCM. The volume of water required for recharge the area is 4.07 MCM. The surface surplus non-committed runoff availability is 1.87 MCM. Therefore, the surface runoff of 1.87 MCM is considered for planning. For this, a total of 7 percolation tank and 16 Check dams are required as recharge measures. The volume of water expected to be conserved/recharged @75% efficiency is 1.05 MCM through Percolation tank and 0.36 MCM through Check dams. The cost estimate for 7 percolation tank and 16 check dams are Rs. 10.5 and Rs. 4.8 crore respectively. The location of artificial recharge structures proposed are given in **Annexure IX** and shown in **Fig 6.1.**

The rainwater harvesting in urban areas can be adopted in 25% of the household with 50 Sq. m roof area. A total of 0.22 MCM potential can be generated by taking 80% runoff coefficient. The estimated cost for rainwater harvesting through rooftop is calculated as Rs. 15.3 crore. Hence, this technique is not economically viable and therefore it is not recommended.

Overall total volume of water expected to be recharged or conserved by artificial recharge is 1.41 MCM with a cost estimate of Rs. 15.3 crore, excluding roof top rain water harvesting which is not economically viable.

Demand side interventions such as change in cropping pattern has not been proposed. About 70% of sugarcane crop area (i.e. 138 Sq km) is proposed to be covered under Drip i.e., about 82.8 sq km. Due to which about 47.2 MCM water is expected to be saved (water req for Surface Flooding 2.45 m., Drip 1.87 = saving 0.57 m). The expenditure of Rs. 122.76 Crore is expected considering Rs. 60,000/- per acre, towards the implementation of micro-irrigation in Miraj Taluka

Thus, following benefits are expected after implementation of above said Aquifer management plan in Miraj Taluka.

1. Additional ground water resources available after implementing above measures is 48.61 MCM which would bring the stage of ground water development from 94.07 % to 67.5% i.e. about 26.57 % reduction in the stage of ground water development with estimated expenditure of Rs. 138.06 crore.
2. About 9581 ha additional area will be covered under assured irrigation after implementation.
3. Apart from this, it is proposed to impose ground water regulatory measures like banning the bore well drilling down to 60 m bgl for irrigation purpose.

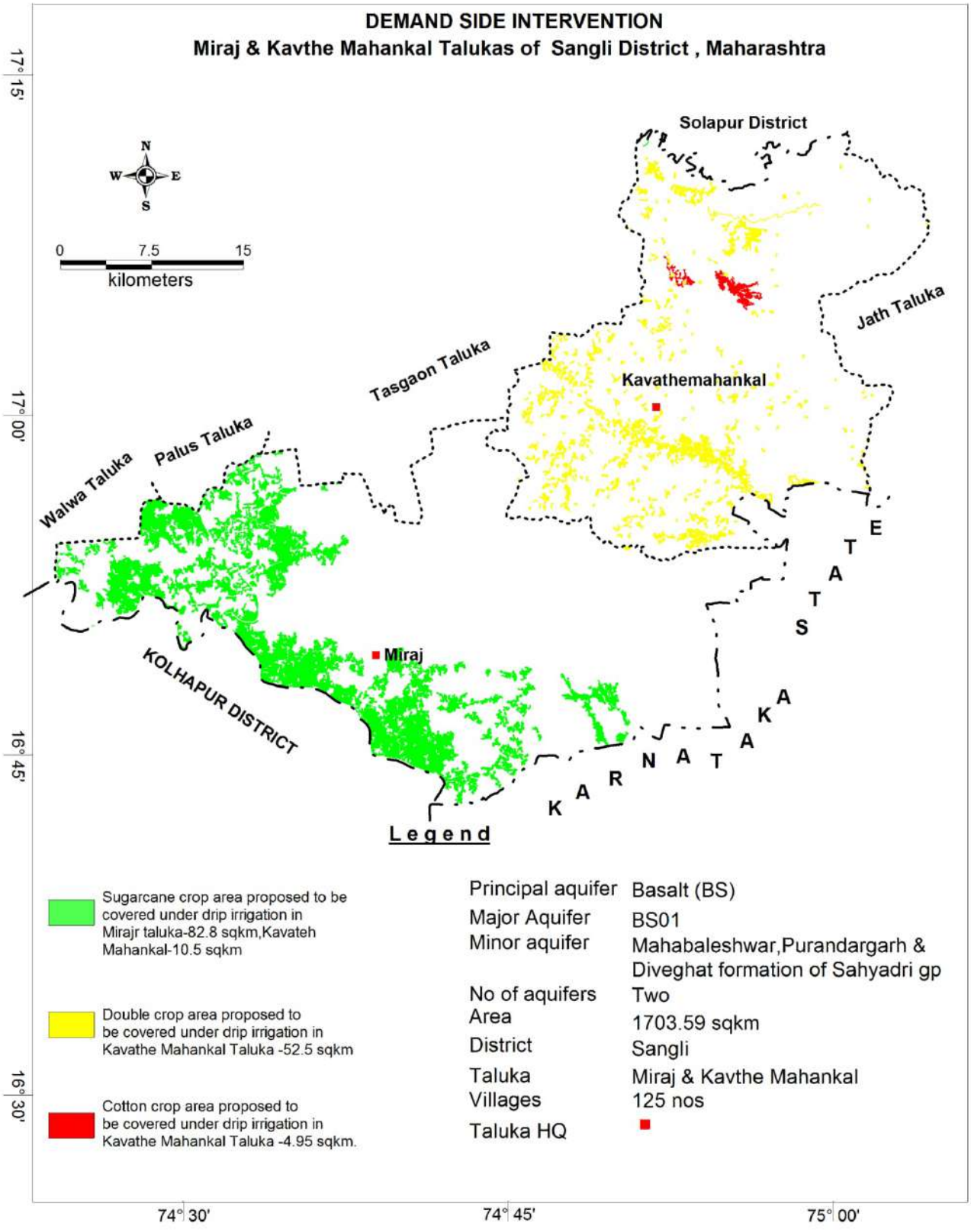


Fig 6.1 Location of crop proposed for drip irrigation

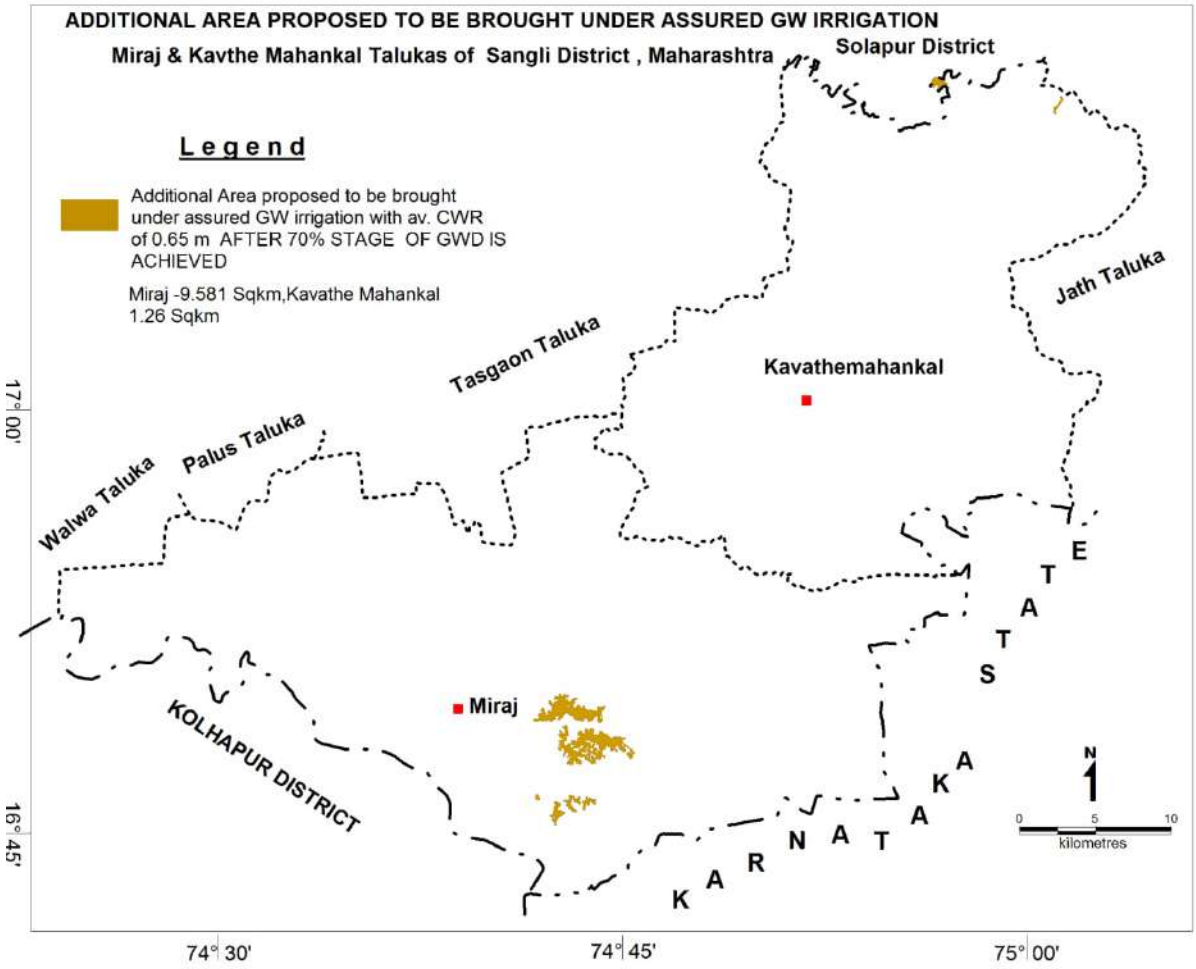


Fig 6.3 Location of additional cropped area proposed for ground water irrigation

Table 6.1: Aquifer management plan of Miraj and Kavthemahankal Taluka Sangali district

Block	**Kavthe Mahankal**		**Miraj**		**Total**
District	Sangli		Sangli		
State	Maharashtra		Maharashtra		
Area	749.53		954.06		1703.59
Major Issues Identified	Over - Exploitation Declining WL Limited Aquifer Potential Water Scarcity - lean period		Over - Exploitation Declining WL Limited Aquifer Potential		
Stage of GW Development	98.10%		94.07%		
Annual Available Resource (MCM)	91.51		123.25		214.76
Gross Annual Draft (MCM)	89.76		115.94		205.70
Domestic Rquirement (MCM)	4.59		2.61		7.20
DEMAND (MCM)					
Agricultural demand -GW	85.18		113.32		198.50
Agricultural demand -SW	41.77		117.17		158.94
Domestic demand - GW	4.59		2.61		7.20
Domestic demand - SW	1.15		0.65		1.80
Total Demand(mcm)	**132.69**		**233.75**		366.44
SUPPLY (MCM)					
Agricultural Supply -GW	85.18		113.32		198.50
Agricultural Supply -SW	41.77		117.17		158.94
Domestic Supply - GW	4.59		2.61		7.20
Domestic Supply - SW	1.15		0.65		1.80
Total supply(mcm)	**132.69**		**233.75**		366.44
DEMAND - SUPPLY GAP (MCM)	**0.00**		**0.00**		0.00
PRESENT DEMAND - SUPPLY GAP (MCM)	**0.00**		**0.00**		0.00
GAP TO BRING STAGE OF GWD UPTO 70%	**36.72**		**42.38**		79.10
TOTAL GAP TO BRING STAGE OF GWD UPTO 70%	**36.72**		**42.38**		79.10
Interventions proposed to deal with overexploitation					
SUPPLY SIDE INTERVENTIONS					
Rainwater Harvesting and Artificial Recharge					
Volume of unsaturated granular zone (MCM)	986.26		152.30		1138.56
Recharge Potential (MCM)	19.73		3.05		22.78
Surface water requirement @ 75% efficiency (MCM)	26.31		4.07		30.37

Block	**Kavthe Mahankal**		**Miraj**		**Total**
Availability of Surplus surface runoff (MCM)	12.08		1.87		13.95
Surplus runoff considered for planning (MCM) @ 70%	12.08		1.87		13.95
Proposed Structures- Percolation Tank (@ Rs.150 lakh, Av. Gross Capacity-100 TCM*2 fillings = 200 TCM) , Check Dam (@ Rs.30 lakh, Av. Gross Capacity-10 TCM * 3 fillings = 30 TCM	Percolation tank	Check dam	Percolation tank	Check dam	
Number of Strcutures	48	83	7	16	**154**
Volume of Water expected to be conserved / recharged @ 75% effeciency (MCM)	7.20	1.87	1.05	0.36	**10.48**
Estimated Expenditure (Rs. in Cr.)	72.00	24.90	10.50	4.80	**112.20**
RTRWH - Urban Areas					
Households to be covered (25% with 50 m2 area)	12982		10614		23595.2
Total RWH potential (MCM)	0.37		0.27		0.64
Rainwater harvested / recharged @ 80% runoff co-efficient	0.29		0.22		0.51
Estimated Expenditure (Rs. in Cr.) @ Rs. 15000/- per HH	19.47, **Economically not viable & Not Recommended**		15.92, **Economically not viable & Not Recommended**		35.39
Total volume of water expected to be recharged/conserved by AR	9.07		1.41		10.48
Total Estimated Expn. For AR	96.90		15.30		112.20
DEMAND SIDE INTERVENTIONS					
Proposed Cropping Pattern change	None		None		
Area proposed to be covered (sq.km.)	-		-		
Volume of Water expected to be conserved (MCM)	-		-		
Estimated Expenditure	-		-		
Micro irrigation techniques					

Block	**Kavthe Mahankal**		**Miraj**		**Total**
Sugarcane crop area proposed to be covered under Drip (sq.km.)	10.5 (70 % area of 15 Sqkm)		82.80(60 % area of 138 Sqkm)		93.3
Volume of Water expected to be saved (MCM). Surface Flooding req- 2.45 m. Drip Req. - 1.88, WUE- 0.57 m	5.99		47.20		53.19
Estimated Expenditure (Rs. in Cr.) @ Rs. 60,000/- per acre	15.57		122.76		138.33
90% of Cotton crop area (5.5) proposed to be covered under Drip (sq.km.)	4.95				4.95
Volume of Water expected to be saved (MCM). Surface Flooding req- 0.81 m. Drip Req. - 0.51, WUE- 0.3 m	1.49				1.49
Estimated Expenditure (Rs. in Cr.) @ Rs. 25,000/- per acre	3.06				3.06
75% of Double crop area (70) proposed to be covered under Drip (sq.km.)	52.5				52.5
Volume of Water expected to be saved (MCM). Surface Flooding req- 0.90 m. Drip Req. - 0.50, WUE- 0.4 m	21.00				21.00
Estimated Expenditure (Rs. in Cr.) @ Rs. 25,000/- per acre	32.43				32.43
Alternate Sources					
Alternative ground water sources	Nil		Nil	Nil	
Location and other details of the sources	Nil		Nil	Nil	
Volume of Water expected to be served from these sources	Nil		Nil	Nil	
Alternative surface water sources	Nil				
Additional GW resources available after implementing above measures (MCM)	37.54		48.61		86.14

Block	Kavthe Mahankal		Miraj		Total
Volume of Water Required TO BRING STAGE OF GWD UPTO 70%	36.72		42.38		79.10
Balance GWR available for GW Development after STAGE OF GWD is brought to 70%	**0.82**		**6.23**		7.05
Additional Area (sq.km.) proposed to be brought under assured GW irrigation with av. CWR of 0.65 m AFTER 70% STAGE OF GWD IS ACHIEVED OR	**1.26**		**9.581**		10.84
Regulatory Measures	**Regulation of wells below 60 m**		**Regulation of wells below 60 m**		

PROPOSED MANAGEMENT PLAN

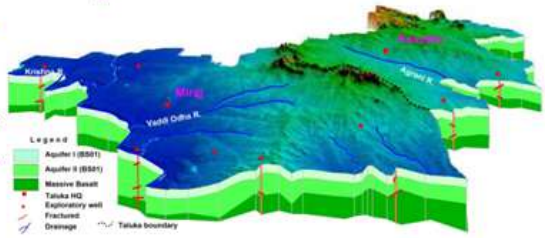
Augmentation by AR – 10.48 MCM

GW quantum saved by WUE – 75.66 MCM

Total Draft – 205.7 MCM

Aquifer I Resources – Dy- 214.76 MCM Instorage- 0.78

Aquifer II Resources – 35.7 MCM



Total Resources – 251.24MCM

ADDITIONAL RESOURCES CREATED/SAVED
10.48 MCM - by AR
75.66 MCM – by WUE
86.14 mcm – TOTAL

PROBABLE BENEFITS AFTER IMPLEMENTING AR & WUE MEASURES

STAGE OF GW DEVELOPMENT IN Miraj AND Kavathe Mahankal TALUKA CAN BE BROUGHT TO 67.5 & 70 RESPECTIVELY.

OR

- ✓ 1612 ha (16.12 sq km) **Additional area under assured irrigation after implementation of artificial recharge to ground water**
- ✓ 11640 ha (116.4 sq km) **Additional double cropped area after implementation of micro irrigational techniques**

7 SUM-UP

A thorough study was carried out based on data gap analysis, data generated in-house; data acquired from State Govt. departments and GIS maps prepared for various themes. All the available data was brought on GIS platform and an integrated approach was adopted for preparation of aquifer maps and aquifer management plans of Miraj and Kavthe Mahankal Talukas of Sanghli district.

The study area is spanning over 1554 sq.km. Geologically the area is occupied by Basalt and the stage of ground water development is 98.1 % in Kavthe Mahankal and 94.07% in Miraj taluka. The area has witnessed ground water depletion and over exploitation over a period of time. In Aquifer-I, The deeper water levels of more than 10 m bgl are observed in limited areas in the central part of the study area covering west to east elongated patch adjacent to the water divide boundary of Agrani River and Krishna River. in Miraj and Kavthe Mahankal taluka, while in Aquifer –II, in western parts of Miraj taluka . The declining water level trend > 0.20 m/yr (2007 to 2016). has been observed in about 879 Sq.km. (56.6% of area) during pre-monsoon and declining water level trend of more than 0.2m/year has been observed in 666 Sq.km. (42.85% of area) in the post monsoon. This has been due to cultivation of water intensive cash crop like Sugarcane (153 sq.km), which are completely dependent on ground water irrigation.

Ground water management plan has been prepared with the objective of bringing the current stage of ground water development down to 70% and decline of water level may be arrested, so that the taluka comes under Safe category by adopting both, supply side and demand side interventions.

As a part of supply side interventions, a total of 55 Percolation Tanks and 99 Check Dam is proposed in Miraj and Kavthe Mahankal Talukas ,which will augment ground water resources to the tune of 10.48 MCM (8.25 MCM by Percolation Tanks and 2.23 MCM by Check Dam). The total cost of implementing these interventions will be Rs. 112.2 crore.

As a part of demand side interventions, change in irrigation techniques from surface flooding to drip irrigation is also proposed. A total of 153 sqkm of Sugarcane crop area in Miraj and Kavthe Mahankal talukas is proposed to be covered under drip irrigation techniques instead of flood irrigation that will save 53.18 MCM of water resources. The total cost of implementing these interventions will be Rs 138.33 crore. Double crop of 70 sqkm and 5.5 Sqkm of Cotton crop areas in Kavthe Mahankal taluka are also proposed to be covered under drip irrigation techniques instead of flood irrigation that will save 22.49 MCM of water resources. The total cost of implementing these interventions will be Rs 25.49 crore.

In Miraj and Kavthe Mahankal Talukas, a total of 10.48 MCM resources will be augmented after adopting artificial recharge, whereas and 75.66 MCM will be saved after implementing water user efficiency measures (drip irrigation). This will bring the stage of

ground water development to 70 % in Kavthe Mahankal and 67.5 % in Miraj talukas from the present stage of 98.1 % in Kavthe Mahankal and 94 07 % in Miraj taluka and 10.84 sq.km area proposed to be brought under assured GW irrigation with av.CWR of 0.65 m.

This will probably result in arresting the decline of water levels. These interventions also need to be supported by regulation of deeper aquifer and hence it is recommended to regulate/ban deeper tubewells/borewells of more than 60 m depth in these talukas, so that the deeper ground water resources are protected for future generation and also serve as ground water sanctuary in times of distress/drought. Similarly IEC activities and capacity building activities needs to be aggressively propagated to establish the institutional framework for participatory groundwater management.

Annexure-I:

Long Term Rainfall Analysis of Kavthe Mahankal and Miraj Talukas, Sangli District, MH

Item	Kavthe Mahankal	Miraj
Period	1998-2016	1998-2016
No of years	19	19
Normal rain fall (mm)	520.3	584.8
Standard deviation(mm)	152	160
Coficient of variation(%)	29	27
Slope	13.112 mm/year	9.434 mm/year
Intercept	644.8 mm	495.2
Eequation of trend line:Y	-9.431 x + 620.2	10.59 x + 482.5

Long Term Rainfall data of Kavthe Mahankal and Miraj Talukas, Sangli District, Maharastra

YEAR	Kavthe Mahankal			Miraj		
	ANNUAL	DEP %	CATEGORY	ANNUAL	DEP%	CATEGORY
1998	859.7	65	EXCESS	524.6	-10	NORMAL
1999	590.7	14	NORMAL	370	-37	MODERATE
2000	718.6	38	EXCESS	503.9	-14	NORMAL
2001	663.6	28	EXCESS	476.9	-18	NORMAL
2002	452.8	-13	NORMAL	465.4	-20	NORMAL
2003	242.4	-53	SEVERE	321	-45	MODERATE
2004	522.3	0	NORMAL	705.5	21	NORMAL
2005	367.9	-29	MODERATE	752.1	29	EXCESS
2006	640.2	23	NORMAL	908.9	55	EXCESS
2007	511.2	-2	NORMAL	622.8	6	NORMAL
2008	463	-11	NORMAL	433.6	-26	MODERATE
2009	608.1	17	NORMAL	823	41	EXCESS
2010	584.5	12	NORMAL	757.6	30	EXCESS
2011	403.5	-22	NORMAL	522.8	-11	NORMAL
2012	312.5	-40	MODERATE	642	10	NORMAL
2013	404.3	-22	NORMAL	523.6	-10	NORMAL
2014	574.2	10	NORMAL	664.6	14	NORMAL
2015	445.2	-14	NORMAL	508.8	-13	NORMAL
2016	628.8	20	NORMAL	747.8	28	EXCESS

CATEGORY	Kavthe Mahankal		Miraj	
	Number of years	% of total years	Number of years	% of total years
DEPARTURES				
POSITIVE	10	53	9	53
NEGATIVE	9	47	10	47
DROUGHTS				
MODERATE	2	11	3	16
SEVERE	1	5	0	0
ACUTE	0	0	0	0
NORMAL & EXCESS R/F				
NORMAL	13	68	11	58
EXCESS	3	16	5	26

Rainfall departure: EXCESS: > +25; NORMAL: +25 TO -25; MODERATE: -25 TO -50; SEVERE: -50 TO -75; ACUTE: < -74

Detailed Data of Soil Infiltration Tests conducted **Annexure II**

INFILTRTATION TEST AT KAVATE MAHANKAL, KAVATE MAHANKAL TALUKA, SANGLI DISTRICT	
Date	22/03/2017
Location	southern side of Jath road,inside fields of Chowan
Co ordinates	17.006085 N, 74.878622 E
Elevation /RL m amsl	624.2
Initial water level	12cm
Geology	Deccan trap
Soil Type	Brownish black cotton soil (highly fractured area)
Final infiltration rate	6.3 cm/hr
Total Precipitation	26.4cm
Infiltration Coefficient(final ifil rate/total pptn)	0.239
Infiltration Coefficient (%)	23.9

Sl No.	Clock Time	Duration (Minutes)	Cumulative time (minutes)	Water level depth (Cm)	Infiltrated water depth (Cm)	Infiltration Rate cm/hr	Remarks
0	10:42	0	0	12.00	0	0	
1	10:44	2	2	11.50	0.5	15	
2	10:46	2	4	10.5	1	30	
3	10:48	2	6	9.5	1	30	
4	10:50	2	8	8.9	0.6	18	
5	10:55	5	13	7.2	1.7	20.4	
6	11:00	5	18	6.1	1.1	13.2	
7	11:05	5	23	5.6	0.5	6	
8	11:10	5	28	5	0.6	7.2	
9	11:20	10	38	3.6	1.4	8.4	
10	11:30	10	48	2.5	1.1	6.6	Refilled upto 8 cm
11	11:40	10	58	6.9	1.1	6.6	
12	11:50	10	68	4.9	2	12	
13	12:00	10	78	3.2	1.7	10.2	Refilled upto 10 cm
14	12:20	20	98	7.1	2.9	8.7	
15	12:40	20	118	5	2.1	6.3	
16	13:00	20	138	2.9	2.1	6.3	Refilled upto 5 cm
17	13:20	20	158	2.9	2.1	6.3	

INFILTRTATION TEST AT SAVALI VILLAGE, MIRAJ TALUKA, SANGLI DISTRICT	
Date	21/03/2017
Location	N side of Savali-Miraj road,inside RIM transport office

Co ordinates	16.872777N, 74.652010E
Elevation /RL m amsl	562.9
Initial water level	15cm
Geology	Deccan trap
Soil Type	Brownish black cotton soil ,clay sized
Final infiltration rate	1.2 cm/hr
Total Precipitation	15cm
Infiltration Coefficient(final ifil rate/total pptn)	0.08
Infiltration Coefficient (%)	8

Sl No.	Clock Time	Duration (Minutes)	Cumulative time (minutes)	Water level depth (Cm)	Infiltrated water depth (Cm)	Infiltration Rate cm/hr	Remarks
0	2:45	0	0	15.00	0	0	
1	2:47	2	2	14.50	0.5	15	
2	2:49	2	4	14.2	0.3	9	
3	2:51	2	6	13.8	0.4	12	
4	2:53	2	8	13.5	0.3	9	
5	2:55	2	10	13.2	0.3	9	
6	3:00	5	15	12.7	0.5	6	
7	3:05	5	20	12.3	0.4	4.8	
8	3:10	5	25	12	0.3	3.6	
9	3:15	5	30	11.7	0.3	3.6	
10	3:20	5	35	11.4	0.3	3.6	
11	3:30	10	45	11.1	0.3	1.8	
12	3:40	10	55	10.5	0.6	3.6	
13	3:50	10	65	10	0.5	3	
14	4:00	10	75	9.5	0.5	3	
15	4:20	20	95	9.1	0.4	1.2	
16	4:40	20	115	8.7	0.4	1.2	
17	5:00	20	135	8.3	0.4	1.2	
18	5:20	20	155	7.9	0.4	1.2	

Details of Ground Water Exploration **Annexure-III:**

Sr. No.	Village	Taluka	Latitude	Longitude	Depth drilled (mbgl)	Depth of casing (mbgl)	Aquifer zones encountered (mbgl)	Aquifer	SWL (mbgl)	Discharge (lps)	DD (m)	Transmissivity (m2/day)	Specific capacity (lpm/m)
1	Ranjani (EW)	Kavthe Mahankal	16° 58' 55''	74° 56' 46''	200	29.5	Water seepage-I: 22 mbgl, II: 135.80-138.80 mbgl, III: 160.20-163.20	I & II: M. basalt- Fr., III: V.basalt-W. and Fr.	93	Meager	_		
2	Ghatnandre (EW)	Kavthe Mahankal	$17^0$10'25"	$74^0$52'00"	200	5.8	22.00-23.00 65.00-67.00 99.00-101.00	Highly Fr. V.Basalt	5.25	13.5	14.1	62.81	57.44
3	Ghatnandre (OW)	Kavthe Mahankal	$17^0$10'25"	$74^0$52'00"	98.9	5.8	22.00-23.00, 65.00-67.00, 95.00-98.90	Highly Fr. V.Basalt	22.25	33.63	4	177.34	504.45
4	Shelkewadi (EW)	Kavthe Mahankal	$17^0$05'52"	$74^0$53'46"	200	5.8	68.40-69.40, 101.90-102.90, 120.00-123.30	Fr. M. Basalt	11.17	2.16	10	7.42	12.96
5	Shelkewadi (OW)	Kavthe Mahankal	$17^0$05'52"	$74^0$53'46"	123.3	5.8	25.70-26.70, 89.70-92.80, 120.00-123.30	Fr. M. Basalt	12	3.17	35	10.03	5.43
6	Kavthe Mahankal(EW)	Kavthe Mahankal	$17^0$00'24"	$74^0$52'05"	200	7.1	97.00-98.00, 138.00-139.00	Fr. M. Basalt	24.7	1.37	10.8	5.85	7.61
7	Arewadi (EW)	Kavthe Mahankal	$17^0$06'41"	$74^0$59'26"	200	5.8	77.00-78.00	Fr. M. Basalt	46.5	0.431	>50	-	-
8	Alkud (M) (EW)	Kavthe Mahankal	$16^0$58'53"	$74^0$45'34"	136	5.8	-	-	-	Dry	-	-	-
9	Alkud (M) (EW)	Kavthe Mahankal	$16^0$58'53"	$74^0$45'34"	200	5.8	56.00-58.00	Fr. M. Basalt	35	2.16	15	6.04	8.64
10	Alkud (M) (OW)	Kavthe Mahankal	$16^0$58'53"	$74^0$45'34"	95.8	5.8	53.00-56.00	Fr. M. Basalt	53.2	3	>50	-	-
11	Kokale(EW)	Kavthe Mahankal	$16^0$59'10"	$75^0$01'33"	200	5.8	132.40-135.50	Fr. M. Basalt	5.3	Traces	>50	-	-
12	Ghorpadi (EW)	Kavthe Mahankal	$17^0$10'46"	$74^0$59'26"	200	5.6	140.00-141.00, 161.00-162.00, 169.00-172.00	Fr. M. Basalt	15	6	11	23.15	32.72

13	Belanki (EW)	Miraj	16° 51' 37''	74° 52' 4'' E	200	29.5	68.70-71.70: 90-92	M. basalt- Fr., V.basalt- W.	85.5	< 0.14 lps	_		
14	Bolvad (EW)	Miraj	16° 48' 32''	74° 41' 25''	200	29.5	water seepage-I:16-18 mbgl, II: 151-153 mbgl	V.basalt- W.	> 150	Meager	_		
15	Madhav Nagar (EW)	Miraj	16° 53' 12''	74° 34' 54''	200	29.5	water seepage-I:21-22 mbgl, II: 40-43 mbgl, water zone: 50-53 mbgl	M. basalt- Fr.	4.5	< 0.14 lps	_		
16	Kalambi (EW)	Miraj	$16^0$53'56"	$74^0$41'31"	200	5.8	172.00-173.00	Fr. V.Basalt	>50	0.431	>50	-	-
17	Arag	Miraj	$16^0$47'42"	74° 48' 33''	200	5.8	24, 135		12	0.78			
18	Malwadi	Miraj	$16^0$59'07"	74° 29' 03''	200	5.75	15,132		11				
19	Mirajwadi	Miraj	$16^0$56'48"	74°25' 52''	200	5.8	12, 142		21	1.37			
20	Shigaon	Kavthe Mahankal	$16^0$52'34"	74° 21' 31''	200	5.75	18, 90		16				

Here, EW- Exploratory Well, OW- Observation Well, W.- Weathered, Fr.- Fractured, J.- Jointed, M.- Massive, V- Vesicular, W. -Weathered

Water Level Data of Aquifer-I (Shallow Aquifer) **Annexure IVa**

Sl. No.	Taluka	Village	Altitude (m)	Longitude	Latitude	Depth (m.bgl)	Water Level (m bgl)		Elec. Conductivity (µS/cm)	
							May 16	Nov 16	May16	Nov16
1	Kawathe Mahankal	Alkud	692.28	74.775	17.0167	11.15	9	4.2		
2	Kawathe Mahankal	Alkud (M)		74.76306	16.97889	10.7	6.1			
3	Kawathe Mahankal	Banewadi	674	74.80147	16.94735	9.3	7.5	3.4	725	630
4	Kawathe Mahankal	Chorochi		75.01944	17.1375	7.3	5.9	5.35		
5	Kawathe Mahankal	Deshing		74.80639	16.97056	9.8	6	3.1		
6	Kawathe Mahankal	Dhalgaon	675	74.98313	17.1104	11.2	8.4	6.4	524	651
7	Kawathe Mahankal	Dudhebhavi	598	75.02162	17.16773	12	10.6	6.9	2060	1749
8	Kawathe Mahankal	Dudhebhavi		75.025	17.17139	9.8	5.3	3.8		

Sl. No.	Taluka	Village	Altitude (m)	Longitude	Latitude	Depth (m.bgl)	Water Level (m bgl)		Elec. Conductivity (µS/cm)	
							May 16	Nov 16	May16	Nov16
9	Kawathe Mahankal	Garjewadi	779	74.86569	17.12814	5.7	5.6	3.4	462	1270
10	Kawathe Mahankal	Ghatnandre	772	74.86671	17.1751	6.7	4.3	2.4	2348	2403
11	Kawathe Mahankal	Ghatnandre		74.86611	17.17306	13.3	12	7.8		
12	Kawathe Mahankal	Hingangaon		74.865	16.97778	13	10.2	6.4		
13	Kawathe Mahankal	Kawathe Mahankal	636.3	74.8694	17.0083	8.9	2.38	2.9		
14	Kawathe Mahankal	Kerewadi		74.93139	17.12	9	7.2	4.9		
15	Kawathe Mahankal	Kognoli	619	74.90912	16.91166	8.6	4.3	2.7	1830	1852
16	Kawathe Mahankal	Kokale	587	75.0274	16.9919	8.3	5.1	3.6	2200	4570
17	Kawathe Mahankal	Kokale		75.02361	16.99	9.4	5.2	2.8		
18	Kawathe Mahankal	Kuchi	662	74.8644	17.0572	16.2	11	10.1		
19	Kawathe Mahankal	Kuchi		74.86444	17.05972	11	5.3	7.45		
20	Kawathe Mahankal	Kundlapur		74.86556	17.11806	6.5	3	1.45		
21	Kawathe Mahankal	Landgewadi		74.83111	17.03111	11	3.1	3.15		
22	Kawathe Mahankal	Moghamvadi	627	74.99012	17.03074	12	8.5	4.2	630	1041
23	Kawathe Mahankal	Morgaon	638	74.83217	16.99289	8	4.8	1.8	2432	1453
24	Kawathe Mahankal	Nagaj	663	74.93762	17.14586	12.3	11.9	10.4	3122	2279
25	Kawathe Mahankal	Nagaj	676.54	74.95	17.15	12.9	0	9.53		
26	Kawathe Mahankal	Nagaj		74.93667	17.11722	12.2	9.85	10.3		
27	Kawathe Mahankal	Nangole	636	74.92299	17.03353	6.6	5.4	3.2	605	1224
28	Kawathe Mahankal	Nimaj		74.97667	17.15833	8.8	5.1	4.85		
29	Kawathe Mahankal	Ranjani		74.94639	16.96861	12.9	10	10.52		
30	Kawathe Mahankal	Ranjani		74.94778	16.97083	67	43	27.1		
31	Kawathe Mahankal	Sarati	629	74.8986	16.9231	13.55	4.2	3.5		
32	Kawathe Mahankal	Sarati		74.89833	16.92639	91	5	4.8		
33	Kawathe Mahankal	Sarati		74.89833	16.92639	45	9.3	2.3		
34	Kawathe Mahankal	Shindewadi	632	74.83858	16.96776	7.6	0.5	1.5	1480	2078
35	Kawathe Mahankal	Shirdhon		74.8075	17.01667	17.9	11	4.9		
36	Kawathe Mahankal	Shirdon	651	74.8128	17.02305	17.3	6.6	1.7	780	1716
37	Kawathe Mahankal	Tisangi	785.96	74.8583	17.1375	36.5	36	0		
38	Miraj	Arag	594.11	74.8167	16.7875	6.5	1	1		
39	Miraj	Arag		74.80361	16.79167	12.5	9.4	5		
40	Miraj	Bedag	595	74.7381	16.8011	10	9	2.6		
41	Miraj	Bedag		74.73611	16.79722	13.7	5	2.5		

Sl. No.	Taluka	Village	Altitude (m)	Longitude	Latitude	Depth (m.bgl)	Water Level (m bgl)		Elec. Conductivity (µS/cm)	
							May 16	Nov 16	May16	Nov16
42	Miraj	Belanki		74.87139	16.85944	31.4	6.1	4.1		
43	Miraj	Belanki		74.87222	16.86139	8.7	4	3.2		
44	Miraj	Bhose	652	74.7428	16.9583	8.7	6.3	4.5		
45	Miraj	Erandoli	602	74.77122	16.85043	15.9	13.1	4.5	3200	6493
46	Miraj	Karnal-1	552	74.5669	16.9169	14.2	3.5	2.9		
47	Miraj	Kasbe Digraj		74.51833	16.90694	30	2.2	1.2		
48	Miraj	Kavlapur	546	74.61273	16.92507	10	8.7	2.3	6890	7176
49	Miraj	Khanderajuri	633	74.78861	16.89628	14	13.4	1.5	1230	1008
50	Miraj	Khatav	570	74.89322	16.79971	9.6	7.8	2.8	2732	4584
51	Miraj	Malgaon	589	74.71349	16.86593	14.4	4.1	1.3	540	1613
52	Miraj	Mhaisal		74.70194	16.74667	13	8	3.2		
53	Miraj	Mhaisal(s)	539	74.70394	16.75291	11.8	9.5	4	2320	3117
54	Miraj	Miraj-1	547.7	74.6447	16.8108	15.5	4	2.65		
55	Miraj	Nandre	545	74.54158	16.9606	18.1	7.5	6.7	2500	2750
56	Miraj	Nimaj-1	560.7	74.6403	16.8333	16.2	12.75	2.8		
57	Miraj	Salgare	608	74.90917	16.88735	12.8	12.3	1	716	400
58	Miraj	Sangli_city	552.6	74.5828	16.8678	11.1	3.7	2.9		
59	Miraj	Sangli_Inamdhamni	553.3	74.5878	16.8383	16.3	7	3.25		
60	Miraj	Sangli_Sangalwadi	549.1	74.5536	16.8831	14.8	12.6	7.4		
61	Miraj	Sawalwadi		74.41944	16.86806	12.55	6	0.4		
62	Miraj	Tung	558.2	74.4931	16.9219	13.8	5.7	3.5		
63	Miraj	Vaddi		74.66528	16.79306	23	6.75	4		

Ground Water Level Trend of Aquifer-I (Shallow Aquifer)
Annexure IVb

Taluka	Village	Y	X	Depth of well (mbgl)	Premonsoon Water level(mbgl)	Trend (m/Year)	Postmonsoon Water level (mbgl)	Post trend (m/Year
Kavthe Mahankal	Hingangaon	16.978	74.865	13	12	0.314939024	6.4	-0.15
Kavthe Mahankal	Nagaj	17.117	74.937	12.2	13	0.290405405	10.3	-0.065695067
Kavthe Mahankal	Dudhebhavi	17.171	75.025	9.8	7.3	-0.01162162	3.8	0.051793722
Kavthe Mahankal	Kerewadi	17.120	74.931	9	9.9	0.293918919	8.8	-0.081838565
Kavthe Mahankal	Shirdhon	17.017	74.808	17.9	14	0.349864865	7	0.101793722
Kavthe Mahankal	Nimaj	17.158	74.977	8.8	8.34	0.054513514	4.85	-0.127130045
Kavthe Mahankal	Ghatnandre	17.173	74.866	13.3	12	0.195810811	7.8	0.131390135
Kavthe Mahankal	Chorochi	17.138	75.019	7.3	8	0.062243243	5.35	0.156726457
Kavthe Mahankal	Kokale	16.989	75.022	6.4	5.2	0.003333333	5.8	0.184529148
Kavthe Mahankal	Alkud (M)	16.979	74.763	10.7	12	0.278918919	8	0.23
Kavthe Mahankal	Ranjani	16.969	74.946	12.9	13	0.59	10.52	0.231255605
Kavthe Mahankal	Landgewadi	17.031	74.831	11	7.3	-0.04168919	3.15	0.249804688
Kavthe Mahankal	Sarati	16.926	74.898	91	12	0.25945122	3.8	0.26629108
Kavthe Mahankal	Kundlapur	17.118	74.866	6.5	6	0.031486486	5	0.29529148
Kavthe Mahankal	Deshing	16.971	74.806	9.8	6	-0.18304054	7	0.354596413
Kavthe Mahankal	Kuchi	17.060	74.864	11	13	0.524594595	7.45	0.434304933
Kavthe Mahankal	Kokale	16.990	75.024	9.4	9.4	0.54	7	0.455357143
Miraj	Kasbe Digraj	16.907	74.518	30	4	-0.1027439	3.4	-0.10210084
Miraj	Kavalapur	16.915	74.615	20.1	8	0.070588235	4	-0.041
Miraj	Belanki	16.861	74.872	8.7	8.1	0.274695122	3.2	0.076326531
Miraj	Arag	16.792	74.804	12.5	9.4	0.231594595	7.2	-0.07877551
Miraj	Vaddi	16.793	74.665	23	9.5	0.151847134	7.1	0.23
Miraj	Sawalwadi	16.868	74.419	12.55	8	0.220588235	6	0.356910112
Miraj	Mhaisal	16.747	74.702	13	11	-0.04493902	7.2	0.393061224

Miraj	Bedag	16.797	74.736	13.7	8	0.305	2.5	0.52

Micro Level Hydrogeological Data – Aquifer-I (Shallow Aquifer)
Annexure-V

Sl. No.	Village	Latitude	Longitude	Elev-ation (m. amsl)	Geology	Well. Depth mbgl)	D.T. W. (Mbgl)	EC (µS/ cm)	Total Thick-ness weath-erd portion (m)	Thick-ness of fractur e zone (m)	Annu al pum ping hours.	HP of Pump	Rate of discharge (m^3/hr)	Khari f draft (m^3)	Rabi Draf t (m^3)	Summer Draft (m^3)	Annual Draft (m^3/yea r)
Kavthe Mahankal																	
1	Agalgaon	17.0936	74.9252	68 8	Deccan Basalt	24	23.5	551	0-6.0 & 16-23		1180	5	1.42	680	935	57	1672
2	Banewadi	16.9578	74.8034	65 6	Deccan Basalt	16	6.5	467	4.5		2020	5 and 7.5	2.06	1151	226 1	740	4152
3	Borgaon	17.0113	74.7952 5	64 9	Deccan Basalt	13	4.5	1002	6		1420	3	0.89	427	782	53	1262
4	Chorochi	17.1465 1	75.0179 5	62 2	Deccan Basalt	15.5	12.6	787	9		910	5	1.25	600	500	38	1138
5	Haroli	16.9734 4	74.8004 6	64 5	Deccan Basalt	13	8.5	922	16		1620	3 and 5	1.75	980	154 0	315	2835
6	Hingangaon	16.9873 7	74.8705 6	62 8	Deccan Basalt	14	10.1	1674	11		1770	5	1.44	708	144 4	404	2557
7	Irali	17.0699 8	74.9698	64 6	Deccan Basalt	9	7.2	845	9		610	3	0.86	310	207	9	525
8	Jakhapur	17.0904 8	74.8732 7	68 9	Deccan Basalt	12	10.2	1082	4		910	7.5	1.86	893	744	56	1694

Sl. No.	Village	Latitude	Longitude	Elev-ation (m. amsl)	Geology	Well. Depth mbgl)	D.T. W. (Mbgl)	EC (µS/ cm)	Total Thick-ness weath-erd portion (m)	Thick-ness of fractur e zone (m)	Annu al pum ping hours .	HP of Pump	Rate of discharge (m^3/hr)	Khari f draft (m^3)	Rabi Draf t (m^3)	Summer Draft (m^3)	Annual Draft (m^3/yea r)
9	Jambhulwadi	17.1251 1	75.0653 7	60 9	Deccan Basalt	10.5	6.4	766	6		1060	5	1.36	762	647	34	1443
10	Kerewadi	17.1180 9	74.9305 1	69 3	Deccan Basalt	8	7.5	1201	3		495	3	0.75	158	203	11	371
11	Kokale	16.9870 6	75.0101 8	59 9	Deccan Basalt	10.5	6	2357	2		1155	3	0.86	413	568	13	995
12	Landgewadi	17.0340 5	74.8293 9	64 0	Deccan Basalt	13.2	2.5	414	6		1940	5	1.61	773	177 2	580	3126
13	Nangole	17.0403 2	74.9284 3	66 9	Deccan Basalt	9	8.1	710	1.5	1	770	3	0.86	310	344	9	663
14	Nimaj	17.1492 1	74.9675 2	64 2	Deccan Basalt	10	8.1	915	3.5		940	5	1.42	595	708	28	1332
15	Pimpalwadi	16.9981 8	74.9490 5	62 3	Deccan Basalt	19. 5	14.5	1244	3.5		1360	5	1.42	595	124 7	85	1927
16	Ranjani	16.9730 5	74.9384 6	60 9	Deccan Basalt	21	20.5	611	21		915	3	0.86	310	465	13	788
17	Sarati	16.9315 8	74.8965 3	63 2	Deccan Basalt	12. 5	2.1	288	4		1840	5	1.44	693	144 4	520	2658
18	Shindewadi	17.1805 3	74.9725 4	61	Deccan Basalt	22	20.2	763	6	3	805	5	1.64	787	492	41	1319

Sl. No.	Village	Latitude	Longitude	Elev-ation (m. amsl)	Geology	Well. Depth mbgl)	D.T. W. (Mbgl)	EC (µS/ cm)	Total Thick-ness weath-erd portion (m)	Thick-ness of fractur e zone (m)	Annu al pum ping hours .	HP of Pump	Rate of discharge (m^3/hr)	Khari f draft (m^3)	Rabi Draf t (m^3)	Summer Draft (m^3)	Annual Draft (m^3/yea r)
				0													
19	Thabadewadi	17.0341 2	74.8564 6	65 5	Deccan Basalt	12	11.1	755	3		890	3	0.86	413	344	9	766
20	Tisangi	17.1606 8	74.8537 5	78 7	Deccan Basalt	14. o	12.9	673	3.5	1	700	5	1.44	520	462	29	1011
21	Zurewadi	17.0303 1	74.8567	64 6	Deccan Basalt	20	2.1	330	8		1920	5	1.42	793	141 7	510	2720
22	Arag	16.7841 8	74.7971 7	60 2	Deccan Basalt	12	7.8	788	8		1340	5	1.42	793	935	170	1898
23	Bedag	16.8011 9	74.7380 9	59 2	Deccan Basalt	15	11.9	335	2		1450	5	1.44	1011	104 0	43	2094
24	Belanki	16.8715 9	74.8809 2	64 5	Deccan Basalt	13. 5	3	437	1		830	3	0.86	310	379	26	715
25	Bhose	16.9586 2	74.7436 6	63 6	Deccan Basalt	13	4.5	902	3		995	5	1.42	510	850	50	1410
26	Budhgaon (CT)	16.9000 3	74.5904 9	54 2	Deccan Basalt	20	13	3440	18		2080	3	0.86	482	947	362	1791
27	Erandoli	16.8512 1	74.7760 4	61 0	Deccan Basalt	20. 5	17.5	2280	9		1175	5	1.44	607	104 0	51	1697

Sl. No.	Village	Latitude	Longitude	Elev-ation (m. amsl)	Geology	Well. Depth mbgl)	D.T. W. (Mbgl)	EC (µS/ cm)	Total Thick-ness weath-erd portion (m)	Thick-ness of fractur e zone (m)	Annu al pum ping hours .	HP of Pump	Rate of discharge (m^3/hr)	Khari f draft (m^3)	Rabi Draf t (m^3)	Summer Draft (m^3)	Annual Draft (m^3/yea r)
28	Gundewadi	16.8819	74.7564 1	61 2	Deccan Basalt	15	12.8	1044	7		1180	3	0.86	413	568	34	1016
29	Kadamwadi	16.8521 4	74.8432 6	64 9	Deccan Basalt	13	4.7	869	8		1420	7.5	1.86	893	148 9	261	2643
30	Kasabe Digraj	16.8810 2	74.4852 5	54 2	Deccan Basalt	11. 5	7.7	1300	3.5		1940	5	1.42	680	155 8	510	2748
31	Kavaji Khotwadi	16.9498 7	74.5748 1	55 1	Deccan Basalt	13	8.1	1995	7		2060	3	0.86	413	947	413	1774
32	Kavalapur	16.9252 8	74.6187 7	55 6	Deccan Basalt	17	8.8	2061	8		2000	3	0.86	413	947	362	1722
33	Kavthe Piran	16.8864 4	74.4573 2	54 8	Deccan Basalt	9.5	6.5	149	5		1760	5	1.42	680	141 7	397	2493
34	Khanderajuri	16.8953 4	74.7529 5	63 2	Deccan Basalt	15	10.8	776	5.8		935	3	0.86	362	431	13	805
35	Khatav	16.962	74.5295 8	55 0	Deccan Basalt	18	8	2610	11		2000	5	1.42	680	155 8	595	2833
36	Lingnur	16.8015 6	74.8497 9	59 2	Deccan Basalt	15	6.1	871	1		1130	3	0.86	482	465	26	973
37	Malewadi	16.8439 9	74.7328 4	58	Deccan Basalt	12. 5	11.3	905	9		990	3	0.86	362	474	17	853

Sl. No.	Village	Latitude	Longitude	Elev-ation (m. amsl)	Geology	Well. Depth mbgl)	D.T. W. (Mbgl)	EC (µS/ cm)	Total Thick-ness weath-erd portion (m)	Thick-ness of fractur e zone (m)	Annu al pum ping hours .	HP of Pump	Rate of discharge (m^3/hr)	Khari f draft (m^3)	Rabi Draf t (m^3)	Summer Draft (m^3)	Annual Draft (m^3/yea r)
				8													
38	Patgaon	16.9468 1	74.6947 4	60 5	Deccan Basalt	15	10.5	1711	12		1250	5	1.42	680	102 0	71	1771
39	Salgare	16.8920 6	74.9235 8	60 3	Deccan Basalt	15	10	677	6		790	3	0.86	310	344	26	680
40	Sangli-Miraj Kupwad (	16.8810 2	74.6157	55 1	Deccan Basalt	12. 5	7.5	810	6		1840	3	0.86	482	947	155	1584
41	Shipur	16.8550 5	74.8184 8	63 0	Deccan Basalt	11	6	723	1.5		895	5	1.33	560	600	33	1193
42	Siddhewadi	16.8787 1	74.719	63 7	Deccan Basalt	9.5	9	912	1.5		990	5	1.33	560	733	27	1320
43	Takali	16.8254 5	74.694	55 8	Deccan Basalt	20	10.5	1866	13		1075	5	1.42	680	779	64	1523

Water Level Data of Aquifer-II (Deeper Aquifer) **Annexure-VI**

S. No.	District	Village	**Longitude**	**Latitude**	**Altitude (m)**	**Depth (m bgl)**	**Premonsoon Water Level (m bgl)**	**Post-monsoon Water Level**

								(m bgl)
1	Sangli	Ghorpadi	74.9906	17.1794	626	200	15	7
2	Sangli	Arag	74.8092	16.795	603	200	21	12
3	Sangli	Malwadi	74.4842	16.9853	560	200	24	11
4	Sangli	Mirajwadi	74.4311	16.9467	564.2	200	50	21
5	Sangli	Shigaon	74.3592	16.8761	555	200	31	16
6	Sangli	Alkud(M)	74.7594	16.9814	691.5	95.8	53.2	22
7	Sangli	Arewadi	74.9906	17.1114	666.7	200	46.5	25
8	Sangli	Ghatnandre	74.8667	17.1736	784.9	200	9.2	5.6
9	Sangli	Kalambi	74.6919	16.8989	612.4	200	50	31
10	Sangli	Kavthe Mahankal	74.8681	17.0067	634.1	200	27.7	18
11	Sangli	Kokale	75.0258	16.9861	606.1	200	14	5.3
12	Sangli	Shelkewadi	74.8961	17.0978	721.5	123.3	21	12

Ground Water Quality Data of Aquifer-I (Shallow Aquifer)
Annexure-VII

Sl. No	SITE NAME	LATITUDE	LONGITUDE	pH	EC µS/cm @25°C	TDS	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	NO_3	SO_4	F	Fe
						←---------- mg/l ----------→												
	Kavthe Mahankal																	
1	Alkud M	16.9786	74.7606	7.4	970	621	484	128	39.9	25.5	0.2	0	419.7	142	23.9	46	0.5	0.2
2	Chorochi	17.1397	75.0200	7.2	651	417	204	56	15.6	55.5	0.9	0.37	247.6	82	27.9	26.2	0.3	0.7
3	Deshing	16.9708	74.8042	7.2	1125	720	356	84.8	35	87	1.4	0	375.8	166	22.2	48	0.4	0.3
4	Dudhebhavi	17.1714	75.0250	7.2	792	507	228	80	6.8	90.5	0.1	0	322.1	126	2.22	1	1	0.6
5	Hingangaon	16.9792	74.8639	7.1	4850	3104	1612	536	66.1	469	14	0	1015	760	177	900	1.1	0.9
6	Kavthe Mahankal	17.0067	74.8667	7.1	833	533	352	96	27.2	43	0.3	0	341.6	108	27.9	51.3	0.8	0.2
7	Kerewadi	17.1203	74.9317	7.4	463	296	188	52.8	13.6	44	0.2	0.47	199.5	64	2.22	22	1	0.3
8	Kokale	16.9875	75.0264	7.2	4250	2720	1580	334	181	360	0.9	0	331.8	800	2.22	1450	1	0.2
9	Kuchi	17.0597	74.8661	7.5	1518	972	540	104	68	134	1.9	0	370.9	280	43.9	200	1.1	0
10	Kundalpur	17.1161	74.9661	7.6	806	516	340	88	29.2	53	2	0	541.7	50	43.9	2	0.7	0
11	Nagaj	17.1444	74.9381	8.1	1935	1238	460	96	53.5	231	3.2	0	522.2	278	84.2	134	1.2	0.2
12	Nimaj	17.1583	74.9781	8.2	1345	861	364	104	25.3	157	3.1	0	439.2	216	35	10	0.8	0
13	Ranjani	16.9708	74.9478	7.7	820	525	372	52.8	58.3	50	4.1	0	341.6	104	73.1	30.1	1.1	0.3
14	Sarati	16.9264	74.8983	7.5	740	474	168	32	21.4	197	0.8	0.7	235.3	110	31	43	0.5	0.2
15	Tisangi	17.1556	74.8614	7.7	1070	685	388	54.4	61.2	67.3	2.3	0	380.6	110	49.2	52	0.1	0.6
16	Banewadi	16.9473	74.8015	8.0	580	371	204	159	11	39	0.81	0	176	54	21	59	0.39	
17	Dhalgaon	17.1104	74.9831	8.0	632	404	204	144	15	64	1.98	0	244	33	7	47	0.77	
18	Dudhebhavi	17.1677	75.0216	7.9	1807	1156	443	199	59	210	3.09	0	259	332	7	223	0.39	
19	Garjewadi	17.1281	74.8657	8.1	623	399	249	144	25	30	4.11	0	215	49	7	63	0.554	
20	Ghatnandre	17.1751	74.8667	7.9	1948	1247	548	269	68	145	73.80	0	488	314	8	128	0.247	
21	Kognoli	16.9117	74.9091	8.2	1574	1007	259	194	16	230	26.00	0	439	154	9	190	1.06	
22	Kokale	16.9919	75.0274	7.9	5274	3375	1818	623	290	370	1.86	0	249	1229	11	647	0.292	
23	Moghamvadi	17.0307	74.9901	7.8	811	519	269	234	8	68	0.63	0	200	85	25	104	0.501	
24	Morgaon	16.9929	74.8322	8.2	1790	1146	583	264	77	92	59.70	0	298	422	7	44	0.135	

Sl. No	SITE NAME	LATITUDE	LONGITUDE	pH	EC µS/cm @25°C	TDS	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	NO_3	SO_4	F	Fe
						←---------- mg/l ----------→												
25	Nagaj	17.1459	74.9376	7.8	2515	1610	792	339	110	210	6.22	0	366	355	44	409	0.438	
26	Nangole	17.0335	74.9230	7.8	780	499	209	184	6	77	1.33	0	273	75	7	66	0.456	
27	Sarati	16.9231	74.8986		1729	915	625	114	82.6	110	0.83	0	311.1	337	37	162	0.19	
28	Shirdon	17.0230	74.8128	7.8	1502	961	418	274	35	154	0.87	0	254	229	9	214	0.273	
29	Alkud	17.0167	74.7750		943	502	525	130	48.6	36.4	2.86	0	402.6	124	49	97	0.14	
30	Kawathe Mahankal	17.0083	74.8694		1600	848	505	122	48.6	86	12.3	15	439.2	206	40	48	0.19	
31	Kuchi	17.0572	74.8644		636	336	285	60.1	32.8	69.2	1.17	0	359.9	78	10	58	0.09	
32	Nimaj-1	16.8333	74.6403		990	522	405	70.1	55.9	62	2.01	0	420.9	145	10	41	0.23	
	Miraj																	
33	Arag	16.7875	74.8167		757	401	280	70.1	25.5	82	3.4	0	335.5	85.1	13	97	0.19	
34	Arag	16.7889	74.8069	8	816	522	320	62.4	39.9	38	0.5	0	229.4	110	106	51.2	0.2	0.2
35	Bedag	16.8011	74.7381		746	396	355	96.2	27.9	48.4	0.85	0	317.2	103	13	63	0.21	
36	Belanki	16.8594	74.8714	7.9	895	573	292	67.2	30.1	92	1.6	0	268.4	130	74.9	67	0.6	0.6
37	Bhose	16.9583	74.7428		585	310	275	60.1	30.4	53.1	0.95	0	341.6	53.2	11	65	0.09	
38	Dhavli	16.7533	74.6528	7.8	4890	3130	1400	256	185	269	2	0	278.2	854	58	321	0.8	0.5
39	Dudhgaon	16.8833	74.4222	7.2	2400	1536	660	32	141	98	3.5	0	375.8	330	146	124	0.4	0.2
40	Erandoli	16.8504	74.7712	7.9	2885	1846	991	473	126	212	1.56	0	244	630	42	284	0.4	
41	Kalambi	16.8978	74.6917	7.7	372	238	152	28.8	19.4	50	0.4	0.56	119.4	62	3.99	44	0.3	0.3
42	Karnal-1	16.9169	74.5669		1965	1042	705	134	89.9	98	0.89	0	610	238	53	113.4	0.1	
43	Kase Digraj	16.9069	74.5183	7.6	1905	1219	728	162	78.7	53.7	4.4	0	203.7	348	2.22	130	0.6	0.2
44	Kavalapur	16.9211	74.6139	7.7	1900	1216	576	153	47.1	100	6.5	0	185.4	320	230	99.9	0.4	0.2
45	Kavlapur	16.9251	74.6127	7.7	7500	4800	2500	1569	226	535	71.00	0	410	1979	44	579	0.13	
46	Kavthepiran	16.8797	74.4650	7.4	164	105	100	16	14.6	22.1	2	0.24	99.75	36	3.99	16	0.6	0.3
47	Khanderajuri	16.8963	74.7886	7.8	1004	643	254	254	0	113	1.19	0	293	111	12	101	0.471	
48	Khatav	16.7997	74.8932	7.8	2528	1618	767	224	132	231	1.46	0	322	468	42	314	0.811	
49	Kupwad	16.8672	74.6200	7.3	1495	957	468	136	31.1	97	0.6	0	180.6	226	80.2	108	0.2	0.2
50	Madhavnagar	16.8875	74.5878	7.4	3280	2099	588	176	36	227	0.8	0	302.6	370	128	50	0.3	0.2
51	Malgaon	16.8659	74.7135	8.1	860	550	279	189	22	69	0.41	0	195	116	7	118	0.228	
52	Mhaisal	16.7783	74.7022	7.3	6270	4012	792	296	12.6	300	4.8	0	253.8	360	66	400	0.1	0.1
53	Mhaisal(s)	16.7529	74.7039	7.6	1854	1187	538	398	34	182	0.19	0	234	344	34	224	0.256	
54	Miraj-1	16.8108	74.6447		1251	663	375	60.1	54.7	120	0.89	0	366	160	22	108	0.21	
55	Nandre	16.9606	74.5416	7.8	2008	1285	329	179	36	309	0.49	0	381	267	28	289	0.158	

Sl. No	SITE NAME	LATITUDE	LONGITUDE	pH	EC µS/cm @25°C	TDS	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	NO_3	SO_4	F	Fe
						←---------- mg/l ----------→												
56	Nandre	16.9542	74.5444	7.4	1310	838	436	88	52.5	53.6	5.2	0	146.4	202	39.9	120	0.3	0.1
57	Palus	16.9886	74.4719	7.2	1640	1050	120	40	4.86	111	2.4	0	219.6	60	35.4	167	0.6	0.2
58	Salgare	16.8874	74.9092	7.8	1189	761	364	169	47	104	0.16	0	273	141	36	129	0.397	
59	Samdoli	16.8667	74.4972	7.5	1254	803	364	72.8	44.2	123	4.5	0	327	150	35	107	0.2	0.9
60	Sangli	16.8556	74.5667	7.8	1447	923	464	152	20.4	120	5.5	0	195.2	256	12.8	119	0.4	0.2
61	Sangli_city	16.8678	74.5828		1506	797	590	82.2	93.6	80	2.95	0	463.6	206	11	164	0.21	
62	Sangli_Inamdhamni	16.8383	74.5878		2448	1300	925	174	119	99	1.69	0	311.1	351	32	286	0.14	
63	Sangli_Sangalwadi	16.8831	74.5536		1376	734	525	62.1	89.9	80	0.65	21	445.3	131	32	140	0.14	
64	Shindewadi	16.9678	74.8386	7.7	1786	1143	677	423	62	88	0.15	0	210	242	36	344	0.144	
65	Tung	16.9219	74.4931		1736	924	670	122	88.7	64	3.65	0	353.8	227	44	113	1.53	
66	Tung	16.9306	74.4806	7.7	1183	757	380	83.2	41.8	106	0.1	0	170.8	206	53.2	116	0.5	0.1

Annexure-VIII: Ground Water Quality Data of Aquifer-II (Deeper Aquifer)

Sl. No.	TALUKA	Location	Latitude	Longitude	pH	EC µS/cm @25°	TDS	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	NO_3	SO_4	Fe
							←---------- mg/l ----------											
1	Kavthe Mahankal	Deshing	16.9708	74.8042	7.2	1125	720	356	212	34.99	87	308	0	375.76	166	5	48	0.40
2		Dudhebhavi	17.1714	75.025	7.2	792	507	228	200	6.8	90.5	264	0	322.08	126	0.5	1	1.00
3		Kavthe Mahankal	17.0067	74.8667	7.1	833	533	352	240	27.22	43	280	0	341.60	108	6.3	51.3	0.80
4		Kerewadi	17.1203	74.9317	7.4	463	296	188	132	13.61	44	200	0.47	199.52	64	0.5	22	1.00
5		Kokale	16.9875	75.0264	7.2	4250	2720	1580	836	180.79	360	272	0	331.84	800	0.5	1450	1.00
6		Nimaj	17.1583	74.9781	8.2	1345	861	364	260	25.27	157	360	0	439.20	216	7.9	10	0.80
7		Ranjani	16.9708	74.9478	7.7	820	525	372	132	58.32	50	280	0	341.60	104	16.5	30.1	1.10
8		Tisangi	17.1556	74.8614	7.7	1070	685	388	136	61.24	67.3	312	0	380.64	110	11.1	52	0.10
9	Miraj	Arag	16.7889	74.8069	8	816	522	320	156	39.85	38	188	0	229.36	110	23.9	51.2	0.20
10	Miraj	Belanki	16.8594	74.8714	7.9	895	573	292	168	30.13	92	220	0	268.40	130	16.9	67	0.60
11	Miraj	Dudhgaon	16.8833	74.4222	7.2	2400	1536	660	80	140.94	98	308	0	375.76	330	33	124	0.40
12	Miraj	Kalambi	16.8978	74.6917	7.7	372	238	152	72	19.44	50	120	0.56	119.41	62	0.9	44	0.30
13	Miraj	Kase Digraj	16.9069	74.5183	7.6	1905	1219	728	404	78.73	53.7	167	0	203.74	348	0.5	130	0.60
14	Miraj	Kupwad	16.8672	74.62	7.3	1495	957	468	340	31.1	97	148	0	180.56	226	18.1	108	0.20
15	Miraj	Madhavnagar	16.8875	74.5878	7.4	3280	2099	588	440	35.96	227	248	0	302.56	370	28.9	50	0.30
16	Miraj	Mhaisal	16.7783	74.7022	7.3	6270	4012	792	740	12.64	300	208	0	253.76	360	14.9	400	0.10

17	Miraj	Palus	16.9886	74.4719	7.2	1640	1050	120	100	4.86	110.7	180	0	219.60	60	8	167	0.60
18	Miraj	Sangli	16.8556	74.5667	7.8	1447	923	464	380	20.41	120	160	0	195.20	256	2.9	119	0.40

Artificial Rechargetructure					Annexure IX	
S.N.	**Village**	**Taluka**	**District**	**X**	**Y**	**Structures**
1	Tanang	Miraj	Sanghli	74.6524	16.8873	Checkdam
2	MIRAJ	Miraj	Sanghli	74.6591	16.8655	Checkdam
3	Malgaon	Miraj	Sanghli	74.67	16.8826	Checkdam
4	Nilaji	Miraj	Sanghli	74.5927	16.8147	Checkdam
5	Takali	Miraj	Sanghli	74.6684	16.8475	Checkdam
6	Vyankuchiwadi	Miraj	Sanghli	74.8032	16.8459	Checkdam
7	Kavalapur	Miraj	Sanghli	74.6311	16.9289	Checkdam
8	Karnal	Miraj	Sanghli	74.5521	16.9207	Checkdam
9	Bolwad	Miraj	Sanghli	74.687	16.8139	Checkdam
10	Bedag	Miraj	Sanghli	74.7161	16.8161	Checkdam
11	Bedag	Miraj	Sanghli	74.7404	16.7684	Checkdam
12	Arag	Miraj	Sanghli	74.8001	16.7954	Checkdam
13	Arag	Miraj	Sanghli	74.8355	16.7822	Checkdam
14	Khatav	Miraj	Sanghli	74.8949	16.7998	Checkdam
15	Salgare	Miraj	Sanghli	74.9157	16.8829	Checkdam
16	Erandoli	Miraj	Sanghli	74.7799	16.8449	Checkdam
17	Ghorpadi	Kavthe Mahankal	Sanghli	74.9677	17.1788	Checkdam
18	Ghorpadi	Kavthe Mahankal	Sanghli	74.9782	17.1808	Checkdam
19	Ghorpadi	Kavthe Mahankal	Sanghli	74.987	17.1863	Checkdam
20	Shindewadi (g)	Kavthe Mahankal	Sanghli	74.9991	17.1825	Checkdam
21	Shindewadi (g)	Kavthe Mahankal	Sanghli	75.0063	17.1852	Checkdam
22	Dudhebhavi	Kavthe Mahankal	Sanghli	75.0115	17.1827	Checkdam
23	Dhalgaon	Kavthe Mahankal	Sanghli	75.0033	17.1446	Checkdam
24	Kadamwadi	Kavthe Mahankal	Sanghli	75.003	17.1477	Checkdam
25	Kadamwadi	Kavthe Mahankal	Sanghli	75.0037	17.1532	Checkdam
26	Dudhebhavi	Kavthe Mahankal	Sanghli	75.0073	17.1597	Checkdam
27	Chorochi	Kavthe Mahankal	Sanghli	75.0512	17.1521	Checkdam
28	Dudhebhavi	Kavthe Mahankal	Sanghli	75.0342	17.1697	Checkdam
29	Shindewadi (g)	Kavthe Mahankal	Sanghli	75.0016	17.1725	Checkdam
30	Shindewadi (g)	Kavthe Mahankal	Sanghli	75.0065	17.1782	Checkdam
31	Jambhulwadi	Kavthe Mahankal	Sanghli	75.0678	17.1455	Checkdam
32	Jambhulwadi	Kavthe Mahankal	Sanghli	75.0691	17.1371	Checkdam
33	Dholewadi	Kavthe Mahankal	Sanghli	75.0441	17.1728	Checkdam
34	Chorochi	Kavthe Mahankal	Sanghli	75.0424	17.1499	Checkdam
35	Chorochi	Kavthe Mahankal	Sanghli	75.0366	17.1475	Checkdam
36	Chorochi	Kavthe Mahankal	Sanghli	75.0271	17.1419	Checkdam
37	Dhalgaon	Kavthe Mahankal	Sanghli	74.9894	17.1178	Checkdam
38	Dhalgaon	Kavthe Mahankal	Sanghli	74.9967	17.1178	Checkdam
39	Dhalgaon	Kavthe Mahankal	Sanghli	75.0007	17.1255	Checkdam
40	Dhalgaon	Kavthe Mahankal	Sanghli	75.0082	17.1284	Checkdam
41	Dhalgaon	Kavthe Mahankal	Sanghli	75.0075	17.1237	Checkdam
42	Chudekhindi	Kavthe Mahankal	Sanghli	75.0281	17.1135	Checkdam

43	Chudekhindi	Kavthe Mahankal	Sanghli	75.0388	17.1177	Checkdam
44	Chudekhindi	Kavthe Mahankal	Sanghli	75.0408	17.1214	Checkdam
45	Chudekhindi	Kavthe Mahankal	Sanghli	75.0523	17.1193	Checkdam
46	Chudekhindi	Kavthe Mahankal	Sanghli	75.0565	17.1246	Checkdam
47	Dhalewadi	Kavthe Mahankal	Sanghli	74.9694	17.0878	Checkdam
48	Arewadi	Kavthe Mahankal	Sanghli	74.9519	17.1087	Checkdam
49	Arewadi	Kavthe Mahankal	Sanghli	74.9505	17.1177	Checkdam
50	Arewadi	Kavthe Mahankal	Sanghli	74.9356	17.1215	Checkdam
51	Shelkewadi	Kavthe Mahankal	Sanghli	74.9114	17.112	Checkdam
52	Agalgaon	Kavthe Mahankal	Sanghli	74.9182	17.1072	Checkdam
53	Agalgaon	Kavthe Mahankal	Sanghli	74.9261	17.1013	Checkdam
54	Langarpeth	Kavthe Mahankal	Sanghli	74.9362	17.1015	Checkdam
55	Agalgaon	Kavthe Mahankal	Sanghli	74.9104	17.0922	Checkdam
56	Agalgaon	Kavthe Mahankal	Sanghli	74.9226	17.086	Checkdam
57	Raywadi	Kavthe Mahankal	Sanghli	74.9228	17.1414	Checkdam
58	Nagaj	Kavthe Mahankal	Sanghli	74.9335	17.1451	Checkdam
59	Nagaj	Kavthe Mahankal	Sanghli	74.9469	17.1461	Checkdam
60	Nagaj	Kavthe Mahankal	Sanghli	74.9368	17.1534	Checkdam
61	Nagaj	Kavthe Mahankal	Sanghli	74.9563	17.1426	Checkdam
62	Garjewadi [n.v]	Kavthe Mahankal	Sanghli	74.8717	17.1224	Checkdam
63	Kundlapur	Kavthe Mahankal	Sanghli	74.8739	17.1153	Checkdam
64	Jakhapur	Kavthe Mahankal	Sanghli	74.8755	17.106	Checkdam
65	Jakhapur	Kavthe Mahankal	Sanghli	74.8763	17.0998	Checkdam
66	Jakhapur	Kavthe Mahankal	Sanghli	74.8772	17.0947	Checkdam
67	Kuchi	Kavthe Mahankal	Sanghli	74.8746	17.0898	Checkdam
68	Kuchi	Kavthe Mahankal	Sanghli	74.8729	17.0838	Checkdam
69	Kuchi	Kavthe Mahankal	Sanghli	74.8693	17.0772	Checkdam
70	Kuchi	Kavthe Mahankal	Sanghli	74.8866	17.0648	Checkdam
71	Agalgaon	Kavthe Mahankal	Sanghli	74.8854	17.0712	Checkdam
72	Agalgaon	Kavthe Mahankal	Sanghli	74.8886	17.0789	Checkdam
73	Agalgaon	Kavthe Mahankal	Sanghli	74.9001	17.0965	Checkdam
74	Agalgaon	Kavthe Mahankal	Sanghli	74.934	17.0775	Checkdam
75	Langarpeth	Kavthe Mahankal	Sanghli	74.9387	17.0763	Checkdam
76	Langarpeth	Kavthe Mahankal	Sanghli	74.9519	17.0775	Checkdam
77	Langarpeth	Kavthe Mahankal	Sanghli	74.9589	17.0804	Checkdam
78	Langarpeth	Kavthe Mahankal	Sanghli	74.9453	17.107	Checkdam
79	Shirdhon	Kavthe Mahankal	Sanghli	74.8107	17.0198	Checkdam
80	Shirdhon	Kavthe Mahankal	Sanghli	74.8107	17.0336	Checkdam
81	Shirdhon	Kavthe Mahankal	Sanghli	74.8167	17.0483	Checkdam
82	Morgaon (n.v.)	Kavthe Mahankal	Sanghli	74.8358	17.0011	Checkdam
83	Zurewadi [n.v.]	Kavthe Mahankal	Sanghli	74.8303	17.024	Checkdam
84	Zurewadi [n.v.]	Kavthe Mahankal	Sanghli	74.8644	17.0251	Checkdam
85	Zurewadi [n.v.]	Kavthe Mahankal	Sanghli	74.8756	17.0427	Checkdam
86	Banewadi	Kavthe Mahankal	Sanghli	74.8041	16.9672	Checkdam

87	Morgaon (n.v.)	Kavthe Mahankal	Sanghli	74.8098	16.9832	Checkdam
88	Shindewadi(h)	Kavthe Mahankal	Sanghli	74.8436	16.9771	Checkdam
89	Hingangaon	Kavthe Mahankal	Sanghli	74.8528	16.9834	Checkdam
90	Karoli (t)	Kavthe Mahankal	Sanghli	74.8866	16.9716	Checkdam
91	Karoli (t)	Kavthe Mahankal	Sanghli	74.8828	16.9539	Checkdam
92	Ranjani	Kavthe Mahankal	Sanghli	74.9252	16.9487	Checkdam
93	Ranjani	Kavthe Mahankal	Sanghli	74.9495	16.9694	Checkdam
94	Ranjani	Kavthe Mahankal	Sanghli	74.9527	16.9845	Checkdam
95	Ranjani	Kavthe Mahankal	Sanghli	74.9581	16.9934	Checkdam
96	Alkud [s]	Kavthe Mahankal	Sanghli	74.9509	17.0127	Checkdam
97	Ranjani	Kavthe Mahankal	Sanghli	74.9665	16.9768	Checkdam
98	Lonarwadi	Kavthe Mahankal	Sanghli	74.9555	16.9553	Checkdam
99	Ranjani	Kavthe Mahankal	Sanghli	74.9844	16.9567	Checkdam
100	Zurewadi [n.v.]	Kavthe Mahankal	Sanghli	74.873	17.0319	Percolation tank
101	Kognoli	Kavthe Mahankal	Sanghli	74.903	16.9125	Percolation tank
102	Karoli (t)	Kavthe Mahankal	Sanghli	74.8952	16.9696	Percolation tank
103	Morgaon (n.v.)	Kavthe Mahankal	Sanghli	74.8107	17.0071	Percolation tank
104	Hingangaon	Kavthe Mahankal	Sanghli	74.8482	16.9911	Percolation tank
105	Hingangaon	Kavthe Mahankal	Sanghli	74.8635	16.9895	Percolation tank
106	Hingangaon	Kavthe Mahankal	Sanghli	74.8698	16.9892	Percolation tank
107	Vithurayachi Wadi	Kavthe Mahankal	Sanghli	74.884	17.0063	Percolation tank
108	Vithurayachi Wadi	Kavthe Mahankal	Sanghli	74.9166	16.9939	Percolation tank
109	Vithurayachi Wadi	Kavthe Mahankal	Sanghli	74.912	17.0126	Percolation tank
110	Thabadewadi	Kavthe Mahankal	Sanghli	74.8843	17.0551	Percolation tank
111	Hingangaon	Kavthe Mahankal	Sanghli	74.8987	16.982	Percolation tank
112	Ranjani	Kavthe Mahankal	Sanghli	74.9146	16.9519	Percolation tank
113	Kognoli	Kavthe Mahankal	Sanghli	74.925	16.92	Percolation tank
114	Pimpalwadi	Kavthe Mahankal	Sanghli	74.9255	17.0085	Percolation tank
115	Karoli (t)	Kavthe Mahankal	Sanghli	74.8973	16.9459	Percolation tank
116	Kognoli	Kavthe Mahankal	Sanghli	74.9137	16.9227	Percolation tank
117	Mhaisal (m)	Kavthe Mahankal	Sanghli	74.8722	16.9704	Percolation tank
118	Ranjani	Kavthe Mahankal	Sanghli	74.918	16.9713	Percolation tank
119	Vithurayachi Wadi	Kavthe Mahankal	Sanghli	74.9247	16.995	Percolation tank
120	Ranjani	Kavthe Mahankal	Sanghli	74.9821	16.9517	Percolation tank
121	Kokale	Kavthe Mahankal	Sanghli	75.0208	16.953	Percolation tank
122	Kokale	Kavthe Mahankal	Sanghli	75.0182	16.987	Percolation tank
123	Kokale	Kavthe Mahankal	Sanghli	75.0248	16.9952	Percolation tank
124	Lonarwadi	Kavthe Mahankal	Sanghli	74.9576	16.9624	Percolation tank
125	Ranjani	Kavthe Mahankal	Sanghli	74.9625	17.0019	Percolation tank
126	Lonarwadi	Kavthe Mahankal	Sanghli	74.9555	16.9376	Percolation tank
127	Ranjani	Kavthe Mahankal	Sanghli	74.9853	16.9657	Percolation tank

128	Kokale	Kavthe Mahankal	Sanghli	75.0138	16.9704	Percolation tank
129	Pimpalwadi	Kavthe Mahankal	Sanghli	74.9281	17.0024	Percolation tank
130	Ranjani	Kavthe Mahankal	Sanghli	74.9752	16.9886	Percolation tank
131	Bassappachiwadi	Kavthe Mahankal	Sanghli	74.9942	17.0355	Percolation tank
132	Irali	Kavthe Mahankal	Sanghli	74.9798	17.0567	Percolation tank
133	Irali	Kavthe Mahankal	Sanghli	74.9705	17.0758	Percolation tank
134	Irali	Kavthe Mahankal	Sanghli	74.9674	17.0565	Percolation tank
135	Nangole	Kavthe Mahankal	Sanghli	74.9247	17.0328	Percolation tank
136	Bassappachiwadi	Kavthe Mahankal	Sanghli	75.0043	17.0355	Percolation tank
137	Kokale	Kavthe Mahankal	Sanghli	75.0228	17.0101	Percolation tank
138	Kokale	Kavthe Mahankal	Sanghli	75.0161	17.0237	Percolation tank
139	Irali	Kavthe Mahankal	Sanghli	74.9818	17.0532	Percolation tank
140	Nangole	Kavthe Mahankal	Sanghli	74.9391	17.0209	Percolation tank
141	Alkud [s]	Kavthe Mahankal	Sanghli	74.9567	17.0264	Percolation tank
142	Chudekhindi	Kavthe Mahankal	Sanghli	75.0435	17.1257	Percolation tank
143	Jambhulwadi	Kavthe Mahankal	Sanghli	75.0661	17.134	Percolation tank
144	Nagaj	Kavthe Mahankal	Sanghli	74.9604	17.1483	Percolation tank
145	Nimaj	Kavthe Mahankal	Sanghli	74.9775	17.1563	Percolation tank
146	Shindewadi (g)	Kavthe Mahankal	Sanghli	74.9942	17.1814	Percolation tank
147	Dudhebhavi	Kavthe Mahankal	Sanghli	75.0228	17.1671	Percolation tank
148	Bolwad	Miraj	Sanghli	74.6708	16.8178	Percolation tank
149	Kasabe Digraj	Miraj	Sanghli	74.4889	16.885	Percolation tank
150	Dudhgaon	Miraj	Sanghli	74.4493	16.8574	Percolation tank
151	Vaddi	Miraj	Sanghli	74.6366	16.793	Percolation tank
152	MIRAJ	Miraj	Sanghli	74.6622	16.8416	Percolation tank
153	Kupwad	Miraj	Sanghli	74.6069	16.8999	Percolation tank
154	Mhaisal(s)	Miraj	Sanghli	74.6958	16.75	Percolation tank