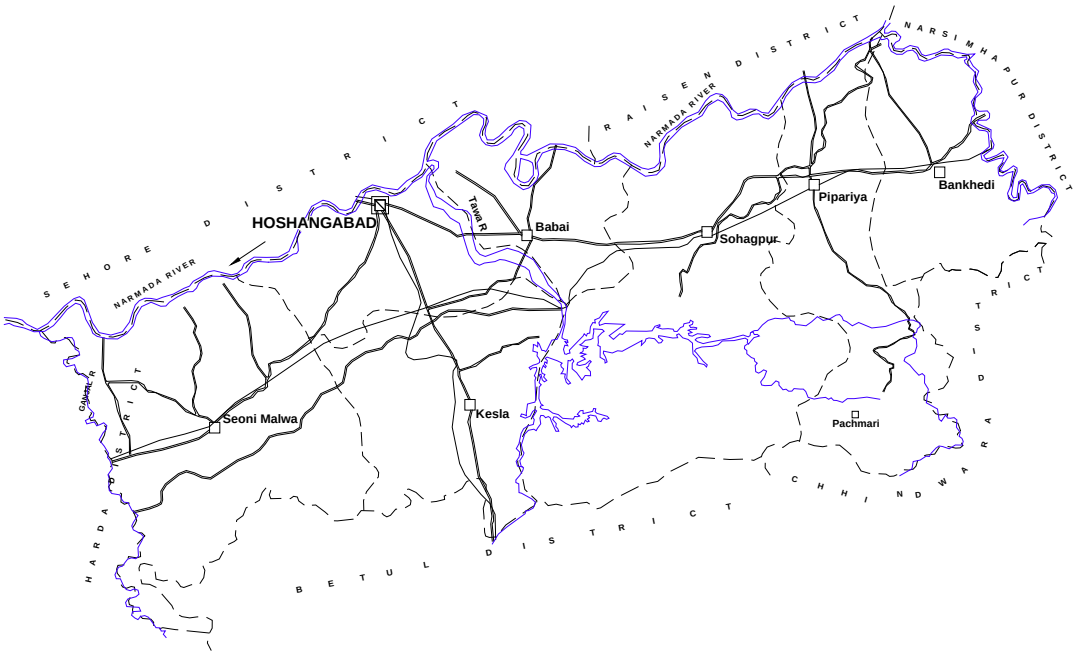
DISTRICT GROUND WATER INFORMATION BOOKLET

HOSHANGABAD DISTRICT
MADHYA PRADESH



Ministry of Water Resources
Central Ground Water Board
North Central Region
Government of India

JUNE, 2009

HOSHANGABAD DISTRICT AT A GLANCE

S. No.	ITEMS	Statistics
1.	GENERAL INFORMATION	
	i) Geographical area	6707 Sq.Km.
	ii) Administrative Divisions (As on 2006) Number of Tehsils	7 (Babai, Bankhedi, Hoshangabad, Itarsi, Pipria, Seonimalwa and Sohagpur)
	Number of Blocks	7 (Babai, Bankhedi, Hoshangabad, Kesla, Pipria, Seonimalwa and Sohagpur
	Number of Panchayats	391 Village Panchayats, 07 Block Panchayats and 14 Revenue Zonal Panchayats.
	Number of Villages	923
	iii)Population (As per 2001 census)	1084265 persons
	iv)Average Annual Rainfall (mm)	1225.9 mm
2.	GEOMORPHOLOGY	
	i) Major Physiographic Units	(1) Satpura range in the south, (2) Alluvial plain in the middle and (3) Badland topography zone confined to the vicinity of Narmada river
	ii) Major Drainage	Narmada river and its tributaries, namely, Tawa river, Denwa river, Morand river, Banjal river, Ajnal river, Ganjal river and Keolari, Hather and Indra Nadi.
3.	LAND USE (Sq. Km.)	
	i) Forest area:	806.47
	ii) Net area sown:	2990.59
	iii) Cultivable area:	3401.75
4.	MAJOR SOIL TYPES	
	Soil Type	Black soils and ferruginous red lateritic soils, Sandy clay loam, sandy loam and clay loam (area lying west of Ganjal river).
	Taxonomy	(Ustocherpts/ Ustorthents/ Haplustalfs/Haplusterts as per pedological taxonomy)

5.	AREA UNDER PRINCIPAL CROPS (Sq. Km.)		
		Wheat	2026.28
		Paddy	140.52
		Jowar	11.61
		Maize	19.28
		Other Grains	24.01
		Gram	501.13
		Tuar	121.53
		Urad	1.72
		Other Pulses	43.28
		Soyabean	1884.95
		Groundnut	0.70
		Til	3.67
		Other Oilseeds	6.03
		Sugarcane	17.96
		Cotton	0.25
		Spices	15.35
		Vegetables	32.02
6.	IRRIGATION BY DIFFERENT SOURCES		
		Number	Area (Sq. Km.)
	Dugwells	20303	544.53
	Tube wells/Bore wells	4757	474.96
	Tanks/Ponds	9	8.84
	Canals (Tawa Canal Command)		1435.16
	Other Sources		134.83
	Net Irrigated Area		2610.22
	Gross Irrigated Area		2610.22
7.	NUMBER OF GROUND WATER MONITORING WELLS OF CGWB (As on 31.3.2007)		
	No. of Dug Wells	22	
	No. of Piezometers	5	
8	PREDOMINANT GEOLOGICAL FORMATIONS		
		Alluvium and Soil Cap, older alluvium & laterite; Basaltic lava flows, dykes, sills & intertrapean beds; Gondwanas (Sandstones, arenaceous mudstones, clays/shales, sandstones, Bagra conglomerates, Talchir Boulder bed, limestones and marls); Vindhyan (Lower Bhander) sandstones & quartzites, Archaean Granite, gneiss etc.	

9	HYDROGEOLOGY	
	Major Water Bearing Formation Pre-monsoon depth to water level during 2006 Post-monsoon depth to water level during 2006 Long Term water level trend in 10 years (1997-2006) in m/yr	Alluvium 3.60 to 17.50 m.bgl 1.89 to 15.20 m.bgl Rise 0.02 to 0.22 (Pre-monsoon) 0.03 to 0.11 (Post-monsoon) Fall 0.04 to 0.61 (Pre-monsoon) 0.02 to 0.75 (Post-monsoon)
10.	GROUND WATER EXPLORATION BY CGWB (As on 31.3.2007)	
	No of wells drilled (EW,OW,PZ,SH, Total)	76 EW and 4 PZ
	Depth Range (m)	24.23 to 330.31 m.bgl
	Discharge (litres per second)	10 to 55 lps.
	Storativity (S)	$1.95x\ 10^{-4}$ to $1.83x\ 10^{-2}$
	Transmissivity (m^2 /day)	50.8 to $5.1x10^3$
11.	GROUND WATER QUALITY	
	Presence of Chemical constituents more than permissible limit (eg EC, F, As, Fe)	High Nitrate (> 45 mg/l) recorded in 11 water samples
	Type of Water	Calcium Bicarbonate type
12	DYNAMIC GROUND WATER RESOURCES (2004) in MCM	
	Annual Replenishable Ground Water Resources	2108.89 MCM
	Net Annual Ground Water Draft	287.46 MCM
	Projected Demand for Domestic and Industrial uses upto 2025	20.09 MCM
	Stage of Ground Water Development	14 %
13.	AWARENESS AND TRAINING ACTIVITY	
	Mass Awareness Programmes Organised Date Place No. of Participants	Nil
	Water Management Training Programmes Organised Date Place No. of Participants	Nil
14	EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING	
	Projects completed by CGWB (No. & Amount Spent)	Nil
	Projects under technical guidance of CGWB (Numbers)	Nil
15.	GROUND WATER CONTROL AND REGULATION	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	Number of Blocks notified	Nil
16	MAJOR GROUND WATER PROBLEMS AND ISSUES	

1.0 INTRODUCTION

Hoshangabad district has predominantly an agricultural based economy. It is situated in the eastern part of Madhya Pradesh. Prior to 1998-99 District Harda was a part of Hoshangabad District. After the division of the district, the present area of the district at present remains 6707 Sq. Km. It is surrounded by Sehore and Raisen districts in the North, Narsinghpur district in the east, Chhindwara district in the south west Betul in the south and Harda district in the west. Hoshangabad district lies between north latitudes 22° 15' and 23° 00' and east longitudes 77º 15' and 78° 42' in part of survey of India toposheet Nos, 55F & 55J. Hoshangabad is the district headquarter and Itarsi, Sohagpur, Piparia, Pachmarhi and Bankheri are some of the major towns. Itarsi is a very important railway Junction lying on Delhi-Chennai, Delhi-Bangalore and Patna-Mumbai railway routes. National Highway No. 69 and State Highway No. 21 and 22 pass through the district. The villages in the district are approachable by fair weather motorable tract.

The district is divided into seven Tehsils and seven development Blocks, namely Bankhedi Block, Pipariya Block, Sohagpur Block, Babai Block, Hoshangabad Block, Kesla Block (Itarsi Tehsil) and Seoni Malwa Block. (Fig-1). The total population of the district is 10,84,265 persons.

DRAINAGE

The entire district is drained by Narmada River and its tributaries. Thus the area falls in the Narmada Basin. The river Narmada flows along the northern boundary of the district.The river Narmada originates from the Amarkantak plateau and after flowing through Hoshangabad, Mandla, Jabalpur from the north-eastern part. The Tawa river is the major tributary of the Narmada river and flows from south to north west before merging into the Narmada river. Denwa river originates from south-eastern part of the Hoshangabad district and flows district and flows from east to west direction before joining the Tawa river (south of Rainpur) where Tawa dam has been constructed. The important nalas are Keolari, Hather and Indra Nadi. The rivers draining the area in the western part are Morand, Banjal and Ajnal. The Morand river joins the Ganjal river near Chhidgaon and flows towards Narmada river.

IRRIGATION

Tawa dam is a major irrigation system in the study area. About 60% of the total area of Hoshangabad district is irrigated by Tawa canal system. The Tawa dam is constructed about 823 m. down stream of the confluence of Tawa and Denwa rivers at east longitude 77° 58'30" and north latitude 22° 33' 40". It has a Catchment area of 5982.90 Sq. Km. with 20055 ha area under submergence. The left Bank Canal starts from Ranipur and runs parralel to Narmada river course along the limits of the foot hill pediments of Satpura. This canal takes off directly from the reservoir with a head discharge of 103.06 cumecs. The first 6.44 km length is lined with thick concrete. The Handia branch canal with a head discharge of 29.9 cumecs takes off from the main canal at 92 km point. The right bank canal is taken through a tunnel from Kamthi and runs parallel more or less to the course of Narmada river. The distributary system has

been planned along the drainage divide. Due to topographic difference between the right and left bank canal has been taken through 6 km long tunnel. Bagra branch canal and Piparia branch canals take off on either side of the pickup weir. The Bagra canal is 60 km long. The total length of distributaries and minors on the right bank is 450 km.

Many minor irrigation Schemes are also operating in the district, amongst which Dokrikhera Tank Project in Bankheri block is prominent. Dokrikhera Tank Project has a gross command area 9104 ha and culturable command area 7625 ha. The area irrigated by canals, tubewells, dugwells and tanks are tabulated below in Table 1.

Table-1 : Irrigation (2005-2006)

S. No.	Source	Hoshangabad District Total	
		Number	Area (In Hactare)
1	Canals	-	1,43,516
2	Tubewlls	4,757	47,496
3	Dugwells	20,303	54,453
4	Tanks	9	47,496
5	Other sources	-	13,483
6	Gross area irrigated from all sources	-	2,61,022

CROPPING PATTERN

District is very rich in the field of agriculture due to good sources of irrigation and fertile alluvial soil. Wheat and gram are the main crops grown during Rabi season. Soyabean, Mustard, Til and Groundnut are the main oilseeds produced here. The farmers have started the production of Sunflowers.

CGWB ACTIVITES

Preliminary hydrogeological studies in parts of Hoshangabad district were carried out by the erstwhile ground water wing of geological survey of India in co-ordination with the erstwhile exploratory tube wells organization from 1953 to 1963 (P.G. Adyalkar, 1975). A comprehensive hydrogeological study of the alluvial area of the district was carried out by Central Ground Water Board, during the Narmada Project period from 1971 to 1978. During the above mentioned studies, besides hydrogelogical, hydrological and hydrometeorological studies, extensive exploratory drilling was also carried out covering the entire Narmada upland alluvial valley. Systematic hydrogeological survey has been carried out by Shri K. Srinivasan, Junior Geologist of the GSI in the western part of the district in 1969-90 and by Shri A. K. Jain, Asstt. Hydrogeologist of Central Ground Water Board in the southern part of the district in 1984-85. Reappraisal of hydrogeological conditions in parts of the Tawa common area of the district was taken up by Shri A. K. Mishra, Jr. Hydrogeologist of the Central Ground Water Board in the year 1984-85 to study and define the extent and causes of water logging and by Shri A. K. Budhauliya, Scientist B, Km. Anu Radha Bhatia, AHG, Seraj Khan, AHG and R. M. Verma AHG during AAP 1991-92 to assess the Scenario of ground water regime and the extent of water logging, its causes and suggesting remedial measures.

2.0 RAINFALL & CLIMATE

The climate of Hoshangabad district is characterized by a hot summer and general dryness except during the south west monsoon season. The year may be divided into four seasons. The cold season, December to February is followed by the hot season from March to about the middle of June. The period from the middle of June to September is the southwest monsoon season. October and November form the post monsoon or transition period.

The normal rainfall of Hoshangabad district is 1225.9 mm. It receives maximum rainfall during southwest monsoon period. About 92.8% of the annual rainfall received during monsoon seasons and only 7.2 % of the annual rainfalls take place during October to May period. The surplus water for groundwater recharge is available only during the southwest monsoon period. The maximum rainfall received in district at Pachmarhi i.e. 2122 mm and minimum at Hoshangabad i.e. 1302.3 mm.

The normal maximum temperature received during the month of May is 42.1^{o}C and minimum during the month of January is 11.7^{o}C. The normal annual means maximum and minimum temperature of Hoshangabad district is 32.8^{o}C and 19.8^{o}C respectively. During the southwest monsoon season the relative humidity generally exceeds 91% (August month). In rest of the year is drier. The driest part of the year is the summer season, when relative humidity is less than 33%. April is the driest month of the year. The wind velocity is higher during the pre-monsoon period as compared to post monsoon period. The maximum wind velocity 7.7 km/hr observed during the month of June and is minimum 2.9 km/hr during the month of December. The average normal annual wind velocity of Hoshangabad district is 5.0 km/hr.

3.0 GEOMORPHOLOGY & SOIL TYPES

The study area is bounded by Satpura ranges in south and by Narmada river in the north. The area slopes north west toward the Narmada river. The slope is generally step at the foothills of Satpura but moderate to gentle towards Narmada river. The land surface attains a maximum altitude of 1352 m above mean sea level at Dhupgarh (77° 22’30”: 22° 27’ 00”), near Pachmarhi and minimum altitude of 270 m above mean sea level at confluence of Ganjal river with the Narmada (77° 12’30”: 22° 33’ 30”).

The area may be divided into three zones on the basis of the Physiography (1) the Satpura range in the south, (2) An alluvial plain in the middle and (3) Badland topography zone confined to the vicinity of Narmada river. The maximum width of the valley between Satpura and Narmada river is about 30 kms.

The famous adamgarh hill, which stands out in the valley portion near Hoshangabad, is known from history stone age. Another hill, which stands out in the valley portion is near Chautalia village close to Narmada river. A large number of north westerly flowing tributaries originating from the Satpura join the Narmada along the left bank.

Soils of the area are characterized by black grey, red and yellow colours, often mixed with red and black alluvium and ferruginous red ravel or lateritic soils. These soils are commonly known as black soils. About 15% of the area is covered by sandy loam soils immediately on the high bank of Tawa river. Remaining part is occupied by clay loam with big pockets of sandy clay loam and sandy loam. The permeability of the soil is low when the clay contains montorillonite. They swell intensively when wet and shrink with deep cracks when dry. Intake of water is very rapid till the cracks disappear after complete wetting.

The soils have been classified as Ustocherpts/Ustorthents/ Haplustalfs/Haplusterts as per pedological taxonomy.

The rocks occurring in the district range in age from Palaeoproterozoic to Quaternary. The Mahakoshal Group of rocks mainly comprise quartzite, slate and phyllites. The rocks of Vindhyan Supergroup comprise Bhander Group. Bhander group consists of Lower Bhander sandstone which is fine to coarse grained and at places, pebbly and quartzitic.

The Gondwana sequence belonging to the Gondwana basin of Central India, comprises of Talchir, Barakar, Motur, Bijori, Panchmari, Denwa, Bagra and Jabalpur Formations. The Talchir formation comprises tillite, diamictite, fine to medium grained sandstone and grey to olive green shales. The Barakar Formation is dominantly made up of coarse grained feldspathic sandstone, grey shales and carbonaceous shale. Motur Formation overlies Barakar Formation with a gradational contact. It comprises coarse grained sandstone with pebbly interbands, variegated shales and clay. The Bijori Formation is exposed as a broad band of olive and buff coloured clays and shales, alternating with massive sandstone. The Pachmarhi Formation consists of thick beds of coarse to granular, white arenite or quartzwacke, separated by lenses or thin layers of conglomerate and thin red clay bands. The Denwa Formation consists mainly of alternating bands of sandstone and red to variegated calcareous clay. The Bagra formation comprises of conglomerate, variegated shales and subordinate limestone bands.

The youngest Gondwana sequence is represented by Jabalpur Formation. It consists mainly of massive sandstone alternating with white clays. Lenses of conglomerate are common. Discontinuous patchy exposures of Lameta Group are seen east of Barapura, Gotabari and Tangna. The basaltic lava flows of Deccan trap are well exposed in the southern and southwestern part of the district. These flows, grouped under Satpura Group are mainly of Aa type and non-porphyritic to porphyritic to mega-porphyritic in nature. The thickness of individual flows varies from 15m to 47m. The Satpura Group comprises of 18 to 21 basaltic flows which are further classified in 5 Formations. Numerous dykes and sills, mostly of doleritic composition intrude the Gondwana rocks and basaltic flows.

The dykes range in the length from few hundred meters to few kilometres, with width ranging from few meters to few hundred meters. Most of the dykes trend in NE-SW direction. Quaternary Narmada alluvial deposits occupy a major part of the district have been sub divided into seven litho-stratigraphic formations viz. Surajkund Formation, Beneta Formation, Hirdepur Formation, Bauras Formation and Ramgarh Formation, on the basis of lithological characters, degree of oxidation, calcification of the sediments, erosional unconformities, soil stratigraphy, morpho-stratigraphy and presence of volcanic ash.

4.0 GROUND WATER SCENARIO

4.1 HYDROGEOLOGY

Aquifer System And Aquifer Parameters

The water bearing properties of different hydrogeological units occurring in Hoshangabad District are described below. Hydrogeology of the district is shown in Plate-II.

Northern part of Hoshangabad district, adjoining the Narmada river is covered with alluvium, which makes for more than 50% of the entire district, are. Deccan traps occur as lava flows in the west central part of the district. The southern part of the area is hilly and occupied by rocks belonging to Gondwanas: southern part of the district around Kesla Railway station Archeans are exposed The Archaeans are exposed south of Itarsi around Kesla railway station between the rocks of Gondwana in the form of inliers they are in very small patches and no ground water structure exist in them for hydrogeological studies. In general ground water occurs in phreatic condition.

Vindhyans

Upper Vindhyans represented by lower Bhander sandstone are exposed south of Hoshangabad in Adamgarh quarry and at the confluence of Hather nala and river Narmada, north of Misrod and Dhamasa village near Chautalai village. These sandstones are medium grained, hard, compact, red light pink in colour and dip 12° due N. top of sandstone is buff colured and fine grained and traversed by two sets of joints, one parallel to the strike and another at right angles to it. The rocks have poor groundwater potential as they form hills in the district. The Vindhyan sandstone serves as a good building stone.

Gondwanas

Lower Gondwanas are well exposed in the Satpura region of the district on the sides of upper Denwa valley in the southern base of Pachmarhi hills, and at the confluence of the Anjan river and at Pathapani due north of Fatehpur (55J/10). The lower Gondwana are divided into the Talchirs (pebbles and boulders and green clays shales and sandstones) and the Damuda series (white to fawn coloured coarse grained sandstones, micaceous flagstones, grits, conglomerates, shales and carbonaceous

shales). Damuda series of the lower Gondwana is overlain by the rocks of the Mahadeva (coarse grained red to buff colured Pachmarhi sandstones with thin intercalations of pebbles, red Denwa clays containing calcitic nodules, with a few bands of white to yellow sandstones and Bagra conglomerates and pebble beds with occasional bands of calcareous sandstones variegated clays, limestones and dolomites) and Jabalpur series (soft, fine grained, occasionally pebbly sandstones with thin subordinate beds of conglomerate, earthy hematite, coal, carbonaceous red clays, shales and chert) of Upper Gondwana system. Gondwana rocks are criss-crossed by dykes/sills in the southern part of the district.

In the Gondwana occupying the southern part of the district, the aquifers are formed by fractured/weathered occurring below alluvium from confined/semi confined aquifer which are not very productive. In the exploratory tubewells, drilled by central ground water board during Narmada Project, water bearing zones in the Gondwana were encountered at Pathrai (Nibhora), Taron, Mahuakhera, Sohagpur Manegaon, Pathrota, Guraria and Kalkuhi. The Pachmarhi sandstone especially in Pachmarhi, though hard and massive, form potential zones wherever fractured and jointed. The transmissivity of Gondwana aquifer in general varies from 249 to 449 m^2/day.

Deccan Trap

Deccan Trap basaltic lava flows, are exposed in the southern part of the district and also criss-cross the Gondwana formations as dykes and are also encountered as basement rock below alluvium around Powarkhera and Itarsi. The phreatic aquifer in weathered/vesicular basalt are tapped by dugwells, which in general does not yield a good discharge.

Alluvium

The alluvial aquifer system in the district is the most extensive. Two to three granular zones and at places more number of potential granular zones comprising of fine to medium to coarse grained sand, gravel and pebbles and laterite are encountered in alluvium. The top phreatic aquifer range in thickness from 2 to 10m and is encountered in the depth range of 4 to 20 mbgl. The phreatic aquifer intercalations of clay and silt, and at places also of coarse sand or gravel.

It appears that all the alluvial aquifer zones constitute a single aquifer system. The unconfined aquifer along the southern fringe adjacent to Gondwana, passes laterally to the north into a number of aquifer zones separated by thick clay zones. The deeper aquifers are of semi-confined to confined nature with varying potentiometric heads. The yield of alluvial aquifers ranges from 180 to 3000 litres per minute.

All the aquifers are principally recharged by a lateral low from the south and also by direct vertical percolation rain/irrigation water/seepage from tanks/canals.

Hot Spring

A hot water spring occurs in the area at Anhoni (55J/5) (west of road from Pipariya to Pachmarhi). The temperature of Anhoni spring water is 41°C. A borehole has been drilled by Geological Survey of India, Geothermal Division,, Nagpur down to a depth of 250 mbgl near the spring. The lithology encountered in the borehole is Gondwana sandstone intruded the borehole is 54°C and free flow discharge is about 30 lpm from top of casing pipe 0.6 mbgl. The water smells of sulphur and occurrence of methane gas during drilling is reported by G.S.I. staff.

WATER LEVELS

Ground water levels form a very important parameter of the ground water system. The groundwater balance expresses itself in the change in water levels; hence a continuous record is important and useful. CGWB has 22 National Hydrograph Monitoring wells and 5 Peizometers in Hoshangabad district.

Pre-monsoon Depth to Water Level (May-2006)

In general depth to water level in the area ranges from 3.60 to 17.50 m below ground level. Shallow water level of less than 6 m has been recorded at Sankhera, Sanwalkhera, Nimsadia and Seonimalwa in the north-central part of the district. Depth to water level between 6 to 9 m bgl. and observed at Semri, Bhilatdeo, Powerkheda, Garhaghat, Baharpur, Pachmarhi, Dolaria and Sohagpur. Depth to water level between 9 to 12 m. bgl. is recorded at Matkuli, Bankheri, Babai and Suktawa. Deep water level more than 12 m. bgl. is recorded at Pipariya, Pathrauta, Gurra, Naserabad, Sandia and Bagratawa. Deepest water level of 17.5 m. bgl. is recorded at Bagratawa.

Post-monsoon Depth to water level (November-2006)

In general, during post-monsoon period, depth of water levels in the district ranges between 1.89 and 15.20 m below ground level. Very Shallow water level of less than 3 has been recorded at Sankhera, Sanwalkhera, Pachmarhi and Babai. Shallow water level of less than between 3 to 6 m bgl. m is occurring in major part of the district and is observed at Suktawa, Nimsadia, Semri, Dolaria, Seonimalwa, Garhaghat, Pipariya and Bhilatdeo. Depth to water level between 6 to 9 m bgl. is observed at Powerkheda, Sohagpur, Matkuli, Bankheri, Bagratawa and Baharpur. Depth to water level between 9 to 12 m. bgl. was not recorded in any monitoring well. Deep water level more than 12 m. bgl. is recorded at Sandia, Pathrauta and Naserabad. Deepest water level of 15.2 m. bgl. is recorded at Naserabad.

CHANGE IN GROUND WATER LEVELS

Water Level Fluctuation between Pre and Post-Monsoon 2006

Baharpur and Naserabad recorded a mild fall in ground water level in post-monsoon period as compared to water level during pre-monsoon.

Rise in water level between pre and post-monsoon seasons have been recorded in rest of the district. Rise in water level ranges between 0.43 m at Powarkhera in north-central part of the district and 8.94 m at Suktawa in southernl part of the area. Rise in water levels of less than 2 m is observed in monitoring wells at Powerkheda, Bhilatdeo, Nimsadia, Seonimalwa, Sohagpur and Sankhera. Water level rise between 2 to 4 m is observed at Garhaghat, Sanwalkhera, Sandia, Bankheri, Semri and Matkuli. Rise in water levels more than 4 m is recorded in monitoring wells at Dolaria, Pachmarhi, Pipariya, Babai, Bagratawa and Suktawa.

Perusal of long term groundwater level trend analysis of 22 National Hydrograph Monitoring wells of Hoshangabad district indicate that Ten National Hydrograph Monitoring wells of the district show declining trend during pre-monsoon as well as post-monsoon period while only one National Hydrograph Monitoring well of the district shows rising trend during pre-monsoon as well as post-monsoon period.

Three National Hydrograph Monitoring wells show rising trend while 15 Monitoring wells show falling trend during pre-monsoon. During post-monsoon period, seven National Hydrograph Monitoring wells show rising trend while 15 Monitoring wells show falling trend.

Average rate of decline is ranging between 0.04 m/year at Sohagpur to 1 m/year at Babai. Areas near canals show a slight rising trend with an average rise of water level from 0.02 m/year to 0.21 m/year.

Long term decline in water levels is perhaps due to increased dependency on ground water resources for various uses and continuous withdrawal of it at various places, even in Tawa canal command.

4.2 Ground Water Resources

The groundwater resource of the District are under-developed and under-utilised. Total annual replenishable groundwater resource of the district is 2219.89 MCM and after deducting unaccounted natural discharge, the net available ground water resource is 86591.7 MCM, while total groundwater draft in the district is only 287.46 MCM. The stage of ground water development of the district is only 13.63%. Bankheri Block has reached the highest stage of ground water development in the district at 57.92% (Table-2).

All blocks of Hoshangabad district come under safe category from ground water development point of view. Net Groundwater Availability for future irrigation development is 1816.62 MCM. There is ample scope for development of groundwater for irrigation, industrial and domestic purposes.

Table-2: Ground Water Resources of Hoshangabad District, M.P.

Assess-ment Unit/ District	Command/ Non-Command/ Block Total	Net Annual Ground water Availability	Existing Gross Ground water Draft for Irrigation	Existing Gross Ground water Draft for Domestic & Industrial water Supply	Existing Gross Ground water Draft for All uses	Allocation for domestic & industrial requirement upto next 25 years	Net Ground water Availability for future irrigation	Stage of Ground water Development- (%)
				Million Cubic Meter				
1	2	3	4	5	6	7	8	9
Bankhedi	Command	0	0	0	0	0	0	
	Non-Command	200.57	113.71	2.46	116.17	3.23	83.62	57.92
	Total	**200.57**	**113.71**	**2.46**	**116.17**	**3.23**	**83.62**	**57.92**
Pipariya	Command	139.76	1.96	0.18	2.14	0.24	137.57	1.53
	Non-Command	258.64	71.35	1.66	73.01	2.18	185.11	28.23
	Total	**398.4**	**73.31**	**1.84**	**75.15**	**2.42**	**322.68**	**18.86**
Sohagpur	Command	126.67	9.53	1.88	11.41	2.47	114.67	9.01
	Non-Command	82.15	5.70	0.31	6.01	0.41	76.04	7.32
	Total	**208.82**	**15.23**	**2.19**	**17.42**	**2.88**	**190.72**	**8.34**
Babai	Command	272.86	14.75	2.08	16.83	2.74	255.38	6.17
	Non-Command	0	0.00	0.00	0.00	0.00	0.00	
	Total	**272.86**	**14.75**	**2.08**	**16.83**	**2.74**	**255.38**	**6.17**
Hoshangabad	Command	313.69	7.16	2.00	9.16	2.63	303.91	2.92
	Non-Command	0	0	0	0	0	0	
	Total	313.69	7.16	2.00	9.16	2.63	303.91	2.92
Kesla	Command	66.76	0.76	0.64	1.40	0.84	65.15	2.10
	Non-Command	124.35	24.06	1.10	25.16	1.45	98.84	20.23
	Total	**191.1**	**24.82**	**1.74**	**26.56**	**2.29**	**163.99**	**13.90**
Seoni Malwa	Command	375.77	3.38	2.09	5.47	2.75	369.64	1.46
	Non-Command	147.67	19.83	0.88	20.71	1.16	126.68	14.02
	Total	**523.44**	**23.21**	**2.97**	**26.18**	**3.91**	**496.32**	**5.00**
	District Total	2108.89	272.18	15.28	287.46	20.09	1816.62	13.63

4.3 Ground Water Quality

Based on National Ground Water Monitoring chemical data 2006-07, applying IS: 10500 (Drinking Water) as amended up to date, all analyzed quality parameters viz. pH, Electrical Conductivity, Total Hardness, Alkalinity, Salinity & Fluoride ion, except Nitrate fall within highest desirable/ maximum permissible limit. In case of Nitrate, 63.15 percent samples contained Nitrate concentration exceeding 45 mg/l at Nimsadia, Bagratawa, Sankhera, Pathrauta, Bhilatdeo, Suktawa, Sandia, Piparia, Baharpur, Semri, Matkuli and Bankheri villages. High concentration of Nitrate in ground water is in general a potential indicator of agriculture and / or municipal pollution. In case of Fluoride, 89.47 percent of samples contained Fluoride concentration below 0.6 mg/l and ground water falls under safe category as regards fluoride. At Bhilatdeo, Total Hardness exceeds 600 mg/l and Calcium ion concentration exceeds 200 mg/l with Nitrate concentration of 200mg/l in groundwater, rendering the water unfit for drinking without proper treatment for removal of excess hardness and nitrate ion. Based on Piper Diagram, 84.21 percent of groundwater samples are of Calcium Bicarbonate Type with exception of Bhilatdeo (Calcium Chloride Type), Bankeri and Nimsadia (Mixed Type).

Based on National Ground Water Monitoring chemical data 2006-07, applying IS: 11624 (Irrigation Water) as amended up to date, 94.74, 100, and 100 percent samples fall under low category of Electrical Conductivity (< 1500 μS/cm at 25°C), Sodium Adsorption Ratio (< 10 (millimole/litre)^{½}), and Residual Sodium Carbonate (< 1.5 milliequivalent / litre) respectively. Ground water Quality of shallow ground water aquifers is shown in Table-3.

According to U S Salinity diagram, 57.89 and 42.11 percent samples fall under C_2S_1 and C_3S1 category respectively, which means 100 percent ground waters are safe (C_2S_1 and $C_3S_{1)}$ on all soils for irrigation.

According to Wilcox Diagram 59.89 and 42.11 percent samples fall under excellent to good and good to permissible categories respectively.

On the whole, groundwater is good for drinking and irrigation.

Table-3 : Different chemical constituents of shallow ground water in Hoshangabad District (2006-07)

S.No.	BLOCK	VILLAGE	pH	EC (µS/cm at 25°C)	Total Hardness as $CaCO_3$ mg/l	MAJOR CATIONS				MAJOR ANIONS					PO_4 mg/l	F mg/l	SAR (millimole/lit)$^{1/2}$	RSC (me/l)
						Concentration in milligram per litre												
						Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3				
1	BEOHARI	Beohari	7.67	790	280	84	17	47	2.3	Nil	232	71	50	56	BDL	0.62	1.22	-1.8
2	BURHAR	Bhikhampur	7.77	534	235	74	12	11	12	Nil	128	35	25	49	BDL	0.26	0.31	-2.6
3	BURHAR	Bahgarh	7.81	328	140	52	2.49	14	1.6	Nil	134	18	13	11	BDL	0.12	0.51	-0.6
4	BURHAR	Burhar	7.76	463	175	60	6.15	16	25	Nil	104	50	20	75	BDL	0.25	0.53	-1.8
5	JAISINGHNAGAR	Amjhor	7.42	679	200	62	11	60	12	Nil	140	89	37	62	BDL	0.29	1.85	-1.71
6	JAISINGHNAGAR	Bansukli	7.73	465	190	60	9.80	19	2.8	Nil	177	50	7.0	3.0	BDL	0.17	0.60	-0.91
7	JAISINGHNAGAR	Jaisinghnagar	7.37	344	95	28	6.11	37	5.1	Nil	73	50	23	29	BDL	0.07	1.65	-0.7
8	JAISINGHNAGAR	Kanadi (khurd)	7.87	352	160	48	9.78	7.0	3.4	Nil	140	18	8.0	25	BDL	0.29	0.24	-0.9
9	JAISINGHNAGAR	Karki	7.69	376	145	42	9.78	18	10	Nil	122	25	22	42	BDL	0.31	0.65	-0.9
10	JAISINGHNAGAR	Sanousi	7.91	252	115	38	4.91	6.0	5.4	Nil	128	11	6.0	4.0	BDL	0.17	0.24	-0.2
11	JAISINGHNAGAR	Sidi	7.40	325	130	48	2.49	16	5.6	Nil	98	21	30	27	BDL	0.14	0.61	-0.99
12	JAISINGHNAGAR	Tihki	7.69	422	170	60	4.94	21	1.9	Nil	195	21	15	3.0	BDL	0.37	0.70	-0.2
13	GOHPARU	Gohparu	7.53	904	370	110	23	42	3.6	Nil	146	128	76	92	BDL	0.39	0.95	-5.01
14	SOHAGPUR	Hoshangabad	7.74	529	185	50	15	37	9.6	Nil	232	32	19	4.0	BDL	0.76	1.18	0.1
15	SOHAGPUR	Singhpur	7.64	953	345	80	35	58	13	Nil	232	103	125	3.0	BDL	0.62	1.36	-3.1

4.4 Status of Ground Water Development

Till 1959 farmer depended mostly on monsoon rainfall and very few dug wells were existed. During the period 1959-60 construction of tube wells was initiated by Exploratory Tubewell Organization (ETO), Govt. of India. There were 59 exploratory tube well drilled by ETO during 1960 and later during the Narmada Project period between 1971 to 1978 twenty more exploratory tube wells were drilled. Till 1978 there were 79 tube wells and area irrigated through these tube wells and area irrigated through these tube wells was 2345 ha. only. In 1990 no. of tube wells increased upto 1028 and area irrigated from then was 10260 ha and the dug wells were 18067 with irrigated area of 42276 ha. In the year 2000 the total no of tube wells are 2626 and dug wells 18760 which irrigated 38173 and 43909 ha of land respectively.

5.0 GROUND WATER MANAGEMENT STRATEGY

5.1 Ground Water related issues & problems

Hoshangabad comes under safe category from ground water development point of view. Due to easy availability of surface water for irrigation, after the construction of major irrigation Tawa project (1975), the development of ground water for irrigation has been negligible in the are falling under the Tawa Command Project. The ground water development is confined only in non command are in the district i.e. in Bankhedi block and parts of Pipariya block. Ground water being the main source of irrigation, ground water level in declining.

Water Logging in Tawa Canal Command Area. Since the commencement of canal irrigation in the area, the heavy import of water from surface water irrigation system to the ground water reservoirs, and practically no draft of water from the ground water system to Tawa Canal command area has resulted in rise in water level leading in water logging conditions.

A general rise in phreatic water level has been recorded in the command area. The rise in water level has especially affected the low lying areas of many village and villages which already has shallow water table conditions even before the commencement of canal irrigation and rise in water level after monsoon has rendered almost 250 sq.km. of land water logged. Water levels of the range of 0.3 to 2 mbgl have been recorded at Nitaya, Raisalpur, Byawara, Rampur, Panjra (55F/14), Kharar, Rawan Pipal, Agra Kalan, Baikheri, Bamhori (55F/10) and in low lying areas around Muhuakhera, Gurari. It is seen that even during the pre-monsoon period, shallow water levels i.e. water logging conditions are seen in small patches around Pipaliya, Bawariabapu, Kharar, Chiidgaon, Basna, Jirahaber, Rawan Pipal, Bara kalan tec. Villages (55F/7) in Seoni Malwa block and also around Jaisalpur, Nitaya, Panjara khurd, Byawara, Raisalpur, Sankhera, Rampur (55 F/14) Dasaniya and Devri (55F/15) villages.

During the canal running days, further recharge takes place from canal seepage, thus bringing larger areas under water logging. Seepage from canal and canal water irrigation being added to the ground water regime is estimated as 77.80 MCM during the monsoon period and 580.14 MCM during the non monsoon (Rabi) period.

The gross ground water draft estimated as 8.108 MCM during the monsoon period and 81.038 MCM during the non-monsoon (Rabi) period, is considered insignificant as compared to surface water irrigation in the command area.

The Tawa reservoir is constructed in the Gondwana which has a hydraulic continuity with the alluvial aquifers and seepage from the reservoir has also causal rise to water table/piezometric head in the right bank command areas lying in the north of reservoir.

The water table gradient in the command area has become steeper as a result of seepage from canals. This has resulted in increased base flow in canals/rivers, making them perennial.

The natural drainage in the area has been severely affected due to land shaping for command area development.

Some stretches of nalas have become choked due to heavy growth of Ipomia, stopping the base flow thus compounding the problems of water logging.

Hydrogeological Scenario in the area outside the Tawa command in the district (Water table depleted area)

In the non command area of the district i.e. in Bankhedi block and parts of Pipariya block ground water being the main source of irrigation, ground water level in declining. Phreatic aquifer is hardly able to meet the needs of irrigation. The dug wells in a large area dry up by April. Since the water availability and potential of deeper aquifer is very good and sufficient to meet the irrigation demands at present, the number of tube wells in this area is increasing at a fast rate and dug wells are being converted into dug-cum-bore wells. Thus now it is the deeper aquifers, which are being exploited for meeting the irrigation demands.

The decline in water level in non command area can be attributed to two main factors.

1. Below normal rainfall in the non command area over the past years.
2. Heavy draft of ground water in the area to meet the irrigation demands.

Scope of Conjunctive utilization of surface and ground water

To deal with the problem of water logging the possibilities of conjunctive use of surface water and ground water should be considered immediately to begin with all existing ground water structures should be put back to their fullest use. All the tube wells constructed in the area should be run to their fullest capacity. Water from this source should be put in to distributaries and minor cutting of the supply from main canal. More number of tube wells could be sunk in the demarcated productive areas and individual command per tube well can be made for efficient and appropriate irrigation.

6.0 RECOMMENDATIONS

Based on the hydrogeological studies the following recommendations are made for proper development and utilization of the available groundwater resources and management of ground water resources.

It is recommended that conjunctive use of surface water and ground water should be planned in the area and to begin with all existing ground water structures should be put back to their fullest use. All the tube wells constructed in the area should be run to their fullest capacity. More number of tube wells could be sunk in the demarcated productive areas and individual command per tube well can be made for efficient and appropriate irrigation. Water of canals be made available to tail-end reaches and areas with less groundwater potential and canal command may be extended further.

Net Groundwater Availability for future irrigation development is 1816.62 MCM. to achieve optimum utilization of presently available ground water resources in Hoshangabad district, a total of about 90000 dug wells and about 25000 tube wells are feasible. The construction of these structures can be taken up over a span of ten years so that the development takes place in a phased manner and the additional power requirement for irrigation can also be met with suitably.

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