Annual Report 2009-2010

CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA
FARIDABAD

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Ministry of Water Resources
Govt. of India

ANNUAL REPORT
2009-10

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CONTENTS

Sl. No.	CHAPTERS	Page No.
	Executive Summary	I - VI
1.	Introduction	1 - 4
2.	Ground Water Management Studies	5 - 51
3.	Ground Water Exploration	52 - 78
4.	Development and Testing of Exploratory Wells	79
5.	Taking Over of Wells by States	80 - 81
6.	Water Supply Investigations	82 - 83
7.	Hydrological and Hydrometereological Studies	84 - 92
8.	Ground Water Level Scenario (Monitoring of Ground Water Observation Wells)	93 - 99
9.	Geophysical Studies	100- 122
10.	Hydrochemical Studies	123 - 132
11.	High Yielding Wells Drilled	133 - 136
12.	Hydrology Project	137
13.	Studies on Artificial Recharge of Ground Water	138 - 140
14.	Mathematical Modeling Studies	141 - 151
15.	Central Ground Water Authority	152
16.	Ground Water Studies in Drought Prone Areas	153 - 154
17.	Ground Water Studies in Tribal Areas	155
18.	Estimation of Ground Water Resources based on GEC-1997 Methodology	156 - 158
19.	Technical Examination of Major/Medium Irrigation Schemes	159

Sl. No.	CHAPTERS	Page No.
20.	Remote Sensing Studies	160 - 161
21.	Human Resource Development	162 - 163
22.	Special Studies	164 - 170
23.	Technical Documentation and Publication	171 - 173
24.	Visits by secretary, Chairman CGWB , delegations and important meetings	174 - 179
25.	Construction/Acquisition of Office Buildings	180
26.	Dissemination and Sharing of technical know-how (Participation in Seminars, Symposia and Workshops)	181 - 198
27.	Research and Development Studies/Schemes	199
28.	Publicity and Public Awareness	200 - 203
29.	Farmers' Participatory Action Research Programme	204
30	Activities in North Eastern Region	205
31.	Propagation and Progressive Use of Hindi Language	206
32.	Vigilance Activities	207
33.	RTI Annual Return Information System	208
34.	Personnel Management	209
35.	Persons with Disabilities 2009-10.	210
36.	Budget and Accounting	211 - 212
Annexure – 1 Location and Jurisdiction of Regional and other offices of CGWB		

EXECUTIVE SUMMARY

Ground water plays a key role in meeting the water needs of various user-sectors in India. With growing awareness, the dependability on ground water as a sustainable resource in nation building reasserts the need for an organization like Central Ground Water Board which is vested with the responsibilities of assessing and managing the ground water resources of the country through ground water management studies, exploration, evaluation and monitoring of ground water regime.

The Central Ground Water Board was constituted as a National apex organization in 1972 by the merger of the Ground Water Wing of Geological Survey of India with the erstwhile Exploratory Tube wells Organization (ETO). The main activities of the Board include macro level Hydrogeological investigations, exploratory drilling coupled with remote sensing studies, geophysical studies and pumping tests to study the subsurface Hydrogeological features and nation-wide monitoring of the behavior of water table and water quality through a network of ground water observation wells. The data generated from these investigations provide the scientific base for preparation of ground water development schemes by the State Governments. Besides advising the States on planning, financing and administration of ground water development schemes, the Board undertakes research & development schemes, ground water assessment, conjunctive use studies and artificial recharge studies. The Board also organizes training of personnel of different disciplines of Central and State Government Organisations in ground water related activities.

OBJECTIVES

Under the mandate given based on principles of economic, ecological efficiency and equity, the major activities of Central Ground Water Board are to :

- Periodically assess the country's ground water resources.
- Monitor and guide ground water development to promote its sustainable management.
- Develop, refine and disseminate basin specific technologies for sustainable ground water development and management.
- Plan augmentation, conservation and regulation of ground water resources.
- Establish a National Information System to collect, store, process and disseminate ground water data.
- Promote the economic and efficient use of manpower, energy and equipment employed in ground water sector.
- Support and co-ordinate the efforts of State Government for planned development of ground water.
- Foster International co-operation to promote scientific exchanges, acquisition of useful technology.
- Promote environmental awareness and water quality consciousness, impart training and promote applied research.

ORGANISATIONAL SETUP

The Central Ground Water Board is headed by the Chairman and has four main wings namely 1) Exploratory Drilling & Material Management 2) Sustainable Management & Liaison 3) Survey, Assessment & Monitoring and 4) Training and Technology Transfer. Each wing is headed by a Member. The administrative financial matters of the Board are being dealt with by the Director (Administration) and Finance & Accounts Officer (FAO) respectively.

The Exploratory Drilling & Materials Management wing is responsible for the drilling and construction of Exploratory and other type of boreholes required for ground water exploration including monitoring of stores, consumption and inventory for efficient and economic machine utilization, purchase action in respect of drilling equipment, vehicles, instruments etc.

The Sustainable Management and Liaison wing looks after sustainable management of ground water related policies, issues etc., work related to monitoring of ground water regime and development, conjunctive use of surface and ground water, urban ground water management, drought management, data collection, storage and retrieval etc.

The Survey, Assessment & Monitoring Wing of Central Ground Water Board is vested with the responsibilities for undertaking Ground Water Management Studies, Aquifer mapping and assessment of aquifer characteristics based on exploration and surveys, Hydro- chemical analyses and studies, pollution studies, short term water supply investigations, special studies, preparation of various Hydrogeological maps, Atlases, Master plans, State reports, District reports, etc.

The Training and Technology Transfer Wing is vested with the responsibility of imparting training at different levels

to entrepreneurs, professionals and administrators concerned with ground water development and management through Rajiv Gandhi National Ground Water Training and Research Institute located in Raipur. The wing is also responsible for formulation of overall training policy, assessment of training needs, conceptualization of the training modules and the programme implementation strategy etc for the organization.

In pursuance of the order passed by the Hon'ble Supreme Court of India, Central Ground Water Board has been constituted as Central Ground Water Authority (CGWA) under sub-section (3) of Section 3 of the Environment (Protection) Act, 1986 vide notification No. S.O. 38 (E) dated 14.01.97 for the purpose of regulation and control of ground water management and development in the country.

The Central Ground Water Authority is functioning under the Administrative control of the Government of India in the Ministry of Water Resources with its Headquarters at Delhi. CGWA is

headed by the Chairman and 14 other members from different Ministries/Department/Organisations/institutions of Government of India including all the 4 Members of CGWB. 5 additional members, one each member from Department of Legislative, Department of Legal Affairs, Central Public Health & Environmental Engineering Organization under Ministry of Urban Development, National Commission for Women and Department of Drinking Water Supply under Ministry of Rural Development have been approved recently for inclusion in the composition of CGWA.

The Authority performs the following functions: -

(i) Exercise of powers under section 5 of the Environment (Protection) Act, 1986 for issuing directions and taking such measures in respect of all the matters referred to in sub-section (2) of section 3 of the said Act.
(ii) To resort to penal provisions contained in sections 15 to 21 of the said Act.
(iii) To regulate and control, management and development of ground water in the country and to issue necessary regulatory directions for the purpose.
(iv) Exercise of powers under section 4 of the Environment (Protection) Act, 1986 for the appointment of officers.

Central Ground Water Authority has been entrusted with the responsibility of regulating and controlling ground water development and management in the country and issuing necessary directives for the purpose. CGWA has notified 43 areas for regulation of ground water development.

For undertaking the activities in field, 18 Regional Offices, each headed by a Regional Director, have been established in the country. 11 State Unit Offices have also been established in those states having large geographical area for better management of field activities. 17 Divisional offices handle the exploratory drilling and related activities, each headed by an Executive Engineer. Both the State Unit offices and Divisional Offices work under the overall administrative control of the respective Regional offices. The details of Regional office wise field formations and their jurisdiction are given in Annexure- 1. The Board has about 500 Scientists, 200 Engineers; and about 3500 technical & administrative/ministerial supporting staff. The Board has a fleet of 88 drilling rigs (34 Direct Rotary, 41 Down the Hole and 13 Percussion Combination types) for taking up drilling operations.

ACTIVITIES & ACHIEVEMENTS

Ground Water Management Studies

Ground Water Management Studies are being carried out to have first hand information on the changes in the ground water scenario with reference to time, due to changes in various input and output parameter and due to human interference. This forms the base for developmental activities and policy making. Special priority is being taken for such studies in hilly areas, valley fill areas, tribal areas, drought areas, urban areas, over-exploited areas, low ground water development areas, mining areas, industrial areas, farmers distress areas, coastal areas, canal command areas, water logged areas and areas having problems of water quality due to geogenic sources. An annual target of 1.5 Lakh sq.km. is earmarked under this item of this study. During the year 2009-10 up to 31st March, 2010, an area of 1.48 Lakh sq. km was covered.

Ground Water Exploration

Ground Water Exploration is being carried out to study the sub-surface hydrogeological setup and to evaluate various aquifer parameters of different aquifer systems. The entire exercise is aimed at quantitative & qualitative evaluation of ground water in the area. It is being carried out by the Board through a fleet of 88 drilling rigs (34

Direct Rotary, 41 Down the Hole and 13 Percussion Combination types) . During the year 2009-10 up to 31st March, 2010, 790 wells (EW-365, OW-148, PZ-277) have been constructed, against a target of 800 wells. Out of 790 wells, 592 bore holes , 184 tube wells and 14 bore holes were constricted in hard rock, alluvium and bouldary formation respectively. 85 wells and 246 wells were constructed for exploration in tribal and drought prone areas respectively.

33 wells with high discharge ranging from 180 LPM to 2205 LPM have been constructed in the states of Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan, Taminadu and West Bengal. The study will help in identifying ground water sources and in guiding the states to adopt follow up action with regard to ground water development for drinking water supply and other demands.

Monitoring of Ground Water Observation Wells

The Board is monitoring the ground water levels in the country four times a year (Jan/May/Aug/Nov) through a network of around 15600 Ground Water Observation Wells. The ground water samples collected during the pre-monsoon monitoring are analysed for the purpose of ascertaining the changes in chemical quality of ground water. Monitoring of Ground Water Observation Wells for May, August, November 2009 & January 2010 have been completed and reports describing fluctuation of water levels during each measurement compared to monitoring of previous year, decadal average and pre-monsoon period have been compiled to have detailed information regarding short term and long term changes in the ground water regime.

Geophysical Studies

The Board undertakes geophysical studies as an integral part of its activities to support and supplement ground water management studies, ground water exploration and short-term water supply investigations to demarcate bedrock configuration and thickness of overburden, saline -fresh water interface etc. During 2009-10 up to 31st March,2010, 1671 Vertical Electrical Soundings, 14.54 line kilometer resistively profiling and geophysical logging of 108 bore holes have been conducted in various parts of the country.

Hydrochemical Analysis

There are 16 Regional Chemical Laboratories in the Regional offices of the Board. Chemical analysis of water samples collected during various studies are analyzed in these laboratories. All the Laboratories are equipped with Atomic Absorption Spectrophotometer to carry out the analysis of toxic elements and heavy metals. 2 chemical laboratories are also equipped with Gas Chromatograph (GC) to take up the analysis of organic pollutants (Pesticides etc). 14176 No.water samples have been analyzed for determination of basic constituents. Analysis of 478 No. water samples for specific studies and analysis of 2484 No.water samples for Heavy metals involving the determination of elements like As, Cd, Co, Cr, Cu Fe, Mn, Ni, Pb and Zn has been carried out. Determination of organic constituents was carried out in 104 No. of water samples..

Artificial Recharge Studies

The Board is carrying out demonstrative artificial recharge studies in high water demand areas with over-exploited / critical stage of ground water development. Artificial Recharge studies have been completed in most of the Regions and impact assessment of ongoing & completed Schemes, monitoring & report submission are in progress. During 2009-10, Six demonstrative schemes on "Rain Water Harvesting and Artificial Recharge to Ground Water" has been taken up in the (1) Taramani, Village of Chennai in Tamil Nadu State (2) Erumapattee, Mohanar and Namakkal blocks of Namakkal district, Tamil Nadu State (3) Coimbatore city of Coimbatore district in Tamil Nadu State (4) Madanapalle, Nagri, Karvetinagaram, Vijayapuram, SR Puram, Palasamudram and Vedurukuppam blocks of Chittoor district, Andhra Pradesh (5) Malur taluka of Kolar district, Karnataka State (6) Sataon block of Rae Bareli district, Uttar Pradesh State. Demonstrative recharge projects are being implemented in states of Kerala, West Bengal, Punjab, Arunachal Pradesh, Andhra Pradesh, Karnataka, Tamilnadu and Uttar Pradesh during XI Plan in which 223 artificial recharge & rainwater structures constructed out of 596 structures as on 31st March, 2010 at feasible sites.

The Scheme of the Ministry of Water Resources on "Artificial Recharge to Ground Water through Dug Wells" in 7 states namely Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Tamilnadu, Gujarat and Madhya Pradesh has been launched. The scheme has been approved for a cost of Rs. 1798.71 Crores with net cost of subsidy to Government in terms of civil works of Rs. 1499.27 Crores. As on 31st March, 2010, Rs.280.822 Crore has been utilized as subsidy to the beneficiaries (Rs.263.58 Cr) and Information, Education and communication (IEC)/ capacity building activities (Rs.17.0 Cr) and awareness by Ministry (Rs.0.242 Cr).

R&D Studies

Central Ground Water Board, is assisting Ministry of Water Resources in carrying out R&D studies as a member of a sub-committee of Indian National Committee on Ground Water (INCGW), with a view to accelerate the research & development programme in ground water sector. This Committee examines the project proposals received by INCGW in the field of ground water for their suitability for funding by MOWR and also monitors the research schemes funded by INCGW. During the year, eight new projects were received. Out of which, seven are under scrutiny and one proposal was rejected. During the year, two meetings of INCGW were held on 6.11.2009 and 5.02.2010 respectively. During the first meeting of INCGW, four new proposals received in INCGW and seven revised proposals already considered in VIII meeting of Reseaerch Committee on Ground Water were considered. Out of which, six projects were approved. Three approved proposals were forwarded to the MOWR for sanction.

Collaborative Studies

Central Ground Water Board has taken up scientific studies in collaboration with premier Govt Organizations/ Institutes which are engaged in specific field of study related to ground water. The areas of collaboration are Ground Water Modeling, Isotope studies, demarcation of fresh- saline water interface, mining hydrogeology, studies on Arsenic in Ground Water, Remote Sensing etc. and the collaborating institutions include NIH, ONGC, NGRI, NLC, RSMML and BIT Mesra. These studies have helped in better understanding and solving various problems in the Ground water sector. The Board, with the help of its multidisciplinary scientific activities, provides assistance to the State Governments through recommendations for better ground water development and management practices.

Reports and Information Booklets

Results of investigations carried out by Central Ground Water Board are suitably documented in the form of reports and maps which are categorized under five main heads viz. Ground Water Year Books, district reports, state reports , survey reports and basic data reports. During 2009-10 up to 31st March, 2010, 12 State Geophysical Reports, 12 State Chemical Quality Reports, 2 State Reports, 24 District Reports, 7 Ground Water Exploration Reports and 23 Ground Water Year Books issued /completed.

Bhujal News, is a quarterly journal being published by Central Ground Water Board highlighting the latest advances in ground water research. Besides scientific papers, the journal also contains technical notes, news items , and regular columns. The journal has more than 1500 readers from all over the country. During the year 2009-10 up to 31st March 2010, the Vol. No 22, 2007 issued and Vol. 24 No. 1 January – March, 2009 (West Bengal Special issue) published.

Water Supply Investigations

The Board carries out short-term water supply investigations for Government Agencies and helps them in augmenting their water supply. Normally minimum financial implications are charged from all other departments except Defence. The Board has carried out a total of 117 investigations during this year .

Dissemination and Sharing of Technical Know-how

Central Ground Water Board, organized / participated in various Seminars/symposia/workshop/conference with a view to share its expertise in Ground Water field and also for getting exposure to new ideas / technological developments in Ground Water science with others. The officers of the Board also participated in various meetings /committees etc. to render advice on ground water development in specific area.

Re-Assessment of Dynamic Ground Water Resource

The Dynamic Ground Water Resource of the country has been jointly estimated by State Ground Water Departments and Central Ground Water Board, based on the methodology recommended by Ground Water Estimation Committee-1997 (GEC-97). The Ground Resource was estimated as on March, 2004. The National level report on "Dynamic Ground Water Resources of India" was finalized and approved by the R&D Advisory Committee in its seventh meeting held at New Delhi on 19th August, 2005. As per the report, the Annual Replenishable Ground Water Resource for the entire country is 433 billion cubic metre (bcm), Net Annual Ground Water Availability is estimated as 399 billion cubic metre where as the Annual ground water draft for irrigation, Domestic & Industrial was 231 billion cubic metre and their Stage of Ground Water Development for the Country as a whole is 58%.

Technical Examination of Major/Medium Irrigation Project proposals

As per directives of the steering committee on Irrigation projects constituted by Planning Commission, the major and medium irrigation project reports and proposals sent by State Governments through Central Water Commission (CWC)/Command area Development (CAD) Authority were scrutinized and cleared by CGWB from Ground Water Development and impact assessment point of view. Suggestions were made for modification / addition of ground water development in these schemes. During the year 2009-2010, Thirteen major irrigation project proposals of Central Water Commission were examined and area specific recommendations were made.

Human Resources Development

It has been the earnest endeavor of the Board to keep its technical personnel abreast with the latest developments in all aspects related to ground water development & management. Trainees from State Departments and candidates from abroad are included in the training programme being organized by the Board.

19 training courses were conducted during 2009 – 10 and 340 trainees trained under Rajiv Gandhi National Ground Water Training and Research Institute.

Hydrology Project II

The Hydrology Project - Phase –II (HP-II) is a follow up project of HP-I. Its major thrust is to use Hydrological Information System (HIS) data effectively and efficiently for water resources planning and management. A longer-term aim of the project is to assist the Governments at both Central and State levels to address the issues of intra-sectoral demands and overall resource planning and management through the establishment of core hydrological organizations serving all specialized water agencies. In this year of the project domain specific training would be imparted, Awareness raising program are being held, tender documents for procurement/upgrading of the equipments have been prepared and construction of the piezometers is being taken up. The expenditure incurred on the project till March, 2010 is Rs 2.98 Crores. During the year 29 Piezometers have been constructed, 7 awareness raising programmes organized, 2 training imparted and IT/ Office equipments were procured.

Mathematical Modeling Studies

The Central Ground Water Board has undertaken two studies in Ranchi and Patna urban area on ground water modeling during the year. Mathematical modeling have been taken up in Lucknow urban area; Coal Mining areas in Nagpur; badnagar block of Ujjain district; Patna urban area; Ranchi urban area; bist-doab, Punjab; Jangipara block of Hugli district, West Bengal; arsenic affected blocks of Amdanga, Barasat-I & II, and Habra-II in North 24 Parganas district, West Bengal; coastal aquifers of southern part of Chennai Metropolitan area, Tamil Nadu; parts of ruparail river basin, Alwar district, Rajasthan.

Remote Sensing Studies

During the year 2009-10, to demarcate the active flood plains of the river Yamuna using Remote Sensing techniques in Haryana; Ravine studies in Sengar river water shed in parts of Kanpur Dehat district & adjoining areas in Hamirpur & Jalaun districts; Sukinda valley, which bears the third largest Chromite deposit of the planet, is situated in Jajpur District, Orissa; Geology layers and Aeromagnetic layers prepared using remote sensing data; Remote Sensing Studies carried out in the Neyyar basin of Trivandrum District; GIS studies have been taken up under the head of District Ground Water Management Studies (DGWMS) in collaboration with Indian Institute of Remote Sensing (IIRS), Department of Space, Dehradun in Almora and Nainital Districts.

Publicity and Public Awareness

With a view to generate awareness among the masses, "Water Resources Day" is celebrated every year since 1986. The Board has played a very active role in organizing Water Resources Day functions jointly with CWC and other State Govt. Organizations. On these occasions, emphasis was laid on educating the rural population on various aspects of water resources in the country. Important technical achievements of the Board were brought to the knowledge of the public through radio talks, television interviews, telecast of a short film on ground water pollution, Newspaper reports, release of district reports and Atlases at various public functions.

Central Ground Water Authority

Central Ground Water Authority has been entrusted with the responsibility of regulating and controlling ground water development and management in the country and issuing necessary directives for the purpose. CGWA has notified 43 areas for regulation of ground water development.

The CGWA has issued directions to all concerned to adopt roof top rain-water harvesting systems. The CGWA has issued directions to all the Chief Secretaries of States

having over-exploited blocks to take all necessary measures to promote/ adopt artificial recharge of ground water/rain-water harvesting.

Farmers' Participatory Action Research Programme (FPARP)

Ministry of Water Resources sanctioned Farmers' Participatory Action Research Programme at 5000 demonstration sites at a cost of Rs. 24.46 crore. This programme is being implemented in 375 districts of 25 States/UTs of the country with the help of 60 Agriculture Universities/ Indian Council of Agricultural Research Institutes / International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Water and Land Management Institutes (WALMIs) and Non-Government Organizations (NGOs) to increase yield and income per drop of water.

519 demonstration were taken up during Kharif and 398 demonstrations were taken up in the Rabi crop season during 2009-10. The performance of the programme is being monitored by the field formations of CWC & CGWB. The experience of implementation of the FPARPs have indicated an increase in yield and income with saving in water use.

IEC Activities

A total 30 Workshops were organized by Eighteen Regional offices and State Unit Office, Delhi of Central Ground Water Board. The workshops were organized under IEC with themes on Chemical Quality of Ground Water and Water Use Efficiency. World Water Day-2010 has been organised in 18 regional offices on "Ground Water Quality Issues" and main function was held on 22-03-2010 at NASC, PUSA, New Delhi.

Budget

Expenditure of 7744.57 lakhs and 10876.88 lakhs of rupees were incurred by the Board during the year under various Plan and Non-plan sub-heads respectively to carry out various activities mentioned above.

1. INTRODUCTION

1.1 HISTORY OF CGWB

The Central Ground Water Board, as the National apex organization under the Ministry of Water Resources, Govt. of India is vested with the responsibilities to carry out ground water management studies, exploration, monitoring of development, management and regulation of country's vast ground water resources. A brief history of the organization follows;

An Exploratory Tubewells Organisation (ETO) was created in 1954 as a subordinate office under the then Ministry of Food, Agriculture, Community Development and Cooperation (Department of Agriculture) to carry out ground water exploration in the alluvial areas of the country to delineate the regional aquifer systems and evaluate their yield potential. On 3rd October 1970 the ETO was renamed as Central Ground Water Board. At that time, it was felt that there was need to have a national unified organization for all works related to ground water surveys, exploration, assessment and management in the country. On the recommendations of the Committee on Science and Technology, the Standing Group of Ministers on Science and Technology chaired by Prime Minister Smt. Indira Gandhi, in its meeting on Sept 9, 1971 approved the merger of Ground Water Wing of the Geological Survey of India (GSI) with the Central Ground Water Board. The merger was effected on August 1, 1972 which gave all the administrative and financial powers and flexibility of operation necessary for CGWB's effective functioning. With this, Central Ground Water Board was constituted as an apex organization at the national level with a full time Chairman and two full time Members namely the Chief Hydrogeologist and the Chief Engineer.

In order to streamline staffing pattern, SIU carried out detailed study (1980) and gave its report on staffing pattern of Headquarters, Regional, Divisional and District Unit Office.

A High Level Multi-disciplinary Committee (HLMC) was set up in 1989 to review the role, functions and responsibilities of CGWB in terms of achievements and developments over the past three decades. The HLMC report (1990) highlighted the importance of ground water development and indicated the measures to be taken for achievement of tasks and mandate assigned to CGWB. The Committee reviewed the functions and gave the revised mandate.

In order to provide scientific and technical support to the mandate, Central Ground Water Board conduct training programmes for various levels of ground water professionals/ sub-professionals from CGWB, States, Universities and NGOs. The courses include induction level courses for newly recruited scientists, engineers and drilling professionals; refresher courses for scientists on advanced techniques of ground water investigation, development and management; and training of trainers. The Board had established Rajiv Gandhi National Ground Water Training & Research Institute in 1997 at Raipur. Infrastructure facilities were created by redeploying officers and staff from Central Ground Water Board. The building of the Institute has since been taken over by the Chhattisgarh State to house Legislative Assembly in 2000. It is proposed to relaunch the institute at Raipur in the newly allotted land by the Government of Chhattisgarh, SFC Memorandum in this regard is under submission. Presently the training courses are being conducted at Central Headquarters and various Regional Offices of the Board.

Central Ground Water Authority has been constituted under Section 3 (3) of the Environment (Protection) Act, 1986 to regulate and control development and management of ground water resources in the country.

The Authority has been conferred with the following powers: (i) Exercise of powers under section 5 of the Environment (Protection) Act, 1986 for issuing directions and taking such measures in respect of all the matters referred to in sub-section (2) of section 3 of the said Act.(ii) To resort to penal provisions contained in sections 15 to 21 of the said Act.(iii) To regulate and control, management and development of ground water in the country and to issue necessary regulatory directions for the purpose. (iv) Exercise of powers under section 4 of the Environment (Protection) Act, 1986 for the appointment of officers.

1.2 MANDATE AND OBJECTIVES

The future of our national food security system as well as the quality of life and livelihood of millions of our people will, to a large extent depend on our ability to conserve and utilize ground water resources in an environment friendly, economically efficient and socially equitable manner. On the basis of the principles of ecology, efficiency, economics and equity, mandate of the Board has been postulated below:

"Develop and disseminate technologies, monitor and implement national policies for the scientific and sustainable development and management of India's ground water resources including their exploration, assessment, conservation, augmentation, protection from pollution and distribution based on principles of economic and ecological efficiency and equity".

Commensurate with the above mandate, the objectives laid down for the Central Ground Water Board are:-

- Periodically assess the country's ground water resources and publish, once in 3 years, a report on the status of India's ground water resources.
- Formulate perspective plans, basin or sub-basin wise, for harnessing ground water resources in a phased or need based manner and resolve regional imbalances.
- Monitor ground water development in the country and promote its sustainable management on principles of ecology, economics, efficiency and equity.
- Develop, refine and disseminate, on its own as well as in coordination with other agencies, basin-specific technologies for sustainable ground water development and management involving priority areas such as major command areas for conjunctive use of ground water and surface water, monitoring, prevention and remedy of pollution and saline ingress and the location, design, operation and maintenance devices, recycling and reuse of waste water, and solutions to other problems of urban areas.
- Plan augmentation, conservation, protection and regulation of ground water resources keeping in view the existing and future ground water demand scenario.
- Establish a National Information System in collaboration with State Governments and other agencies to collect, store, process and disseminate ground water data as part of an overall water resources data bank.
- Forecast the manpower, equipment, energy and financial requirements for the ground water sector, in the context of demand projections.
- Promote the economic and efficient use of manpower, energy and equipment employed in the ground water sector through various measures including setting up performance appraisal and management information systems, training, development of technical and managerial skills, and personal development.
- Support and coordinate the efforts of State Ground Water Organizations for the planned development of their ground water resources on the above lines, specially where inter-state issues arise.
- Foster international cooperation to promote scientific exchanges, acquisition of useful technologies including the use of renewable sources of energy for pumping ground water and assistance in other developing countries.
- Establish benchmarks and methodologies for ground water studies in coordination with the State Governments.
- Promote environmental awareness and water quality consciousness.
- Establish a National Institute for Ground Water Research, Training & Management and organize All India Coordinated Research Projects involving appropriate institutions and universities, in order to foster the growth of a national grid of R&D institutions, covering different aspects of ground water conservation and utilization.

1.3 ORGANIZATIONAL SET UP

The Central Ground Water Board is headed by the Chairman and has four full time Members namely, Member (Exploratory Drilling & Material Management), Member (Sustainable Management & Liaison), Member (Survey Assessment & Monitoring) and Member (Training & Technology Transfer). The other Members of the Board are all ex-officio being the nominees of institutions in related fields of expertise. The ex-officio members are:

1. The Joint Secretary (A), Ministry of Water Resources.
2. The Joint Secretary & Financial Adviser, Ministry of Water Resources
3. The Joint Secretary, Ministry of Environment & Forests, Paryavaran Bhawan, New Delhi.

4. The Chief Engineer, IMO (WP & P), CWC, Sewa Bhawan, New Delhi.
5. The General Manager, ONGC, Ministry of Petroleum & Natural Gas, Dehradun.

Central Ground Water Board has four main wings. Each wing is headed by a Member post.

The Exploratory Drilling & Materials Management Wing broadly looks after the drilling and construction of Exploratory Tubewells and other types of bore holes required for assessment of aquifer parameters during ground water exploration. Other activities of this wing include monitoring of Stores, consumption and inventory for efficient and economic machine utilization, Procurement of drilling equipment, vehicles, instruments etc. This wing also looks for the need of improvement in drilling technology, design of abstraction structures, improvement of efficiency of pumps and other water lifting devices, maintenance and up keeping of drilling machinery and related equipment in the Board.

The Sustainable Management and Liaison Wing looks after sustainable management of ground water related policies & issues, augmentation of ground water resources including artificial recharge and monitoring of artificial recharge studies, It also undertakes studies related to recycling and reuse of ground water, urban ground water management, Drought management, Regulation of ground water development and model legislation, National Information System for ground water data collection, storage and retrieval, Planning and Programme formulation for ground water development including techno-economic studies, analysis and associated aspects of ground water development and technical examination of major, medium and minor Irrigation Projects.

The Survey, Assessment & Monitoring Wing has the responsibility of monitoring the works being done in ground water management studies, works related to monitoring of ground water regime and development and conjunctive use of surface and ground water for the entire country, aquifer mapping and assessment of aquifer characteristics based on exploration and surveys, hydrochemical analysis and studies, pollution studies, short term water supply investigations, special ground water studies, preparation of hydrogeological maps, Atlases, Master plans, State reports, District reports, etc. The other activities of this wing include ground water balance studies, periodic assessment of ground water resources and potential, ground water zoning for guiding economic activity areas, rationalization of water rates, forecasting manpower, energy and financial requirements for ground water sector, site selection for Rajiv Gandhi National Drinking Water Mission, dissemination of data & information to various user agencies and publication of quarterly magazine "Bhujal News" by the Board.

The Training and Technology Transfer Wing of the Board is vested with the responsibility for laying the overall training policy, assessment of training needs, conceptualization of the training modules and the programme implementation strategy, identification of thrust area needing technology import from advanced sources, maintenance of effective liaison and interaction with voluntary agencies and Non Governmental Organisations and the other renowned national and international bodies for training and research purposes. The Member heading this wing also functions as the Principal of Rajiv Gandhi National Ground Water Training and Research Institute of the Board.

The administrative & financial matters of the Board are being dealt with by the Director (Administration) and Finance & Accounts Officer (FAO) respectively.

In order to achieve better results in the Water Resources Sector and have better coordination with the State Government departments, Central Ground Water Board had undertaken various studies in the above mentioned fields being monitored by four wings of the Board through 18 Regional Directorates, supported by 17 engineering divisions, 11 State Unit Offices for carrying out different investigations. The Board had a fleet of 88 rigs for taking up drilling operations during 2009-2010.

1.4 ACTIVITIES OF THE BOARD DURING 2009-10

The following activities had been undertaken during the period 2009-2010.

- Ground Water Management Studies
- Ground Water Exploration aided by Drilling.
- Monitoring of Ground Water Observation Wells.
- Short Term Water Supply Investigations.
- Periodic Assessment of Ground Water Resources.
- Technical Documentation and Publication of Maps & Reports.
- Publication of Quarterly Journal "Bhujal-News".
- Taking over of Wells by State Govt.
- Organizing Exhibitions, Seminars, Workshops etc.
- Hydrochemical Analysis.

- Geophysical Studies.
- Hydrological and Hydro meteorological Studies.
- Mathematical Modeling Studies.
- Artificial Recharge studies.

- Organizing training of Central and State Government personnel.
- R & D Studies.
- Basic Research in Hydrogeology/ Special studies

1.5 ANNUAL ACTION PLAN 2009-2010

The activities of the Board are being pursued on a continuing basis as per National Water Policy (2002) and in accordance with the overall development strategy for the XI Plan.

Ground Water Management studies were carried in more utility oriented way and in areas facing ground water problems like decline in water levels, water logging, salinity ingress and quality deterioration, and other problems were accorded priority.

In ground water exploration, emphasis was given to carry ground water exploration activities on long-term planning and schemes were prepared for different geologic formations and areas. As far as possible, contiguous and composite areas hitherto unexplored, were selected keeping in view scientific requirements and priorities of State Governments were also taken into consideration. Thrust was given to explore areas having artesian flow, bouldary and hard rock formations. Ground Water Exploration in alluvial areas was done to delineate geometry of aquifer systems by constructing slim holes. During the year, special emphasis was given on tribal, drought and desert areas in exploratory program of the Board. Special studies for computation of specific yield of phreatic aquifers in different parts of the country was also the part of exploratory program.

The Central Ground Water Board is implementing demonstrative "Studies on Artificial Recharge of Ground Water". Under the scheme, recharge structures are constructed by State Government departments, local NGOs, VOs or other beneficiaries under the technical guidance of the Board. Under the scheme, funds and technical guidance were provided by the Board for pilot recharge projects and the implementing agencies were encouraged to replicate similar types of structures in other areas attheir own.

Conjunctive use studies were taken up with the objectives to ascertain the Hydrogeological conditions in command areas, to identify areas affected by water logging and salinity, to assess the availability of ground water. The studies provided insight of the problem and helped to formulate action plan for coordinated use of surface and ground water to ensure development on optimal level.

Water logging is a common phenomenon in canal command areas, which causes serious social and economic problems. Micro level mapping of a few water logged areas were taken up to understand and mitigate the problem. Feasibility studies were also carried out to suggest anti water logging measures for reclaiming the affected areas.

Remote sensing and application of GIS as supplementary tool has been considerably utilized to map geomorphological feature, change in land use, fracture zones, vulnerable areas of pollution etc which helped in locating promising areas for ground water exploration and development. These studies provided additional update scientific information in synoptic manner about land use pattern and its temporal changes to ground water exploratory programme, reappraisal surveys, ground water pollution studies, water logging condition, erosion problem and artificial recharge studies taken by the Board during the year.

2. GROUND WATER MANAGEMENT STUDIES

Ground Water Management Studies are being carried by the Board at district level to evaluate the changes in quantity & quality in the ground water regime owing to development and also to identify related issues for future management strategies. A major part of replenishment of ground water is through infiltration from rainfall. Return flow from irrigation and seepage from surface channels and reservoirs also contribute substantially to the ground water recharge. The effect of ground water withdrawals and out-flows are directly measurable through water table. Since all these inputs and outputs frequently change with time, the ground water situation is being periodically reappraised. As the development of resource leads to changes in its regime and water quality therefore planning for further development of the resource is to be done on the basis of findings of the studies, which provide valuable information for reorienting ground water development programme keeping in view the emerging scenarios. During the year 2009-2010, an area of 1.48 Lakh Sq.km. have been covered by the Board under Ground Water Management studies as against target of 1.59 Lakh Sq km. State/District wise target vis-a-vis achievements during the year 2009-2010 is shown in Table 2.1 and fig. 2.1.

Table : 2.1 TARGET AND ACHIEVEMENTS OF GROUND WATER MANAGEMENT STUDIES DURING 2009-10

Sl. No.	States	Districts	Target (Sq. km.)	Achievement (Sq. km.)
1	Jammu & Kashmir	Pulwama	1210	1398
		Ramban	2000	1527
		Samba	1000	1000
2	Himachal Pradesh	Kangra	5739	5739
3	Punjab	Nawanshahr	1190	1190
		Amritsar	200	200
4	Haryana	Mewat	1860	1860
		Faridabad	200	200
		Yamuna flood plain area of Haryana(Remote sensing)	2000	2000
5	Rajasthan	Parts of Churu	5897	5897
		Dholpur	3009	3009
		Kota	310	310
6	Gujarat	Mehsana	3000	3000
7	Madhya Pradesh	Umaria	4593	4593
		Anuppur	3258	3258
		Ujjain & Ratlam	2479	2479
		Mandsaur	800	800
		Ujjain	700	700
8	Chhattisgarh	Durg	3000	3000
		Korba	2437	2437
9	Maharashtra	Part of Jalgaon and Aurangabad	3000	3083
		Part of Wardha	3000	3202
		Part of Ahmednagar	3500	3598
		Amravati district	500	500
10	Uttar Pradesh	parts of Kanshi Ram Nagar & Farrukhabad districts	2562	500
		parts of Budaun district	2655	2655
		parts of J P Nagar & Bijnor districts	2677	2677
		parts of Meerut & Muzaffar Nagar districts	1996	1996
		parts of Ghaziabad, Bulandshahar & Aligarh districts	2023	2023
		parts of Sengar River watershed, Kanpur dehat district	1375	1375

Sl. No.	States	Districts	Target (Sq. km.)	Achievement (Sq. km.)
11	Uttarakhand	Nainital	3860	3860
		Almora	3083	3083
12	Bihar	Supaul	2429	2429
		Saharsa-Madhepura	3435	3435
13	Jharkhand	East Singhbhum	4048	3500
		West Bokaro coal field in Hazaribagh district	500	850
		Parts of Darbhanga & Samastipur District	1230	1230
14	West Bengal	Murshidabad district	2000	2000
		Uttar Dinajpur district	2750	2750
		Birbhum district	1250	1250
15	Andaman & Nicobar	Middle & North Andaman	1000	1000
16	Assam	Barpeta & Parts of Baksa district	3300	3300
		Nalbari & Parts of Kanmrup district (Rural)	3000	3000
		Bongaigaon & Parts of Dhubri district	3000	3000
17	Tripura	Dhalai District	2314	2314
18	Meghalaya	East Khasi Hill District	2560	2560
		East Khasi Hill District	1151	1151
19	Orissa	Parts of Sambalpur District	3000	3000
		Anugul District	3000	3000
		parts of Kendrapara, Jagatsingpur and Cuttack	3800	3815
		Parts of Anugul District	3000	3000
		Jajpur district	300	300
20	Andhra Pradesh	E. Godavari	3000	3000
		Chittoor	3500	3650
		Ranga Reddy	110	110
		Mahabubnagar	95	95
		E. Godavari	1600	1600
		Visakapatnam	700	700
21	Karnataka	Hassan district	3150	1550
		Koppal disitrict	2703	2703
		parts of Chikmagalur, Shimoga & Davanagere districts	1100	1100
		In parts of Chitraddurga district	625	625
22	Tamil Nadu	Parts of Nagapattinam and Thiruvarur Districts	2,000	2000
		Ramanathapuram & Sivaganga Districts	2,000	2215
		Parts of Thanjavur & Tiruvarur districts	3132	3132
		Pallikaranai-Chennai Sub urban area	200	200
		Salem(Remote Sensing)	410	410
23	Kerala	Kozhikode district	2344	2344
		Trivandrum	500	500
		Kollam and AAlappuzha	1500	1500
		Trivandrum district	200	200
		Kozhikode (Over-exploited) and Balusseri (Critical blocks)	400	400

SALIENT FEATURES OF DISTRICT GROUND WATER MANAGEMENT STUDIES:

2.1 NWHR, Jammu

Ground Water Management Studies were carried out in Pulwama (1398 sqkm), Ramban (1527 sq.km) and Samba districts (1000 sqkm) of Jammu & Kashmir state.. The detailes are given below.

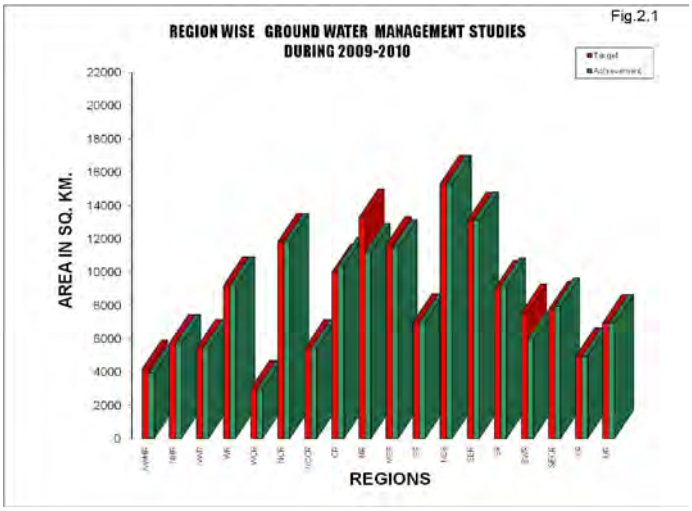
2.1.1 Pulwama District:

Ground water management studies were carried out in 1398 Sq.km of area covering the entire district of Pulwama of J & K state covering parts of degree sheet No's 43 J,K,N,O. As per the 2001 census, the district has a population of 6, 52,607 persons with density of population 467 persons per Sq.km. The rural areas accounting about 89.5%. The annual average precipitation in Pulwama district varies from 175.40 mm to 1347.8 mm.

The district can be divided into five distinct geomorphological units namely Sharp and high rise Hard Rock Ridges, High table Karewa Plateaus Degraded Karewa Plateus around Pulwama town, Karewa Plains lands and Alluvial plains with Deep River valleys and Channel beds. Rambiara, Romshi and Jhelum Rivers form the main drainage. Pulwama district is one of the well-irrigated districts in J & K state. About 895 Sq.km area is covered by canals irrigating about 35136 ha area. Because of dense network of canals and lack of proper drainage system resulted in water logging problems in canal command areas. Based on depth to water level maps of the district, it is observed that 2.5 sq.km area of Pampore tehsil and 15 sq. km area of Pulwma tehsil are having shallow water levels of less than 2 m throughout the year. About 7.5 Sq.km area in Pampore tehsil and 105 sq.km area in Pulwama tehsil falls in with in 5 m range. A total of 130 sq.km of area is having shallow water levels where remedial measures need to be followed for solving the water logging problems.

Geologically, Pulwama district is underlain Karewa formations and in north and northeastern part and southern part of the district by Triassic limestones and Panjal traps. Thin Alluvium of the thickness of about 5-10 meters is overlying the Karewa Formations of the Quarternary period. The depth of Karewas is extending beyond 300 mts. The geological layers occur up to the top 100 meters as multiple layer dispositions, whereas from the 100-250/300 mts, it occurs as single layer dispositions.

Fig.2.1



The piedmont zones comprising of scree/talus deposits of limestones, slates, shales and andesites occupies along the foot hills form the potential aquifer system in the northern part resulting in high discharges of tubewells. The Central and southern portions of the district was underlain by the sedimentary deposits of Karewas, comprising of sediments ranging in size from the boulder to clay. The Denuded Karewa Terraces Karewas comprising mainly of boulders gravel, Sand, Silt and clay formed due to erosional activities of Recent rivers viz., Jhelum, Rambiara, Romushi etc. Major part of the district is underlain by the Recent Alluvium and Karewa sedimentaries of Quarternary period. The Occurrences of un-confined aquifers is extensive in the district and being tapped through Dug wells, Hand pumps, and Shallow tube wells. The Karewas have multiple aquifer dispositions. In Pampore area, it is observed 3-4 aquifers are present normally up to a depth of 110-120 mts. The general thickness of Aquifers available for tapping through tube wells is about 20-25 mts. High table Karewa lands are extensive in their occurrence in Shupiyan area. (Zainapora, Reshipora and surroundings). Prolific aquifers are present extending up to 140 mts. The total thickness is about 60 mts. High discharge tube wells are present in this area (Littar, Zainapora, Reshipora) with discharges ranging about 1500 lpm. The occurrence of ground water under high pressure resulted in the artesian flows in the eastern and southeastern parts of the district. The boulders, cobbles, gravel, sand (coarse) form the main artesian aquifer bed capped by thick clay mixed with silt deposits as confining layer on the top. The free flow discharges ranges in between 300-400 lpm.

The aquifers of Karewas show the low transmissive characteristics when compared to the Transmissivities of Alluvium (Bouldery) and Piedmont zones and Hard rock

aquifers. The transmissivity Values of Karewa varies from as low as 39.8 m^2/day to 240 m^2/day. Whereas the Trnsmissivity values are more than 1300 m^2 /day in denuded Karewa terraces and ranges from 60 – 1918 m^2 /day in Hard rock aquifers and more than 5000 m^2 /day in Piedmont Zones. The Specific capacities of tube wells located in the Northern parts of the district varies between 0.16 lpm/m to 87.80 lpm/m. The Sp. Capacities of Auto flow wells are at the range of 15-50 lpm/mts, where as the Sp. Capacity of the well in degraded Karewa Terraces is 117 lpm/mts. The highest Sp. Capacity of the wells is shown by the EWs in Piedmont Zones (2975 lpm/mts) and Hard rock aquifers (2422 lpm/mts). The piedmont zones, the hard rock ridges in the northern and north eastern parts and the degraded Karewa terraces of the southern parts forms the high yielding aquifers of the district. The

Karewas in the South eastern and eastern parts (artesian belt) and south central parts of the district forms the moderately yielding aquifers and the Karewas of the North eastern parts of the district (Tral area) forms Low yielding aquifers of the district.

The depth to water level is in between less than 01 mts to 10 mts in Alluvium and Karewa plains, where as it occurs at the range of 15- 20 mts in high Karewa Plateus. In between the hard rock ridges of Panjal traps and Karewa deposits in the northern and north eatern parts of the district, lies the piedmont zone consisting of talus/scree material of lime stone, slates, shales and clay derived from the hard rock ridges (Triassic lime stones). The depth to water level is between 10-60 mts. Deeper water levels are observed in piedmont zones towards hills and become shallower towards Valley. The Depth to piezometric heads varies from 1.50 mts at Gunabal (Karewa Plains) to 44.24 mts at Hayatpur (High table Karewa Plateus). Generally, the water levels of the tube wells drilled in the Karewa table lands are deeper at the range of 20 mts and more. The water levels in the Karewa table land ranging from 19.04 mts at Green-Colony-Wuyan to 44.24 The water table elevations in Pampore area varies from 1600 – 1640 m amsl. The ground water occurs in the artesian conditions in the Eastern and South Eastern parts of the district covering an area of 45 & 60 km^2 respectively. These two artesian belts are associated with the occurrences of springs and surrounded by high table Karewa Plateus. The artesian zone in the southeastern parts of the district is located towards south of Pulwama town around Turk-Wangam, Kigam and Shankarpora and surroundings.

During the present study, 31 No.s of springs are inventoried and chemical quality parameters were analyzed. Fracture type springs are originating from the fractures of Hard rock area generally seen in Tral and Shupiyan areas. These are commonly high discharge springs. Spring of Arapal which is Krastic spring is one such fine example where it originates from Triassic lime stone having a discharge of 1400 lps and is the source for Arapal Nallah draining in Tral area. Contact type Springs occur between the hard rock / piedmont area and Karewas. These springs occur all along the Northern part of the district in Pampore area (e.g. Zewan Khreuh, Zawura etc). Springs of Seepage/depression type occurs all along the southern part of the district in degraded Karewa Terraces/Boulder areas of Pulwama (E.g. Babagund, Kangan, Gudura, Tahab, washbug etc.). Most of the springs in study area falls in Fifth (5^{th}) order classification where discharge at the range from 01-10 liters/second.

The ground water recharge during November to April is estimated as 15494 ha m. The rainfall recharge during May to October is worked out based on rainfall infiltration factor is 8757 Ha.m. The Annual ground water draft is estimated as 1209 ha.m.

The ground water is fresh with Electrical Conductivity ranging from 175 micro-mhos/cm at 25 ^{o}C to 2800 micro-mhos/cm at 25 ^{o}C. Most of the water is very hard in nature (70% of samples analysed) with domination of Calcium and Bicarbonate, Ca-HCO_3 type. About 39.1% wells of shallow ground water is Ca-Mg–HCO_3 type. About 17.4% samples are having mixed type of water comprising of Ca, Mg and Na. The chemical quality data reveals that spring water is acidic to alkaline in nature and pH ranges from 6.95 (Armul) to 8.65 (Ladu Village). Spring water is potable and fresh having specific conductance from 172 µmhos/cm (Thumlahal) to 625 µmhos/cm (Rajpur). In the deeper aquifer maximum Specific Conductance of 587µmhos/cm at 25°C is recorded in the water samples collected from CSB Pampore.

Though the stage of Ground Water development in three tehsils of the district is less than 10%, and in one tehsil Pampore it is more than 25%, The potentialities of denuded Karewa terraces and alluvium in the Southern parts and piedmont zones and hard rocks in the Northern parts along with Karewas has to be developed with sound ground water management strategies. At few places in Karewa terraces, the drawdown in tubewells is so high resulting in pumping head so high it is becoming very difficult to operate pumps throughout the year resulting into failure of pumps and burning of pumps very frequently. The Valley area of the Pampore tehsil is 144 km^2 and the ground water draft was calculated is 579 Hec. Meters per annum. This ground water draft is mainly from the tube wells meant for Public water Supply and is fairly on higher side when compared to the rest of the district. If

the present trend goes unabated, without proper precautionary measures, in long run may be after a few more years water levels in Pampore Block may decline at alarming rates.

Two high artesian pressure zones are demarcated in the study area. Zone-I is present around Badrivan, Banderpora. Zone-II is extended from Turk wangam, Shankarpora, Kigam. Exploratory drilling to a desired depth could not be achieved at Badrivan due to high artesian pressure encountered during the time of drilling. Though the construction of deep tubewells in these zones is very difficult, if managed to construct tubewells with proper

assembly lowering, they will yield promising discharges. If artesian condition is encountered at shallow depths, wide diameter casing pipes are lowered to control artesian flow and to drill further in the same bore hole. If successful tubewells are constructed tapping artesian aquifers, the same can be utilized without lowering the pumping devises and thus saving lot of money on energy front.

2.1.2 Samba District :

Samba district lies is situated in south western part of the state falls in survey of India Degree sheet 43 P & L. District Head Quarter Samba is situated at a distance of forty kilometer from Jammu city on the bank of Basantar river. District Samba is bounded on the southern side by International Border with Pakistan. About two third of the area of Tehsil Samba is Kandi & rain fed. The area on southern side downside the national highway is irrigated through Ravi Tawi Irrigation canal network. Basantar River is major Perennial River flowing in the district and forms a part of the Chenab Basin. Number of other local Nallas & Khads flow in the district and show parallel drainage pattern from north- east to south-west. The rivers/streams have wide channels, shallow depth and flash floods are reported during monsoons.

The district experiences a typical sub- humid to sub-tropical in climate. It experience severe cold in winter when temperature plummets to as low as freezing point in hill and about 6°C in rest of the area. The average annual rainfall of the district is 1150mm, about 85% of the total rainfall is received during monsoon period.As per 2001 Census, the total population is 2.86 lakh, The density of the population is 317 per sq km.

Siwalik Group of rocks of Tertiary period occupy northern half of the district are composed of loosely cemented sand stone, clay and thin beds of boulders, gravels and pebbles. Quaternary alluvium lies over the Siwalik rocks and occupy the southern part of the district called as outer plain. It is further divided into Kandi formation and Sirowal formation.

Ground water occurs in deep water table condition in Kandi region, whereas in Sirowals it is both under water table as well as confined condition. Central Groundwater Board has drilled 45 exploratory wells in the district with a depth ranges from 62.00 m (Mothlikhurd) to 347.00 m bgl (Chamlial). Out of which 18 nos of wells were drilled in Kandi area. Water level in the wells drilled in Kandi formation ranges from 3.20 m (Laoukli) to 71.25 m bgl (Jatwal) with a discharge range from 198 lpm (Paramandal) to 1900 lpm (Raya patti). In Sirowal, formation the water level in the exploratory wells ranges from free flow to 17.63 (Sagaal), with a discharge ranges from 23 lpm (Ghobrahmna) to 2680 lpm (Rajpur).

There are 19 nos of National Hydrograph Network Stations in outer plains of Samba district. Depth to Water level in the district ranges from 1.21 (Didyal) to 21.28 m bgl. (Raiyan). From the last decadal water level data it has been worked out that decline in water level in greater part of the district is less than 20 cm except the eastern margin where the decline is more than 20 to 40 cm per year.

The chemical quality of the ground water samples reveals that water is fresh and suitable for domestic purpose, with its Electrical Conductivity ranging form 463 µs/cm to 1260 µs/cm in Didyal and Bishnah respectively. Ground water in major part of the district shows Electrical Conductivity Value less than 750 µs/cm at 25°C. Forty-five number key wells were established and pre-monsoon as well as post-monsoon samples were collected.

2.1.3 Ramban District:

Ground water management studies were carried out in 1527 Sq.km of area covering the entire district of Ramban which is situated in the south-west part of J & K state. As per the 2001 census, the district has a population of 2.15 lakhs persons, with density of population 141 persons per Sq.km and the rural areas accounting about 95%. Cultivation is the main Occupation in Ramban District and Paddy and Maize is the main crop grown in this district with total cropped area of 24,937 ha. The area enjoys Temperate and Sub-Tropical type of climate. The annual average precipitation in Ramban district varies from 86.8 mm to 428.2 mm. The forest area covers about 42.0 percent of the total area of the district.

The district can be divided into three distinct geomorphological units namely Sharp and high rise Hard Rock Ridges, High table Ramban Plateau, and Alluvial plains with Deep River valleys and Channel beds. Chenab is

the principal river of Ramban district. Ramban district is one of the well-irrigated districts in J & K state, about 1453 ha is irrigated by canals, springs, and other sources.

Geologically, Ramban district is underlain by Shiwalik and Murree formation. The Shiwalik group is composed of thick succession of sedimentary rocks of fluviatle and lacustrine nature. The chief rocks types are loosely consolidated and poorly badded conglomerites, grits, sandstones, silts and clay. The Shiwalik range exhibits a rugged and restive topography. The Murree group is composed of thick sediments of brakish and fresh water origin. The chief rock types are conglomerate, red clays. The Murree formation constitutes hill range showing comparatively mature topography marked by gentle hill slopes and flat hill tops.

Ground water in the area of investigation occurs in cracks, joints, fractures and secondary openings in hard rocks and voids within alluvium and manifests in the form of springs. In the terraces of flat terrain underlain by the unconsolidated formations, the ground water also occurs under water table conditions. During the present study, 87 No.s of key monitoring stations are inventoried and chemical quality parameters were analyzed, which include 49 springs, 17 Handpumps, 16 Nallahs, 3 Waterfalls, 2 Tubewells. The springs are the principle source of ground water in the area. There are number of springs which are being used for water supply. Fracture type springs are originating from the fractures of Hard rock area generally seen in Batote and Ramban areas. Both cold and hot springs are present in the study area. The discharge of these springs varies from merger to 12 lps. One hot spring Tatapani is inverted during the course of study. The temperature of this hot spring is 41 and 43 ^{o}C respectively during Pre and Post monsoon season. Most of the springs in study area falls in Fifth (5^{th}) order classification where discharge at the range from 01-10 liters/second. During the course of study the discharges of 16 major nallahs are also measured which ranges from 18 to 3220 lps.

The exploratory well at Banihal EW was drilled down to the depth of 79.00 mbgl. The results of the PYT test are:-Static water level : 49.25 mbmp, Duration of pumping : 100 m, Discharge : 9.0 lpm, Drawdown :3.25 mbgl. The well recouped back in 100m after stopping the pump. The exploratory well at IRCON Complex Banihal was drilled down to the depth of 70.12m, the results are:- Static water level : 51.82mbgl, Discharge : 4000 g/h, Drawdown: 3.04mbgl

The spring water is fresh with Electrical Conductivity ranging from 100 micro-mhos/cm at 25 ^{o}C to 980 micro-mhos/cm at 25 ^{o}C. Most of the water is very hard in nature (70% of samples analysed) with domination of Calcium and Bicarbonate, About 9.6% spring water is Ca-HCO_3 type. About 28.2% spring water is Ca-Mg–HCO_3 type. About 22.9% spring water is Ca- Mg-HCO_3-SO_4 type. The chemical quality data reveals that spring water is acidic to alkaline in nature and pH ranges from 6.92 (Kundapani) to 7.95 (Nal). Spring water is potable and fresh. In the deeper aquifer maximum Specific Conductance of 1980µmhos/cm at 25°C is recorded in the water samples collected from Kanga.

2.2 NWR, CHANDIGARH

Ground Water Management Studies was carried out 3050 Sq.Km covered in Nawanshahr of Punjab and Mewat districts of Haryana State. The detatis are given below

2.2.1 Nawanshahr , Punjab

Nawanshahr district, located in the eastern part of the Punjab State, forms a part of the Bist-Doab region, covering a geographical area of 1190 sq.km. Nawanshahr district is divided into 2 tehsils namely Nawanshahr and Balachaur comprising five-development blocks. There are 4 towns and 471 villages, out of which 465 are inhabited and 6 are uninhabited.

Physiographically, the area is bounded by NNW- SSE trending Siwalik hills in the northeast and Sutlej River in the south, which forms the main drainage basin. A number of seasonal streams (''choes'' in local parlance) originate from the Siwaliks, which drain the area during monsoon season. At times these choes bring down flash floods in sub-mountainous region, particularly in Balachaur and Saroya blocks. The deforestation carried out in the Siwalik foothill zones has further aggravated the menace of flash floods as they are causing extensive soil erosion on one hand and deposition of sand and silt in fertile fields on the other. The Sutlej River being snow fed is perennial although the flow varies considerably during the year.

Agriculture constitutes the main source of economy and most of the area is fertile and good land use management is practiced. The land utilization pattern of 2005-06 shows that net area sown is 940 Sq.km. while area under forest cover and land put to non-agricultural uses are 170 Sq.km. and 70 Sq.km. respectively.

The Hydrogeological details are as follows:-

- The Nawanshahr district is covered by Quaternary alluvial deposit except in the northeastern part, where the Siwalik hills of Tertiary age are exposed.
- The Central Ground Water Board has drilled 8 exploratory wells and 2 piezometers to delineate

the aquifer geometry and quality of formation water. The wells drilled were in the depth range of 101-451 m bgl.

- Groundwater occurs under both unconfined as wells as confined conditions.
- In unconfined aquifer, the depth to water level varies from 8.8 to 29.7m during pre monsoon and 8.3 to 23.7m during post monsoon season. Deeper water levels are observed in the north eastern part of the district.
- In major part of the district, the water level ranges between 10 and 20 m while the water levels in the western and southern part is within the depth range of 5 to 10 m bgl.
- The long term trend of water level of 10 years shows that there is a decline in water level in major part of the area ranging from 0.25 to 0.86 m /year. 54 no. of key wells were established and monitored for pre and post monsoon ground water levels in the area. Micro level survey of Aur block area of 218 sq.km has been carried out
- The ground water in the district is alkaline in nature with low to medium salinity.
- In the western part of the district, electrical conductivity is slightly higher than 700 microsiemens/cm. While, the maximum value of 940 microsiemens/cm is reported at village Rahon.
- The minor constituents such as iron, nitrate and fluoride, which are essential for plant and animal growth, are found below the permissible limit. Similarly the trace element arsenic is also found below the permissible limit.
- There is need to notify the over-exploited blocks for regulation of construction of all groundwater abstraction structures for sustainability of ground water resources.

2.2.2 Mewat, Haryana

The Mewat district is having a total area of 1860 sq.km and is situated in southern most part of Haryana state. As per census 2001 the total population of the district is 9,93,603 with population density of 534 persons/sq. km. The district has been divided into two sub divisions and six development blocks for the purpose of administrative control.

Physiographycally, the district is marked by undulating sandy and alluvial plains through which ridges strike trending N-S to NNE-SSW. Arround 140.29 sq. km area is covered by hills of Delhi system. 1740 sq. km area of the district is under agriculture, out of which 1240 sq.km area is sown more than once. The irrigation in the district is mainly dependent on ground water and canals.The gross irrigated area is 2030 sq.km, and percentage of gross irrigated area to gross cropped area is 67.40%. The climate of the district is semi-arid type with mean annual rainfall of 629 mm.

The main aquifer in the district is unconsolidated alluvium deposits of quaternary age. The hard rock formations also have limited ground water potential. The main source of recharge to ground water is rainfall added with seepage from canals and return flow from irrigation.Depth to water level in the district varries between 2 and 31 m bgl. Deeper water levels are recorded in fresh water areas whereas shallow water levels have been observed in saline areas. Ground water in the area is being exploited mainly through shallow tubewells which are 31669 in numbers and yield ranges from 100-400 lpm.

45 no. of water samples have been collected for ground water quality analysis and got analysed in CGWB laboratory, Chandigarh.The pH value in the area ranges between 7.2 at village Kira to 8.61 at village Bhogipur.The EC values in the area ranges between 511 at village Mahaban to as high as 28100 at village Rampuri.The fluoride concentraton is well within permissible limits except at village Dungri where it is 1.76 mg/l.

A microlevel survey in the Taoru block was carried out covering 225 sq. Km. Area. The area is facing

scarcity of water and the water levels are very deep.

The depth to water level ranges from 13.29 m bgl at Taoru to 31.75 m bgl at Sahsola. Around 10 numbers of big resort with golf game facility are there in Taoru block and are exploiting water through deep tubewells and are responsible for the depleting ground water resources in the block. It is necessary to regulate the construction of groundwater abstraction structures. The ground water in Taoru block is potable. EC, Nitrate, Chloride and Fluoride are also within permissible limit.

2.3 WR, JAIPUR

Ground Water Management studies were carried out in Ratangarh and Surajgarh blocks of Churu and Dholpur districts during 2009-10 covering a total of 8906 sq. km

area, with the objective to evaluate changes in ground water regime owing to developmental stresses, to identify issues of concern and to suggest future management strategies.

fluctuation between pre-& post monsoon,2009 were computed and indicates positive fluctuation in the range of 0.02 to 3.54m negative fluctuation from (-)0.01 to (-)4.70 m. Block wise summary of hydro-geological details of the area is given in the table .

Sl. No.	Name of the Bock	Hydrogeol-ogical formation.	D.T.W. (Pre-Mon.) (mbgl)	D.T.W. (Post-Mon.) (mbgl)	Water level fluctuation (m)	Category
1	Churu	Alluvium	17.80 to 51.12	17.76 to 51.20.	0.02 to 0.95 & -0.01 to - 075	Safe.
2	Ratangarh	Alluvium, Nagaur & Jodhpur Sandston.	28.20 to 95.50	28.24 to 94.0	0.04 to 0.87.& -0.04to– 4.70	Safe.
3	Sujangarh	Alluvium, Marwar Supergroup of rocks &Intrusives	10.90 to 88.50	10.47 to 89.25	0.03 to 0.87 & -0.01 to -.3.39.	Critical

2.3.1 Churu, Ratangarh and Surajgarh blocks of Churu district

Churu, Ratangarh and Sujangarh blocks of Churu district covering an area of 5897sq.km. and forms south western part of the Churu district which is located on the eastern periphery of Thar desert. The area is covered in the Survey of India Top- Sheet No. 44, 45E, 45I and 45P. The area experiences semiarid to arid type of climate and the vegetation is desertic type. The frequencies of mid and normal type of drought are quite common. The rate of potential evapotranspiration is quite high. The soils in the area are mostly desertic & sandy which are poor in fertility and water retentions capacity.

A total 106 nos. of wells including Dug wells, Piezometers, DCBs and Tube wells, were inventoried for detailed hydrogeological studies. The water samples were also collected for chemical analysis

Practically, the whole of the surface geology of the area is cancealed under wind blown sand. The principal water bearing formations in the area are unconsolidated Quaternary alluvium, semi consolidated Palana sandstone, consolidated Marwar Supergroup of rocks and Post Delhi intrusive. Ground water occurs mainly under unconfined to semi-confined conditions.

Ground water in alluvium occurs under water table condition having average yield of Tube wells & D.C.B ranging from 100 lpm to 650 lpm. In Palana sandstone & Marwar Super Group of rocks, ground water occurs in unconfined to semi-confined condition. Average yield of tube wells range from 50 to 250 lpm.

Depth to water level in the area varies from 10 to 95.50mbgl during pre-monsoon and 10.47 mbgl to 94.00mbgl during post- monsoon.Seasonal water level

Results of chemical analysis of ground water samples collected during pre–monsoon indicates that ground water is alkaline having pH values from 7.21 to 8.6 and is hard to very hard in major part of the study area. In general, the ground water is brackish to saline having EC values from 880 to 16500 mmhos/cm. at 25C^{o}. Fluoride concentration ranges from 0.1 to 9.6 mg/lt. Nitrate content is more than permissible limit in major part of study area. Ground water quality in shallow aquifer is comparatively better and has less salts than deeper aquifer.

The stage of groundwater development in Churu, Ratangarh & Sujangarh blocks is 89%, 59% & 97% respectively. Deep water level, desertic & saline soil, scanty rainfall, poor forest wealth are some of the hazards for the development of the area.

During the hydro geological investigation in the area, an attempt has been made to study the feasibility of integrated approach for conservation and management of water resources in the area. The ground water resources estimation data as on 31-03-2004 reveals that Churu and Ratangarh blocks fall in safe category, thereby giving a scope of future ground water development agriculture purposes (for high tolerant crops). Ground water development may be enhanced through construction of tubewells in these blocks in a phased manner. Combination rig is suitable for drilling tubewell in the area. In alluvial area, tubewells of 8" diametre and depth up to 110m is recommended. In Sujangarh block, no ground water development is recommended since block falls in over-exploited category.

2.3.2 Dholpur district

Dholpur district is the eastern most district of the Rajasthan state with an area of about 3009 sq. km.

comprising Bari, Baseri, Dholpur and Rajakhera tehsils. According to 2001 census, total population in the district is 983258. The area is covered in the survey of India Toposheet No. 54F/6,7,9,10,11,13,14 and 54J/1,2.

During the Pre and Post monsoon studies, a total of 75 number of well (Dugwell, DCB's, and tubewells) were

inventoried for detailed hydrogeological studies. The water samples were also collected for chemical analysis.

Declining in water level is due to over exploitation of ground water resources from the potential aquifers. As the major part of the district is characterized by hard rock area (Vindhyan Sandstone), peoples are facing scarcity of water for drinking and other domestic purposes which need attention. As far as groundwater quality is concerned in the area, it is suitable for the drinking and irrigation purposes.

The south western part of the district is hilly covering about 40% area and the rest being alluvial plain. The general land slope is from SW to NE with an average gradient of 1.63 m/km. Parbati river is the tributary of Gambhiri river passes through the central part while Gambhiri river passes through the northeastern part of the district. Chambal river is one of the perennial river in the state passes along the southern border of the district. All these rivers flow from southwest to northeast direction. The climate of the district is of semi arid type being extremely hot in summer and cold in winter. The average annual rainfall is 653.4 mm.

Among different hydrogeological formations, alluvium is the principal groundwater bearing formation. The groundwater in alluvium occurs under water table condition. Depth to water in this formation varies between 12.10 m and 40.12 m bgl (Rajakhera Block) having average yield of the tubewells from 45 m^3/d to 75 m^3/d. The second important aquifer in the district is upper Bhandar sandstone which covers the Bari, Baseri and Dholpur Blocks. The depth to water level in the Vindhyan Sandstone ranges from 6.10 m to 20.22 m bgl (Baseri Block) while the discharge of wells depend upon the joints,fractures and weathering of the formation. However, during the survey, the average discharge of wells has been found in the range of 20 m^3/d to 55 m^3/d. Long term water level fluctuation data (NHS) (between pre monsoon 1999 and pre monsoon 2009) shows that in major part of the district especially toward northern and eastern part (Rajakhera Block), maximum fall (3-5 m) in water level has been recorded. Positive fluctuation or rise in water level is recorded in Vindhyan Sandstone and Shale formation in southern and western part (Baseri Block) of the district where it ranges from 1m to 2.5 m. About 66.67% of wells show negative fluctuation more than 3m during the period (may 1999 –may 2009), whereas 33.33% of wells showing rising fluctuation in the range of 0 to 2m. The summary of hydrogeological details of the area is given in table as follows:-

Table-: Summary of Hydrogeological Details (Blockwise)

Sr. No.	Block	Hydrogeological Formation	Depth to Water Level (mbgl)		Average W.L.Fluctuation (m)	Well Yield (m^3/d)	Category (As on 31.3.2004)
			Pre Monsoon	Post Monsoon			
1	Bari	Alluvium	13.40-40.12	13.57-40.22	0.16	45-75	Semi Critical
		Vindhyan Sandstone	14.65-18.28	14.77-17.68	0.25	20-55	
2	Baseri	Vindhyan Sandstone	6.10-20.22	6.00-20.15	0.35	20-55	Critical
3	Dholpur	Alluvium	12.10-23.30	12.76-22.44	-0.21	45-75	Overexploited
		Vindhyan Sandstone	7.22-17.15	6.34-17.21	-0.15	20-55	
4	Rajakhera	Alluvium	17.25-38.95	17.67-38.70	-0.20	45-80	Overexploited

Chemical analysis of ground water samples indicates that in the district groundwater is alkaline and in major part of the district it is hard to very hard. According to Wilcox's classification, majority of samples lie in the C2S1 & C2S2 categories, indicating that ground water is good to permissible for irrigation purpose. Generally, the ground water is fresh and potable in the area.

Following water management strategies may be applied to the area:

i. As in the area, there is a perennial river Chambal flows through the area so far drinking purpose this water can be used in conjunction with ground water. So the dependence on mainly groundwater can be minimized and declining water level can be checked.
ii. In Dholpur and Rajakhera block, emphasis must be given on the implementation of artificial recharge to ground water technique like construction of small check dam, SSB, contour bunding, plugging etc.
iii. Dug Well Recharge Scheme of Ministry of Water Resource in the district is not pacing up, which

needed extra efforts to implementation the scheme.

iv. There are number of village ponds in the Bari and Baseri bloks which can be revived and used to recharge the groundwater of the area and for other domestic purposes.
v. In the district, new improved irrigation techniques such as drip and sprinkler irrigation to be encouraged.
vi. In the overexploited block namely Rajakhera and Dholpur block, construction of new bore well and tubewell should be banned immediately.
vii. To increase the awareness of people/ villagers on water conservation and management issues, mass awareness programme should be conducted.

2.3.2 Kota Urban & Industrial Area, Kota district (Urban Hydrogeolgical studies)

Kota urban lies in the north western part of Kota district. Area is underlain by sandstone belonging to Upper Vindhyan Group and a patch of limestone occurs in the north eastern part. Physigraphically, area is characterized by gentle plane with undulating plateau. The land slopes from south west to north east and is drained by perennial Chambal river and its tributaries. The soil of the area is brown to dark colour alluvium which is clayey loam to clay in composition and generally non-calcareous.
During premonsoon, 24 wells were inventoried and a total of 20 ground water samples collected from various GW Abstraction structures viz. hand pumps/tubewells for complete analysis and also industrial effluent samples for heavy elements determination. Depth to water level varies from 1.80 to 4.54 mbgl(pre-monsoon). Ground water quality is potable having EC from 270 to 1845 ms/cm at 25^{o}C and other chemical parameters are also within permissible limits of Drinking Water Standards.

During post-monsoon details survey, 27 Nos. of ground water samples were collected fromn various GW Abstraction structures. Depth to water level varies from 1.10 to 6.90 mbgl(post-monsoon). Ground water quality in general, is suitable for domestic purposes except in the close vicinity of industrial effluents disposal.

2.4 WCR, AHMEDABAD

2.4.1 Mahesana district

Ground Water Management studies were taken up in parts of Mahesana district covering an area of about 3000 Sq. Km.

The Rupen, Khari and Puspavati rivers constitute the drainage network in the study area. These rivers are ephemeral in nature and mainly flows in response to the rainfall. The study area experiences an average annual rainfall of 602mm. It experiences a semiarid climate. Extreme temperatures, erratic rainfall and high evaporation are the characteristic features of this type of climate. It is characterized by hot summer, cold winter, scanty rainfall and a general dryness except during short monsoon period. Alluvial plain is the single most prominent geomorphic unit and covers the entire part of the study area and is part of the North Gujarat alluvial plain. The area is characterized by gently sloping, slightly rolling to undulatory topography with gradual slope toward southwest.

Geologically the district is underlain by formations ranging in age from Precambrian to recent. The study area is characterized by the quaternary alluvium, which mainly consists of fine-grained sand, gravel, silt and clay. The alluvium at surface represents the windblown or aeolian deposits. The river alluvium is observed only along the rivers.

The thick alluvial deposit, which mostly occupies the study area, forms the most prolific multi-aquifer system. The thickness of alluvium is less in the north and gradually increases towards south and south-west. Within the explored depth of 600m, the alluvium is underlain by Miocene sediments (Tertiary) and Himatnagar sandstone (Mesozoic). The study area is characterised by multiple aquifer system. Within alluvial plains, two major aquifers have been identified upto the explored depth of about 600m below surface. The upper unit is mainly phreatic, but at places becomes semi-confined to confined and has been designated as aquifer "A". The lower unit comprises a few hundred metres of alternating arenaceous (sandy) and argillaceous beds and forms the confined aquifer system. It is sub-divided into aquifer B, C, D and E contained in post Miocene deposits and aquifer F and G in Miocene sediments. Himatnagar sandstone (Cretaceous) forms local aquifer in north-eastern part and has been designated as aquifer 'H'.

Ground water is extensively developed by dug wells, dug-cum-bore wells and tube wells in the study area. Ground water occurs under unconfined condition in the upper unit i.e. the phreatic aquifer where as in the lower unit of the alluvial formations (deeper aquifer) comprising of few hundred meters of alternate sandy and clayey horizon in semi-confined to confined conditions. Ground water development from phreatic aquifer is low to moderate due

to limited saturated aquifer thickness and at place due to low yield and/or salinity.

Water level was monitored in 96 observation wells established, spread over the entire study area and to bring about the change in water level between the pre monsoon and the post monsoon period. The depth to water level during the pre monsoon period ranges between 2.71 to 21.03 mbgl where as during the post monsoon period it varies between 1.74 and 13.11 mbgl. The fluctuation in water level (pre-post) ranges from 0.59m to 8.76m. The depth of tube wells tapping the deeper aquifer varies between 115 mbgl to 390 mbgl and the water level varies between 41 to 163 mbgl during the pre monsoon period where as during the post monsoon period it varies between 35 to 161 mbgl. The fluctuation in water level (pre-post) ranges from 0.51m to 10.93m. Deeper water level is noticed particularly in Unjha and Mahesana taluka. The yield of the dug wells varies between 200 to 300 lpm where as the yield of the tube wells in general is high and ranges from 400- 900 lpm.

Pumping tests conducted in large diameter wells show that the specific capacity value thus calculated varies between 0.019m³/min/m draw down to 0.065m³/min/m draw down. The optimum yield value varies between 79.25m³/day and 219.12m³/day.

Ground water is the main source of irrigation in the study area. There are no perennial rivers. However, part of the study area is covered by irrigation canals of Dharoi project and Sardar sarovar project that provide irrigation water during the period mid October to the month of February and sometimes even up to March depending on the availability of sufficient storage in the reservoir, which in turn depends on the rainfall.

Drinking water supply in the study area, both urban and rural, is both surface water and ground water dependent. Major part of the study area is covered by the Regional Water Supply Scheme namely, Narmada Canal Based Regional Water Supply Scheme and Dharoi Regional Water Supply Scheme. 119 villages of Kadi taluka, 52 villages of Bechraji taluka and 115 villages of Mahesana taluka are covered by the Narmada canal based drinking water supply where as the Dhoroi regional water supply scheme caters the demand of drinking water in 60 and 28 villages of Visnagar and Unjha talukas respectively.

The groundwater quality of the shallow/phreatic aquifer is generally fresh with EC less than 3000 µS/cm. However, in the western part of Mahesana taluka and southern parts of Kadi talukas, shallow aquifers are brackish to saline; with EC more than 3000µS/cm. Slight deterioration in groundwater quality is observed in the canal command areas. The quality of groundwater in deeper aquifers, down to 300 m depth, is in general good in most parts of the study area. High fluoride concentrations both in shallow and deep aquifers have been reported at many places in the study area.

Many check dams, check dam cum recharge tube wells, percolation tanks in village ponds have been constructed by the irrigation department, GWSSB at different locations on Khari River, Rupen River. 247 percolation tanks have been constructed by the Jilla Panchayat Irrigation division in the entire Mahesana district. However this percolation tanks do not cater the demand of water for irrigation directly. Recharge due to these percolation tanks contribute to the rise in water level in the nearby areas. Thus there is an indirect benefit to irrigation as the water level in the ground water abstraction structures in the nearby areas rises due to recharge. About 2892 Ha area gets benefited by this. Jilla Panchayat Irrigation division has constructed 73 check dams in the entire district till date. 40 check dams have been constructed on cause ways and about 783 Ha area gets benefit for irrigation indirectly.

The western part of Mahesana taluka and southern parts of Kadi talukas, where shallow aquifers are brackish to saline, proper isolation of deeper aquifers by cement seal is necessary while constructing tube wells.

2.5 NCR, BHOPAL

Ground Water Management Studies were carried out in Umaria, Anuppur and mapping of flood plain aquifer in parts of Kshipra basin (parts of Ratlam & Ujjain districts) covering area of 10330 sq.km.

2.5.1 Parts of Kshipra water shed (Mapping of flood plain aquifer)

Ground Water Development Studies in parts of Kshipra basin have been carried out in parts of Ujjain and Ratlam District covering and area about 2479 Sq.km in toposheets nos. 46 M/5, M/6, M/9, M/10, M/11 and M/15. The area is mainly covered by Deccan Trap basaltic flows. Consisting weathered, vasicular, hard massive fractured basalts. A few patches around Alot blocks, Vindhyan sandstones are observed in the area. During investigation 74 Nos of key wells has been established and monitored Depth to Water levels of the key wells. Depth range varies from 5.63 to 24.85 mbgl and Depth to water level varies from 5.33 to 24.44 mbgl in the study area. The average yield varies from 2 lps to 5 lps in the study area. Mainly four prominent flows have been encountered during drilling in the study area. The ground water occurs in Phreatic and semi confined aquifer

conditions. About 30 Nos. of water samples have been collected to know the chemical quality of ground water in the area which is found inferior, as E.C of 40% samples is higher in the area. Based on detailed survey carried out in the field, post monsoon water levels varies from 2.61 to 20.74 mbgl at Khajuria-Deona (M/9) Moreover Area comes under Kshipra, Chambal sub-basin. Only Alot block comes under Chambal Sub- Basin.

As study area have drinking water problem due to scarcity during summer, suggestions have been given to State authorities to solve the drinking problem in the area. Technical guidance also given to encourage dug well recharge which is being implemented in Semi-critical,critical &OE areas by MOWR.

2.5.2 Manpur, Karkeli and Pali blocks of Umaria district

Ground Water Management Studies was carried out in parts of toposheet nos. 64A/10, 11, 13, 14, 15, 64E/2 and 3 in Manpur, Karkeli and Pali blocks of Umaria district covering an area of 4593 sq km and 57 key wells were established. In major part of the area, the depth to water level in pre monsoon ranges from 6 mbgl to 9 m bgl. Shallow water level occurs in pockets only. The post monsoon water level ranges from 3 mbgl to 6mbgl in dug wells. About 80% of the area is covered by Barakar sandstone (Gondwana formations). Seven exploratory boreholes have been drilled by CGWB in Gondwana formation. Depth of these wells ranges from 118.2m (Kaudiya Salaiya) to 281.82m (Birsinghpur –Pali). Discharge of the exploratory wells ranges from 1.33 lps to 39 lps. Chemical quality of the water of these wells is good. All the Auto flowing bore holes occur in the Barakar sandstone as coal seams act as confining layer.

2.5.3 Anuppur District (Study of GW Pollution in and around Amarkantak Thermal Power Station)

Ground Water Management Studies was carried out in the three blocks of the district viz. Anuppur, Pushprajgarh and Jaithari with special emphasis on study of GW Pollution in and around Amarkantak Thermal Power Station (ATPS) due to its operation.

The district falls under two river basins i.e. the Ganga and the Narmada. Almost entire district forms part of Ganga river system except narrow belt along the southwest boundary in Pushprajgarh tehsil, which is drained by Narmada River. The Normal annual rainfall of the district is 1235mm. The district receives maximum rainfall during south-west monsoon period from June-Sept. Anuppur is predominantly hilly and forested district and is famous for Amarkantak hill station from where two important rivers namely: Narmada & Son Originates. Anuppur district is underlain by various geological formations, forming different type of aquifers in the area. Main geological units in the area are – Archaen, Gondwana, Lameta & Deccan trap formations. Occurrence and movement of ground water in hard rocks is mainly controlled by secondary porosity through joints & fractures. Primary porosity in Gondwana sandstone and vesicular basalts in Deccan Traps play an important role in ground water movement. Ground water in general occurs under unconfined to semi-confined conditions. A total of 60 dug wells have been monitored during the course of study & extensive water sampling has been carried.Depth to water level during Premonsoon ranges from 3.15 mbgl (Merhakhar, Pushprajgarh block) to 15.86 mbgl (Venkatnagar, Jaithari block). Depth to water level during post monsoon ranges from 1.10 (Khatgaon, Pushprajgarh block) to 14.65 mbgl (Venkatnagar, Jaithari block). Ground water fluctuation ranges from –1.65 m (Anuppur, Anuppur block) to 10.18 (Sakra, Anuppur block). Depth to water level during Premonsoon predominantly remains within 5.0 to 10.0 mbgl in the western half whereas it remains within 5.0 to 10.0 mbgl in the eastern half of the district .Depth to water remains more than 10.00 mbgl in the northern part of the district around Anuppur due to urbanization and coal mining activity. Depth to water during post monsoon fallows more or less the same pattern but depth to water becomes shallower. Water table elevation in the area ranges from 467 mamsl to 915 mamsl. Water table elevation coutours reveals that the rivers Son and Narmada in the district are effluent in nature. General Ground water quality in the district is potable and fit for irrigation. Chemical parameters viz. EC, Cl, F, NO_3 etc. largely remain within the permissible limits. At a few locations NO_3 values between 45 and 100 mg/l have been observed which are due to dug well waters being stagnant and not in use. High values of Iron and Manganese around ATPS, Chachai in ground as well as surface water have been observed, which may be due to the influence fly ash disposal sites and / or imperfect treatment of overflow of such sites and discharge from nearby industrial units.

2.6 NCCR, RAIPUR

Ground Water Management Studies were carried out in parts of Korba and Durg District. Toal area covered under Ground Water Management Studies was 5437 sq.km.

2.6.1 Korba district (Ground Water Resource Estimation)

Ground Water Management studies includes Ground Water Resource Estimation using field parameter were

taken up in Korba and Kartala blocks, which are located in north and eastern part of Korba district. The study area covers an area of about 2437 sq. km. and is a tribal dominated area where tribal population is 45% of the total population. The rural population accounts 69%. The study area has subtropical climate characterized by hot summer and cold winter season. The normal average rainfall ranges from 1089-1473 mm. The area is drained by Hasdeo river and its tributaries like Teti, Aharan, and Tan, Chornai rivers that comes under Mahanadi basinsThe main Geomorphological features and landforms developed in the district are structural plain, plateau, and denudation hill. The study area is underlain by rocks of Chhota Nagpur gneisses, Chhattisgarh and Gondwana Supergroup of Archean to Corboniferous age. The formation comprises Granite, granite gneisses, sandstone and shale with coal seams. Ground water occurs under unconfined condition in the phreatic zone and semi-confined to confined conditions in the deeper formations.

For groundwater regime monitoring in the study area a total of 75 observation wells were established which included both dug wells and bore wells. The pre-monsoon water level ranges between 2.68 mbgl to 15.30 mbgl whereas post monsoon water level ranges between 0.45 mbgl to 9.52 mbgl. Total 49 no. of ground water samples were collected from dug wells and hand pumps for analysis of basic parameters and 8 acidified samples were collected for determination of iron to assess the groundwater quality. The chemical analysis of these samples reveals that in general ground water is potable in nature. No significant change has been observed in the ground water regime when compared with the previous reappraisal survey.

The objective of the study was the determination of field parameter to estimate the ground water resources. The findings are under process and data under refine. The findings can be summarized as under:-

Determination of rate of Infiltration-

Sl.No	Formation	No of Infiltration test conducted	Rate of Infiltration (cm/hrs)
1	Unclassified Granite gneiss	19	1.62
2	Barakar- Arkosic sandstone, shale and coal seams	15	4.44
3	Talchir- Shale, Sandstone, Boulder bed	7	0.97
4	Kampti -Sandstone, ferruginous sandstone	6	3.06
5	Alluvium	2	16
	Total Test	49	

Specific Capacity of large dia well (Dugwell) -By Slichters Method

Sl.No	Formation	No of Pumping test on Dugwell conducted	Average Specific Capacity (lpm/m)
1	Unclassified Granite gneiss	9	41.3
2	Barakar- Arkosic sandstone, shale and coal seams	11	22.59
3	Talchir- Shale, Sandstone, Boulder bed	2	18.66
4	Kampti -Sandstone, ferruginous sandstone	3	31.41
	Total Pumping test on dugwell	**25**	

Determination of Specific Yield- In Julianala Miniwatershed covering 45 sq km, in Granite gneiss specific yield has been calculated as 1.76 using Dry season balance method

2.6.2 Durg district (Conjunctive use of surface and groundwater)

The study of conjunctive use of surface and groundwater in Tandula Command Area of Seonath sub-basin in Chhattisgarh State was taken. The command area is bounded by Seonath River in the west and Kharun River in the east. The entire Tandula Command Area lies within Durg district, Chhattisgarh

Tandula reservoir complex embodies three reservoirs; salient features are given in table 2. In addition to this, Tandula Reservoir also gets feed from Pt. Ravishankar Reservoir (Gangrel) through the Mahanadi Feeder Canal. Tandula reservoir has a command area of nearly 3000 sq. Km.

A total of 94 key wells were established for the study. The key wells are well- distributed representing head and tail areas of the canals, different geological formations, rural and urban areas etc. All the key wells were monitored every month. As per the data of department of Revenue, in the present year (2009-10), the study area experienced deficit rainfall. Upto 30% deficit in monsoon rainfall was recorded in different blocks of the command area. The

catchment of Tandula Reservoir Complex is spread in parts of Raipur, Durg, Kanker, Dhamtari and Bastar Districts.

Most of these districts experienced deficit rainfall during monsoon period. The maximum deficit of 41% was recorded for Kanker District. Canal water supply Due to deficit rainfall during the monsoon period, canal water for rabi crop has not been released .

The area is covered by meso to neoproterozoic, unmetamorphosed sedimentary rocks of Chhattisgarh Supergropup The rock types are: Chandarpur Sandstone, Charmuria Limestone, Gunderdehi Shale, Chandi Limestone (with Deodangar Sandstone), Tarenga Shale and Hirri Dolomite. Chandi Limestone and Sandstone cover 50% of the study area.

During pre-monsoon period, the water levels vary from 1 to 16mbgl with the modal class being 5-7 mgl Similarly, during post-mosoon period, the water levels vary from 1 to 11 m bgl with the modal class of 3-5 mbgl. Water table contour map was prepared based on the reduced levels collected by hand held GPS. There are two perennial rivers on both sides of the study area with a water divide at the centre that has an NNE trend. Regional groundwater flow is towards the major rivers i.e. towards east and west from the regional water divide.

2.7 CR, NAGPUR

Ground Water Management Studies were carried out in parts of Jalgaon and Aurangabad districts, parts of Wardha district (Farmers Distress Area), part of Ahmednagar district and parts of Amravati district covering area of 10433 sq.km.

2.7.1 Jalgaon and Aurangabad districts (Impact of agricultural pollution on groundwater quality as well as remote sensing studies in hilly areas)

Ground Water Management Studies were carried out in parts of Tapi river basin covering an area of 3000 sq.kms mainly in Jalgaon district and also in parts of Aurangabad, Jalna and Buldhana districts. The theme of study was to assess the impact of agricultural pollution on groundwater quality as well as remote sensing studies in hilly areas of the study area. The plain area surveyed falls Jalgaon, Jamner, Bhusawal, Muktainagar and Bodwad talukas of Jalgaon district. The hilly area in southern and southeastern part forming fringe of the basin area falls in Aurangabad, Jalna and Buldhana districts respectively. The study area comprises of 20 watersheds.

The area forms part of Tapi river basin and drained by the river Purna and major tributary of Tapi river i.e. Vaghur river. There is a general decrease in elevation from south to north from the height of about 750 m amsl to about 250 m amsl.

Basalt is the main hydrogeological unit in the area. Groundwater occurs under phreatic condition in the exposed lava flows and under semi-confined conditions in the subsurface flow. Dug wells are the main ground water abstraction structures in the area and the yield ranges from 20 to 100 m^3/day.
During pre-monsoon 84 key wells (dug wells) were established to monitor the water level in the area and to study the impact of agricultural pollution on groundwater quality. The depth of these dug wells ranges from 5.10 m to 33.8 m. The pre-monsoon depth to water level varied between 2.85 m.bgl and 25.70 m.bgl. During post-monsoon the water levels varied between 0.40 m.bgl and 26.70 m.bgl. Both rise and fall in water level fluctuation were observed in the study area. Out of the 77 key wells were considered for analyzing the water level fluctuation in the study area, 53 wells (69%) has shown the rise in water level and remaining 24 wells (31 %) have shown fall in water level.

During March 2010, thirty water samples were collected from the banana growing areas of the district to study the impact of agricultural pollution viz. sulphate, nitrate and phosphate and other pesticides like Endosulfan, which was reported by the farmers to be using. Data pertaining to pesticides used for the banana growing farms and other crops was collected from the Department of Agriculture in Jalgaon district. The socio-economic data was also collected from the Collector office and District Statistical Officer of Jalgaon and Aurangabad district.

Remote sensing data in the form of imagery available in the office was also analysed with the expert from the North Maharashtra University, Jalgaon and the study revealed that the overall hydrogeological condition in the hilly area is almost similar to that of other part of the study area.

2.7.2 Wardha district

An area of 3200 sq.kms was covered in northern parts of Wardha district, which includes five talukas namely Wardha, Ashti, Arvi, Karanja and Selu. The area includes 20 watersheds.

The area is underlain by basaltic lava flows with patches of inter-trappean beds. A small pocket of alluvium is also seen in the southwestern part. The district forms part of Godavari basin and the river Wardha is the main river that traverses through the district, which separates Amravati district with Wardha in the western part.

During premonsoon survey, 55 key wells (dugwells) were established to monitor the water level in five talukas of Wardha district viz. Wardha, Ashti, Arvi, Karanja and Selu. The depth of the wells varies from 6.30 m.bgl to 19.31 m.bgl and diameter varies from 1 to 6.80m. The pre-monsoon water level ranges from 4.60 m.bgl to 15.29 m.bgl and the post-monsoon water level ranges from 2.23 to 15.46 m.bgl. The water level fluctuation ranged from -2.86m to 5.85m.

As a part of study in the Farmers Distress area, 23 farmers were selected in different hydrogeomorphological conditions in the above five talukas and their dugwells apart from 55 key wells were studied. The information regarding performance of their dugwells in both pre and post monsoon was collected. The main kharif crops grown in these talukas are cotton and soyabean whereas the main rabi crops are wheat, gram, tur and oranges. About 80-90% of farmers informed that their wells goes dry after 1-2 hour pumping in summer season and the rate of recovery ranges from 4-5 hours and sometimes it took 20-22 hours. Due to failure of monsoon in 2009, the farmers lost their kharif crops and damage to the oranges was noticed.

The overall study reveals that the farmers in all these 5 talukas of Wardha district do not have ground water problems for irrigation and drinking purpose. The Availability of power and laborers are the main problems for the irrigation.

2.7.3. Amravati district(parameter estimation studies for the refinement of GEC norms)

An area of 549.58 sq. km. was covered in Amravati district covering Amravati, Tivsa and Morshi talukas. The selected area comprises of two watersheds namely WR-4 and WR-5. The theme was parameter estimation studies for the refinement of GEC norms.

The study was carried out based on watershed as a unit hydrogeological feature. The watersheds WR-4 and WR-5 watershed have geographical area of 138.68 and 410.9 sq. kms respectively. The area forms a part of Godavari basin and drained by Wardha river on the eastern boundary of these two watersheds. The maximum elevation of the study area is 405 m amsl near Chikhli in NW part of watershed WR-5 and the minimum elevation is about 314 m amsl near Varkhed in the eastern part of WR-5.

The area is covered by weathered and fractured massive and amygdular basalts. The eastern part of both the watershed falls under the command area of Upper Wardha Project situated at Simbhora near Morshi at about 10 km north of the study area. The right bank canal of the Up. Wardha Project passes through these watersheds. The total command areas in WR-4 and WR-5 is about 33.55 and 75.28 sq. km respectively.
The basalt is the main formation of the area. Ground water occurs under phreatic conditions in the exposed lava flows and in semi-confined to confined state in the subsurface flows. During premonsoon survey, 45 key wells (dugwells) were established to monitor the water level in the area out of which 15 lie in WR-4 and the rest in WR-5 watershed. The depth of the wells varies from 4.3 mbgl to 18.1 mbgl. 32 shallow aquifer water samples from some of the key wells were collected for determination of chemical quality. The monitoring of keywells was done both in pre-monsoon and in post-monsoon periods. Pre-monsoon water level ranged from 2.25 mbgl to 14.35 mbgl and Post-monsoon water level from 1.37 to 14.2 mbgl with the water level fluctuation ranging from 0.9 to 4.5 m.

Infiltration tests were carried out at 18 locations using single ring infiltrometer. The collection of information on ground water draft, unit draft of abstraction structures, yield of dugwells etc., were also done.

2.7.4 Ahmednagar District :

An area of about 3598 sq.kms was covered under Ground Water Management Studies in parts of Ahmednagar District. The area includes 17 watersheds namely GV- 124, 125, 126, BM 5,14,15,16, & 28, SA- 1, 2, 3,4,5,6,7,8, & 10.

The area is drained by Godavari, Bhima and Sina Rivers and their tributaries. Most part of the area is rain fed and the irrigation in these areas is mainly through ground water structures (Dugwells and Borewells) and rain water abstraction structures (percolation tanks, Nalla Bunds, KT weir etc).
The area is mainly underlain by Deccan traps. Alluvium of Recent age occur along the river courses and valley portions. At places the thickness of the alluvium cover ranges from 3.0 to 15.0 m.

During pre-monsoon, 125 key wells were established. The depth of dug wells varied from 5.1 to 24.40 m.bgl. The DTW during pre-monsoon ranges between 1.60 & 23.8

m.bgl. The DTW during post- monsoon ranges between 0.30 & 14.80 m.bgl. The fluctuation of the water levels ranged between 0.55 & 10.05 m.

The yield cum draft of the dug wells in Deccan traps formations ranges between 5 to 1 00 cubic meter/day where the pumping hours are in the range of 2 to 8 hours/day with the pump sets of 3 to 10 HP, while the yield cum draft of the dug wells in Alluvium areas between 100 to 300 cubic meter/day where the pumping hours are in the range of 8 to 16 hours/day
62 water samples were collected for the study of chemical quality of the ground water. In general, the quality of water is good to brackish. Two industrial areas are located in the study area. Ralegaon Siddi and Hivre Bazar are the two ideal villages developed by the efforts of local Gram Panchayat and NGO"s are located in the study area.

2.8 NR, LUCKNOW

Flood Plain Aquifer Mapping and hydrogeological investigations along Ganga River with the view to prepare developmental plan to meet out water supply demand of habitations in flood plain areas and for domestic, irrigation & other purposes. Total area covered was 11913 Sq km distributed in parts of Kanshi Ram Nagar, Farrukhabad, Budaun, J P Nagar, Bijnor, Meerut, Muzaffar Nagar, Ghaziabad, Bulandshahar & Aligarh districts. In addition 1375 sq km area was also studied in Sengar river water shed in Kanpur Dehat district & adjoining areas in Hamirpur & Jalaun districts and feasibility study for suggesting measures of run-off control & artificial recharge using remote sensing technique for ravine reclamation.

Ground Water Management Studies were carried out in Hardoi & Shahjahanpur, Kanpur Nagar & Kannauj, Unnao, Lucknow & Barabanki districts .

2.8.1 In parts of Budaun district District (Flood Plain Mapping)

Ground Water Management Studies in parts of Budaun district has been undertaken for Mapping of flood plains & surrounding area of blocks along Ganga river and potentially assessment of shallow & deeper aquifers & preparation of developmental plan for drinking water supply & irrigation needs

The river Ganga forms the southeren boundary of the Badaun district ,U.P. The part of the study area lies from North West Rajpura block to South East Usawan block falling along the Ganga river, lying in the survey of India toposheet no 54 I/13,54 L/12,54 M 1,5,6. There 8 blocks namely Rajpura ,Gunnaur ,Junawai,Dahigawan ,Sahswan , Ujhani,Quader chowk and Usawan of Badaun district,U.P.The area lies on the bank of Ganga River ,about 2655 Sq.Km was covered

The area is underlain by a thick pile of Quarternary unconsolidated sediments .The thickness of unconsolidated sediments is likely to be 740 m at Ujhanias per ONGC record.The alluvium consist of clay ,silt,various grades of sand with occasional garvel at depth.The sand is generally fine to medium grained in shallow depth which tends to become coarser with depth.

In the study area most of the dug wells have been gone dry due to the installation of Handpumps (Mark II). The people have stopped using dugwells . During survey of the study area in the pre-monsoon 18 key wells were established and inventoried.

The depth of water level during pre-monsoon-2009 in the area ranges between 3.50 mbgl at Semeri and 10.83 mbgl at Akbarpur. Along the Ganga river ,the depth of water level is more than 10 mbgl in the block Usawan .In this block ,the dug wells have gone dry and water level could not be measured.In total 18 numbers of water samples were collected (near key well established)or from the Hand pump (Mark II)during premonsoon period. The depth of water level during post-monsoon- 2009 in the area ranges-between 3.26 mbgl at Kachha village (Ujhani block) and 10.35mbgl at Akbarpur(block Usawan)The water level is deeper as we go away from the river though water level could not be measured as dug wells were not avilable in the area. The water level fluctuation ranges from 0.01to 1.15m in the study area. In total 15 no water level samples were collected for detailed analysis and 8 numbers of samples are collected for Arsenic (one from each block along Ganga river)

2.8.2 J P Nagar & Bijnor districts (Flood Plain Mapping)

Mapping of flood plains & surrounding area of blocks along Ganga river and potentially assessment of shallow &Dee per aquifers & preparation of developmental plan for drinking water supply & irrigation needs in parts of J P Nagar & Bijnor districts

The area covering 2677 Sq.km area were studied under Mapping of flood plains & surrounding area of along Ganga river for potentially assessment of shallow &deeper aquifers & preparation of developmental plan for drinking water supply & irrigation needs in parts of J P Nagar &

Bijnor districts The Ganeshwari, Hasnpur,Gajraula & Dhanaura blocks of J.P.Nagar district and Mohamadpur-Deomal,Haldaur (Khari Jhalu ,& Jalilpur blocks of Bijnor district were covered under the study.

The Mahawa, Bhagad, Malin and Chhaiya are the major tributaries of the river Ganga forming a dendritic pattern in the alluvial plains of Quaternary age. The area has three tier sub aquifer system upto the inventoried depth 600 mbgl (Gajraula) of which the top " Phereatic Aquifer system "upto an aaverage depth of 50 mbgl is generally unconfined nature having ground water under water table condition which is more dependable in the food plain area and contributing to agriculture productions . The quality of groud water is good for domestic purposes and for irrigation also.

During premonsoon period key wells were established in the study area for water level measurement. About 70 numbers of key wells /Pz/Hand pumps were established and water levels was measured premonsoon & postmonsoon period.. In the area 98 % dug wells are dry pizometeres of GWD department and shallow hand pumps were used for water level measurement.

The pheretic aquifer system has the depth to water level ranging from 2.80mbgl (in the Younger alluvium- in Khader area) to 14.00mbgl (in the older alluvium) in the premonsoon and 2.00 to 13.00 mbgl during the post monsoon seasons respectively except at chandok of Bijnor district.where depth to water level is 17.00mgl in the premonsoon & 9.00 to 10.00 mgl in the post monsoon. For the assessment of water quality in the study area, water samples were collected from the handpump, borewells, tubewells, and Ganges river. In total 30 water samples were collected for the Arsenic study from the study area.
The additional ground water potential existing in the shallow depth to water areas and in the flood plains may also be utilized to meet out irrigation & drinking water needs of the local people. In general the ground water quality of the area is good and potable & fit for domestic & irrigation purposes. The Deeper aquifer system are of semi confined to confined in nature and have ground water under pizometeric pressure head.

2.8.3 Parts of Meerut & Muzaffar Nagar districts (Flood Plain Mapping)

Mappiing of flood plains & surrounding area of blocks along Ganga river and potentially assessment of shallo & deeper aquifers & preparation of developmental plan for drinking water supply & irrigation needs in parts of in parts of Meerut & Muzaffar Nagar districts

Under Ground water Management studies the blocks covered having an area of 1996 Sq, Km for the purpose of Mappiing of flood plains & surrounding area of blocks along Ganga river and potentially assessment of shallow &deeper aquifers & preparation of developmental plan for drinking water supply & irrigation needs in Meerut district covering blocks which are Parikshat garh,Hastinapur & Machara,whereas Jansath,Morna & Purkazi blocks in Muzaffer Nagar district.

The Ganga river forms the easteren parts of the district, the area of study.The tract is known as Ganga- Khadar region.and characterized by ravines ,depression and water courses. The study area is the alluvial plain of Indus-Ganga Region of Midle to Upper Pleistocene period. The lithology is alluvial clay and river silt, sand

During pre monsoon period 20 numbers of key wells established in the study area to monitor water level fluctuation . The depth of key wells ranges from 5.56m bgl (Satla village) to 30.00 mbgl at (Seekri village).The water level during premonsoon ranges from 3.38 mbgl (Kharhali, block Parikshat garh)and 16.20 mbgl (Seekri, block Morna) and during postmonsoon it varies from 3.00 mbgl to 16.11mbgl . In total 24 No of water samples were collected for assessment water quality in the study area.

2.8.4 Parts of Ghaziabad, Bulandshahar & Aligarh districts (Flood Plain Mapping)

Mapping of flood plains & surrounding area of blocks along Ganga river and potentially assessment of shallo & deeper aquifers & preparation of developmental plan for drinking water supply & irrigation needs in parts of Ghaziabad, Bulandshahar & Aligarh districts.

Pre-monsoon Phase: Covered 2023 sq km area under above survey along Ganga river in Garh Mukteshwar block of Ghaziabad district, Dibai, Anup Shahar, Siyana, Unchagaon, B.B. nagar, Danpur and Jahangirabad blocks of Buland Shahar district and Bijauta block of Aligarh district. During pre-monsoon survey took hydrogeological traverses of about 60 villages and fixed 20 key wells additional for water level monitoring in the area. The study area is the alluvial plain of Indus-Ganga Region of Midle to Upper Pleistocene period. The lithology is alluvial clay and river silt, sand. The depth to water level ranges from 1.32 to 11.32 mbgl, the depth of well ranges from 2.40 to 12.80 mbgl, the dia ranges between 0.93 and 2.66m and MP of dug well ranges from G.L. to 1.20 magl. The water samples were also collected from nearest hand pumps and existing dug wells.

Post-monsoon Phase:The post-monsoon water level measurements of key wells completed. The DTW varies from 1.25 to 11.20 mbgl and the seasonal fluctuation ranges between 0.03 to 1.27m . During the detailed survey it is seen that the Simbhawali sugar mill (Garh Mukteshar block of Ghaziabad district affect to village Pawara,Bhadogarh,Sehal & Langa Sarai , the effluents of this sugar mill badely affectsto the villages. The "Gopal Ji Milk Plant " also exist near Simbhawali sugar mill and the effluent of this plant also add the water pollution like sugar mill,all ultimately add the Ganga river with pipe line.In the study it is found alomg the traverse from GarhMukteswar,Pooth ,Paswara, Palwara and Mohammadpur (along Ganga river) ,the water level in KHADAR area range between 2 to 3 mbgl where as in Bangar area it ranges between 5 to 6m bgl (water level increases from Kahdar to Bangar area). During studies along Ganga river in AnoopShahar block traverse taken across Aahar,Awantika temple,Rajghat,Dedh Meel and Niwari places of Dibai block of Buland Shahar district. It is observed in the above areas the water level ranges 3 to 5 mbgl in 'Kahdar'area and 12 to 15 mbgl in Bangar area. In floodplain area the farmers took only single crop either Sugar cane or wheat etc. At Khadar portion the villagers grew tomato etc.

2.8.5 Parts of Kanshi Ram Nagar & Farrukhabad districts

Mapping of Flood Plains & Surrounding Area of Blocks Along Ganga River and Potentiality Assessment of Shallow & Deeper Aquifers & Preparation of Developmental Plan for Drinking Water Supply & Irrigation Needs in parts of Kanshi Ram Nagar & Farrukhabad districts. Pre- & post-monsoon monitoring and detailed studies in respect of the 2562 Sq Km area in parts of in parts of Kanshi Ram Nagar & Farrukhabad districts completed. Detailed survey was covered for an area of 500 Sq Km.

2.8.6 Parts of Unnao district

The Ground Water Management Studies were carried out in Unnao District, covering an area of 1496 sq.km. In order to assess the potability of water, the water samples 48 nos. were collected in the blocks (Sikandarpur Sarsoi, Sikandarpur Karaon, Bagamau, Fatehpur, Chourasi, Gan Moradabad, Safipur, Bighapur and Sumerpur) from hand pump (II),and private H.P., Shallow tube well and deeper tube wells. Pre-monsoon the watersamples results of Chemical analysis reveals that the, 6 water samples indicate high fluoride concentration beyond the permissible limits of 1.5 mg/l (BIS-1991). High concentration of Flouride has been found from 1.53(Akbarpur, Bangarmau block) to 2.0(BoniThana, Fatehpur block)

2.8.7 Kanpur Dehat District (Remote Sensing Studies)

Feasibility of study for demarcating ravenous area in parts of Sengar River watershed, Kanpur dehat district and suggesting measures of run off control & artificial recharge using remote sensing technique

Ground Water Management Studies in parts of Kanpur Dehat, Hamirpur & Jalaun districts covered in S.O.I., Topographic sheet Nos. 54N/15 & 54N/16 by Remote Sensing techniques (Ravine studies in Sengar river water shed in parts of Kanpur Dehat district & adjoining areas in Hamirpur & Jalaun districts).

The special study has been taken up basically with a broad objective to suggest, through remote sensing studies, the measures to conserve and upgrade land and water resources of the area in an integrated manner to restore ecological balance and arrest rapid degradation of land under the Ground Water Management Studies.

The remote sensing interpretation were done on Black & White MSS images and FCC's and currently acquired Satellite data (IRS-1D LISS III Geo- coded 54N/15 & 54N/16) for the mapping of ravine land. The image interpretations were validated through field checks.

The large parts of the area form plain topography with highly undulating surfaces in the vicinity of the trunk river which is resulted due to heavy fluvial erosion. The Yamuna River and its tributary Sengar river flows in meandering pattern with high degree of sinuosity along their courses. The various erosion features identified in the area represent the different stages of fluvial erosion viz. sheet erosion, rill erosion, gully erosion which ultimately transform in to ravines.

The ground water scenario of the area is quite poor in ravenous tracts. The ground water levels of the area rests at deeper levels particularly along the river course where the levee sides are generally developed as ravines. The Depth to Water Levels were monitored at specified interval through out in the area in about 45 dug wells.
The gradual headword erosion leads to upward migration of the ravine in the area which is manifested in terms of widening aerial extent. Such features and locations are identified through imagery data analysis and field survey where excessive erosion leads to develop ravines and need

to apply the measure to check the erosion. Various measures in vogue to develop such areas are construction of check dams along first and second order streams, gully plugs, bonding, trenching across the slopes ets. are practiced by Soil Conservation & forest Departments and other organizations and NGO's working in the area.

2.9. MER, PATNA

The Ground Water Management Studies were carried out in East Singhbhum district (Jharkhand) & Supaul, Saharsa-Madhepura (Bihar) and area covered 9364 sq.km.

2.9.1 Supaul district

The District covers an area of 2,420 sq km. It is a part of the Kosi division. The district comprises 4 sub-divisions: Supaul, Birpur, Triveniganj and Nirmali. Supaul sub-division consists 4 blocks: Supaul, Kishanpur, Saraigadh-Bhaptiyahi and Pipra. Birpur sub-division is further divided into 3 blocks: Basantpur, Raghopur and Pratapganj. Triveniganj sub-division has 2 blocks: Triveniganj and Chhatapur. Nirmali sub-division comprises 2 blocks: Nirmali and Maruna. The district has a population of 1,745,069 (2001 census). The urban population constitutes 19% of the total population. The population density is 735/km².

The Kosi River flows through the western boundary of the district. This river is considered as the sorrow of not only this area, but whole of the state of Bihar. The river frequently overtops it banks and causes flooding. Tilyuga Chhaimra, Kali, Tilawe, Bhenga, Mirchaiya, Sursar are the tributaries to it.

The soil is basically sandy and it varies from acidic to basic in nature. The geomorphology of the district and the regional architecture has been carved out by the frequently shifting Kosi River and other misfit channels (groundwater fed) flowing in the abandoned channels of Kosi. The district is situated in the heart of the " Kosi megafan ", known to be the biggest inland delta in the world. The upper 5-9 m of the sub-surface lithology is in general finer (laid down by the shifting Kosi) in nature, below which the lithology is coarser.

Agriculture is the major occupation of this district and paddy is the main crop. Net sown area stands at 55 % of the total geographical area of the district. The agricultural intensity of the district stands at 151 %. The district show an irrigation status of 58 % of the gross area cultivated. Though canal water form a good part of the total irrigation demand, groundwater form the major irrigation source and it fulfills 50-60 % of the gross irrigation demand.

Water level in Supaul district remains largely shallow (<3mbgl) in both pre- as well as post-monsoon period with exceptionally reaching 4 – 5 m bgl at places. As a part of groundwater management study of the Supaul district, 42 key wells were set and their water level data were collected during pre- as well as the post-monsoon period of the year 2009. Pre-monsoon water levels of the district were found to vary from 1.34 mbgl at Narhi to a maximum of 5.44 mbgl at pipra chowk, whereas the post-monsoon water levels in the district varied from a minimum value of 1.2 mbgl at Narhi to a maximum of 3.6 mbgl at Pipra chowk. In both the seasons the water levels were found to be shallower along the active Kosi channel and deeper towards the west and southwest parts of the district. Few of the important observations during the water level study in the district are summarized below:

- In both the seasons, despite shallow water levels, distinct patterns of ground water flow are evident.
- In both the seasons of water level measurement, the elevation of water table remains within ~ 70 m amsl to > 45 m amsl.
- In general ground water level flows in a NW-SE to north south trend.
- It is interesting note that the active channel of Kosi acts as a recharge source from ground water in the western part of the districts in both the seasons.
- The small streams flowing in the abandoned channels of Kosi are gaining in nature i.e. those are fed from ground water.

Long term water level data have been evaluated for a maximum up to last 24 years. The interpretation of hydrographs indicate both pre- and post-monsoon rising trend of water level up to the year 2007-08 at 7 out of 8 monitoring stations. After 2007, there has been a general falling trend. The rising rates vary from the minimum of 3.11 cm and 2.78 cm per year at Bhimnagar during pre- and post-monsoon respectively to maximum of 9.33 cm and

8.00 cm per year at Bhawanipur during pre- and post-monsoon respectively.

However, during last 3-4 years, the whole of the district faces a water level declining scenario. This may have been due to the deficient rainfall in the district in these years.

2.9.2 Saharsa-Madhepura district

The study covered 3435 sq. km of Saharsa and Madhepura districts. Quaternary unconsolidated sediments consisting of sand, gravel and pebbles constitute potential ground water repository. Shallow aquifer is about 40-70 meters within a depth of 80 meters. A thin veneer of clay is present overlying the granular zone in the northern part of the district. Though lateral facies changes have been observed, the aquifer system behaves as single continuous one. The aquifers are highly potential and yield 200m^3/hr for nominal drawdown of 2 m. Pre-monsoon depth to water level has been found varying from 2 to 5.5 m bgl while Post-monsoon level was found between 2.12 and 4.10 m bgl. Water samples have been collected from representative wells for analysis of groundwater quality. Groundwater quality of the area is potable except for incidence of high iron in localized pathes.

2.9.3 East Singhbhum district

Total area covered is 3216 sq. km. Altogether 40 no. Of ground water samples have been collected from Jamshedpur sadar, Patamda, Bahragora, Chakulia, Mosabani, Dhalbhumgarh and Potka blocks of East Singhbhum district. Water samples have been collected both from dug wells and hand pumps to have an idea of shallow and deeper aquifer quality.

Block wise details of East Singhbhum district

Sl. No.	Name of Block	Area (Sq. km.)	Population	Range of Pre-monsoon Water level(mbgl)	Range of Post-monsoon Water level(mbgl)
1	Patamda	511.53	1,31879	7.30-11.60	2.50-8.00
2	Jamshedpur sadar	334.39	1076544	6.00-10.90	1.80-7.90
3	Ghatsila	346.35	115130	5.90-10.05	2.05-5.00
4	Dhalbhumgarh	324.10	72528	2.10-6.65	0.60-4.40
5	Potka	594.22	170657	4.00-9.45	2.10-4.25
6	Mosabani	244.99	104299	6.00-9.05	1.05-2.10
7	Chakulia	427.76	108806	3.70-18.20	2.10-10.00
8	Bahragora	433.31	149530	4.70-9.70	3.50-5.70

The major rock type of the area is mica schist, Schist, phyllite and Quartzite of Singhbhum group.Eastern area of the district is underlain by Tertiary formations consisting of gravel,Pebbles and Sands. Northern area is hilly is of Dalma volcanic consisting of tuffs, hornblende schists, Carbon phyllite, Quartzite etc.

The ground water occurs both under unconfined condition and semi confined to confined condition. The unconfined condition exists in the weathered mantle portion of the rocks. Depth of weathered mantle varies from 15-34 m in general. The general ground water flow is towards southeast. The main potential aquifers are found in the secondary porosity developed by tectonic activities as fractures and joints. The bore wells drilled up to 150 m deep tapping these fractures (2 to 3 numbers) yield 12 to 20 cubic m/hrs. of discharge having 12 to 30 m of draw down.

Ground water quality in the area is potable. All the constituents are within permissible limit of Bureau of Indian standards except Iron and Fluoride. Fe concentrations in these areas are found in the range of 1-5 ppm. Kudada, Parsudih, Baghbera, Ghorabandha and Chota Gobindpur areas have fluoride concentration in hand pump samples (1.5- 2.5 ppm). Some portion of Jamshedpur urban areas like Sidgora, karandih, Parsudih, Baghbera, Kitadih and Chotagobindpur are devoid of fractures so deeper aquifers do not have ground water.potential .

Long-term water level data of East Singhbhum indicate that Chakulia, Bahragora and Patamda areas are suitable for artificial recharge. In Jamshedpur urban area, Adityapur, Khasmahal, Karandih, Mango, Pardih areas are suitable for artificial recharge.

2.10 ER, KOLKATA

An area of 7000 sq.km. was covered under Ground Water Management Studies in parts of Middle and North Andaman, parts of Murshidabad, Uttar Dinajpur and parts of Birbhum District.

2.10.1 Middle and North Andaman Districts(Feasibility of rainwater conservation using Remote sensing technique)

Hydrogeological survey was carried out over an area of 1000 sq km in the Blocks of Diglipur, Mayabander, Rangat of North and Middle Andaman Districts of Andaman & Nicobar island.The objectives of the studies are to to assess the present ground water condition in the water scarce area and to study the feasibility of rain water conservation using Remote sensing technique.

The study area comprises of fine grained sandstone, shale, conglomerate, grit, igneous volcanics and intrusives of Cretaceous age. This is overlained by coralline limestones and limestone of Recent to Sub Recent age. As the sedimentaries are devoid of high porosity and permeability, these are not potential aquifer. Igneous rock Formations are potential aquifer. But its presence in high altitude scope of ground water exploration is very limited. Dug well, ponds and perennial streams are the main sources of irrigation in this area. But during peak summer ground water is the only source of irrigation. Pipe water supply schemes are only dependent on availability of spring water to meet up domestic and drinking needs for the people in the study area. For daily domestic needs dugwells are useful. Due to Tsunami, pipeline water supply was damaged and present water supply is manly based on from intake well constructed in the Kalpong river bed.

A detailed ground water management study was conducted in water scarce areas of North and Middle Andaman Districts. In North Andaman District pre and post monsoon depth to water level ranges from 2.74 to 5.35 mbgl and 1.06 to 3.37 mbgl respectively. In Middle Andaman District pre and post monsoon depth to water level varies from 2.88 to 5.35 and 0.93 to 3.36 mbgl respectively. Remote sensing technique has been used to locate the valley area where construction of ground water abstraction as well as rainwater conservation structure is possible. In Middle Andaman District 14 Valley areas have been located and 8 valley areas have been identified on Diglipur road in North Andaman District.

2.10.2 Murshidabad District(Flood Plain Aquifer)

An area of 2000 sq. km. including 12 Blocks in parts of Murshidabad district was covered. The Objective are to understand the disposition of flood-plain aquifer along Ganga River.

Geologically the interfluve is represented by huge thickness of Recent to Sub-Recent Alluvium of the Ganga river system (Quaternary age) with presence of basaltic rocks at depth along the northern margin. The study area partly covered by older alluvium & partly by recent alluvium of Quaternay age. The aquifer occurs under unconfined to semi confined condition in unconsolidated sands of various grades within a depth span of 19.8 mbgl to 143.50 mbgl. Discharge of tubewell ranges from 22.5 to 199.84 m^3/hr. Transmissivity ranges from 75 to 8500 m^2/ day and Stotativity varies from 1.8 X 10^{-2} to 9.9 X X 10^{-4} .

2.10.3 Uttar Dinajpur District

An area of 2750 sq.km was covered and a detailed study in 'Barind track' of Itahar, Hematabad and Raiganj Block were carried out. The study was conducted through inventory of key observation wells, collected water samples from dugwells & tube wells.The objectives is to to understand the change in ground water regime due to agricultural activity.

The area is covered by alluvium deposits of Recent age. The sediments are thickening towards northern part of the district. The northern part of the area is covered with a broad piedmont alluvium plain overlapping the Older alluvium. The Recent alluvium are fluviatile deposits of sand, silt and clay with occasional gravel beds. Aquifers composed of medium grained to coarse grained sands and gravels are responsible for the ground water development in the district. In the northern part of the study area ground water occurs under water table condition and in southern part of the district groundwater occurs under water table to semi-confined condition. In the central and southern part of the district thin clay layer alternate with fine to medium sand layers occurring 30 to 40 m below ground level. In the study area shallow tube wells are capable to yield 40 m^3/ hr with insignificant drawdown and deep tube wells are capable to yield 150-200 m^3/ hr with a maximum drawdown of 4-5 m only. During hydrogeological survey a total of 52 key observation wells were established. Water level during premonsoon period ranges from 3.050 to 6.80 meter below ground level whereas postmonsoon water level ranges from 1.20 to 5.5 mbgl. Transmissivity value is about 2000 m^2/ day.

Based on the study the following recommendations were given:

- As all the Blocks in the study area falls under "Safe" category large scale ground water

development for agricultural use can be feasible for shallow aquifers.

- Close monitoring of depth to water level for both shallow and deep aquifers is essential to know the long term behavoiur of aquifer.
- Shallow ground water abstraction structure is feasible in northern part of study area and deep tube wells can be constructed in southern part of the study area.
- In water logged areas stress has to be given on ground water development and drain out the excess surface water to the adjacent Blocks. (v) Roof top rainwater harvesting and conservation of rainwater can be adopted in southern part of the district. (vi) Modern irrigation practice should be adopted in "Barind"tract areas of Itahar and Hemtabad Blocks.

2.10.4 Birbhum District (Naturally contaminated Area)

An area of 1250 sq.km was covered in Nalhati II, Rampurhat II, Mayureswar I & II, Saithia and Labpur blocks of Birbhum district. The study was conducted through inventory of key observation wells, collected water samples from dugwells & tube wells. The Objective is to study the high fluoride concentration in ground water.

The area is almost flat terrain with a general gradient is towards southwest direction. Geologically the area is underlain by Quaternary Alluvium deposits of sand, silt and clay, caliche nodules. Basement consists of Chotonagpur Granite gneiss of Archaean age.

Total 93 key observation wells were established in the area for quantitative & qualitative monitoring of ground water. Depth to water level in the key observation wells in the pre monsoon period ranges from 4.92 to 22.65 meter below ground level and that of post monsoon water level ranges from 2.15 to 14.00 mbgl. Exploration in the area reveals that potential granular zones exist in the depth span of 46 - 64 and 125 - 160 mbgl. The deeper aquifer is having fluoride content to the tune of 6 mg/l, whereas the fluoride content in the shallow aquifer is 0.4 mg/l (ie below the permissible limit of 1.5 mg/l). High fluoride concentration can be mitigated by dilution and artificial recharge techniques.

2.11 NER, GUWAHATI

The Ground Water Management Studies were carried out in Goalpara,Sonitpur,Dibrugarh, Nagaon (Assam), West Tripura (Tripura) and Papumpare (Arunachal Pradesh) and area covered 15000 sq.km.

2.11.1 Barpeta district & parts of Baksa district of Assam

The study area is located in the northern bank of Brahmaputra river comprises Barpeta district (2645 sq. km) and parts of Baksa district (655 sq. km) in Assam.

The general topography of the study area varies from low-lying plains to highland having small-hillocks. Tropical monsoon climate of the District provides two distinct seasons- summer and winter.

The River Brahmaputra flows from east to west across the southern part of the district. The tributaries of this river that flows through the study area are Beki, Manah, Pohumara, Kaldia, Palla, Nakhanda, Marachaulkhowa and Bhelengi flowing from north to south. Rivers Pohumara and Kaldia join near Barpeta town to form river Nakhanda whereas Palla and Beki join with Nakhanda to ultimately form Chaulkhowa River.

Out of total geographical area of 3300 sq. km approximately 1770 sq.km constitute net sown area forming 53% and of this 620 sq.km constitutes area sown more than once giving cropping intensity of 135%. The main crops of the district are paddy, wheat, rape, mustard, tea, lentil, green gram, black gram, potato, vegetables.

Hydrogeologically, the study area is covered by alluvial sediments of Recent to Sub-recent age. Depending upon hydrogeological set up the study area can be divided into three distinct hydrogeological horizons viz. Bhabar, Terrai and Flood Plain areas.

The Bhabar belt is underlain by pebbles, boulders with gravel and sand in clay matrix in the northern part of the land and is about 8-12 km wide. The second- Terai zone towards south, which is made up of medium to coarse sand down to 20 m and underlain by gravels and pebbles. The third horizon occurring immediately south of Terrai zone constitutes the Flood plain area and is composed of sands of various grades within thin clay intercalations. This zone constitutes almost single horizons with 90% of sand.

Ground water in the area is found to occur under water table condition with some local variations where its occurrences restrict to semi-confined conditions. Average depth to water level varies from 4 to 5 mbgl during lean period in major parts of the flood plain area. However, in a small portion of the northern part of the district immediately below foot hill zone covering Simla Anchali area, water level is less than 4 mbgl, perhaps this is due to occurrence of clay horizon at shallow depth giving rise to

perched water table conditions. In the extreme northern parts of the district in the Bhabar zone water levels are generally more than 10 m.

Exploration at Pathsala down to 40 m reveals potential aquifer horizon capable of supporting shallow tube wells of 30 m^3 / hr yield capacity. Tube wells constructed within 170 m at Keotkuchi and Bongaon taps 57 and 53 metres respectively of aquifer horizon and are found to yield more than 100 m^3 / hr for draw down of less than 6 metres. Transmissivity values obtained from the pumping test were found to vary from 5061 m^2 /day to 9942 m^2 / day with permeability of about 70 m/day.

More than 90% populace in the study area is agrarian with only little industrial development / growth. Ground water development in the study area is negligible. The farmers have either very little or no access to irrigation facilities in any form. A network of drinking water supply utilizing ground water sources has been developed by PHED, Govt of Assam at Panchayat / village levels the command area of which is yet to be expanded to about 3/4th of the total area.

Analysis of ground water samples collected from the study area with special reference to localities where new industrial set up are coming up and where pesticides are applied in the agricultural fields reveals no deviation from the norm of chemical quality. So far as earlier reports of CGWB refers to occurrence of fluoride in more than permissible limits in certain pockets in the study area, no manifestation of any form of fluorosis has been either observed or reported . However water samples from different sources have been collected for further chemical analysis to determine the present level of fluoride. Possibility of arsenic contamination has so far been withdrawn in the study area.

A network of 57 nos of key observation wells has been established in Barpeta and parts of Baksa Districts to study the water level regime in the study area. A perusal of the water level data shows that there is no depletion of water level so far.

2.11.2 Nalbari district & parts of Kamrup district (Rural), Assam

Nalbari District:

Physiographically, the study area can be divided into two units which are northern alluvial region and southern swamps or flood plains of river Brahmaputra. The alluvial parts form a flat land of 120 – 140 m above MSL with a gentle local slope towards the river Brahmaputra. The regional gradient is from E-W which is general flow direction of Brahmaputra River. Near the banks of the river, the elevation is only 5 – 10 m above river bed. This area is inundated during flood and the water is retained in swamps even after flood recedes.

Geologically, the area forms part of the great alluvial valley of Brahmaputra river of Assam and West Bengal. The district almost entirely comprise of older and younger alluvium of Quaternary Group of sediments.

Depth to water level ranges between 1.22 m bgl to 3.39m bgl in flood plains. In most of Northern and Southern parts of the district, the depth to water level lies below 2 m bgl. Hydrogeological data of Shallow aquifers in the district is studied in existing dug wells of 7-12 m depth. A thin soil and clay cover generally occurs over sand and gravel mix alluvial aquifers. Water level in the plain ranges from 2-6 m bgl, hence 7-12m deep dug wells have 3- 6 m saturated zones. Hydraulic parameters of shallow aquifers are good, and dug wells can yield ground water of 50-100 m^3 per day. The rate of infiltration is about 34 mm/min in recent alluvium and 0.4mm/min in alluvial fans. Aquifer parameters of shallow aquifers are more or less uniform along northern bank of Brahmaputra River and their hydraulic conductivity value ranges from 25 to 50 m/day.

Data of exploratory tube wells constructed by the Central Ground Water Board and State Agencies show that no hard rock basement is encountered and alluvium occurs down to the depth of 200m. Water level in deeper aquifers varies from 3.00 to 3.92 mbgl and for a drawdown of 4 to 10m, the discharge recorded for the deep tube well is 100 to 150 m^3/hr.

Kamrup District (Rural):

Physiographically, the study area in parts of Kamrup District (Rural) can be broadly sub-divided into three generalized units i.e. hills (hilly tracts of Shillong plateau occurring in southern and eastern parts and sporadic inselbergs), plains (valley fills as well as alluvial tracts with elevation ranging from 45m to 60m amsl) and marshy lands (Low relief areas)

Drainage pattern has been studied by preparing drainage map of the area. Study of drainage patterns shows that apart from the river Brahmaputra, the initial order streams (1st to 3rd order) show three distinct drainage patterns, namely Dendritic, Radial and Directional Trellis Pattern. Based on drainage pattern study, it can be interpreted that hill ranges of the study area are structurally controlled as evidenced by presence of trellis pattern

Based on morphogenetic and hydrogeological properties along with relative ground water potentialities, the subsurface lithology can be broadly grouped into two major hydrogeological units *i.e.* a) Crystalline formations and b) Granular formations. The Crystalline Formations comprising granite gneiss, biotite gneiss, amphibolites *etc*., are predominant at shallow depth mostly in eastern and southern parts and are sporadic at central and northern parts of the study area. They are characterised by a weathered layer (zone C) at top, followed by a semi-weathered layer (Regolith) containing pebbles and boulders of basement rocks (zone B) and fractured rocks (zone A). Ground water occurs in the weathered zone under water table conditions. Depth to water level ranges from 5-15 m bgl during pre-monsoon period. On the other hand, ground water occurs under semi-confined to confined conditions in the fissured and fractured part of crystalline formations (within Zone A) at various depths.

Pre-monsoon water level varies from 0.95 mbgl (Chamaria) to 5.10 mbgl (Dirgheswari Temple) and that post-monsoon varies from 1.22 (Chamaria) to 6.38 mbgl (Dirgheswari temple) for phreatic aquifer. Pre-monsoon water level for semi confined aquifer varies from 1.02(Panitema) to 6.47 mbgl (South Mandakata) whereas post-monsoon water level varies from 1.28mbgl (Panitema) to 26.47 mbgl (South Mandakata) in the district.

2.11.3 Bongaigoan district & parts of Dhubri district, Assam

Ground Water Management Studies were carried out in an area of 3511.10 sq. Km in Dhubri and Bongaigoan districts of Assam. The area falls in lower part of Brahmaputra river basin. The study area is drained by major rivers viz, Champamati;Manas; Aie;Gangadhar;Gadhadhar;Sonkosh and Gaurang.

Physiographically, the area forms a part of a alluvial plain with flat topography with isolated hillocks. The general elevation varies from 25 to 455 meter above msl.The area experiences subtropical humid climate and receives a normal annual rainfall in the range from 2062 (Dhubri) to 4021 mm (Bongaigoan) The net sown area covers 52% in Bongaigoan and 55% in Dhubri district. The total irrigated area by all sources is 4364 ha in Bongaigoan district and 6765 ha in Dhubri district.

The area underlain by two distinct formation viz, Pre Cambrian granite gneiss and Quaternary alluvial deposits. Ground water occurs under phreatic, semi confined to confined conditions. Depth to water level during pre monsoon period varies from 4.45 to 17.80 m bgl and 3 to 17.20 mbgl during post mon-soon period.

As per GEC 1997 as on March, 2004, the total annual ground water recharge in Bongaigaon and Dhubri districts are estimated to be 94,774.28 ham and 66,935.91 ham respectively. Out of which the net annual ground water availability for Bongaigaon and Dhubri districts are estimated 90,030.94 ham and 63,381.24 ham respectively. The existing stage of ground water development is categorized as safe. Ground water in general is good and potable, while in some areas hardness, iron, fluoride and Nitrate contents are high.

2.11.4 Dhalai district, Tripura state(Mapping of Current availability of ground water of artesian belt)

In course of the survey, artesian zones are found in Salema, Ambasa, Dumburnagar, Manu and Chawmanu blocks of Dhalai district, Tripura. Valley-wise and block-wise brief description of artesian zones has been shown in table

Artesian wells in the district tap mainly deeper granular zones (between 60 – 200 mbgl), except a few artesian wells tap shallow granular zones (within 50mbgl) in Kamalpur valley. Aquifer-wise details of artesian zones are given below:-

- Groundwater occurs under flowing (confined) condition within shallow depths in some areas like Abhanga and Lambucherra of Salema block in Kamalpur valley. In deeper aquifer, groundwater occurring under flowing (confined) condition are found in Bhatkhowri to Bilascherra (eastern bank of Dhalai river); in Ambasa, Jagannathpur area of Kamalpur valley, Harincherra, Jagabandhu para area of Gandacherra valley and Manu, Nepaltila, Khetricherra, Durgapur, Chawmanu areas of Manu valley.
- Artesian wells tapping shallow aquifer (granular zones) are reported to be constructed within a depth range of 35 – 75 mbgl. The piezometric head in wells varies from 0.10 to 4.97 magl. Discharge varies from 0.4 to 2.9 m^3/hr during pre-monsoon and from 0.2 to 3 m^3/hr during post-monsoon.
- Artesian wells tapping deeper aquifer (granular zones) are reported to be constructed within a depth range of 95 – 326 mbgl. The piezometric head in wells varies from 0.25 to 4.10 magl. Discharge varies from 0.1 to 9 m^3/hr during pre-monsoon and from 0.7 to 32 m^3/hr during post-monsoon.

Findings and Recommendations:

The artesian wells are having limited use in Dhalai district for irrigation, drinking, domestic and fishery purposes. Artesian wells with good discharge i.e., 2 to 9 lps is found but most of this water is going unused and flowing through the streams / rivers. As this water is available for 24 hours throughout the year, if arrangements are done to store this water from deep artesian wells then drinking water for another 4000 to 8000 persons (@ 100 lpcd) can be catered or 4 to 8 ha of paddy land can be brought under assured irrigation. Until some measures are taken to use this water properly and to arrest the wastage of water, parapet of the tubewells should be increased, for shallow artesian wells it should be increased by an average of 1.5m agl and for deep artesian wells it may be increased by 2 to 4m agl. This holds good for upcoming tubewells also which are turned out to be free-flowing artesian wells.

Groundwater discharging from the artesian wells contains high concentration of iron. Iron should be removed before put into use.

Rainwater harvesting should be encouraged, particularly in hilly terrains. Rainwater harvesting structures constructed on the boundaries or edges of artesian zones will not only help in maintaining the flow but also providing irrigation water during crisis and can be used for fisheries.

Table : Valley-wise and block-wise salient data of artesian zones in Dhalai district

Block	Shallow artesian zones / wells				Deeper artesian zones / wells			
	Depth of construction (m bgl)	Piezometric head (m agl)	Discharge (m^3/hr)		Depth of construction (m)	Piezometric head (m agl)	Discharge (m^3/hr)	
			Pre-monsoon	Post-monsoon			Pre-monsoon	Post-monsoon
Kamalpur Valley								
Ambasa	–	–	–	–	125 – 256	0.40 – 4.00	0.1 – 7.2	0.7 – 9.0
	Tubewell with smaller dia 1 to 4 inches				80 – 110	0.15 – 2.05	0.8 – 2.6	0.8 – 3.3
Salema	35 – 75	0.10 – 4.97	0.4 – 2.9	0.2 – 3.0	95 – 219	0.28 – 4.10	4 – 21.6	3.2 – 32.4
Gandacherra Valley								
Dumburnagar	–	0.70	0.3	–	–	0.25	9.1	–
Manu Valley								
Manu	–	–	–	–	119 – 171	0.55	–	–
Chawmanu	–	–	–	–	126 – 326	0.76	0.2	0.1

2.11.5 Jaintia Hills District, Meghalaya(Hydrology in mining areas)

The study area is located in the Jaintia Hills District about 60 Km. From the State capital of Meghalaya i.e. Shillong.The total area covered under this study is 1151 sq. Km.

Geologically , the area under study consists of Quartzite belonging to Shillong group of rocks and sedimentary rocks belonging to Tertiary group. Coal extraction in the area is done mainly by applying primitive mining method commonly known as "rat hole mining". Most of these mining activities are small scale ventures controlled by individuals who own the land. The main coal bearing areas are Jarain and Shkentalang under Amlaren block. The coal seam are found to be embedded in sedimentary rocks (sandstone and sand) of the Eocene age. Large scale denudation of forest cover, scarcity of water, pollution of air, water and soil and degradation of agricultural land are some of the environmental implications of coal mining.Development of ground water in the district is still in nascent stage. The narrow, linear valleys and intermontane valleys offers scope for development of ground water.The depth to water level varies from 2 m to .50 m bgl and the spring discharge from 5 lpm to 60 lpm.Results of the previous study carried out by different organization reveals that majority of rivers and streams in the mining areas are affected by contamination of acid drainage. The influx of acid water oozing out from mines into the rivers and streams are mainly responsible for degradation of water quality and aquatic habitat. Others parameters which characterized the degradation of water quality are low pH, high conductivity, high concentration of sulphates, iron and toxic metals, low dissoleved oxygen. Following measures are suggested to mitigate the environmental problem and improvement of water quality:

1) Scientific method of coal mining and disposal of mine water as well as soils.
2) Filling of mine pits, channeling of seepage water for checking " Acid Mines Drainage" contamination of water bodies.

3) Extensive afforestation and vegetation on coal mines areas is an important step of ecorestoration.
4) Conservation of top soil is essential for plant growth and agricultural productivity.

2.11.6 East Khasi Hills district, Meghalaya(Development of water supply through springs)

During the survey, an area of 2560 sq. km. Has been covered in East Khasi Hills district. The total area of East Khasi hills district is 2748 sq km with a population of 660994 (Census 2001). The district is famous for its picturesque natural beauty, congenial climate attracting large numbers of tourists and immigrants. The water supply is mainly catered by state Government agencies like Shillong Municipal Board (SMB), Public Health Engineering Department (PHED) and local community called *Durbar*. Within the Municipal area, Shillong Municipality supplies water from its seven water sources (both spring and surface water) namely Wahrisa, Wahjalynnoh, Crinoline, Umjasai, Madan laban, Patta khana and Wahdienglieng. PHED provides drinking water through piped water supply scheme (Greater Shillong water supply scheme I and II) and spot sources schemes. Piped water supply schemes can be river pumping, gravity feed spring/stream source and deep tube well, whereas spot sources are hand pumps, ring/dug wells and springs.

Springs are common in East Khasi hill district acting as an important source of water. These are tapped by

a) Constructing a weir and the spring water is conveyed by gravity to a conventional sedimentation, filtration type treatment plant and distributed by network of pipelines and public distribution taps.
b) Constructing a chamber at the mouth of the spring called as spring tapped chamber (STC) and water being collected without treatment.

A total of seventy springs were studied covering all the eight blocks and the discharges of those possible springs were monitored in pre monsoon and post monsoon period. To assess the water quality of the spring, totally thirty-five water samples (for both partial and iron) were collected and submitted to chemical laboratory, NER, Guwahati for analysis. The results of the analysis are awaited.

Findings:

1. There is old age practice of protecting seepages (locally called as *pung*) and springs (referred locally as *sniar*) by constructing concrete weir or chambers.
2. Majority of the springs were spring tapped chambers (STC) type where a concrete chamber is constructed at the mouth of the spring to protect the water from pollution. Some untapped and undeveloped springs are also observed.
3. Springs are developed by state government agencies, missionaries, NGOs, local durbars or through MLA sponsored schemes.
4. The occurrence of spring is observed in various geological formations. Majority of the springs are concentrated types that occur along hillsides in mountain and piedmont areas at points where groundwater emerges naturally from openings of the country rock.
5. In most of the cases, the spring water is used for drinking and washing of clothes. In some, spring water is diverted to the adjacent farms for irrigation.
6. The pre monsoon and post monsoon discharge of the spring varies from (0.03 to 3.0) lps and (0.5 to 3.3) lps respectively.
7. In the dry period, some of the high discharge springs also showed low discharge and some were reported to be dry.
8. There is not much variation in the pre monsoon and post monsoon temperature of the spring. It ranges from 15 to 24°c.
9. There is no proper storage tank for storing the water flowing out from the spring. Most of its flows downstream washing the topsoil cover thereby affecting the fertility of the soil.
10. Washing of clothes is very common in the vicinity of the spring. This poses a threat to the quality of water nearby and further downstream.
11. The chambers of some of the developed spring are not cleaned properly. In come places, there is algal growth or film of detritus is seen deposited. This water when consumed for drinking can cause water borne disease.
12. It has been found that treatment plants like Iron removal plant (IRP) are in use for river, deep tube well water supply schemes, whereas there is no treatment plant for the water that is tapped from spring,
13. Wherever springs are not developed, untapped water is flowing out. This leads to water wastage.
14. Dumping of solid wastes in the surface water adjacent to the spring is observed in Mawpadang (91°52'31", 25°35'11"), Laban (91°52'46", 25°34'02") etc. This trend is mostly reported from

the urban areas of Mylliem block that can lead to water pollution.

15. In some catchments areas of spring, shifting cultivation, deforestation is going on unchecked.
16. Some of the high yielding springs are laid with excessive pipes due to water disputes between different communities or adjacent villages. This decreases the water pressure and leakage if any leads to water wastage.
17. Some spring lines are reported in Jongska (91°58'46", 25°28'8") which are already developed whereas in localities like Mawpat Wahtieh under Mylliem block, (91°55' 42", 25°35'44", 91°55' 50"25°35' 57") , Sohryngkham, Mawutieng under Mawkynrew block (91° 58' 19", 25° 32' 59", 91° 58' 04"25° 32' 57") can be developed further.
18. Proper scientific utilization and management of spring can be adopted in some springs. For eg Umsawli, Mawpat pyllun (91°57' 08", 25°36' 43") etc.
19. Commercializations of high yielding springs are taking place where private tankers are supplying water at an exorbitant price to the public. For e.g. is Demthring (91°54' 06", 25°32' 08") along National highway 44, Mawdatbaki Umjan (91°53'37", 25° 36'02") near NEHU, . In some localities, washing and servicing of vehicles are also taking place.
20. There is lack of awareness about management and conservation aspects of spring water among local people.
21. There are many spot and piped water supply schemes that are not working efficiently leading to water scarcity at places.

2.12 SR, HYDERABAD

The Ground Water Management Studies were carried out in Khammam, Nizamabad, Prakasam, East Godavari, Ranga Reddy and Mahabubnagar districts and area covered 10375 sq.km.

2.12.1 East Godavari district (Polavaram Irrigation Command)

The objective of the study was to generate base line data and bring out pre project ground water scenario for future evaluation and assessment of impact of the project in the command area.The study are covers Twenty-two Mandals, which forms middle part of the East Godavari district starting from Rajahmundry in the West to Tuni in the East, which also forms part of Polavaram left bank command area. These manadals are; Sithanagaram, Korukonda, Rajanagaram, Rajahmundary (u) & (r), Rangampeta, Gandepalle, Jaggampeta, Kiralampudi, Gollaprolu, Peddapuram, Pithapuram, Prathipadu, Shankhavaram, Tuni, Kadiam, Anaparthi, Biccavolu, Mandapeta, Samalkota, Kotanandru and Rayavaram.

The study area is underlain by granite gneiss, charnockites and khondalites in western part whereas southern part is underlain by soft rocks consisting of sandstone and alluvium.. The depth to water levels (DTWLs) are shallow, <2 meter below ground level (m bgl) in the southern part especially in areas closer to existing Dawleshwaram barrage canal. In the uplands the DTWLs vary from 3 to 6 mbgl. Ground water in the soft rock formation occurs in phreatic conditions with depth of weathering and potential zone extending down to 15 to18 mbgl and yields of the wells range from 5 to 8 lps. In hard rock terrains, which occupy northern part, the DTWLs are moderately deep (8 to 9 mbgl in some cases), depth of weathering is shallow <10 m bgl, fracturing and potential zones extend down to 60 to 80 mbgl, discharges of wells range between 3 and 5 lps. Since the proposed main canal lined there is no possibility of water logging and creating impact on the existing ground water scenario. There could be a rise in DTWL in the range of 0.5 to 1.5 m in upper command areas (present uplands) but possibility of development of water logging condition in Southern parts is very high. In general, ground water quality is good.

2.12.2 Chittoor District:

The objective was to generate base line data and to evolve at suitable strategies to address the Farmers' distress. The study area consists of 18 over Exploited mandals viz; Nagari, Nindra, Vijayapuram, Palasamudram, S. R. Puram, Vedhurukuppam, Vadmalpet, Puttur, Nagalapuram, Karvet Nagar, Sri Kalahasti, Thottambedu, B. N. Kadiggai, Pitchattur, Narayanavanam, Satayavedu, Varadaiahpalem and K. V. B. Puram of Chittor district covering an area of 3560 Sq. km.

The area is underlain by granites and genisses of peninsular complex of Archean age. Depth of weathering varies from 3 to 15 m bgl. Ground water is being developed by bore wells/dug wells ranging in depth from 60 to 120 mbgl and 8 to 15 m bgl respectively. The yields of the bore wells range from 1 to 5 lps. The upper unconfined aquifer is de-saturated due to over-exploitation. Deepest water levels of 34 m bgl and shallow water levels of 2 to 5 mbgl have been noticed in R.S. Puram and Satyaveedu Mandals respectively.

Ground Water pollution in Nagari Mandal due to textile dyeing industry is identified. Electrical Conductivity of

Ground Water varies from 3,500 to 4,000 micro siemens/cm at 25°C. Demarcated the area affected by pollution.

The socio-economic conditions of farmers become worse in the study area due to frequent failure / delayed monsoon/Reduction in crop yield/Dwindling of ground water resources/Failure of bore wells/Re-investment for digging of new/additional bore wells

Mainly the agricultural activities of farmers depend on institutional finance. The loans could not be repaid due to unforeseen worse economic problems. Unfortunately the debt ridden farmers committed suicide. Deterioration of groundwater resources is one of the causes of farmer's distress and suicidal cases. Immediate measures may be taken to control the situation.

1. Before drilling of bore well, the site should be selected scientifically and should be certified by the state ground water department to avoid failures of bore wells.
2. Bore well / crop insurance schemes may be planned.
3. Water conservation techniques like sprinkler / drip irrigation may be implemented.
4. Artificial recharge may be implemented for recharge of ground water.
5. More awareness may be created for adopting artificial recharge of groundwater by media and individual programs
6. farmers participatory program for development/ management of ground water resources in each village may be encouraged and awards / incentives may be given for best agricultural practices, water conservation and recharge.
7. CGWB is constructing artificial recharge structures (Check dams and Percolation Tanks - 20 Nos.) under Central Sector Scheme.

2.12.3 Ravirala watershed, Maheswaram Mandal, Ranga Reddy District

The objectives was to generate baseline data in the proposed industrial corridor area,to prepare vulnerability map of the area and to suggest appropriate measures, to evolve management strategies for sustainable development of ground water and protecting ground water quality from the probable pollutants and impact on environment. The study covers the Ravirala watershed falling in the Survey of India Toposheet No.56 K/8 & 56 K/12.It forms the part of Maheswaram Mandal, Ranga Reddy District, Andhra Pradesh.

The general slope of the area is towards North-East and the drainage in the area is dendritic to sub-dendritic. The area is drained by Musi river, which is tributary of Krishna river. The average rainfall in the area is 738 mm.The major part of the area is occupied by red and sandy soils. The soil thickness in the area varies between 0.4 and 5.0 m The area is underlain by granites of gneisses of Archaean age.

The pre monsoon DTW varies between 8.05 and 33.42 m bgl. The post monsoon DTW range between 6.412 to 23.99 m bgl. The seasonal fluctuation in the water level ranges between 10.17 and 14.12 m. The weathered position thickness varies from 6.0 to 18.0 m. The depth range of the bore wells ranges between 3.0 and 190.0 m bgl. The piezometric heads in bore wells varies between 8.1 and 27.07 m bgl. The discharge of the wells varies between 2.0 and 5.0 lps. The capacity of the pump lowered ranges between 3 HP to 7 HP and the depth of lowering varies from 24.0 to 50.0 m bgl. The infiltration coefficient ranges from 2.9 to 19.2%.

The quality of ground water is good, in general. pH ranges from 7.28 to 8.25. The EC (µS/cm at 25°C) of formation water ranged from 404 to 3470. The chloride values range from 14 to 553 mg/l. The concentration of fluoride ranges from 0.13 to 2.3 mg/l. Fluoride concentration is more than the permissible limit of BIS is recorded at Hardware Park.

2.12.4 Mahabubnagar District:

The objectives of the Study was to fine-tune/improve the existing groundwater estimation parameter norms/methodology for quantitative assessment of ground water resources of the watershed. The Study area covers MBNR-D-44-Tarnikal watershed (Madharam basin)' consisting of 9 villages in Midjil and Kalwakurthy mandals.

The DTW varies from 11.1 to 31.73 m bgl during pre monsoon and from 4.44 to 25.44 mbgl during post monsoon. The seasonal fluctuation in water levels varies from 6.3 to 6.7 m. Daily rainfall monitored and during the year through outsourcing from the established rain gauge station at Urulonda village. Monthly abstract of the rainfall is given below. The normal annual rainfall is about 620 mm and during the year about 724.5 mm of rainfall occurred which is an increase of about 17% rainfall above the normal.

Water levels were monitored at regular intervals in the irrigation tank at Madharam village which is located at the discharge area of the watershed. The measurement is connected with mean sea level.

Soil consists of sand + silt + clay in varying proportions. Sand % varies from 59 to 75 %, silt from 2.8 to 5.4% and clay from 22.3 to 36% in the study area. The specific yield was calculated by various suitable methods according to the geology of the area. The average specific yield of the area is calculated to be around 0.36%.

Site	Infiltration rate (cm/hr) & (%)	Soil type	Area
Bommarajpally	11.3 (15.2%)	Red clayey sand	Recharge
Urukonda	11 (20%)	Red clayey sand	Recharge
Ramreddipally	9.2 (19%)	Red clayey sand	Transient
Timmanapally	0.1 (0.5%)	Red clayey sand	Transient
Madharam (Tank)-right bank	3.80 (11%)	Red clayey sand	Discharge
Madharam(Tank)-left bank	0.30 (1.2%)	Red Clayey sand	Discharge
Velikatta	1.9 (8%)	Red clayey sand	Discharge

Tracer Studies, in association with NGRI, was conducted. During the study, vertical soil samples, at 20 cm interval (depth-wise), were collected using recovery pipes (Hoffer type augers) of 45 cm diameter up to 3 m during post-monsoon season or after post harvest. Samples were collected from 7 sites only (3 rain fed and 4 Irr. Paddy). The net recharge values obtained are given below.

Natural Recharge (%)		Recharge from Irrigation Return Flow (%) (Through GW) (For A Applied 5750 M^3 Of Ground Water/Acre)	
Recharge Area	Discharge Area	Recharge Area	Transient Area
8 to 14 Avg. 11	2	4 to 24 Avg. 14	6 to 28 Avg. 17

The specific yield (Sy) plays an important role in estimation of ground water resources of any basin/watershed. The average Transmissivity and specific yield determined for the watershed with the pumping tests conducted are given below.

Location	Transmissivity (T) (m^2/day)	Sy (%)	Method used for analysis of the data	Remarks
Bommarajpally Well field-1	107	1.75	Jacob's and Ramsahoye and Lang	Recharge Area Estimation of Sy by other methods is under progress
Bommarajpally Well field-1 (low yield)	58	1.65	Distance Drawdown	Do
Bommarajpally Well field-2	22	1.4	Distance Drawdown	Do
Urukonda	110	1.96	Jacob's	Shallow Aquifer Estimation of Sy by other methods is under progress
Urukonda	102	1.54	Jacob's	Middle Aquifer Estimation of Sy by other methods is under progress
Urukonda	106	1.3	Jacob's	Deeper Aquifer Estimation of Sy by other methods is under progress
Madharam	50 Average of all	0.36 Average of all	Boulton's, Jacob's, Theis, Distance Drawdown and Ramsahoye and Lang	Discharge Area

Out of 27 samples in 12 samples the fluoride concentration is above the maximum permissible limits of BIS (2003) 1.5 mg/l. The maximum concentration of 3.22 mg/l is encountered at Ramreddi pally village. The NO_3 in 13 wells is beyond the maximum permissible limits of 45 mg/l. The maximum concentration of NO_3 i. e, 270 mg/l is encountered at Urukondapeth village. The total hardness in 2 wells is beyond the maximum permissible limits of 600 mg/l. Magnesium in one well is beyond the maximum permissible limits of 100 mg/l. The other parameters are within the maximum permissible limits of BIS (2003).

2.12.5 Coastal aquifer management in parts of East Godavari District

The objective was to study Coastal Aquifer Management and to decipher sub-surface geometry and bring out fresh-

salt water interface.Ground Water Management Studies in the coastal aquifer in East Godavari district covering 13 mandals viz; with an area of approximately 1642 sq. kms. was continued in the Current AAP. This area covers part of Godavari delta and covers approximately 250 kms. of coast line.

This area is underlain by coastal and deltaic alluvium of Recent age. The ground water occurs under un-confined and confined conditions. Three aquifers were delineated in the area within a depth of 100mbgl. First aquifer which is unconfined in nature extends up to a depth of 18m bgl and the second aquifer is from 20 to 62mbgl and the third aquifer lies between 66 and 95 m bgl.

The pre-monsoon water level lies from 1.58 at S.Yanam to 7.30 m bgl at Lankala Gannavaram. The pre-monsoon ground water temperature varies from 29 to 34°C. In general, the Electric Conductivity(EC) varies from 380 (µS/cm at 25°C) observed at Sarpavaram to 13222, at S.Yanam. The exceptionally high values of EC were observed at Gachchakayala Pora (6630), N. Kothapalli (8010), Gollapalem (6060), Dinda beach Road (7800), S. Yanam (13220), N. Rameswaram (11000), A. Kothapalli (8980). In general the salinity in the area is found to increase during the season.

The post monsoon water levels vary between 1.07 m bgl, at Gachchakayal Pora, and 7.09 m bg,l at L. Gannavaram. The ground water temperature varies from 28 to 31°C. The E C values vary from 370 (µS/cm at 25°C) at Sarpavaram to 16870 at Dinda Beach road. The exceptionally high values of EC are noticed at Gollapalem (9250), Dinda Beach Road (16870), Kandikuppa Light House (12920), S. Yanam (11480), N. Rameswaram (11000), A. Kottapalli (10800). In general, the salinity in the coastal tract has increased.

Even though the groundwater in the area is considered saline, fresh ground water resources are available in the first aquifer which can be abstracted for various uses. Being the command of Major Irrigation Project, the ground water requirement in the area is less. Even then conjunctive use of surface water and ground water may be planned in some parts of the area to prevent the adverse effects of surface water irrigation. Coastal Area being very sensitive in nature, construction of well and heavy abstraction of ground water in the scarce season may be restricted considering the consequential effects.

2.12.6 Visakhapatnam District

The objective was to assess changes in hydrogeological environment due to intensive urbanization and the impact of climate changes. The study area is a part of Visakhapatnam district which is located in northeastern corner of Andhra Pradesh State. The district is bounded by Bay of Bengal in the East. The area bordering this urban area are Gajuwaka, Pedagantyada, Visakhapatnam (rural), Bhimunipatnam (part), Pendurti (part) and Paravada (part) mandals.

To know the behavior of ground water level scenario, 59 key wells were established in the study area and water samples collected to know the in chemical quality. Acidified samples were collected in industrial areas. A number of large and medium size industries are located in the area, including Steel Plant, Hindustan Zinc Ltd., BHPV, Coromandal Fertilizers, L.G.Polymers, Visakhapatnam Port Trust and HPCL. The climate of the study area is characterized by high humidity throughout the year. The mean annual rainfall is 982 mm, SW monsoon contributes 65% total rainfall. The area has 4 major hill ranges viz., Kailasa, Yarada, Narava and Kambhalakonda which is characterized by undulating topography. The area is mainly drained by Hanumanthavaka, Narvagedda, Peddagadda and other minor streams which are having their origin in adjoining hills. The area forms a part of Eastern Ghat tectonic complex of Archaean age consisting of Khondalities, Charnockites, and Migmatite group of rocks. These are overlain by laterites of sub-recent age. The un-consolidated sediments of recent age comprise red sediments, stream born Alluvium, Colluvium and coastal sand.

Findings: Ground water occurs under water table conditions in weathered residuum and under semi-confined to confined conditions in deeper fracture zones. The thickness of weathering varies from 4 to 20 m, in general. The weathered zone is porous and extends to deeper levels in Khondalites as compared to other formations. The ground water abstraction is mostly through dug wells or shallow bore wells. The ground water is used mostly domestic purpose. The depth of the dug wells ranges from 2 to 22 mbgl while the general depth in between 7 and 12 mbgl. The depth of bore wells ranges from 15 to 80 mbgl and their yields are between from 0.5 and 3 lps. Higher yields are observed in Khondalites than in quartz-feldspathic gneisses and Charnockites. The unconsolidated sediments in MVP area and Sandy aquifers in old city area are good aquifers. However, the ground water development is restricted to shallow zone only.

In the areas close to Kailasa hills and Waltair highlands the water levels are found to be deeper. The ground water exploitation is done through deep open wells and bore

wells. In areas like MVP colony, Isukathota, parts of Lawson's Bay, Mudusarlova valley ground water prospects are good. In industrial areas like R.Venkatapuram (L.G. Polymers), Mindi, Chukkavanipalem (Hindustan Zinc Ltd.,) the ground water is found to be highly contaminated. In port and surrounding areas, the ground water has been contaminated initially due to sea water and subsequently due to industrial effluents. The domestic pollution is high in urban residential localities.

2.13 SER, BBSR

The Ground Water Management Studies were carried out in Parts of Sambalpur, Anugul, in parts of Kendrapara, Jagatsingpur, Cuttack and remote sensing studies in Jajpur districts and area covered 10115 sq.km.

2.13.1 Parts of Sambalpur District (Ground Water Resource estimation) :

A detail hydrogeological survey was carried out in 5 blocks – (i) Dhankauda, (ii) Maneswar, (iii) Jujumura,(iv) Kuchinda & (v) Jamankira covering an area of about 3000 sq.km

Physiographically, the area has two divisions Undulating plains with isolated hillocks and mounds occurring in Dhankauda, Maneswar & Jujumura blocks and Hilly terrain with intermittent valleys mainly in Kuchinda and Jamankira blocks. The area falls in Mahanadi basin and tributaries of Mahanadi controls the drainage pattern in this area. Normal Rainfall in the area is 1527 mm and the average annual rainfall as observed from the available data is 1789 mm in the study area.

Geologically, the major part of the area is underlain by Pre-Cambrian formation composed of granite, granite-gneiss, khondalites, charnockites etc. Lower Gondowana formation composed of shale, sandstone etc. occurs at isolated patches. Laterites occur as thin capping over the country rocks mainly in up landed. Recent alluvium occurs along the prominent drainage channels.

To observe the ground water regime, a total of 70 observation key wells (NHS – 35 nos & established key wells – 35 nos.) were monitored during pre and post monsoon periods in 2009. The average pre and post monsoon water levels were found in the study area as 5.84 mbgl and 3.222 mbgl respectively with an average water level fluctuation as 2.62 m.

To evaluate ground water resources through recharges, GEC -97 methodology was adopted which becomes equal to 388.71 MCM in the study area covering 5 blocks.

Based on water level fluctuation method, the ground water resources in the study area is estimated as 226.79 MCM; and based on straightway rainfall infiltration method, it is estimated as 369.39 MCM.

Considering the 'Net' and 'Utilizable'(60% of net) ground water resources for future irrigation development in the study area as 344.58 MCM and 206.75 MCM respectively, the number of feasible ground water structures (dug wells) is determined as 32,300 and thereby creating additional irrigation potential as 426.4 sq. km. at an estimated cropping intensity of 200 percent.
As such, there is no major ground water problems except water logging at a few isolated pockets in the canal command area and fluoride contamination in ground water slightly at higher side, but within permissible limit at one or two places in the study area.

Regarding scope of artificial recharge structures in the water scarce areas during lean period in isolated pockets particularly in hill slopes suitable artificial structures are feasible to increase the ground water storage.

2.13.2 Parts of Angul District (Mining areas).

Angul district is situated in the central part of Orissa and spread over an area of 6232 sq.km. The district is bounded by Deogarh district in the north; Khondhamal, Nayagarh and Cuttack district in the south. Dhenkanal & Keonjhar in the east and Sambalpur and Suvarnapur in the west.

The area which is covered for the Ground Wayer Mangement studies include Angul, Banarpal & Talcher block covering 3000sq. km. The coal mining activities are centred around Talcher and spread over an area about 1814 sq.km. The anticipated resource is about 44,309,43 million tones comprising of all grades of coal. Out of this reserves of 5,207 million tones have already been proven. There are four underground mines namely Nadire, Handiduha, Deulbera and Talcher and 7 open cast mines at Balanda, Jagannathpur, Ananta, Kalinga, Bharatpur, Lingaraj and Hingua are in the area. 83 key wells have been established and depth to water level data for premonsoon were collected.

2.13.3 Parts of Anugul District (Industrial areas):

Ground Water Management studies in parts Angul District with special reference to mining areas was assigned during APP 2009-2010. Detailed hydrogeological studies were carried out in 3000 sq.km. area. During Pre-Monsoon 2009 86 no. of observation wells were established and ground

water samples were collected for detail as well as trace element analysis. More wells were established in mining areas to study the impact of mining on ground water. The observation wells were monitored during Post-Monsoon. Field data were collected from CMPDI, RWSS, PHED, Minor Irrigation and Irrigation departments. Data were compiled and various maps were prepared. Report writing is under progress.

2.13.4 Irrigation scheme in Mahanadi in parts of Kendrapara, Jagatsingpur and Cuttack dsitrict

Ground Water Management Studies in Parts of Mahanadi Delta Stage – I Irrigation Command spanning across Cuttack, Jagatsinghpur, Kendrapara districts of Orissa Project was taken up under the sub-head of conjunctive use studies. The above mentioned study area is bounded within the latitudes of 19° 59′ to 20° 31′ north and longitudes of 85° 46′ to 86° 47′ east and covers approximately 3815 sq. Kms.

The main objectives of the Ground Water Management study (conjunctive use of surface water and ground water) in the Mahanadi Delta Stage -1 are

i. Evaluation of Hydrogeological situation and quantification of the different components of water balance in the canal command area.
ii. Identification of the critical areas of water logging, water scarcity in tail end areas(if any) and soil salinity
iii. Identification and evolving a suitable plan for controlling the problems of rising water table(if any) in the study area and providing irrigation water to the water scarce areas in the tail end by adopting the technique of conjunctive use of surface water and ground water and proper drainage.
iv. Preparation of suitable plan(sector wise if needed) for development of ground water resources in conjunction with surface water

Problems Reported in the Study Area:

During the course of previous pilot scale studies undertaken by the various State Govt. agencies in collaboration with other scientific agencies like NRSA, Hyderabad(using remote sensing techniques – thermal infrared data) and also from the studies carried out by CGWB, the following problems have been reported to be occurring in the study area

(i) **Water Logging :** As per the available data the extent of water logging was delineated and classified based on their seasonal occurrence. These water logged areas were classified as perennially water logged, seasonally water logged, marshy lands and mangrove.

(ii) **Soil Salinity Affected Areas :** As per the pilot scale studies conducted by NRSA, Hyderabad, it has been reported that soil salinity affected areas of the command areas are confined to the coastal plain and adjoining low areas. They have classified them into two kinds – Slightly Saline and Moderately Saline. As per their report the development of soil salinity is basically due to the proximity to the sea. The ingress of saline sea water during high tides through creeks and cyclonic storms impregnate the land with sodium chloride which is the primary cause of soil salinity.

Ground Water Scenario in the Command Area – Current Study

Under the Annual Action plan of 2008 - 10, the Ground Water Management Studies to study Conjunctive use of surface water and ground water in parts of the Mahanadi Delta Stage –1 was taken up.

Regular monthly monitoring have been carried out for the months of - May 2008 to November 2009. Monthly monitoring of water level shows that most of the area remains affected by water logging. Comparing and averaging the water level data of both the years, in the Pre-monsoon about 858.75 sq. km i.e., 22.5% of the total study area is water logged (depth to water level 0 – 2m) and about 1710.45 sq. km. i.e., 44.8 % of the total study area is prone to water logging (depth to water level 2 – 3m). Maximum of this water logging condition is found in the area that lies between the rivers Mahanadi and Kathajodi and few patches near the coast. Where as in the post monsoon however the extent of water logging increases to 2708 sq. km area i.e., around 70.9%(almost the entire Jagatsinghpur district) and area prone to water logging is about 683 sq. km i.e., roughly 17.9% of the study area. The average Pre and post monsoon water level maps are shown in plate.

Depth to Water Level in mbgl	Pre-Monsoon Average		Post-Monsoon Average	
	Area in Sq. Km.	%	Area in Sq. Km.	%
0 - 2	858.80	22.51	2708.00	70.98
2 - 3	1717.00	45.01	683.10	17.91
3 - 5	1134.00	29.72	359.20	9.42
5 - 10	105.20	2.76	64.70	1.70
	3815.00	**100.00**	**3815.00**	**100.00**

Conjunctive Use of Surface water and Ground Water

The major problem in the study area is not any scarcity of water but instead there is plenty. Conjunctive use is planned for optimal usage of surface and ground water and like wise alternate cropping patterns are suggested to avoid stress on any of the components and to prevent water scarcity as well as water logging conditions leading to soil salinization. The depth to water table of the phreatic aquifers in the study area are mostly within 2 metres in the post monsoon season and within 5 metres in the pre monsoon season. More over the irrigation system operates to provide surface water almost all throughout the year and more specifically in the end kharif and entire rabi season. As such there is no dearth of water availability. Since most of the water demand is for agriculture and in the absence of any big industrial unit in the study area there is no problem of water deficit. However certain observations have been made for conjunctive use planning which are as follows:

- The area has very shallow depth to water level with almost non-significant pre and post monsoon fluctuation and suffers from water logging condition – both in terms of surface water as well as ground water. Even the deeper aquifers are under auto flowing conditions almost all through the year. This causes very less amount of recharge to ground water. Most of the water from rain fall infiltration as well as from canal seepage get converted to rejected recharge and adds to the drainage run off component. So in terms of hydrodynamics there is no effective flushing mechanism within the aquifers.
- The topography of the land is very gently sea ward sloping and the master slope of the land is very very low(0.02%). This causes very slow movement of surface run-off.
- The combination of the above causes extensive drainage congestion and increases the risk of flooding and extensive damage to life and property as well as of the crops.
- Hydrogeologically the area is entirely composed of un-consolidated alluvial formation of Quaternary and Recent age underlain. The aquifer disposition is very complex in nature. The porous formations open up, merge and get juxtaposed in a very complex manner.
- There are inherent salinity problems in many of the porous formations due to absence of any flushing mechanism. Some of the wells near the coastal reaches, particularly in the Ersama Block of Jagatsinghpur district, which got affected due to Super Cyclone of 1999 are yet to be restored to its original state in terms of water quality.
- All the wells constructed in the area are production wells tapping a multiple aquifer system. The yield, drawdown, hydraulic parameters etc. represent a composite system. Reliable data on individual aquifers are not available as of present.
- This hampers the interpretation of the system as a whole since the mutual interaction and the hydrodynamics between the individual aquifers are yet to be established in both horizontal as well as in a vertical domain.

Recommendation:

- In most of the Irrigation command areas, cultivators are discouraged to adopt ground water irrigation. As per the existing rules there is no or very bare minimal subsidy / help from the State Government towards individual cultivators for construction of ground water abstraction structures and utilizing them for irrigation purpose. This should be modified suitably to encourage ground water irrigation both from the phreatic as well as from the deeper aquifers wherever possible and feasible.
- For the Community water supply in the semi-urban and rural settlements the source should be ground water.
- There should be extensive development of drainage channels to prevent surface water logging and thus preventing development of soil salinization process.
- Efforts are to be made to reduce the conveyance losses in the system. The current irrigation efficiency is only of the order of 34.7 %.
- If some industrial units come up in the area, they may be permitted to augment their water requirement from the ground water in a controlled and regulated manner in addition to surface water.
- The main essence of all the above mentioned solutions is to create a suitable draw down in the aquifer system. This would ensure periodic recharge in the system and thus an active flushing mechanism would be initiated. This will definitely help to improve the water quality of the areas in proximity to the seas and all those suffering similar problems.
- Desperate problems need desperate cures. If in spite of best efforts, all the above methods fail, suitable measures may be taken to abstract water

from these areas and supply them upstream or in water scarce areas as well as constructing large clay screens / dykes near the sea to prevent any additional salinity ingress.

- A lot of people near the coastal sand dunes(allegedly illegal immigrants / settlers) because of the inherent salinity problems and unproductive / barren lands resort to prawn / shrimp cultivation. The so called 'shrimp mafias' pumps the brine inland and thereby further degrades the land. They should be counselled and monitored properly and periodically to prevent the inland salinization menace.
- To properly construct a working simulation flow model, the area may be taken up for extensive ground water exploration with the objective of tapping individual aquifers and testing them individually. They may be kept as sanctuary wells for emergency use, later on and may also be used as ground water observation wells.

2.14 SWR BANGALORE

The ground water management studies have been taken up in Hassan, Koppal, Shimoga, Chikmagalur, Davanagere and Chitraddurga districts.

2.14.1 Arsikere, Belur and Sakhaleshpur Taluks of Hassan district (Farmers distress district)

An area of 3150 sq. km was covered in the study area during Premonsoon survey. Sixty eight key observation wells were established. Depth to water level ranged from 0.20 to 28mbgl. During Post monsoon studies, Belur and sakleshpur taluks were covered with an area coverage of 1550 sq.km. Postmonsoon depth to water level ranged from 1.0 to 15.0 mbgl.Seasonal fluctuation in the entire area ranged from 0.39 to 13.11m.

The water level in Arsikere taluk have shown rising trend during premonsoon and postmonsoon seasons.In three stations, the trend was falling, while in the remaining stations, both rising and falling trend was observed.

In Belur taluk, all the five wells showed rising trend of water level during pre and postmonsson period.Out of the three stations located in Sakleshpur taluk, two showed rising trend and the remaining one station showed falling trend in water level.

Stage of ground water development in Arsikere taluk is 87.71% categorizing the taluk under over exploited and semi critical. Ground water development is 74.1% in Belur taluk, where as Sakleshpur taluk is categorised as safe.

Ground water quality is generally potable. Localised pockets in the study area shows nitrate concentration above the permissible limit.

2.14.2 Koppal and Gangavathi Taluks in Koppal district

An area of 2703 sq. km was covered which falls under topo sheet no.48 M and 57A of Survey of India. The study area is underlain by schistose formation in east of Gangavathi taluk,granite in the border of Koppal and Gangavathi taluks in the south and gneiss in the rest of the area. There are three major soil types. The red sandy soil is observed mostly in Granitic and Gneissic terrain particularly in the central and north central part of the study area. The Black cotton soil is observed in north east, east, west and southwest of the study area irrespective of the formation either it is schist or Gneiss. However black cotton soil is mostly not found in granite terrain. Mixed soil is found along the nala course and found as valley fill.

Total forty seven key wells were established and one hundred seventy five ground water structures were monitored during post monsoon period to study the ground water scenario in the area.Details of key wells inventoried in the study area are as below.

Koppal taluk

Type of well	Dug well		Bore well	
Depth range(m bgl)	4.50	17.10	55.00	100.0
DTW range (Pre.)(m bgl)	1.20	14.40	3.40	29.60
Dia range (m)	2.00	5.00	0.15	0.15

Gangavathi taluk

Depth range m bgl)	4.45	14.20	50.0	70.0
DTW range(Pre.)(m bgl)	2.80	5.90	3.48	15.00
Dia range (m)	1.00	10.0	0.15	0.15

Ground water quality problem is the major issue in the study area. The nature / type of the soil play a major role in deciding the quality of ground water.To study the ground water quality problem one hundred twenty five water samples were collected during post monsoon period other

than forty five pre monsoon water samples. Ground water samples were collected from the area to study the fluoride content.

Quality problem is observed mainly in black cotton area in the west of the study area around Gudigere, Marlapur, Nilogi, along Bikkanahalli – Alavandi road, along Halgeri – Hire Sindagi road and north east of the study area around Nauli village. Around Belagatti, Gatereddihal,Hatti, Belagatti ground water quality problem is observed even though the area is covered with mixed soil.The ground water quality problem is also observed in the mixed soil area along the nala around the villages Chikka Bommanal, Hiremudihal, Chika Khed, Gudadur, Katapur, Mallapur, Sulekal, Batnarsapur, Kalkeri, Lingadahalli, Guddenahalli etc. Ground water samples were collected to study the fluoride content.

The ground water quality problem is also observed in black cotton soil in canal command area. The intensive irrigation in canal command area reduces the effect of salinity on the crop growth. For eg: Buduguppa, Nandihal, Eliganur, Eliganur camp, Jamapur, Kuntoji, Kakargal etc. . In areas having salinity problem and covered by mixed soil, paddy crop is yielding less. It is observed that, paddy cultivated in red sandy soil area in non-command area is getting wilted, as the water provided does not reach the crop because of the sandy nature of the soil. For eg: Hosur, Idargi, Ingaldal etc

Recommendations

- In areas covered by black cotton soil, particularly west of Koppal taluk and North west of Gangavathi taluk, ground water quality problem is observed. The ground water quality can be improved by implementing artificial recharge structures on large scale.
- In non canal command area covered by sandy soil, less water intensive crops are recommended and the practice of paddy growing should be avoided.

2.14.3 Shimoga, Chikmagalur and Davanagere districts(Conjunctive use of Surface and Ground Water studies in Bhadra Command area)

The study was continued from previous AAP to carry out long term analysis of quantitative and qualitative aspects of surface and groundwater in Bhadra Command areas. Detailed study was taken up in the whole area of 1100 sq.kms .The command area covers parts of Shimoga, Chikmagalur, and Davangere districts. The Bhadra reservoir having a capacity of 2023 MCM of water irrigate an area of 1100sq.kms through Bhadra Left and Right bank canals, with branch canals like Anveri, Davangere, Malebannur and Harapanahalli canals.
The area forms part of hard rock crystalline terrain underlain by gneiss, Gneissic granites and granites of Arechean age. The main sources of ground water in the area are precipitation, seepage from canals, and return flow from applied irrigation water. Ground water occurs in weathered / semi weathered formations of granites/gneisses and fractured zones in deep seated formations.

The pre-monsoon depth to water levels ranged from 0.70m to 9.72m with an average of 4.31m. The post monsoon depth to water level ranged from 0.87m to 7.40m with an average of 3.21m. The seasonal water level fluctuation ranged from 0.00 m to 13.77m with an average of 1.43m. The wells showed negative fluctuation adjoining the canals due to discharge in the canal. The analysis of monthly water levels from December-09 to March-10 indicates that the average depth to water level is 3.33m, 3.86m, 3.96m and 4.23m during December-09, January, February, and March-10 respectively. This indicates average monthly fall from Dec to Jan is 0.48m, Jan to Feb is 0.15m and Feb-March is 0.27m respectively, maximum fall in water levels is in between Dec-Jan.

The analysis of long term water levels in 15 NHS maintained by CGWB indicates that the pre monsoon depth to water level ranged from 2.53m to 7.13m and the post monsoon depth to water levels ranged from 1.68m to 5.59m. The seasonal fluctuation ranged from 0.88m to 4.52m.

Water logging conditions are observed in isolated pockets during the period from June to January. This is due to the water being released from the reservoir through canals for irrigation. In addition, monsoon rains also contributes.

Based on monthly water levels, seasonal water logging is observed in the villages viz., Kadaranayakanahalli, Kokkanur, Nanditavare, Kurki, Arasanaghatta and Lakkavalli. Around Chikkakodali, Mangote, Mallapura water logging is observed. This is due to encroachment of tank bed for agricultural activies.

The state government of Karnataka has taken up number of projects on reclamation of waterlogged area through department of Water Shed Development. As a remedial measure, numbers of projects have been taken up to dispose the excess seepage or applied irrigation water through surface and subsurface drains. Forty six villages were covered as per the list provided by Water Shed Development Department, where in about fourteen

villages are observed to be permanently water logged and thirty two villages are temporary water logged.
The analysis results indicate that the pH ranged from 7.3 to 8.5, EC ranged from 290 to 3040micro mhos/cm at 25° C. Total hardness ranged from 130 ppm to 1200ppm. Similarly all other parameters are well with in the desirable/permissible limits, indicating that the water is potable for drinking purposes. As per Wilcox classification (based on EC) five samples viz. Arasanaghatta, Kundur, lokikere, Doddapathy and Kakkaragola are falling under unsuitable class, whose EC values ranged from 2530 to 3040 micro mhos/cm at 25°C. For studying seasonal variations in chemical quality due to water logging (seasonal/permanent) 80 water samples were collected. The samples are being analysed.

Findings of detailed surveys:

- Physiographically the study area is plain to undulating topography.
- The depth to water levels ranged from 0.50 to 11.00m.
- Ground water development is negligible and no irrigation dug wells or bore wells are in use.
- Sufficient surface water exists through Bhadra right and left bank canals and with branch canals. However, shortage of irrigation water is observed in tail end areas of the canal and lands on elevated planes in northern parts of the command area around Shingrehalli in Harappanahalli taluk.
- The main crops are paddy and arecanut and water scarcity is felt in some places. Water management practices like drip/sprinkler irrigation will help to avert the crisis.
- Farmer's suicide cases are mostly related to financial crisis, long illness of farmers, and partly due to crop loss. Crop loss is due to crop diseases, lack of proper crop maintenance and cropping pattern and rarely due to shortage of water.
- Lift irrigation practices are common in adjoining villages of river Bhadra/Thungabhadra.

Conclusions and Recommendations:

- Depth to water level in the Bhadra command areas is not alarming.
- Based on the survey in 46 villages, it is envisaged that the water logging in isolated patches is seasonal, which is mainly due to canal seepage and excess flow during rainy season. At places permanent water logging is observed due to the encroachment of farmland into the village tank bed or the area adjoined to the tank towards down stream directions. Water logging is mostly observed in areca garden, where the crops require continuous water and lack of proper drainage system to drain the excess water.
- Since the farmers in command areas are getting water on rotation basis for irrigation conjunctive use of ground water and surface water will improve the irrigation efficiency.
- Drip/sprinkler irrigation practices are recommended for improved water mangement.
- Farmers should be educated through agricultural scientists regarding protection of crops from crop diseases.

2.14.4 Chitradurga district (Remote Sensing Studies for impact assessment of artificial recharge structure)

In the present study, Using IRS-ID, LISS-III digital data, surface water body has been mapped. Geomorphology, Geology, Lineament and Landuse/landcover maps have been prepared. These layers were integrated to demarcate the area suitable for the constructing of artificial recharge structures. Surface water body and drainage map has been superimposed for finding the source for the recharge. Geomorphologically, the area mainly consists of pediplain shallow, moderate, and denudational hill. The groundwater prospect is moderate to very good in pediplains and recharge condition is also very good in this landforms. Granite gneisses, granite and metabsalat and tuff are the major formation in the study area. The high fracture aquifer is generally found in the gneissic formation. The lineament is generally trending NW-SE and NE-SW direction. NW-SE direction is parallel to general trend of the rock formation and parallel weaker zones. The landuse practice followed in the area is generally indicating the groundwater conditions in the area. Considering the features, which are favouring for the recharge, all layers were integrated and demarcated zones for the artificial recharge. The artificial recharge zones were superimposed and checked the source for recharge.

2.15 SECR, CHENNAI

2.15.1 Parts of Nagapatnam & Thiruvarur districts (Delineation of alluvial and tertiary fresh water aquifer units, Define recharge & discharge area and Formulation of Aquifer Management Plan

The objective was to delineate alluvial and Tertiary fresh water aquifer units- Sand / Sandstone / Silt / Calc.

Sandstone / Limestone and define Recharge Area & Discharge area - Local / distant / Vertical / Lateral

The study area comprise mainly of porous sedimentary formations of Cretaceous, Tertiary and Recent age. A small portion of the western part is occupied by crystalline rocks of Archaean age. The depth of aquifers deciphered based on the study is tabulated below;

Depth range of different aquifers

Sl. No	Formation	Depth (m)	Water Quality
1	Cretaceous aquifers (also Known as Nakkudi Aquifer)	Down to 50	Good
2	Eocene Aquifer	Down to 80 (very limited use)	Good
3	Lower Miocene deep Aquifer System		
a	Orathanadu Aquifer (also Known as Aquitainian Aquifer)	Down to 150	Good
b	Main flowing zone or Burdigalian Aquifer	Deeper aquifer 350	Good
4	Pliocene –Miocene Shallow Aquifer		
a	Pliocene Aquifer (also Known as Podakkudi Aquifer)	Shallow open wells (down to 40) (lesser salinity in the New Delta area)	Good
b	Quaternary aquifer	Shallow open wells (20) & Filter points	Good

Finding

- The aquifers of these porous formations are broadly divided into two group's i.e. shallow aquifer group occurring down to 100 m depth and deeper aquifer group occurring below the depth of 100 to 450 m.
- Ground water in shallow aquifers occurs under phreatic and semi- confined conditions and groundwater occurs in deeper aquifers under confined conditions.
- The comparison of ground water during May 2009 and January 2010 indicates a rise in ground water levels of 0 – 5 m in about 66 percent of wells analyzed. The groundwater level fluctuation of more than 5 m is noticed in the northwestern part.
- The yield of the bore wells in Sedimentary formation varied between 40 and 500 lpm.
- The recharge area for Orathanadu aquifer occurs in the north of kollidam-Mayavaram and south of Thiruvarur-Mannargudi.
- The quality of ground water in the porous formation is generally good and is suitable for both domestic and irrigation. However, saline groundwater exists at shallow depth. The EC values ranges from 430 to 7600 µS /cm. The chloride, Calcium and magnesium in shallow ground water exceeds desirable limit for drinking uses.

2.15.2 Ramanathapuram & Sivaganga Districts (Delineation of aquifer units, Define recharge & discharge area and Formulation of Aquifer protection and Sustainable Management Plan)

The objective was for delineation of aquifer units, define Recharge Area & Discharge area - Local / distant / Vertical / Lateral and formulation of Aquifer protection and Sustainable Management Plan. The area is underlain by recent alluvium, Gondwana Sandstone, Cuddalore Sandstone (Tertiary) and Cretaceous Sandstone.The depth of aquifer deciphered based on the study is as follows:-

Depth range of different aquifers

Sl. No	Formation	Depth (m)	Water Quality
1	Recent-Alluvium	Down to 30	Good
2	Gondwana-Sandstones	Down to 100	Good
3	Tertiary-Cuddalore sandstones	Down to 100	Good
4	Cretaceous aquifers (Thiruvadanai aquifer)	100 - 300	Good

Finding

- Ground water occurs under both phreatic and semi- confined conditions in the shallow aquifer, where as in the deeper aquifers it occurs under confined conditions.

- Tank irrigation is more predominant than irrigation by groundwater.
- The depth of the dugwells ranged between 15 and 35m bgl and the tubwells ranged between 70 and 400m bgl.
- The depth to water level varied between 1.4 and 20.56m bgl
- Tank irrigation is more predominant than ground water irrigation.
- Ground water is of bad quality except in Thiruvadanai aquifer and in Tertiary and alluvium aquifers at some places.
- All fresh water aquifers are under stress, especially Tiruvadanai aquifer which is a confined aquifer due to development for the past thirty years. Piezometric head of the aquifer has reduced considerably.
- Artificial Recharge need to be taken up in the recharge area (near Sarugani) of Tiruvadanai aquifer

2.15.3 Thiruvarur and parts of Thanjavur districts (Conjunctive Use of surface and ground water resources in command area of Cauvery Delta).

The objective of the study was Evaluation of hydrogeological situation and quantification of different components of water balance in the canal command area, Identification of the critical areas in respect of water logging, water scarcity in the tail end areas and soil salinity and Preparation of suitable conjunctive use plan for development of ground water resources in conjunction with surface water.

An area covering 3132 sq.km identified for carrying out conjunctive use in part of cauvery command area of Thiruvarur and parts of Thanjavur districts. 17 administrative blocks falls in the study area. The study area has a hot tropical climate. The average rainfall of the study area is 1150 mm and receives maximum rainfall of about 65% during North East monsoon session and South West monsoon contributes 20% and remaining portions contributed during summer and winter session. The study area in general is a flat plain terrain with gentle slope towards east with surface elevation of 30 m above msl. The deltaic plain, formed due to major Cauvery River and its tributaries flowing in the region. Sedimentary plain, natural levees marsh lagoon/back water coastal plain, beach and beach ridges are seen in the southern part of the study area. Major river systems in the study area are Vennar, Vettar and Bamni rivers, which are the tributaries of the river Cauvery. There are several canal network systems, which are spread all over the terrain acting as source for ground water system

The area is underlined by Tertiary and Quaternary formations comprising Cuddalore formations, Podakudi formations and Alluvium. The important aquifer systems in the study area are constituted by unconsolidated and semi-consolidated formations.

It is observed that the water level in dug wells during pre-monsoon during May 2008 vary from 1.25 m bgl (Thirukarukkavur) to 13.60 m bgl (Mariamman Koil) and in tube wells 6.0 m.bgl to 15.0 m.bgl. During post monsoon water level during January 2009 vary from 0.48 m bgl (Alankottai) to 4.75 m bgl (Mariamman Koil) and in tube wells 3.80 m bgl to 11.25 m bgl.

The tubewells within the study area tap groundwater from 40m bgl to maximum of 150m bgl. Howere, in Manargudi block, deeper tubewells down to depth of 300m bgl. The yield of the tubewell range between 3 and 17 lps. The transmissivity of the alluvial aquifer varies from 200 to 250 m^2/day.

The Electrical Conductivity (EC) ranged between 750 and 2500 µS/cm. Groundwater with low EC values exists at Cholapuram (416 µS/cm) and High EC values (> 6000 µS/cm) are observed in Thiruturaipoondi and Kumbakonam.

Findings:

1. The major source for irrigation in the study area is through canals. Canal irrigation constitutes 100%, except in Madukkur, Pattukottai and Papanasam blocks, where the ground water contribution is 43%, 40% and 13% respectively. The net sown area of the study area constitutes 71% of the total geographical area.
2. Number of ground water abstraction structures increased by 15 – 20% during the last 5 years.
3. Data on groundwater extraction has been collected and it is noticed that depth of wells for agricultural purpose ranges between 40 to 120 m and few blocks wells tap deeper aquifer down to 350 m.
4. It is observed that the patched saline pockets available blocks of Muthupettai, Thiruthuraipoondi, Kattur and part of Thiruvarur.

5. Water logging (8 – 10 % of the area under study) occurs as localized pockets in Papanasam, Muthupet, Thiruthuraipoondi and Muthupet blocks.

2.15.4 Pallikaranai-Chennai sub-urban area (Hydrochemistry of Land fill sites)

The main objectives of the study is to assess the Ground water quality around Municipal solid waste disposal in Pallikaranai-site and its adjacent areas, Migration of leachate both vertically and laterally and to find Remedial measures to reduce further groundwater contamination.

Findings

- High concentration of TDS, EC, Hardness, Nitrates, Chlorides, Sulphate, in ground water near landfill
- Leachates have significant impact on groundwater quality near the area of Pallikaranai landfill site.
- Groundwater quality improves with the increase in distance of the well from the pollution source.
- Inadequately controlled landfills leachates escape to the surrounding and underlying ground.

2.16 KERALA REGION, TRIVENDRUM

2.16.1 Kozhikode District

The total area of the district is 2344 sq km. The district is bounded on the North by Kannur district, on the East by Wayanad district, on the South by Malappuram district and on the West by the Lakshadweep Sea. Kozhikode district is situated between North latitudes 11°08′ and 11° 50′ and East longitudes 75° 30′ and 76° 06′.

The district has a generally humid climate with a very hot season extending from March to May. The main rainy seasons are during the South West Monsoon and the North East Monsoon. The average annual rainfall is 3266 mm.

Topographically the district includes three distinct regions –sandy coastal belt, the rocky highlands formed by the hilly portion of the Western Ghats and lateritic midland. Of the total area of the district 362.85 sq km area comprises of sandy coastal belt, 1343.50 sq kms of lateritic midlands and 636.765 sq kms of rocky highlands. The district has a coastal length of about 80 kms. The highland region accounts for 29.80 percent and the lowland region for 15.55 percent of the total area of the district. The important rivers draining through the district are Mahe river, the Morrad (Kuttiadi river), the Korapuzha, the Kallai river, the Chaliyar and the Kadalundi river.

A total of 117 key wells have been established in this survey out of which 15% represents coastal alluvium, 25% represents bedrock aquifers and the remaining in the lateritic area.

Aquifer	Yield (lps)	Depth of the well (m bgl)	DTWL (m bgl)		Specific capacity (m3/hr/m drawdown)
			premonsoon	postmonsoon	
Laterite	0.5-1.5	4-20	6-13	3-10	1-8
Unconsolidated aquifers					
River plain aquifers		2-10	2-5	1-4	1-2
Coastal sand dune aquifers		2-6	2-4	1-3	1-2
Lacustrine aquifers		3-5	2-3	1-3	2-3

Three major aquifers are identified in the district viz (i) Lateritic aquifers (ii) Weathered Basement complex rock aquifers and (iii) Unconsolidated granular aquifers.

Aquifer characteristics in Kozhikode district

Apart from the above, aquifer system area covered by coastal mangrove swamps are underlain by aquifers of highly saline water without any developmental potential except for the purpose of shrimp and brackish water aqua culture.

Findings

- The major aquifers are Lateritic aquifers, alluvial aquifers shallow aquifers, coastal sand, coastal wetland and estuary deposits , confined regoliths and fractured crystalline aquifers
- Laterite aquifers are dominantly residual weathering products of basement rock. Water quality slightly acidic and is overexploited in urban areas like Kozhikode, Balussery, Vadakara and Quilandy townships. Enhanced levels of nitrates is also observed in urban area.
- The shallower and small alluvial aquifers occur within the alluvial deposits of the minor rivers ansd streams. These aquifers are generally shallow and are directly connected to the surface

water in streams and rivers. Even in periods of low surface flow, these aquifers are quickly recharged. These aquifers are exploited to varying degree without experiencing major hazards. A reliable volume of ground water can be extracted from these alluvial aquifer throughout the year.

- Coastal aquifer are unconsolidated dune sands, beach sands and clayey sands of quarternary and Recent age. The Aqufer thickness is upto 25 m. ground Water level is between 2-6 m bgl. High transmissivities upto 2500 m2/day. Highly vulnerable to contanmination from direct infiltration of contaminants from agricultural practices and domestic waste.
- Coastal wetland and estuary deposits have low and highly variable transmissivities between 2 – 80 m2/day. Water quality is often brackish.

Recommendations

- The lateritic aquifers show rapid depletion of ground water resource in the post monsoon phase especially in the urban area and artificial recharge is suggested as a remedial measure.
- Scientific construction of septic tanks are recommended to avoid nitrate contamination of the aquifer under the scenario of increasing population density.

2.16.2 Trivandrum District

Sea water ingress studies were taken up along the coastal tract and parts of midland area of Thiruvananthapuram district. The coastal tract stretches from Pozhiyur in the south to Edava in the north. The main objective of the study is to identify the areas affected by saline water intrusion by means of hydrogeological, geochemical and geophysical studies.

Physiographically, the study area comprises coastal plain and midland. Coastal plain extends from Pozhiyur to Edava where the elevation is less than 6 m amsl except at Kovalam, Puvar and Varkala where the elevation is more than 6 m amsl. The midland area gently rises from the coastal plain and extends to the foothills zone upto elevation of 80 m amsl characterized by undulating often highly dissected topography. The area is well drained by three rivers Chirayinkil, Karamana Ar and Neyyar river. The region is dotted with backwater lakes (kayal) viz Akkulam, Kadinamkulam and Vellayani (freshwater). Apart from natural water bodies there are man made canals which connects these water bodies viz Parvathy Puthanar. Due to the presence of backwater lagoons a narrow stretch of land is getting sandwiched between the sea and the lagoon. The lagoons are intermittently connected to the sea. The normal rainfall of coastal area is 1885 mm. The area is characterized by wet type of climate. The population density is high in the coastal area. The major soil types of the area are coastal alluvium, riverine alluvium and laterite soil. Red loams are seen in the southern part of Thiruvanthapuram district.

The area is underlain by sedimentary formations ranging in age from Miocene to Recent which overlies the crystalline rocks along the coast. Laterite of sub recent age is encountered along the midland area which also overlies the crystalline rocks. The sedimentary formation encountered in study area belongs to Warkali formation and Quilon formation only in the northern part. The Warkali formation comprises of alternate layer of sand and clay with thin seams of lignite which forms the potential aquifer, Recent formations are represented by alluvium.

Groundwater occurs under phreatic conditions in the coastal alluvium and laterites. Semi-confined to confined conditions exists in underlying deeper sedimentary formations and in fractured crystalline rocks. The present study is restricted only to phreatic aquifers. Coastal alluvium along the coast and riverine alluvium along the river forms the major aquifer in the area.

During the first year of study, preliminary surveys were done to demarcate the area affected by salinity including geophysical survey coupled with groundwater sampling Geophysical survey was carried out from Kappil to Chackai. 76 Soundings (VES) and 15 line km profiling were carried out along several East West traverses perpendicular to the coast using ABEM SAS 300 C terrameter during the summer season. This study has enabled to identify areas which show very low resistivity of less than 10 ohm meter at several locations between Puthukuruchi and Anjengo showing that there is variation in resistivity.

Preliminary hydrogeological survey was conducted during the month of April and 60 key wells were established along the coastal belt. Field EC & PH were monitored. On the basis of field EC, detailed study area were demarcated where EC>500 µs/cm.

In the second year the study was carried out in the affected areas demarcated from the preliminary studies. The detailed study area extends from Vettukad in the south to Vettur in the north covering an area of 500 sq.km. A total of 35 key wells fall in

the detailed study area. This is in conformity with geophysical study where the same area showed low resistivity values.

Pre-monsoon and post-monsoon surveys were done. The depth to water level ranges from 0.85 to 18.3 and 0.54 to 17.54 m bgl during pre-monsoon and post-monsoon respectively. Chemical analysis were done only for selected parameters. The EC ranges from 101 to 1800 and 111 to 1952 µsiemens/cm during pre and post-monsoon respectively. In general the EC value is more than 750 µsiemens/cm in the area. The Sodium ranges from 8.5 to 206 and 14 to 204 milligram/litre during pre and post-monsoon and the Chloride value ranges from 16 to 387 and 19 to 394 during pre and post-monsoon seasons.

Groundwater quality is poor in the narrow stretch of land in between the coast and the backwaters, especially in Pudukurichi areas. The ground water quality is affected in the entrapped land due to tidal activity. The resistivity survey also show very low resistivity in these areas.

During the summer season, sea water enters through the coastal inlet and enters into the backwaters. The mixed up water percolates down affecting the ground water quality of the wells located along the fringes of the backwaters especially Pudukurichi, Matanvila and Anjengo coasts. The resistivity values along the fringes of the backwaters were very low and substantiated by the higher conductivity of ground water samples analyzed chemically in the range between 1010 and 3640 microseimens/cm at 25°C.

Field photograph during the Sea Water ingress studies of Kadhinamkulam lake, in Trivandrum district

2.16.3 Kollam District

Sea water ingress studies along the coastal tracts of Kollam and Alleppey districts were carried out under Ground Water Management Studies. The survey was completed in two phases namely; pre-monsoon reconnaitory hydrogeological survey and post-monsoon detailed studies. During pre-monsoon survey, 90 key wells

Field photograph during the Sea Water ingress studies of coir retting in the vicinity of the Kadhinamkulam lake in Trivandrum district

were established to study the ground water behavior and water samples were collected for chemical analysis. During post-monsoon survey, water levels have been monitored from the key wells water samples collected for chemical analysis from key wells and through field traverse carried out demarcation of areas of sea water intrusion.

The study area is located on the south-western part of Kerala State. It is accessible by roads and railways. The NH-47 Kanyakumari-Salem and the Southern Railway line from Kanyakumari to Mumbai and Chennai are passing through the area. The study area comprises (i) the coastal plain, low-lying plain area adjacent to coast extending inland. The general elevation of coastal plain is less than 6.0 a.msl. and (ii) mid-land. These gently rise from the coastal plains and extend to the foothill zone up to an elevation of 80 m. a.msl. The area is drained mainly by Ithikara and Kallada rivers and their tributary systems. The study area covers the coastal and part of midland in the above said river basins. The coastal and midland area enjoys a humid wet type of climate. The area experiences moderate rainfall during south-western and north-eastern monsoon.

The area is underlain by sedimentary formations ranging in age from Miocene to Recent which overlie the crystalline rocks along the coast. Laterite of sub recent age is found along the midland which again is underlain by crystalline of Archaean age.

Groundwater occurs under phreatic conditions in the coastal alluvium, river alluvium and laterites in the area and under semi confined to confined condition in the deeper sedimentary formations and fractures in the crystallines below laterites. In alluvial formation depth of

dug wells ranges from 3.00 to 7.00 m bgl and depth to water level ranges from 0.30 to 5.35 m bgl. In laterites, depth of dug wells ranges from 6.00 to 20.00 m bgl and water level ranges from 5.43 to 18.8 m bgl.

The common groundwater abstraction structures in alluvium are dug wells and filter point wells. In laterites, large diameter wells and in crystallines, dug wells and shallow to deep bore wells are feasible. The quality of ground water is generally good for drinking, irrigation and industrial purposes except in some part of coastal areas.
For the assessment of contamination of ground water due to sea water and tidal back water in the area, an area of about 800 sq.km was selected for detailed study. Pre-monsoon and post-monsoon water levels were monitored in the key wells and water samples collected for chemical analysis. On the basis of analytical results and field traverse areas showing sea water intrusion have been demarcated.

Findings:

1. The study area comprises coastal plain and adjoining midland area.
2. The coastal alluvium forms the major aquifer in the area followed by riverine alluvium and laterite in the midland area
3. In tidal back water limits and certain isolated pockets further inland high EC values were observed
4. In coastal areas and near estuaries the phreatic ground water is showing contamination due to ingress of sea water.
5. Higher concentration of iron content which results in a reddish brown stain is observed around Ochira, Karunagappally and Chavara areas.

2.16.4 Trivandrum District

Trivandrum urban area is bounded by Kazhakuttam in the north, Karakulam on the northeast, Thirumala on the east, Balaramapuram on the south and Lakshadweep sea on the western side. 17 numbers of key wells were established. Monthly water levels were monitored from April 2009 to March 2010.

Trivandrum district experiences a humid type of climate with an oppressive summer. The district is characterized by very high precipitation which is spread over very few wet days and a long dry season (December – May). The average annual rainfall of the district is 1623.9 mm. The southwest monsoon contributes 48.9 % of the total rainfall followed by northeast monsoon which contributes 28.3%. The normal rainfall of the district is 2001.6 mm.

Trivandrum has a high density of population compared to other cities due to which the built up areas and surface roads are more which reduce the ground water recharge. The area can only withstand low to moderate capacity of bore wells and tube wells. But along the coastal tracts filter point wells are feasible. Reclamation of low lying areas and paddy fields for construction purposes contribute to loss of natural recharge areas.

The area is underlain by sedimentary formations ranging in age from Miocene to Recent which overlies the crystalline rocks along the coast. Laterite of sub recent age is encountered along the midland area which also overlies the crystalline rocks. Recent formations are represented by alluvium.

Groundwater occurs under phreatic conditions in the coastal alluvium and laterites. Semi-confined to confined conditions exists in underlying deeper sedimentary formations and in fractured crystalline rocks. The present study is restricted only to phreatic aquifers. Coastal alluvium along the coast and riverine alluvium along the river forms the major aquifer in the area.

The Trivandrum Urban Water Supply Scheme draws water from Karamana river from the reservoirs at Peppara, Aruvikara and Kundamankadavu near Thirumala. The Southern parts namely Nemon and its surroundings draw water from the Vellayani Lake. Generally the ground water in urban area is of good quality. The pre monsoon water level in the study area ranges from 2.0 to 17 m bgl and the post monsoon water level ranges from 1.6 to 13.22 m bgl. The fluctuation is in the range of 0.5 to 4.5 m bgl. 17 samples were collected during the study and results of analysis are given below:

The quality of ground water is generally good for both drinking, irrigation and industrial purposes except in some part of coastal areas.
The Specific Electrical Conductance of ground water varies from 89 µs/cm to 737 µs/cm and Total Hardness varies from 18 to 105 mg/l in the area.

Findings

- The study area comprises coastal plain and adjoining midland area.
- Groundwater occurs under phreatic conditions in the coastal alluvium and laterites.

- Semi-confined to confined conditions exists in underlying deeper sedimentary formations and in fractured crystalline rocks
- The hard rock aquifers are low yielding. The formation encountered is Khondalite and most of the fractures are clay filled.

2.17 UR, DEHRADUN

2.17.1 Almora District

Ground Water Management Studies have been carried out in Almora district during AAP: 2009-10. Almora district forms part of Kumaon Division of Uttarakhand State. The area is bounded by Chamoli and Bageshwar in the north, Pithoragarh and Champawat in the east, Nainital in the south and Pauri Garhwal district in the west. The geographical area of the Almora district is 3083 km^2. The district comprises of nine tehsils namely, Almora, Ranikhet, Salt, Chaukhutia, Dwarahat, Someshwar, Jaiti, Bhanauli and Bhikiyasain and eleven developmental blocks viz; Syalde, Chaukhutia, Bhikiyasain, Tarikhet, Salt, Dwarahat, Takula, Bhansiya Channa, Hawalbagh, Lamgara and Dhaula Devi. The total population of the district is 630567 (Census, 2001). The density of population is 205 persons per sq. km

The average elevation in the southern part of the district is 6939 m amsl and in northern part is 7603 m amsl. The master slope of the district is to the south. River Saryu in the eastern part, Kosi in central part and River Ramganga along with its tributaries in the western part of the study area comprise the principal drainage. District got a humid and cold climate; temperature ranges from -3.7 to 28.8 $^{\circ}C$ and May being hottest month. Annual average rainfall is 1029 mm whose major share is received from S-W monsoon. July receives about 24.8% if total rainfall; November is the driest month and receiving less than 0.6% of total rainfall. The monsoon withdrawal generally is taking place from 19th September. There are average annual normal rainfall at three rain gauge stations has been recorded like 1061 mm at Almora, 1332 mm at Ranikhet and 1597 mm at Kausani.

The agriculture is the main occupation of the habitant of district. Being a hilly terrain, much cultivation is not in practice. The gross cultivated are during 2005-2006 was 181446 hectare and 42461hectare barren land can be sued as agriculture land. The surface water is main source to provide irrigation facilities, source wise irrigation facilities available are Hauze, Hydrums, and Gules etc. In the district there is different type crops has been cultivated like Maize, Rice, Wheat, Barley, Pulses Gram, Potato, Oil seeds, Madra and Tabacco etc.

Geomorphologically, the Almora district is a part of lower Himalayas and characterized by WNS-ESE trending rounded to flattish-topped gently sloping ridges. Except for ridge and narrow inter mountain valley there are no other prominent geomorphic units. The terrain is overall rugged with sudden rise and /or fall in relief and slope.

The Garhwal group occupies a remarkable stratigraphic position in the lesser Himalayan belt. It is tectonically bounded by the two major planes of dislocation, Main Central Thrust in the north and the North Almora Thrust in the south. It extends for a length of about 250 km from the Kali River in the east to Yamuna Valley in the west.

The Almora district may be subdivided into four NW-SE trending zones characterized by distinctive geology. Form south to north, there are (i) Sub Himalayan zone contributed by lower Shivalik sediments forming the south-western fringe area (ii) Outer Sedimentary belt constituted by arenaceous, arglillaceous and calcareous sediments and low grade meta sediments (iii) Central Allothonous belt, the Almora Nappe unit constituted by crystalline rocks as quartzite, Phyllite schist, granite and gneiss (iv) Inner Sedimentary belt formation northern part of the district which are unfossilliferous and constituted by metasediments. The formation exposed over Almora span a considerable length of stratigraphic time scale possibly from Precambrian to upper Miocene. The stratigraphy is not unequivocally established due to tectonic complication and lack of paleontological evidences.

Hand pumps: The hand pumps were installed by Uttarakhand Jal Sansthan, which are located all along the road sides in the hilly areas. The water levels were monitored in selected hand pumps in both season (Pre & post-monsoon). In pre-monsoon water level ranges from range from 1.32 to 61.84 m bgl with an average value of 20.01 m bgl. The present study reveals that 11% hand pumps shows decline and rest 89% shows the rise in water level in post-monsoon.

Springs: A spring is a concentrated discharge of ground water appearing at the ground surface as a current of flowing water under favaurable geomorphic situation. To be distinguished from spring are seepage areas, which indicate slower movement of groundwater, direct infiltration takes place through the saprolite zone, fractured and joints and then moves along interconnected openings. Despite a good amount of rainfall over district to recharge the groundwater storage, the extreme hilly

terrain cause either excessive run off of loosing precious ground water in form of springs seepage to the lower reaches. In Almora district springs are the main source of drinking/ domestic water. Most of the springs are situated at higher altitude, which have been tapped and supplied to near by villages/towns and spring which are situated at lower altitude used for irrigation purpose also. Discharges of springs measured in both season (pre & post-monsoon). In pre-monsoon discharge of springs ranges from <0.5 to 90.0 lpm with an average value of 11 lpm and having temperature between 12° and 24° C with an average value of 19° C. in post monsoon discharge of spring ranges from <0.5 to 129 lpm with an average value of 16.82 lpm.

A total of 194 representative water samples (79 normal, 65 nitric acid treated and 50 hydrochloric acid treated) from these structures (129 from hand pumps and 65 from springs) were collected and sent to the Chemical Lab, North Western Region, Chandigarh for complete chemical, heavy metals and iron analysis in order to know the water quality as these structures are being used for drinking water.

2.17.2 Nainital District

Ground Water Management Studies have been carried out in Nainital district of Kumaon Division of Uttarakhand State. The district is surrounded by Almora district on north, Champawat on east, Pauri Garhwal on west and Udham Singh ngara districts are southern side. The district comprises of four tehsils namely, Nainital, Dhari, Haldwani and Kosya Kutoli and eight developmental blocks viz., Haldwani, Ramnagar, Kotabagh, Dhari, Betalghat, Ramgarh, Bhimtal and Okhalkanda. The total population of the district is 7,62,909 (Census, 2001). The density of population is 198 persons per sq. km. The geographical area of the district is 3860 km^2.
The district is mainly drained by the Ramaganga, Gola, Kosi, Dabka, Baur and Bhakra rivers. The study area enjoys sub-tropical to sub-humid climate. The maximum temperature in the plain areas ranges from 42°C to 46°C and the minimum between 1°C and 9°C. The annual normal rainfall in the district varies from 1200 mm to 2647 mm. The average annual rainfall is 1246 mm. The intensity of rainfall generally increases from north to south. The southern half of the district is primarily an agrarian belt. Besides traditional rain-fed crops, *Kharif* and *Rabi* crops are also cultivated taking the advantage of the available irrigation facilities in certain parts of the hilly terrains. The principal crops are wheat and paddy and mandua.

Geomorphologically, the study area comprises of three broad physiographic divisions, from north to south viz., i) *Lesser Himalayan Zone*, which comprises of deep valleys and distinct terraces, both of alluvial and glacial origin. The terrain is overall rugged with sudden rise and/or fall in relief and slope with a maximum elevation of 2610 m amsl, ii) *Himalayan Foot Hill Zone*, which runs in NW-SE direction with a maximum elevation of 1677 m amsl. The lower Siwaliks are truncated towards south by major/minor structural discontinuities. The slopes are relatively moderate, with flat-topped hills and iii) *Piedmont Alluvial Tract*, which is corresponding to the major geo-tectonic sub-divisions of the Himalayas. At the Himalayan foothills, extensive zone of Recent sediments were deposited by the streams running downhill and can be broadly classified into two distinct zones namely Bhabar and Tarai.

Geologically, the study area can be classified into three broad geotectonic divisions namely, i) Lesser Himalayas, which comprises of unfossiliferous meta-sedimentary sequences along with low to medium grade metamorphics ranging in age from Precambrian to Palaeogene, and the main rock types are granite, granodiorite, phyllite, slate, quartzite, schist and gneiss. ii) sub Himalayas, which has been classified as Shiwaliks, Middle Shiwaliks and the Upper Shiwaliks. The lower Shiwaliks are characterized by hard, massive, grey to brownish grey sandstones interbedded with grey to maroon clays. The middle Shiwaliks are characterized by massive light grey micaceous sandstones. The Upper Shiwaliks are constituted of pebbles, cobbles, boulders, conglomerates and clay lenses. The pebbles and boulders are mostly quartzitic. Thin lenses of grey to light green colour clays are common and iii) piedmont alluvial plains (Bhabar), which is mainly comprised of poorly sorted unconsolidated sediments viz, cobbles boulders, gravel, pebbles, sand and silt with intervening clay layers. The lithological constituents are of heterogeneous nature viz., basic, acid and intermediate along with epiclastics and metamorphiclasts. Clay lenses are of limited extent. The belt is elongate with NW-SE trend. Its northern boundary has an abrupt structural contact (Main Boundary Thrust) with lower Shiwaliks.

During the course of Hydrogeological investigation a total of 93 hand pumps and 80 springs/ gadheras were identified, established and measured water level from hand pumps and discharge of springs both in pre-monsoon and post-monsoon seasons, respectively in order to know the change in water level fluctuation and discharge of the springs.

Hand pumps: The hand pumps were drilled by Uttarakhand Jal Sansthan, which are located all along the road sides and river terraces in the hilly areas. The water

levels were monitored in selected hand pumps, pre-monsoon range from 1.09 (Naukhuchiya Tal) to 92.23 (Duthkhandhar-Cloud 9/Khabrar) m bgl and post-monsoon water level range from 0.19 (Naukhuchiya Tal) to 90.13 (Duthkhandhar-Cloud 9/Khabrar) m bgl. Hand pump exhibited artesian conditions in Matiyala village in both the periods. The discharge of the auto-flow hand pump could not be measured due to much leakage inside the pump. The present study reveals that all the hand pumps shows rise in water level both in pre-monsoon and post-monsoon periods.

Springs: Springs are the main source of drinking/domestic water in hilly areas of Nainital district. Most of the springs are situated at higher altitude, which have been tapped and supplied to near by villages, situated at lower altitude through the gravity system. Discharge of springs measured during pre-monsoon ranges from 1.0 to 146.0 lpm (Sipahi Dhara) having temperature between 12° and 24°C. The same structures (springs) were monitored during post-monsoon and the discharge ranges from 1.0 to 688.0 (Sipahi Dhara) lpm. All these 80 springs shows increase in discharge during the post monsoon period. The representative water samples form these structures were collected and sent for complete chemical analysis in order to know the water quality as these structures are being used for drinking water. A total of 56 representative water samples (39 from hand pumps and 17 from springs) were collected for complete chemical analysis and the same were sent to the Chemical Lab, North Western Region, Chandigarh.

Special Studies: Special studies were proposed to study the behaviour of lake districts of India, Nainital. Nainital district consists of Nainital, Bhimtal, Naukhuchiya Tal, Sattal etc. the lake has a tectonic origin and is characterized by dolomites, limestone, shale and silicate rocks. Lithology around Nainital consists of carbonate rocks, calcareous slates, argillaceous limestone, ferruginous shale, algal dolomites, black shale with marlite, greywacke, siltstone etc. of the Krol Formation (Permo-Triassic). The Bhimtal is comprised of metabasites associated with shallow water quartzite, grits, conglomerates, phyllite and rocks of zeolite and greenschist facies. Naukhuchiyatal Lake is surrounded by metavolcanics and quartzite, whereas Sattal Lake is developed in quartzitic country. There are no industrial activities in the catchments of the lakes. The lake waters are mostly used for potable water supply, fish production, irrigation and recreation. Naukhuchiyatal Lake is fed by several underground springs. Among these lakes, Nainital Lake is major tourist destination and has most visiting/floating population, whereas the other three lakes have attracted much attention lately. A total of 66 representative lake water samples were collected (Normal: 22 samples, HCl treated: 22 samples and HNO_3 treated: 22 samples) to study the behavior, hydrodynamics, recharge and water balance of these lakes.

2.18 NHR, DHARAMSHALA

The Ground Water Management studies were carried out in Kangra district and area was covered 5739 sqkm.

2.18.1 Kangra District

Ground Water Management Studies in Kangra district were carried out in pre and post-monsoon season as per AAP 2009-2010. Kangra district occupies the western most part of the state located between latitude 31° 45′ and 32° 28′ and longitudes 75° 35′ and 77° 05′and covers an area of 5739 sq.kms. It is bounded by Chamba and Lahaul & Spiti in the north; Kulu and Mandi in the east, Hamirpur and Una in the south; and Gurdaspur & Hoshiarpur districts of Punjab.

Western Part

The study area occupies the western part of the district covers an area of 2523 sq.kms. It is bounded by Chamba district in the north; Shahpur, Kangra, Baroh tehsils in the east; Una in the south; and Gurdaspur & Hoshiarpur districts of Punjab in the west. Geologically, the rock formations occupying the study area in age from Tertiary to Quaternary period. The study area can broadly be divided into Tertiary and Post Tertiary(Quaternary deposits). The valley fills occurs mainly in the western part and as isolated deposits along the terraces/rivers/streams and Tertiary in most of the part. All the formation are trending in NE-SW direction. Kangra district is drained by streams/rivers forming part of the drainage basins of the Beas. There are numbers of tributaries of Beas Rivers flows in the district. The northernly flowing tributaries are ephemeral and have flash floods during the monsoons. The important (khads) are Pragpur, Nalsuha, Chanour and Dada .The Beas River has been bounded at Pong reservoir resulting in a vast body of water covering about 26,400 hectares of land at maximum storage level. Hydro-geologically, the unconsolidated valley fill or alluvial formation occurring in the valley area such as Andora-Nurpur-terrace valleyfills, Jassur-Jawali-Dehra valley fills, Pragpur-Dada Siba valley fills and Jawalamukhi Structural Terrace valley fills and semi-consolidated formations belonging to Siwalik Group form aquifer in the Study area. Porous alluvial formation occurring in the valley area forms the most prolific aquifer system where as the

sedimentary semi-consolidated formations and hard rocks form aquifer of low yield prospect. Springs are the main ground water structures that provide water for domestic and irrigation in major rural and urban centers in the hilly area. In valley area of Indora-Nurpur, the ground water occurs in porous unconsolidated alluvial formation (valley fills). Ground water occurs both under phreatic & confined conditions. Wells and tube wells are the main ground water abstraction structures. Ground water is being developed in the area by medium to deep tube wells, dug wells, dug cum bored wells. Depth of open dug wells and dug cum bored well in area ranges from 4.00 to 35.00 m bgl wherein depth to water level varies from near ground surface to more then 28 m bgl. Yield of shallow aquifer is moderate with well discharges up to 15 lps.Seasonal artesian flow conditions also occur during and after the rainy season around Andaura. In Andaura area the yield of the tubewell varies from 15 lps to 35 lps for a drawdown of 6 m to 10 meters. In this tract Central Ground Water Board has constructed many exploratory tubewells ranging in depth from 145 m to 429.50m. Yield of these tubewells ranged between 674 lpm and 2574 lpm. Apart from this, State Government has also constructed many tubewells for irrigation and domestic purposes.In the study area, there are 21-hydrograph network stations where depth to water level is monitored four times a year and ground water quality once during pre-monsoon period. Apart from this 110 dugwells has been inventoried and monitored during Pre-monsoon and Post-monsoon period (2009). Depth to water table shows wide variation. During pre-monsoon period (May 2009) it ranged between 1.16 & 28.55 m bgl, while during the post-monsoon period (November 2009) depth to water level ranged from 0.42 to 24.10 m bgl. Deeper water levels are observed mainly in Jassur-Jawali-Dehra valley fills. In major parts of the study area the depth to water level are less than 15.00 m bgl.Ground water is being recharged from rainfall infiltration, seepage from khuls, streams, rivers and water reservoirs. The net ground water resource available in the Indora-Nurpur valley is 9438.70 hect.m. The existing gross ground water draft for all uses being 2915.30 hect.m. The existing ground water draft for irrigation is 2393.30 hect.m. Net Ground Water availability for future irrigation development is 6430.40 hect.m. The stage of ground water development as on November 2009 is 30.88 % and categorized as 'safe'.

Eastern Part

The study area occupies the eastern part of the district covers an area of 3206 sq.kms It is bounded by Chamba and Lahaul & Spiti district in the north; Nurpur, Harchekian, Jawalamukhi and Dehra in the west; Hamirpur in the south, Kullu and Mandi in east. Geologically, the rock formations occupying the study area of the district range in age from Pre-Tertiary to Quaternary period. Hydro-geologically, the unconsolidated valley fill i.e. Fluvio Glacial deposit occupies the foot hills of the Dhauladhar in Kangra and Palampur valley, There are numbers of alluvial fans in the Palampur valley and Jawalamukhi Structural Terrace valley fills and semi-consolidated formations belonging to Siwalik Group form aquifer in the Study area. Porous alluvial formation occurring in the valley area forms the most prolific aquifer system where as the sedimentary semi-consolidated formations and hard rocks form aquifer of low yield prospect. Springs are the main ground water structures that provide water for domestic and irrigation in major rural and urban centers in the hilly area. Springs in the study area are mainly gravity, contact or fracture type and springs located along major thrust/faults or structurally weak planes are high yielding.During the study, total 35 springs and 15 Bawries (Seepage) were inventoried in pre-monsoon season and from the same has been re-monitored in post-monsoon season to know the fluctuation in discharge. The studies shows that 88 % of the springs monitored shows increase in discharge during post-monsoon compared with pre-monsoon season while 3 % of the springs shows decrease in discharge. Three of the springs show no change in discharge.The springs in the district are generally grouped under the category V,VI & VII of Meinzer's classification for springs. The pre-monsoon and post-monsoon fluctuation of spring discharge ranges from <zero to 4.6 lps at Jaisinghpur. Springs located along or at the inter section of faults/fracture zones are yielding upto about 20 lps are indicative of their high potentialities. Phyllites, Quartzites, Limestone, Sandstones exposed in the eastern parts of the district forms comparatively a poor aquifer except in the lower valley areas. Springs in these areas are yielding low quantity of water varying in discharge not more than 10 lps.

Recommendation:

- In valley areas, in addition to traditional ground water structures like dug wells, springs, medium to deep tube wells can be constructed for developing the ground water resource for domestic, agricultural and irrigational use.
- Valley fill deposits and terraces are to be fully explored by constructing test wells for studying the precise distribution of ground water horizons and scope for development.
- In hard rock area all the weak zones, like thrust, faults, fractures, lineaments, and contact of different formation are to be studied in detail for demarcating the aerial extent and vertical distribution of ground

water potential zones by micro level hydrogeological/geophysical studies followed by exploratory drilling based on which suitable ground water structures can be constructed for the development of ground water resources.

- In alluvial areas of Indora-Nurpur valley, though there is scope for ground water development as stage of ground water development is only 30.88 %, however, there is need to adopt cautious and phased manner ground water development approach in view of depleting water levels in some parts. This decline can be attributed to fast pace of development in recent years, both in agriculture sector and industrial sector.
- This industrial area is highly prone and vulnerable to surface & ground water pollution thus water quality monitoring at close network is essential.
- Proper waste/effluent disposal measures are required to be adopted by industrial units and state authorities needs to check this.
- There is need to protect traditional water harvesting structures like ponds, tanks, talavs to utilized these for rain water harvesting and recharging shallow aquifers.
- In hilly and mountainous terrain, traditional ground water sources viz., springs, *bowries* etc needs to be developed and protected for better health and hygiene with proper scientific intervention.
- Springs needs to be inventoried & studied for optimum utilisation of their discharge either by fracturing, horizontal drilling or by constructing galleries etc.
- Proper development of springs is essential as it is observed that most of the spring in the district does not have collection chamber or tanks from where water can be distributed under gravity. The objective of spring development should be to collect the flowing water underground, to protect it from surface contamination and store it in sanitary spring box for supply. Similarly, *seepage springs* along hill sides also need to develop for harnessing ground water in such areas.
- Spring water should be tested before and after heavy rains each year for bacteria, pH, turbidity, and conductivity.
- Springs are often contaminated with bacteria during construction or maintenance. All new and repaired water systems should be disinfected using shock chlorination.
- Roof top rainwater harvesting practices can be adopted in hilly areas and urban areas, since the district receives fair amount of rainfall. Construction of roof top rain water harvesting structures should be made mandatory in all new construction and rain water harvesting in rural areas should be promoted. Traditional water storage systems need to be revived.
- In Study area valley for most of the households, IPH department supplies water, so the people put their dugwells abandoned without using it. These unused and abandoned dugwells can be used as rainwater harvesting and artificial recharge structure to recharge ground water.
- People's participation is a must for any type of developmental activities. So proper awareness for utilization and conservation of water resources is required.

3. GROUND WATER EXPLORATION

Ground water exploration aided by drilling is one of the major activities of the Board. It is aimed at delineation of aquifers in different hydrogeological conditions and determination of their hydraulic parameters. The exploratory drilling operations have enabled demarcation of aquifers both in lateral and vertical extensions and evaluation of various aquifer parameters, designing of suitable structures and assessment of their yield capabilities in various hydrogeological settings. These studies have helped in identifying areas worthy for further ground water development. Ground Water Exploration contributes to a large extent in guiding the States to implement ground water development schemes.

Ground Water Exploration is being carried out to study the sub-surface hydrogeological setup and to evaluate various aquifer parameters of different aquifer systems. The entire exercise is aimed at quantitative & qualitative evaluation of ground water in the area. It is being carried out by the Board through a fleet of 88 drilling rigs (34 Direct Rotary, 41 Down the Hole and 13 Percussion Combination types) . During the year 2009- 10 (up to 31st March, 2010), 790 wells (EW-365, OW-148, PZ- 277) have been constructed, against a target of 800 wells. It is heartening to report that out of 790 wells, 592 wells, 184 wells and 14 wells were constricted in hard rock, alluvium and bouldary formation respectively. 85 wells and 246 wells were constructed for exploration in tribal and drought prone areas respectively. The Board has so far has drilled a total of 29118 bore holes to identify areas worthy for ground water development in the country till March, 2010.

33 wells with discharge ranging from 180 LPM to 2205 LPM have been constructed in the states of Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan, Taminadu and West Bengal. The study will help in identifying ground water sources and in guiding the states to adopt follow up action with regard to ground water development for drinking water supply and other demands.

The statement showing State-wise distribution of boreholes drilled / completed during 2009-2010 in the country is presented in Table 3.1 & Table-3.2. Region wise & Division wise status of bore holes drilled during 2009-2010 is shown as graph in fig. 3.1 & 3.2 .

Table 3.1 : State-wise wells constructed by central ground water board during the year 2009-2010

Sl No.	State/UTs	EW	OW	PZ	SH	DW	Total
1.	Andhra Pradesh	22	08	105	0	0	135
2.	Arunachal Pradesh	0	0	0	0	0	0
3.	Assam	15	13	0	0	0	28
4.	Bihar	02	03	10	0	0	15
5.	Chhattishgarh	17	13	23	0	0	53
6.	Gujarat	20	07	16	0	0	43
7.	Haryana	02	01	10	0	0	13
8.	Himachal Pradesh	8	0	0	0	0	08
9.	Jammu & Kashmir	11	0	0	0	0	11
10.	Jharkhand	10	05	0	0	0	15
11.	Karnataka	39	11	0	0	0	50
12.	Kerala	18	12	0	0	0	30
13.	Madhya Pradesh	42	11	27	0	0	80
14.	Maharashtra	34	16	03	0	0	53
15.	Orissa	54	15	0	0	0	69
16.	Punjab	05	06	0	0	0	11
17.	Rajasthan	23	05	25	0	0	53
18.	Tamilnadu	04	04	47	0	0	55
19.	Uttar Pradesh	19	13	02	0	0	34
20.	Uttarakhand	02	0	0	0	0	02
21.	West Bengal	15	05	01	0	0	21

Sl No.	State/UTs	EW	OW	PZ	SH	DW	Total
	TOTAL(A)	**362**	**148**	**269**	**0**	**0**	**779**
	UNION TERRITORIES						
1	Delhi	03	0	07	0	0	10
2.	Daman&Diu	0	0	01	0	0	01
	TOTAL(B)	**03**	**0**	**08**	**0**	**0**	**11**
	GRAND TOTAL(A+B)	**365**	**148**	**277**	**0**	**0**	**790**

Table 3.2 Division wise wells constructed by central ground water board during the year 2009-2010

Sl No.	DIVISION	EW	OW	PZ	SH	DW	Total
1	I- AHMEDABAD	20	07	17	0	0	44
2	II- AMBALA	10	07	17	0	0	34
3	III- VARANASI	14	06	0	0	0	20
4	IV- CHENNAI	14	09	47	0	0	70
5	V- RANCHI	12	08	10	0	0	30
6.	VI-NAGPUR	34	16	03	0	0	53
7.	VII-GUWAHATI	15	13	0	0	0	28
8.	VIII- JAMMU	11	0	0	0	0	11
9.	IX-HYDERABAD	22	08	105	0	0	135
10.	X- BHUWANESWAR	54	15	0	0	0	69
11	XI- JODHPUR	23	05	25	0	0	53
12.	XII BHOPAL	42	11	27	0	0	80
13	XIII- RAIPUR	17	13	23	0	0	53
14.	XIV- BANGALORE	47	18	0	0	0	65
15.	XV- KOLKATA	15	05	01	0	0	21
16	XVI- BAREILLY	07	07	02	0	0	16
17	XVII- DHARAMSALA	08	0	0	0	0	08
TOTAL		**365**	**148**	**277**	**0**	**0**	**790**

EW - Exploratory Well OW - Observation Well PZ - Piezometers SH - Slim Hole DW - Deposit Well

SALIENT FINDINGS OF GROUND WATER EXPLORATION STUDIES

3.1 NWHR, Jammu, Jammu & Kashmir

In North Western Himalayan Region, ground water exploration was carried out in Jammu, Kathua, Srinagar, Ramban, & Rajauri district of Jammu & Kashmir. In all 11 exploratory wells were drilled/constructed against the target of 16 EW. This includes seven wells in Jammu province and four wells in Kashmir province.

3.1.1 District wise summarized details of ground water exploration

Kathua District: One exploratory well was drilled at Kharot to explore alluvial formations of the outer plain. Drilling was carried down to 109.40 m well constructed up to 105.00 m. total thickness 6 m of granular zones was tapped.

Jammu District : Three exploratory wells were drilled at Kote Meira, Jadd and Sunail-III sites. Drilling was carried out up to 101 m at Kote Meira and constructed upto 90.00 m. At Jadd exploratory well site drilling was carried upto 80.00 m and constructed upto 79.00m. At Sunail-III, Drilling was carried out up to 89.5 m and constructed upto 89.5 m.

Srinagar District: Four exploratory wells were drilled and constructed in Srinagar district. Depth of drilling ranges from 8.50 m bgl at Shalimar Garden to 200.00 m bgl at Nishat Garden. Static water level ranges from 2.0m at Shalimar Garden to 24.40 m bgl at CITH Rangreth.

Ramban District: One exploratory well was drilled at Bhanihal down to a depth of 79 m bgl with constructed up to depth of 72 m.

Rajouri District: One exploratory well was drilled at Bhanihal down to a depth of 50.5 m bgl with constructed up to depth of 50.5 m.

High yielding wells

District	Site	Drilled Depth (m)	Discharge (lpm)	Formation	Month /year
Srinagar	Shalimar	44.00	1200	Boulders	Nov 2009

Aquifer Performance test results

Sl. No	Location	District	SWL (m bgl)	Discharge (lps)	Draw Down (m)	Sp. Cap. (lpm/m)	T (m2/day)
1	Nihalpur	Kathua	28.83	15.08	0.83	1090	434.4
2	Govindsar	Kathua	51.55	5	6.25	48	114.79
3	Kote Maira	Jammu	13.05	13	6.85	116.06	419.8
4	PHE-Rajouri	Rajouri	10.41	1	18.96	3.164	1.980
5.	Shaidpora Jahngar	Baramulla	2.75	4.5	13.54	19.94	27.21
6.	Chaki – Wangund	Anantnag	33.42	0.5	23.48	1.27	-
7.	Kahagmalpora	Badgam	12.18	4.5	90	--	--
8.	Dhamal Hanjipora	Anantnag	7.13	7.8	25.48	18.37	22.88
9.	Mamhet	Badgam	25.69	1.66	45.46	2.199	
10.	Badrivan	Pulwama	Auto flow	18	18.45	50	
11.	Pohal Brien	Srinagar	26.15	0.5.0 – 5.0	>50	--	--
12	Upper Ishber	Srinagar	34.75	4.5	10.74	25.6	
13	Upper Athwajan	Srinagar	3.72	12	20.18	35.67	60.35
14	Sofi Mohalla	Srinagar	6.54	44	1.09	2422.01	
15	Warsun Gujran	Kupwara	33.73	0.6 - 5.2	32.34	1.175	
16	Gulgam	Kupwara	15.87	0.6	17.86	--	--
17	Khan pora	Baramulla	5.79	10	3.3	181.81	316

3.2 WR, JAIPUR , RAJASTHAN

Ground water exploratory drilling were undertaken in Bikaner,Bharatpur, Daus, Hanumangarh, Sri Ganganagar, Jaisalmer, Jodhpur & Tonk district during the AAP 2009-10 in order to delineate various water bearing formations, their geometry, potentiality, quality aspects, bridging the gap of information as well as to render assistance to the State Government for mitigating the drought situations. Piezometer construction for long term ground water regime monitoring was taken up in areas of heavy withdrawal which led to drying of dug wells. A total of 26 exploratory wells, 06 observation wells and 21 piezometers have been constructed in the State.

District wise summarised details of groundwater exploration in the Rajasthan

Sl. No	District	Depth Drilled(m) / Depth of Well(m)	Zones Tapped (mbgl)	SWL (mbgl)	Discharge (lpm)	Draw Down (m)	Formation
1	Bikaner	75-202 / 64-137	53-135	32-60	20-400	-	Alluvium, Tertiary S.St.
2	Hanumangarh	146-201 / 39-150	30-158	7-20	150-600	-	Alluvium
3	Ganganagar	170 / 68(shallow pz)/ 112(deep pz)	37-110	18.6-18.7	115-400	-	Alluvium
4	Tonk	155 / 155	Naked	16.50	250	-	Phyllite
5	Dausa	50-166 / 50-166	10-67	5-46	15-200	-	Alluvium/ Quartzite/schist/ Gneiss/phyllite
6	Bharatpur	41-200 / 41-200	Naked & 29-149	4-84	15-700	-	Alluvium/quartzite /sst./
7	Jaisalmer	201-254 / 200-248	180-245	1.5 magl - 1.8	180 free flow to 1100	3.95	Tertiary Sst.
8	Jodhpur	93-203	Naked	12-144	Meagre to 960	14-75	Sst/limestone/ ganite/rhyolite/ shale

3.2.1 District wise summarized details of ground water exploration:

Bikaner district:-In Bikaner 5 PZ, 1 EW and 1 OW were constructed. The exploratory activity was carried out in

northern and western part of the district. In northern part shallow Pz was constructed in alluvium to a maximum depth of 66.00 metres except at Sangrew where alluvium along with tertiary sand stone was tapped down to a depth of 106.00 metres. The yield is low in all the PZ (from 20 to 50 LPM) except at Sangrew where 220 LPM yield was recorded. Electrical conductivity ranges from 1260 to 5040 micromhos/cm. The fluoride values in all the PZ are more than permissible limit for drinking water, the highest being at Sangrew (7.5 mg/l).In the western part of the distt, EW at Govindsar has been constructed, where presently water is being supplied from a distance of 13 Kms .The EW will augment the water supply to the village from its own source.

Bharatpur District: Twelve boreholes were drilled in part of Bharatpur district. The formation water is highly saline in north eastern part of the district. In south western part of the district the ground water in alluvium is potable and occurs in pockets. The secondary porosity has developed in hard rock comprising of quartzites and other meta sedimantries. The quality of ground water in quartzites is potable with discharge ranging from 150 to 300 LPM. The alluvium in the SW part of Bharatpur has now desaturated and water occurs only below 100 metres in the hard rock, the electrical conductivity of water in the hard rock is around 1000 micromhos/cm. At Nithar an exploratory well was drilled down to 112.00 metres in softrock formation and further drilling down to a depth of 165.00 metres was carried out in hard rock formation. The well yielded 300 LPM of potable water from the fractured ultrabasic rock. The Nithar village was facing drinking water problem for quite some time.

Dausa District:- A total of nine borehole were drilled in the Dausa district. Both the Piezometers drilled in soft rock formation, yielded meager quantity of water as alluvium is desaturated and consist of mainly clays. The yield potential of wells drilled in hard rock areas consisting of Quartzites, schist and gneisses is around 250 LPM. The quality of ground water is potable.

Hanumangarh district:- Five EW, One OW and one PZ were constructed in Hanumangarh district by direct Rotary Rig. The yield of wells ranges from 150lpm to 600 lpm, static water level in all the wells is below 20 mbgl. At Kalusar the water is highly saline the Electrical conductivity being 38800 micromhos/cm. In rest of the wells electrical conductivity varies from 700 to 1640 micromhos/cm, nitrate between nil to 13 mg/lit and fluoride from 0.28 to 1.61 mg/lit. In Hanumangarh district Geophysical logging is always required for well designing as salinity varies both vertically and horizontally.

Sri Ganganagar District:-Two piezometers (one shallow and one deep) have been constructed in the same well assembly tapping alluvial formation. Shallow piezometer is 68 metre deep and deeper piezometer is 112 metre. Quality for formation water is saline having EC 8400 and 8550 ms/cm at 250 C in deeper and shallow aquifers respectively.

Jaisalmer District: The formations ranging in age from pre-cambrian to quaternary are exposed in the district but predominant hydrogeological formations are lathi, tertiary and quaternary. The southern & western part of the district is having vertical zoning of ground water quality and patches of potable quality of ground water as well as variations in the ground water potentiality. Hard core villages in the area are devoid of source of potable drinking water. A total of 2 EW and 2 OW have been constructed. One exploratory bores hole has drilled at site Jaluwala upto the depth of 202 mbgl .On the basis of the lithological log and electrical logging of bore hole one promising granular layer has demarcated at the depth of 180 mbgl below the upper saline ground water Aquifers. The bore hole is converted into the exploratory well by providing the cement plugging to seal the upper saline groundwater zone and tapped the 180 m to 198 m deep relatively fresh water. It becomes artesian Autoflowing tube well. The auto flow discharge of Artesian well is180 liters per minute, making relatively fresh water available without operational cost, which is like a dream in Desert. Discovery of the artesian autoflow aquifers in such water scarcity area is a scientific achievement of the Central Ground Water Board. At Jaluwala 2 observation well were constructed having the depth of 246 mbgl,248 mbgl and the zone tapped 226m-244m, 186-198 respectively, both are autoflow. The bore hole at Raichandwala drilled upto the depth of 254 mbgl is electrically logged and potable zone is encountered at the depth of 230m – 245m, depth to water level 1.8 m and discharge of wells 1100 lpm (EW) quality of ground water is potable

Jodhpur District: Hard core villages in the area are devoid of source of potable drinking water. In the district 3 EW, 7 PZ and 1 OW (total 11 nos.) have been constructed. The formation in the Jodhpur district comprising of sandstone, limestone, granite, rhyolites has been encountered at different drilling sites. A high discharge exploratory well has been constructed at Boyal site having discharge of 960 lpm, when preliminary yield test was conducted, comprising pinkish granite formation and highly fractured. However the quality of formation water is brackish and the result of chemical analysis is awaited. This water is blended with the canal water supply for domestic purposes in the area to meet the public requirement.

Tonk District:- One exploratory well (spill over from 2008-09) has been drilled in hard rock(phyllite) down to depth of 155.40m. Static water level is 16.50 having discharge 250 lpm measured during PYT. Quality of formation water is potable having EC 960 ms/cm at 250 but fluoride concentration is 3.34 mg/l.

Aquifer Performance Test Details in Rajasthan

Location	District	SWL (m)	Discharge (lpm)	Duration (min)	Drawdown (m)	Transmissivity (m2/day)
Fatehpur	Hanumangarh	20.41(EW) 20.13(OW)	880	600	7.73(EW) 4.86(OW)	191.96
Rampura	Hanumangarh	8.34(EW) 8.30(OW)	1500	600	4.63(EW) 0.37(OW)	6160.91
Peer Ka Mariya	Hanumangarh	17.14(EW) 17.00(OW)	1575	600	5.6(EW) 0.33(OW)	1075.75
Daulatpura	Hanumangarh	17.33(EW) 17.20(OW)	904	600	7.74(EW) 2.909(OW)	184.80
Kharakheda	Hanumangarh	5.50	900	1000	6.50	533.61
Rajpura Balaji Ka Jhoda	Sikar	61.00	400	600	5.40	1259.75
Sabalpura	Sikar	20.71(EW) 20.68(OW)	1015	600	8.19(EW) 0.85(OW)	2139.27
Bagri	Tonk	15.35(EW) 14.81(OW)	660	280	21.30(EW) 2.10(OW)	62.47
Peeplu Ki Dhani	Tonk	6.15	1320	500	4.44	623.29
Malvi	Udaipur	14.72	125	200	31.40	-
Tilchivi	Bharatpur	36.44	322	500	18.38	35.26
Raipur	Bharatpur	61.34	426	500	5.02	725.11

3.3 NWR, CHANDIGARH, (Punjab & Haryana)

Ground water exploratory drilling were undertaken in Gurudaspur, Jalandhar, Kapurthala district in Punjab and Jind, Fatehabad, Gurgaon , karnal district in Haryana. Total 22 wells have constructed including 7 EW, 5 OW and 10 PZ.

3.3.1 District wise summarized details of ground water exploration:

Punjab: - A total of five exploratory wells and four observation wells were drilled in Punjab State. One exploratory well at village Hariyal in Gurdaspur district, four exploratory wells and five observation wells at Bhatnura in Kapurthala district and Lallian and Malsian in Jalandhar district were drilled. The exploratory wells were drilled in the depth range of 93.5 m bgl to 206 m bgl whereas observation wells were drilled in the depth range of 43.80 m to 339 m bgl. The sub-surface lithology comprises of sands, clays and kankar. Well assembly in depth range of 41 to 336 m were designed and lowered in the exploratory wells and observation wells. Aquifers in depth range of 70 – 280 m bgl were tapped in exploratory wells whereas in observation wells, aquifer in the depth range of 25 – 332 m bgl were tapped to monitor ground water regime in the area. Depth to water level in the exploratory well Hariyal (district Gurdaspur) recorded 18.14 m bgl and exploratory wells of Jalandhar district area ranges from 20.60 m to 20.90 m bgl.

Haryana- A total of two exploratory wells and ten piezometers were drilled in the State. Three piezometers at village Mohalkhera, Lohchop and Baroda in Jind district, three piezometers at village Aharwan, Jhandhikalan and Mehuwala in Fatehabad district, Two in Pataudi and Manesar in Gurgaon district and one at village Kairwali in Karnal district were drilled. The piezometers were drilled down to depth of 143 m bgl and were constructed in the depth ranges from 21 m to 139 m bgl. Sub-surface lithology consists of gravels, sands and clays. Coarse sand

forms a predominant aquifer material. Aquifers in depth range of 21 – 139 mbgl were tapped to monitor ground water regime in the area. Depth to water level in the area ranges from 7.0 to 35 m bgl.

Rehabilitation of old and sick Piezometers:- Thirteen old and sick piezometers in Punjab were rehabilitated.

Kachchh District: The area explored is underlain by Deccan traps followed by Sandstone (Bhuj Sandstone) formation. Deep Exploration was carried out in Anjar, bhuj, Mandvi, Abdasa talukas of the district with an aim to explore possibility of occurrence of deep seated aquifers i.e. Bhuj sandstone underlying the Deccan Trap formation in the area under exploration and to ascertain the quality

3.4.1 District wise summarised results of ground water exploration:

Sl. No	District	Depth drilled (m bgl)	Zones tapped/ Fractures encountered (m)	SWL (m bgl)	Discharge (lpm)	Draw down/ Residual Drawdown (m)	Formation
Ground Water Exploration (Departmental)							
1	Dahod	80-202.70	56-97	12.48.-12.55	360-402	20.9-30.6	Phyllite/ Quartizite
2	Ahmedabad	450.60-450.85	186-379	115.7-125.95	60-84	6.15-8.14	Alluvium
3	Mahesana	140.35	112-136	102	12	-	Alluvium
4	Panchmahal	139.5-202.7	51-84	4.78-16.68	15-480	10.7-56.27	Phyllite/ Quartizite
5	Kachchh	136.10-453.30	19.10-266.20	7.85-63.10	408-900	0.6-55.88	Basalt/ Sand stone
6	Amreli	178.80-239.80	174-220	38.26->50	300-1200	22.43	Basalt
Piezometers							
1	Gandhinagar	47-202.53	21-192	24.46-113.06	108-126	0.36-1.13	Alluvium
2	Vadodara	50-145	25-142	14.64-30.81	57.6-354	1.03-8.67	Alluvium
3	Banaskantha	62.9-200.5	44-196	47.03-134.75	13.8-204	0.12-1.01	Alluvium
4	Bhavnagar	62.22-156.6	29-152	23.30-64.12	10.2-118.2	0.75-46.08	Alluvium/ limestone
5	Junagadh	30.17	14-20	6.24	39	0.88	Alluvium
6	UT of Diu	18	8-11	5.96	12	0.12	Milliolitic Limestone

3.4 WCR, AHMEDABAD (Gujarat State & UT of Diu)

Ground water exploration was carried out by in the districts of Dohad, Panchmahals, Kachchh, Amreli and Ahmedabad. Peizometer construction was taken up mainly in the districts of Banaskantha and Gandhinagar, in coastal Saurashtra (Bhavnagar, Junagadh districts) and UT of Diu. In all 44 wells(20EW, 7 OW & 16 PZ, 1 SH have been constructed.

Hard Rock Formations

3.4.2 Formation/District wise salient Features of ground water exploration

The ground water exploration was envisaged in the hard rock areas of the Kachchh, Dohad and Panchmahal districts.

of ground water in this formation. Five Exploratory wells and three Observation wells were constructed in Anjar, Bhuj, Mandvi and Abdasa talukas of the district with depth range of 136.10 to 453.30 m bgl. The Bhuj sandstone was encountered between 136-273 m. The depth to water level ranged from 7.85 m bgl (Sherdi EW) to 63.10 m bgl (Chunddi EW). The compressor discharge of the wells varied between 408 lpm (Sherdi EW) to 900 lpm (Chiyasar EW). The EC values ranged from 1256 µS/cm (Nana Bandra OW) to 24000 µS/cm at 25°C (Sherdi EW).

Panchmahal and Dahod Districts: Ten exploratory wells and three Observation wells were constructed in parts of the district of Panchmahal & Dohad covering Devgarh Baria, Dhanpur, Gohghambha talukas tapping weathered – fractured zones in Quartzite, Phyllites and Granite & Granite-gneissic terrains. The depth of wells ranges from

80 & 202.70 m bgl. The depth to water level ranges from 4.78 m bgl (Gothib EW) to 16.78 m bgl (Sevaniya OW). The discharge of the wells varies from 12 lpm (Antela EW) to 900 LPM (Lawariya EW). The EC values ranges from 460 µS/cm to 1960 µS/cm.

Exploratory wells drilled upto 200m tapping mainly phyllites and also/ or partly quartzite yielded negligible to about 1.5 lps. Wells drilled tapping quartzites yielded 2 – 4 lps water heavy drawdown from 6 – 60 m. There are strong indications of presence of fracture zones at depth below 120 meters however contribution of yield of such fracture zones was limited to the extent of 0.2 to 2 lps. In most of the cases minor fracture zones encountered at depth below 100 were of not much significance for contribution to the total yield of the well. However the presence of deep seated fractures of meager to low yield is significant in water supply to tribal hamlets in isolated areas.

Soft Rock Formations

The ground water exploration was envisaged in the soft rock areas of the Ahmedabad and Mahesana districts.

Mahesana District: One observation well was constructed in Gamanpura village. The area under exploration is characterized by multiple aquifer systems. The village has experienced out burst of tubewells due to oil and gas exploration activities. Exploration was taken up with the objective to identify mixing of water between aquifer.

The explored depth was 140.35 mbgl and the depth of construction was 139.00m bgl. The depth to water level ranges from 15.41 mbgl (Gamanpura OW-I) to 125.66 m bgl (Gamanpura EW). The compressor discharge was measured to be 12 lpm. The quality of groundwater in the well is 3510 µS/cm at 25°C .

Ahmedabad District: The area under exploration is characterized by multiple aquifer systems. Exploration was taken up with the objective to identify hydraulic connectivity between the aquifers. Two exploratory wells were constructed in Telavi village, taluka: Detroj Rampura of Ahmedabad district. The explored depth of EW-I and EW-II was 450.85 and 450.60 m bgl respectively where as the depth of construction was 228 and 383m bgl respectively. The depth to water level measured at EW-I and EW-II are 115.70 bgl and 125.95m bgl respectively. The compressor discharge was measured to be 60 and 84 lpm respectively.

3.4.3 Piezometer Construction in alluvial area

As a part of AAP 2009-2010 Piezometer were constructed for monitoring purpose mainly to improve the network in the districts of Gandhinagar, Vadodara, Banaskantha, Bhavnagar and coastal district of Junagadh & UT of Diu. A total of 17 piezometers were constructed.

Banaskantha and Gandhinagar districts form parts of the North Gujarat region and the ground water resources are highly developed. Most of talukas in these districts are OE/critical. Due to overdraft of groundwater the water level in deeper aquifer are declining at alarming rate. The area is underlain by alluvium. A multiaquifer system has been established during previous studies. Two major aquifer units have been identified in the area. The upper unit is mostly unconfined and designated as aquifer 'A'. The lower unit, comprising a few hundred metres of alternating sandy and argillaceous beds, form confined aquifer system and the aquifers has been designated as 'B', 'C', 'D' and 'E' within post Miocene sediments, 'F' and 'G' in the Miocene sediments and aquifer 'H' in the Himmatnagar sandstone (Mesozoic). Aquifer 'A' shows the most favourable hydraulic parameters and contains the best quality of ground water in the vicinity of the recharge zone in the northeast. It deteriorates towards southwest. The same trends noticed in the confined aquifers also. Piezometers were constructed tapping different Aquifers down to the depth of 196 mbgl.

Gandhinagar District: In Gandhinagar district four piezometers were constructed in Gandhinagar and Kalol taluka. Two piezometers were constructed at Adalaj village tapping Semi confined aquifer (PZ-II) and Phreatic aquifer (PZ-III). The piezometer head in PZ-II tapping zones between 59-139 mbgl is 85.35

mbgl with good quality. The static water level in PZ-III tapping zones between 21-45 mbgl is 24.46 mbgl with good quality. Two piezometers were constructed at Kalol tapping confined aquifer (PZ-I), and Phreatic aquifer (PZ-II). The PZ-I tapping zones between 150-192 mbgl has a piezometric head of 113.26 mbgl with good quality. The PZ-II tapping zones between 36 -61 mbgl has a static water level of 57.6 mbgl.

Vadodara District: In Vadodara district three piezometers were constructed. One Piezometer was constructed at Vadshala tapping semi confined aquifer (PZ-II), with zones between 90-142 mbgl has a piezometric head of 26.92 mgl with brackish water. One replacement piezometer was constructed at Sankarda tapping the phreatic aquifer between 30-51 m bgl and has a Pz head of 30.91 mbgl and moderate water quality. Another replacement piezometer was constructed at Raypura tapping the phreatic aquifer between 25-43 mbgl, with water level at 14.64 mbgl with good quality of water.

Banaskantha District: Four wells were drilled in Banaskantha district, out of which three were constructed as piezometers and one was abandoned due to mechanical breakthrough. Two piezometers were constructed at Deesa tapping semi-confined aquifer between 152-196 mbgl with water level at 54.76 mbgl with good quality water and phreatic aquifer between 44-60 with water level at 47.03 mbgl with good quality of water. One replacement piezometer was constructed Mahi tapping confined aquifer between 146-176with piezometic head at 134.75 with good quality of water.

Rehabilitation of Defunct Piezometers:

Two piezometers were rehabilitated at Chitral and Ghayaz in Vadodara district.

Summarized results of Aquifer Performance Test

Sl.No.	Location	Taluka	District	Duration of Pumping (min)	Depth (mbgl)	SWL (mbgl)	Discharge (lps)	Dradown (m)	Specific Capacity(lpm/m)	Transmissivity (m^2/day)
1	Methan	Limkheda	Dohad	1000	200.6	10.53	8.45	19.33	26.22	-
2	Singhbad	Limkheda	Dohad	1000	200.7	16.54	4.3			-
3	Lawariya	Devgarh Baria	Dohad	1000	80.7	7.25	11.15	12.01	58.70	-
4	Limdiya	Devgarh Baria	Dohad	600	200.6	9.41	3.14	37.08	5.08	-
5	Boriya	Sehera	Panch mahals	1000	180.3	6.42	5	38.26	7.84	-
6	Dadas hrinagar	Morbi	Rajkot	600	150	14.26	3.6	43.83	4.92	13.33

3.4.4 Piezometer Constructed in Coastal areas

In coastal areas of Saurashtra and UT of Diu, a total number of six piezometers were constructed in semi-confined and phreatic aquifers.

Bhavnagar District: Four piezometers were constructed tapping phreatic and semi-confined aquifers. One piezometer was constructed at Malvav, taluka Mahuva tapping the Miliolitic limestone. The total depth of construction was 43 m bgl and the zones tapped were between 29 and 41 m bgl. The SWL in and around the area was about 23 m bgl and the quality is brackish having 3800 ppm. 3 more piezometers were constructed collectively in Sihor and Bhavnagar talukas tapping the closed alluvium deposits deposited due to shear contacts. The explored alluvial thickness of this area is about 200m. There is a sudden contact of alluvium with the Deccan traps in this area. Ground water occurs in semi confined to confined conditions. The depth range of piezometers constructed in this area is 107 – 153.50 m bgl. The piezometric level varies from 20 to 64 m bgl. Owing to the deep water levels, the zones were tapped between 50 and 152 m bgl. The quality of ground water in this area is brackish having TDS between 2600 and 6400 ppm.

Junagadh District: One piezometer was constructed in Gangda at taluka Una in phreatic coastal alluvial aquifer. The depth of the piezometer is 21m bgl and the zones were tapped between 14 - 20 m bgl. The static water level was 6.24 mbgl. The quality of the ground water is good i.e. the TDS is 1400 ppm.

UT OF DIU: One piezometer was constructed at Chakartirth tapping the coastal alluvium and milliolite limestone. The depth of piezometer is 18 m tapping 8-11 m bgl. The static water level was about 6 m bgl and the quality is brackish (TDS is about 4000 ppm.)

3.5 NCR, BHOPAL (Madhya Pradesh)

Ground Water Exploration has been undertaken in Betul, Panna, Damoh & Sagar district of Madhya Pradesh and constructed 42 EW, 11 OW, 27 PZ, Total-80 wells

District wise summarized details of Ground Water Exploration in the State (in range)

Sl. No.	District	Depth Drilled (mbgl)	SWL (mbgl)	Discharge (lps.)	Formation
1.	Betul	152.5	16.5-19.8	-	Deccan Trap,
2.	Panna	60.00-205.30	3-50	0.4-8.33	Sand stone and shales

3.	Damoh	19.3-305	3.03-90	0.2-12.86	Shales, Lime stone
4	Sagar	26.2-201.3	4.5-21.	0.5-2.5	Basalt, Vindhyans

3.5.1 District wise summarised results of ground water exploration:

Betul District: An exploratory well was drilled down to a depth of 152.5 mbgl at Kurmur site with water level ranges from 16.5 to 19.8 mbgl.

Panna district: In Panna district, 21 wells were constructed. Panna district is covered mostly by sandstone and shales of upper vindhyan age. The depth of drilling ranges between 67.10 to 205.30 m bgl. Water level ranges between 3 to 50m bgl. Maximum yield has been encountered at Piparmah (EW) 8.33 lps. Quality of ground water in general is good and electrical conductivity ranges from 155 (Amjhria) to 6360 (Ghatari) µs/cm at 25 °C. Chloride value ranges from 11 mg/l (Amjhria) to 1135 (Shahnagar). Fluoride values ranges between 0.03 mg/l (Amjhria) to 2.15 mg/l (Nayagaon).

Damoh district: Ground water Exploration in Damoh district has been undertaken upto the maximum depth of 305 m at Narsinghgarh, Damoh (Poly-technic) and Bansatra in vindhyan formation. The lime stone of vindhyan formation forms the promising aquifer in Patharia and Batiagarh blocks of Damoh district. High yielding wells were constructed at Chirola, Patharia, Sitanagar and Kindraho exploratory sites. The vindhyan sand stone and shales forms the poor aquifer in the area. The wells constructed in Damoh and Tendukheda blocks yields meager to moderate discharge of ground water.

Sagar District: Ground Water Exploration in Sagar district has been undertaken to a maximum depth of 180.7 mbgl at Maharajpur in Basalt. Water level varies from 4.5 (Kesli) to 21.0 m bgl (Sahajpur). Yield of exploratory wells ranges from 0.5 to 2.5 lps.

3.6 NCCR, RAIPUR, Chhattisgarh

Ground Water Exploration has been undertaken in Dhamtari, Sarguja, Durg, Korba district of Chhattisgarh and constructed 17 EW,14OW and 22 PZ (Total-53 wells)

3.6.1 Summarized details of Ground Water Exploration :

Dhamtari District: In Dhamtari district, 18 wells were drilled in the depth range of 15.9-202 m. The area of the district is mainly covered with alluvium and Charmuria formation of Raipur group of the Chhattisgarh super group. Charmuria formation mainly consist of limestone and shale. Cavernous limestone form potential formation in the area, with zones extended down to 100 m, in addition to cavernous zones Weathered mantle also forms the potential aquifer in the area. Ground water occurs under unconfined conditions in weathered mantle and semi confined to confined condition in cavernous zones, potential zone recorded at 21-24, 35-40, 50-58, 78-80, 145-155 m bgl and yield varies from 0.4 to 7 lps with a maximum draw down of 30 m. Static water level range from 10-23.0 mbgl. In seven places (Amdi,Arjuni,Demar,Khapri,Mujhgaha, Palari and Rawan) observation wells are constructed for demarcation /extension of potential aquifer and assessment of aquifer parameter

District	Depth Drilled (mbgl)	Zones tapped/ Fractured encountered (mbgl)	SWL (mbgl)	Discharge m^3/hr	Draw Down (m)	Aquifer parameter T (m^2/day)	Formation
Dhamtari	15.9-202	21-155	10-23	1.8 – 28.8	4-30	T-5-90	Alluvium m Limestone, Sst and Granite
Surguja	77-200	20-60	3-12	0.72-18	14-37	1-30	Granite – Gneiss
Durg	36 - 150	22-130	8-25	1.8 – 15	15-40	T -2-75,	Limestone, Sst and Granite – Gneiss
Korba	35-150	30-120	3-30	0.72 – 16.38	10-30	2-14	Sandstone , Shale and Coal seam

Durg District: Fourteen Piezometers were drilled in the district in Tandula Command area with an aim to understand the geometry and potentiality of aquifers as well to obtain and supplement the water level data of the area for the conjunctive use studies, being carried out in the area by department. The area is occupied by sedimentary rocks of Chandrapur and Raipur Group, Chhattisgarh Super Group. The caverns developed in the Cherty Lime stone of Lower Charmuria Formation of Raipur Group have been proved highly potential and have been developed accordingly. Due to the excessive pumping of Ground water from this formation, for irrigation purposes, the water table of the area has been lowered considerably, which has resulted into the extinction of dugwells in the area. The depth of piezometers drilled in the area ranges between 38 and 152 metres. The weathered thickness varies from 6.50 to 27.50 metres bgl. The caverns in Cherty Limestone have been developed within 30 m depth as well between 73-76

in eastern part. At Pipercherri a cavern was encounterd between 25 and 27 m bgl, consequently the borewell drilled down to 150 meters but no water bearing zone was encountered below. In Chandrapur sandstone deep minor fractures have been encountered down to 90 meters. The exact discharge in limestone caverns could not be confirmed with air compressor due to air loss during drilling and PYT also. Shallow Piezometer at Khairwahi has yielded 3.5 lps discharge during PYT. The transmissivity of cherty limestone lies between 0.55 and 46 m2/day. The fractured sandstone in Chandrapur Formation has yielded 0.63 lps of discharge where as weathered granite formation encountered between 82-85 m at Padkibhat Pz has yielded 1.2 lps of water. The aquifers in limestone show semi-confined conditions. In Cherty Limestones water level remains between 20 -25 m bgl thoughout the year due to heavy pumping for irrigation purposes. Water level in Chandrapur Formation was observed as 31.90 m bgl whereas in weathered granite it was measured as 25.50 m bgl.

Surguja District: In Surguja district, 12 wells were drilled in hard rock area in the depth range of 77-200 m. The discharge of well varies from 0.5-12 LPS and SWL from 4-12 mbgl. Generally the aquifers are within 70 m depth in the granitic formation. In granite the general discharge of phreatic aquifer (weathered granite) varies from 0.80 to 3.0 lps. Due to repeated deformation the weathered thickness in ChhotaNagpur Granitic Gneisses is very high but does not possess good aquifer. Aquifer encountered in granites, just below the weathered mantle or within the massive granite down to 60 metres, has comparatively yielded good water in the range of 1 - 5 lps for a draw down ranging between 22.76 and 33.74 m. Static water level in granites varies between 3.00m bgl and 12 m bgl. The values of transmissivity ranges between 0.95 m2/day to 30.0 m2/day.

Korba District: In Korba district, in the Barakar formation eight piezometers were drilled to study the behaviour of phreatic and confined aquifers and effect of the coal mining. The piezometers were drilled in the range of 25-150 m, with the discharge in the range of 0.2-4.5 LPS. The formations encountered is Barakar sandstone. In general three wells are constructed in each site, tapping different aquifer of the Baraker Formation. Exploration data of existing bore wells drilled in the area marked presence of

potential granular zones below 100 mbgl, yield varies from 0.5 to 4.55 lps with a draw down of 30m. Potential zones observed at depth of 30-40, 50-70, and 110-120m

List of High Yielding Wells in Chhattisgarh

SL. No..	District	Location	Drilled depth (mbgl)	Discharge (lpm)	Formation
1	Dhamtari	Demar	153.2	240	Alluvium and Charmuria fm Chandrapur Fm and Granite
2		Khapri	131	330	
3		Palari	122.3	273	
4		Rawan	168	420	
5	Surguja	Parsa	200	240	Chhota Nagpur Granite Gneiss.
6		Belkota	198.6	210	
7		Bilaspur	118.6	720	
8		Chiranga	122.6	720	

3.7 CR, NAGPUR (Maharasthra)

Ground Water Exploration has been undertaken in Amravati, Beed/Parbhani, Satara and Raigarh/Thane districts for the construction of exploratory bore wells in hard rocks. Altogether 53 wells (34EW, 16 OW & 3PZ) have been constructed. District-wise summarized details of Ground Water Exploration given below

Sl. No.	Salient Features	Amravati	Beed	Satara	Thane and Raigarh
1	No. of Exploratory Wells	6	10	11	7
2	Depth range (mbgl)	165.0 - 300.0	95.0 - 200.00	175.0-200.0	141.70 – 200.00
3	Depth of casing (mbgl)	8.00 – 88.50	3.50 - 15.00	4-11	5.70 – 8.30
4	Number of zones encountered	1 to 4	1 to 4	1 to 3	1 to 2
5	Thickness of individual zone (m)	2 to 12	2 to 5	1 to 3.10	1 to 2
6	SWL range (mbgl)	10.20-81.00	7.36 to >100m	2.00-22.30	1.40 to 36
7	Yield range (lps)	1 - 5.15	0.14 to 19.66	<0.14 - 12.18	0.38 to 13.5
8	No. of EW's with yield >3 lps	3	5	4	2
9	EC range (micromhos/cm)	1100-13000	790 to 1000	--	--
10	Formation	Alluvium & Basalt contact	Basalt	Basalt	Basalt

3.7.1 Highlights of Ground Water Exploration

Out of 34 exploratory wells drilled, 14 EW's (about 41 %) have yielded more than 3 lps. The district-wise break up of high yielding bore wells is given in table

Sl. No.	District	No. of EW Drilled	No. of EW with yield > 3 lps	% of High yielding EW	Depth Range (mbgl)	Yield Range (lps)
1	Amravati	6	3	50.0	165.50-273.80	3.17 - 5.15
2	Beed	10	5	50.0	95.00-200.00	3.17 - 19.66
3	Satara	11	4	36	140.00-200.00	3.00 - 12.18
4	Thane and Raigarh	7	2	23	141.7 – 143.20	10.0 - 13.5

3.7.2 List of High Yielding Wells :

District-wise break up of High Yielding Exploratory Borewells

Sl. No	District	Location	Drilling Depth (mbgl)	Discharge (lps)	Formation
1	Raigarh	Nere, Panvel Taluka	147.70	13.5	Fractured Vesicular Basalt
2	Thane	Dongarnhave Murbad Taluka	143.20	10.00	Fractured Massive Basalt
3	Satara	Chimangaon, Koregaon Taluka	200.00	12.18	Fractured Massive and Vesicular Basalt
		Lhasurne, Koregaon Taluka	200.00	3.00	Vesicular Basalt, Fractured Vesicular Basalt and Fractured Massive Basalt
		Pingli Bk, Man Taluka	200.00	10.00	Fractured Massive Basalt
		Pingli Bk, Man Taluka (OW)	178.20	10.00	Fractured Massive Basalt
		Pingri, Man Taluka	200.00	3.00	Fractured Massive Basalt
3	Beed	Chausala, Patoda Taluka	95	3.17	Fractured Vesicular Basal
		Manjarsumbha, Beed Taluka	200.00	3.77	Fractured Vesicular Basalt, Fractured Massive Basalt
		Kumbhepha, Kaij Taluka	122.50	9.84	Highly Fractured Basalt
		Adas, Dharur Taluka	200.00	4.43	Vesicular Basalt
		Bansarola, Kaij Taluka	98.10	19.66	Highly Fractured Vesicular Basalt
4	Amravati	Adgaon, Morshi Tq.	273.8	5.15	Fractured Vesicular Basalt
		Yavli Shahid, Amravati Tq.	165.00	3.17	Fractured Basalt
		Karajgaon, Amravati Tq.	202.00	3.17	Vesicular Basalt

3.8 NR, LUCKNOW, Uttar Pradesh

Ground Water Exploration has been undertaken in Ballia, Mau, Bulandashar, Ghazipur, Merrut, Varanasi, Mathura, Chitrakut, Allahabad districts of U.P and constructed 19 EW, 13 OW, 2 PZ(Total-34 Wells) District wise Summarized details of Ground Water Exploration in the State (in range).

Sl. No.	District	Depth Drilled	Zones tapped/ Fracture encountered	SWL (mbgl)	Discharge (lpm)	Formation
EXPLORATORY WELL IN ALLUVIUM FORMATION						
	Ballia	255.00	156-242	7.42	2100	Alluvium
1	Mau	300.00	51-236	4.34	1850	Alluvium
2	Ghazipur	355.00	126-215	7.52	1835	Alluvium
3	Buland Shahar	260.00	142-250	-	-	Alluvium
4	Meerut	338.00	176-323	-	-	Alluvium
5	Varanasi	200.00	32.50-182	-	-	Alluvium
6	Mathura	151.50	18-75	6.10	140	
EXPLORATORY WELL IN HARD ROCK FORMATION						
1	Chitrakoot	126.65	Fr-7.70-93.15	3.00	497	Quartzite/ Vindhyan Sand Stone
2	Allahabad	203.30	35-65	7.43	162	Quartzite/ Phyllite/sand Stone
EXPLORATORY WELL IN ALLUVILA FORMATION						
	Merut	451	44-50	-	-	Alluvium

3.8.1 Summarized details of Ground Water Exploration :

Meerut district:-Meerut district, forming a part of Ganga Plain, occupies part of doab region of rivers Ganga and Hindon. The district is underlain by thick pile of alluvium sediment of Quaternary age comprising of sand of various grades, clay and kankar. The sandy horizons at different depths form the main repository of ground water. For delineation of aquifer system , assessment of potentiality, quantitative and qualitative assessment and sustainability of deeper aquifer (Ganga-Yamuna doab) an exploratory drilling was carried out at site Bahsuma down to a depth of 445.00 mbgl and electrically logged down to a depth of 445.00mbgl Three aquifer group appears to exist in the entire depth logged i.e. (I) 44-162mbgl,(II) 167-284 mbgl and (III) 293mbgl to depth logged.. The quality of formation water is fresh throughout the bore hole depth drilled. One Observation well and one piezometer were also constructed down to a depth of 324.00mbgl and

53.00mbgl respectively to determine aquifer parameters and behaviour of water level and connectivity of Ist and IInd aquifer groups.

Lakhimpur Kheri District: Ground Water exploration was carried in Lakhimpur Kheri district to mitigate the problems arising due to Arsenic contamination in ground water at sporadic spots in the villages of the district and for delineation of aquifers with Arsenic free formation water for safe drinking water supply. Geologically the area is underlain by Quaternary alluvium consisting of clay, kankar, sands of various grades & gravels in different proportions. The ground water occurs under water table condition in shallow aquifer and in deeper aquifer it occurs in confined condition. During 2009-10 2 OW I & II wells constructed at Persia. The depth drilled ranges from 54.00 to 156.00 m

Ballia District: In Ballia district Arsenic contamination in ground water at sporadic spots has been found in the villages located mostly in Recent flood plain of Ganga and Ghaghra river. The exploratory drilling was carried out in Ballia district for delineation of aquifers with arsenic free formation water for safe drinking water supply.1 Exploratory well namely Sohan has been drilled. The depth of well ranges from 254.00 mbgl.

Varanasi District: During current AAP 2009-10, 2 Exploratory wells namely Pindra and Phulwaria are constructed. The depth drilled is 200.00m and well constructed is ranges 158-190 mbgl. The area is characterized by the two distinct morphological units .The first Ganga alluvial plain unit occupying trans –Ganga area in the north of the Ganga –Yamuna doab area, and the second hard rock unit occur in trans Yamuna area in the south.

Chitrakoot District: During current AAP 2009-10, 3 Exploratory wells and 1no.observation well has been drilled. The depth of well ranges from 49.65- 125.85 m bgl. The geological setup of the area is mostly characterized by marginal alluvium of Quaternary age ,rewa sandstone and Trioham limestone. The basement pf the area is mostly madeup of Bundelkhad Granite gneiss.

High Yielding Wells

District	site	Drilled depth (m)	Discharge (LPM)	Formation
Mirzapur	Banki	87.00	896	Vindhayan Sand Stone

Summarized results of Aquifer Performance Test

District	Location / site	Duration of test (minutes)	Discharge (LPM)	Drawdown(m)	Specific Capacity (lpm/m)
Meerut	Sardhan	2000	2165	8.53	253
Gonda	Kankpur	500	1627	12.27	132
Varanasi	Phulwaria	500	903	2.52	358
Chitrakoot	Gall Mandi	240	230	16.65	13
Chitrakoot	Guyan Khurd	360	242	18.71	13
Chandauli	Muzaffarpur	300	439	7.2	52
Chandauli	Raghunathpur	300	507	0.59	851
Pratapgarh	Kusfera	300	937	8.7	40
Pratapgarh	Bhupia	300	652	3.46	188
Mirzapur	Durmanganj	300	488	15.01	32
Ballia	Adampur	1015	1419	9.12	155

3.9 MER, PATNA, (Bihar & Jharkhand State)

Ground Water Exploration has been undertaken in Bihar & Jharkahnd and constructed 30 wells(12 EW, 8 OW and 10 PZ). In Bihar a total 02 EWs, 03 OWs and 10 PZs has been constructed in alluvial formation in Begusaria, Saran, Patna district while in Jharkahnd 10 EW & 5 OW have been constructed in hard rock areas of Bokaro district. The piezometers have been drilled as a part of Special Study on arsenic contamination in parts of Beusarai and Saran districts. In Patna urban area 06 deep piezometers were constructed to monitor the piezometric level of the deeper aquifers in the urban area. The piezometric level of the deeper aquifer in Patna urban area is essentially required to prepare the groundwater development related plans of this city which almost entirely depends upon groundwater resources to meet its water demand.

3.9.1 Summarized details of Ground Water Exploration

Bihar:- The ground water exploration in Bihar has been carried out to study the natural contamination of aquifer with arsenic in Alluvial areas of Bihar. In alluvial formations, exploratory drilling were carried out in Begusarai, Saran and Patna districts, which drilled 02 Exploratory wells, 10 peizometers and 03 observation wells. The peizometers have been drilled for assessing arsenic concentration in ground water of aquifers disposed at various depths. It has been observed that the aquifers are affected with arsenic down to a depth of 60 m (considering max. permissible limit

as 50 ppb). The exploratory wells have been drilled up to depth of 252.5 m bgl with an objective to tap sufficient thickness of arsenic free aquifers for drinking water supply in the Arsenic affected localities. The aquifers tapped in the exploratory wells are confined in nature. In Patna urban area 06 Piezometers have been drilled tapping depth zones varying from 84 to 208 m to monitor the piezometric level of the deeper aquifers in the urban area.

Jharkhand: Exploration has been carried out in parts of Bokarao district where a total 10 EWs and 05 OWs have been drilled down to the depth of 26-200 m, with the discharge in teh range of 1.5-8.0 LPS. High yielding well at Barmasia, Bokaro district has been drilled with discharge of 8.0 LPS

High Yielding Tube wells

High yielding tube wells drilled (>50 lps discharge)

District	Location/Site	Drilling Depth (m)	Formation
Begusarai, Bihar	Barauni Flag	252.50	Quaternary Alluvium.
	Bihat	233.75	-do-

Summarized results of Aquifer Performance Test

Locations	District	SWL (m bgl)	Discharge (m^3/day)	Draw down (m)	Transmissivity (m^2/day)	Storetivity
Narepur	Begusarai	5.80	2022	5.23	11998	
Tajpur	Jamui	5.64	449.28	22.06	54.80	$5.9*10^{-5}$
Barauni Flag	Begusarai	7.51	4310	9.11	7888	
Tetiya	Munger	2.84	587.52	3.83	143.35	
Tetiya	Munger	2.98	250.56	15.70	50.94	
Haveli Kharagpur	Munger	5.13	388.8	2.57	406	
Sitabdiara	Saran	5.125	4737.6	7.865	21636	$6.27x10^{-5}$

3.10 ER, KOLKATA, (West Bengal)

Ground Water Exploration has been undertaken in Jalpaiguri, Birbhum, Nadia, North 24 Paragana, Kooch Behar & Hugli district of West Bengal and constructed 30 wells(12 EW, 8 OW and 10 PZ)

District wise Summarised Details of Ground Water Exploration in the State is given below table

Birbhum: The main objectives of ground water exploration was to identify extension of Fluoride contaminated aquifers & to delineate Fluoride free aquifers, if any. Exploration reveals that fluoride concentration in shallow aquifers (between 46 & 64 mbgl) is 0.4 mg/l, i.e. below permissible limit (1.5 mg/l), whereas that in deeper aquifers (between 125 & 203 mbgl) is to the tune of 6.1 -7.4 mg/l. The tube well tapping shallow aquifers yielded about 94 m^3/hr, whereas the deep tube well has lower discharge of about 22 m^3/hr.

Nadia: In the district, Potential arsenic free aquifers between 134-158 mbgl have been identified.

North 24 Pargana: To delineate extension of arsenic free aquifers, groundwater exploration was taken up in Panihati Municipality and in parts of two blocks namely Haroa & Bashirhat -II blocks of North 24 Parganas district. It has been observed that:

- Panihati Municipality: Exploration shows that single potential aquifer exists from 40 – 220 mbgl depth and beyond this depth sticky clay is encountered. Analysis (by field kit) of water samples collected from the constructed exploratory wells shows that arsenic concentration is around 0.01 mg/l. Hence tube well tapping aquifers within this depth may yield arsenic free water and capable to yield 98.10 m^3/hr discharge.
- Haroa block: The present exploration reveals that two aquifer systems have been identified i) within 40 mbgl & ii) between 160 - 220 mbgl. The upper aquifer is contaminated with arsenic (> 0.05 mg/l measured by arsenic kit) and is the most developing aquifer for irrigational use (where discharge is 44.93 m^3/hr). The 2^{nd} aquifer, separated from the upper aquifer by a thick regionally extensive clay layer, is arsenic free and regionally extensive and capable of yielding 41.33 m^3/hr. The 2^{nd} aquifer may be tapped with cement sealing against the clay layer between the two aquifers. Arsenic concentration in 2^{nd} aquifer is <0.01 mg/ l as measured by field kit.
- Bashirhat II block: Exploration data reveals that the presence of two aquifers within the depth of 325 mbgl - one is within 110 mbgl and the another

3.10.1 Summarized details of Ground Water Exploration :

Jalpaiguri:- Exploration in the alluvial tract at Jalpaiguri Sadar block of Jalpaiguri distict reveals that fine sands with gravels are encountered right from the top to the drilled depth of 205 mbgl, with clay concretion in the depth span of 128-141 mbgl. To know the potentiality of the deeper

District wise Summarised Details of Ground Water Exploration in the State is given below table

Sl. No	District	Location	Depth drilled (mbgl)	Zones tapped (m bgl)	SWL (m bgl)	Discharge in m^3/hr	Formation
1	Jalpaiguri	Jalpaiguri Sadar block	205.14	162- 186	1.96	7.63 (C)	Alluvium
		Dhupguri Block	98.50	55-58 & 75-96	0.17	108 (C)	Bouldary Formation
2.	Birbhum	Rampurhat II Block	225.30	125-128, 132-135, 141-149, 153-157	12.91	22.32 (C)	Alluvium
		Ranpurhat II Block	95.00	46 - 64	17.66	93.60 (C)	Alluvium
3.	Nadia	Chapra Block	331.00	134-158	3.15	129.6	Alluvium
4.	North 24 Parganas	Panihati Municipality	325.04	185-215 mbgl with cement sealing between 160-163 mbgl	12.38	44.28	Alluvium
		Haroa Block	325	175-205 mbgl with cement sealing between 100-105 mbgl	4.33	41.33	Alluvium
		Haroa Block	56	20-26, 30-36	0.89	44.93	Alluvium
		Bashirhat II Block	325.51	135- 159 mbgl with cement sealing between 33-36 mbgl	7.10	4.104 (C)	Alluvium
		Bashirhat II Block	121.62	90- 108 with cement sealing between 33-36 mbgl	7.86	49.79 (C)	Alluvium
5.	Kochbihar	Haldibari Block	226	90-102, 116-128, 140-146	1.41	111.60 (C)	Alluvium
		Dinhata Block	225.23	135- 165	3.99	90 (C)	Alluvium
6.	Hugli	Pandua Block	91	70-88	15.10	59.18 (C)	Alluvium
		Pandua Block	31.90	10-16	2.20	52.20 (C)	Alluvium

aquifers, tube well constructed by tapping granular zones between 162 & 186 mbgl. The well yielded only 7.63m^3/hr.

To study the disposition & potentialities of aquifers in bouldery formation , exploratory well drilled down to the depth of 98 mbgl in Dhupguri block of Jalpaiguri district. The cumulative thickness of aquifers of 24 m encountered in the depth span of 55-96 mbgl . The well yielded about 30 lps (108 m^3/hr).

Birbhum:- The main objectives of ground water exploration was to identify extension of Fluoride contaminated aquifers & to delineate Fluoride free aquifers, if any. Exploration reveals that fluoride concentration in shallow aquifers (between 46 & 64 mbgl) is 0.4 mg/l, i.e. below permissible limit (1.5 mg/l), whereas that in deeper aquifers (between 125 & 203 mbgl) is to the tune of 6.1 -7.4 mg/l. The tube well tapping shallow aquifers yielded about 94 m^3/hr, whereas the deep tube well has lower discharge of about 22 m^3/hr.

Deep exploratory Well constructed by CGWB, at Khasbalanda village, Haroa block, North 24 parganas district, West Bengal using cement sealing techniques

Kooch Behar: In Kooch Behar district,hiighly potential aquifers between 90-165 mbgl have been identified.

Hoogly: Exploration in a part of Pandua block of Hoogly district reveals the existence of two distinct aquifer systems- the shallower one lies within 20 m depth with average cumulative granular zones of 10-15 m & the deeper one within the depth of 92 m with average cumulative granular zone of more or less 40 m. The first aquifer system is in phreatic condition with SWL within 2.21-2.20 mbgl and the second aquifer is in confined condition lying beneath a thick layer of 25 m.

Deep exploratory Well constructed by CGWB, at Khasbalanda village, Haroa block, North 24 parganas district, West Bengal using cement sealing techniques (cement sealing depth 100 to 105 m bgl) tapping the deeper arsenic free aquifer (175 to 205 m bgl) yielding 34 lps of arsenic free water.

Summarized results of Aquifer Performance Test in W.B.is given below:

Sl. No.	Location/ Block/ District	Geology	Zones tapped/ Fracture encountered (mbgl)	Discharge (lpm)	Draw down (m)	Transmitivity (m^2/ day)	Storativity (S)
1.	Rampara Chenchra/ Tapan block/ Dakshin Dinajpur Dt.	Older Alluvium	122-140, 143-161 mbgl	216	10.95	56.92	1.35×10^{-3}
2.	Rampara Chenchra/ Tapan block/ Dakshin Dinajpur Dt.	Older Alluvium	52-62	110	SEW: 4.66 (after 300 mins of pumping)	69.0	7.23×10^{-4}
3.	Gangarampur Municipality/ Dakshin Dinajpur Dt.	Older Alluvium	170-188, 191-203 mbgl with cement sealing between 92 & 96 mbgl	440	3.15 (after 400 mins of pumping)	579.76	-
4.	Sarbamangola / Gangarampur block/ Dakshin Dinajpur dt	Alluvium	176-188, 191-203 with cement sealing between 117&121 mbgl.	234	20.01 (after 400 mins of pumping)	33.60	
5.	H.B.Town/ Panihati Municipality/ North 24 Parganas Dt.	Alluvium	185-215, cement sealing at 160-163 mbgl.	738	2.29 (after 360 mins of pumping)	1296.55	-
6.	Khasbalanda, Haroa block, North 24 Parganas dt.	Alluvium	175-205. cement sealing at 100-105	689	DEW: 1.41 (after 300 mins of pumping)	2269.62	8.438×10^{-4}
7.	Khasbalanda, Haroa block, North 24 Parganas dt.	Alluvium	20-26, 30-36.	749	2.12 (after 360 mins of pumping)	789.52	-
8.	Uludanga / Amdanga block/ North 24 Parganas dt.	Alluvium	45-51, 53-59	794.4	2.865 (after 300 mins of pumping)	2096	-
9.	Bokunda, Barasat II, N-24 Parganas dt.	Alluvium	194-212, 256-262, 275-281 with cement sealing between 177&180 mbgl.	844.2	2.65 (after 360 mins of pumping)	1711	
10.	Bokunda, Barasat II, N-24 Parganas dt.	Alluvium	130-136, 139-145, 148-154, 157-163 mbgl with cement sealing between 79-82 mbgl	844.2	10.43 (after 360 mins of pumping)	556.4	-
11.	Bokunda, Barasat II, N-24 Parganas dt.	Alluvium	46-58 mbgl	-	4.75 (after 500 mins of pumping)	231.91	-
12.	Odlabari, Malbazar block, Jalpaiguri dt.	Bouldery Formation	37-46, 49-61, 70-73	440	1.02 (after 400 mins of pumping)	724.69	-

3.11 NER, GUWAHATI(NE States)

Ground Water Exploration has been undertaken in Marigaon, Karimganj, Dibugarh, North Sonitpur & Kamrup District, Assam by construction of 28 wells(15EW & 13 OW)

Summarized details of Ground Water Exploration in the Assam (based on departmental drilling)

District	Depth drilled (m) bgl	Depth of construction (m)	Zones tapped (in mbgl)	S.W.L (m bgl)	Dicharge m3/hr.	Formation
Marigaon	32.5-180	32-119	24-116.	2.50-7.42	8.4-94.44	Alluvial
Karimganj ,	159-200	138-171	98-167	Auto flow at one well	12.26(Auto flow)	Alluvium
Dibrugarh,	123-201	118-131	42-126.	0.55-3015	35-59	Alluvium
North Sonitpur,	82-85	80-85	42-83	0.51-4.0	29.95-34.47	Alluvium
Kamrup district,	51-92	62-89	32-77	1.60-12	23-29	Alluvium

3.11.1 Summarized details of Ground Water Exploration :

Morigaon District, Assam: 4 EW and 4 OW were constructed in the district within 104–180m bgl. The formation encountered belong to Alluvium of Recent to Sub-Recent age and comprise clay, silt, sands of all grades. Ground water exploration was confined to southern, northern part and the active flood plain areas of the district with Static water level ranges from 2.50 to 7.42m bgl. The air compressor discharge ranges from 8.4 to 94.44 m^3/hr. The exploration has revealed that the area posses potential aquifer of homogeneous type sediments and the deposition of sediment is in normal sequence.

Karimganj & Hailakandi District, Assam: Ground Water Exploration was confined in the Barak valley of Karimganj district, Assam. Only one exploratory well down to 170 m bgl and one observation well down to 140 meter bgl was constructed in Karimganj district.

Dibrugarh district, Assam: The area under exploration is a valley plain, underlain by unconsolidated alluvial sediments, deposited over a semi consolidated Tertiary group of rocks. The area can be divided into two groups of water bearing granular zones 1) Shallow aquifer group & 2) Deeper aquifer group.

Shallow aquifer group: Top clay layer followed by mono aquifer with a thickness of 15 to 45 m occurs down to a depth of 50 meters bgl in most part of the district. But in flood prone areas i.e north of Dibru river, top clay layer is absent exposing sand with occasional silt down to the depth of 50 meters. Ground water occurs under unconfined to semi-confined conditions.

Deeper aquifer group: Zone extending below 50 meter depth is considered deeper aquifer. Exploratory wells constructed by CGWB,NER reveals the presence of mono aquifer in the northern part and multiple aquifer system in the southern part. Transmissivity values range from 1442 to 8234 m^3/day. The yield of wells varies from 81.7 m^3/hr to 164.9 m^3/hr with nominal drawdown. Thickness of aquifer increases from east to west.

Sonitpur, district, Assam: The foothill area of Arunachal Himalayas is extended beneath the Brahmaputra alluvium in the northern part of the Sonitpur district. The Himalayan Frontal Fault marks the boundary of the Brahmaputra alluvium with that of the Arunachal Himalayas. Due to sudden drop of gradient, the bed load of the river originating from the Arunachal Himalayas deposited it in the plain area of Assam. Therfore the thickness of alluvium increases from north to south of Sonitpur district. The permeability of the gravely aquifer at Tupia EW is 15m/day and it can be rated as good. The transmissivity is 705.73 m^3/day. Therefore it can be concluded that the aquifer is prolific one. In the Udamari EW under Balipara block similar gravely zone is also encountered with a conglomeratic horizons of 2 meter thick at 68m and 80 m depth respectively. The sand is micaceous and are similar with Kimin Formation of Siwalik Group.

Kamrup district, Assam: A total of 06 nos exploratory wells & 05 nos observation wells were constructed . The maximum drilling depth is 93 meter bgl. Three sets of granular zones were identified within the depth range of 93 m.. The first granular zone exist at 30-40m , second zone exist at 45 to 55m and third zones exist at 65 to 75 meter bgl in all these exploratory bore wells drilled in Kamrup district..Static water level varies from 1.6 m to 12 meter bgl. .Air compressor discharge in all these exploratory wells is approximately 30 m^3/ hr.

3.12 SER, BHUWANESHWAR, (Orissa State)

Ground water exploration was undertaken in Deogarh, Nuapada, Boudh,Sonepur, Mayurbhanj, Sundargarh, Jajpur and Cuttack district by constructing 69 wells(54 EW and 14 OW)

3.12.1 Summarized details of Ground Water Exploration :

Deogarh District : In Deogarh district, 12 exploratory wells and 3 observation well was constructed. The major formation encountered are quartzite, granite gneiss and garnetiferous granite gneiss. The depth of drilling varies from 78.3 metres below ground level in Belam, Barkote block to 190.35 metres below ground level at Donra, Markandpur, Barkote block of Deogarh District with the overburden depth ranging from 8.3 metres below ground level at Kansibahal of Deogarh to 37.5 metres below ground level at Jharabahal, Barkote. The water bearing fracture-zones have been encountered from 10 to 124 mbgl. The static water level varies from 0.25 metres below ground level at Baliposi to 9.79 metres below ground level at Donra. The cumulative discharge varies from 0.5 lps at Donra to 8 lps at Nuasahi (Barkote). The net drawdown varies from 4.75 to 33.35 m.

Boudh/Sonepur District : In Boudh district, 2 exploratory wells and 3 observation wells have been drilled during 2009 – 10. The depth of drilling varies from 93.5 metres below ground level at Kardi,Harbhanga Block to 166.7 metres below ground level at Sagada, Boudh Block. Formations encountered are mainly granite, granite gneiss and basic rocks. The depth of overburden varies from 8.5 metres below ground level at Sagada to 21 metres below ground level at Gundulia. The yield of the wells varies from 3.1 lps at Sagada to 4.8 lps at Karadi. Two to three sets of saturated fractures zones exists within a depth of 50 metres below ground level. The static water level varies from 2.92 metres below ground level at Sagada to 7.62 metres below ground level Kardi. The transmissivity values varies from 4 m2/ day at Kardi to 18.54 m2/ day at Sagada.
In Sonepur district 8 exploratory wells have been drilled in the depth ranges from 75.2 to 154.4 mbgl. Formations encountered are mainly quartzite and anorthosite. The wells are found to be dry in Singhijuba and Dubla of Binika and Tarabha block. Two to three sets fractures encountered.

Cuttack District : In the alluvial terrain of Cuttack district, only 5 exploratory well and 1 observation wells have been drilled at Nischintakoili, Mahanga and Salepur blocks. The depth of drilling is 66.50 metres below ground level at Kotpada to 142 at Kisinapur. Formation encountered is alternate layers of sands and clays with occasional presence of thin semi consolidated arenaceous and calcareous materials. Sand and gravels are very fine to coarse in texture, angular to sub-angular and sub-rounded in shape with moderate sorting. These are mostly quartzo-

feldspathic in composition with ferruginous concretion at shallow depths. On an average three to four sets of granular zones are encountered .The water bearing zone encountered at 45 metres below ground level to 130 metres below ground level. The cumulative discharge ranges between 10-22 lps

Nuapada District : In Nuapada District,5 Exploratory wells and 2 observation wells have been drilled. The depth of drilling varies from 102.2 metres below ground level at Darlinuapada to 184.25 metres below ground level at Guditor & Veterinary Hospital. Formations encountered are granite, granite gneiss and its variants. The depth of overburden varies from 14.46 metres below ground level at Darlinuapada to 32 metres below ground level at Shraddhapur UP School. The yield of wells varies from 1.5 lps at Bhalukona to 6.5 lps at Darlinuapada. The static water level varies from 3.5 metres below ground level at Veterinary Hospital to 7.5 metres below ground level at Bhlukona.

Sundargarh District : In Sundargarh District, 14 Exploratory wells and 3 observation wells have been drilled. The depth of drilling varies from 65 metres below ground level at Mahulpalli to 166 metres below ground level at Chatasargi. The formation encountered are mica schist, granite and limestone. The depth to overburden varies from 10 metres below ground level at Petford to 26.4 at Kinjerkela. The yield of the well varies from 1.5 lps at Old Jalda to 9.24 lps at Balijodi. Mica schists have poor yields. Granite and granite gneiss have poor to moderate yields and yield is higher where granites are intruded by pegmatite veins. In general two saturated fracture zones within 100 metres below ground level are of most common occurrence.

Mayurbhanj District : In Mayurbhanj district 7 Exploratory wells and 3 observation wells have been drilled during the year 2009-10. The depth of drilling varies from 31.6 metres below ground level at Fire Station, Udala to 153.8 metres below ground level at NAC Office, Udala. Formation encountered is mostly granite gneiss. The depth of overburden varies from 17.6 m at Fire Station to 27.5 m at Chuliaposi. The yield of well varies from 0.5 lps Horticulture compound & NAC office to 18 lps at Police Station. In general two saturated fracture zones within 100 metres below ground level are of most common occurrence.

District wise Summarized details of Ground Water Exploration in the State

District	Depth Drilled	Zones tapped	SWL	Discharge	Drawdown	Transmitivity	Formation/ Aquifer
	mbgl	mbgl	mbgl	m3/hr	m	m2/day	
Deogarh EW: 12 OW: 3	78.3-190.35	10,22,34,45,75,102,124	0.25 - 9.79	0.5-8	4.75-33.35	13.47-45.21	Granite Gneiss, Quartzite, Garnetiferous G.gneiss
Jajpur/ Cuttack- Alluvium EW: 5 OW: 1	66.50/96.15 – 142/199.7	36-42,48-58,77-97,120-132		10 - 22			Recent Alluvium
Nuapada EW: 7 OW: 2	102.2 – 184.25	30.8-27.8,60 - 67,101-102,138-140		0.2-6.5			Granite Gneiss,
Mayurbhanj EW: 7 OW: 3	31.6-154.5	26.5,70,116, 128,	3.2-6.2	0.5-9.5	5.73 – 18.77	7.19 – 14.31	Granite Gneiss,
Boudh/ Sonepur EW: 10 OW:: 3	75.2-166.7	20-23,35-38,63-66,97-101,	1.2-7.62	2.5 – 4.8	4.04 – 30.85	1.8 – 56.97	Granite
Sundargarh EW: 13 OW: 3	56.5-160.2	24-26,46-49,77-78,102-103	3.10-18.02	1.5-9.24	4.55-16.92		Mica Schist, Granite gneiss, Limestone

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High yielding wells

Sl No	District	Location	Drilling Depth (m)	Discharge (LPS)*	Formation
Hard Rock Terrain					
1	Boudh	Karadi	93.5	4.8	Charnokite
2	Boudh	Sagada	166.7	3.1	Granite
3	Boudh	Sagada	166.0	3.4	do
4	Boudh	Gundulia	136.2	4.5	Charnokite
5	Sonepur	Tithipalli	75.2	5.71	Granite
6	Sonepur	Singhari	148.4	3.66	Granite
7	Sonepur	Bagbahali	148.4	4.74	Anorthosite
8	Deogarh	Jharabahal	123.10	5	Granite gneiss
9	Deogarh	Barkote (Nuasahi)	135.3	8	do
10	Deogarh	Barkote (Nuasahi)	92.6	8	do
11	Deogarh	Barkote (Police stn)	86.5	7	do

12	Deogarh	Kaliapal	123.1	8	do
14	Deogarh	Belam	78.3	5	do
15	Deogarh	Belam	111.2	7	do
16	Deogarh	Majhichakundapal	147.50	5	do
17	Mayurbhanj	Fire Station - EW	80.30	5	do
18	Mayurbhanj	Fire Station - OW	105.30	9	do
19	Mayurbhanj	Police Station - EW	31.6	18	do
20	Mayurbhanj	Police Station - OW	93	3.8	do
21	Mayurbhanj	Revenue Compound - EW	129.6	4.3	do
23	Mayurbhanj	Revenue Compound - OW	135.7	4.4	do
24	Mayurbhanj	Chuliaposi	153.6	9.5	do
25	Mayurbhanj	Nududiha	132.2	4.3	do
26	Nuapada	Darlinuapada - EW	102.2	6.0	do
27	Nuapada	Darlinuapada - OW	102.2	6.5	do
28	Nuapada	Shradhapur UPSchool - EW	172.1	5	do
29	Nuapada	Bhalukona -EW	140.6	4	do
30	Sundergarh	Jharbeda- EW	62.6	4.16	do
31	Sundergarh	Barpalhi-EW	83.0	7	do
32	Sundergarh	Balijodi - EW	148.0	4.4	do
33	Sundergarh	Balijodi - OW	123.6	9.24	do
34	Sundergarh	Teliposh - EW	129.70	3.8	do
Alluvial Terrain					
1	Cuttack	Kakudiapada -EW	117/120	22	Alluvium
2	Cuttack	Barkolia -EW	135.0/209.74	15	Alluvium
3	Cuttack	Padampur -EW	135.0/146.13	16	Alluvium
4	Cuttack	Kishinapur -EW	142.0/199.7	15	Alluvium
5	Cuttack	Kotpada - EW	66.50/96.15	10	Alluvium
6	Cuttack	Kotpada - OW	66.50/96.15	10	Alluvium
7	Cuttack	Narendrapur - EW	117.0/218.0	15	Alluvium

3.13 SR, HYDERABAD, Andhra Pradesh

Ground water exploration was undertaken in Prakasam, Nizamabad, Karimnagar, E-Godavarir, Guntur & Krishna district by constructing 135 wells(22 EW ,10 OW, 103 PZ)

3.13.1 Summarized details of Ground Water Exploration :

Guntur & Krishna Districts: 6 exploratory wells and 2 observations wells were constructed to the maximum depth of 200 m in the areas underlain by gneisses and limestones under Ground Water Exploration Program. A total of 25 piezometer wells constructed down to the maximum depth of 38.60 m at 9 locations in the different hydrogeological environments to estimate specific yield.

The main objectives of exploratory drilling is delineation of Potential aquifer zones, aquifer geometry and to find the aquifer characteristics by drilling exploratory wells down to the depth of 200 m in crystalline and sedimentary formations in Guntur and Krishna districts. Construction of Piezometer well field to estimate specific yield of phreatic aquifers in different hyrogeologcial environments as well as for monitoring of ground water levels where the dug wells are dry

The potential aquifer zones were deciphered in the depth range of 20-100m. The depths to piezometric surfaces are found to be in the depth range of 0.25 m bgl (Rompicherla) to 15 m (Muktyala). The weathered mantle is found to be in the depth range of 5 to 8.50 mbgl. The aquifer characteristics were estimated through long duration pumping tests and the T values are ranging from 3 to 113.52 sq. m/day. The storage co-efficient is 4.0x10-5 (Muktyala). It is observed that the high yields are recorded in limestones of Krishna district. Through construction of six exploratory wells, 1500 sq. km area has been proved to be ground water worthy. Water samples were tested for general parameters. The successful wells along with findings were handed over to the Panchayat Raj Department for the public utility.

Karimnagar District: Twenty-seven Pzs, in 9 well fields were constructed, in different hydrogeological environs, to estimate Specific yield in Karimnagar District. In addition to well fields, 3 Pzs were constructed up to a depth of 70 m bgl for the ground water monitoring purposes. The area is underlain by crystalline rocks of Archean age. The rock types are granite and granite gneiss with minor variation in mineral composition. The main objectives for Construction of Piezometer well field is to estimate specific yield of phreatic aquifers in different hyrogeologcial environments and to establish net work of piezometers for monitoring GW Regime. The depth of Pzs varied from 26 to 45 m bgl by tapping weathered and first fracture zones. The depths to piezometric surfaces are in the range of 2.11 to 10.77 m bgl. Casing pipe lowered in weathered zone up to a maximum depth of 20.50 m bgl. The drilling discharge varied from traces to 1.70 lps.

Nizamabad District: Six exploratory wells and 1 observation well were constructed to the maximum depth of 200 m in the area underlain by Granites and gneisses. A total of 31 piezometer wells at 10 sites were constructed down to the maximum depth of 41mbgl falling in different hydrogeological environments to estimate Specific Yield.

The main objectives are to delineate Potential aquifer zones, aquifer geometry and find the aquifer characteristics by drilling exploratory wells down to the depth of 200 m in crystalline formations of Nizamabad district. Construction of Piezometer well field to estimate specific yield of phreatic aquifers in different hyrogeologcial environments.

The Potential aquifer zones were encountered in the depth range of 30 to 40 mbgl. The depth of the weathered zone ranges around 10mbgl. The depth to piezometric surfaces are generally in the range of 10 to 20 m bgl and major part of weathered portion is desatruated due to drought conditions and irrigation pumping through maximum number of shallow bore wells.

Prakasam District: Six exploratory wells, 2 observation wells and 2 piezometer wells were constructed to the maximum depth of 200mbgl. A total of 18 piezometers were constructed down to the maximum depth of 38 mbgl, at 8 locations, in the different geological formations and hydrological conditions to estimate specific yield.

The main objectives are to determine aquifer parameters in consolidated and unconsolidated rocks and to delineate potential aquifer zones in deeper aquifer by drilling exploratory wells down to the depth of 200 m in Igneous, Metamorphic formations of Prakasam district. Construction of piezometer well fields to estimate specific yield of unconfined/Phratic aquifers in different hydrological and geological formations.

Ground water exploration was taken up in schist, gneisses, phyllite and quartzites of Archeaen-proterozoic to recent age were. The Aquifer zones were encountered in between 21 and 180 mbgl. In these, exploratory bore wells the static water levels ranges from 6 m bgl (Dekhana Khonda) to 13 m bgl (Tadivaripally). The weathered mantle is found to be in depth range from 3 to 10mbgl. The aquifer characteristics were estimated through long duration pumping tests and slug tests to evaluate T values. The 'T' values range from 5 to 22 sq.m/day whereas storage coefficient is 4.0x10-4 at Tadivaripally site. It is observed that high yields are recorded in quartzites of Cuddapah formations and schist of Archaean-proterozoic age of Prakaam district. As far as quality is concerned two sites namely; Marripadu and Darsi areas high fluoride concentration which varied from 2 to 4.3 mg/l is recorded and the rest of the sites fall under the permissible limit. The successful wells along with findings were handed over to Panchayat Raj Department (RWS) for the public use.

High yielding wells in Andhra Pradesh :

District	Location / Site	Drilling Depth (m)	Discharge (lpm/lps)	Formation	Months/ Year
Muktyala	Krishna	130.1	504/8.4	Shale	March 2010
Allur	Nizamabad	120.5	480/8	Granites	June 2009
Nizamabad	Do	30	294/4.9	Do	August 2009
Prakasam	Kanigiri	123	372/6.2	Quartzite	Dec. 2009

3. 14 SWR, BANGALORE, Karnataka

Ground Water Exploration was undertaken in Chamarajanagar, Hassan, Belgaum, Chikkaballapur & Gulbarga district of Karnataka and constructed 49 wells(38 EW & 11 OW). District wise summarised details of ground water exploration:

District	Depth Drilled	Fracture Encountered (m)	SWL (mbgl)	Discharge (m3/hr)	Draw Down (m)	Transmitivity m2/day.	Formation
Chamarajanagar	104.7-191.10	34.55 - 144.35	7.39 to 34.90	Negligible to 16.17	4.79 – 9.11	---	Gneiss
Hassan	165-200	<50 and >100	---	Negligible to 24.37	3.9-31.88	1.7-304.96	Granitic gneiss
Belgaum	46.75-204.7	15.5-138	3 to >50	Negligible to 0.55	---	---	Gneiss, schist and phyllite
Chikkaballapur	25.6-501	41- 352	---	Negligible to 3.89	---	---	Granitic gneiss
Gulbarga	131.50 - 302.30	16.6-299.2.	1.95 to139.4	11.74 to 21.13	2.8 to 18.19	5.49 to 65.95	Basalts

3.14.1 Summarized details of Ground Water Exploration :

Chamarajanagar District: Four exploratory and two observation wells were drilled in Chamarajanagar district.The area is underlain by granite & granite gneiss. Depths of the wells range from 104.7 to 191.1 mbgl with static water level in the range of 7.39 to 34.9mbgl. Discharge ranges from negligible to 4.49 lps with drawdown in the range of 4.79 to 9.11m. Transmissivity ranges from 22.58 to 59.66 m2/day. Specific capacity ranges from 22.95 to 80.99m3/day/dd.

Water yielding fractures are encountered at different depths between 34.55 - 50.8m, 55.9 - 90.45 m, 128-144.35m

Hassan District: Under groundwater exploration in Hassan district, drilling was carried out in Arsikere and Belur taluk. Totally seven wells comprising of five exploratory wells and two observation wells were drilled. Based on remote sensing, aeromagentic breaks and hydrogeological survey, the sites were selected and recommended for geophysical survey. The sites were finalized for drilling based on the results of the above surveys. The depth of the bore well drilled in both taluks are ranging from 165 m to 200m and the yield of the borewell ranges from negligible to 6.77 lps. The highest yield was encountered in Mallaikallu Tirupath site followed by S.Diggenahalli where the yield of the bore well was 4.20 lps. Based on the ground water exploration results, the groundwater yielding fracture zones are generally occurring in two depth ranges i.e. within 50m and below 100m. The interrelation between two fractures systems is significantly low in nature. It has also been proved through the pumping test. Mallaikallu Tirupathi site is located on the pediment of Closepet granite. The closepet granite exposed in the area indicates the multiple fractures and traversed by the pegmatites veins and joins.

Based on the PYT, drawdown ranges from 3.90m to 31.88 mts. The minimum drawdown is recorded in Mallikallu Tirupathi and the maximum recorded in the Adaguru well. The Transmissivity of the borewell is ranging from 1.7 m2/day to 354.96 m2/day.

Belgaum district: Ground Water Exploration was carried out in Khanapur, Belgaum and Bailhungal taluks of Belgaum district. Gneiss, schist and phyllites underlie the explored area. Totally eleven exploratory wells were drilled. Depth of the bore wells ranged from 46.75 to 204.7 mbgl with casing lowered in the range of 3.00 to 32.10 mbgl. Static Water Level ranged from 3.02 to >50.0 mbgl. Zones tapped are 15.5 - 16.5 m, 19.1 - 20.1m, 51.1 - 52.2m, 71.3 - 72.3m, 137-138m with yield ranging from negligible to 2.0 lps.

Chikkabalapur district: (Deep drilling Programme – 500 m depth target): A total number of 8 borewells were drilled during the AAP under 'Deep Exploratory Drilling Programme' in Siddlaghatta and Chintamani taluks of Chikkabalapur district. Of these, five are exploratory wells and three are observation wells. The explored area is underlain by granites gneiss of the Peninsular Gneissic Complex of pre-Cambrian age. Phreatic zone is practically dry except in the topographic lows and vicinity of existing surface water bodies like MI tanks. The depth explored ranged from 225.6 to 501.0 m. Casing depth ranged from 12.2 mbgl to 90mbgl. Yield ranged from negligibe to 14 lps. Water yielding fractures are encountered at different depths between 41 to 47m, 102 to 144m, 297 to 352 m.

Gulbarga District: Ground water exploration studies were carried out at thirteen exploratory wells and four observation wells in Gulbarga and Aland taluks of Gulbarga district. The depth of thee well ranges from 131.50 to 302.30 m. Promising aquifer zones were encountered in Basalt at Narona (exploratory well and observation well-I), SyaidChincholi (exploratory well & observation well) and HadgilHuruth (exploratory well) and recorded discharge ranges from 11.74 to 21.13 m3 /hour for drawdown ranges between 2.80 and 18.19 m. Preliminary Yield Test of the bore wells reveals that the basaltic aquifers have Transmissivity ranges from 5.49 to 65.95 m2/day and Specific capacity ranges from 23.75 to 100.36 lpm/m.dd. Water yielding fractures are encountered at different depths between 16.6- 19.6m, 42 - 48m, 61-63.3m, 92.8-115.2m, 123.3-127.4m, 160-183.3m, 200.6-219.9m, 298.2-299.2m.

High yielding wells

District	Location	Drilling Depth (m)	Discharge (LPM)	Formation	Month and Year
Chamarajanagar	Palya EW	132.15	412.80	Gneiss	Sept/09
Chamarajanagar	Palya OW	104.70	660.00	-do-	Sept/09
Chamarajanagar	Kollegal town EWx	171.80	261.60	-do-	Nov/09
Chamarajanagar	Kollegal town OW	132.15	332.40	-do-	Dec/09
Hassan	Mallaikallu Tirupathi (EW)	174.08	406.22	Granite	June/09
Hassan	S.Diggenahhali EW	200.00	252.00	Granitic Gneiss	July/09
Hassan	S.Diggenahhali OW	200.00	221.40	Granitic Gneiss	Sept/09
Gulbarga	Narona – EW	162.00	300.00	Basalt	Oct/09
Gulbarga	Narona – OW	217.00	300.00	Basalt	Oct/09
Gulbarga	Syaid Chincholi-EW	300.00	196.00	Basalt/ Limestone	Nov/09
Gulbarga	Syaid Chincholi-OW	253.60	196.00	Basalt/ Limestone	Dec/09
Gulbarga	HadgilHuruth-EW	302.30	352.00	Basalt / Limestone /Pink Granite	Feb/10
Kolar	Chintamani-B.M.Halli OW	328.50	403.80	Granitic Gneiss	Aug/09

Kolar	Nadumpalli EW	225.60	765.76	Granitic Gneiss	Oct/09
Kolar	Nadumpalli OW	234.8	840.00	Granitic Gneiss	Nov/09

3.15 SECR, CHENNAI, Tamil Nadu

Ground Water Exploration was undertaken in Cuddalore,Kancheepuram, Namakal, Salem, parts of Ariyalur district of Tamil Nadu and constructed 55 wells(4 EW, 4 OW & 47 PZ)

District wise Summarized details of ground water exploration

District	Depth drilled/ constructed depth (m)	Zones tapped/ Fractures Encountered (m)	SWL (mbgl)	Discharge m 3/hour	Formation
Kancheepuram	52.3 – 200	9.3 – 106.75	2 to > 50	1.08 to 7.2	Charnockite & Granite gneiss
Thiruvallur	70 – 200	12.68 – 151	1.75 to > 50	2.98 to 15.336	Granite gneiss
Namakkal & parts of Salem District	23.74 – 245	6 – 191	2.12 to 37.90	3.6 to 86.4	Gr.gneiss, Pink granites, Pegmatites, Garnetiferrous gneiss
Coastal sedimentary tracts of Neyveli Hydrogeological Basin (Parts of Ariyalur, Cuddalore districts)	155 – 445/148 - 405	127 – 430	36.88 to 50.00	15.12 to 108.00	Cuddalore sandstone

3.15.1 Summarized details of Ground Water Exploration :

Cuddalore district: In the district 3 Exploratory wells and 3 observation wells were constructed. The exploration work was carried out in Neyveli Basin. The Neyveli Hydrogeological basin is famous for lignite deposits. Discovery of large lignite deposits around Neyveli and its development to the Asia's biggest lignite mining centre giving it the pride of place on energy map of India is a story of adventure. The large scale pumping has induced a significant change in the hydrogeological system over a large area. The artesian flowing wells in the south and southeast of the mining area have transformed into non-flowing wells. There has been a phenomenal increase of ground water draft from these aquifers for industrial and agricultural purposes in the last few decades in addition to the ongoing pumping by NLC. The increase in ground water draft from the basin has resulted in major changes in the hydrodynamics of the basin and consequent lowering of ground water levels and piezometric heads in the aquifers.

The formation of the area is Cuddalore sand stone.In Palayamkottai Exploratory well the discharge was measured as 30.5 lps and in Vadalur Exploratory well rhe discharge was measured as 30 lps. The water level was varies from 36.88 mbgl to 68.50 m bgl. Long duration pump test was conducted in Gangaikondacholapuram Exploratory well with discharge of 16.78 lps for the period of 1000 minutes. The drawdown was 11.52 m and T value was 120 m 2/day.

Kancheepuram: Sixteen Pz were constructed in the hard rock terrains of kancheepuram District,Tamilnadu. The charocoknites occupy major part of the district and granitic gneiss exists in the southern part. The major Geological formations are Charnockites, Granite and Granitic Gneiss. The depth of exploration was from 52.30 to 200m bgl. The obverburden thickness was about 5.4 to 17. 4m. The aquifer within the district is unconfined with the groundwater level ranging between 2 and 50m bgl. Fractures were encountered between 9 and 106m bgl and the discharge ranged from 1.08 to 7.2 m3/hr.

Namakal and parts of Salem : A total of 25 piezometers (Shallow and deep) were constructed for monitoring of water level and quality. Data gaps were identified from CGWB-NHS and HP-Pz maps and available monitoring structures in each Block were enumerated. Number of Piezometers to be constructed was arrived as per norms. The sites were selected with a view to have a representative water level in the over-exploited blocks and agricultural intensive areas. The deeper fractures were mainly tapped for agricultural purposes in this district. The resulting changes in ground water regime of deeper fracture system due to ground water development and the extent of urban pollution were taken into consideration. Twenty sites were targeted with 250 m bgl depth range.

The yield of the well ranged between 1 lps and 24 lps. The fractures varied in depth from very shallow as 6 to 7 m bgl to deeper depths of 180 to 191 m bgl. The lithology encountered was Granitic Gneiss, Garnetiferous Gneiss, Pegmatites, Quartz veins and Pink Granites. During drilling through Pink Granites, large cavities were encountered, which were synchronous with the functions of rock during the rock formation. Fractures oriented on Strike direction, especially in Granitic Gneisses yielded higher discharge when compared to Pegmatite and Quartz

veins. High discharge of 26 lps has been observed at Olapalayam village, Namakkal district in Hard rock terrain.

Coastal sedimentary tracts of Neyveli Hydrogeological Basin (parts of Ariyalur and Cuddalore districts):-

The large scale pumping has induced a significant change in the hydrogeological system over a large area. The artesian flowing wells in the south and southeast of the mining area have transformed into non-flowing wells. There has been a phenomenal increase of ground water draft from these aquifers for industrial and agricultural purposes in the last few decades in addition to the ongoing pumping by NLC. The increase in ground water draft from the basin has resulted in major changes in the hydrodynamics of the basin and consequent lowering of ground water levels and piezometric heads in the aquifers. The main aim of the exploration work is to get additional information on Neyveli basin and to utilise the data for the ongoing project on Colloborative studies between CGWB and NLC.

A total of 6 wells (3 EW and 3 OW) were constructed within Neyveli Hydrogeolgical Baisn. The formation of the area is Cuddalore sand stone. The water level vaired from 36.88 to 68.50 m bgl. The wells drilled at Palayamkottai and Vadalur yielded 30.5 and 30 lps respectively. Long duration pump test was conducted in Gangaikondacholapuram Exploratory well with discharge of 16.78 lps for the period of 1000 minutes. The drawdown was 11.52 m and the estimated T value was 120 m 2/day. High Discharge of 36 lps was observed at C.Keeranur (Sedimentary formation in Neyveli Hydrogeological Basin). 72 hours of well injection has been carried out and the possibility of recharge of deeper confined aquifer in Neyveli Hydrogeological Basin has been proved.

3.16 KR, TRIVENDRAM, Kerala

Ground Water Exploration was undertaken in Kollam, Pathanmitha, Palghat & Trissur district of Kerala and constructed 30 wells(EW & OW).

District wise summarized details of ground water exploration in the state

District	Depth drilled (m bgl)	Zones tapped/ fracture encountered (m bgl)	SWL (m bgl)	Discharge m3/hr	Draw down (m)	Formation
Kollam	56.10 - 200	22-25, 162-164	1.50 – 19.70	10-3.50	3.05 – 21.50	Khondalite Charnockites
Pathanamthitta	175-200	22.5-25.6 143.6-144.5	2.0 - 5.18	0.50-7.80	11.82-14.70	Khondalites Charnockites Calc granulites
Palghat	100	15.0-16.0 79-80	5.0 - 27.30	32.4-64.8	0.24-4.90	Hornblende biotite gneiss Quartzo feldspathic gneiss
Trissur	68-102	13-15 100-101	2.1-36.60	0.72 – 64.8		Hornblende biotite gneiss

3.16.1 Summarized details of Ground Water Exploration :

Kollam district: three exploratory and two observation wells were drilled whereas six exploratory wells and four observation wells were drilled in Pathanamthitta district. The geological formations encountered during drilling were mainly Khondalite and Charnockite in Kollam district. In Pathanamthitta district, Khondalites and Calc granulites were encountered during the exploration. The weathered zone varied from 2.00 to 30 m bgl in Kollam district and from 5 to 20 mbgl in Pathanamthitta district . The depth of the bore well ranges from 56.10 mbgl to 200 m bgl and the yield ranges from 0.50 lps to 10 lps. Potential fracture zones were encountered between 22.50 mbgl to 182 mbgl and the water level ranged from 1.50 to 19.70 mbgl. Draw down observed during preliminary yield tests ranged= from 3.00 to 21.50 m bgl. The general trend of lineaments and fractures in the area are mostly in North West - South East direction.

Thrissur district: fractured hornblende biotite gneiss with pegmatite, granite and charnockite form important aquifer systems. The drilling discharge of the bore holes varied from 4.00 to 18.00 lps. Potential fracture zones were encountered between 25 m to 100 m bgl. The static water level ranged from 2.70 to 35.00 m bgl and the drawdown created was 0.60 m to 12.45 m.

Palakkad district: the aquifer encountered is fractured hornblende biotite gneiss with pegmatite as intrusive body. The drilling discharge of the boreholes varied from 1.0 to 18.00 lps and the potential fracture zones are encountered from 17 m to 85 m bgl. The static water level ranged from 0.27 to 5.09 m bgl and the drawdown created was 0.60 m to 10.00. Out of 15 bore wells drilled in Thrissur and Palakkad district, 9 wells had discharge ranging between 3.00 to 18.00 lps.

High Yielding Wells

Location	District	Drilling Depth in (m)	Discharge in lps	Formation	Month /Year
Ariyankavu	Kollam	200	7.00	Charnockites Hornblende biotite gneiss	June/2009

Edapalayam EW	Kollam	115	10.00	Charnockites Quartz felsdpathic gneiss	September/2009
Edapalayam OW	Kollam	164	5.60	Hornblendes biotite gneiss	October/2009
Koduman EW	Pathanamthitta	200	6.80	Khondalite	December/2009
Koduman OW II	Pathanamthitta	200	5.55	Khondalite	January/2010
Konni EW	Pathanamthitta	190	4.50	Charnockites	February/2010
Konni	Pathanamthitta	175	7.80	Charnockites	March/2010
Ottapalam EW	Palakkad	100	15	Hornblende biotite gneiss with pegmatite	June / 2009
Ottapalam OW	Palakkad	100	9	Hornblende biotite gneiss with pegmatite	July / 2009
Puthukode EW	Palakkad	100	18	Biotite gneiss	August / 2009
Puthukode OW	Palakkad	100	9	Biotite gneiss	August / 2009
Mayannur EW	Palakkad	100	12	Hornblende biotite gneiss	October / 2009
Vadakethara EW	Thrissur	102	4	Hornblende biotite schist	October/2009
Nelluvai EW	Thrissur	100	10	Hornblende biotite schist	January/2010
Nelluvai OW	Thrissur	70	14	Hornblende biotite schist	February/2010
Vadakethara OW 1	Thrissur	68	18	Hornblende biotite gneiss	January/2010
Vadakethara OW II	Thrissur	90	18	Hornblende biotite gneiss	January/2010

3.17 UR, DEHRADUN, Uttarakhand

Ground Water Exploration was undertaken in Dehradun & Haridwar district of Uttarakhand and constructed 2 wells (2 EW).

3.17.1 Summarized details of Ground Water Exploration :

Haridwar: Exploratory drilling at Industrial Park, Haridwar was completed with a total drill depth of 127.85 m. Geophysical logging of the bore hole was conducted with Uptron Multi Channel Logger from NWR, Chandigarh and well assembly was recommended with a slot size of 1/16 inch (1.6 mm). A total of four potential zones were deciphered at: 37.0 to 56.0, 58.0 to 61.0, 71.0 to 86.0, 95.0 to 112.0 m bgl having thickness varying between 3.0 to 19.0 m.

Dehradun: At Doctor Ganj, Vikas Nagar block, Dehradun District, electrical logging was also carried out up to a depth of 156.0 m and well assembly was recommended with a slot size of 1/16 inch (1.6mm). Six potential zones were deciphered – 40.0 to 52.0 m, 66.0 to 70.0 m, 72.0 to 77.0 m, 80.0 to 88.0 m, 91.0 to 96.0 m, and 100.0 to 120.0 m. Thickness of the zones were varying between 4.0 and 12.0 m. The well was tested by compressor in February 2010 and the discharge during the compressor development was measured to be 2400 LPM with zero drawdown.

High Yielding Wells

District	Location/ site	Drilling Depth (m)	Discharge (LPM)	Formation
Dehradun	Doctor Ganj	156.0	Compressor Discharge: 2400 LPM	Doon Gravels

3.1.18 NHR, DHARAMSALA, Himachal Pradesh

Ground Water Exploration was undertaken in Kangra, Una, Hamirpur & Mandi district of HimachaL Pradesh AND constructed 8 wells(8 EW).

District wise summarized details of Ground Water Exploration in the State (in range)

District	Depth Drilled (m)	Zones tapped (m)	SWL (mbgl)	Discharge (lpm)	Draw down (m)	Aquifer parameter (T &S)	Formation
Kangra	45.50-79.50	37-40 to 70-76	4.63-24.16	214-852	9.41-13.92	53.86-78.08 m2/day	Valley Fills / Morainic Deposits
Una	50.00	33-39 43-47	-	-	-	-	Valley Fills
Hamirpur	69.00	38.50-44.50 47.50-50.50 63.50-66.50	1.23	3.60	43.19	1.39lpm	Valley Fills
Mandi	38.25	22-27 32-35	2.18	632.04	7.13	166.88 m2/day	Valley Fills

3.18.1 Summarized details of Ground Water Exploration :

Kangra: Kangra district comes under Beas drainage Basin. Geological successions encountered in the district are alluvium, glacial moraines, Siwalik and the basement comprising of older metamorphics. During the year, ground water exploration was carried out in glacial deposits in Alhilal, Ustehr and Gad area. The drilling depth

ranges from 45.00 to 79.00 m bgl. The zone tapped pertains to shallow to deep unconfined aquifer and ranges from 39-45 to 70-76 m bgl. Transmissivity ranges from 53.86 to 78.08 m2/day .The pumping test of exploratory well at Ustehr, Kachha Khoo and Gad has a very low discharge.

Hamirpur: Ground water exploration was taken up in valley fill areas. One exploratory well was drilled at Dhangota. The area is drained by tributaries of river Beas. The valley fill deposits comprises of boulders, cobbles, pebbles mixed with sand and silt. The well was drilled up to a depth of 69.50 m bgl. The ground water potential zone encountered from 38.50-44.50, 47.50-45.50 and 63.50-66.50 m.

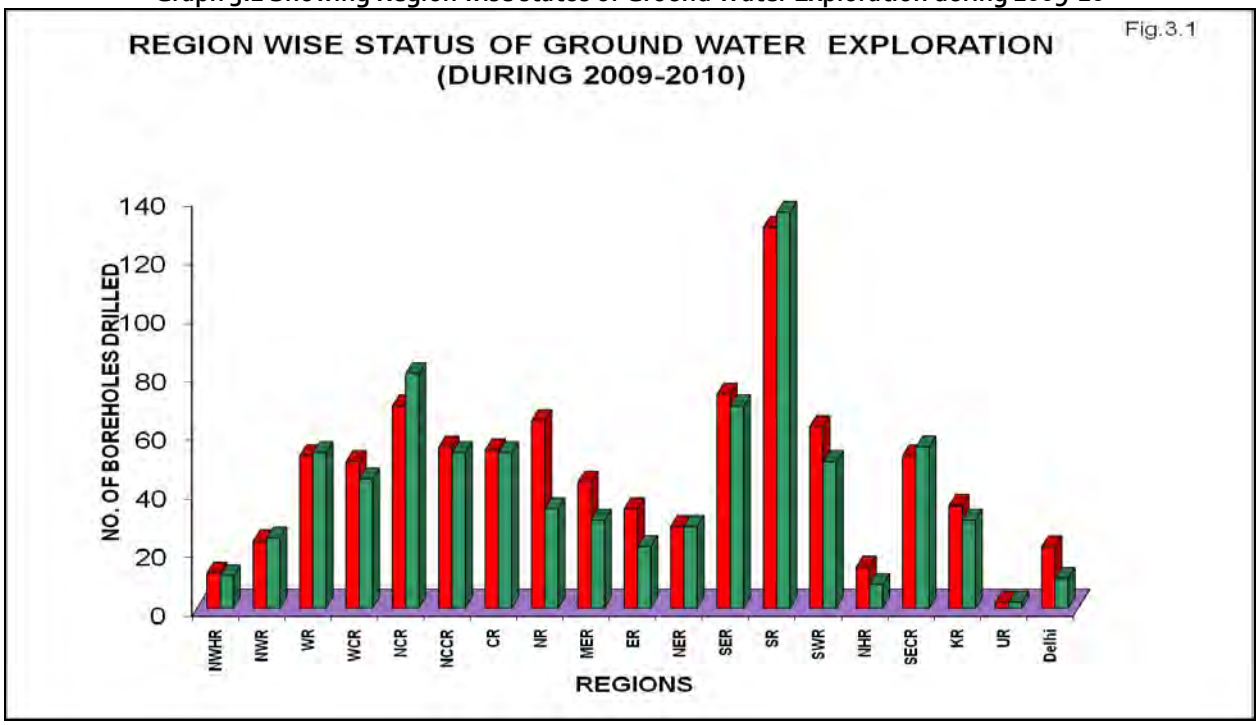
Una: Una district comes under Soan drainage Basin. The area is occupied by alluvium and Siwalik. One exploratory well at Raipur has been drilled to the depth of 50.00 m bgl. The main water yielding aquifers comprises of sand, gravel, pebbles and boulders and were encountered at a depth range of 33-39 and 43-47 m.

Mandi:The exploratory well at Ratti has been drilled to the depth of 38.25m bgl. The main water yielding aquifers comprises of sand, gravel, pebbles and boulders and were encountered at a depth range of 22-27 and 32.35 m. Transmissivity of the well is 166.88 m2/day.

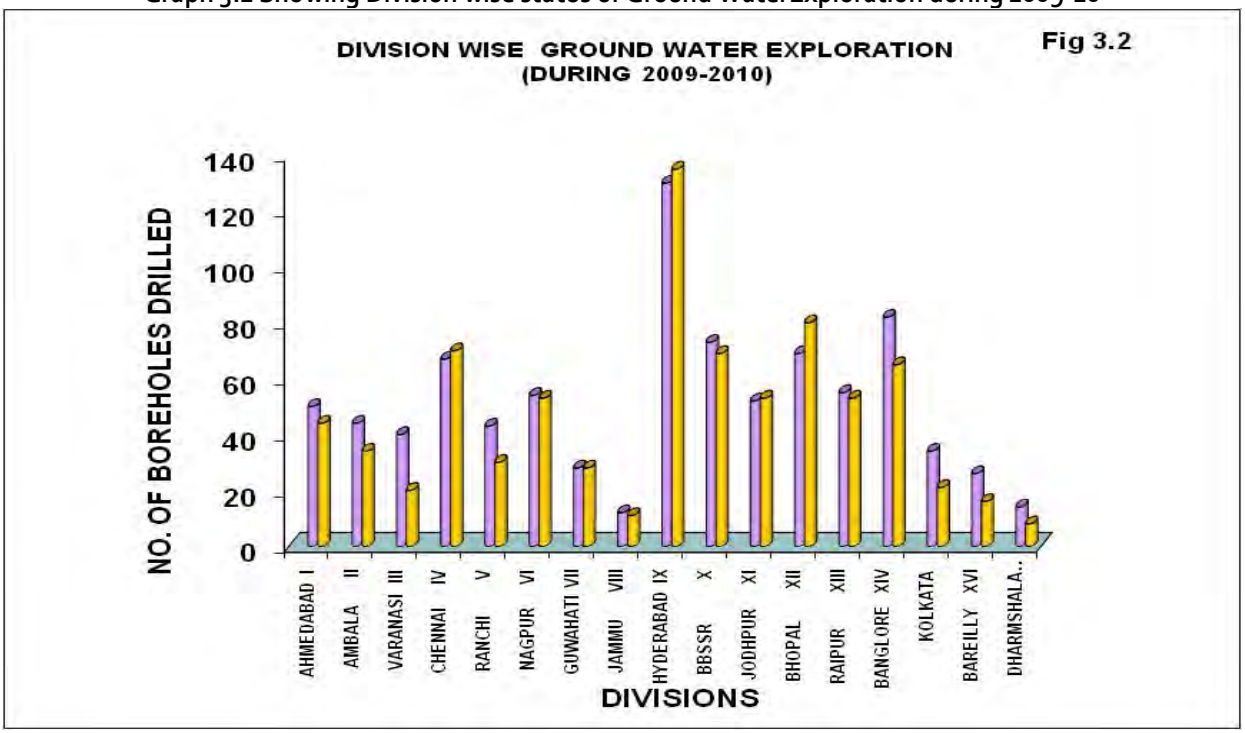
Dense vegetation due to construction of Check Dam, Village Jharipnai, Nainital district

Auto Flow in Hand Pump in post monsoon at Village Sunderkhal, Ramnagar block

Graph 3.1 Showing Region wise status of Ground Water Exploration during 2009-10



Graph 3.2 Showing Division wise status of Ground WaterExploration during 2009-10



4. DEVELOPMENTS AND TESTING OF WELLS

A tube well, is developed during its construction to increase its specific capacity to prevent sand rushing into the well and to obtain maximum well life. Thereafter, pumping tests are conducted for evaluating aquifer characteristics i.e. transmitivity, storage co-efficient and well characteristics viz. specific capacity and well efficiency, with a view to evolve efficient design for tube wells, assessment of yield capabilities and spacing criteria for tube wells. The Board has got the capacity of conducting 175 to 200 pumping tests per annum with the existing infrastructure facilities. With the increasing drilling activities, the Board is constructing, on an average, about 400 pumping wells every year, which have resulted in backlog of pumping tests. Procurement action has been initiated in the Board to equip each rig unit with adequate pumping test units. However, in spite of constraints faced by the Board in this aspect, a total of 165 wells were developed and tested during the year 2009-2010. Region wise achievement has been presented in Table 4.1

Table 4.1: Regionwise/Statewise Pumping Tests Conducted in the Year 2009 – 2010

Sr. No.	Regions	State/ Union Territories	No of wells tested during 2009-10 Upto March,2010		
			No. of E. wells constructed during 2009-10 and tested	No. of E. wells constructed in earlier Year and tested	Total No. of wells tested
1	NWHR, Jammu	Jammu & Kashmir	2	16	18
2	NWR,Chandigarh	Haryana	0	0	0
		Punjab	0	2	2
		Delhi	1	2	3
3	WR, Jaipur	Rajasthan	5	7	12
4	WCR, Ahmedabad	Gujrat	1	4	5
5	NCR, Bhopal	Madhya Pradesh	1	2	3
6	NCCR, Raipur	Chhattisgarh	3	1	4
7	CR, Nagpur	Maharashtra	3	9	12
8	NR, Lucknow	Uttar Pradesh	0	11	11
9	MER, Patna	Bihar	-	8	8
		Jharkhand	-	-	-
10	ER,Kolkata	West Bengal	4	8	12
11	NER, Guwahati	Assam	1	5	6
		Arunachal Pradesh	0	1	1
		Meghalaya	0	0	0
		Tripura	0	0	0
12	SER ,Bhubneswar	Orissa	14	11	25
13	SR, Hyderabad	Andhra Pradesh	12	0	12
14	SWR, Bangalore	Karnataka	3	8	11
15	SECR, Chennai	Tamilnadu	1	2	3
16	KR, Kerala	Kerala	7	1	8
17	NHR, Dharamshala	Himachal Pradesh	3	6	9
18	UR, Dehradun	Uttarakhand	0	0	0
TOTAL			**61**	**104**	**165**

5. TAKING OVER OF WELLS BY STATES

5.1 Exploratory Wells

The exploratory drilling sites are selected in consultation with the State Government Departments considering that, successful exploratory wells would be converted into production wells once taken over by States. Till March 2010, a total of 13291 wells have been drilled, out of which 10416 successful exploratory wells have been constructed and only 5664 wells have so far been accepted /taken over by State Governments while 3755 successful wells are yet to be accepted/ taken over by them and only 955 successful wells to be offered. The status of handing over of exploratory wells drilled by Central Ground Water Board to the State Government as on 31-03-2010 is presented in table 5.1

Table 5.1: Handing over of wells drilled by CGWB (As On 31.03.2010)

Sl.No.	States/Union Territories	Total Wells drilled	No. of Successful Wells	No. of Wells Handed Over		No. of Wells yet to be handed over to state agencies
				No. of wells accepted by the state agencies	No. of wells offered to the state agencies but yet to be accepted	
A. STATES						
1	Andhra Pradesh	1233	888	728	97	63
2	Arunachal Pradesh	32	28	14	2	12
3	Assam	335	284	120	71	93
4	Bihar	273	220	61	135	24
5	Chhattishgarh	567	514	139	301	74
6	Goa	58	49	0	49	0
7	Gujarat	906	589	431	104	54
8	Haryana	365	196	145	48	3
9	Himachal Pradesh	178	164	77	60	27
10	Jammu & Kashmir	320	253	160	63	30
11	Jharkhand	289	240	75	139	26
12	Karnataka	1184	1023	471	474	78
13	Kerala	396	286	230	44	12
14	Madhya Pradesh	886	582	476	67	39
15	Maharashtra	1106	922	794	90	38
16	Manipur	25	15	14	0	1
17	Meghalaya	80	69	14	8	47
18	Mizoram	3	3	3	0	0
19	Nagaland	11	7	5	1	1
20	Orissa	1277	1199	405	725	69
21	Punjab	169	145	78	55	12
22	Rajasthan	1088	788	251	499	38
23	Sikkim	31	10	6	0	4
24	Tamilnadu	911	658	496	147	15

25	Tripura	60	54	36	12	6
26	Uttarakhand	54	44	23	10	11
27	Uttar Pradesh	795	649	189	341	119
28	West Bengal	416	367	135	173	59
	Total	**13048**	**10246**	**5576**	**3715**	**955**
B.UNION TERRITORIES						
1	Andaman & Nicobar	46	12	0	10	2
2	Chandigarh	7	7	6	0	1
3	Dadra &Nagar Haveli	12	8	8	0	0
4	Delhi	148	130	61	30	39
5	Pondicherry	30	13	13	0	0
	Total	**243**	**170**	**88**	**40**	**42**
	GRAND TOTAL(A+B)	**13291**	**10416**	**5664**	**3755**	**997**

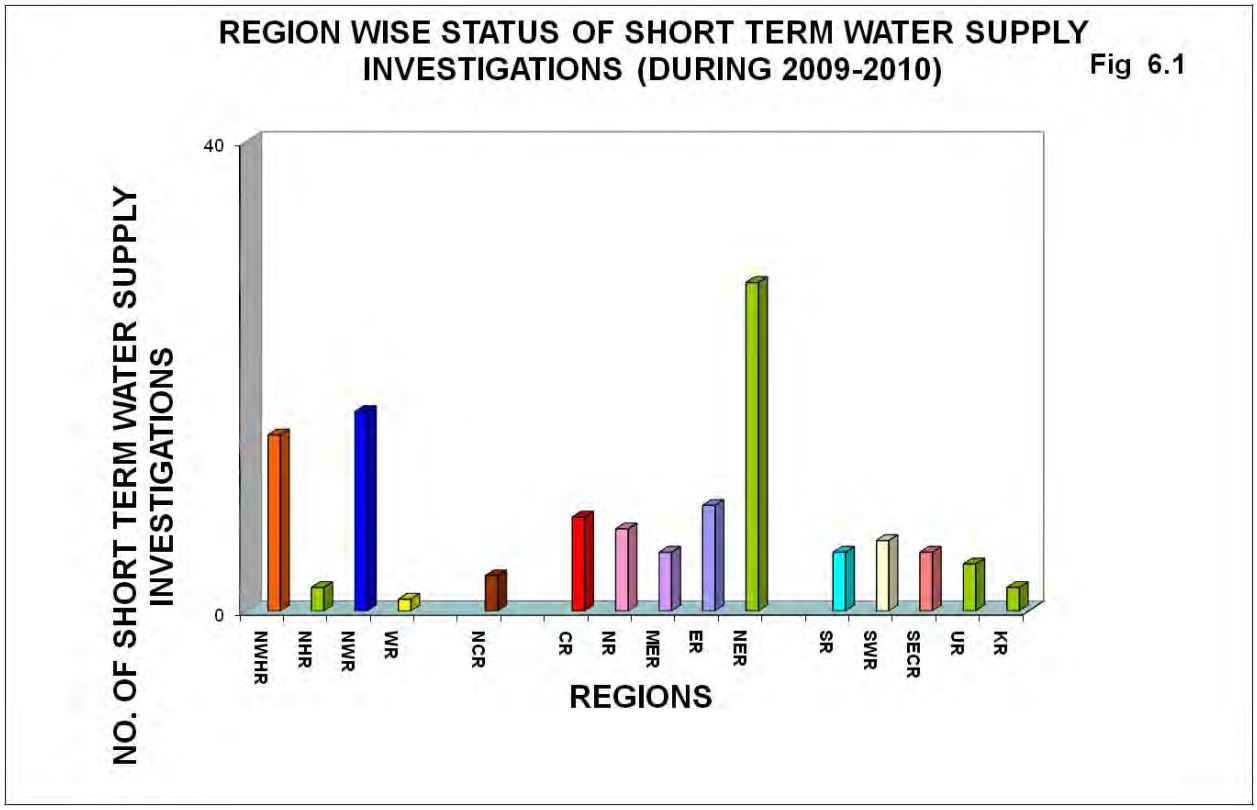
6. WATER SUPPLY INVESTIGATIONS

The Board provides assistance to various urban, defence and public sector establishments to solve their immediate water supply problems by selecting suitable sites for construction of ground water abstraction structures. During 2009-10, 117 Water Supply Investigations were carried out and region wise/state wise status is given in table 6.1 and fig. 6.1.

Table 6.1 : Region/Statewise Water Supply Investigations Taken up During 2009-2010

Sl. No.	Regions	States	Number of Water Supply Investigations
1	NORTHERN WESTERN HIMALAYAN REGION	Jammu & Kashmir	15
2	NORTHERN HIMALAYAN REGION	Himachal Pradesh	2
3	NORTH WESTERN REGION	Punjab	08
		Haryana	05
		Delhi	04
4	WESTERN REGION	Rajasthan	01
5	WEST CENTRAL REGION	Gujarat	0
6	CENTRAL REGION	Maharashtra	08
7	NORTHERN REGION	Uttar Pradesh	07
8	UTTARANCHAL REGION	Uttaranchal	04
9	EASTERN REGION	West Bengal	09
10	NORTH CENTRAL REGION	Madhya Pradesh	03
11	NORTH CENTRAL CHATTISGARH REGION	Chhattisgarh	0
12	MID EASTERN REGION	Bihar & Jharkhand	05
13	NORTH EASTERN REGION	Assam,Meghalaya,A.P.	28
14	SOUTH EASTERN REGION	Orissa	0
15	SOUTERN REGION	Andhra Pradesh	05
16	SOUTH WESTERN REGION	Karnataka	06
17	SOUTH EASTERN COASTAL REGION	Chennai	05
18	KERALA REGION	Kerala	02
Total			**117**

Graph 6.1 Showing Short term Water Sypoply Investigations during 2009-2010



7. HYDROLOGICAL AND HYDROMETEROLOGICAL STUDIES

Hydrological and Hydrometeorological studies play an important role in the assessment and management of ground water resources of an area. Hydrological and hydrometeorological data collected during the course of various hydrologeological surveys & investigation, exploration, hydrograph network monitoring etc are being entered into the computer and analysed following standard techniques. The results are incorporated suitably in different reports.

7.2.1 NORTH WESTERN REGION (Chandigarh)

Compilation of weekly rainfall data of North Western Region comprising 20 districts of Punjab, 20 districts of Haryana and Chandigarh (U.T.) for the year 2009-10 and utilized the same to estimate district mean monthly, seasonal and annual rainfall. The data is being analyzed and used to compute the following after each GWMW water level monitoring.

- Deviation percentage of rainfall of May 2008-May 2009, Aug 2008-Aug 2009, Nov 2008- Nov 2009 and Jan 2009 to Jan 2010with respect to respective month of the same period were calculated.
- Analyzed rainfall data along with graphs and also prepared a write up on hydrometeorology which is used Ground Water Year Book.

7.2.2 WESTERN REGION (Rajasthan)

- Computerized rainfall data January, February, March & April 2009, of all the R.G.Stations of the State.
- Compilation and analysis of hydro-meteorological data of Dholpur, Kota & Chittorgarh districts.
- Computerized monthly rainfall data of May & June2009, of all the R.G.Stations of the State and compilation of Hydrometeorological report of Rajasthan state.
- Analysis of hydro-meteorological data of Jhotwara, Sheo & Churu blocks.

7.2.3 NORTH CENTRAL REGION (Madhya Pradesh)

The Hydrometeorological data such as rainfall, maximum and minimum temperature, wind velocity relative humidity etc have been collected and complied. The different seasonal rainfall distribution., departure of rainfall from normal rainfall, drought frequencies etc have been worked out for different districts. Number of Maps such as isohyetal map, departure of rainfall map, isotherm map etc have been prepared. The detailed Chapter on Climeotology of Vidisha, Chhatarpur, Umaria and Ratlam districts has been prepared for district reports and area proposed for re-appraisal surveys.

7.2.4 CENTRAL REGION (Maharashtra)

7.2.4.1 Climatological Input For District & RHS Reports:-

Climatological input for the following District Reports were provided a) Gadchiroli and Nashik districts. These Climatological chapters include detailed analysis of rainfall of all rain gauges in the district with isohytal maps, temperature, relative humidity and wind speed and direction and plates showing:

- Normal annual rainfall and probability of occurrence of normal annual rainfall.
- Co-efficient of variation of rainfall and demarcation of drought area
- Rainfall trend

Apart from the above, rainfall data for District Headquarters of Maharashtra were analysed.

7.2.4.2 Development of hydrometeorological data base: -

Updated and maintained hydrometeorological database of Maharashtra, which includes:

- Compilation of rainfall data of 42 IMD observatories from daily weather reports of Nagpur.
- Entry of daily rainfall data in GEMS software for IMD observatories of Maharashtra.
- Daily RF data from 1986 to 2008 entered in GEMS for 34 Observatory Stations Maharashtra.

7.2.4.3 Hydrometeorological Data Analysis for Ground Water Year Book

The hydrometeorological data for Ground water Year Book for 2008-09 was analysed and were prepared for inclusion in the yearbook.

7.2.5 NORTHERN REGION (U.P.)

Hydrometerological studies with findings/conclusion :

1. Collected & compiled daily & monthly rainfall data of all the raingauge stations of U.P for the year 2007-2008 and 2008-09 .

2. Measurement of daily rainfall at raingauge station at Bhujal Bhawan continued.
3. Prepared write up of climate and rainfall chapter for ground water year book for the year 2008-09.
4. Collected & compiled the annual rainfall data of Bundel Khand for year 2003-2008
5. Computed mean monthly and mean Annuals rainfall of all the raingauge stations of U.P

7.2.6 SOUTH EASTERN REGION (Bhubaneswar)

Block wise monthly rainfall data for all the 30 districts were collected and compiled upto 2008. The existing database is updated and strengthened for use by various users. Also rainfall data of IMD stations from IMD office, Bhubaneswar were collected.

7.2.7 SOUTH WESTERN REGION (Karnataka)

Hydrological and hydro meteorological work involved collection, compilation, analysis and interpretation of all relevant data. During this year rainfall, data pertaining to the year 2008 was collected from various central and state departments. The same is compiled and computerised with a view to efficient management and retrieval. Presently rainfall data is available from 1901 to 2009.Data analysis and interpretation was carried out for periodic NHS reports, hydrogeological survey reports and ground water resource estimation reports.

Rainfall Distribution During 2009:

South west Monsoon Season (June – September)

South-Interior Karnataka: The cumulative rainfall was excess in Bangalore urban, Bangalore rural, Ramanagara, Kolar, Chikkaballapura, Tumkur, Chitradurga, Davanagere, Mysore and Mandya districts and normal in Chamarajanagara district. Among the 63 taluks, rainfall was excess in 55 taluks and normal in 8 taluks. Last year for the same period rainfall was excess in 34 taluks; normal in 22 taluks and deficit in 7 taluks.

North Interior Karnataka: The cumulative rainfall was excess in Bellary, Koppala, Belgaum, Bagalkote, Bijapur, Gadag, Haveri and Dharwad districts and normal in Raichur, Gulbarga and Bidar districts. Among the 69 taluks, rainfall was excess in 44 taluks; normal in 21 taluks and deficit in 4 taluks. Last year for the same period rainfall was excess in 5 taluks; normal in 33 taluks; deficit in 30 taluks and scanty in one taluk.

Malnad Region: The cumulative rainfall was excess in Hassan district and normal in Shimoga, Chikkamagalur and Kodagu districts. Among the 25 taluks, rainfall was excess in 13 taluks, and normal in 12 taluks. Last year for the same period rainfall was excess in 8 taluks; normal in 16 taluks and deficit in one taluk.

Coastal Region: The cumulative rainfall was normal in all the 3 districts of this region. Among the 19 taluks, rainfall was normal in 18 taluks and deficit in one taluk. Last year for the same period rainfall was normal in 13 taluks and deficit in 6 taluks.
District wise percentag departure of the cumulative rainfall from normal since 1970 in the above regions of the state is given in table-7.1.

Northeast monsoon season (October – December)

South Interior Karnataka: The cumulative rainfall was excess in Chitradurga and Davanagere districts deficit in Chamarajanagara, Bangalore urban, Bangalore rural, Ramanagara, Kolar, Chikkaballapura, Tumkur, Mysore and Mandya districts.

North Interior Karnataka : The cumulative rainfall was excess in all the districts, i.e Gadag, Bellary, Koppala, Haveri, Raichur Gulbarga, Bidar, Belgaum, Bagalkote Bijapur and Dharwad districts

Malnad Region : The cumulative rainfall was excess in Kodagu, Shimoga and Chikkamagalur districts and deficit in Hassan district.

Coastal Region : The cumulative rainfall was excess in Dakshina Kannada, Uttara Kannada and Udupi districts.
Districtwise percentage departure of the cumulative rainfall from normal since 1970 in the above regions of the state is given in table 7.2 .

7.2.8 SOUTH EAST COASTAL REGIOPN(Tamilnadu)

Report on correlation of Hydrographs of river water volume and ground water table behaviour in respect of some select points in Palar River Basin in the State of Tamil Nadu

Introduction

The main objective of the study is to ascertain interaction between surface water flow in the river and ground water levels in parts of Palar basin in Tamil Nadu. The Palar river basin is one of the important basins in Tamil Nadu. The river Palar drains an area of 17,871 Sq.Kms as a whole

across 3 southern states of India. Most of the drainage area (57%) lies in the state of Tamil Nadu and the rest covers the South-Eastern and South-Western parts of Karnataka (17%) and Andhra Pradesh (26%) respectively. The basin area is distributed in 11 blocks of Kancheepuram district, 13 blocks of Tiruvannamalai district and 16 blocks of Vellore district either fully or partly. In order to ascertain the behaviour of ground water table due to river discharge, the data such as seasonal / daily runoff of river and ground water levels of pre-monsoon and post-monsoon are pre requisite. The surface flow data in the river Palar is monitored by CWC at Avaramkuppam, Arcot, Magral and Chengalpattu sites and ground water level data of observation wells established by CGWB nearer to the gauging sites are utilized.

Interaction of surface and ground water

Correlation of hydrographs at Arcot site:

The combined hydrograph showing annual river discharge and ground water levels of pre monsoon and post monsoon collected at Arcot station for the period of 1986 to 2004 are given in fig. 7.1.

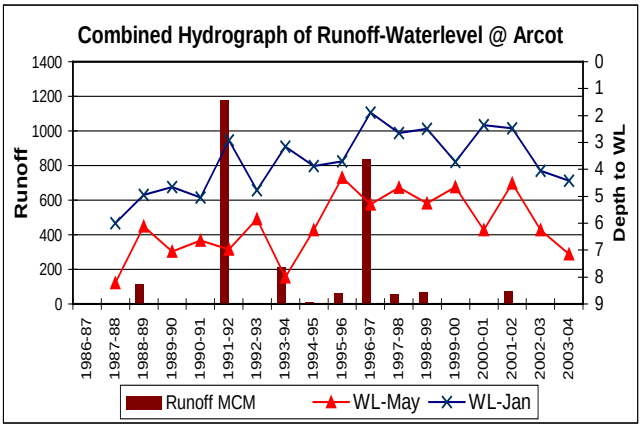
Table- 7.1 District-Wise Cumulative Rainfall During 2009 South-West Monsoon Period

Sl. No.	DISTRICT	NORMAL (mm)	ACTUAL (mm)	DEPARTURE (%)
1	Bidar	705	575	-18
2	Dakshina Kannada	3338	3001	-10
3	Kodagu	2129	2097	-2
4	Udupi	3670	3627	-1
5	Gulbarga	640	634	-1
6	Uttara Kannada	2537	2585	2
7	Chamarajanagara	315	326	3
8	Chikkamagalur	1506	1642	9
9	Raichur	479	547	14
10	Shimoga	1483	1754	18
11	Bangalore Rural	426	523	23
12	Haveri	484	627	30
13	Belgaum	561	756	35
14	Dharwad	478	651	36
15	Gadag	365	512	40
16	Chikkaballapura	412	581	41
17	Bangalore Urban	460	657	43
18	Bellary	387	564	46
19	Hassan	583	859	47
20	Kolar	362	535	48
21	Mysore	335	506	51
22	Tumkur	362	558	54
23	Bijapur	428	660	54
24	Koppala	383	591	54
25	Bagalkote	361	569	58
26	Ramanagara	425	672	58
27	Mandya	295	478	62
28	Davanagere	360	593	65
29	Chitradurga	283	489	73
	State	**820**	**954**	**16**

Table-7.2: District-Wise Cumulative Rainfall During 2009 North-East Monsoon Period

Sl.No.	District	Normal(mm)	Actual(mm)	Departure %
1	Bagalkote	130	314	142
2	Bangalore Rural	209	75	-64
3	Bangalore Urban	222	112	-50
4	Belgaum	142	276	94
5	Bellary	136	333	145
6	Bidar	100	141	41
7	Bijapur	125	274	119
8	Chamarajanagara	239	167	-30
9	Chikkaballapura	202	140	-31
10	Chikkamagalur	206	302	47
11	Chitradurga	160	206	29
12	Dakshina Kannada	323	484	50
13	Davanagere	160	203	27
14	Dharwad	153	206	35
15	Gadag	142	267	88
16	Gulbarga	124	203	64
17	Hassan	210	156	-26
18	Haveri	153	212	39
19	Kodagu	251	341	36
20	Kolar	206	116	-44
21	Koppala	119	325	173
22	Mandya	218	122	-44
23	Mysore	198	152	-23
24	Raichur	131	349	166
25	Ramanagara	222	79	-64
26	Shimoga	180	232	29
27	Tumkur	201	130	-35
28	Udupi	291	513	76
29	Uttara Kannada	192	417	117
	State	**179**	**143**	-20

Fig. 7.1



The analysis reveals that between years 1986 to 2004, the flow in the river was observed in 9 years and rest of the periods recorded as dry. The minimum flow of 7.486 MCM was recoded during 1994-95 and maximum flow of 1176 MCM was recorded during the year 1991-92. In general the flow in the river starts around mid of October and ends by first week of January. Rest of the months, the river was dry. As far as impact on water level is concerned, gentle rise in water level has been observed in all the years during post monsoon period and steep rise noticed only in the year of peak flow.

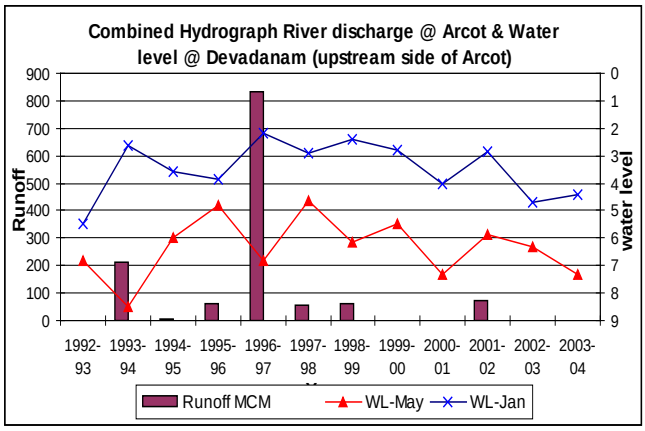
During the years 1991-92, 1993-94 and 1996-97, the rise in post monsoon water level with respect to pre monsoon water level is 4.05m, 4.86m and 3.42 m respectively. A rise in the range of 0.6 – 2.75m was observed in rest of the period. Additional rise in water level may be due to combined effect of natural recharge from monsoon rainfall as well as the effect of surface flow in the river. Change in ground water volume observed from the graph that during the year 1991-92, 1993-94 and 1996-97 also support that existence of impact of river volume on ground water regime.

Correlation of hydrographs at Arcot - Devadanam site:

The combined hydrograph showing river discharge data at Arcot and pre and post monsoon ground water levels of Devadanam village, located upstream side of the Arcot River gauging station is given in fig. 7.2.

On perusal of hydrograph and data pertaining to Arcot-Devadanam site, it is to notice that when the river was dry, water levels during pre and post monsoon recorded deep. Over the period between 1992 to 2004, river recorded 2 peak flow during 1993-94 and 1996-97. As the river is flowing only during monsoon, the post monsoon water level has risen to the extent 3.32 m to 5.87m when compared with the respective pre monsoon levels during the peak flow years. During the normal flow years and also during dry years, the response of aquifer is comparatively less which is ranging from 0.93 m – 2.88 m . The hydrographs also reveals that steep rise in water level noticed only during the years where the flow was high. Over all it is observed that during the period when the river flow exist the water level also shows rise due to the contribution of recharge from the river.

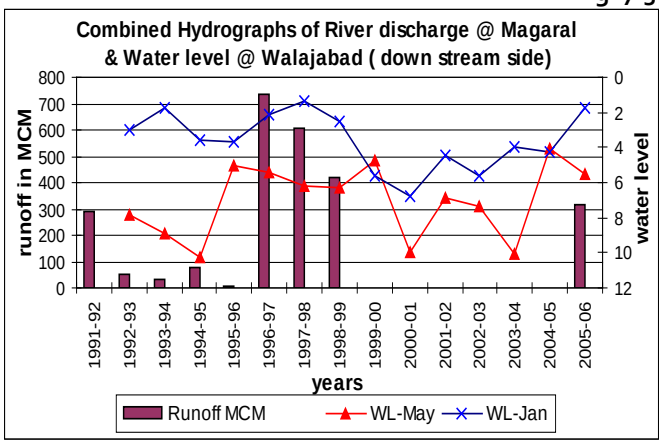
Fig. 7.2



Correlation of hydrographs at Magaral site -Walajabad Devadanam site:

The combined hydrograph showing river discharge data at Magaral and pre and post monsoon ground water levels of Walajabad, located on the downstream side of the Magaral river gauging station is given in fig. 7.3:

Fig. 7.3



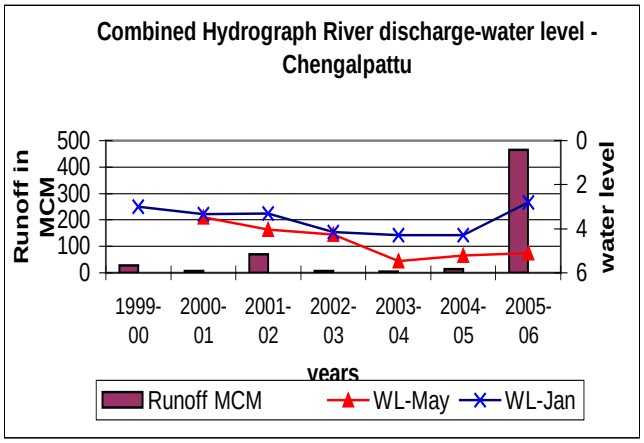
On perusal of data and hydrograph, it is noticed that peak flow in the river was recorded 5 times for the period between 1991 and 2006. Peak flow was recorded in the years of 1996-97, 1997-98 and 1998-99 and have

contributed the risein the water level upto 2 m below ground level during jan-98. During the period between 1999 to 2005, there was no flow in the river but rise in water level during post monsoon is due to the rainfall. Where as during the peak flow period, the rise in post monsoon water level was high, this may be due to combined effect of recharge from rainfall and contribution from river volume.

Correlation of hydrographs at Chengalpattu site:

The combined hydrograph showing river discharge and pre and post monsoon ground water levels monitored at Chengalpattu is given in fig. 7.4:

Fig. 7.4



On perusal of data and hydrograph, it is observed that the minimum flow of 4.113 MCM was recorded during 2003-04 and maximum of 464.3 MCM during 2005-06 between the years 1999 to 2006. While comparing the recharge verses river flow, it is observed that when the flow in the river was minimum the respective recharge also shown as minimum. When the flow in the river recorded maximum, the recharge also recorded its maximum. It is clearly indicating the direct response of ground water system to the river flow. The river flow data in comarisson to water level data indicate that the river is influent in nature during monsoon period.

7.2.9 KERALA REGION(Trivendrum)

Hydrological studies during the AAP 2009-10:

Hydrological studies on Meenachil basin (a west flowing river of Kerala) has been taken up during the AAP. The analysis and findings of the study is as given as below:

Meenachil basin:

The length of the river is 78 km and the total drainage area is 1272 km^2. The entire catchment lies within the Kerala State. The basin lies between 09° 28′ and 09° 48′ N latitudes and 76° 23′ and 76°56′ E longitudes. The average slope of the river is approximately 1 in 110.

The Meenachil river basin is bounded by the Muvattupuzha basin on its north and the Manimala basin on its south. The river is formed by several streams originating from the Western Ghats. The Kadapuzha Ar originates from Anakkunnu mudi and Pazhavathi Mudi at an altitude of about 1000 m above M.S.L. This stream flows in a southerly direction and joins the Konipaduthodu to form the Kalathukadavu Ar. The Tikovil Ar, which originates from Maradi malai also joins Kalathukadavu Ar at Cheripad. At Erattupettah, the main river takes a sharp turn and flows towards west till Pala. In this reach the tributaries namely Chittar-Ar and Payappara thodu join at South and North flanks respectively.

The river then traces a south-westerly course till it reaches Kottayam. A few kilometers downstream of Kottayam town the river bifurcates and the Neelimangalam branch flows northwards to join the Vembanad lake. The other branch after flowing in a westerly direction for some distance turns sharply and takes a southerly course skirting the Kottayam town. This branch known as the "Nagampadam" also discharges into Vembanad lake.

Climate:

Good rainfall and humid atmosphere throughout the year are the characteristic features of the basin. Within a short span from the ghats to the sea coast, the climatic conditions reveal remarkable variation due to diversity in the physical features. For the mid land and coastal belt, the climate is mainly humid tropical to humid temperate. In the mountainous regions, the temperature is comparatively low. The nearest IMD observatory is located at Alappuzha in Pamba basin.

Rainfall:

There are 26 rain gauge stations located in and around the basin. Out of 26 rain gauge stations, 9 stations are located inside the basin.

Meenachil basin experiences both south –west and north – east monsoons. The south-west monsoon sets during June and lasts till August. The north-east monsoon, which is uncertain strikes in October and continues till the end of November. For the hydrological studies, the period from June to November is considered as monsoon period and the rest of the period is considered as non-monsoon season.

The annual normal rainfall of different rain gauge stations in the basin varies from a minimum of 2569 mm at Kumarakom to a maximum of 4655 mm at Penshurst Estate.

Hydrometeorological studies

Introduction:

Rainfall is the major source of ground water recharge and the rainfall pattern plays an important role on the water levels in the phreatic aquifer and also to the deeper aquifers. The rainfall data received from India Meteorological Department, Trivandrum for the period of April 2008 to March 2009 is analyzed and the findings were as given as below;

Annual rainfall distribution:

The total rainfall ranged from 1727 to 3150 mm during the period from April 2008 to March 2009. The maximum rainfall was recorded in Calicut district and the minimum in Trivandrum district. During the south-west monsoon season, Trivandrum district recorded 775 mm and Kasaragod district recorded 2453 mm, which are the lowest and highest rainfall respectively. During the northeast monsoon season, Kasargod district recorded the lowest rainfall of 222 mm and Quilon district recorded the highest rainfall of 507 mm.

Monthly rainfall distribution:

The monthly rainfall for all the fourteen districts are given in the table. The maximum rainfall occurred during the months of June to August in all the 14 districts. Almost all the districts recorded with sufficient rainfall during the month of June to September due to the influence of southwest monsoon.

Normal rainfall vs actual rainfall:

The actual rainfall during different seasons has been compared with the normal rainfall of the seasons to find out the variation of the rainfall and is discussed in detail in the following paragraphs:

Hot weather period:

The seasonal and their percentage departure from normal rainfall are given in the table. During the months of April-May 2008, the departure of pre-monsoon rainfall varied from 14.0 to -58% at different districts. As per the IMD norms districts were recorded with normal and deficient type of rainfall during the period. The maximum departure of negative side was observed in Pathanamthitta district and the maximum deviation of -58% from the normal was noted in Pathanamthitta district in the southern part of Kerala. Normal rainfall was observed in five districts and deficient rainfall in eight districts. There is no excess and scanty rainfall was observed.

South-west monsoon period:

During the southwest monsoon season from June to September 2008, the departure of rainfall varied from -52 to 0% at different districts. The maximum deficient rainfall is for Wayanad district in the northern part of the State and normal rainfall had occurred in six districts. Seven districts had recorded with efficient type of rainfall.

North-east monsoon period:

During the northeast monsoon season from October to December 2008, the departure of rainfall varied from -42% to 16% at different districts. The maximum departure in the deficient type of rainfall from the normal is recorded in Idukki district. Excess type of rainfall recorded in Thiruvananthapuranm, Kannur and Wayanad districts. Deficient rainfall is recorded in Ernakulam, Idukki, Kasaragod and Kottayam districts. Normal rainfall is recorded in seven districts.

Winter period:

During the months of January to March 2009, the departure of rainfall varied from -13 to 97%. Idukki district recorded the maximum departure and in the excess type category and Kasargod district recorded with the minimum departure from the normal rainfall in the Positive side. All other districts have received less rainfall in comparison with the previous year. The rainfall during the season for the State is 1636 mm which is 67% of the year. Eight districts have been recorded with excess rainfall and none of the districts with deficient rainfall.

7.2.10 SOUTHERN REGIOPN(A.P.)

7.2.10.1 Hydrological studies with findings/Conclusions

1) **Infiltration Tests:**

Six Infiltration tests were carried out in Maheswaram Watershed using Double Ring
Infiltrometers during March 2010. The results are summarized as follows:

Village	Constant Infiltration rate(cm/yr)	Infiltration Coefficient (%)
Tukkuguda	2	7.4
Maheswaram	8	12.8
Saraswathiguda	5.8	14.3
Harshaguda	32.8	20.8
Raviral	11.4	14.6
Kotwalcheruvu Tanda	0.60	2.8

7.2.10.2 Hydrometeorological studies with findings/Conclusions

1) Compilation and analysis of rainfall data in support of Ground Water Regime studies during the months of May 2009, Aug 2009, November 2009 and January 2010. The analysis involves preparation of following eight maps with tables and write-up.

a) **Rainfall departure map: June2007-May2008 w. r. t June2008-May 2009**
→The whole state recorded less rainfall than the previous period except parts of Khammam, Nalgonda, Guntur, Warangal and Krishna districts. The mean rainfall in the state during this period is 827mm, about 29% less than the previous year, same period.

b) **Rainfall departure map: mean of June-May (1999-2008) w. r. t June'08-May'09.**
→ The whole state recorded less rainfall than the decadal mean except in parts of Khammam, Nalgonda, Guntur, Warangal, Prakasham, Rangareddy, Mahabubnagar, West Godavari, Anantapur and Krishna districts. The mean rainfall in the state during the decade is 909mm, which is 9% more than the rainfall of June'08 to May '09.

c) **Rainfall departure map: June'08-Aug'08 w. r. t June'09-Aug'09**
→ The whole state recorded less rainfall than the previous period except in Chittoor, and parts of Nellore, Kadapa, Vishakhapatnam, Vizianagaram and Srikakulam districts. The mean rainfall in the state during this period is 318mm, about 15% less than the previous year, same period

d) **Rainfall departure map: mean of June-Aug (1999-2008) w. r. t June'09-Aug'09.**
→ The whole state recorded less rainfall than the decadal mean except in Chittoor and parts of Nellore, Kadapa districts. The mean rainfall in the state during the decade (1999-2008) is 408mm, which is 10% more than the rainfall of June'09 to Aug '09.

e) **Rainfall departure map: June'08-Oct'08 w. r. t June'09-Oct'09**
→ the whole state recorded less rainfall than the previous period i.e June-Oct 2008 except parts of Chittoor, Kadapa, Kurnool, Medak, Vishakhapatnam, Vizianagaram and Srikakulam districts. The mean rainfall in the state during this period is 534mm, about 19% less than the previous year, same period.

f) **Rainfall departure map: mean of June-Oct (1999-2008) w. r. t June'09-Oct'09.**
→ The whole state recorded less rainfall than the decadal mean except in parts of Warangal, Kurnool, Mahabubnagar and Chiottoor districts. The mean rainfall in the state during the decade June 1999-Oct 2008 i.e. mean of June-Oct for 10 year period , is 704mm, which is 32% more than the rainfall of June'09 to Oct '09

g) **Rainfall departure map: Jun'08-Dec'08 w. r. t Jun'09-Dec'09**
→ The whole state received less rainfall than the previous year same period except parts of Kurnool, Mahabubnagar, Chittoor, Nellore and Kadapa districts. The mean rainfall in the state during this period i.e. Jan – Dec 2009 is 724mm, about 21% less than the previous year, same period.

h) **Rainfall departure map: mean of Jun-Dec (1999-2008) w. r. t Jun-Dec 2009.**
→ Except parts of Mahabubnagar, Kurnool, Rangareddy, Chittoor and Nellore the whole state received less rainfall than the decadal mean (1998-2008). The decadal mean rainfall in the state (Jan-Dec) is 877mm. On the whole, the state received less rainfall than the previous year as well as decadal mean.

2. Ground Water Year Book (2008-09) :

Monthly, seasonal and annual rainfall of June'08 to May'09 compiled from daily weather reports of India Meteorological Department and its analysis in support of Ground Water Year Book 2008-09.

The normal annual rainfall of the state is 930mm. The normal seasonal rainfall is 617mm, 241mm, 13mm and 60mm in monsoon (June-Sept), post-monsoon

(Oct-Dec), winter (Jan-Feb) and summer (March-May) respectively. Annual normal rainfall ranges from 570mm in Anantapur in southern part to 1167mm in Ramagundam. The rainfall recorded during the period June'08-May'09 is 998mm, about 7% more than normal. During the study period i. e., June'08 to May'09, it is 598mm, 334mm, 1mm and 52mm in monsoon, post-monsoon, winter and summer period respectively. It is 3% less than normal, 39% more than normal, 95% less than normal and 13% less than normal in monsoon, post-monsoon, winter and summer period respectively. During the period June'08-May'09, about 60% of the total rainfall is received during the southwest monsoon season and about 33.5% of the annual rainfall is received during the post-monsoon season. Winter rainfall is almost insignificant and summer rainfall is only 5%. The total rainfall during the period ranges from 712mm (deficit by 33%) in Medak to 1362mm (more by 37%) in Machilipatnam. The rainfall has been normal to excess in the entire state except deficit in Medak (-33%) and Kalingapatnmam (-27%).

3) Mahabubnagar district report:

The normal annual rainfall of the district is 758mm recorded in 44 rainy days. Southwest monsoon contributes about 78% of annual rainfall in 34 rainy days. It increases from 750mm in southeast to 925mm in northwest. Mean annual rainfall for the period 1978-2008 648mm, which is 14% less than the IMD normal. During this period drought occurred in ten years and is drought prone. Potential evapotranspiration (PET) ranges from 111mm in Dec to 198mm in April. Annual PET is 1678mm.

4) Hyderabad rainfall analysis report:

The annual normal rainfall at Hyderabad is 770mm recorded in 48 rainy days. Seasonal distribution of rainfall is 601mm, 90mm, 14mm, 65mm in southwest, northeast, winter and summer seasons respectively. Southwest monsoon season contributes about 78% of annual rainfall in 37 rainy days. Potential evapotranspiration (PET) ranges from 99mm in Dec to 220mm in May and the annual PET is 1759mm. September is the rainiest month with 186mm in 10 rainy days contributing 25% of annual rainfall. Mean rainfall for the period 1970-2009 is 832mm, with coefficient of variation of 26%, which is high. . During this period minimum rainfall of 416mm has occurred in 1972 and maximum rainfall of 1326mm has occurred in 1975. There is a rise in the non-monsoon rainfall trend during this period in December to 201mm in August. Percentage variation of southwest. There is a fall in the contribution of monsoon rainfall as a percentage of annual rainfall over the years. Mean monthly rainfall ranges from 3.4mm monsoon rainfall is 28% and northeast monsoon is 67%. On observation it is found that, the rainfall in the city is highly erratic both spatially and temporally. At very short distances even, the rainfall amount varies considerably. Occurrence of high intensity rainfall is increasing over the years. High density of self-recording rain gauge is required to understand the true behaviour of rainfall and quantification of the same in the city. '

5) Hyderabad rainfall analysis report:

A Self Recording Rain gauge (SRG) station was established during May 2008 in Bhujal campus, Office Complex of SR and it is being maintained to record continuous rainfall. Rainfall data collected and compiled from the SRG is being analyzed. From June to Dec 2008, SRG in the office campus recorded 600mm of rainfall in 32 rainy days. From Jan 2009 to Dec 2009, it recorded 408mm only in 30 rainy days. Rainfall here is very less compared to rainfall recorded at Begampet IMD station. The rainfall is not evenly distributed during the 120 days of the monsoon period but ours in pockets of medium to high intensity. Number of rainy days during the southwest monsoon of 2008 was 4, 5, 12 and 18 recording 5, 55, 306 and 18mm rainfall in June, July, Aug and September respectively. Number of rainy days during the southwest monsoon of 2009 was 3, 6, 9 and 7 recording 46, 94, 122 and 94mm rainfall in June, July, Aug and September respectively. Year 2009 has received much less rainfall than the year 2008.

8. GROUND WATER LEVEL SCENARIO

8.1 INTRODUCTION:

Monitoring of ground water regime is an effort to obtain information on ground water levels and chemical quality through representative sampling. The important attributes of ground water regime monitoring are ground water level, ground water quality and temperature. The primary objective of establishing the ground water monitoring network stations is to record the response of ground regime to the natural and anthropogenic stresses of recharge and discharge parameters with reference to geology, climate, physiography, land use pattern and hydrologic characteristics. The natural conditions affecting the regime involve climatic parameters like rainfall, evapotranspiration etc., whereas anthropogenic influences include pumpage from the aquifer, recharge due to irrigation systems and other practices like waste disposal etc.

Ground water levels are being measured four times a year during January, April/ May, August and November. The regime monitoring started in the year 1969 by Central Ground Water Board. At present a network of 15640 observation wells located all over the country is being monitored. Ground water samples are collected from these observation wells once a year during the month of April/ May to obtain background information of ground water quality changes on regional scale. The database thus generated forms the basis for planning the ground water development and management programme. The ground water level and quality monitoring is of particular importance in coastal as well inland saline environment to assess the changes in salt water/fresh water interface as also the gradual quality changes in the fresh ground water regime. This data is used for assessment of ground water resources and changes in the regime consequent to various development and management activities.

The State-wise distribution of the ground water observation wells is given in table 8.1, graph is given in fig. 8.1 & 8.2. and depicted in fig. 8.3.

TABLE 8.1 : STATEWISE DISTRIBUTION OF OBSERVATION WELLS

Sl No.	Name of the State	Total No. of Observation Wells (as on 31.03.2010)
1	Andhra Pradesh	981
2	Arunachal Pradesh	19
3	Assam	381
4	Bihar	373
5	Chhatishgarh	516
6	Delhi	87
7	Goa	53
8	Gujarat	966
9	Haryana	426
10	Himachal Pradesh	85
11	Jammu & Kashmir	206
12	Jharkhand	208
13	Karnataka	1499
14	Kerala	864
15	Madhya Pradesh	1325
16	Maharashtra	1496
17	Manipur	25

Sl No.	Name of the State	Total No. of Observation Wells (as on 31.03.2009)
18	Meghalaya	38
19	Nagaland	17
20	Orissa	1214
21	Punjab	261
22	Rajasthan	1373
23	Tamil Nadu	906
24	Tripura	42
25	Uttar Pradesh	1218
26	Uttaranchal	44
27	West Bengal	909
	UTs	
1	Andaman & Nicober	63
2	Chandigarh	16
3	Dadra & nagar Haveli	10
4	Daman & Diu	4
5	Pondicherry	15
	Total	**15,640**

8.2 Ground water level scenario - pre-monsoon, 2009

A perusal of depth to water level map of India for Pre-Monsoon period (May 2009) (fig. 8.4) reveals that that in sub- Himalayan area, north of river Ganges, generally the depth to water level ranges from 2 to 10 meter below ground level (mbgl). In the eastern part of the country in the Brahmaputra valley water level generally ranges from 2-5 mbgl, except in isolated pockets where depth to water level is less than 2 mbgl. However, in upper Assam, isolated pocket of deeper water level, 5-10 mbgl has been observed. In major parts of Indus basin, depth to water level generally ranges from 5-20 mbgl. In the western part of the country covering states of Gujarat and Rajasthan deeper water level is recorded in the range of 10-20 m.bgl. Relatively deeper water level in the range of 20-40 mbgl and > 40 mbgl have been observed in Alwar, Barmer , Bikaner, Churu, Nagaur, Jhunjhunu, Sikar and Jaipur district of Rajasthan and also in central and north Gujarat. In Punjab and Haryana deeper water level in the range of 10-20 mbgl and 20-40 mbgl has been observed. In Maharashtra water level recorded is mostly in the range of 5-10 mbgl except western Maharashtra where water level is generally less than 5 mbgl. In the east coast i,e coastal Andhra Pradesh, Orissa and Tamil Nadu, generally the water level ranges between 2-5 mbgl. However, isolated pockets of water level more than 5 mbgl have also been recorded. Eastern most part of West Bengal recorded water level in the range of 5-10 mbgl. In central India water level generally varies between 5-20 mbgl, except in isolated pockets where water level is more than 20 mbgl. The peninsular part of country generally water level ranges between 5-20 mbgl except in pockets where water level is less than 5 mbgl. Isolated patches of deeper water level in the range of 20-40 mbgl and more than 40 mbgl have also been observed in various parts of the country.

A comparison of depth to water level during Pre-Monsoon (May 2009) with decadal mean (1999-2008) (fig 8.5) reveals that in general, there is decline in the water level throughout the country except in the states of Andhra Pradesh, Gujarat, Karnataka and Tamil Nadu where more nos. of wells showing rise in water level than fall. Most of the wells have been showing rise / fall of water level in the range of 0-2 m and are common in all the states. Fall in water level more than 2 meters on long term basis has also been observed in various parts of the states such as Madhya Pradesh, Uttar Pradesh, Gujarat, Rajasthan, Haryana, Punjab and Maharashtra. In Gujarat fall of more than 4 m is observed in isolated patches in Banaskantha, Sabarkantha, Kheda, Gandhinagar, Ahmedabad, central & eastern parts of Kachchh districts and Saurashtra region. In Maharashtra districts of Amravati, Aurangabad, Beed, Jalna, Nanded, Nagpur, Sindudurg and solapur fall in this category. In Rajasthan fal of more than 2 m is observed in districts of Bikaner, Jaisalmer, Barmer, Jodhpur, Churu, Jalore, Nagaur, Jhunjhunu and Jaipur. In Haryana districts of Ambala, fatehabad, Kaithal, Karnal and Panchkula showing decline in this category. In Punjab more than 2 m decline is observed in isolated patches in Bathinda, Faridkot, Jalandhar, Rupnagar, Patiala and Sangrur districts.

8.3 Ground water level scenario - August, 2009

A perusal of depth to water level map of India for August 2009) (fig. 8.6) reveals that that in sub-Himalayan area, north of river Ganges, generally the depth to water level ranges from 0 to 5 meter below ground level (mbgl). In the eastern part of the country in the Brahmaputra valley water level generally less than 2 mbgl, except in isolated pockets where depth to water level is in the range of 2 to 5 mbgl. However, in upper Assam, isolated pocket of deeper water level, 5-10 mbgl has been observed. In major parts of Indus basin, depth to water level generally ranges from 5-20 mbgl. In the western part of the country covering states of Gujarat and Rajasthan deeper water level is recorded in the range of 10-20 m.bgl. Relatively deeper water level in the range of 20-40 mbgl and > 40 mbgl have been observed in Rajasthan, Punjab, Haryana and also in central and north Gujarat. In Maharashtra water level recorded is mostly in the range of 2-5 mbgl except western Maharashtra where water level is generally less than 2 mbgl. In the east coast i.e. coastal Andhra Pradesh and Tamil Nadu, generally the water level ranges between 5-10 mbgl. However, isolated pockets of water level more than 5 mbgl have also been recorded. In Orissa water level generally is less than 2 mbgl with isolated pockets showing water level in the range of 2-5 mbgl. West Bengal recorded water level in the range of 2-5 mbgl except in coastal parts where water level is in the range of 5-10 mbgl. In central India water level generally varies between 2-10 mbgl, except in isolated pockets where water level is more than 10 mbgl. The peninsular part of country generally water level ranges between 5-10 mbgl except in isolated patches where water level is more than 10 mbgl. Isolated patches of deeper water level in the range of 20-40 mbgl have also been observed in various parts of the country.

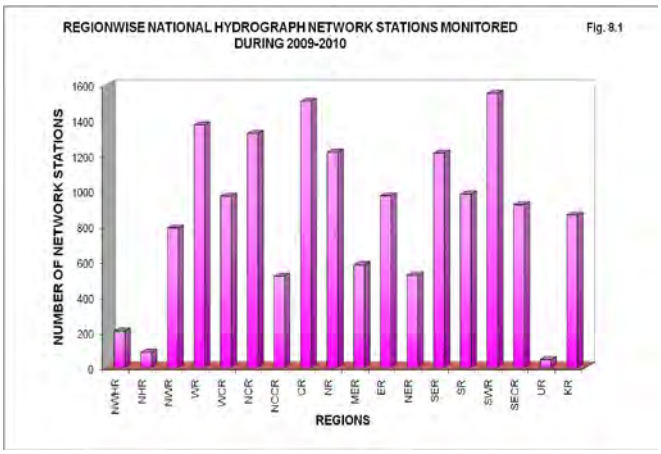
A comparison of depth to water level during August 2009 with decadal mean (1999-2008) (fig. 8.7) reveals that in general, there is decline in the water level throughout the country except in states of Assam, Gujarat, Karnataka,

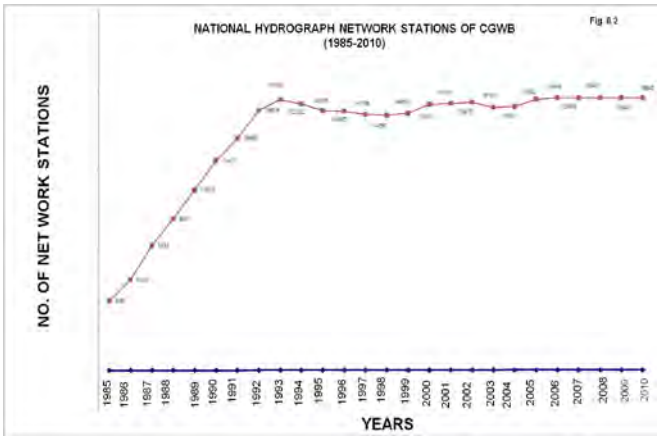
Kerala, Orissa and Tamil Nadu. Most of the wells have been showing rise / fall of water level in the range of 0-2 m and are common in all the states. Rise / fall in water level in the range of 0-2 meters may not be significant in view of dynamic nature of groundwater resources. Fall in water level more than 2 meters on long term basis has also been observed in various parts of the states such as Andhra Pradesh, Delhi, Madhya Pradesh, Uttar Pradesh, Gujarat, Eastern Rajasthan, Haryana, Punjab and Eastern Maharashtra.

8.4 Ground water level scenario - Post-monsoon, 2009

A perusal of depth to water level map of India for Post-Monsoon period (November 2009) (fig. 8.8) reveals that in Sub-Himalayan area, north of river Ganges and in the eastern part of the country in the Brahmaputra valley, generally the depth to water level varies from 2-5 meter below ground level (mbgl). Isolated pockets of shallow water level less than 2 mbgl have also been observed. In major parts of north-western states (Indus basin), depth to water level generally observed in the range of 10-20 mbgl. In the western parts of the country deeper water level is recorded in the range of 10-20 mbgl. In the west coast water level is generally less than 10 m and in western parts of Maharashtra State isolated pockets of water level less than 2 m has also been observed. In the east coast i.e. coastal Andhra Pradesh and Orissa, shallow water level of less than 2 m have been recorded. In eastern states, water level in general ranges from 2-5 mbgl. However South-eastern part of West Bengal recorded water level in the range of 5-10 mbgl. In central India water level generally varies between 2-10 mbgl, except in isolated pockets where deeper water level more than 10 mbgl has been observed. Similarly pockets of shallow water level less than 2 mbgl is also observed. The peninsular part of country generally recorded a water level in the range 5-10 mbgl. In some patches water level ranges from 10-20 mbgl. Isolated patches of water level of 10-20 mbgl and 20-40mbgl have been observed as well.

A comparison of depth to water level during November 2009 with decadal mean (1999-2008) (fig. 8.9) reveals that, in general, there is declining trend in water level in rainfall deficient states. Isolated pockets of rise in water level in the range of 0-2 m are also common in all these states. Majority of wells in Gujarat and Karnataka have shown rise in water level. Rise / fall in water level in the range of 0-2 meters may not be significant in view of dynamic nature of groundwater resources. Fall in water level more than 2 meters on long term basis has also been observed in various parts of the states such as UP, Andhra Pradesh, Madhya Pradesh, Maharashtra, Tamil Nadu and West Bengal. In Madhya Pradesh parts of Katni, Satna, Neemuch, Rewa, Shahdol, Sidhi districts fall in this category. In Maharashtra districts of Chandrapur, Latur, Nanded, Parbhani, Ratnagiri, Wardha and Yavatmal fall in this category. In Uttar Pradesh fall of more than 2 m is observed in Agra, Allahabad, Banda, Chitrakoot, Fatehpur, Ghazipur, Hamirpur, Jaunpur, Hathras, Mirzapur, Pratapgarh and Varanasi districts. In Andhra Pradesh fall in this category is observed in parts of central Telangana Region, West Godavari, Nellore districts of coastal region and also in Kurnool, Anantpur, Chitoor districts of Rayalseema region.





8.5 Ground Water Level Scenario - January, 2010

A perusal of depth to water level map of India for January 2010 (fig. 8.10) reveals that in Sub-Himalayan area, north of river Ganges and in the eastern part of the country in

the Brahmaputra valley, generally the depth to water level varies from 2-5 meter below ground level (m bgl). Isolated pockets of shallow water level less than 2 m bgl have alsobeen observed. In major parts of north-western states (Indus basin), depth to water level generally varies from 10-20 m bgl with pockets of deeper water level of more than 20 m bgl. In the western parts of the country covering the states of Rajasthan and Gujarat deeper water level is recorded in the range of 10-20 m bgl. In Rajasthan pockets of deeper water level in the range of 20-40 m bgl and > 40 m bgl have also been also recorded. In the west coast water level is generally less than 10 m and in western parts of Maharashtra State isolated pockets of water level less than 2 m has also been observed. In the east coast i.e. coastal Andhra Pradesh and Orissa, water level in the range of 2-5 m bgl have been recorded while in coastal Tamil Nadu shallow water level of less than 2 m bgl have been recorded. However South-eastern part of West Bengal recorded water level in the range of 5-10 m bgl. In central India water level generally varies between 2-10 m bgl, except in isolated pockets where deeper water level more than 10 m bgl has been observed. The peninsular part of country generally recorded a water level in the range 5-10 m bgl. In some patches water level ranges from 10-20 m bgl. Isolated patches of water level of 10-20 m bgl and 20-40 m bgl have been observed as well.

A comparison of depth to water level during January 2010 with decadal mean (2000-2009) as shown in fig. 8.11 indicates that, in general, there is decline in water level in rainfall deficient states. Isolated pockets of rise in water level in the range of 0-2 m are common in all these states. Majority of wells in Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa and Tamil Nadu have shown rise in water level. Rise / fall in water level in the range of 0-2 meters may not be significant in view of dynamic nature groundwater resources. Fall in water level more than 2 meters on long term basis has also been observed in various parts of the states such as UP, Andhra Pradesh, Rajasthan, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Tamil Nadu and West Bengal.

8.6 Pre - Post water Level fluctuation Scenario - 2009

Water level of Post monsoon 2009 when compared with Pre-monsoon 2009 as shown in Plate X indicates that in general there is rise in water level in various states of India except in isolated pockets of fall in the states of Rajasthan, Punjab, Haryana, Tamil Nadu, Andhra Pradesh, Uttar Pradesh and Gujarat. Rise of more than 4 m has been observed in the state of Maharashtra, Gujarat, Karnataka, and Orissa and in the central Part of India. Isolated pockets of fall in water level exceeding 4 m have been observed in parts of Rajasthan, Gujarat and Tamil Nadu. The Ground Water Level Scenario of India during the year 2009-10 is shown as Ground Water Level at a Glance in fig. 8.12.

8.7 Rainfall Variations

In India, rainfall is unevenly distributed spatially and temporally. The average annual rainfall of the country for 2009 is around 954 mm against the Normal rainfall of 1197 mm (Departure of 20% less than the Normal). From the perusal of Average Annual Rainfall map given as fig. 8.13 , it can be observed that the rainfall is normal in southern states except in Andhra Pradesh and Eastern Maharashtra. In the northern and north western part of the country rainfall is deficient except for the states of Bihar and Saurashtra region of Gujarat where rainfall is normal. Rainfall is deficient in Central India except for western Madhya Pradesh. States of West Bengal and Orissa witnessed normal rainfall. The whole of north-eastern states have deficient rainfall. A review of annual ground water availability, contribution from monsoon rainfall recharge and annual ground water draft in different states falling under overexploited category and the rainfall distribution in space brings a paradoxical situation in the sense that, withdrawal of ground water is not solely responsible for declining trends, the scantly and low rainfall resulting in meager monsoon recharge is equally important. Majority of the ground water stress areas categorized as overexploited and critical units also lies in these states.

Fig. 8.3

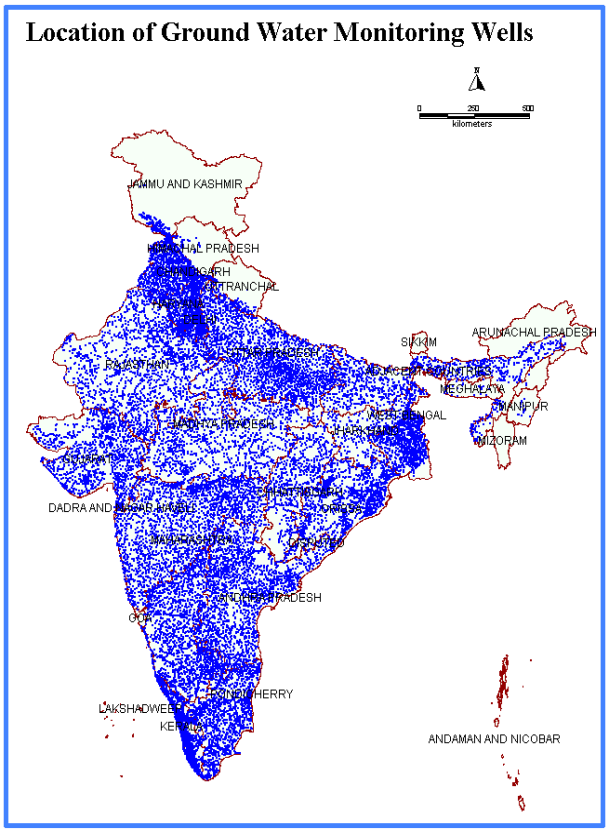


Fig. 8.4

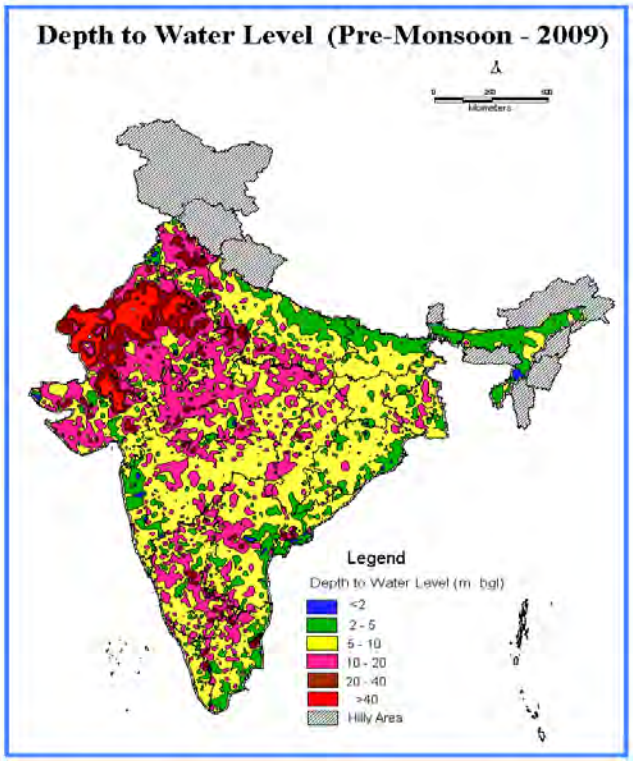


Fig. 8.5

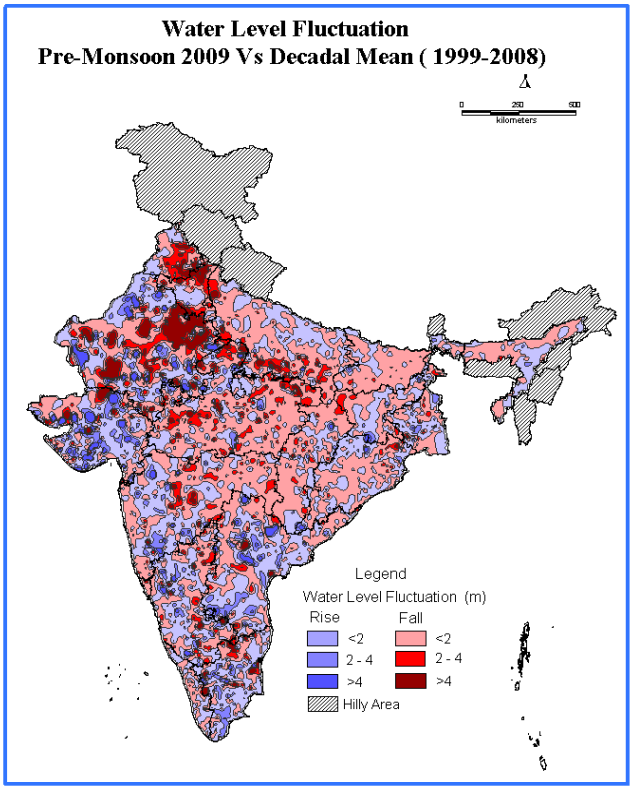


Fig. 8.6

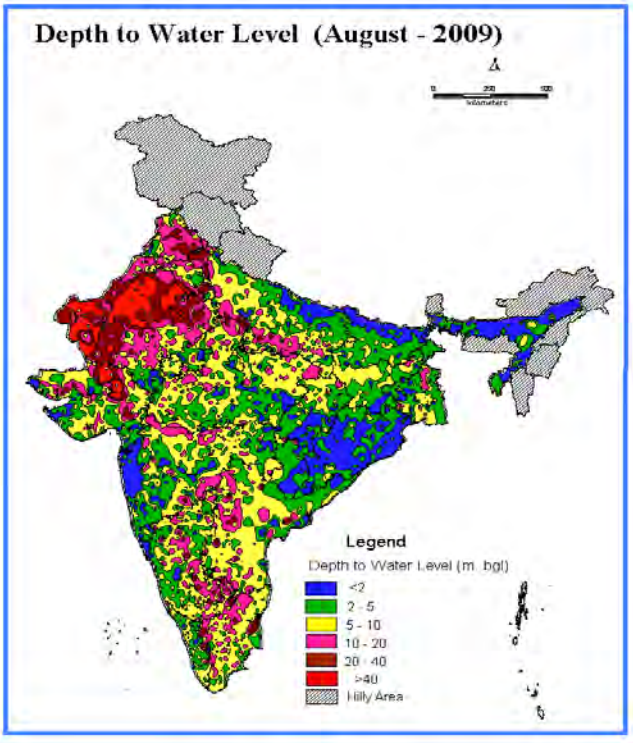


Fig.8.7

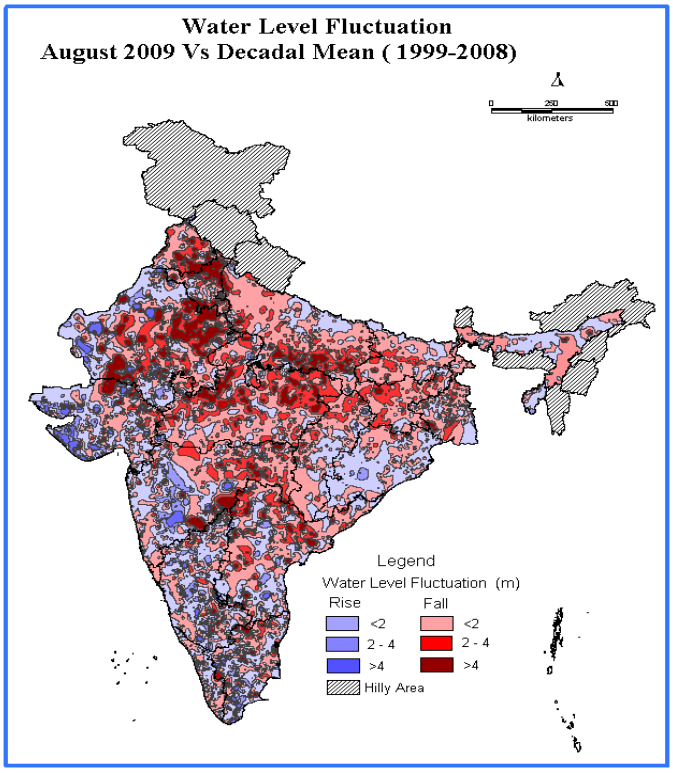


Fig.8.9

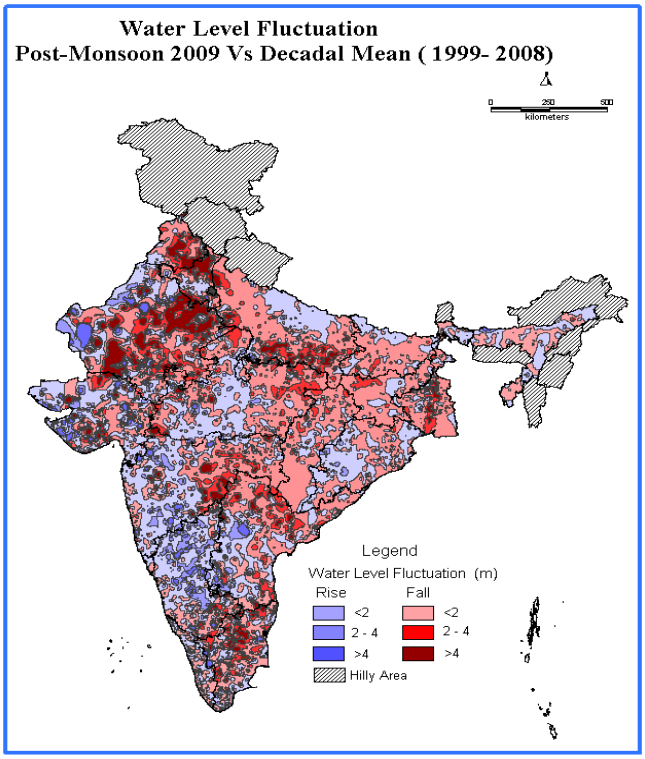


Fig. 8.8

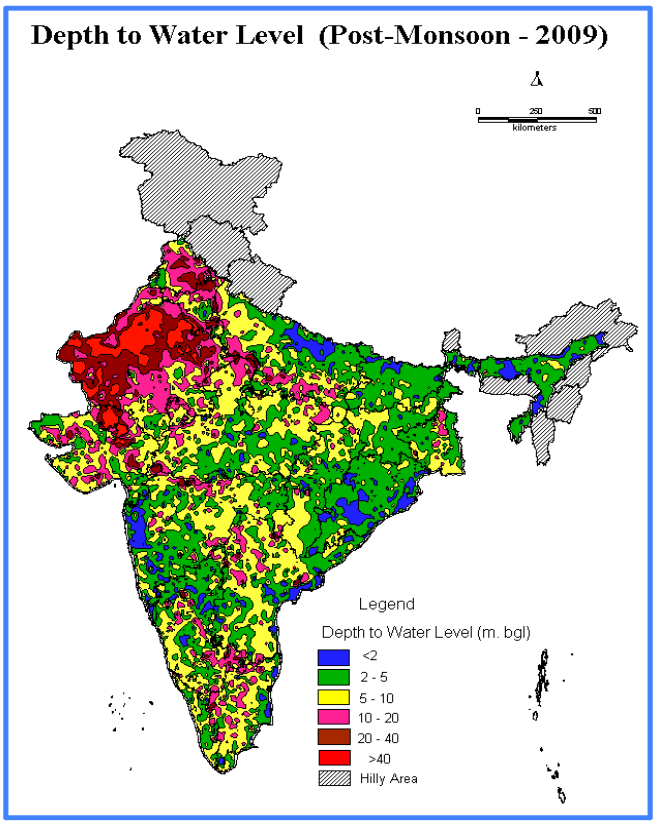


Fig.8.10

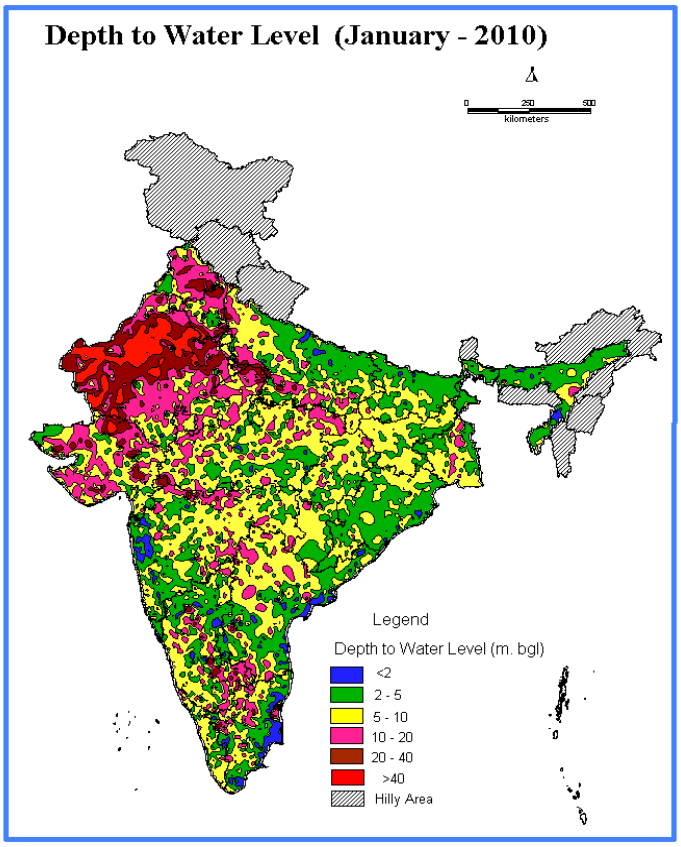


Fig.8.11

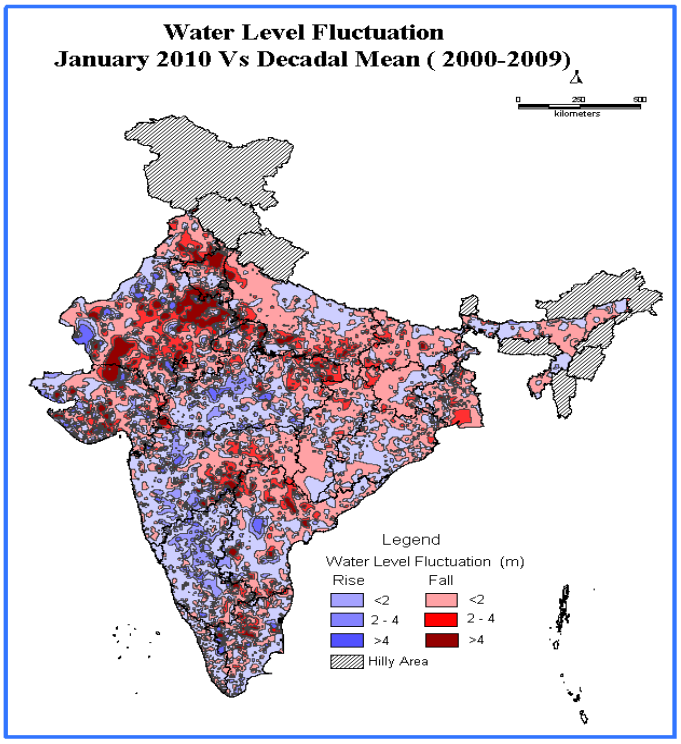


Fig.8.12

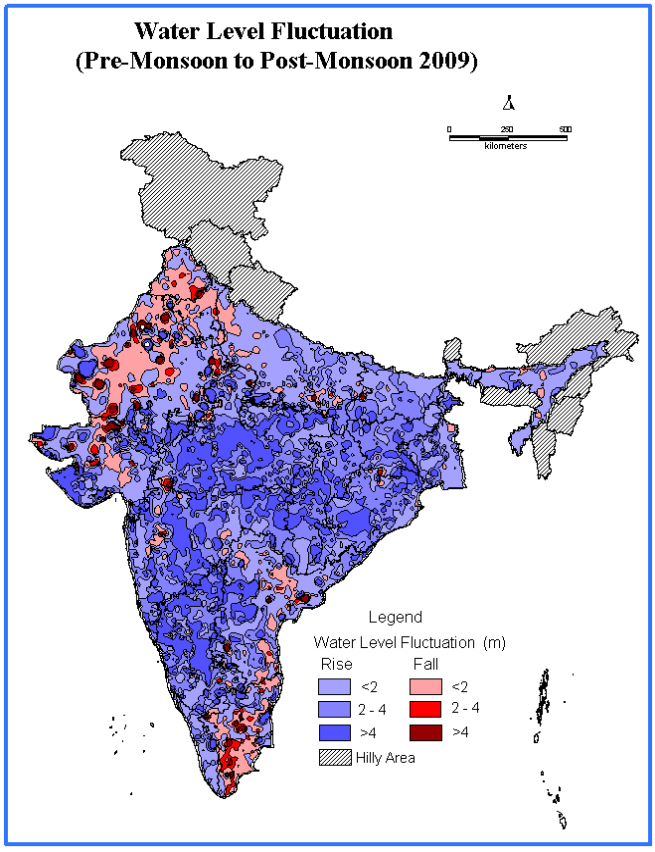
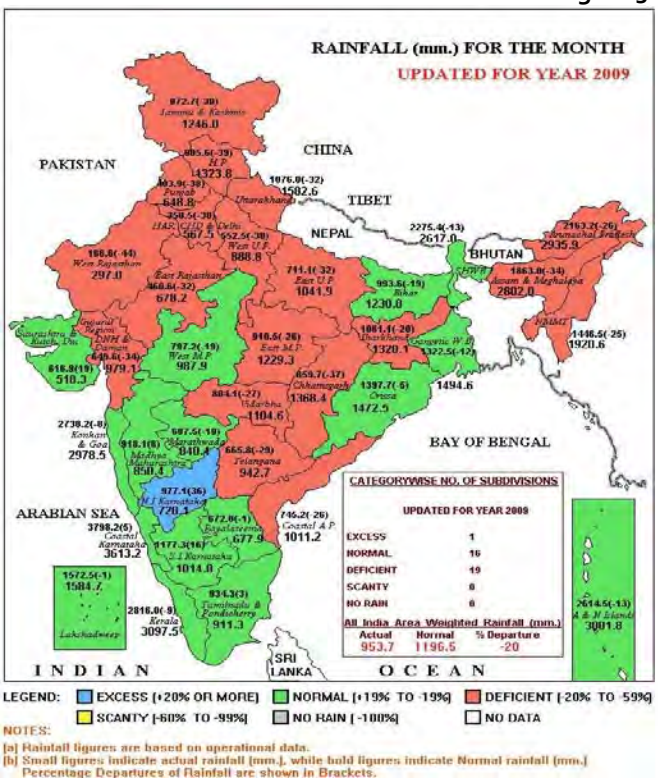


Fig.8.13



Source:IMD

9.0 GEOPHYSICAL STUDIES

In Geophysical studies basically electrical, electromagnetic, magnetic and seismic methods are used for pre estimation of aquifer geometry, water quality and quantity. Whereas borehole logging is used for estimating the quality of formation water, identification of litho boundaries and recommending well assembly. The integrated approach helps in accurately designing the well assembly

Geophysical surveys were undertaken to support, supplement and corroborate the hydrogeological surveys, ground water exploration and short-term water supply investigations as an integral part of its AAP activities. These surveys were mostly carried out with an objective of selecting, pinpointing the sites and delineating the depth to potential water bearing zones in ground water exploration and short-term water supply investigations..

Besides, geophysical surveys were also undertaken for demarcating saline - fresh water interface, Coastal aquifer management studies, estimation of overburden thickness and bedrock configuration, identifying favourable sites for artificial recharge structures, flood plain studies and in farmer distress villages etc.

The resistivity survey results were analyzed and interpreted for delineating the depth and thickness of ground water potential zones. The interpreted results of the Vertical Electrical Sounding (VES) conducted near the exploratory wells were correlated with the lithologs to establish the resistivity ranges for different formations. The field VES data has been entered in computer software for easy analysis, retrieval, presentation and dissemination and was analysed both manually and computer software like 'SCHLUM and IPI2WIN etc., The field VES data along with the interpreted results were also entered in GEMS.

9.1 Central Geophysical Cell

Planning & Programming of Geophysical surveys in CGWB, Finalization of AAP of different Regions for Geophysical investigation and monitoring of progress of geophysical work.

- Acquisition of geophysical equipments, drawing of Specifications and organizing performance testing of Geophysical equipments. Convened several meetings of the Technical Committee, with the committee members from NGRI, GSI to formulate the specifications for the geophysical equipment (Resistivity Imaging System and Electromagnetic equipment) that is to be procured for the Board with HOO, S R, Hyderabad as its Chairman and Suptdg as one of the members and submitted the report.
- Coordination of Geophysical Surveys and related activities: Preparation of inventory of equipments in different Regional Offices and assessment of present capability of Board as regards instrumentation. Prepared replies for the points emerged in the meeting of Member (SAM) and Joint Secretary (Admin), MOWR on the issues related to the geophysical wing of the Board. A note was prepared and put up to the Member (SAM) regarding the Natural Gamma ray attachment along with the propriety item certificate.
- Co-ordination of Training Activities for personnel in geophysical Survey and related items- Prepared the training module for the Training Course on "Refresher Course on Surface Geophysical Surveys for Geophysicists/Hydro geologists." which was conducted during 8th Dec. 2009 – 18th Dec. 2009 at Southern Region, Hyderabad
- Repairs/servicing of logger stationed at Central Region, Nagpur was under taken and the calibration of the equipment was demonstrated to the local Geophysicist.
- Discussions with the ONGC officials at Rajahmundry and collected data pertaining to oil well logs so as to decipher the deep water bearing formations for the future exploration.

9.2. GEOPHYSICAL SURVEYS AT A GLANCE

Central Ground Water Board was entrusted with a target of 2100 nos. of VES and need based Resistivity Profiling. Against this target, a total no. of 1671 VES and 14.52 LKm of Resistivity profiling were carried out. Apart from this a total no. of 104 boreholes were logged geophysically with different parameters viz. SP, PR, 16" & 64" Normals and Natural Gamma. The total depth logged is 16,451.3m. Details of Geophysical surveys & geophysical bore hole logging carried out in different regional offices are furnished below in Table 9.1.

During the period under review, in addition to the routine field investigations, many assignments/works were attended by the Geophysical Section.

Table 9.1: Geophysical Surveys & Bore Hole Logging During 2009-2010

Region	No. of VES	Resistivity Profiles (line km)	No. of boreholes logged	Total meterage Logged (m)
NWHR, Jammu	54	1.14	5	681
NWR, Chandigarh	156	0	24	3789
WR, Jaipur	71	0	16	2545
WCR, Ahmedabad	0	0	4	613
NCR, Bhopal	29	11.00	0	0
NCCR, Raipur	102	0.2	0	0
CR, Nagpur	120	0	2	152
NR, Lucknow	36	0	10	1461
MER, Patna*	167	2	6	1281.5
ER, Kolkata	150	0	4	897.5
NER, Guwahati	8	0	5	577.3
SER, Bhubaneswar	60	0	5	789
SR, Hyderabad	360	0.18	12	646
SWR, Bangalore	150	0	2	673
SECR, Chennai	101	0	11	2066
KR, Thiruvanantha puram	54	0	0	0
NHR, Dharamshala	0	0	0	0
UR, Uttarakhand	53	0	2	280
TOTAL	**1671**	**14.52**	**108**	**16451.3**

*Magnetic profiles to a total length of 10 line km were covered in MER, Patna.

9.3 NWHR, JAMMU & KASHMIR

9.3.1 Surface Geophysical Studies:

A total of 54 VES and 11 Resistivity Profiles totalling to a length of 1.14 have been carried out in the parts of J&K State.

9.3.2 Summarized findings of the resistivty surveys:

- The resistivity surveys at Hanjan and Manchoo (Anantnag) sites were conducted with an objective of delineating the depth & thickness of boulder bed to ascertain the type of rig to be deployed for drilling, besides determining the distribution of ground water potential zone/s, both laterally and horizontally, if any. Two VES at Hanjan with maximum current electrode separation (AB) of 200 m and four VES with maximum current electrode separation (AB) of 170 m at Manchoo site were only possible, due to the spread constraint. At Hanjan site the resistivity of the 1st layer varies from 49 to 60 Ohm-m with thickness of 0.64 m, representing moist top soil layer. Resistivity of the 2nd layer is of the order of 18 Ohm-m and thickness varies between 2.43 m to 0.62 m indicating clay. In both of the VES, at the depth range of 18.4 m to 20 m, there is high resistivity

value in the background of clay, indicating boulder, gravel bed. The thickness of this boulder layer is 28.5 m, in VES 1 interpretation. Similarly the last layer in all of the four VES, at Manchoo site, the resistivity value is very high in the range of 1560 to 2800 Ohm-m, representing boulder bed at the depth range of 14.4 m to 20.24 m. In VES 4, this high resistive last layer is interpreted in the depth range of 30.82 m, indicating the boulder bed. On the analysis of pseudo cross-section, it is clearly evident that the boulder bed (high resistivity value zone) is in the depth range of 20 m in the playground and at 30 m near the graveyard and road. Seeing the boulder bed at shallow depth, with thickness in the range of 28.5 m (Hanjan site), the Percussion rig was recommended for exploratory drilling.

The resistivity surveys in Kargil District were conducted at Kaksar Army Unit, 821 (Ind) TP ASC (MA Mule) Unit and TCP, Kargil. (Fig. 9.1) The VES curves obtained in the area were mostly of AHQ, HQ, A or AH type. The resistivity values of the sub-surface geo-electrical layers ranges from 23.5 Ohm-m to 6900 Ohm-m. The low resistivity value corresponds to clay formation whereas the high resistivity value represents hard compact massive formation. The

resistivity values in the range of 150 Ohm-m to 500 Ohm-m, indicates the ground water feasible zone, fractured / weathered, depending upon its position from clay / hard massive layer. At these sites besides selecting and pinpointing the site for ground water exploration, sites feasible for snow harvesting / snow melt conservation were also selected. The study of environmental and physiographical parameters were made for the viability to harness the non-depleting, environmental friendly, absolutely clean renewable sources – Solar and Wind – which are plentiful in this area. To adopt these natural resources initial investigation was done for their suitability, controlling factors, design parameters etc. and the data collection and analysis was done for the same. By adopting these renewable resources, fragile environmental and ecosystem of Kargil area, as well as lot of money, can be saved. The pilot project was recommended to be taken up to install Wind - Solar Hybrid Power-Generating units on small scale in this suitable area, as small-scale power generating systems are more efficient and cost effective.

Fig. 9.1: Resistivity surveys in Kargil District were conducted at Kaksar Army Unit

- One VES each was conducted at Nishat and Shalimar Gardens (Srinagar) with the maximum current electrode separation (AB) of 140 m and 52 m respectively, due to the field constraints. The interpretation of Nishat's VES revealed seven sub-surface geo-electrical layers upto the interpreted depth range of 28.75 m bgl with resistivity value of 90 Ohm-m which can be inferred as the sand mixed gravel formation. Seeing the continuous decreasing trend in the last segment of VES curve, it is inferred that subsurface formation is unconsolidated, so Rotary Rig was recommended for deployment.

- During the drilling operations at Sunail (Akhnoor, Jammu) site, the clay horizon at the depth of 52.80 m bgl was not getting drilled through due to its hardness. To ascertain its thickness and ground water potential zone/s below it, the resistivity survey was conducted. A total of 3 VES were conducted to delineate the thickness of clay horizon in depth range of 53 m bgl with maximum current electrode separation (AB) ranging from 200 m to 400 m. The resistivity sounding curves obtained in the area were of QH and KH type. The interpretation showed that the clay layer is only upto the depth of 55 m bgl and below it is sand, gravel mixed boulder layer, with the possibility of encountering the ground water potential zone at 70 m bgl. On the geophysical survey recommendations, the drilling was again resumed and the clay layer ended at 55 m bgl and ground water potential zone encountered at 69 m bgl, which corroborated with the geophysical results both in terms of clay thickness and depth to ground water potential zone.

- A total of fourteen VES were conducted at 52 Bn. BSF, Sunderbani (Rajouri) with the maximum current electrode separation (AB) ranging from 80 m to 320 m. The resistivity sounding curves obtained in the area were multi-layered in nature and represent Q, K, AH and QK type curves. The interpretation of the VES indicates four to nine sub-stratum geo-electrical layers. The true resistivity value ranges from 1.1 Ohm-m to 210 Ohm-m. The main finding of this integrated investigation was the ground water feasible zone at VES 1, 2, 5, 7 & 8 in the depth range of 50 – 55, 60 – 65, 90 & 100 m bgl. These VES points are suitable for drilling borehole/s with the possibility of encountering ground water feasible zones in the given depth with DTH odex drilling. The nature of formation of these ground water feasible zones is such that they may not give high yielding boreholes. Dug wells were also recommended for construction to augment the water source. The dug well may be constructed to the depth of 10 to 15 m bgl with diameter in the range of 3 to 5 m. A rainwater harvesting structure was also recommended to collect the rainwater from the roof top of main store, quarter guard, q/store, officer's mess and office buildings which can be channelized and collected in the storage tank. A check dam was also recommended which can be made by excavating the nala till hard base is found and dam be constructed to the height of ground level, with provision of spillway. The distribution pipeline from BSF's dug well in the

Sunderbani town to BSF campus may be repaired / renovated to avoid leakage and distribution losses.

- A total of two VES were conducted near the exploratory well at Central Institute of tropical Horticulture (CITH), Rangreth (Srinagar) (Fig. 9.2) with the maximum current electrode separation (AB) of 380 m. The resistivity survey was conducted to assign the resistivity values for differentlitho- units, delineate the ground water potential granular zone/s with their depths and thickness and corroboration of resistivity layer parameters with electrical logging layers. Also, two VES were conducted at Snow & Avalanche Study Establishment (SASE) Rangreth (Srinagar) to pinpoint the site for construction of tubewell under short term water supply investigation and decipher the potential ground water zones.

Fig. 9.2: Conducted VES at Snow & Avalanche Study Establishment (SASE) Rangreth (Srinagar) to pinpoint the site for construction of tubewell under short term water supply investigation

9.3.3 Borehole Logging:

A total of 6 Borehole Electrical loggings were conducted in boreholes drilled in the Jammu and Kashmir State, with total depth logged being 681 **m.** The electrical logging of the bore hole were conducted by measuring the SP, N16" & N64" parameters by deploying the Uptron (EL-600) multichannel logger.

9.4 NWR, CHANDIGARH

9.4.1 Surface geophysical studies with result

During AAP-2009-10, surface geophysical studies were conducted in Punjab and Haryana. In all a total of 156 VES (Vertical Electrical Soundings) were conducted in both the states as part of electrical resistivity surveys. The target set for GP Surveys was 150 VES. Out of 156 VES, 106 Vertical Electrical Soundings were conducted in Haryana and remaining 50 VES were conducted in Punjab. Two short term surface geophysical investigations in Haryana were also carried out as part of assigned work.

9.4.2 Resistivity Surveys

(A) Resistivity Surveys in Haryana

Resistivity Surveys along Yamuna Flood Plains of Haryana: The Yamuna Flood Plains along Sonepat, Panipat, Karnal and Faridabad in Haryana is partly affected with the problem of ground water salinity. The area studied forms eastern part of the state and mainly drained by the Rivers Yamuna and Markanda. It forms a part of Indo-Gangetic alluvial plain.

The objective of the studies was to infer the shallow unsaturated horizon to assess feasibility of artificial recharge to ground water, extent of fresh and saline water interface and observe the lateral and vertical variation in quality of groundwater.

A total of 56 Schlumberger vertical electrical soundings were conducted with current electrode separation varying between 200 and 1000 m in general covering approximately an area of 450 sq.Km. The instrument used was CRM 500 Aquameter. The study of the resistivity data indicates groundwater is saline over a few pockets in study area and several geo-electrical layers with moderate thickness thickness are suitable to re-tap the excess water of Yamuna river particularly during flood seasons. The findings in respect of parts of every district lying along Yamunas flood plains in Haryana covered by geophysical surveys are described as follows:

Yamuna Nagar: In Yamuna Nagar district, the maximum value of Interpreted resistivity value observed is of the order of 5000 Ohm meter representing unsaturated layer comprising of sand with boulders.The high values of Interpreted resistivity values are observed at shallow depth in the Northern part of the district. The values of interpreted resistivity values go on decreasing from Northern to Southern part of the district indicating the change in subsurface geology from boulders to coarse sand with gravels and sandstones. The minimum value of true resistivity observed is in the form of last layer which is 105 Ohm m representing coarse sand. The interpreted resistivity of the second layer is with in the range of 150 to 400 Ohm m represening unsaturated layer in the depth range of 2 to 12 meters of thickness. This layer is highly

permeable and comprising of sand with gravels. This layer is followed by third layer having true resistivity of the order of 100 to 200 Ohm m representing saturated layer with fresh ground water and comprising of coarse sand with gravels in general. The thickness of this layer is with in the range of 15 to 60 meters of depth. The thickness of fourth layer is not known being the last layer. The high values of resistivity of the top layer are due to the dryness and high degree of compactness.

Karnal: The district is located in the northern part of the state. In general the maximum resistivity value observed is within the range of 500 to 700 Ohm m represents dry layer comprising of coarse sand with gravel. The thickness of this layer is within the range of 5 to 12 m which is suitable for recharging of ground water with excess water of River Yamuna during monsoon season. This layer is uniformly distributed along the entire section and this layer is present after first top layer. The third layer is having true resistivity in the range of 65 to 225 Ohm m in general. This indicates saturated layer with fresh ground water comprising of coarse sand with gravel. At few places coarse sand is present in the form of third layer. The resistivity of the last and forth layer is in the range of 25 to 50 Ohm m representing finer sediment comprising of fine sand with clay. On the basis of exploration borehole data, thin layers comprising of fine sand with clay could not be inferred as they are thin and due to limitation of resistivity survey techniques.

Panipat: This district is also located in the northern part of the state. The thickness of top layer is within the range of 2 to 4 meters comprising of clay and fine sand. This layer is followed by second layer having interpreted resistivity value in the range of 200 to 750 Ohm m representing the presence dry coarse sand and coarse sand mixed with gravel and the thickness of this layer is 4 to 15 meters in general. This layer is uniformly distributed along the entire section with varying thickness except one or two places. This layer is underlained by third layer having true resistivity within the range of 100 to 200 Ohm m representing saturated layer comprising of sand and gravel. Low value of resistivity of the order 14 Ohm m is obtained at VES no. 36 (Nanhera) representing clay dominating horizon. The resistivity of the fourth layer is within the range of 15 to 25 Ohm m which is indicative of fine sand with clay. The thickness of this layer is unknown as this is a last layer.

Sonipat: This district is situated in the central part of the Haryana state. It is a part of Indo-Gangetic Alluvium Plain.The thickness of the top layer is in the range of 1.5 to 5 meters and the corresponding resistivity values are in the range of 50 to 240 Ohm m. The high value of observed resistivity is due to the compactness of top layer. The resistivity of the second layer is high which is in the range of 500 to 1000 Ohm m is indicative of unsaturated layer comprising of coarse sand along with gravel. The high value of this layer may be because of some lateral inhomogenity. The thickness of this layer is in between 5 to 10 meters. The interpreted resistivity of the third layer is in the range of 100 to 200 Ohm m representing saturated sand along with gravels and Kankar with varying proportion. The resistivity of the last layer is low which indicates the presence of saline water(less then 10 Ohm m) and finer sediments. The thickness of this layer is unknown as this layer is last layer. Low resistivity values, less then 10 Ohm m at few places indicate the presence of saline water.

Faridabad: This district is situated in the south-eastern part of the state adjoining to Delhi and is drained mainly by River Yamuna flowing on its eastern side and divided from the state of UP. The alluvial plain is bound in the east by River Yamuna.The thickness of the top layer is in between 1.5 to 4 m and the corresponding resistivity values are in the range of 20 to 70 Ohm m in general except at one or two places were high resistivity value is present due to high degree of compactness of top layer. This layer mainly comprising of clay along with fine sand. The thickness of layer second layer is about 5 m and its resistivity values are in the range of 100 to 300 Ohm m. This indicates the presence of dry, unsaturated permeable layer comprising of sand with gravel. Low resistivity values are also present at few places which represent the presence of coarse sand only and at these locations, no significant difference is observed due to which dryness of second layer could not be ascertain. The third is thick and its thickness is in the range of 25 to 50 m and moderate resistivity value of 25 to 50 Ohm m represents the presence of coarser sediments. The presence of thin clay dominating horizons in the third layer could not be detected. This layer is underlained by forth layer having resistivity in the range of 10 to 20 Ohm m representing the presence of finer sediments. Low resistivity values which are around 10 to 12 m are also present in forth layer at few places which represents clay dominating horizons. This layer is last layer hence its thickness is unknown.

(ii) Resistivity surveys in Tauru Block, Mewat Distt. (Haryana): This area in the north & northwest of the Mewat distt. Comprises the Tauru block. The area around Tauru suffer depletion in ground water level in the summer season .

To delineate the interface of saline and fresh water and study lateral and vertical variation in quality of ground water the surface geophysical studies were conducted in the entire Tauru block of Haryana during AAP-2009-10. An area of 225 sq.km. (approx.) conducting 36 vertical electrical soundings (VES) using ABEM Terrameter. Major numbers of boreholes drilled were abandoned either due to absence of granular zones with poor discharge or bad quality of ground water / insufficient thickness of granular zones.

The fresh water sediments are represented by the interpreted resistivity above 15 ohm . while less than 15 Ohm m resistivity represents presence clayey / saline water sediments.

Possibility of fresh water at around 100 m depth is expected at Tauru, Chahalka, Sarai, and Kankarka in the Northwest of the district around Touru Block. Below the depth interval of 100 and 200m possibility of encountering hard / consolidated formation/ bedrock or continuation of saline horizon has been inferred. The results of present and previous studies do not support the possibility of sufficient yield of fresh ground water in Tauru block, however,exploratory drilling is recommended at some of the locations in Tauru block, such as Kalbari, Sundh , Tauru town and Sarai, as a reappraisal measure to further examine the actual potentiality of the shallow and deep aquifers.

(B) Resistivity Surveys in Punjab

Resistivity surveys in Aur Block of Nawanshahr district : The studies were targeted to study for delineation of aquifers. A total of 50 Schlumberger shallow vertical electrical soundings were conducted with current electrode separation varying between 200 and 1000 m in general covering approximately an area of 218 sq.Km. The instrument used was ABEM Terraameter. The objective of the study was to study the lateral and vertical variation of aquifer. The study area located in the west of Nawanshahr Ditrict and Geologically it forms a part of Indo-Gangetic alluvial plains is covered by alluvial deposits comprising sands of various grades and clays with varying amount of silt and kankar.

Resistivity against the granular zones bearing fresh quality of ground water was categorized within 200 Ohm m. This zone mainly consists of sand, gravel and kankar and clays etc. Less than 50 ohm.m. resistivity corresponds to the geological formation consisting of clays etc. The top layer comprised of soil and clay has thickness within 30 m in general and resistivity less than 430 Ohm m in general. The layer of fresh water is seen all over the section comprising sand etc. characterized with interpreted resistivities in the range of 38 and 123 ohm m intercalated with thin clay layer having thickness within 10m and resistivity within in the range of 12 and 36 ohm m mainly within the depth of 100m and 150m and 300m and within other different depths intervals.

Considerable thickness of potential saturated has been inferred all over the area specially along the river bed of Satluz River.In order to arrest depletion of water level some preventive measures are to be taken, such as motivation to the users for change in crop pattern and exploit the deeper aquifers. Over exploitation of ground water should stopped.

(C). Short term surface geophysical investigations

Short term surface geophysical investigations were carried out at 2 places in Haryana located in the premises of Defence area, Kalka, Distt. Panchkula and at ITBP campus in Jatusana (Rewari distt.). In total 14 VES were conducted for the short term investigations. No suitable site for construction of tubewells could be recommended due to ground water salinity and suifficient thickness fresh water granular zone was availableat Jatusana. Similarly at Defence area , Kalka no sufficient thickness of saturated granular zone inferred, hence No suitable site for construction of tubewells could be recommended there.

9.4.3 Borehole Logging :

A total number of 28 boreholes were geophysically logged during AAP 2009-10, out of which 10 boreholes are located in Haryana, 4 boreholes in Punjab, 5 boreholes in New Delhi, two in UR Dehra Dun, two in NWHR (J & K), two boreholes in Northern Region and remaining 3 boreholes in WR Rajasthan.

Following are the conclusions in respect of borehole loggings conducted.

District wise details of boreholes logged

1. The overall assessment of all the geophysical logs recorded follow that the sufficient thickness of fresh water granular zones was encountered within the borehole sites logged in the districts of Jalandhar, Hoshiarpur (in Punjab), Mujaffarnagar (U.P.), Bikaner (Rajasthan), Dehra Dun (UttaraKhand) and Yamunanagar (Haryana).

2. Ground water salinity within few granular zones was seen at few boreholes logged in the districts of Fatehabad, Jind, Gurgaon (in Haryana) and Hanumangarh (Rajasthan).
3. Depth to fresh-saline interface is very shallow in Matura district (U.P).
4. The ground water quality is marginal to brackish in Jaisalmer District (Rajasthan), though the conditions of auto-flow occur in this area.

9.4.4 Recommendations to State Governments:

(i) After the analysis of the results of the surface geophysical study in Aur and Tanda Blocks in Punjab it is recommended that balanced use of aquifer should be maintained by the users as well as concerned authorities should be encouraged for deep tubewells rather than shallow ones to avoid the over-exploitation of the shallow aquifers. The excessive over-exploitation of shallow aquifers particularly for paddy crop is recommended to be stopped and proper awareness be propagated to avoid excess irrigation to help arrest alarming depletion of water level in the affected areas.

(ii) On the basis of conclusion drawn on the basis of Resistivity Surveys in Yamuna flood plains of Haryana, it is recommended that the shallow layer beneath the top layer within 20 m depth is suitable (which is dry) to recharge with the excess water of River Yamuna during monsoon seasons by adopting suitable recharge methods.

9.5 WCR, AHMEDABAD

During the AAP 2009-10, geophysical borehole loggings were carried out in 04 boreholes drilled in alluvial area.

9.5.1 Borehole logging

During the field season 2009-10 a total of 04 wells were Electrical logged. Electrical Logging in all the wells were done through outsourcing from GWSSB and GWRDC Ltd, Govt. of Gujrat. Salient feature of logging are given below:

Logging conducted	Aquifer	District	Nos. of Boreholes logged	Total depth of bore holes logged(m)
Conducted by GWSSB & GWRDC, Ltd., Govt. of Gujarat	Alluvium	Ahmedabad	01	200
	Alluvium	Banaskantha	01	200
	Alluvium	Bhavnagar	02	213
	Grand Total		**04**	**613**

9.6 WR, JAIPUR

9.6.1 Surface geophysical studies.

A total of 71 Vertical Electrical Sounding were conducted during the A.A.P. 2009-10, details of which are follows.

District wise details of surface Resistivity surveys

District	Pupose of survey	No. of VES
Nasirabad Cantt.,Ajmer	Short Term Investigation	12
Hingonia Reservoir, Jaipur district	Ground water potential study	38
BSF BPO,Jaisalm & Pokaran	Shrot Term Investigation	21

9.6.1 Summarised findings and results of Resistivity surveys along with resistivity values and selected photographs

(A) Resistivity survey carried out in parts of Jaisalmer district for BSF, Ministry of Home Affairs,Govt. of India

In Thar desert of Western Rajasthan, Jaisalmer is a chronically drought prone district of the Region. There is a serious concern on the availability of rain and potable water in Indo-Pak border area of the District and forcing the people, cattle, Border Security Forces to face the vagaries of dry summer months and severe conditions. The population has to undergo undue hardship and misery for drinking water and mostly engaged in water hauling from 20 to 40 kms distances.

Under these circumstances there is a need to explore the area to combat the acute water shortage problem. With this point of view, Central Ground Water Board has taken up the ground water exploration during FSP 2009-10 in the north eastern part of the Jaisalmer District. The area has inherent groundwater salinity in the upper aquifers and underlain by thick sequence of Quaternary and Tertiary Sediments.

Application of geophysical methods in source finding is made mainly to identify the groundwater targets, their geometry and water quality. Compared to the other geophysical methods the electrical resistivity is commonly used in delineating different subsurface layers both in terms of thickness and resistivity of the layered formations. It helps to assess the groundwater potentiality, to estimate thickness, lateral extent of saturated zones, to delineate resistive granular zones in sedimentary and assess quality of groundwater.

Data Interpretation

Vertical electrical sounding (VES) at 21 locations with Schlumberger configuration were carried out with maximum current electrode separation (AB) ranging from 100m to 500m depending on the availability of space. The values of apparent resistivity were plotted against the half current electrode separation, on double log paper. Preliminary quantitative interpretation of VES curves was attempted by using two and three layers master curves and auxiliary curves of Orellana-Money and Rijkswaerstaat. The data were also processes and interpreted on computer using IPI2WIN and IXID software's.

It is concluded from the resistivity survey that the quality of ground water is deteriorating with depth. In some area fresh water cushion has been developed over impervious formations. The thickness of fresh water cushion below water table is varying from place to place due to hydrogeological conditions. Somewhere this fresh water cushion is ranging between 40to48m except Naurangwala post which is 80 mts. Therefore attempts have been made to locate those points where maximum thickness can be ascertained like sounding no.1,2,4,5,7&8.

Maximum AB/2 in m	Resistivity of Layers in Ohm - m				
	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5
160	601	348	69	4.77	1609
200	497	1449	219	1211	12.1
140	1004	642	225	9.24	-
100	529	253	1.6	-	-
160	373	192	685	68.8	0.031
50	3.52	39.2	6.6	-	-
140	569	346	79	0.06	-
180	2453	128	1.4	1907	-
140	263	7233	386	4.34	8685
160	382	0.384	307	-	-
50	263	0.02	206	-	-
50	0.028	56	175	-	-
60	0.806	1.93	932	-	-
10	0.087	12.8	12.8	-	-
160	4.38	0.020	3809	-	-
250	0.5	1341	1703	-	-
120	0.184	520	1816	-	-
180	*0.289*	*3208*	*3724*	-	-
160	*4.25*	*14.1*	*5559*	-	-
120	*0.626*	*94.8*	*6595*	-	-
120					

Maximum AB/2 in m	Depth to the Layers thickness in m				Remarks
	h_1	h_2	h_3	h_4	
160	3.07	12.6	19.7	44.6	80
200	1.63	1.26	6.92	12.7	48
140	0.6	5.93	25.2	-	31.7
100	1.99	45	-	-	45
160	1.71	1.21	8.52	35.7	47.2
50	0.905	0.257	-	-	1.16
140	2.88	11.0	31.6	-	45.4
180	3.66	20.6	22.6	-	46.9
140	0.5	0.325	15.7	16.5	33.1
160	18.4	13	-	-	31.5
50	0.5	0.07	-	-	-
50	0.5	3.52	-	-	4.02
60	0.5	24.4	-	-	24.4
10	1.09	2.91	-	-	4.0
160	0.5	0.021	-	-	0.521
250	0.5	17.8	-	-	18.3
120	0.5	5.79	-	-	6.29
180	*0.5*	*21.4*	-	-	21.9
160	*0.5*	*0.639*	-	-	1.14
120	*0.6*	*0.826*	-	-	1.33
120					

9.6.2 Borehole logging

The multi - channel electrical and gamma logger of Uptron logger (EL – 600) is available in the region which can measure the Self potential, single point resistance, Resistivity (Short and long normal), 6"- Lateral resistivity and gamma logging parameters.

During A.A.P. 2009-10, 16 boreholes amounting to a cumulative logging depth of 2545 m. were carried out in different parts of Rajasthan State. Well log parameters thus recorded were interpreted to infer formation character and ground water quality and the well assembly was designed accordingly to tap appropriate zones yielding potable formation water.

9.7 NCR, BHOPAL

9.7.1 Surface Geophysical Surveys:

Surface Resistivity surveys have been conducted to study the subsurface hydrogeological conditions. The area of study is underlain by Deccan Traps/Vindhyan Sandstones. For conducting the Resistivity investigation DD4 and SSR – MP1 Resistivity meters have been used. The VES curves have been interpreted through conventional curve matching techniques and modeled with computer software's like 1PI2WIN. The resistivity ranges for different lithounits as deciphered from the survey results are given below:

Sl. No.	Formation	Resistivity in Ω m.
1	Intertrappean beds	< 15
2	Weathered formation	15 – 100
3	Fractured formation	100 - 200
4	Compact rock formation	>200

9.8 CR, NAGPUR

9.8.1 Surface Geophysical Surveys:

Resistivity Surveys:

Electrical resistivity surveys were carried out to delineate potential water bearing zones in the farmers distress areas of Wardha district underground water management studies and also for ground water exploration in Amravati district. Systematic electrical surveys were also carried out to estimate the depth of Gondwana formations in Nagpur district and also for short-term water supply investigations for various Defence establishments located at Pune and Raigarh districts. VES was also carried out for special project study of NBSS & LUP in Gondia district.

District wise details of VES

120 Vertical Electrical Soundings (VES) were conducted in Wardha, Nagpur, Amravati, Pune, Gondia,Mumbai Raigarh districts of Maharashtra.

- Electrical resistivity surveys were carried out to delineate potential water bearing zones in the Farmers' Distress areas of Wardha district. The resistivity of the top soil ranges from 02-130Ωm with thickness of 0.9-3.3m, the resistivity of the highly weathered basalt is 02-130Ωm and have a thickness of 3.5-8m, the resistivity of the fractured basalt with thickness 3.5-8m is 10-35Ωm, resistivity of vesicular basalts with thickness 10-30m ranges between 40-60Ωm, and the resistivity of the massive basalt is >60Ωm.
- Preliminary interpretation of VES in Nagpur district infers that the Gondwana formations extending to more than 100 m depth in and around Patansawangi, Saoner, Brahmanwada and Bopkhara. These are at shallow depths at in and around Dahegaon (40m) and Kelod (15m). The interpreted geoelectric parameters were standardized keeping in view of the local hydrogeology.

Resistivity range (Ωm)	Probable lithology	Thickness (m)
4 - 130 <5	Top soil Clay	0.4-4 1-10
5-50	Sandstones	5-10
50-100	Moderately compact sandstones	10-25
100-500	Compact sandstones	10-25
100-500	Fractured granite gneiss	10-22
>500	Massive granite gneiss	

- VES results at Air Force Station of Sonegaon, Nagpur: The area is occupied by basaltic formations followed by granite gneisses. Based on VES study it is identified that the resistivity of the top soil ranges from 10-100Ωm with thickness 0.3-2.7m, the resistivity of the clay is 5Ωm with thickness 0.3-0.9m, the resistivity of the highly weathered basalt with thickness 1-3.6m is between 8-45Ωm, the resistivity of the fractured basalt ranges between 9-40Ωm with thickness of 15-44m, the resistivity of the vesicular basalt with thickness 10-18m range from 45-80Ωm, and the resistivity of the massive basalt is more than 80Ωm.
- VES results at Training Battalion-I, Pune: The area is underlain by basaltic formations. Based on VES study it is identified that the resistivity of the topsoil is 5-50Ωm with thickness 0.5-3.6m, for clay resistivity ranges from 2-5Ωm with thickness of 0.9-1.2m, the resistivity of the highly weathered basalt is 5-10Ωm and have a thickness of 4-5m, the resistivity of the fractured basalts with thickness ranging from 15.9-19.3m is 13-25Ωm, the resistivity of the vesicular basalt is 40-60Ωm with thickness 4-28m and the resistivity of the massive basalts is more than 60Ωm.
- VES results at IIIrd Infantry Battalion, Anudh, Pune: The area is underlain by basaltic formations. Based on VES study it is identified that the resistivity of top soils ranges from 4.6-7.6Ωm with thickness of 0.9-2.2m, the resistivity of the highly weathered basalt with thickness 3.2-5.2m is 4.5-12Ωm, fractured basalts are having a resistivity range of 12-27Ωm with thickness 2.5-9m, and the resistivity of the massive basalt is more than 75m.
- VES results at NBSS, Gondia infer that the resistivity of the top soil is 13-64Ωm with a thickness of 0.5-3.6m, the resistivity of the clay ranges from 1.3-5.3 Ωm with thickness 0.7-2m, the weathered rocks are of resistivity 10-30 Ωm and thickness0.6-20.8m, the resistivity of the fractured rock ranges from 220-425 Ωm and have a thickness of 18-20m, the clay with thickness 0.7-1.1m have resistivity of 3-5 Ωm, and the resistivity of the massive rock is more than 500 Ωm.
- VES results at Naval Station, Karanja identified the following subsurface lithologies viz: top soil with resistivity 14-42 Ωm and thickness 0.6-1.9m, clay with resistivity 3-5 Ωm and thickness 2-3m, highly weathered basalt with resistivity of 7-10 Ωm and

thickness 3.2-6.7m, fractured basalt having resistivity of the is 27-33 Ωm and thickness 17-18.5m, vesicular basalts yielding resistivity of 42-46 Ωm and thickness 5.2-13.7m and the massive basalt with resistivity more than 70Ωm.

- VES results at Hindustan mills, Mumbai infer that the resistivity of the top soil is 370-4000 Ωm with thickness 0.6-1.05m, weathered rock is having resistivity of 11.45-40 Ωm with thickness 1.7-12m, massive rock with resistivity more than 240 Ωm and the resistivity of the saline water formation identified range from 0.3-3 Ωm below 7.0m.
- The VES results at AIT, Pune show that the resistivity of the topsoil is ranging from 25-90 Ωm with thickness from 0.2-5.5m.The highly weathered or fractured rock resistivity is ranging from 3-30 Ωm with thickness from 6.8-55m. Whereas the resistivity of the basaltic formation dominated by vesicular basalt is ranging from 40-60 Ωm with thickness from 10-12m. The resistivity of massive basalt is >60 Ωm with thickness varying from 7-65m.Two sites for bore well upto 70m depth and one site for dugwell upto 12m depth were recommended.
- The VES results at IOF, Pune show the following subsurface lithologies: topsoil with resistivity 3-70 Ωm and thickness 0.9-2.6m, highly weathered basalt with resistivity 10-15Ωm and thickness 1.7-1.8m thickness, weathered or fractured rock with resistivity 5-50 Ωm and thickness from 9-60m, massive basalts with resistivity >60Ωm and thickness varying from 2-71m. Two sites for borewell upto 70m and 100m depth and one site for dug cum borewell upto 35m depth were recommended.
- Two geophysical loggings were carried out in Amravati district at Arala, and Khirgavan. The quality of groundwater below 40m depth at Arala and below 14m depth at Khirgavan is saline.

9.8.2 Borehole Logging

A total of two boreholes were logged in Buldhana district. These logging were done using the ABEM-SAS-200 Logging unit attached to the ABEM-SAS 300 Resistivity meter. The district-wise details are given below:-

The granular zones inferred from geophysical log at Khirgavan, Amravati district are given below.

Depth range (m)	Thickness (m)	SP (mv)	Long Normal Resistivity (Ohm m)
0-3	3	No data	No data
3-12	9	122-133	4
12-18	6	136	2.7-1.7
30-33	3	149	1.5
35-7	2	147	1.5
49-54	5	160-156	1.4

Table 9.3:Details of Borehole logging

District	Logged	Location	Depth Drilled (mbgl)	Depth Logged(mbgl)	Date of Logging	Parameters Recorded
Bualnd Shahar	01	Jhangira Bad	360	358.00	24.9.09	SP, N16", N64" & Normal Resistivity Logs
Mathura	02	Bhim Bhangar	150.25	148.00	29.09.09	SP, N16", N64" Natural Gamma
Mathura	02	Agriculture Science Center	150.50	150.00	24.5.09	SP, N16", N64" Natural Gamma
Ballia	02	Sohaon	360.00	355	24.04.09	SP, N16", N64" Natural Gamma
Meerut	02	Sakoti Ttanda Merrut	151.00	150.00	23.7.09	SP, N16", N64" Natural Gamma
	01	WalidPur	300	300	June,09	SP, N16", N64 Natural Gamma

The granular zones inferred from geophysical logging at Arala, Amravati district are given below.

Depth range (m)	Thickness (m)	SP (mv)	Long Normal Resistivity (Ohm m)
21-24	3	-116	2.9
24-53	29	-110	3.1
71-74	3	-109	2.4
80-83	3	-105	1.3

The maximum thickness of aquifer is 150 m. At most of the VES points in the surveyed area, a coarse grained sandy layer occurs upto 10 m depth above the aquifer. Such areas appear to be suitable for groundwater recharge. The details of bore hole logging is given in table 9.3.

9.10 ER, KOLKATA

9.10.1 Surface Geophysical studies :

In total 150 VES were conducted in parts of Murshidabad and Birbhum districts. The details of the surveys conducted are given in the below table 9.4.

9.10.2 Bore hole logging

A total of 4 nos. of borehole have been electrically logged in West Bengal. Electrical logging details and findings are given in table 9.5.

Table 9.5: Details of Electrical Logging and Findings

District	No. of borehole electrically logged	Location	Depth drilled (mbgl)	Depth logged (mbgl)	Granular Zones identified mbgl)
Nadia	1	Madhavpur Junior Basic School, Chapra block	331.0	325.0	20.-163
North 24 Parganas	2	Khasbalanda, Haroa block	325.0	64.50	50.0-64.50
		Brahmanandapur Vidya Mandir, Jaffarpur, Basirhat-II block	325.0	205.0	42.0-198.0
	1	Bokunda Free Primary School, Barasat-II block	304.01	303	85-162, 194-232 & 243-282

9.9 NR, LUCKNOW

9.9.1 Surface geophysical studies

Surface Geophysical Surveys:

Electrical resistivity surveys were carried out at Mat block and Nohjhil block, Mathura district for pinpointing water well site and to decipher fresh / saline interface. Threee VES points are considered as containing fresh quality water column thickness varies between 45 to 60 m . Seven electrical resistivity soundings were conducted at Gajrajnagar, Obra, Sonebhadra district. One VES points are recommended for well construction down to 100 mbgl depth.

Surface geo-electrical surveys were conducted on right bank of Gomti river, Mal block, Lucknow district over an area of 5 sq. kms to delineate and define the top layer characteristics for the purpose of artificial recharge.

9.11 MER, PATNA

9.11.1 Surface Geophysical studies

A total of 167 Vertical Electrical Soundings (VES) , 2000 m GRP and 10000 m magnetic profiling have been conducted during the AAP 2009-10.

A. BIHAR

Highlights of the geophysical survey conducted during AAP 2009-10 is disused below

Geophysical survey for pinpointing water well drilling site in Power Grid Corporation complex, Bodh Gaya, Gaya:

On the pursuance of the request from Power Grid Corporation, Bihar, several VES were conducted in different parts of the campus according to hydrogeological suitability. Surveys show that a thick (15-20m) clay layer

occurs below the top soil and behaves as an aquitard. At few places thick sand lenses occurs below the clay layer which forms the potential aquifer. Massive bedrock occurs at 30-35 m below ground level and this is devoid of potential fracture zones. Over all groundwater potential of the area is low. On the basis of sand layer thickness, three sites have been recommended for drilling. A geological section based on VES results in consultation with lithological information collected from local people is presented in figure 9.3 and the results of VES are given in Table 9.6.

Table 9.4:Details of VES completed

District	Location	No. of VES	Studies & Findings		
Murshidabad	Flood Plain Studies of Padma River	50	**Resistivity Range (Ohm-m)**	**Depth (mbgl)**	**Interpretation**
			6.0-112.0	2.2-4.9	Top soil
			8.0-14.0	1.5-12.0 & below 90.0-120.0	Clay
			15.0-25.0	4.0-35.0	Fine to medium sand
			25.0-90.0	40.0-90.0	Medium to coarse sand
	Along the both banks of the River Bhagirathi	50	**Resistivity Range (Ohm-m)**	**Depth (mbgl)**	**Interpretation**
			330.0-2800.0	3.5-4.5	Dry top sand
			35.0-80.0	4.5-75.0	Sand layer
			6.0-8.0	75.0 to deeper depth	Clay
			38.0-50.0	Below 75.0 mbgl (where identified)	Second sand layer
			N.B. Dry and loose sand present above the water table shows very high resistivity values. The resistivity values gradually decrease as it approaches towards the water table. A thick clay layer is present below this sand layer. At few places, the interpreted results indicates the presence of another sand layer below this clay layer.		
Birbhum	Nalhati-I	10	**Resistivity Range (Ohm-m)**	**Depth (mbgl)**	**Interpretation**
			2.0-900.0	1.0-2.0	Top soil
			10.0-V.High	5.0-14.0	Weathered Mantle
			V.High	-	Compact Rock
			Interpreted fracture zones: 15.0-25.0 and 50.0-80.0 mbgl.		
	Rampurhat-I	10	3.0-9.0	1.0-5.0	Clayey Soil
			25.0-V.High	4.0-18.0	Weathered Mantle
			V.High	-	Compact Rock
			Interpreted fracture zones: 40.0-50.0 and 70.0-100.0 mbgl.		
Birbhum	Rampurhat-II	10	**Resistivity Range (Ohm-m)**	**Depth (mbgl)**	**Interpretation**
			3.0-10.0	6.0-18.0	Clayey Soil
			65.0 (Average)	20.0-95.0	Medium to Coarse Sand
			V.High	-	Compact Rock
	Md. Bazar	10	3.0-10.0	1.0-5.0	Clayey Soil
			25.0-V.High	4.0-18.0	Weathered Mantle
			V.High	-	Compact Rock
			Interpreted fracture zones: 20.0-30.0, 60.0-80.0 & 90.0-120.0 mbgl.		
	Suri-I	10	70.0 (Average)	1.2 (Average)	Sandy Soil
			18.0 (Average)	8.8 (Average)	Weathered Mantle
			220.0 (Average)	-	Semi- Compact Rock
			Interpreted fracture zones: 20.0-25.0, 40.0-50.0 & 90.0-150.0 mbgl.		
		150 VES			

From the results the following resistivity ranges are ascribed to different lithological units:

Sl. No.	Lithology	Resistivity range in Ωm.
1	Surface soil	11-19
2	Clay	4-8
3	Fine to medium sand	11-22
4	Granite gneiss (Hard and compact)	Very High

Geophysical survey for pinpointing water well drilling site in CRPF complex, Rajgir Nalanda:

Integrated Geophysical survey was conducted at CRPF complex, Rajgir for pinpointing water well drilling site. Resistivity as well as Magnetic surveys were carried out in this area and were shown in figure 9.4.

i) Magnetic Survey: Magnetic survey was carried out in six profiles having total length 6 km to record the variation of total magnetic field intensity. The two profiles (MP7, MP6), covering entire longitudinal stretch (2 km) of the study area
run parallel to the strike of the hills. Remaining profiles run perpendicular to the strike of the hill,

Table 9.6:Interpreted geoelectrical parameters at Power Grid, Matithani, Bara, Gaya dist.

VES No.	1st Layer		2nd layer		3rd Layer		4th Layer	
	ρ_1 in Ωm	h_1 in m	ρ_2 in Ωm	h_2 in m	ρ_3 in Ωm	h_3 in m	ρ_4 in Ωm	h_4 in m
1	11.0	1.0	6.7	5.5	11.5	13.2	V.H.	-
2	15.5	1.2	6.0	7.8	12.4	10.7	V.H.	-
3	11.3	1.2	5.3	6.2	14.0	13.3	V.H.	-
4	15.7	1.0	6.0	6.8	14.0	11.5	V.H.	-
5	15.3	1.0	4.1	0.4	7.2	12.5	V.H.	-
6	24.0	1.0	5.2	0.7	8.0	12.5	V.H.	-
7	15.2	1.5	6.0	3.0	14.0	11.2	V.H.	-
8	13.7	1.2	6.5	11.7	V.H.	-	-	-
9	15.3	1.2	7.3	11.7	V.H.	-	-	-
10	17.5	1.0	6.6	7.2	13.8	9.0	V.H.	-
11	13.8	1.3	4.8	2.1	8	13.6	V.H.	-
12	18.8	1.4	7.2	8.5	11.4	7.5	277	-
13	11.6	1.0	7.7	6.6	21.8	14.9	V.H.	-

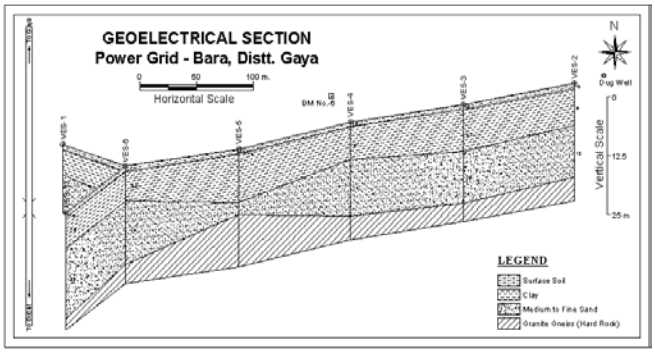


Fig. 9.3 VES results based east-west geological section

each having length of 500 m. These profiles have provided a qualitative estimate of variation of bedrock topography along and perpendicular to the hill strike and variation of thickness of colluviums and the weathered zone within the area.

ii) Electrical Resistivity Survey: Resistivity profiling of 1000 line m. using Gradient array and 22 Vertical Electrical Sounding (VES) were carried out at sites selected through resistivity profiling or considering hydrogeological suitability to investigate vertical resistivity profile down the depth using conventional Schlumberger configuration. The locations of the VES and the profiles lines are shown in Fig. 2. The field data was interpreted in terms of layer

parameters viz. layer thickness and layer resistivity. Keeping the local geology in view the following resistivity ranges were assigned to different litho units, to facilitate recommendations of the sites for future drilling.

Resistivity ranges of different lithological units in CRPF Campus, Rajgir, Nalanda district.

Sl. No.	Lithology	Resistivity range in Ω m
1	Top soil/Surface soil	7-56
2	Clay	4-15
3	Weathered Granite	15-80
4	Semi weathered /fractured Granite	80-250
5	Massive Granite	>300

Groundwater pollution (Fluoride) study at Khaira, Muger district, Bihar:

A total of 22 VES were conducted with Schlumberger array along two traverses one in N-S direction covering a length of 2 km and other one in E-W direction, with aim of evaluating sub surface hydrogeological sequence within the study area and to demarcate fluoride safe aquifer zone.

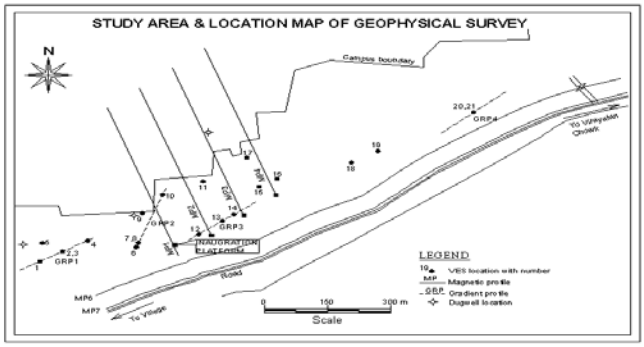


Fig. 9.4 (Map showing the locations of VES and Gradient profiles in CRPF Training Campus, Rajgir, Nalanda district.

Following conclusions are drawn based on the study:

i. The fluoride concentration in groundwater in the study area is strongly influenced by its interaction with hydrogeologic condition such as lithology, flow path and residence time. This study also confirms that at Khaira village, in general, fluoride concentration in groundwater is above the upper limit proposed by WHO for human consumption.

ii. A coarse sand bed is present at eastern part of Khaira village, which has maximum thickness at VES-21. This bed forms fluoride safe aquifer. This zone need to be sustained and to be recharged through dug well recharge process. This zone can be exploited through dug well only for catering the need for drinking water.

iii. Sandy clay zone extending up to the average depth of 20-25 m with 10-15m average thickness is fluoride-contaminated aquifer at Khaira village. Tapping this aquifer for drinking water purposes must be avoided.

iv. At Muluktand village, dug wells tapping the top fine sand bed which is fluoride safe and hand pumps tapping the sandy clay zone is relatively safe for drinking water purposes. This sandy clay aquifer is not in hydraulic contact with the sandy clay aquifer at Khaira village; hence it has remained relatively fluoride safe aquifer.

v. Once the fluoride concentration, lithology and resistivity ranges are established the geoelectrical parameters obtained for the VES can be utilized to identify spots/ area with fluoride contamination and fluoride free aquifer.

vi. Fluoride contamination is mainly controlled by the lithological set up of the study area and residence time of groundwater for rock water interaction.

vii. Geophysical surveys were also conducted in Ranchi urban for water shed management study. Report finalization is in the process

viii. Geophysical logging reports deciphering potential aquifer zones separated by aquitards after each logging conducted are submitted to the office.

B. JHARKHAND:

A total of 72 VES were carried out in the year 2009 – 10 for CGWB, SUO, Ranchi. The objective was to pinpoint sites for exploratory wells in Bokaro district and for studies related to delineation of weathered formation for artificial recharge. The details of study are as follows:

Geophysical survey for Ground Water Exploration in Hard Rock areas:

An integrated geophysical survey comprising magnetic, resistivity profiling and resistivity sounding were conducted at Ajadnagar and Mamarkudar villages at Chas, Bokaro. In both places deep fracture zones were not identified through geophysical surveys. However, drilling points were recommended on the basis of

weathered zone thickness. Subsequent drilling confirmed the recommendation of geophysical survey.

a) In Govt. Mahila polytechnic campus, Bokaro 04 VES were carried out after gradient resistivity profiling. The VES no. 2 was recommended for exploratory drilling at the site. The interpreted result reveals that the first layer thickness is 4.5m and resistivity 78 Ohm-m which is surface soil. The second layer is weathered formation having resistivity of 129 Ohm-m and thickness 14m .The third and fourth layers resistivities are very hard and compact. The fracture was deciphered at a depth of148-151m. The drilling has been carried out and the discharge was found 6cm in V notch.
b) 4 VES were carried out in Govt. boys polytechnic campus, Khutri (Bokaro) after gradient resistivity profiling. The VES no. 3 was found suitable for drilling. The interpreted result reveals the four-geoelectric layers at this point. The first layer thickness and resistivity is 1.5m and 135 Ohm-m respectively. The second layer thickness is 4.55m and resistivity 61.5 Ohm-m reveals the weathered formation. The third layer resistivity is 205 Ohm-m and thickness 12 m indicates semi weathered formation. The fourth layer is very hard and compact. At this point drilling has been carried out but found very low discharge.
c) Geophysical Investigations in Namkum: - The study area is located in Namkum block of Ranchi district. Vertical Electrical Sounding were carried out along National Highway-33 from Patra Toli to Ladnapri village. A total of 64 VES were conducted in water shed area, Namkum (Ranchi). The interpreted results reveal that four geoelectric layers have been deciphered. The first layer resistivity varies from 80 to 56.5 Ohm-m with thickness of 1 to 6.50m indicating surface soil. The second layer resistivity varies from 50 to 260 Ohm-m and thickness 6.50 to 52m that is highly weathered formation. The third layer resistivity varies from 260 to 3015 Ohm-m and thickness 52 to 87m indicating semi weathered formation. The fourth layer resistivity is very high in all the VES of water shed area indicating hard rock.
d) In Patra Toli area the weathered formation is more than the Sidroul village area. The result reveals a basin like structure in the study area and the bedrock deciphered at depth. In Rampur village and Sarjomdih village the weathered thickness is low compare to the Patra Toli village area. In Ladnapiri village area there is very hard and compact rock.

Loation and depth of the bore holes logged in Bihar.

9.11.2 Borehole logging

District/Location	No. of bore wells logged	Total depth of bore well logged (m)
Teghra, Begusarai	1	227 m bgl
Govt Polytechnic College	1	132 m bgl
Guljarbagh, Patna	1	100 m bgl
B.N.College, Patna	1	165 m bgl
B.V.College, Patna		
Gram Panchayat Bhawan, Begusarai	1	302.5 m bgl

9.12 NER, GUWAHATI

9.12.1 Surface Geophysical studies

Electrical Resistivity method has been employed for carrying out geophysical survey in various parts of Meghalaya and Tripura. A total of 08 Vertical Electrical Soundings (VES) have been conducted adopting the Schlumberger/Half-Schlumberger electrode configurations to know the vertical extension of different litho-units and to delineate the existing potential fractures in hard rocks. All these 08 VES have been taken up under short-term water supply investigation and for pinpointing of exploration sites to facilitate the construction of tube wells for augmentation of drinking water.

In soft rock areas, a sequence of sand and clay with varied thickness has been identified where as in hard rock areas, weathered and fracture zones, semi-compact and compact formations have been identified. All the reports have been finalized and the findings/results are discussed in the next item.

Meghalaya:

A total of 04 No. of VES has been conducted in the campus of **Umroi Military Station,Barapani** with maximum available Current Electrode Separation AB/2 = 150 m. The interpreted result of VES Curve thus generated from raw field data are as follows: -

VES-1: Expected potential fractures at the depth range of 60 to 70 m bgl
VES-2: Existence of potential fractures are expected within the depth range of 90-100 and 100 to 120 m bgl
VES-3: Potential fractures are expected to occur within the depth ranges of 30-35;40-50; & 100-120 m bgl
VES-4: Expected potential fractures within the depth ranges of 90-100 and 100-120 m bgl

Tripura:

A total of 04 nos VES has been conducted in the campus of NEEPCO Gas Turbine Plant with maximum available Current Electrode Separation AB/2= 150 AND 200 m. The interpreted results of VES curve thus generated from the raw field data are as follows :-

VES-1: Expected potential fractures within the depth range of 120-150 and 170-200m bgl.
VES-2: No ground water bearing potential fractures has been identified.
VES-3: Expected potential fractures at the depth range of 100- 120 m bgl.
VES-4: Existence of potential fractures are expected within the depth ranges of 70-80 and 100-120 m bgl.

9.12.2 Bore hole logging with results/findings/ conclusions:

State/UT	District	No. of boreholes logged	Depth drilled (m)	Total depth of boreholes logged (m)
Assam	Dibrugarh	01	200.5	200
	Kamrup	01	90	90
	Morigaon	01	154	110
	Kamrup	01	87.75	87
	Kamrup	01	92.7	90.3

9.13 SR, HYDERABAD

9.13.1 Surface Geophysical studies

During the year 2009-10, a total of 360 Vertical Electrical Soundings (VES) and 0.180 Line km of Resistivity profiling were conducted in parts of Ranga Reddy, East Godavari, West Godavari, Hyderabad and Medak districts. The objectives of these surveys were to assess the weathered zone thickness and to map the depth to bed rock in the Maheswaram Mandal and to supplement the Hydrogeological data for Ground Water modeling studies. In East Godavari district the surveys were aimed to draw the bed rock profile along the Polavaram Left Bank Canal and the impact of the Polavaaram Left Bank Canal on the Ground Water Recharge. The surveys in Medak and Hyderabad districts were mainly for the short term water supply investigations.

Resistivity Surveys:

I. **Ranga Reddy district**: A total of 208 VES were taken. Out of these 188 were carried out in Maheswaram Mandal for ground water modelling studies:
   a. To map the top soil, weathered zone thickness, fracture geometry and depth to bed rock in Fab city and other villages of Maheswaram Mandal, which falls in

      Ravirala watershed area in Maheswaram Mandal of the district. These surveys are mainly aimed to supplement the Hydro geological data in the GW modelling studies.
   b. The rest 20 VES were carried out for short term water supply investigations, in the premises of DRDO, Kanchanbagh and the DRDO's proposed laboratory and residential township in Devathalagutta. These surveys were carried out to suggest suitable sites for tapping the ground water source through boreholes/dug wells

ii. **East Godavari district:** VES (102 Nos.) were taken, out of which (90 VES) were carried out along the Polavaram Left Bank Canal with an objective to map the bed-rock profile and to study the impact on GW recharge along the canal. The rest 12 VES were taken in Rajole area to estimate the depth to the fresh/saline water interface.
iii. **West Godavar district**: VES (19 Nos.) were observed to fill the data gaps of earlier investigations in Bhimavaram area, to identify the palaeo channels in saline water environment.
iv. **Hyderabad district:** VES (6 Nos.) were carried out as part of short term water supply investigation to locate suitable sites for tapping the ground water source through boreholes/dug wells, in the premises of the Administrative Staff College of India, Hyderabad.
v. **Medak district***:* VES (11 Nos.) were carried out in the premises of the Ordinance Factory at Yeddumailaram as short term water supply investigations, to select ground water potential sites for sinking boreholes.
vi. **Mehabubnagar district:** In continuation of earlier investigation in Madaram Water Shed area 14 VES and 0.180 LKM of Gradient resistivity profiling was carried out.

- **Ground Water Modelling studies in Ravirala water shed:**

From the interpreted results of the VES data collected from the Midjil Mandal of Mahaboobnagar district the

following layer parameters are assigned to different litho units. (Granites and Gneisses)

Litho unit	Resistivity range (Ohm m)	Thickness ranges (m)
Weathered zone	15-106	0.6 – 30.0
Fractured zone	110 – 375	5.0 - 40.0

Highly weathered and deep seated fractures were identified along Urukonda- Kalwakurti road in Madharam watershed area. The depth to basement in the area is found to be in the range of 5.0 – 57.0 mbgl. The Misa-la-Masse survey conducted near the Borehole No. 6 of the Urukonda well field indicated the presence of fracture in N60°E – S60°W direction.

- **Coastal aquifer management studies in East Godavari district:**

In continuation of Resistivity surveys taken up in AAP 2008-09 for Coastal Aquifer Management studies in East Godavari district, 12 deep VES with AB up to 700 m were carried out to delineate fresh water pockets in coastal area. Wenner electrode configuration was employed for carrying out these surveys in Razole, Malikipuram, Mamidikuduru and Sakhinetipalli mandals (Parts of toposheets 65H/11, 14, 15). The interpreted results indicate fresh water pockets at 4 sites viz. Chintalapalli, Kadali, Sivakodupalem and Medicherlapalem. The fresh water zone exists at depth varying from 10 -20 m bgl.

- **Resistivity surveys along Polavaram canal in East Godavari district:**

Under Special Studies, Resistivity surveys were carried out along Polavaram Left Bank Canal in East Godavari district to know the litholgical variations (depth-wise) of subsurface formations during AAP 2009 -10. The canal, stretching around 90 km. in this district, starting from Purshottapuram in the west and passing through Tuni in the east (Degree Sheet No. 65 G and K) covers different geologic formations namely gneises, khondalites and sandstones. Initially, about 50 km. stretch was covered by conducting VES using Schlumberger electrode configuration with AB up to 200 m. A total of 90 VES were conducted and the data are being analyzed. Interpreted results show 3 to 4 layer geoelctric substrata. The 1st layer with the resistivity ranging 4 to 290 ohm-m and the thickness ranging 0.4 to 4.4 m represents top soil. Below this, a highly weathered/weathered layer exists with the resistivity varying from 3 to 50 ohm-m and the thickness varying from 1-30 m. This is underlain by semi-weathered/fractured zone with the resistivity ranging from 50 to 240 ohm-m and the thickness varying from 5 to 30 m. This is followed by hard formation of resistivity >300 ohm-m. Data is being processed further by other methods of interpretation. The depth of the basement is varying from 6 to 67 mbgl.

- **Water Supply Investigations:**

The Geophysical Surveys in the farmers' distress areas of Prakasam district indicate that the area is covered with thick overburden followed basement which is devoid of joints and fractures and hence the possibility of occurrence of Ground Water is less and not suitable for constructing ground water structures for larger extraction of ground water. Some sites were identified in the DRDO Township for the Artificial Recharge structures like check dams and percolation tanks.

9.13.2 Borehole logging:

A total of 12 Boreholes were logged in Mahaboob Nagar and East Godavari districts. The SP, 16" & 64" Normal Resistivity and Natural Gamma logs were collected from all these wells. Out of these 12 loggings, 10 borehole loggings were conducted in boreholes drilled by the Panchayat Raj Department, Govt. of Andhra Pradesh in Midjil and Madharam Mandals of Mahaboob Nagar district. These boreholes were logged in connection with the artificial recharge studies in selected watershed. Two wells drilled by CGWB in Mungonda village of Amalapuram Taluk, East Godavari district were logged and the logging reports in terms of different litho units and depth-wise quality of formation waters were deleniated.

The borehole geophysical logging of the boreholes drilled in the Madharam Watershed area indicate that the occurrence of the fractured granite is at varying depths and mostly they occur between the depths 26 to 34 m. The geophysical logs have shown wide range of resistivity values and Natural Gamma radiation Counts (cps) for different litho units. The values are tabulated below:

Litho unit	Resistivity range (Ohm m)	Natural Gamma Radiation (Counts/sec)
Semi weathered/ Fractured Granite	200-5700	250-800
Massive Granite	200-8000	250-800

9.14 SER, BHUBANESWAR

9.14.1 Surface Geophysical Studies:

Resistivity Surveys: Resistivity Surveys comprising of 60 Vertical Electrical Soundings (VES) were conducted with different objectives during AAP 2009-10.

Resistivity Surveys for Ground Water Exploration:

A total of 46 VES were conducted in parts of Cuttack, Sonepur & Sundergarh districts to delineate the nature and depth of different subsurface formations, occurrence and direction of fractures in the hard formations and feasibility for drilling of production bore wells. Based on the VES results twenty sites were recommended for drilling under ground water exploration programme which yielded copious water to meet the drinking water requirement of those areas.

Resistivity Surveys for Fresh / Saline Ground water interface studies:

The complex hydrogeological set up in the coastal tract of Orissa poses a serious problem for ground water management. 14 VES were conducted in Jajpur district to delineate fresh/saline ground water interface and to demarcate areas with fresh water aquifers.

9.14.2 Borehole logging:

The borehole geophysical loggings were conducted in five exploratory borehole of Cuttack district drilled with Direct Rotary Rig in coastal alluvial areas to demarcate the saline/fresh and pervious & non-pervious zones. SP, Short Normal (N16") and Long Normal (N64") resistivity logs were recorded using Uptron Multi-channel Logger. Based on the logging results the productive zones and water quality estimations of the different zones are deciphered for recommending the tube well assembly.

9.15 SWR, BANGALORE

9.15.1 Surface Geophysical

Findings/results of Geophysical survey

Under exploration programme, geophysical surveys were carried out at 150 locations in Chamarajanagar, Belgaum, Gulbarga, Hassan, Chikkballapur and Bangalore Urban districts. The geophysical survey mainly comprising of Vertical Electrical Soundings (VES) was carried out at the hydrogeologically selected sites in order to know the nature of sub-surface such as extent of weathering, fracturing and the quality of ground water and to select comparatively better sites for taking up drilling. VES was conducted by employing Schlumberger electrode configuration up to a maximum spread length (AB/2) of 500 mts. The VES curves were interpreted initially by using two and three layer master curves of Orellana and Mooney (1966) & final interpretation was carried out by using iterative VES interpretation technique with the aid of a personal computer. The details of surveys carried out district wise along with the results are presented below.

Chamarajanagar district:

Kollegala taluk, Chamarajanagar district is situated in the southeastern part of the Karnataka state. The taluk is underlain by granulite formation comprising of Charnockites and granitic gneisss. As part of the exploration programme,geophysical surveys comprising of 58 Vertical Electrical Soundings(VES) were conducted.

The VES curves obtained indicated 3-4 layered geoelectric section in which the last layer is basement. The first layer obtained from the interpreted results was soil whose resistivity was varying in the range 50-90 Ohm.m. with thickness in the range 1.5 - 5 mts. Depending on the resistivity contrast the second and / or third layer resistivity was varying in the range of 25-50 Ohm.m. with thickness in the range of 27 – 35 mts and is considered as highly weathered to weathered formation. Partially weathered to hard formation's resistivity was in the range of 30-300 Ohm.m and thickness in the range of 50-95 mts. The fourth layer was recorded as hard formation with occasional fractures. By considering the interpreted results and existing borewells data 10 sites were recommended for drilling bore wells.

Belgaum district:

In Belgaum taluk VES were conducted at the sites selected through hydrogeological survey. Nine VES were carried out at these sites. The study area is covered by mainly schist granite and Banded Haematite Quartzite formations. The interpreted data has shown 5 layered geoelectric section in which the last layer was massive formation associated with fractures. From the VES results it was inferred, that the first layer was considered as a soil having resistivity range of 66-850 ohm m with the thickness in the range of 1-1.7 m. The second and third layer was characterised by the resistivity in the range of 18 – 900 ohm m which is considered as weathered / semifractured and massive formation in nature. The thickness of this formation is varying in the range of 3.5 to 87 m. The fourth and fifth layer resistivity is very high which is expected as massive formation . By considering qualitative and quantitative interpreted results, 10 sites were recommended for drilling borewells.

Gulbarga district:

A total of 34 (thirty four) VES were carried out in Gulbarga, Aland and Afzalpur taluks of Gulbarga district. The study area is covered by mainly Basaltic formation of Deccan trap with various number of flows along with red bole beds. Ground water occurs in weathered /fractured formation. The VES curves obtained in the district have given to 5 layered geoelectric section.. From the VES results it was inferred that the first layer was considered as a soil having resistivity in the range of 23 -240 ohm m with the thickness in the range of 1 – 3.5 m. The second and third layer was characterised by the resistivity in the range of 7-300 ohm m which is considered as weathered / semi weathered formation in nature. The thickness in this formation is varying in the range of 3.5 to 66 m. The fourth and fifth layer resistivity is very high which is expected as massive formation. By considering the interpreted results and existing borewells data, 4 sites were recommended for drilling bore wells.

Hassan district:

As a part of the ground water exploration programme nine Vertical Electrical Soundings (VES) were conducted in Belur taluk of Hassan district. The VES curves obtained indicated 3-4 layered geoelectric section in which the last layer is basement. The first layer was soil whose resistivity was varying in the range of 5-1050 Ohm.m. with thickness in the range of 1.0-8.5 mts. Depending on the resistivity contrast the second and / or third layer resistivity was varying in the range of 10-160 Ohm.m. with thickness in the range of 4-45.5mts and is considered as highly weathered to weathered formation. Partially weathered to hard formation resistivity was in the range of 90-415 Ohm.m.with thickness in the range of 20-45 mts. The fourth layer was recorded as massive formation.

Chikkaballapur district:

In total 13 VES were conducted in Sidlaghatta taluk, Chikkaballapur district for deep drilling. The area is underlain by the granites, schists and peninsular gneissic complex of Pre-cambrian to Archaean age. The interpreted results at the recommended sites indicated 4 layered geo electric sections in which the last layer is massive formation.

The first layer was soil whose resistivity was varying in the range 20-140 Ohm.m. with thickness in the range of 0.5-3 mts. Depending on the resistrivity contrast the second and / or third layer resistivity was varying in the range of 10-55 Ohm.m. with thickness in the range of 2 – 26.25mts and is considered as highly weathered to weathered formation. The partially weathered to hard formation resistivity was in the range of 100-335 Ohm.m. with thickness in the range of 29.75 - 110mts. The fourth layer was recorded as massive formation. By considering the interpreted results and existing bore wells data, 5 sites were recommended for drilling bore wells.

Bangalore Urban District:

Bangalore south taluk of Bangalore Urban district is situated in the southern part of the Karnataka state.Bangalore south taluk is underlain by the granites, schists and peninsular gneissic complex of Precambrian to Archaean age.A total of 9 VES were conducted in Bangalore south taluk, Bangalore Urban district for short-term water supply investigation in the campus of CRPF. The interpreted results at the recommended sites indicated 4 layered geo electric sections in which the last layer is massive formation.

The first layer was soil whose resistivity was varying in the range 22-140 Ohm.m. with thickness in the range of 0.5-3 mts. Depending on the resistrivity contrast the second and / or third layer resistivity was varying in the range of 9-55 Ohm.m. with thickness in the range of 2 – 26.25mts and is considered as highly weathered to weathered formation. The partially weathered to hard formation resistivity was in the range of 97-335 Ohm.m. with thickness in the range of 29.75 - 110mts. The fourth layer was recorded as massive formation with fractures. By considering the interpreted results and existing bore wells data 5 sites were recommended for drilling bore wells.

Special Studies:

Geophysical survey was carried out in Doddaballapur taluk of Bangalore rural district. VES profiling was carried out along two stream courses where 4 check dams were proposed.VES profiling was carried out in NW-SE directions to decipher the subsurface hydrogelogical disposition. The area is underlain by granite gneiss.Interpretataion of VES data indicated 3-4 layered geo electric section with H-type of VES curves. First layer is top soil with a resistivity range of 25- 200 ohm.m and thickness in the range of 0.5-2.0m. Second layer having resistivity range of 10-40ohm.m & thickness range of 4.5 –43m, may be attributed to highly weathered to weathered formation. Third layer is semi weathered to hard formation with Shallow fractures with a resistivity range of 30-90 ohm.m in the thickness range of 37-54m in the second profile. In the first profile, third layer with 50 ohm.m to very high resitvity indicated fractured to massive formation towards north of the profile up to a

depth of 155m (Existing borwewell). Fourth layer is massive with resistivity above 290ohm.m in both profiles. Thus, geophysical survey depicted depth of overburden in the range of 12-46m along first profile and 4.5-30m along second profile. Fractures are well demarcated in the second profile and basement is shallow towards downstream of the nalla.

9.15.2 Borehole Logging :

Sl. No.	Location District	Taluk	Parameters measured	Depth logged
i	Chikkaballapur	Chintamani	SP, N16 & 64''	346 mts.
ii	Chikkaballapur	Chintamani	SP, N16 & 64''	327 mts

9.16 SECR, CHENNAI

9.16.1 Surface Geophysical studies

During the AAP 2009-10, the Surface geophysical target was 100 Vertical Electrical Soundings (VES) in different heads of studies. 101 VES were conducted in locations selected on the basis of hydrogeological studies using Schlumberger configuration with maximum current electrode separation of 60 to150 m. The primary objective is quantification of geoelectrical parameters viz. resistivity and thickness of subsurface geological formations including weathered layer, depth to bedrock and selecting suitable exploratory sites. Resistivity Surveys are also conducted for Pollution studies in Landfill sites of Pallikaranai area.

A) Special Geophysical Studies:

- A total of 83 (VES) Vertical Electrical Soundings were conducted in landfill site in Pallikaranai-Chennai Sub-urban area. The Schlumberger configuration with maximum current electrode separation of 60m was employed. The thickness of weathered zone and the subsurface geological formations were deciphered.

In the landfill areas, the leachate accumulates at the bottom of the landfill and percolates through the soil. Areas near landfills have a greater possibility of ground water contamination because of the potential pollution source of leachate originating from the nearby site. Solid wastes are being dumped on the land without adopting any acceptable sanitary land filling practices. Leachate from a solid waste disposal site is generally found to contain high concentration of major elements like Calcium, Magnesium, Potassium, Nitrogen, Ammonia, Sulphates and trace elements like iron copper, manganese, chromium etc.

The objectives of the present studies are to determine

- the thickness of weathered zone in terms of resistivity values of various shallow subsurface geological formations in the area and tracing of movement of pollutants.
- the integrity (spatial distribution) of ground water pollution around a Municipal solid waste disposal site in Pallikarini and its adjacent area.
- the lateral extent of contamination from the landfill site.

Vertical Electrical Soundings (VES) were carried out in the study area by employing Schlumberger four electrode configuration with spread lengths AB/2=50m and a total of 80 VES were conducted in an area of 200 Sq. km in and around Pallikarini dump site where ever open place is available. The data analysis had been done both manually (graphically) and through computer software package. Based on the interpreted results the following resistivity ranges were assigned to various litho units in the area.

Resistivity range (in Ω m)	Lithology
1 - 300	Top soil
1 - 5	Sand with saline water
5 - 10	Clay
10 - 20	Sandy clay
20 - 100	Highly Weathered formation
100- 300	Semi weathered formation

- VES were also carried out for Short-Term water supply investigation in Air Force Station, Tambaram, NTTTR, Taramani and Palmgrove Ecological park Chennai to identify most feasible sites for production well.

9.16.2 Borehole Logging

Electrical well logging at 11 locations (2066 m. depth) were conducted to find out fresh water granular zones in Ariyalur, Cuddalore and Thiruvallur district, Tamil Nadu. Electrical logging was carried out by deploying indigenous UPTRON logging unit for recording the geoelectric parameters viz. Spontaneous potential, Point Resistance and Normal / Lateral Resistivity in mud filled mud filled boreholes. Critical analysis of E-logs in Conjunction with drill time log and lithologs, facilitated in identification of subsurface geological formation groups, delineation of zones comprising granular / finer sediment formations and approximate assessment of quality of interstitial waters at depths. Logging played a vital role in deciding effective well assembly recommendations.

9.17 KR, TRIVENDRUM

9.17.1 Surface Geophysical studies

In Palakkad, Thrissur and Pathanamthitta districts a total of 54 Vertical Electrical Soundings (VES) were carried out in order to know the subsurface conditions such as variation of soil layer, extent of weathering and fracturing etc and to recommend sites for ground water exploration. The surveys were conducted by employing Schlumberger electrode configuration up to a maximum spread length of (AB/2) of 180 m. The obtained VES data was interpreted by both manually and using computer software.

I. In Palakkad district, a total of 14 sites covering 6 villages were investigated by conducting 15 VES. The interpreted results have given rise to 3 to 4 layered geoelectric sections. At about 8 sites the last layer was recorded as massive formation and at the remaining sites the last layer was extending with depth.

The first layer resistivity was varying in the range of 60-1300 ohm.m which is top soil with thickness in the range of 0.8-4 m. The second layer resistivity was varying in the range of 45-550 ohm m which was considered as weathered to partially weathered hornblende biotite gneiss formation. The thickness of this formation is varying in the range of 3.7-21 m. At one site this layer recorded resistivity of 2000 ohm m which was considered as very hard formation. The third layer resistivity was varying in the range of 250-820 ohm.m and was considered as hard hornblende biotite gneiss formation with fractures at some of the sites. The thickness of this formation was estimated at 7 sites only which was in the range of 10.5-38 m. At two sites the fourth layer resistivity was recorded as 680 and 1500 ohm m with thickness of 10.5 m and 16 m respectively and was considered as hard formation. The formation with resistivity in the range of 250-700 ohm m was considered as fractured formation. The interpreted results of the sounding curves were tabulated and presented in below table.

Sl. No.	Formation	Resistivity in Ω m.	Thickness in m.
1	Top soil	30-3000	0.8-6
2	Weathered hornblende /biotite gneiss	17-185	2.6-24
3	Partially weathered hornblende /biotite gneiss	140-190	8-33
4	Fractured hornblende /biotite gneiss	120-800	>10.5
5	Massive hornblende /biotite gneiss	120-2000	>10.5

By considering the type of VES curves, resistivity and thickness of weathered and fractured formations, 4 no. of sites were recommended for drilling. The exploratory drilling carried out at these sites confirmed the survey results and the discharges are in the range of 1-15 lps.

II. In Thrissur district, a total of 25 VES were carried out covering 20 sites in 10 villages. The first layer resistivity was varying in the range of 30-1300 ohm.m which is soil with thickness in the range of 1-6 m. The second layer resistivity was varying in the range of 17-280 ohm m which was considered as weathered to partially weathered and fractured hornblende biotite gneiss formation. The thickness of this formation is varying in the range of 3.7-21 m. At few sites this layer resistivity was varying in the range of 675-900 ohm.m which was considered as hard biotite gneiss/schist formation. The thickness of this formation was varying in the range of 2.6-24 m. The third layer resistivity was varying in the range of 120-1200 ohm m which is partially fractured to hard formation with fractures at some sites in hard formation. At nine sites this formation thickness was in the range of 30-42 m and at the remaining sites it was extending with depth. At three sites the fourth layer resistivity was varying in the range of 380-750 ohm m which is hard formation and is expected to be fractured at two sites. The formation with resistivity in the range of 110-800 ohm m was considered as fractured formation.

The interpreted results of the sounding curves were tabulated and presented in table below-

Sl. No.	Formation	Resistivity in Ω m.	Thickness in m.
1	Top soil	750-2300	2-4.5
2	Weathered Khondalite	75-110	18-22
3	Massive Khondalite	250-550	5-25
4	Fractured Khondalite	250	25 and above

In total 8 sites were recommended for drilling in this district. The exploratory drilling carried out at four no. of sites confirmed the survey results and the discharges are in the range of 6-18 lps.

III. In Pathanamthitta district a total of 14 VES were carried out covering 13 sites in 7 villages. The interpreted results have given rise to two to four layered geoelectric section in which the last layer was extending with depth. The study area is underlain by Khondalite/leptinite, hornblende biotite gneiss and Charnockite gneiss.

The interpreted results indicated that the first layer resistivity was varying in the range of 650-9000 ohm m which is top soil. The higher order of resistivities indicates lateritic nature of soil. The thickness of this layer is varying in the range of 1.5-5 m. The second layer resistivity was varying in the range of 75-1400 ohm m. In this range also lower order of resistivities up to 110 ohm m indicates weathered nature of formation where as higher order of resistivities indicates partially weathered to hard Khondalite/Charnockite gneiss formation. The thickness of this formation is varying in the range of 5-23 m except at one site where it was 62 m. The third layer resistivity was varying in the range of 130-800 ohm.m which is hard Khondalite/Charnockite gneiss formation with fractures at some sites. In this range the formation with resistivity in the range of 130-340 ohm m was considered as fractured formation and was recorded at 6 (six) sites. The thickness of this formation is varying in the range of 21-86 m.

The interpreted results of the sounding curves are given below .

Sl. No.	Formation	Resistivity in Ω m.	Thickness in m.
1	Top soil	650-9000	1.5-5
2	Partially weathered Charnokite gneiss	130-250	19-62
3	Fractured Charnokite gniess	130-800	>21
4	Massive charnokite gniess	130-340	>21

Based on the survey results one bore well was drilled and the discharge was 5 lps.

9.18 UR, DEHRADUN

9.18.1 Surface Geophysical studies

A total of 53 Vertical Electric Sounding (VES) were carried out in parts of Dehradun, Pithorgarh, Champawat and Nainital districts of Uttarakhand against target of 50. The resistivity meter (Model SSR-MP-1) make IGIS, Hyderabad was used for carrying out Vertical Electrical Soundings (VES). Investigations in Dehradun district was carried out for Central Soil and Water Conservation research & Training Institute, Selaqui Farm, Dehradun.

Based on the geophysical studies two sites were found to be feasible for artificial recharge studies. At one site in the premise of Water Shed Management Directorate at Indira Nagar, Dehradun, an injection well to depth of 50 m bgl was suggested for artificial recharge to ground water. At another site near the school at village Chudiala in Haridwar district artificial recharge to ground water was suggested through the available pond by excavating it to a depth of 2 m bgl for removing the surface silt deposited in the pond.

9.18.2 Borehole logging

Geophysical loggings of 2 exploratory wells were carried out using Multichannel Uptron Logger. The parameters SP, N64", N16", 6' Lateral and Natural Gamma Ray were recorded during the borehole logging. At Doctor Ganj, Dehradun district six potential zones were identified and subsequently well assembly was recommended. At Industrial Park, Haridwar four granular zones were deciphered up to a depth of 126.0 m bgl.

The geophysical Logging of the exploratory well reveals the following granular zones in the depth ranges of 34 – 37, 44 – 53, 60 – 64, 76 – 80, 88 – 96, and 109 – 113 and 130 – 138 m bgl. The value of apparent resistivity in the range of 90 – 270 Ohm-m was recorded against the granular zones indicating thereby the presence of subsurface formation comprising of coarse sand, gravels, pebbles, cobbles and boulders. Accordingly the well assembly was recommended by the combined analysis of Litholog and Geophysical Logs

9.19 NCCR, RAIPUR

9.19.1 Surface Geophysical Studies

A total of 102 Nos. Vertical Electrical sounding (VES) and 2 Nos. (0.20 line kms) Gradient Resistivity Profiling (GRP) were carried out during the year 2009-2010 against the target of 100 VES.

Surface resistivity investigations have been conducted to unravel the subsurface hydrogeological condition in different parts of Durg, Dhamtari , Korba and Surguja district in Chhattisgarh to support the groundwater exploration and ground water management studies. For conducting the resistivity investigation CRM-500 and TRSM-A D.C. Resistivity meter have been used. To achieve the objectives a total of 102 Vertical Electrical Sounding (VES) and 0.20 line-km Gradient Resistivity Profiling (GRP) have been carried out. Most of the VES curves have been interpreted through conventional curve matching techniques and finally modeled with

computer software like SCHLUM and IPI2WIN. The GRP data have been interpreted qualitatively in terms of resistivity `low' with respect to the background resistivity. The Microsoft EXCEL software has also been used for plotting VES and GRP data.

Durg district:

To assist the groundwater exploration program geophysical studies have been conducted in parts of Durg district for pinpointing of drilling sites. In this regard 37 Vertical Electrical Sounding (VES) have been conducted at different locations in parts of Durg district. The VES data have been processed and analyzed. The interpretation of VES data indicated that the weathered zone thickness varies from very shallow to 10 m bgl. Shallow as well as deeper fractures have also been indicated in the limestone & Gunderdehi shale formations. The depth of fracturing in the area varies from 15 to 55m bgl.

Korba district:

In connection with Ground water management studies a total of 43 Vertical Electrical Sounding (VES) were conducted in Korba district. To study the prevailing subsurface hydrogeological conditions beneath the area, the VESs were carried out in different geological formation like Sandstone, Shale, Granite, Gneisses and Recent alluvium. The VES data have been processed and analyzed. The interpretation of VES data indicated that the weathered thickness varies from very shallow to 15 m bgl. Shallow as well as deeper fractures were also identified in the Granite & Gneiss formations. The depth of Fracturing in the area varies from 20 to 75m bgl. The resistivity values range from 50 to 70 Ohm-m for recent Alluvium, 180 to 230 Ohm-m for Sandstone and 10 to 25 Ohm-m for Shale. The resistivity values of coal seams are very high.

Dhamtari district:

As a part of groundwater exploration programme in Dhamtari district, 10 Vertical Electrical Soundings were carried out in alluvium formation of this district. It is found that the surface resistivity method could help in deciphering the overburden/alluvium thicknesses at observed VES locations.

Sarguja district:

12 Vertical electrical soundings (VES) carried out in Sarguja district to pinpoint the exploratory borehole locations. The investigations conducted in the district have given very encouraging results. Some of the boreholes like Bilaspur and Chirenga drilled on positive geophysical anomaly in grainitic terrain have yielded very high discharge of groundwater.

10. HYDROCHEMICAL STUDIES

Central Ground Water Board has 16 Regional Chemical Laboratories to carry out chemical analysis of major and minor inorganic constituents in water samples. All the Chemical Laboratories are well equipped to carry out Basic analysis & Heavy and Toxic elements determinations using sophisticated instruments like Atomic Absorption Spectrophtometer (AAS), Digital PC based Spectrophotometer, Ion meter, Flame Photometer, ph meter, Conductivity meter, and Nephelometer. The laboratories are also provided with Electronic Monopan and Top loading Balances, Deionizer, Double Distillation Plant, Hot Air Oven, Water Bath, Magnetic Stirrer and Hot Plates. Four Regional Laboratories at Kolkata, Hyderabad, Lucknow and Raipur are also equipped with Gas Chromatograph (GC) to undertake the analysis of organic pollutants (Pesticides) at µg/l level. The Chemical Laboratory at Hyderabad is additionally equipped with Inductive Coupled Plasma Spectrometer (ICPS) for sequential analysis of multiple toxic elements with high accuracy. Total Organic Carbon (TOC) analyzer is installed in the Regional Chemical Laboratory at Kolkata. Some of these laboratories are also equipped with instruments and equipment to carry out biological and bacteriological analysis. The chemical data generated by these laboratories is utilized for monitoring and evaluating the groundwater quality in compliance with National Standards for its designated use, to study the impact of anthropogenic activities on ground water quality, to demarcate critical areas where there is water quality deterioration and to assess the point and non-point sources of ground water pollution so as to take necessary action for management of ground water resources.

During 2009-2010, 14176 No.water samples have been analyzed for determination of basic constituents. Analysis of 478 No. water samples for specific studies and analysis of 2484 No. water samples for Heavy metals involving the determination of elements like As, Cd, Co, Cr, Cu Fe, Mn, Ni, Pb and Zn has been carried out. Determination of organic constituents was carried out in 104 No. of water samples. Besides the analytical work, chemists from the various laboratories have participated in mass awareness programmes and trade fairs and have prepared exhibits, posters, handouts diagrams, etc. on water quality, for display. They have demonstrated the testing of various chemical parameters present in water and their impact on human body. The importance of water quality for artificial recharge to ground water through rain water harvesting and impact of chemical quality of the water being used for drinking, agricultural and industrial purposes has also been explained to farmers, visitors and students. The details of water samples analyzed by different Chemical Laboratories during 2009-2010 are tabulated (Table 10.1)

Table 10.1: Region-wise Water Samples Analysis

Regions	Basic Analysis		Specific Analysis		Heavy Metals	
	Samples	Constituents	Samples	Constituents	Samples	Constituents
NWHR	696	9052	449	549	68	476
NWR	1153	14991				
WCR	751	12016	_	_	157	157
WR	1032	16882			74	592
NCR	1379	17927			336	336
NCCR	324	4212			155	155
CR	1067	12652			178	890
NR	928	12312			496	2330
ER	1130	12563			250	250
MER	855	8293			184	552
NER	340	3509			208	208
SER	845	6308				
SR	765	9945			4	4
SWR	489	6358	29	145		
SECR	1335	13687			200	1600
KR	526	6142			55	495
UR*	205	2665			119	846
NHR*	200	2581				
SUO Delhi*	156	2028				
TOTAL	**14176**	**174123**	**478**	**694**	**2484**	**8891**

*Regions don't have their own chemical laboratory, samples analyzed at other Regional chemical laboratories.

Hydrochemical studies carried out in the regions with findings/conclusions:

10.1 North Western Himalayan Region, Jammu

On the basis of chemical data of ground water samples collected from National Hydrograph Stations, Reappraisal Hydrogeological Surveys, GW Exploration, and other Investigations carried out during the AAP 2009-2010, it is observed that the ground water of Jammu province, comprising of Jammu, Kathua, Udhampur and Rajouri districts, is generally fresh having low mineralization value of Electrical conductivity varying from 220 µmhos / cm at 25ºC (Chittiar) to 3420 µmhos / cm at 25ºC (Suchetgarh). Ground water at Barni, Karol, Krishna, Suchetgarh are of calcium bicarbonate type, but at few places it changes to sodium bicarbonate type or mixed type. In Jammu provinces more than 50% of ground water samples are of very hard type.

The concentration of fluoride in ground is generally low (less than 1.0 mg/l) with only two exceptions, one at at Bangular (1.76mg/l) in Jammu, and other at Karol Krishana (1.58 mg/l) Kathua district which is higher than the desirable limit of BIS-2007 for fluoride.

Nitrate concentration in ground water is generally low and ranges from traces to 310 mg/l. Nitrate values more than the permissible limit (45 mg/l) BIS-2007 have been observed at Jandi (265 mg/l) in Kathua district and Gho Brahamna (310 mg/l) in Jammu district.

10.1.1 Heavy metals:

A total 68 nos. of ground water samples were collected from Samba, Ramban, Pulwama district under RHS and analysed for determination of heavy metals by Atomic Absorption Spectrophotometer (AAS). The heavy metals determined Cu, Pb, Zn, Ni, Mn, Cr & Cd and it is found that in ground water samples collected the concentration of heavy metals are within the permissible limits for drinking water (BIS-2007).

10.1.2 Kashmir valley

In Kashmir Valley, concentration of Iron (Fe) is generally less in shallow ground water than in water from deep aquifers. In shallow aquifer it varies from traces to 1.32mg/l (Drugmula). In deeper aquifer it ranges from 0.07mg/l (Sofimohala) to 12.85mg/l (Mamat). It is observed that in majority of the ground water samples iron concentration is higher than maximum permissible limit of 1.0 mg/l..

10.2 North Western Region, Chandigarh

Collaborative Isotopic studies with NIH Roorkee:

Colloaborative Isotopic studies with NIH Roorkee for identifying the source of GW in shallow and deeper aquifers are in progress and these studies are being carried out in Jalandhar, Kapurthala, Ropar, Hosiarpur & Nawanshahr districts of Punjab state. 14 Samples were collected & sent to NIH Roorkee for analysis. (C14;O18 Deuterium and Tritium). Also compiled the basic data of 34 water samples.

10.3 Western Central Region, Ahmedabad

Distribution of different pollution parameters observed during analysis is summarized as under:

Electrical conductivity/ TDS/ Salinity is the major quality parameter, which represents total number of cations and anions present in ground water, indicating ionic mobility of different ions, total dissolved solids and saline nature of water. In general water having EC < 1500 uS/cm, is considered as fresh water, EC 1500 – 15000 uS/cm, is considered as Brackish water and > 15000 uS/cm is considered as saline water. In general EC values are high to very high in the many parts of the state. A total number of 75 samples were having EC > 3200 uS/cm, out of 480 totals number of samples analyzed shows the gravity of salinity problem in the area.

High salinity problem is observed in Northwestern parts of the state to the extent of EC having > 15000 uS/cm, showing brackish water problem at Miani (Surendranagar)and Santhalpur (Patan). Saline nature of water is also eminent in Kumarkhan, Gamph,(Ahmedabad), Bhoombali(Bhavnagar), Shardagram, Bamanwara, Lohej (Junagarh), Oddar (Porbander), Sara (Surendranagar) having EC in the range of 10000 uS/cm- 15000uS/cm. Further EC values ranging between 3200uS/cm –10000uS/cm have been observed in places of the districts Ahmedabad, Amreli, Anand, Banaskantha, Bharuch, Bhavnagar, Dohad, Jamnagar, Junagadh, Kacchh, Khera, Mehsana, Navsari, Patan, Porbander, Rajkot, Sabarkhantha, Surat, Surendranagar, and Vadodara In most other places of rest of the places water is almost fresh with respect to EC and salinity.

Chloride > 1000mg/l, have been found in 56 number of samples out of 480 total number of samples analyzed indicating saline nature of water in most part of the state. Maximum chloride values are observed in western parts of the state to the extent of Chloride having >5000 mg/l, showing high salinity problem at Santhalpur (Patan), Miyani (Surendranagar). Chloride values ranging between 2500 – 5000 mg/l have been found in Kumarkhan & Gamph

(Ahmedabad), Bhumbali (Bhavnagar), Arena, Bamanwara, Khambaliya 1,Shardagram, lohej, Kukaswada, (Junagarh), Motichander (Patan), Bhavpura, Kadegi & Oddar (Porbander),Kherwa, Sara (Surendranagar), Chloride values ranging between 1000–2500mg/l have been found in Bharwala,Dhanduka 1, Mandal 2 (Ahmedabad), Jaferabad, Lotpur, Mandal, (Amreli), Kansari 1 (Anand), Khoda, Amrgarh, Manglore (Banaskantha), Roja Tankariya (Bharuch), Vallabhipur, Bhudel & Ghogha (Bhavnagar), Garbada (Dahod), Armada, Bhatia, Samrasar 1, Verwada (Jamnagar), Khorada 1, Chorwad (Junagarh), Gagodar, Tera, Sukhpar, & Lilpur (Kacchh), Khera, Shekhupura (Khera), Bandupara (Mehsana), Navsari 1 (Navsari), Radhanpur 2(Patan), Kuchadi, Navibander, Kutiyana (Porbander), Ganod & Movaiya (Rajkot), Silwad (Sabarkantha) , Wadoli (Surat), Muli 1,Tametar (Surendranagar), In most of other places chloride problem is not eminent.

Nitrate > 100mg/l, have been found in 77 number of samples out of 480 total number of samples analyzed indicating high nitrate pollution due to use of nitrogen containing fertilizer, domestic and agriculture waste and man made anthropogenic activities. Nitrate value as high as 500 mg/l at Paliyad 2(Bhavnagar) and Santhalpur(Patan).. Further nitrate values have been found in the range of 200mg/l – 500mg/l at Gamph, Dhanduka 1, Rajpara (Ahmedabad), Govadka, Goradka, Mandal, Bagasara (Amreli). Khoda(Banaskantha), Kavi (Bharuch), Bhudel, Ghogha,Porbada,Tansa (Bhavnagar), Ambardi, Bed I, Haryana, Motimatli, Sumana,(Jamnagar), Khokharda(Junagadh),Nemaria (Narmada), Sant Road (Panchmahal),Movaiya, (Rajkot), Bibipur 1, Boral, Ghadavan, Modasa 2, Matoda, Revas, Wadali & Silwada (Sabarkhantha), Kherwa, Vithalgarh (Surat). In addition to above 34 samples, another 43 samples have been found to contain nitrate > 100mg/l which is maximum permissible limit indicating the high intensity of nitrate problem in these areas. Further 95 water samples in the range of 45mg/l-100mg/l representing desirable limit of nitrate content and alternate source of drinking water may be used in High nitrate content area. In most of other places having nitrate < 45mg/l there is no problem with respect to nitrate pollution.

Fluoride >1.5mg/l, which is mainly attributed due to geogenic conditions, have been observed in 33 water samples out of 480 water samples analyzed. Fluoride values to the extent of 11.0mg/l(Kumarkhan, Dhanduka 1), 4.25mg/l(Barvala) Ahmedabad, 3.50mg/l (Kavi, Sarod) Bharuch, 3.0mg/l (Dabhava, Dohad2, Garbara) Dohad, 4.00mg/l (Samrasar 1) Jamnagar, 5.20mg/l (Halwad2, 7.25mg/l(Muli), 5.50mg/l(Miani), 4.50mg/l(Ratanpur) Surendranagar have been observed indicating prominence of fluoride problem in these areas. Apart from above locations another 20 samples at different location have been found to contain fluoride values in the range of 1.5mg/l-3.00mg/l which indicates fluoride problem in patches.

10.4 Western Region, Jaipur

Chemical Quality of Ground Water

For the beneficial use of water its purity is essential otherwise it may affect human health adversely. The quality of water depends on its physical and chemical properties. Physical properties include color, smell, transparency which can be determined by our senses. The chemical properties depend on the nature & quantity of various chemical constituents individually or jointly.

Total dissolved Solids (TDS) –Table- 10.2 shows that 15.74 % of hydrograph stations monitored have TDS value within desirable limit, 57.38 % stations have values within maximum permissible limit and rest 26.89 % stations have TDS value beyond permissible limit of 2000 mg/l. In Barmer ,Churu, and Nagaur districts high TDS values have been observed as more than 50 % stations have high TDS value, while in Jalore, Hanumangarh, Jaisalmer and Jodhpur, Bharatpur districts 30 to 44.44 % of stations have TDS values beyond permissible limit. The minimum value of TDS in the state has been found at Gorawa (Dungarpur) as 72 mg/l and maximum value as 26650 mg/l at Nachna of Jaisalmer district.

Chloride (Cl) -Out of 610 water samples analysed only 12.13 % have chloride value beyond permissible limit of 1000 mg/l and rest 51.64 % and 36.23 % samples have values within desirable and maximum permissible limit (Table –10.2) respectively. In the districts of Barmer (36.59%), Bharatpur (22.22%),Churu (28.0%), Nagaur (24.39%), Jaisalmer (20.83%) stations have chloride value beyond permissible limit of 1000mg/l. In the districts of Alwar, Banswara, Baran, Bikaner, Chittorgarh, Dholpur Dungarpur, Jaipur, Jhunjhunu, Karauli , Sikar, Pratapgarh , Kota, Ganganagar, no station has chloride value beyond permissible limit of 1000 mg/l.The maximum value of chloride in the state as 14960 mg/l has been found at Nachna of Jaisalmer district and minimum value as 11 mg/l has been found at Nathusar of Sikar district.

Sulphate (SO4) - 58.85 % of stations have sulphate value within desirable limit. Only 22.62% stations have sulphate value within maximum permissible limit. Rest 18.52% of stations have Sulphate value beyond permissible limit of 400 mg/l (Table-10.2).In Barmer (53.66%), Churu (60.0%),

Bharatpur (40.74%), Hanumangarh (35.29%) Jaisalmer (31.25%), Nagaur (29.27%) of stations have sulphate value beyound 400 mg/l.In the district of Alwar, Banswara, Bundi, Chittorgarh, Dungarpur, Jaipur, Jalore, Karauli, Pratapgarh, Sirohi and Udaipur no station has sulphate value beyond permissible limit of 400 mg/l. The minimum and maximum values of sulphate in the state are as follows-

Minimum – 1.0 mg/l at Chunawala of Ganganagar district, Maximum – 4500 mg/l at Nachna (Jaisalmer).

Nitrate (NO3) -Pollution of nitrate is a major problem in the state. Barmer, Bhilwara, Chittorgarh, Churu, Dholpur, Jalore, Jhalawar, Nagaur, Sikar districts are much affected with nitrate concentration as 52 to 88% of stations have nitrate values beyond permissible limit Ajmer, Alwar, Baran, Bikaner, Hanumangarh, Jaipur, Jaisalmer, Jhunjhunu, Jodhpur, Sirohi districts are slightly less contaminated (30 to 47 %). Around 56.56% of monitored stations have nitrate values within desirable limit & rest 43.44 % stations have value beyond permissible limit (Table –10.2). The minimum value of nitrate in Rajasthan has been observed as 0.5 mg/l in Rajwas of Bundi district.The maximum value of nitrate as 2300 (mg/l) has been observed at Luna Kalan of Jaisalmer district.

Fluoride (F)-Occurrence of high fluoride in the ground water of Rajasthan is a great concern as 27.70 % of 610 ground water samples collected for chemical analysis contain fluoride value beyond maximum permissible limit of 1.5 mg/l. Around 53.77 and 18.52 % of stations are within desirable and maximum permissible limit respectively (Table – 10.2). The districts of Ajmer, Churu, Jalore are much affected districts with fluoride contamination where more than 50 % of stations have fluoride value greater than 1.5 mg/l. Similarly in Barmer, Bhilwara, Ganganagar, Hanumangarh, Jaisalmer, Nagaur, Sikar and Tonk districts 33 to 48% of stations have fluoride values beyound permissible limit. The districts of Dholpur, Bundi, Dausa, Jhalawar, Baran, Chittorgarh & Pratapgarh appears to be free from fluoride contamination. The minimum value of fluoride in the state has been observed as 0.02 mg/l at Motipura of Bundi district and the maximum value of 12.00 mg/l has been observed at Ratanpura of Churu district.

Total Hardness - Table- 10.2 shows that 53.77% of stations are within desirable limit of 300 mg/ l. Only 17.54 % of stations have value beyond permissible limit of 600 mg/l. Churu, Jhalawar, Barmer, Bharatpur, Hanumangarh, Rajsamand are the much affected districts where 29 to 48% of stations have total hardness value beyond permissible limit. In Alwar, Banswara, Bikaner, Jaipur**,** Jalore, Karauli, Sawaimadhopur districts no sample has total hardness value beyond permissible limit. The minimum value of hardness in the state as 45 mg/l has been found at Gorawa of Dungarpur district & the maximum value has been observed as 4508 mg/ L at Biramsar of Hanumangarh district.

Calcium (Ca) – There is no cause of concern about the calcium hazard as only 3.93 % of stations have calcium values are beyond the permissible limit of 200 mg/l (Table – 10.2). The majority of the districts of the state do not have calcium value beyond permissible limit. Only in Hanumangarh district 24% of monitored stations have high (>200 mg/l) calcium value in the ground water. The minimum value of calcium in the state has been observed as 4.0 mg/l in Bharatpur, Dausa and Sikar district and the maximum value as 710 mg/l has been found at Pipar city (Jodhpur district) .

Magnesium (Mg)-Only 15.08% of stations have magnesium value beyond permissible limit of 100 mg/l & rest are within desirable (33.77%) and maximum permissible limits (51.15%) (Table-10.2). No station in the district of Alwar, Banswara, Bikaner, Dungarpur, Jaipur, Jalore, Jhunjhunu, karauli, Kota, Pali, Pratapgarh & Sawaimadhopur have magnesium value beyond permissible limit. In Barmer, ,Bharatpur, Churu, Dholpur 32 to 48 % of the sample have Mg value beyond permissible limit. The minimum value of Mg as 2.0 mg/l has been found at Mandore and Rohilakalan of Jodhpur district and maximum value as 742 mg/l has been observed at Ratanpur of Churu district.

Iron (Fe) -Out of 610 water samples analysed 24.92 % of samples have iron value beyond the permissible limit of 1.0 mg/l & 54.75% samples are within desirable limit of 0.3 mg/l and rest 20.33% are within maximum permissible limit (0.31to 1.0 mg/l). Iron contamination is mostly observed in southern part of the state which includes the districts of Bhilwara, Bundi, Kota, Udaipur, Chittorgarh, Jhalawar, Baran, Kota, Dungarpur, Rajsamand. In the eastern part, districts of Alwar, Bharatpur, Dausa, Tonk, Jaipur, Ajmer have high concentration of iron in ground water. Similarly in Ganganagar district of northeren Rajasthan iron contamination has been observed. Minimum value of iron in the state as 0.0 mg/l has been observed at various places in Alwar, Bharatpur, Bundi, Barmer, Ganganagar, Hanumangarh, Jalore, Jhalawar, Jodhpur and Nagaur, districts and maximum value of 24.00 mg/l has been observed at Binjbalia of Ganganagar district.

10.5 North Central Region,Bhopal

1715 water samples were analysed. Out of these, 1379 water samples have been analysed for determination of basic constituents. Analysed 336 water samples for heavy

Table 10.2, Percentage distribution of major constituents in Rajasthan.

Sl. No.	Limits	Constituents								
		TDS	Cl	SO4	F	NO3	TH	Ca	Mg	Fe
1	Within desirable	15.74	51.64	58.85	53.77	56.56	53.77	74.43	33.77	54.77
2	Within Max. permissible	57.38	36.23	22.62	18.52	-	28.69	21.64	51.15	20.33
3	Beyond permissible	26.89	12.13	18.52	27.70	43.44	17.54	3.93	15.08	24.92

metals involving the determination of elements like AS,Cd,Cr,Co,Cu,Fe,Ni,Pb,and Zn.

10.6 North Central Chattisgarh Region, Raipur

As per the available facilities in the Regional Chemical Laboratory, 13 parameters like pH, EC, Carbonate, Bicarbonate, Chloride, Total Hardness, Calcium, Magnesium, Sodium and Potassium have been determined. A total of 479 nos of water samples were analyzed during AAP 2009-10 in regional laboratory, out of which 155 samples were analyzed for determination of Iron.

Hydrochemical Studies and Findings

A total 644 nos of water samples were collected during AAP 2009-10 from Hydrographs Networks Stations, District Ground Water Management Studies and Exploration. Out of 644 samples 324 were analyzed for 13 no of parameters and the silent feature of the analysis results are given in the Table 10.3.

Table 10.3 : Concentration of the Major ions in ground water

Sl. No	Constituent	Range in mg/l	
		Min	Max
1	pH	7.2	8.6
2	EC µs/cm at 25° C	50	4350
3	Total hardness	10	1375
4	Calcium	2	328
5	Magnesium	1	135
6	Sodium	1	390
7	Potassium	0.1	120
8	Carbonate	0	12
9	Bi-Carbonate	12	488
10	Choride	4	724
11	Fluoride	0.1	2.8
12	Nitrate	0	2660
13	Sulphate	0	750
14	Iron	-	
15	Silica	3	11

The analytical results show that the chemical quality of ground water is good in Chhattisgarh. The pH value shows that the ground water is neutral to alkaline in nature. The electrical conductivity value in most of the samples are less than the 1000 µs/cm at 25° C which, indicate that the ground water is of low mineral content over Chhattisgarh. Exceptionally higher value of EC is recorded in samples of Chataud in Durg district (4350 µs/cm at 25° C) where as the lower value is recorded at Hatti (50 µs/cm at 25° C) in Raigarh district. Total hardness is observed within the permissible limit except in few locations of Bilaspur, Durg, Janjgir- Champa and Raigarh districts due to the presence of higher sulphate content. The concentration of nitrate is found to be less than 100 mg/l in majority of the samples. The Fluoride concentration in the ground water of Chhattisgarh State is generally below the recommended limits of BIS i.e. 1mg/liter. In few water samples of Bastar, Raipur, Kanker, Jashpur and Surguja districts it is found to be more than the 1.5 mg/l.

10.7 Central Region, Nagpur

Preparation of State Report on Chemical Quality

The State Report on the "Ground Water Quality of Maharashtra and Union Territory of Dadra and Nagar Haveli" has been prepared.

Ground Water Year Book (2008-2009)

The chemical inputs required for the preparation of Ground Water Year Book 2008-2009 has been submitted.

Water Quality Maps

Water Quality Maps for TDS, TH, Cl, NO3, & F of Maharashtra & U/T of DNH were prepared based on HS 2008 data for inclusion in the yearbook.

Ground Water Quality Database Compilation, Validation & Computerization

Compilation, validation and computerization of all ground water quality data generated after analysis in chemical laboratory were carried out. Updating the ground water quality database for the year 2008 in GEMS software was carried out.

Coordination with PRL for IWIN Programme

A National Programme of Isotope Finger printing of Waters of India (IWIN) for investigating spatial and temporal fingerprinting of water resources of India using stable isotopes and tritium is undertaken by Physical Research Laboratory (PRL), Ahmedabad. CGWB being project partners has a role to provide input for IWIN component of ground water. The Regional offices of CGWB have given the responsibility of collecting ground water samples from CGWB Monitoring Stations falling in their areas. All the officers of CGWB, CR, Nagpur who have been assigned the monitoring work in May-2009 (Premonsoon period) carried out ground water sampling for IWIN as per Ground Water Sampling Protocol, compiled the sampling database and dispatched the samples to PRL, Ahmedabad and coordinated all the IWIN activities.

10.8 Northern Region, Lucknow

Hydro chemical studies with finding/conclusions:

Ground water is generally more mineralized than surface water as it remains continuously in contact with minerals & rocks. The quality of shallow ground water in phreatic zone is further affected by urban, industrial or agricultural activities. Large scale concentrated sources of pollution such as industrial discharges, landfills and subsurface injection of chemicals and hazardous wastes are obvious sources of ground water pollution too.

In general, shallow ground water in the state of Uttar Pradesh is fresh except for or few places where concentration of ions has been found above permissible limits (BIS-1991).

Hydrogen Ion Concentration (pH): The pH value of ground water in the state of U.P. varies from 7.80-8.76 which is within the permissible limits and water is found to be slightly alkaline in nature.

Electrical Conductivity (EC): The Electrical Conductance of ground water is a measure of various chemical constituents present therein. It gives an overall quality of ground water for its use in various spheres of life like drinking, irrigation and other purposes. Electrical conductance ranges from 230 to 7390 μs/cm at 25^{o}C in the entire study area of Uttar Pradesh. High EC (>3000 μs/cm) is observed in the shallow ground water of Hamirpur, Agra, Mathura, Fatehpur & Kanpur Nagar districts. Excessively high values of EC (>4000 μs/cm) is observed at Padhera (7100 μs/cm) in district Fatehpur; Kaharia (7250 μs/cm) & Ghusiary (5700 μs/cm) in district Hamirpur. Highest value of EC is observed (7390 μs/cm) in district Fatehpur. Such high values observed in the above mentioned districts indicate occurrence of saline water in the arreas.

Chloride (Cl): It is one of the major ions present in water. Chloride ranges from 7.0 to 3834 mg/l in the state of Uttar Pradesh. Values of Chloride >250 mg/l (BIS-1991) are observed in the shallow ground water from Unnao, Fatehpur, Kanpur Nagar, Mau, Gautambudhnagar, Mahamayanagar, Mahoba, Hamirpur, Banda, Agra & Mathura districts. Extremely high values >1000 mg/l are observed at Padhera (2236 mg/l) district Fatehpur & Charkhari (1099 mg/l) district Banda. Highest value of Cl is observed at Kichakpur (3834 mg/l) in district Fatehpur. Such high values of Cl contribute to the saline nature of ground water.

Nitrate (NO3): The concentration of nitrate has been found to vary widely in the state. It ranges from nd-226mg/l. High values of N03 (>45 mg/l, BIS 1991) are associated with well waters all over the state in scattered form and thus is indicative of point source pollution. Very high values of nitrate (>200 mg/l) are observed at Kanism (218 mg/l) & Mahoba (226 mg/l) district Banda. Moderately high values of N03 are observed in the ground water from Hamirpur, Gautambudhnagar, Mau, Kannauj, Etah, Mahoba & Kanpur Nagar.

Fluoride (F): Small quantities of Fluoride are beneficial in reducing dental caries whereas excess concentration (>1.5 mg/l, BIS 1991) is harmful and causes staining of tooth enamel and even fluorosis. Fluoride values range from nd-2.2 mg/l in the state of Uttar Pradesh. Values of Fluoride >1.5 mg/l are observed in the shallow ground water at Bairagipur(1.7 mg/l), Amlahmaham (1.9) district Fatehpur, Unnao City (2.2 mg/l) district Unnao. However Fluoride values >1.0 mg/l are observed in Hardoi, Shahjahanpur, Lucknow, Barabanki, Firozabad & Kanpur Nagar districts.

Total Hardness as CaCO3: The total hardness of ground water ranges from 40-3400 mg/l in the state of Uttar Pradesh. Higher permissible limit of 600 mg/l (BIS, 1991) has been set in the absence of alternate source. Values of total hardness >600 mg/l are observed in the shallow ground water from Agra,Mathura, Fatehpur,Kushinagar, Mahoba, Hamirpur & Kanpur Nagar districts. A maximum value of 3400 mg/l total hardness is observed in the ground water from Padhra (Fatehpur district).

Compilation of Chemical studies:

(i) Occurrence and distribution of pesticides residues in ground water in Loni block of Ghaziabad district and Khekra block of Baghpat district., U.P.
(ii) Occurrence and distribution of pesticides residues in Gomti River, Lucknow
(iii) Occurrence and distribution of Arsenic in Ganga River water and ground water of the surrounding area long Ganga River in its stretch from Kanpur and onward in UP.

10.9 Eastern Region, Kolkata

Hydro chemical studies with finding/conclusions:

Chemical analysis of ground water samples, collected during AAP 2009-10, revealed that

- Fluoride content above permissible limit (1.5 mg/l) was found in some isolated patches of Dakshin Dinajpur, Birbhum, Malda, Midnapur, Haora and Purulia districts. Maximum value of 10.1 mg/l observed at Sarbamangala H.S. Compound, Gangarampur, Dakshin Dinakpur district. In Sikkim maximum value of fluoride was observed in water samples collected from Kali Khola (Stream).
- Similarly concentration of Iron above permissible limit (1 mg/l) was found in isolated patches covering all districts of West Bengal. Maximum value of 7.68 mg/l was observed at Dinhata, Kochbehar district.
- Nitrate concentration above permissible limit (45 mg/l) was found in some isolated patches of Malda, Murshidabad, Purulia, Hugli and Uttar Dinjpur districts. Maximum value of 53 mg/l was observed at Gaisol, Uttar Dinjpur district.
- Phosphate content above permissible limit (0.2 mg/l EPA) was found in some isolated patches of North 24 Parganas and Kochbehar districts. Maximum value of 1.62 mg/l was observed at Murarisa, Hasnabad block in North 24 Parganas district.
- Arsenic concentration above permissible limit (0.05 mg/l) was found in some isolated patches of North 24 Parganas and Murshidabad districts. Maximum value of 0.120 mg/l was observed in Murshidabad district.

10.10 Mid Eastern Region, Patna

10.10.1 Bihar

Hydrochemical studies with findings / conclusions (As per HNS sample analyzed)

1. The groundwater in the state of Bihar is mildly alkaline in nature. Most of the samples contain no carbonate but are characterised by the presence of bi-carbonate.
2. The value of electrical conductivity indicates wide variation in dissolved constituents in groundwater of Bihar. The maximum conductivity value (4190 μs/cm) has been observed at Sahpur Patori, Samastipur district whereas minimum conductivity value (100 μs/cm) has been observed at Bathnaha Araria district.
3. In general, the quality of groundwater in terms of Total Hardness as $CaCO_3$ has been found as hard to very hard. The maximum concentration of Ca has been found as 168 mg/l at Sahpur patori, Samastipur district, whereas the minimum concentration of Mg has been observed as traces at Bathnaha, Araria district.
4. The concentration of Chloride in majority of the ground water samples has been found to be within the desirable limit for drinking purpose (250 mg/l, IS:10500: 1991). The maximum concentration of chloride has been found as 710 mg/l at Sahpur Patori, Samastipur district.
5. The concentration of Na ranged from 2.3 mg/l at Shahkund, Bhagalpur District to 475 mg/l at Sahpur patori, Samastipur district and of K ranged from 0.4 mg/l at Boarijore,Godda district to 375 mg/l at Benipatti, Madhubani district.
6. Ground water in major part of the state has been found suitable for irrigation.

10.10..2. Jharkhand

Hydrochemical studies with findings / conclusions (As per the HNS Samples)

1. The groundwater in the state of Jharkhand is mildly alkaline in nature. Most of the samples contain no carbonate but are characterized by the presence of bi-carbonate. The maximum concentration of HCO_3 was found as 976 mg/l at Tandwa (Hazaribag,Chatra, Koderma district).
2. The maximum conductivity value, 3500 micro Siemens/Cm, has been found at Jarmundi, Dumka district, whereas minimum value was found as 113 μs/cm at Balumath, Palamu district. The value of electrical conductivity indicates wide variation in dissolved contents in groundwater of Jharkhand.
3. The concentration of chloride in majority of the groundwater samples has been found to be within the desirable limit for drinking purpose (250 mg/l, IS:10500: 1991). Its concentration ranged from 7.1mg/l at Baharagora, E. Singhbhum district to 437 mg/l at Jamua, Giridih district.
4. Generally, the quality of ground water in terms of total hardness as CaCO3 has been found as hard to very hard.
5. The maximum concentration of Ca has been found 206 mg/l at Jamua, Giridih district whereas the minimum concentration of Mg has been reported as 2.4 mg/l at Dalbhumgarh, E. Singhbhum district.
6. The concentration of Na ranged from 4.8 mg/l at Dalbhumgarh, E. Singhbhum district to 365 mg/l at Chandrapura,Bokaro district.
7. The concentration of K in groundwater samples varied from 0.3 mg/l at Msarjor,Dumka district to 83mg/l at Palkot, Gumla district.

10. 11 North Eastern Region, Guwahati

10.11.1 Tripura

Hydro chemical studies with finding / conclusions:

A study of the analytical results of the water samples collected both from the water table aquifers and deeper aquifers indicate that there is no considerable difference between quality of ground water from water table aquifers and deeper aquifers. The water is slightly alkaline in reaction . The pH values of the ground water ranges from 6.94 to 8.38 except for the sample collected from Gurjee where it is 5.28. specific conductance of ground water in the state varies from 62-519 micromhos/cm at 25°c. Carbonate content is nil in ground water but is found in negligible quantities in a few samples. Bicarbonate is the chief source contributing to the alkalinity of the water. Bicarbonate content of the ground water in the state ranges from 18 to 207 mg/l. Sulphate concentration is comparatively low and ranges from BDL to 29 mg/l. This low concentration of Sulphate indicates that water is of recharging type.

Chloride content of the water in general ranges from 7 to 64 mgl, however 117 mg/l has been found at Nalmura. Calcium and Magnesium in the form of carbonate and bicarbonate presence in the water sample is within the permissible range. Thus the ground water of the state is generally soft.

Iron concentration ranges from 0.27 to 2.029 mg/l in the state except for a few high values of 5.6 and 10.1 mg/l in the water samples collected from Gaptoli and Dakshin Kalamchoura.

10.11.2 Meghalaya

Hydro chemical studies with finding / conclusions:

In general chemical quality of ground water in the state of Meghalaya is found good and potable. EC value ranges from 45 to 533 μs/cm at 25^0C. The pH is an important factor in determining the chemical and biological properties of water. The pH value in the study area varies from 6.84 to 8.41. Carbonate concentration is below detection limit to 2 mg/l in ground water samples of Meghalaya. In the deeper aquifers Bicarbonate ranges between 18 to 88 mg/l. And chloride content ranges between 7 to 10 mg/l.which is well within the permissible limit . The fluoride concentration in the study area ranges from BDL to 0.12 mg/l in deeper aquifers, which is well within the permissible limit of 1.5 mg/l. The total hardness of the analyzed water samples varies from 55 to 75mg/l.

In Meghalaya, concentration of iron ranges from below detection limit to 2.51 mg/l. The quality assessment of ground water in the study regions shows that all elements of water samples fall well within the desirable limits of BIS.

10.11.3 Assam

Hydro chemical studies with finding / conclusions:

The quality of ground water is suitable for both domestic and irrigation purposes. Concentrations of different chemical constituents in most of the GWM stations are found within permissible limit. However concentration of

some constituents exceeds permissible limit in pockets. EC value ranges from 51 to 1584 µmhos/cm at 25^{0}C. In seven ground water sample EC value were more than 1000 µmhos/cm at 25^{0}C. The pH is an important factor in determining the chemical and biological properties of water. In the study area pH ranges between 6.27 to 8.68 In Bongaigaon, Darrang and Dhubri districts pH value is found beyond permissible limit in some wells. Fe concentration exceeds permissible limit in pockets in Dhemaji, Lakhimpur and Sonitpur districts. Fe concentration in the study area ranges from below detection limit to 14.69 mg/l. The Cl concentration of the ground water in the study area ranges between 3 to 205 mg/l. The maximum concentration of Cl was 205 mg/l. At Lalmati of Greater Guwahati area, Carbonate concentration was found below detection limit to 21 mg/l.

It is observed that Fluoride content in the study area increases with depth. High Fluoride content(10.1 to 19.8) has been reported from a few tube wells. In Guwahati area also high fluoride content is reported.

In Majuli Island, Arsenic concentrations were found higher. Out of 24 samples it was found that 16 samples were having Arsenic concentration of more than 0.01 mg/l., which is permissible limit for Arsenic. The Arsenic concentration in the Majuli Island ranges from below detection limit to 0.09 mg/l. In general, the ground water quality in the state of Assam is found suitable for various purposes of drinking, domestic and agricultural uses.

10.12 Southern Region, Hyderabad

Hydro chemical studies with finding / conclusions:

Water quality problems observed are high salinity (EC) and Chloride at Munganda in East Godavari district, Total Hardness, Magnesium, Sulphate and Nitrates at Phirangipuram of Guntur District, Calcium at Amalapuram of East Godavari district, and Fluoride at Darsi of Prakasam district. High Fluoride was observed in deeper bore well water. Out of all the exploration samples 14 samples were observed to contain Fluoride more than 1.5 mg/l. Highest concentration of Nitrate observed was 769 mg/l at Phirangipuram and 20 samples have nitrate more than 45 mg/l. High salinity >3000 µS/cm was observed at 10 sites.

Major ground water quality problems observed were high salinity, nitrate and fluoride. Districts affected were Nalgonda, Prakasam and Anantapur. Highest Salinity (EC) recorded at Ibrahimpatnam of Krishna district.

Ground Water Management studies: During Ground Water Management Studies Water Samples were collected from Guntur, Khammam, Mahboobnagar, East Godavari and Nellore district and analysed. Salinity, high fluoride and Nitrate are the main water quality problems observed.

10.13 South Eastern Region, Bhubneshwar

The Parameters determined in during the year were - pH, E.C., Carbonate, Bicarbonate, Chloride, Sulphate, Nitrate, Fluoride, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Phosphate and Iron. Samples from National Hydrograph Network Stations were analysed for pH, E.C., Fluoride, Chloride, and Nitrate contents apart from total Iron analysis in all the acidified samples from National Hydrograph Network Stations.

10.14 South Western Region, Bangalore

In the Regional Chemical Laboratory, a total of 518 ground water samples were analyzed for 6503 chemical constituents. Thirteen basic chemical constituents includes, Electrical conductivity, pH, Carbonate, Bi-carbonate, Chloride, Nitrate, Sulphate, Flouride, Calcium, Magnesium, Total Hardness, Sodium and Potassium. In addition, specific analysis of NHS groundwater samples were carried out for five chemical constituents viz., EC. pH,Flouride, Nitrate, Chloride.Item wise details of the water samples analysed.

10.15 South East Coastal Region, Chennai

Hydrochemical studies with findings/conclusions:

The quality of shallow ground water in Tamil Nadu state has been evaluated by sampling and analysis of water sample collected from National Hydrograph Network station (NHNS). 410 National Hydrograph Network stations (NHNS) were monitored for water quality during May 2009.

The ground water quality in the state is fresh in about 19% of the National Hydrograph Network stations (NHNS), as indicated by the EC value less than 750 µs/cm at 25^{0}C. In about 53% of the NHNS, the EC varied between 751- 2250 and 12% of the NHNS, are between 2251-3000 indicating that the ground water is slightly mineralized and about 16% of NHNS the EC is more than 3000 µs/cm at 25^{0}C indicating that the ground water is highly mineralized.

The chloride content is less than 250 mg/l in about 55.5% of the sample analyzed and 36.5% of the samples are between 251-1000 mg/l and 8% shows more than 1000mg/l, which are from the districts Viz., Chennai, Cuddalore, Pudukottai, Ramanathapuram, Nagapattinam,

Thiruvarur, Tuticorin and small patches in districts Viz., Tirunelveli, Dindigul, Namakkal, and Coimbatore.

The Fluoride content is less than 1.5 mg/l in about 90% of the sample analyzed and 10% of the sample shows F more than 1.5 mg/l in Dharmapuri, Krisnagiri, Salem, Namakkal, Erode, Coimbatore, Pudukottai, Sivagangai, and Virudhunagar districts. Nitrate content is less than 45mg/l in about 65% of the sample analyzed and 18% is within the permissible limit of 46-100 mg/l and 17% of sample shows more than 100 mg/l. High Nitrate concentration > 100 mg/l occurs in Salem, Namakkal, Erode, Kancheepuram, Kanyakumari and dindigul districts.

Compilation of Chemical studie:

- Interim report on " Assessment of Ground water quality in and around Ambathur Area" Tiruvallur district, Tamil Nadu submitted & issued.
- Report on Chemical quality of Tamil Nadu And U.T. of Puducherry has been submitted.
- Interim report on "Hydrochemistry of Landfill sites in and around Pallikaranai- Chennai suburban area submitted and issued.

10.16 Kerala Region, Trivendrum

Hydrochemical studies with finding/conclusions.

By observing the chemical analysis data of GWMW it can be concluded that over majority of the area, quality of ground water is suitable for domestic and irrigation purposes. The chemical contamination of groundwater in the state is in parts due to agricultural activities, industrialization, population growth and geological reasons in certain areas of Palakkad and Alappuzha districts registering relatively higher electrical conductivity and fluoride consistently for over a decade.

Compilation of Chemical Studies:

The general quality of ground water in the state is being monitored through a network of Ground Water monitoring stations once a year (April). The results of these studies are being documented in the Ground Water Year Book of the region year wise. Apart from these observation wells, the quality of groundwater is also being monitored during various studies such as ground water management studies, ground water exploration and special studies. The basic data reports and the reappraisal survey reports documenting these studies also features the chemical quality of ground water in it. Besides the district wise quality of ground water is highlighted in the district reports assigned during the AAP.

10.17 Uttaranchal Region, Dehradun

Hydrochemical studies with finding / conclusions:

The physico-chemical characteristics of ground water in Uttarakhand State have been studied to evaluate their suitability for domestic and irrigation uses. Ground water samples, both from tube wells (hand pumps) and dug wells were collected and analyzed for pH, E.C., chloride, bicarbonate, nitrate, fluoride, total hardness, calcium, magnesium, sodium and potassium. It has been observed that the quality of ground water of most of the area is suitable for both drinking and irrigation purposes. However, water of few locations needs treatment before its use. Though, the entire area is at present free from any major pollution problem, suitable measure should be taken to protect and efficiently utilize this precious resource.

The chemical quality of ground water of shallow aquifers in the Uttarakhand is found to vary widely, depending upon the physiography, soil texture and underlying soil formations. The shallow aquifer is mostly dominated by Ca-Mg-HCO_3 and $CaHCO_3$ types of water. The general chemical quality reflects that most of the wells contain low dissolved minerals content, which brands the ground water as quite fresh in Uttarakhand except some samples in Udham Singh Nagar falling in slight to moderate restriction category, should be utilized for irrigation after taking some precautionary measures.

10.18 North Himalayan Region, Dharamshala

A total numer of 82 samples were collected from Ground Water Observation Wells during May 2009-10 and analysed for 1066 determination of basic parameters. 118 number of ground water samples collected for exploration reappraisal and other surveys were also analysed.

10.19 State Unit Office, Delhi

During May 2009, about 156 water samples from GWMS and exploration studies from Delhi were collected for detailed chemical analysis and no specific treatment such as acidification or filtration was given to them at site. Samples were analyzed for major anions (CO_3, HCO_3, Cl, SO_4, NO_3) and cations (Ca, Mg, Na, K) in addition to pH, EC, F, TH as $CaCO_3$, in the Regional Chemical Laboratory at Chandigarh.

11.0 HIGH YIELDING AQUIFERS EXPLORED

During 2009-10, Board under its scientific exploratory drilling programme has explored high yielding aquifers in the various states of the Country based on hydrogeological studies utilizing remote sensing and geophysical techniques. High yielding wells with discharge ranging from 190 litre per minute to 2205 litre per minute have been constructed in the states of Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Rajasthan, Tamilnadu and West Bengal. The study will help in identifying ground water sources and in guiding the states to adopt follow up action with regard to ground water development for drinking water supply and other demands. High Yielding Wells constructed during 2009-10 is given Table 11.1 .

Table 11.1: High Yielding Wells Constructed During 2009- 2010

Sl. No.	Name of States	Description
1.	**Andhra Pradesh**	• An exploratory bore well drilled at Alluru , Nizamabad district down to a depth of 120m bgl piercing the granitic formations has yielded a high discharge of 480 litre per minute. This well can cater to drinking water requirements of a population (for SC/ST) of about 4800 (@ 60 lpcd for ten hours of pumping a day) in the area.
2.	**Gujarat**	• A well drilled (auto flowing) at Chandrora village, Taluka Anjar, Kachchh district has yielded a high discharge of 600 litre per minute with potable quality water. This well can cater to drinking water requirements of a population of about 6000 (@ 60 lpcd for ten hours of pumping a day) in the area. • A well drilled at Lawaria village, Taluka Devgadh Baria, Dohad district has yielded a high discharge of 870 litre per minute with potable quality water. This well can cater to drinking water requirements of a population of about 8700 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at village-Morjar, Taluka Dhari, Amreli district has yielded a high discharge of 1200 litre per minute in Deccan Trap formation under assistance to State Govt. towards Drought mitigation programme. This well can cater to drinking water requirements of a population of about 12000 (@ 60 lpcd for ten hours of pumping a day) in the area.
3.	**Karnataka**	• An observation well drilled at Chintamani, Kolar district down to a depth of 328.5m bgl has yielded a high discharge ranges 197-404 litre per minute in highly fractured Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 4000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Kollegal taluk, Chamrajnagar district down to a depth of 60m bgl(progress) has yielded a high discharge of 480 litre per minute in fractured Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 4800 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Chintamani taluk, Kolar district down to a depth of 225 bgl has yielded a high discharge of 894 litre per minute in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 8900 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Kollegal taluk, Chamrajnagar district down to a depth of 144.35m bgl(in progress) has yielded a high discharge of 201 litre per minute in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 2000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An Observation well drilled at Kollegal taluk, Chamrajnagar district down to a depth of 132.15m bgl(in progress) has yielded a high discharge of 332 litre per minute in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 3300 (@ 60 lpcd for ten hours of pumping a day) in the area.

Sl. No.	Name of States	Description
4.	**Kerala**	• An exploratory well drilled at Ottappalam, Palakkad district down to a depth of 100m bgl has yielded a high discharge of 900 litre per minute. This well can cater to drinking water requirements of a population of about 9000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Puthukodu, Palakkad district down to a depth of 65m bgl has yielded a high discharge of 1560 litre per minute in Biotite Gneiss formation. This well can cater to drinking water requirements of a population of about 15600 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Mayyanur, Trichur district down to a depth of 100m bgl has yielded a high discharge of 720 litre per minute. This well can cater to drinking water requirements of a population of about 7200 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Kodumon, Pathanamthitta district down to a depth of 200 m bgl has yielded a high discharge of 408 litre per minute in Leptynite and Khondalite formation. This well can cater to drinking water requirements of a population of about 4000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An Observation well drilled at Vadakkethara, Palakkad district down to a depth of 68 m bgl has yielded a high discharge of 1080 litre per minute in Hornblende formation. This well can cater to drinking water requirements of a population of about 10000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An Observation well drilled at Nelluvai, Trissur district down to a depth of 70 m bgl has yielded a high discharge of 840 litre per minute in Hornblende Biotite Gneiss formation. This well can cater to drinking water requirements of a population of about 8400 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled at Vadakethara, Trissur district with depth 90 m bgl has yielded a discharge of 900 litre per minute in Hornblende Biotite Gneiss and Quartz feldspathic Gneiss. This well can cater to drinking water requirements of a population of about 9000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled at Elephant Campus, Konni with depth of 175m has yielded a high discharge of 468 litre per minute in Charnokite Gneiss. This well can cater to drinking water requirements of a population of about 4600 (@ 60 lpcd for ten hours of pumping a day) in the area.
5.	**Maharashtra**	• An Exploratory Well drilled down to a depth of 200 m.bgl at Manjarsumbha village in Beed taluka of Beed district has yielded 226 LPM in Deccan Trap formation. Two water-bearing zones were encountered, at 25-28 and 48-51 m bgl. The SWL was at 9.00 m.bgl. The formation is fractured vesicular basalt. This well can cater to drinking water requirements of a population of about 2300 (@ 60 lpcd for ten hours of pumping a day) in the area. • An Exploratory Well drilled down to a depth of 200 m.bgl at Lhasurne village in Koregaon taluka of Satara district has yielded 190 LPM in Deccan Trap formation. Three water-bearing zones were encountered, at 16-17, 29-30, and 129-130 m bgl. The SWL was at 2.00 m.bgl. The formation is highly fractured massive and vesicular basalt. This well can cater to drinking water requirements of a population of about 1900 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Kumbhephal village in Kaij taluka of Beed district down to a depth of 122.5 m bgl has yielded a high discharge of 590 litre per minute in Deccan Trap formation. Two water bearing zones were encountered at 9-12 and 112-116 m bgl. The formation is fractured vesicular basalt. This well can cater to drinking water requirements of a population of about 5900 (@ 60 lpcd for ten hours of pumping a day) in the area.

Sl. No.	Name of States	Description
		• An exploratory well drilled at Adgaon village in Morshi taluka of Amravati district down to a depth of 273.8 m bgl has yielded a high discharge of 309 litre per minute in Deccan Trap formation. Two water bearing zones were encountered at 53.10-59.20 and 71.40-74.50 m bgl. The formation is fractured massive and highly vesicular basalt This well can cater to drinking water requirements of a population of about 3100 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory bore well drilled down to a depth of 98.00 m.bgl at Bansarola in Ambejegoai taluka in Beed district has yielded about 10.98 lps (39, 528 lph) in Deccan Traps. Two water-bearing zones were encountered. The first water bearing zone between 84.00 & 87.00 m.bgl has yielded 659 LPM, while the second water bearing zone below 90.00 m.bgl turned negative. Cement sealing of the negative zone is taken up to maintain the discharge of the first zone. This well can cater to drinking water requirements of a population of about 6500 (@ 60 lpcd for ten hours of pumping a day) in the area.
6.	**Orissa**	• An exploratory well drilled at Barkote block, Deogarh district down to a depth of 86.50m bgl has yielded a high discharge of 480 litre per minute in Quartzite formation. This well can cater to drinking water requirements of a population of about 4800 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Rajgangpur, Sambalpur district down to a depth of 62.60m bgl has yielded a high discharge of 249.6 litre per minute in Limestone formation. This well can cater to drinking water requirements of a population of about 2500 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Barkote, Deogarh district down to a depth of 78.30m bgl has yielded a high discharge of 420 litre per minute in Granite Gneiss formation.This well can cater to drinking water requirements of a population of about 4200 (@ 60 lpcd for ten hours of pumping a day) in the area. • An Observation well drilled at Barkote, Deogarh district down to a depth of 101.80m bgl has yielded a high discharge of 300 litre per minute in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 3000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Udala, Mayurbhanj district down to a depth of 25.5 m bgl has yielded a high discharge of 900 litre per minute in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 9000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An Observation well drilled at Udala, Mayurbhanj district down to a depth of 90 m bgl has yielded a high discharge of 420 litre per minute in Granite & Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 4200 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled at Nuapada, Nuapada district down to a depth of 140.6 m bgl has yielded a high discharge of 300 litre per minute in Granite & Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 3000 (@ 60 lpcd for ten hours of pumping a day) in the area.
7.	**Rajsthan**	• An exploratory well drilled and constructed down to a depth of 200m bgl tapping 180 to 198m zone in Tertiary sandstone having confining layer as shale. Auto flow discharge was 180 LPM whereas discharge measured using air compressor was 1800 LPM. The quality of ground water has been found potable and E.C value measured is 2500ms/cm at 25^{o}C. This well can cater to drinking water requirements of a population of about 18000 (@ 60 lpcd for ten hours of pumping a day) in the area.

Sl. No.	Name of States	Description
8.	**Tamilnadu**	• A tube well drilled at Gangaikondacholapuram, Ariyalur district has yielded a high discharge of 1002 litre per minute. This well can cater to drinking water requirements of a population of about 10000 (@ 60 lpcd for ten hours of pumping a day) in the area. • A Piezometers constructed at Ezhur-Olapalayam village, Namakkal district down to a depth of 100 m bgl having a high discharge of 1440 litre per minute inspite of the area having deficit rainfall in the current year.
9.	**West Bengal**	• An exploratory tube well has been constructed at KHASBALANDA, tapping the deeper arsenic free aquifers in the arsenic infested block of North 24 Parganas district. The yield of the tube well was recorded as 2205 LPM during compressor development. This well can cater to drinking water requirements of a population of about 22000 (@ 60 lpcd for ten hours of pumping a day) in the area.

12.0 HYDROLOGY PROJECT II

The Hydrology Project - Phase –II (HP-II) is a follow up project of HP-I. Its major thrust is to use Hydrological Information System (HIS) data effectively and efficiently for water resources planning and management. A longer-term aim of the project is to assist the Governments at both Central and State levels to address the issues of intra-sectoral demands and overall resource planning and management through the establishment of core hydrological organizations serving all specialized water agencies.

The Project will further extend and promote the sustained and effective use of the HIS by all potential users concerned with water resources planning and management, including both public and private, thereby contributing to improved productivity and cost-effectiveness of water-related investments in the 13 states and eight Central agencies. The coverage of existing states under the project is to help these agencies from moving over from development of HIS (as in HP-I) towards use of HIS in water resources planning and management. The project objectives will be achieved by:

a. Strengthening the capacity of hydrology departments to develop and sustain the use of the HIS for hydrological designs and decision tools thus creating enabling environment for improved integrated water resources planning and management;
b. Improving the capabilities of implementing agencies at state/central level in using HIS for efficient water resource planning and management in reducing vulnerability to droughts and thereby meeting the country's poverty reduction objectives;
c. Establishing and enhancing user-friendly, demand responsive and easily accessible HIS to improve shared vision and transparency of HIS between all users; and
d. Improving access to the HIS by public agencies, civil society organizations and the private sector through awareness building supporting outreach services.

Greater use of an improved HIS is expected to have a broad but definite impact on the planning and design of water resources schemes, from which the rural and urban poor will have secure and sustainable access to water for multi-purpose livelihood uses.

CGWB is participating agency in HP-II and has a budget provision of Rs 33.4 Crores and project has duration of 6 years staring from May 2006 to 2012. The revised provision for the year 2009-10 is Rs 5.66 Crore. H-P-II has two major components i.e Horizontal Expansion in three new States covering Goa, Himachal Pradesh and Punjab and Vertical Extension in the 9HP-I peninsular States. Under Horizontal Expansion, HP-I type of activities and facilities will be extended to new states, however, under Vertical Extension special knowledge enhancement type of activities such as Hydrological Design Aid, Decision Support System and Purpose Driven Studies would be taken up. In this year of the project domain specific training would be imparted, Awareness raising program are being held, tender documents for procurement/upgrading of the equipments have been prepared and construction of the piezometers is being taken up. The expenditure incurred on the project till March, 2010 is Rs 2.98 Crores. During the year 29 Piezometers have been constructed, 7 awareness raising programmes organized, 2 training imparted and IT/ Office equipments were procured.

13. STUDIES ON ARTIFICIAL RECHARGE OF GROUND WATER

13.1 Demonstrative Projects on "Artificial Recharge to Ground Water & Rain Water Harvesting"

During 2009-10, Six demonstrative recharge projects on "Artificial Recharge to Ground Water and Rain Water Harvesting" have been approved for taking up at following areas.

i. Taramani, Village of Chennai in Tamil Nadu State.
ii. Erumapattee, Mohanar and Namakkal blocks of Namakkal district, Tamil Nadu State.
iii. Coimbatore city of Coimbatore district in Tamil Nadu State.
iv. Madanapalle, Nagri, Karvetinagaram, Vijayapuram, SR Puram, Palasamudram and Vedurukuppam blocks of Chittoor district, Andhra Pradesh.
v. Malur taluka of Kolar district, Karnataka State.
vi. Sataon block of Rae Bareli district, Uttar Pradesh State.

The approved cost of six projects is Rs.1374.591 lakhs for implementation by the departments of states under overall technical guidance of Central Ground Water Board for construction of 355 recharge structures in four States.

The details of demonstrative projects on artificial recharge to Groundwater and Rain Water Harvesting approved and being implemented in the States of Kerala, West Bengal, Punjab, Arunachal Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu and Uttar Pradesh during XI Plan are given in table 13.1. On completion of civil works of recharge facility, impact assessment studies will be taken up to demonstrate the efficacy of artificial recharge and rain water harvesting in above mentioned sites selected on scientific basis in different hydrogeological situations. Successful examples would be replicated by the States in similar set ups in future.

13.2 Scheme on "Artificial Recharge to Ground Water Through Dug Wells"

1. The government has sanctioned a state sector scheme of "Artificial Recharge of Ground Water through Dug Wells" amounting to Rs.1798.71 Crore for implementation in seven states namely Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu having majority of Over exploited, critical and semi critical blocks of ground water development. 1180 Over-exploited, Critical and Semi-Critical blocks in 149 districts affected by declining ground water levels, water quality problems were taken for implementation of dugwell recharge by farmers.
2. The scheme envisages installation of 4.45 million ground water recharge structures in the existing irrigation wells of the farmers to facilitate large scale ground water recharge in the area, of which 2.72 million are owned by the small and marginal farmers and 1.73 million owned by other farmers. Average cost of recharge per well is Rs.4000, varying from Rs.3600 in Maharashtra to Rs.5700 in Andhra Pradesh. In order to encourage farmers in dugwell recharge scheme, provision has been made for giving subsidy to the beneficiary farmers to the extent of 100% for marginal and small category farmers and 50% for farmers of other category in the scheme.
3. Recharge of ground water with dugwell recharge approach in scheme is expected to improve availability of ground water and water quality. Sustainability of drinking water supplies and socio-economic conditions of the population of the affected areas. Outcomes of the scheme would be evaluated through impact assessment studies by an independent agency and dissemination of information to public.
4. In order to implement the scheme, state nodal department was identified in each participating states having role of identification of beneficiaries, preparation of list of beneficiaries with information of their agricultural land, dug well and bank accounts and capacity building & awareness of beneficiaries for construction of dug well recharge facility. Further District Level Implementation & Monitoring Committee (DLMIC) were responsible for implementation of dugwell recharge scheme in each district.
5. An amount of Rs. 1499.27 Crores has been released by the Ministry of Finance (MoF) to NABARD (programme partner) for releasing subsidy to beneficiary farmers and funds to state for awareness activities. The Ministry of Water Resources (MoWR) is the Nodal Ministry for the purpose of monitoring the Progress of the scheme at National level and to take measures for experience sharing among all stakeholders, knowledge transfer and awareness.
6. As on 31 March, 2010, Rs.280.822 Crore has been utilized as subsidy to the beneficiaries (Rs.263.58 Cr) and Information, Education and communication (IEC)/ capacity building activities (Rs.17.0 Cr) and awareness by Ministry (Rs.0.242 Cr).

The statement showing the details of funds released in the scheme as on 31st March, 2010 given in table 13.2.

Table 13.1: Demonstrative Artificial Recharge Projects sanctioned under CSS "Ground Water Management and Regulation" XI Plan As on 31.03.2010

Sl. No.	State	Demonstrative Recharge Project	Number of Structures	Structures completed	Approved cost (in Lakhs)	Funds released (in Lakhs)	Remarks
During 2008-09 Total 8 projects							
1.	Kerala	Artificial Recharge to Groundwater using Roof Top Rainwater in the premises of government upper primary school, Kolathur II, Bedadka Gram Panchayat of Kasargod district.	1	0	8.750	2.625	Released as first installment on 31.03.2009.
2.		Artificial echarge Scheme Manjeshwar Govind Pai Memorial College campus Kasargod.	83	0	24.500	7.350	
3.		Desiltation of Pond at **Pallipara / Nileshwar** at Kayyur Cheemeni, Kasargod district, Kerala	1	0	1.450	0.435	
4.		Rainwater harvesting to recharge groundwater at Govt. college, Chittoor, Palakkad district	1	0	4.350	1.305	
5.	Punjab	Pilot project on Artificial Recharge to augment declining ground water resources of **Moga** district.	62	0	179.453	53.836	
6.	Arunachal Pradesh	Roof Top Rainwater Harvesting in Arunachal Pradesh	36	10	259.668	77.900	
7.	West Bengal	Study of Artificial Recharge in the blocks of Nalhati I and Murarai I of Birubhim district.	30	20	111.091	33.327	
8.	Tamil Nadu	Artificial Recharge to Groundwater in Thalavasal block of Salem district, Tamil Nadu.	27	27	111.000	111.000	Released balance fund on 19.02.10
During 2009-10 Total 6 projects							
9.	Tamil Nadu	Rainwater Harvesting Arrangements in the premise of the National Institute of Technical Teachers Training and Research, Taramani, Chennai, Tamil Nadu	1	0	40.000	28.000	Released first installment on 26.10.2009
10.		Artificial Rechargeb to Groundwater in Karuvatur watershed Namakkal district, Tamil Nadu.	30	7	275.350	192.745	
11.		Artificial Ground Water Recharge through road side and open space rainwater harvesting structures in Coimbatore city Tamil Nadu.	215	159	100.000	70.000	
12.	Andhra Pradesh	Construction of Artificial Recharge structures in Chittoor district, Andhra Pradesh	29	0	130.020	91.014	
13.	Karnataka	Demonstrative Artificial Recharge Project in Malur Taluk, Kolar district, Karnataka	52	0	109.158	76.410	
14.	Uttar Pradesh	Artificial Recharge to Groundwater in Sataon block of Rae Bareli district, Uttar Pradesh.	28	0	720.063	504.440	Released as 1st installment on 30.03.10
		Total	**596**	**223**	**2074.853**	**1250.387**	

Table 13.2: **State wise details of funds released in the scheme as on 31st March, 2010**

Sl. No.	States	Fund released as subsidy to beneficiaries (Rs. In Cr)	Fund released to State/Min. for IEC activities (Rs. in Crores)	Total fund released As on 31.03.10 (Rs. in Crores)	Dug well recharge structures constructed as on 31.03.10
1.	Andhra Pradesh	0.00	0.00	0.000	0
2.	Gujarat	48.41	3.25	51.66	5498
3.	Karnataka	26.68	2.00	28.68	508
4.	Madhya Pradesh	40.14	2.00	42.14	0
5.	Maharashtra	14.04	2.00	16.04	35195
6.	Rajasthan	30.48	2.00	32.48	412
7.	Tamil Nadu	103.83	5.75	109.58	19510
	Ministry		0.242	0	0
	Total (in Rs. Crores)	**263.58**	**17.242**	**280.822**	**61123**

RECHARGE SHAFT

Providing Rainwater harvesting arrangement in the premises of National Institute of Technical Teachers Training & Research, Chennai

14. MATHMATICAL MODELLING STUDIES

A model is any device that represents an approximation of a field situation. A ground water model can be defined as a simplified version of a real ground water system. Ground Water simulation models provide a platform to study that problems in broader perspective and resolve solution for the optimal benefit taking into considerations the simplest and complex aspects along with economic, social and environmental aspects. Mathematical modeling studies under taken are given below:

14.1 Area of Study : Lucknow urban area

Justification For Selecting the Area For Modeling Studies:

1. Rising population, urbanisation and associated anthropogenic activities have left a debilitating effect on the qualitative and quantitative aspects of the ground water resources in the city area. Lucknow being the capital and an important city naturally calls for such types of studies to be undertaken to understand and address the problem realistically.
2. A lot of exploratory and related hydrogeological data is already available for the city. CGWB has already constructed a number of Piezometers in the city to facilitate ground water level monitoring. The water level data of more than 5- years is available with the office.

Objective

The present study in and around Lucknow city is to be carried out with a view to :

(i) Studying the ground water regime in the area with a view to make predictions in response to ground water withdrawals, rainfall and ever increasing urbanization.

(ii)Quantitative estimation of the ground water resource potential of shallow as well as deeper aquifers in the urban area of Lucknow.

Details of the model area

The present day Lucknow city covering an area of approximately 340 Sq. Km. falls in Survey of India toposheet Nos. 63B/13 & 63B/14 (Scale 1:50,000). It falls within N Lat. 26043' to 26056' and E Long. 80049'30" to 81004'. Lucknow urban area is covered by parts of three blocks – Chinhat, Sarojini Nagar and Kakori .

Hydrometeorology

The climate of the city is sub-tropical. The city experiences three distinct seasons viz. monsoon, summer and winter. Winter starts usually in the month of November and lasts till February. Summer season begins in March/April and continues upto June followed by monsoon season from July to September/October. The normal maximum mean temperature is 40.50C during the month of may and the minimum is 6.90C during the month of January. The average wind speed varies from 4.0 to 8.6 Km/hr and from 8.0 to 11.7 Km/Hr during winters and summers respectively .The average relative humidity of the air varies from 22% in dry season to 81% in rainy season. The annual normal rainfall at Lucknow City is around 1000 mm .

Physiography:

Lucknow City falls in the central gangetic plain and is part of Sai-Gomti Sub-basin. It is almost a flat country with conspicuous natural depressions around Bakshi Ka Talab, Janaki Puram, Saleh Nagar etc. The general slope of the area is from NNW to SSE. The highest elevation is 123.5 mamsl around Bara Birwa in Alambagh area & lowest being 108.5 mamsl in the flood plain at Pragya Dham near Patang Park.

Draiage :

Older alluvial fill in the area probably belongs to the older Ganga river system in which subsequently Gomati has carved out its own valley forming the lower terrace (T1) and the active flood plain in the area. The Gomati flows from NW to SE direction and forms a prominent meander between Lamartiniere School and Shahid Smarak. The river is characterised by sluggish flow throughout the year, except during monsoon season when heavy rainfall causes a manifold increase in the runoff.

There are 23 nalas which drain into Gomti between Gaughat and Gomti barrage out of which 11 nalas viz. Gaughat nala, Patanala, Sarkata nala, Gazi Haider canal etc are located on the right bank and 12 nalas viz. Nadwa nala, Khadra nala, Mahanagar nala, Kukrail nala etc are located on the left bank of Gomati.

The drainage exhibits dendritic and sub dendritic pattern and streams are highly sinuous in nature. Sai river flows on the outer south of Lucknow City from NW & NNW to SE and SSE direction. It also has a few tributaries exhibiting dendritic to sub dendritic pattern of drainage.

Geomorphology

In the area three geomorphic units can be deciphered. They are as under :

1. Younger Flood Plain
2. Older Flood Plain
3. Interfluve Plain or Upland

Younger Flood Plain :

It occupies the area adjacent to Gomati river channel. The characteristics geomorphic forms present in this zone are point bars, channel bars etc. It has an area of about 40 Sq. Km. within the city which has been restricted to about 10 Sq. Km. due to urban habitation and earthern embankments on either side of Gomati. The area gets periodically flooded and is widely cultivated, upstream of Gaughat. The sediments in younger flood plain belong to younger alluvium and are poor in calcareous matter. Some authors classify the river's active flood plain as T0 and rest of the younger flood plain as T1.

Older Flood Plain :

The older flood plain of Gomati in the city is present as detached pockets in the central (north of river) and south-eastern part (south of river). The characteristic landforms in this zone are abandoned channels, meander scars, meander cutoff etc. The sediments are fine grained sand with silt and occasional clay beds. The characteristic feature of this zone is absence of alkaline soil.

Ravinous tracts can be seen at the junction of younger flood plain with the older flood plain, where occasionally thin kankar beds are seen indicating presence of older alluvium at depth.

Interfluve Plain/Upland Area :

The interfluve plain can be called as composite flood plain and occurs between major drainage ways. The sediments are sands and clays admixed with kankar in varying proportions. The soils are clayey to coarse loamy in nature. The morphozone slopes towards drainage ways and has been cut by minor channels.

The prevalence of Paleochannels and water bodies (Tals) resembling oxbow lakes, cutoff meander indicate that this area has undergone drainage course changes in the past. The occurrence of alkaline/Usar soils, characteristic in this zone indicate poor drainage and poor vertical permeability.

Geology

Lucknow City, a part of Central Ganga Plain, is covered by alluvial deposit of Quaternary age. The sediments can be classified as Newer alluvium and Older alluvium.

The newer alluvium occupies the tract adjacent to Gomati forming active channel, younger and older flood plain, a part of which, sometimes gets flooded during monsoon period. The sediments are non-oxidized, grey micaceous sand, silt and clays. It belongs to upper Pleistocene to recent age.
Older alluvium occupies topographically higher levels which do not get flooded. The sediments are oxidized reddish brownish sands, silt and clays frequently interspersed with kankars. It belongs to upper to middle Pleistocene age.

Sub-surface geology

The available lithological and electrical log data of CGWB exploratory tubewells reveal five aquifer groups, broadly in the following depth range, occuring in the city area.
(1) 8-112 m
(2) 120-254 m
(3) 268-379 m.
(4) 371-483 m
(5) 483-620 m

Ist Group of Aquifer (8 m to 96/112 m):

It has a sandy layer occuring between 8-35 mbgl depth, ranging in thickness from about 15 to 25 m. This zone is the unconfined aquifer which supports handpumps and dugwells. In the central part sands are coarser but become finer away in all directions.

The unconfined zone is underlain by a thick clay layer occuring in the depth range of 25-60 mbgl with an average thickness of 20-25 m. In the north and south, this clay layer is intercalated with sand, 15-20 in thickness which pinches out towards the central part of the city.

The clay layer is underlain by a granular zone almost continuous between 51 and 112 mbgl depth range. This is intercalated by clay layer of 20-25 m. thickness at variable depth broadly between 65 and 100 mbgl restricting the granular zone to an average thickness of 25-30 m.

The sands of the first aquifer group are coarser towards the top but become successively finer with depth. The cumulative thickness of the granular zone in the first aquifer ranges from 32-66 m. averaging about 51 m. within the depth of 112 mbgl. The sand content on an average is about 48 percent but the average sand content at Patang Park and Lalbagh is about 36 percent.

IInd goup of aquifer (120/138 m to 226/254):

The second aquifer group is highly silty in nature below 150 m depth. It has several discontinuous bands of silty layers. The reasonably continuous granular zone occurs between 120 and 148 m and between 220 and 254 mbgl with their thickness ranging from 6-20 m. The other two conspicuous granular zones occur between 144 and 158 mbgl and 175 and 194 mbgl, they appear to be discontinuous.

The average sand content within the depth upto 254 mbgl is 29 percent and cumulative thickness of the granular zone within this aquifer, on an average is about 38 m. but in the flood plain of the city area, average sand content is about 34

Table 14.1: Water Level Data and Fluctuation (Pre and Post) for 2009

Sl No.	Well Name	Pre-Monsoon (mbgl)	Post-Monsoon(mbgl)	Fluctuation(m)
1	Arya Nagar	19.90	-	-
2	Bhujal Bhawan	18.40	18.82	-0.42
3	CAMPBELL ROAD	11.30	9.80	1.50
4	Cantt	22.45	22.80	-0.35
5	Dilkusha	31.70	23.00	8.70
6	Gulistan Colony	33.10	32.65	0.45
7	Lu New Campus	12.25	12.10	0.15
8	Lu Old Campus	28.35	28.25	0.10
9	Mahanagar H Park	28.30	28.35	-0.05
10	Mahila College-Aminabad	14.55	-	-
11	Narhi	32.35	33.70	-1.35
12	New Hyderabad	22.40	21.60	0.80
13	Rajajipuram	28.60	27.00	1.60
14	Rakabganj Crossing	7.45	6.85	0.60
15	River Bank Colony	22.30	21.80	0.50
16	Sarojininagar	11.20	10.25	0.95
17	Vikasnagar	26.60	26.10	0.50

percent and cumulative average granular zone thickness is a little higher.

IIIrd Group of Aquifer (254/283 m to 353/379 m):

This group of aquifer is constituted by three reasonably continuous thin layers of fine sand 6 to 20 m. in thickness occuring between 254 and 294 mbgl, 307 and 321 mbgl and 339 and 368 mbgl. The aquifer is highly interlayered sequence of sands and clays.

The sand content in this aquifer ranges between 23 and 42 percent averaging about 33 percent. The cumulative granular zone thickness is about 28 m. The flood plain area is in conformity with the rest of city with respect to the sand content.

IVth Group of Aquifer (371/379 m to 483 m):

The fourth group of aquifer comprises of broadly three relatively thicker granular zones occuring between 380 and 404 mbgl, 421 and 443 mbgl and 463 and 483 mbgl depth range. This aquifer is also highly interlayered sequence of sands and good clays.

The sandy zones between 421 and 443 mbgl and 463 and 483 mbgl are admixed with 1-3 mm chips of sub-angular to sub-rounded not too compact or friable sandstone, bluish grey sand different from above and highly interlayered nature of the aquifer indicates that the sediments of this aquifer may be related to the middle Siwalik super group.

The sand content in this aquifer ranges from 35 to 52 percent averaging about 42 percent. The cumulative granular zone thickness ranges from 36 to 59 m. averaging about 46 m.

Vth Group of Aquifer (483 m to 620 m):

This aquifer group is highly interlayered or intercalated with very fine sand, silt and clay sequence, sandy layers are thin and predominantly silty in nature, clays are variegated in colour towards the bottom.

Hydrogeology:

(A)Unconfined Aquifer :

Unconfined aquifer in Lucknow City occur between 8 and 35 mbgl, which at places goes upto 45 mbgl average depth. It is constituted of medium to coarse-grained greyish, micaceous sand admixed with silt and clays at places. Most of the handpumps are constructed within this zone. It also supports the dugwells in the flood plain area and outer peripheri of the city area. The resistivity value of such sands varies from 30 to 45 ohm/m. ground water occurs in the pore spaces of sands and silts.

(i) Depth to Water Level:

Pre and Post-monsoon water level data of Ground Water Monitoring Wells-Piezometers is tabulated and shown in Table 14.1:

The water level data collected during May'2009 shows that water level is shallower in eastern part and deepest in the central part of the city. Water level is deepest at Gulistan colony(33.10 mbgl) and shallowest at Rakabganj Crossing(7.45 mbgl). Water level is deeper in the central part along Gomti river. Water level is greater than 20 mbgl at Cantt, Dilkusha, Gulistan colony, Mahanagar- H Park, New Hyderabad, Lucknow University Old Campus, Rajajipuram, Narhi, River Bank colony and Vikas Nagar.

The water level during Post monsoon i.e., November'2009 is deepest in the central part and along Gomti river. Water level ranges from 6.85(at Rakabganj Crossing) to 33.70 mbgl (at Narhi).Water level is greater than 20 mbgl at Mahanagar-H Park,New Hyderabad, Vikas Nagar, Lucknow University Old Campus, Rajajipuram, Dilkusha, Cant, River bank colony and Gulistan Colony.

ii) Water Level Fluctuation :

Fluctuation of Pre and Post-monsoon water level data of Ground Water Monitoring Wells is tabulated and shown In Table-1. Most of the areas show fluctuation of water level in a range of 0 to 1 m .Few wells show fluctuation in the range of 1 to 2 m.

iii) Water Level trend:

Pre monsoon and Post monsoon DWL trends, based on DWL data collected from Piezometers in Lucknow urban area from the period 2003 to 2009, are compiled and tabulated in the Table-14.2. Table 14.2 reveals that all the Piezometers show decline in Pre-monsoon water level except at Arya Nagar and Campbell Road where rise is observed. The range of decline in Pre monsoon DWL is 0.40 to 0.99 m/year. The rate of decline in Pre monsoon period of 2003 to 2009 is categorized and given in Table14.2 :

Table 14.2: Categorisation of Pre-monsoon Trend for 2003 to 2008

Period: Pre monsoon of 2003 to 2008	**Number of Piezometers**
Total wells/Pz analysed	18
No. of wells showing declining trend	16
No. of wells showing decline of 0 – 25cm/year	0
No. of wells showing decline of 25 – 50cm/year	5
No. of wells showing decline of 50 – 75cm/year	5
No. of wells showing decline of 75cm – 1m/year	6

During Pre and Post monsoon period of 2003 to 2008 ,rate of decline is maximum at Gomti Nagar, Narhi and Indira nagar .

Table reveals that all the Piezometers show decline in Post-monsoon water level except at Arya Nagar,Dilkusha,Campbell road . The range of decline in Post monsoon DWL is 0.15 to 1.07 m/year. The rate of decline in Post monsoon period of 2003 to 2009 is categorized and given in Table 14.3:

Table14.3: Categorisation of Post-monsoon Trend for 2003 to 2008

Period: Post monsoon of 2003 to 2008	Number of Piezometers
Total wells/Pz analysed	18
No. of wells showing declining trend	15
No. of wells showing decline of 0 – 25cm/year	1
No. of wells showing decline of 25 – 50cm/year	5
No. of wells showing decline of 50 – 75cm/year	4
No. of wells showing decline of 75cm – 1m/year	4
No. of wells showing decline of > 1 m /year	1

ii) Groundwater resource potential

Ground water is a replenishable resource. Reasonable quantitative estimates are needed for drawing up plans for its utilisation, management and conservation. The ground water potential of an area has to be evaluated to regulate the withdrawl of water as large scale injudicious exploitation of ground water resources has led to declining water level in some areas whereas excessive surface water irrigation has caused water logging conditions in canal command areas.The ground water development in Lucknow City has taken place indiscriminately without regard to annual replenishment. The ground water level of a ground water reservoir fluctuates according to inputs to it and withdrawl from it.

Dynamic ground water resources of lucknow district as on 31.03.2004

Sl. No.	Assessment Units - Blocks	Annual Ground Water Recharge (in ham)	Net Annual Ground Water Availability (in ham)	Existing Gross Ground Water Draft For All Uses (in ham)	Net Ground Water Availability For Future Irrigation Development (in ham)	Stage of Ground Water Development (in %)	Category of Block
1	CHINHAT	8729.80	8293.31	6002.30	2141.56	72.38	SAFE
2	KAKORI	7125.60	6413.04	4751.00	1426.47	74.08	SEMI CRITICAL
3	SAROJANI NAGAR	9090.15	8181.13	7116.11	733.55	86.98	SEMI CRITICAL

The entire area has been covered during monitoring of Ground Water Monitoring wells in Pre- monsoon, Post-monsoon periods of 2009 and in January'2010. Designing of model initiated.

14.2 Coal Mining areas in Nagpur district

The Ground Water Modelling studies in one Watershed namely WGK-3, falling in the coal mining areas of Nagpur district has been incorporated in the ground water management studies. The study was commenced during AAP 2008-09 was continued in AAP 2009-10 also. For this study, the monitoring of monthly water levels was continued in the key wells already established in WGK-3 Watershed till March 2010. Some VES was carried out in the area to get additional input on the subsurface geology. One DWLR was installed at Shivnagar Kandri camp in Kandri village situated on the periphery of Kamptee opencast coal mines to study the behaviour of water level in the vicinity of the coal mine. Water level was recorded at each 2 hrs interval starting from 20th of February 2009. Detailed hydrogeological survey was carried out in the watershed to get maximum informations that can be user in the ground water model.

The conceptual model, model grid, initial boundary conditions was formulated and the data entry on to the computer model using PMWIN software was under progress. The model area covers a rectangular area of 23 km X 18 km with 92 columns and 72 rows with node spacing of 250 m.

14.3 Feasibility studies for reclamation of ravines using remote sensing techniqes in badnagar block of Ujjain district:

An area of 600 sq km was covered for reclamation of ravines using remote sensing techniques in the Chamala Watershed in parts of (TS 46M/8 and 46N/5), Badnagar block Ujjain District. IRPS P6-LIS-III data were procured (1:50,000) from NRSA. The field mapping along 16 villages were carried out to identify the extent and nature of ravines along the Chamla river. The post monsoon DW of the studied area varies between 15.10-27.10 mbgl. The discharge of shallow tube wells of depth ranges 60-90m varies in the range of 1.60-4.30 lps. The shallow alluvium aquifer occurs in the depth ranges 15.30-17.0m Thickenss of alluvium in the area varies from 19.80-22.50 m. 20 Recharge pond with recharge shaft are identify at feasible location have to developed saturation of pharatic aquifers. These structures are posed at discharge area microstructures and at contact of river Chamla in the south of Badmnagar area.

14.4 MER,Patna

(A) Patna urban area:

The city has near total dependence on ground water sources. There are 96 high discharge deep tube wells drawing about 375 MLD water. In addition about 40% of the households have their own private bore wells. Two Hundred and Eighty Four state owned hand pumps also caters the needs of the population. The city entirely depends upon ground water resources to meet its water requirement and has witnessed upswing in both vertical and horizontal expansion over the past few years leading to increased stress on ground water regime. Numerical modelling has been envisaged to work out the quantitative

sustainable limit for utilization of groundwater from principal aquifer.

Objectives:

(i) To ascertain the sustainable limit of utilization of ground water from the principal aquifer.

(ii) Simulating the ground water domain under different stress conditions i.e to project the response of ground water system to any assigned excitation and then employ the projected response to determine the feasibility of the assigned excitation.

(iii) to understand the ground water system in order to analyze various assumptions about its nature and dynamics

Conceptual model and model boundary: A two tier aquifer system exists within the urban area. The overlying layer forms several perched aquifers of limited lateral extent. The water level of this layer has been recorded at several locations through open dugwells and it has been found that these can be grouped into several separate entity. The levels of these perched aquifers and that of the underlying principal aquifer are markedly different within the urban area with the hydraulic head of the prinicipal aquifer resting at greater depth. However, towards the southern and the western part of the urban area i.e towards the Punpun and the Sone Rivers the hydraulic head as recorded in the dugwells and in the deep tube wells exhibit variation in a similar range. As is evident from the lithological records of the exploratory wells of CGWB drilled at Khagaul and Bikram, a single aquifer system exists towards the southern and western part. Similar aquifer configuration has also been delineated with the help of the geophysical investigations (VES) conducted in this part. It is thus clear that the recharge area of the prinicipal aquifer forming the lifeline of water supply system of Patna Urban area lies towards the Southern and Western margins with Punpun and Sone Rivers forming the physical boundary of this aquifer. The boundary towards the north is formed by Ganga River. The thickness of the overlying clay layer along this boundary is significant and extends below the bottom of the river bed. Thus the physical boundary of the principal aquifer is formed by River Ganga towards the north, Sone River towards west and Punpun Rriver towards South and east. The model boundary and the Grids are depicted in fig.14.4.

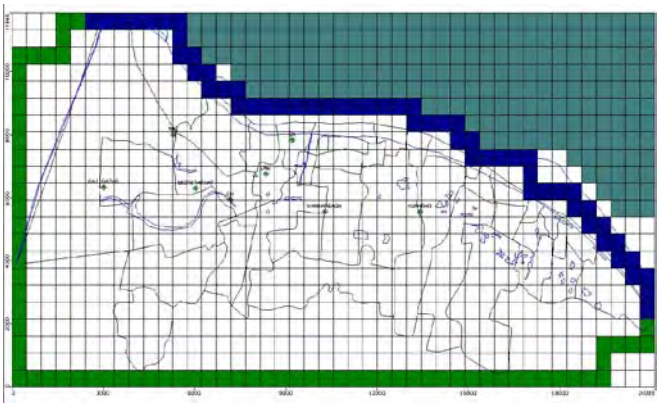


Fig 14.4: Model grids, boundary and inactive cells: The southern and the western boundary are the general head boundary. NW-SE flow of the river Ganga forms the northern and the eastern boundary.

Model Inputs:

Model Grids and top and bottom of the layer: The entire study area has been discretised into 44 columns and 22 rows with a uniform spacing of 500mX500m. The ground elevation data of 47 stations of the study area were assigned and these were interpolated for other locations through kriging. In similar fashion the bottom of layer 1 and 2 were also assigned for known locations and were interpolated through kriging for other locations.

Model grids, boundary and inactive cells: The southern and the western boundary are the general head boundary. NW-SE flow of the river Ganga forms the northern boundary.

Pumpig wells: Municipal water supply wells and their discharge data have been assigned to the respective grids and for other grids the pumping wells and its discharge has been assigned based on the water requirement worked from the population density.

Head monitoring stations: Systematic monitoring of the hydraulic head of the principal aquifer began from June 2008 as part of this study. The record of 2008-09 is being used for calibrating the model.

Initial head estimate: The initial head has been assigned based on the one time records of few wells drilled during the 1960's in different parts of the study area. This period may be considered valid for reasonable estimate of the initial head as groundwater extraction was comparatively very less.

Model Parameters:

a) Hydraulic conductivity**:** The principal aquifer has been divided into six hydraulic conductivity zones based on the pumping test data. The K value ranges from 45 m/day to 120 m/day

b) Specific storage: The specific storage of the principal aquifer at Patna has been worked out using the relationship Ss = $\rho wg(\alpha + \theta\beta)$

ρw = density of water, g = acceleration due to gravity, α = compressibility of aquifer skeleton, θ = porosity of aquifer material, β = compressibility of water.

The compressibility of aquifer skeleton made of sand/sandy gravel varies from 2x10-8 to 5.2x10-9 m^2/N and for water at 25^oC the compressibility is 4.6x10-6m^2/N. From the lithological record of exploratory wells of Central Ground Water Board (CGWB) it is apparent that the predominant aquifer material forming the deeper aquifer is coarse sand or gravely sand having 20% porosity (approx.). Calculated Ss varies between $7.93016x10^{-5}$ and $1.47902x10^{-4}$. The mean Ss has been considered as $1.14x10^{-4}$. With these data inputs the model fabrication has been completed. The model is under calibration stage.

B) Ranchi urban area:

As part of groundwater modeling study for Ranchi Urban area, monthly monitoring of water level of 37 key wells is being carried out since April 2007. At present 40 dug wells and 13 piezometers are being monitored for the study. Based on the data generated quarterly Ground Water Bulletin for Ranchi urban area the period Apr – June'09 , July-Sep'09 & Oct-Dec'09 , Jan'-March'10 has been released.

14.5 Ground water modeling studies, Bist-Doab, Punjab

A ground water modeling study of Bist-Doab area is under progress with a view to develop a mathematical model to simulate hydrogeological conditions and ground water flow systems in the area and generate alternate management scenarios and also develop optimal allocation for the water resources. The studies have been taken in view of most of the blocks in this region falling under the over exploited category. During 2009-10 following activities were taken up

- Monthly monitoring of selected wells and compilation of water level data.
- Digitization of the base map and river stage map
- Compilation of all the data.

14.6 ER, KOLKATA

Annual target	Achievement
Ground water modeling study in Jangipara block of Hugli district, West Bengal.	▪ Preparation & digitization of soil maps. ▪ Estimation of no. of draft wells from Minor Irrigation Census & WBSEB well energization data. ▪ Preparation of digitized elevation map using SRTM data and imagery mosaic using google earth data. ▪ Compilation of village level data regarding population. ▪ Demarcation of village boundary and preparation of land use map. ▪ Compilation of Borehole data ▪ Completed Geophysical Survey (VES) ▪ Completed construction of one EW ▪ Compilation of water body data. ▪ Compilation of rainfall data • Computation of evapo-transpiration from rainfall data. • Attended Modelling training.
Ground water modeling study in arsenic affected blocks of Amdanga, Barasat-I & II, and Habra-II in North 24 Parganas district, West Bengal	i.Demarcate shallow, deep observation well in model area & input of depth to water level (msl) data of observation well. ii.Evapotranspiration data entry is under progress. iii.Grid wise ground water abstraction structure with discharge. iv.Digitised base map of the study area. v.Determined total volume of ground water abstraction in the study area. vi.Grid wise rl value entered. vii.Compilation of borehole lithological log. viii.Compilation of geophysical log. Completed basic data report of constructed exploratory wells at uludanga and bokunda in the model area. ix.Compilation of rainfall data. x.Data entry of storage and conductivity for all four layers into the modflow software.

14.7 Groundwater Flow modelling in coastal aquifers of southern part of Chennai Metropolitan area, Tamil Nadu

Background Information

In the study entitled *"Hydrodynamics of Coastal Aquifers in Southern part of Chennai Metropolitan Area, Tamil Nadu"*

carried out by the region, the conceptualisation of the coastal aquifers of Southern part of Chennai Metropolitan Area was brought out using conventional techniques of hydrogeology, hydrochemistry and isotope techniques but the author could only attempt budgeting using lumped model approach but distributed model could not be completed due to data constraints.

In the present study, the results of earlier work were taken as input for the modelling studies and an attempt was made to simulate the groundwater flow conditions in the area. The depth to water level data for the period Jun 2000 - May 2005 was used to calibrate and validate the groundwater flow model and predictive simulation was attempted for the period Jun 2005 to May 2015 with different strategies to formulate sustainable groundwater development plan.

The study area comprising coastal aquifer of southern part of Chennai Metropolitan Area is located between longitudes $80^{o}13'30''$ and $80^{o}16'30''$ and Latitudes $12^{o}48'15''$ and $12^{o}59'15''$. The area is bounded by Bay of Bengal in the east and Kovalam Creek on the south while in the north Tiruvanmiyur area was taken as boundary and about 1 – 3 km west of Buckingham canal was taken as western boundary.

Processing Modflow Version 5.3 was used for groundwater flow modelling in the present study. Only the top sandy layer was considered for modeling purposes and hence the number of layer considered for the modeling is one. Initially, the model has been run in steady state condition. The parameters were adjusted and smoothened head was taken as initial piezometric head for transient flow simulation.

Results and Discussion

The model was run and the results were studied. The water budget was taken up to 11^{th} Stress Period, covering the period from July 2000 – May 2001. The cumulative water budget for the distributed model shows that there is an inflow of 13.700743 M.Cu.m while there is an outflow of 13.700729 M.Cu.m with a change in storage of 0.000014 M.Cu.m.

In order to validate and calibrate the model data, spatial variation of both observed and simulated water table elevation data of the study area at the end of stress period 11 (May 2001) has been compared and furnished. A perusal of the figure shows that there is a good match between the two values. Subsequently, the calibration and validation has been extended up to 59^{th} stress period (May 2005) and plot of both observed and simulated water table elevation data is depicted in Fig. 14.7.1& Fig 14.7.2. A comparison of the simulated and observed values showed there is a good match between the two.

In the next step, the temporal variation of observed and simulated water table elevations has been compared using hydrograph analysis. The plots of observed and simulated water level are given below in Fig. 14.7.3 & Fig 14.7.4 along with the variance in the computed and observed values. A perusal of the figure shows that the difference in the observed and simulated values are less than 0.5m and the variance of the computed and observed values also range between 0.16 to 0.6, thereby indicating a sufficiently good match. As per the modeling protocol, the predictive simulation can be extended up to 3.5 times the validated period. In the present study, the model has been validated for the period of Jun 2000 to May 2005 for a period of 5 years. It was decided to carry out predictive simulation for additional 10 years, ie., up to 2015, as the coastal system is fragile and can have faster rate of development. Hence the predictive simulation has been restricted only up to 2015.

The predictive simulation was extended up to 179 stress periods (May 2015). The various option consisting of increasing draft, increasing recharge and its combination have been tested. The increase in draft has been uniformly spread all over the area in all the stress periods but the recharge has been restricted to the monsoon month (June-December) and only in the selected cells eastern side of Buckingham canal, which border the sand dune formations so as to have the maximum impact of recharge.

The various options tested are as follows.

1. Recharge using Normal rainfall & same draft – STRATEGY1
2. Recharge using normal rainfall using 10% addition in draft- STRATEGY2
3. Recharge using normal rainfall using 25% addition in draft – STRATEGY3
4. 10% augmentation with 25% additional draft- STRATEGY4
5. 25% augmentation with 25% additional draft- STRATEGY5
6. 10% augmentation with the same draft- STRATEGY6

A perusal of the table shows that in Strategy 1 & 6, where the groundwater draft has not been increased show positive inflow-outflow, while Strategy 3, 4 & 5 show negative inflow-outflow, where groundwater draft has been increased. It is also to add that with increase in draft by 10% in Strategy 2, still the inflow-outflow has remained positive. In strategy 4&5, the recharge has also been augmented by 10% & 25% respectively and even then the inflow-outflow component is negative. The same results

have been pictorially represented to visualize the changes in inflow-outflow component over the years (Fig. 14.7.5).
The inflow-outflow component of groundwater budgeting may give for the whole model domain but there may be select patches showing declining or rising water level. In order to study the vulnerable pockets, the spatial variation of rise/fall in water level was studied for all strategies.

A perusal of the figures (Fig. 14.7.5) show that the fall in water level are generally found on the eastern side of the study area around Kottivakkam, Nilangarai, Injambakkam & Uthandi, where metrowater wells are used for domestic water supply. In Strategy1, where the existing recharge and groundwater draft has been continued, it is restricted to Kotivakkam to Injambakkam area, while it spreads to Uthandi also in Strategy 2, where the draft has been increased by 10% from 60th Stress Period onwards (June 2006). In strategy 3, where groundwater draft has been increased to 25%, the fall has spread to western side and also to the southern side up to Muthukadu. In strategy 4 & 5, where 10% & 25% augmentation has been effected in select cells as shown and uniform increase of 25% groundwater draft, there is not much change with respect to strategy 3. In strategy 6, where 10% augmentation has been effected in select cells as shown and the existing groundwater draft, there is certain reduction in the area showing fall in comparison to Strategy1. It indicates that the impact of groundwater draft on lowering the water table is more pronounced than the rise in water level due to augmentation. It is all the more pertinent to regulate groundwater extraction in addition to groundwater augmentation.

It is very difficult to reduce the groundwater extraction with out the participation of all the stake holders including public & government. It would be ideal to reduce the groundwater extraction but being on the pragmatic side, it is suggested that the strategy 6 comprising continuance of existing groundwater draft with augmentation in the select cells by 10% during the monsoon period may be adopted for the management coastal aquifers in the southern part of Chennai Metropolitan area.

14.8 Groundwater flow modelling in parts of ruparail river basin, Alwar district, Rajasthan

Ruparail River Basin covering parts of Alwar district experiences extreme environmental conditions of drought and erratic rainfall. In recent years groundwater withdrawal from Ruparail river basin has increased to meet the growing demands of domestic, Industrial and agricultural sectors. This has resulted in over exploitation of aquifers and reduction in availability of fresh groundwater.

Central Ground Water Board is taking active role injudicious management of groundwater resources and its response to various recharge and pumping rates in the study area. However, lack of adequate hydro-geological data is one of the greatest challenges for planning and management of groundwater resources. The study herein is undertaken to enhance the understanding of the groundwater flow system through development of groundwater flow model and to provide a comprehensive hydro-geological analysis of the aquifer system.

Objective

An understanding of the groundwater flow system can be achieved through the review and compilation of available information, development of conceptual geological model and construction of three dimensional groundwater flow model that represents the elements of the conceptual geological model. The groundwater model can be utilized as a tool to further understand and simulate the groundwater flow system.

To meet the objective, following goals have been identified for the study:

1. Development of spatially referenced database of hydrogeological information for visualization of regional hydrogeological scenario and construction of numerical model.
2. Development of a Regional Scale three dimensional conceptual geological model within the study area.
3. Develop and calibrate a steady state regional groundwater flow model.
4. Develop and calibrate a transient regional groundwater flow model.
5. Behavior of Groundwater regime under different hypothetical scenarios.

MAJOR TASKS

To achieve the goals, following major task will be completed:

Fig 14.7.1

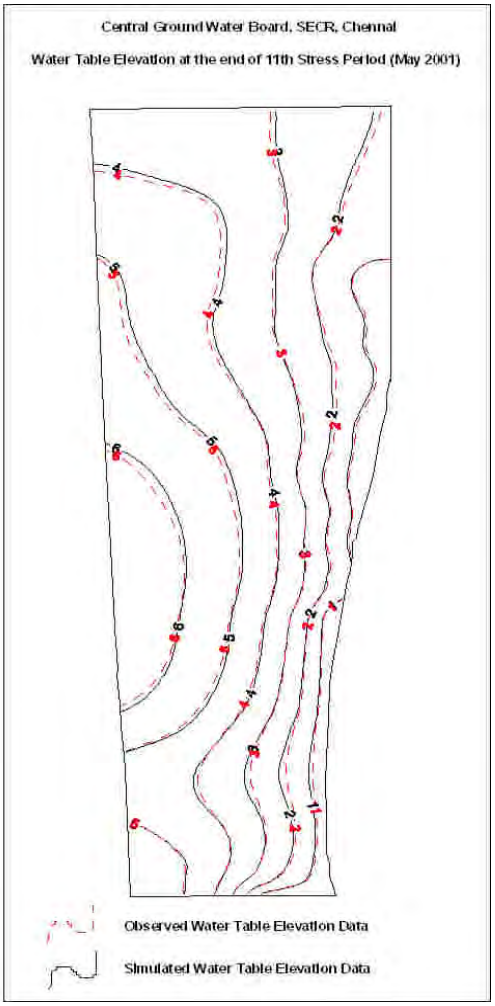


Fig 14.7.2

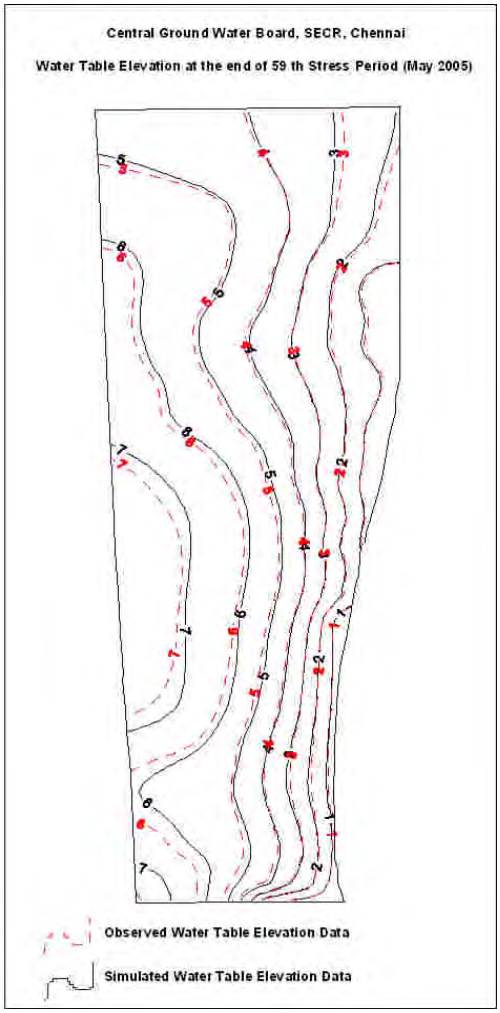


Fig 14.7.3

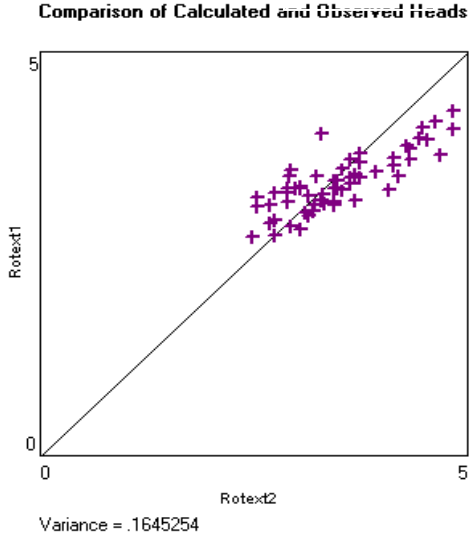
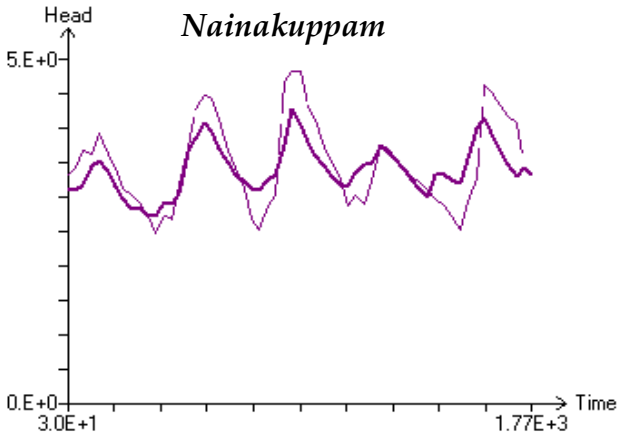


Fig 14.7.4



(a) Identify, acquire and review all available data including previous studies.

(b) Develop a spatially referenced data base of information on the hydrogeology of the study area and complete mapping using GIS to characterize the aquifer and aquitards.

(c) Identify regional and local boundaries for groundwater flow and develop a conceptual geological model.

(d) Construct and calibrate a three dimensional hydrogeological model based on conceptual geological model. The focus of the model calibration will be at the regional scale.

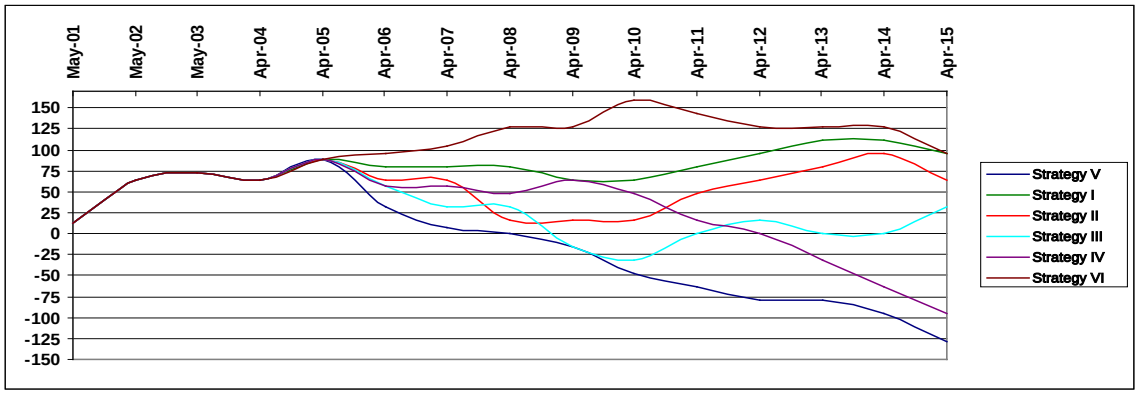
(e) Apply the groundwater model to evaluate groundwater flow condition and flow rates for different hypothetical future scenarios in the area.

Stataus of work done

Task (a) to (c) have been completed for the development of flow model.

The approach taken to construct the three dimensional geologic model which will be used to build and calibrate the groundwater flow model. The model being developed will represent the full three dimensional regional groundwater flow and extend deep into the underlying bedrock to incorporate interaction with deepergroundwater system. Through this approach the model being developed will allow district authorities to accurately evaluate water balance and assess the potential impact of additional stress on the water balance. In addition, this model provides a robust and flexible tool that can be updated as new information becomes available and refined as necessary to focus calibration and prediction capabilities in local areas of concern.

Fig. 14.7.5



15. CENTRAL GROUND WATER AUTHORITY CGWA)

In pursuance of the order passed by the Hon'ble Supreme Court of India, Central Ground Water Board has been constituted as Central Ground Water Authority (CGWA) under sub-section (3) of Section 3 of the Environment (Protection) Act, 1986 vide notification No. S.O. 38 (E) dated 14.1.97 for the purpose of regulation and control of ground water management and development in the country.

The Central Ground Water Authority is functioning under the Administrative control of the Government of India in the Ministry of Water Resources with its Headquarters at Delhi. CGWA is headed by the Chairman and 14 other members from different Ministries/Department/Organisations/institutions of Government of India including all the 4 Members of CGWB. 5 additional members, one each member from Department of Legislative, Department of Legal Affairs, Central Public Health & Environmental Engineering Organization under Ministry of Urban Development, National Commission for Women and Department of Drinking Water Supply under Ministry of Rural Development have been approved recently for inclusion in the composition of CGWA.

The Authority performs the following functions: -

i. Exercise of powers under section 5 of the Environment (Protection) Act, 1986 for issuing directions and taking such measures in respect of all the matters referred to in sub-section (2) of section 3 of the said Act.
ii. To resort to penal provisions contained in sections 15 to 21 of the said Act.
iii. To regulate and control, management and development of ground water in the country and to issue necessary regulatory directions for the purpose.
iv. Exercise of powers under section 4 of the Environment (Protection) Act, 1986 for the appointment of officers.

Decentralization of powers and functions of CGWA-

As part of streamlining the regulatory function of "Central Ground Water Authority (CGWA)", District Magistrates have been appointed as authorized officers for grant of permission for extraction of ground water for drinking/domestic uses in 36 out of 43 blocks/talukas notified by CGWA in 10 States for ground water regulation. They have been advised to process requests for grant of permission for extraction of ground water for drinking/domestic purposes in notified areas as per guidelines issued by CGWA. Central Ground Water Authority has also framed revised guidelines for grant of NOC for ground water abstraction by industries/projects in the country.

Website of CGWA: The detailed activities and achievements of CGWA have been put on the website of CGWB at http:// cgwb.gov.in/ GroundWater/ gw_regulation.htm

Micro level studies: Micro level studies have been taken up in the following notified /OE areas.

(A) Taoru Block, District Mewat, Haryana: A microlevel survey in the taoru block, district mewat, haryana was carried out covering 225 sq. Km. Area. The area is facing scarcity of water and the water level are very deep. The depth to water level ranges from 13.29 m bgl at Tauru to 31.75 m bgl at Sahsola. Around ten numbers of big resort with golf game facility are there in Taoru block and are exploiting water through deep tubewells. It is necessary to regulate the ground water withdrawl. The ground water in Taoru block is potable, EC, Nitrate Chloride and Fluoride are within permissible limits

(B) **Over Exploited blocks of Nagari Mandal in Chitoor** : Micro Level Studies: Micro Level studies have taken up in Over Exploited blocks of Nagari Mandal in Chitoor District. Village wise survey was carried out and data was collected. Report is under process.

16. GROUND WATER MANAGEMENT STUDIES IN DROUGHT PRONE AREA

An area of 31329 sq. km. categorized as drought prone in Rajasthan, Maharashtra, Orissa, Andhra Pradesh and Karnataka States of the country under ground water management studies. In addition to this, 246 bore holes (161 EW, 45 OW & 40 PZ) by departmental rigs were drilled in drought prone areas of Karnataka, Kerala, Madhya Pradesh, Orissa, Rajasthan and Uttar Pradesh States.

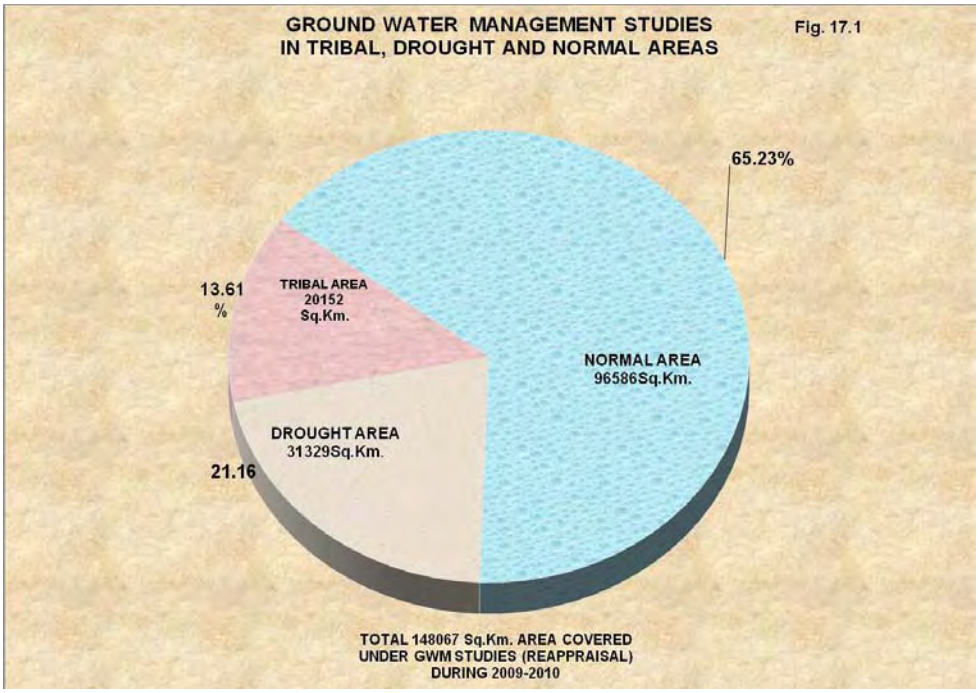
Table 16.1 : Area covered under ground water management studies in drought prone areas (DURING 2009-2010)

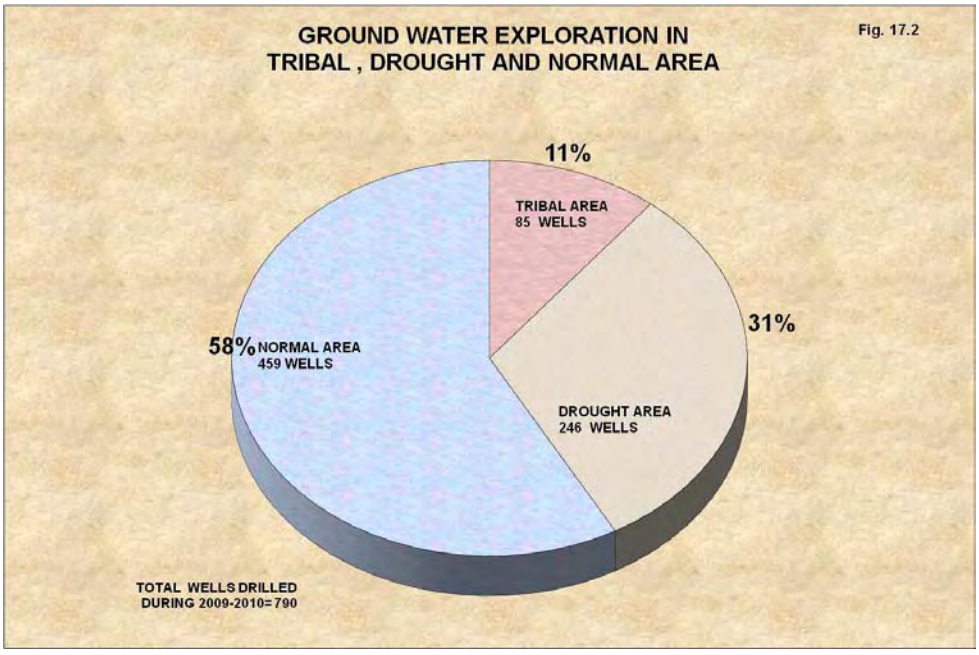
Details of area covered under ground water management studies and status of exploration in drought prone areas are shown in Table 16.1, 16.2 & Fig 17.1 & depicted in 17.2 respectively.

Sl. No.	Regions/ State	Districts	Achievement Sq.Km.
1.	**WESTERN REGION**	Churu district(part)	5897
		Dholpur district	3009
	Rajasthan	**Total**	**8906**
2.	**CENTRAL REGION**	Ahmednagar	3590
	Maharashtra	**Total**	**3590**
3.	**SOUTH EASTERN REGION**	Anugul (Mining)	3000
	Orissa	Anugl(Industries)	3000
		Parts of Sambalpur	3000
		Total	**9000**
4.	**SOUTHERN REGION**	Ranga Reddy	110
	Andhra Pradesh	Mahbubnagar	95
		Chitoor	3650
		Total	**3855**
5.	**SOUTH WESTERN REGION**	Hassan	1550
	Karnataka	Koppal	2703
		Parts of Chikmagalur, Shimoga & Davanagere	1100
		In parts of Chitraddurga district	625
		Total	**5978**
GRAND TOTAL			**31329**

Table 16.2 : Exploratory wells drilled in "drought prone" area
(2009-2010)
(By Departmental Rigs)

Sl. No	States	Districts	EW	OW	PZ	T
1	Karnataka	Chamrajnagar	05	02	-	07
		Belgaum	2	-	-	2
		Kolar	05	03	-	08
		Gulbarga	13	03	-	16
		Total	**25**	**08**	**-**	**33**
2	Kerala	Kollam	3	2	-	5
		Pathnamthitta	7	3	-	10
		Total	**10**	**05**	**-**	**15**
3	Madhya Pradesh	Sagar	6	1	7	14
		Panna	9	3	9	21
		Damoh	24	6	11	41
		Total	**39**	**10**	**27**	**76**
4	Maharashtra	Satara	11	4	-	15
		Total	**11**	**4**	**-**	**15**
5	Orissa	Mayurbhanj	7	3	-	10
		Deogarh	11	3	-	14
		Boudh	3	3	-	6
		Sundergarh	13	3	-	16
		Nuapada	7	2	-	9
		Sonepur	8	-	-	8
		Total	**49**	**14**	**-**	**63**
6	Rajasthan	Dausa	-	-	2	2
		Ganganagar	1	-	-	1
		Hanumangarh	4	1	3	8
		Bikaner	1	-	6	7
		Jaisalmer	2	2	-	4
		Bharatpur	10	-	2	12
		Total	**18**	**03**	**13**	**34**
7	Uttar Pradesh	Chitrakoot	3	1	-	04
		Alahabad	6	-	-	06
		Total	**09**	**01**	**-**	**10**
GRAND TOTAL			**161**	**45**	**40**	**246**


GROUND WATER MANAGEMENT STUDIES
IN TRIBAL, DROUGHT AND NORMAL AREAS
Fig. 17.1
65.23%
13.61
%
TRIBAL AREA
20152
Sq.Km.
NORMAL AREA
96586Sq.Km.
DROUGHT AREA
31329Sq.Km.
21.16
TOTAL 148067 Sq.Km. AREA COVERED
UNDER GWM STUDIES (REAPPRAISAL)
DURING 2009-2010


GROUND WATER EXPLORATION IN
TRIBAL , DROUGHT AND NORMAL AREA
Fig. 17.2
11%
TRIBAL AREA
85 WELLS
31%
58%
NORMAL AREA
459 WELLS
DROUGHT AREA
246 WELLS
TOTAL WELLS DRILLED
DURING 2009-2010= 790

17. GROUND WATER MANAGEMENT STUDIES IN TRIBAL AREAS

The Central Ground Water Board, in its 2009-2010 Annual Action Plan gave emphasis to Ground Water Management Studies and exploratory drilling programme in districts falling under tribal areas of the country. An area of 20152 sq. km. was covered in Madhya Pradesh, Chhattisgarh, West Bengal and Jharkhand States under tribal areas and 85 bore hole (EW- 40, OW-22, PZ- 23) were drilled in Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra and West Bengal States under tribal areas of the country to explore the possibility of tapping potential aquifers.

The status of coverage under ground water management studies and exploratory drilling in tribal areas are given in Tables 17.1 & 17.2. and depicted in Fig 17.1 & 17.2 respectively.

Table 17.1 : AREAS COVERED UNDER GROUND WATER MANAGEMENT STUDIES IN TRIBAL AREAS DURING 2009-2010

Sl. No	Regions/state	District	Achievement (Sq.Km.)
1.	**NORTH CENTRAL REGION** Madhya Pradesh	Umaria, Annuppur	7851
		Total	**7851**
2.	**NORTH CENTRAL CHHATTISGARH REGION**	Korba and Durg	5437
		Total	**5437**
3.	**EASTERN REGION** West Bengal	Uttar Dinajpur	2284
		Murshidabad	310
		Birbhum	770
		Total	**3364**
4.	**MID EASTERN REGION** Jharkhand	East Singhbhum	3500
		Total	**3500**
GRAND TOTAL			**20152**

Table 17.2 : EXPLORATORY WELLS DRILLED IN "TRIBAL" AREA DURING 2009-2010
(by Departmental Rigs)

Sl. No	States	Districts	EW	OW	PZ	T
1.	Chattisgarh	Surguja	07	5	-	12
		Korba	-	-	08	08
		Durg	-	-	15	15
		Dhamtari	10	8	-	18
		Total	**17**	**13**	**23**	**53**
2.	Jharkhand	Bokaro	10	05	-	15
		Total	**10**	**05**	**-**	**15**
3.	Madhya Pradesh	Betul	1	1	-	02
		Dindori	2	-	-	02
		Total	**03**	**01**	**-**	**04**
4.	Maharashtra	Raigarh	1	1	-	02
		Thane	6	1	-	07
		Total	**07**	**02**	**-**	**09**
5.	West Bengal	Dakshin Dinajpur	1	-	-	01
		Birbhum	2	1	-	03
		Total	**03**	**01**	**-**	**04**
Grand Total			**40**	**22**	**23**	**85**

18. ESTIMATION OF GROUND WATER RESOURCE BASED ON GEC - 1997 METHODOLOGY

As per the National Water Policy 2002, the ground water resource potential need to be re-assessed periodically on scientific basis. Accordingly, the ground water resource of the entire country is being re-assessed jointly by the Central Ground Water Board and the States based on the Ground water resources estimation methodology, (GEC – 97) .

The Total Annual Replenishable Ground Water Resources of the Country have been reassessed as 433 Billion Cubic Metres (bcm) and the Net Annual Ground Water Availability is estimated as 399 bcm. Annual Ground Water Draft as on March, 2004 for all uses is 231 bcm. The Stage of Ground Water Development is 58%. The state – wise availability of ground water resources is given in Table 18.1.

The development of ground water in different areas of the Country has not been uniform. Highly intensive development of ground water in certain areas in the country has resulted in over – exploitation. As per the latest assessment of ground water resources out of 5723 assessment units (Block/Mandals/Talukas) in the country, 839 units in various States have been categorized as ' over-exploited' i.e. the annual ground water draft exceeds the annual Replenishable ground water resources and significant decline in long term ground water level trend has been observed either in pre-monsoon or post-monsoon or both. In addition 226 units are 'Critical' where the stage of ground water development is 100% of annual replenishable ground water resource and significant decline is observed in the long term water level trend in both pre-monsoon and post-monsoon periods. There are 550 semi-critical units, where the stage of ground water development is between 70 - 90% and significant decline in long term water level trend has been recorded in either Pre-monsoon or Post-monsoon. The state – wise status of over – exploited and critical and semi-critical areas is given in Table 18.2.

Table 18.1: STATE-WISE GOUND WATER RESOURCES AVAILABILITY, UTILIZATION AND STAGE OF DEVELOPMENT

Sl. No.	States/ UTs	Annual Replenis-hable Ground Water Resource	Natural Discharge during non-Monsoon season	Net Annual Ground Water Availability	Annual Ground Water Draft			Stage of Ground Water Development (%)
					Irrigation	Domestic and Industrial uses	Total	
1	2	3	4	5	6	7	8	9
	States							
1	Andhra Pradesh	36.50	3.55	32.95	13.88	1.02	14.90	45
2	Arunachal Pradesh	2.56	0.26	2.30	0.0008	0	0.0008	0.04
3	Assam	27.23	2.34	24.89	4.85	0.59	5.44	22
4	Bihar	29.19	1.77	27.42	9.39	1.37	10.77	39
5	Chattisgarh	14.93	1.25	13.68	2.31	0.48	2.80	20
6	Delhi	0.30	0.02	0.28	0.20	0.28	0.48	170
7	Goa	0.28	0.02	0.27	0.04	0.03	0.07	27
8	Gujarat	15.81	0.79	15.02	10.49	0.99	11.49	76
9	Haryana	9.31	0.68	8.63	9.10	0.35	9.45	109
10	Himachal Pradesh	0.43	0.04	0.39	0.09	0.02	0.12	30
11	Jammu & Kashmir	2.70	0.27	2.43	0.10	0.24	0.33	14
12	Jharkhand	5.58	0.33	5.25	0.70	0.38	1.09	21
13	Karnataka	15.93	0.63	15.30	9.75	0.97	10.71	70
14	Kerala	6.84	0.61	6.23	1.82	1.10	2.92	47
15	Madhya Pradesh	37.19	1.86	35.33	16.08	1.04	17.12	48
16	Maharashtra	32.96	1.75	31.21	14.24	0.85	15.09	48
17	Manipur	0.38	0.04	0.34	0.002	0.0005	0.002	0.65
18	Meghalaya	1.15	0.12	1.04	0.00	0.002	0.002	0.18
19	Mizoram	0.04	0.004	0.04	0.00	0.0004	0.0004	0.90
20	Nagaland	0.36	0.04	0.32	0.00	0.009	0.009	3
21	Orissa	23.09	2.08	21.01	3.01	0.84	3.85	18
22	Punjab	23.78	2.33	21.44	30.34	0.83	31.16	145
23	Rajasthan	11.56	1.18	10.38	11.60	1.39	12.99	125
24	Sikkim	0.08	-	0.08	0.00	0.01	0.01	16
25	Tamil Nadu	23.07	2.31	20.76	16.77	0.88	17.65	85
26	Tripura	2.19	0.22	1.97	0.08	0.09	0.17	9
27	Uttar Pradesh	76.35	6.17	70.18	45.36	3.42	48.78	70
28	Uttaranchal	2.27	0.17	2.10	1.34	0.05	1.39	66
29	West Bengal	30.36	2.90	27.46	10.84	081	11.65	42
	Total States	**432.43**	**33.73**	**398.70**	**212.38**	**18.04**	**230.44**	**58**
	Union Territories							
1	Andaman & Nicobar	0.330	0.005	0.320	0.000	0.010	0.010	4
2	Chandigarh	0.023	0.002	0.020	0.000	0.000	0.000	0
3	Dadra & Nagar Haveli	0.063	0.003	0.060	0.001	0.007	0.009	14
4	Daman & Diu	0.009	0.0004	0.008	0.007	0.002	0.009	107
5	Lakshdweep	0.012	0.009	0.004	0.000	0.002	0.002	63
6	Pondicherry	0.160	0.016	0.144	0.121	0.030	0.151	105
	Total Uts	**0.597**	**0.036**	**0.556**	**0.129**	**0.051**	**0.181**	**33**
	Grand Total	**433.02**	**33.77**	**399.25**	**212.51**	**18.09**	**230.62**	**58**

Table 18.2: CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN INDIA AS ON 31st MARCH, 2004

Sl. No.	States /Union Territories	Total No. of Assessed Units	Semi-Critical		Critical		Over-exploited		Remarks
			Nos.	%	Nos.	%	Nos.	%	Nos.
	States								
1	Andhra Pradesh	1231	175	14	77	6	219	18	-
2	Arunachal Pradesh	13	0	0	0	0	0	0	-
3	Assam	23	0	0	0	0	0	0	-
4	Bihar	515	0	0	0	0	0	0	-
5	Chattisgarh	146	8	5	0	0	0	0	-
6	Delhi	9	0	0	0	0	7	78	-
7	Goa	11	0	0	0	0	0	0	-
8	Gujarat	223	69	31	12	5	31	14	Rest 14 talukas Saline
9	Haryana	113	5	4	11	10	55	49	-
10	Himachal Pradesh	5	0	0	0	0	0	0	-
11	Jammu & Kashmir	8	0	0	0	0	0	0	-
12	Jharkhand	208	0	0	0	0	0	0	-
13	Karnataka	175	14	8	3	2	65	37	-
14	Kerala	151	30	20	15	10	5	3	-
15	Madhya Pradesh	312	19	6	5	2	24	8	-
16	Maharashtra	318	23	7	1	0	7	2	-
17	Manipur	7	0	0	0	0	0	0	-
18	Meghalaya	7	0	0	0	0	0	0	-
19	Mizoram	22	0	0	0	0	0	0	-
20	Nagaland	7	0	0	0	0	0	0	-
21	Orissa	314	0	0	0	0	0	0	Rest 6 blocks Saline
22	Punjab	137	4	3	5	4	103	75	-
23	Rajasthan	237	14	6	50	21	140	59	Rest 1 block Saline
24	Sikkim	1	0	0	0	0	0	0	-
25	Tamil Nadu	385	57	15	33	9	142	37	Rest 8 blocks Saline
26	Tripura	38	0	0	0	0	0	0	-
27	Uttar Pradesh	803	88	11	13	2	37	5	-
28	Uttaranchal	17	3	18	0	0	2	12	-
29	West Bengal	269	37	14	1	0	0	0	-
	Total States	5705	546	10	226	4	837	15	-
	Union Territories								
1	Andaman & Nicobar	1	0	0	0	0	0	0	-
2	Chandigarh	1	0	0	0	0	0	0	-
3	Dadra & Nagar Haveli	1	0	0	0	0	0	0	-
4	Daman & Diu	2	1	50	0	0	1	50	-
5	Lakshdweep	9	3	33	0	0	0	0	-
6	Pondicherry	4	0	0	0	0	1	25	Rest 1 Region Saline
	Total UTs	**18**	**4**	**22**	**0**	**0**	**2**	**11**	**1**
	Grand Total	**5723**	**550**	**10**	**226**	**4**	**839**	**15**	**30**

Blocks- Bihar, Chhattisgarh, Haryana, Jharkhand, Kerala, Madhya Pradesh, Manipur, Mizoram, Orissa, Punjab, Rajasthan, Tamilnadu, Tripura, Uttar Pradesh, Uttaranchal , West Bengal

Mandals (command/ non-command) - Andhra Pradesh

Talukas - Goa, Gujarat, Karnataka, Maharashtra

Districts - Arunachal Pradesh, Assam, Delhi, Meghalaya, Nagaland

Districts (Valley) - Himachal Pradesh, Jammu & Kashmir

State – Sikkim

Islands – Lakshdweep

UT - Andaman & Nicobar, Chandigarh, Dadra & Nagar Haveli,Daman & Diu, Pondicherry.

19.0 TECHNICAL SCRUTINY / EXAMINATION OF SCHEME / PROPOSALS

19.1 MAJOR AND MEDIUM IRRIGATION SCHEME / PROPOSALS

As per the directives of the Planning Commission, the Board scrutinizing the major and medium irrigation project reports/proposals from State Govt. , Central Water Commission, Command Area Development and Water Management from the point of view of their impact on ground water regime and specific recommendations are being made to protect quality and quantity of ground water. During 2009-10 (up to 31st March, 2010), thirteen major irrigation project proposals of Central Water Commission listed below were examined and are listed below.

i. Halon Irrigation Project, Madhya Pradesh.
ii. Upper Narmada Irrigation Project, Madhya Pradesh.
iii. Umarhut Pump Canal Phase II Project, U.P.
iv. Lower Wardha Project.
v. Rajeev Samoda Nisada Diversion Scheme, Chhattisgarh.
vi. Bembla River Project, Maharashtra.
vii. ERM of Mahanadi Reservoir, Chattisgarh.
viii. Upper Wardha Project, Maharashtra.
ix. Warna Irrigation Project, Maharashtra.
x. Malprabha Irrigation Project, Karnataka.
xi. Bhima Lift Irrigation Scheme, Karnataka.
xii. Lower Dudhna Project, Maharashtra.
xiii. Andhra Pradesh Water Sector Improvement Project.

20. REMOTE SENSING STUDIES

Satellite images/ aerial photographs / remote sensing soft ware are being utilized by Central Ground Water Board for ground water studies . These studies provide Science &Technology back up to ground water exploratory drilling programme, ground water management studies, conjunctive use studies, mathematical modeling, ground water pollution studies and artificial recharge studies. Central Ground Water Board has taken up the following Remote Sensing studies during 2009-10.

20.1 NWR, Chandigarh

A study was conducted to demarcate the active flood plains of the river Yamuna using Remote Sensing techniques and consequently develop a methodology which could be utilized for flood plains of Haryana to estimate the ground water potential and recharge potential of these geological units/ hydrogeological units. An attempt was also made to check the feasibility and to calculate the amount of water that can be withdrawn from these shallow aquifers during the pre-monsoon period and refilling these shallow aquifers during monsoon floods even with lesser recurrence interval, so that they can provide water on sustainable basis in flood plain area, especially during crises or to support water based activity in state.

The result of the above study revealed that Active flood plains if managed properly holds the answer for problem of utilizing excess flow of monsoon water. During non-monsoon period flood water travel time in the entire stretch of Yamuna river in Haryana State, has been estimated to be 4 days, whereas during monsoon period it reduces to 1.56 days. It is Herculean task to utilize this excess water during monsoon period. However if space is created in aquifer of flood plains to accommodate this water a part of it can be utilized. Space can be created by lowering the water table by developing the ground water potential of the area. During the flooding of the excess water, contact area of aquifer increases and having the higher transmissivity this area holds a potential status for direct recharge.

Active flood plains have recharge potential of the order of 1250 MCM. Out of this 350 MCM potential can be generated by raising the water table by 3.0 m and other 900 MCM can be created by lowering the water table by 5.0 m. This water can be utilized by the Haryana state for water based activities. In addition ground water development potential can be created by dewatering the first aquifer of the active flood plains by 5.0 m. Active flood plain holds the potential of ground water to the tune of 500 MCM which can be supplied to nearby areas to be used by town/ cities/ industries to support their water based activities.

20.2 WR, Jaipur

Pre-monsoon Studies for reclaimation of Ravines in Sawai Madhopur district completed. Data procurement from NRSC, Hyderabad in progress.

20.3 NR, Lucknow

Ground Water Management Studies in parts of Kanpur Dehat, Hamirpur & Jalaun districts covered in S.O.I., Topographic sheet Nos. 54N/15 & 54N/16 by Remote Sensing techniques (Ravine studies in Sengar river water shed in parts of Kanpur Dehat district & adjoining areas in Hamirpur & Jalaun districts).

The special study has been taken up basically with a broad objective to suggest, through remote sensing studies, the measures to conserve and upgrade land and water resources of the area in an integrated manner to restore ecological balance and arrest rapid degradation of land under the Ground Water Management Studies of AAP 2009-10.

The study was conducted in a targeted area of 1375 Sq Km. covered under Survey of India Topographic Sheets No 54N/15 & 54N/16 covering parts of Sengar river water shed in Kanpur Dehat District, U.P.

The remote sensing interpretation were done on Black & White MSS images and FCC's and currently acquired Satellite data (IRS-1D LISS III Geo- coded 54N/15 & 54N/16) for the mapping of ravine land. The image interpretations were validated through field checks.

The large parts of the area form plain topography with highly undulating surfaces in the vicinity of the trunk river which is resulted due to heavy fluvial erosion. The Yamuna River and its tributary Sengar river flows in meandering pattern with high degree of sinuosity along their courses. The various erosion features identified in the area represent the different stages of fluvial erosion viz. sheet erosion, rill erosion, gully erosion which ultimately transform in to ravines.

The ground water scenario of the area is quite poor inravine tracts. The ground water levels of the area rests at deeper levels particularly along the river course where the levee sides are generally developed as ravines. The Depth to Water Levels were monitored at specified interval through out in the area in about 45 dug wells.

The gradual headword erosion leads to upward migration of the ravine in the area which is manifested in terms of widening aerial extent. Such features and locations are

identified through imagery data analysis and field survey where excessive erosion leads to develop ravines and need to apply the measure to check the erosion. Various measures in vogue to develop such areas are construction of check dams along first and second order streams, gully plugs, bonding, trenching across the slopes ets. are practiced by Soil Conservation & forest Departments and other organizations and NGO's working in the area.

20.4 SER, Bhubaneswar

Sukinda valley, which bears the third largest Chromite deposit of the planet, is situated in Jajpur District, Orissa. Chromite occurs mainly as stratified deposit in highly altered and weathered talc and serpentinite zones developed on Dunite and Peridotite bodies. Large scale opencast mining has led to heavy dewatering of the aquifer thus rendering both phreatic and deeper aquifer non productive. The surrounding quartzite hills and granites formations are massive in nature and not promising from ground water point of view. In this backdrop 300 square kilometer area surrounding the Sukinda valley is taken for RS & GIS studies to delineate potential aquifer zones in an otherwise massive formation. False Colour Composite (FCC) created using different Spectral Bands of Landsat-7 and Principal Component Analysis are used for hydrogeomorphological mapping. Edge Enhancement Filtering technique is used for demarcation of potential lineaments. Normalized Difference Vegetation Index (NDVI) map is prepared to study the different land use pattern of the study area. The slope map created from Digital Elevation Model of the area gives a good idea about the high surface run off zones indicating the poor occurrence of ground water. Based on all these above maps, probable ground water potential zones are delineated, which will help in planning for ground water utilization in the study area.

20.5 SR, Hyderabad

Procured digital remote sensing data for the rabi season crops (2008) (LISS-IV data) of Madahvaram watershed. Efforts are being made to study the data khraiff crops data along with rabi crops data in collaboration with NRSC, Hyderabad.

20.6 SWR, Bangalore

Ground water exploration:

Geomorphology, lineament, geology layers and aeromagnetic layers prepared using remote sensing data were overlaid and integrated map was generated for pin pointing potential sites for ground water exploration in Hassan district. Some of the sites were selected using the above data and recommended for geophysical survey. Exploratory wells drilled at these locations were found to be high yielding.

Special studies:

Impact assessment of artificial recharge structures in Kodihalla and Gundihalla drainage basin, Hosadurga taluk, Chitradurga district using remote sensing and conventional studies.- Details are given under Item no.1.

20.7 SECR, Chennai

In the present study, Using IRS-ID, LISS-III digital data, surface water body has been mapped. Geomorphology, Geology, Lineament and Landuse/landcover maps have been prepared. These layers were integrated to demarcate the area suitable for the constructing of artificial recharge structures. Surface water body and drainage map has been superimposed for finding the source for the recharge. Geomorphologically, the area mainly consists of pediplain shallow, moderate, and denudational hill. The groundwater prospect is moderate to very good in pediplains and recharge condition is also very good in this landforms. Granite gneisses, granite and metabsalat and tuff are the major formation in the study area. The high fracture aquifer is generally found in the gneissic formation. The lineament is generally trending NW-SE and NE-SW direction. NW-SE direction is parallel to general trend of the rock formation and parallel weaker zones. The landuse practice followed in the area is generally indicating the groundwater conditions in the area. Considering the features, which are favouring for the recharge, all layers were integrated and demarcated zones for the artificial recharge. The artificial recharge zones were superimposed and checked the source for recharge.

Different layers like Geomorphology, Geology, Lineament Map and Landuse/landcover were integrated to demarcate the area suitable for constructing the artificial recharge structures in the area. Surface water body and drainage map has been superimposed for finding the source for the recharge.

20.8 KR, Trivendrum

Remote Sensing Studies carried out in the Neyyar basin of Trivandrum District. Satellite imagery of IRS-IC and IRS-P6 were utilized for the study. Image interpretations is in progress.

20.9 UR, Dehradun:

During AAP 2009–10, Remote Sensing and GIS studies have been taken up under the head of District Ground Water Management Studies (DGWMS) in collaboration with Indian Institute of Remote Sensing (IIRS), Department of Space, Dehradun in Almora and Nainital Districts. Field works were carried out by the respective officers and the data were being analyzed / processed for further study as on 31st March 2010.

21. HUMAN RESOURCES DEVELOPMENT

It is the earnest endeavor of Central Ground Water Board to keep its technical personnel apprised with the latest development in all aspects related to ground water and drilling techniques. The Board also includes trainees from State Departments and candidates from abroad for different training programmes.

21.1 TRAINING AND AWARENESS RAISING PROGRAMME'UNDER UNDER HYDROLOGY PROJECT

- Imparted training to Hydrological Data Users of HIS developed under Hydrology Project on 24.06.2009 at Ernakulam in association with State Ground Water Department.
- Awareness Raising Programme under HP-II was conducted in Panaji, Goa state on 17.03.2010. Shri. Rajeev Yaduvanshi, IAS, Commissioner and Secretary, Water Resources Department, Goa was the Chief Guest. Shri. Vivek B. Kamath, Director, Directorate of Technical Education and Principal, Goa Engineering College was the Guest of Honour. Shri. T.M.Hunse, Regional Director, CGWB,SWR, Bangalore presided over the function. About 65 delegates from various departments of Goa State. Seven lectures were given by CGWB Scientists and NIO, Goa and Goa Engg. College.
- Organised one day Awareness Raising Programme on "Hydrological Information System" under HP-II at NITTTR, Taramani, Chennai on 24.09.09. Shri. S. Manoharan, I.A.S., Additional Secretary, Ministry of Water Resources, Dr. SM. Ramasamy, Vice-Chancellor, participated

21.2 RAJIV GANDHI NATIONAL GROUND WATER TRAINING AND RESEARCH INSTITUTE

Nineteen training including one special training courses were conducted during 2009 – 10 up to 31st March 2010 under Rajiv Gandhi National Ground Water Training and Research Institute. The details of training courses are given below -

1. The training course on "Request for Proposal – Process and Practices" conducted by Standardization Training and Quality Control, IT Services, Department of IT, New Delhi through Ministry of Water Resources from 27th to 28th May, 2009. 5 officers attended the training course.
2. A one week Refresher course for Chemists on "Analysis of Basic Water Quality Parameters in ground water and Data Validation" was successfully completed on 21st August 2009 (Aug 17 - 21, 2009) at Central Ground Water Board, Northern Region, Lucknow. 21 participants attended the training course from CGWB and State Govt. organizations.
3. The training course, on "Hydrogeological Investigations, Development & Management of ground water in Hard Rock Terrain - Techniques, Equipments and Practices" was completed (August 18 – Sept.12, 2009) at CGWB, SR,Hyderabad. 22 trainees attended the course, out of which six were form CGWB and remaining 16 from state and other organizations. The valedictory of the training programme was held on 12.09.2009. Sri B.M. Jha, Chairman, CGWB graced the occasion as Chief Guest and distributed certificates to the Trainees.
4. The training course on "Refresher Course on Material management" was completed(8-12 Sept,2009) at Div-XII, CGWB, Bhopal.17 trainees from CGWB attended the course.
5. The training course on "Application of Geophysical Techniques for Ground Water Exploration and Management" was completed (2-15 Sept.2009) at CGWB, NCR Bhopal. 22 trainees attended the course. Among them eight were form CGWB and rest 14 from state and other organizations. Shri B.M.Jha, Chairman, CGWB, inaugurated the course and the valedictory function was presided over by Shri Subrata Kunar, Member (T&TT), CGWB, Faridabad.
6. A refresher training course on "Ground Water Resource Estimation" was completed (26-30 October, 2009) at Rajiv Gandhi National Ground Water Training & Research Institute(RGI), Faridabad. 18 trainees attended the course. Among them five were form CGWB and rest 13 from other organizations. Chairman, CGWB, inaugurated the course and presided over the valedictory function.
7. A training course on "Artificial Recharge Techniques in different Hydrogeological Conditions" was completed on 13th November 2009 (November 9-13,2009) at Central Ground Water Board, Raipur. 19 trainees attended the course.
8. A training on "Hydrogeological Investigations, Development & Management of Ground Water in Alluvial Terrain-Techniques, Equipments and Practices" was successfully completed on 11th December 2009 at Central Ground Water Board, North Western Region, Chandigarh (November 17 – December 11, 2009). 24 trainees attended the course.
9. A refresher course on "Surface Resistivity Surveys for Geophysicist and Hydrogeologist" was completed on 18th December 2009 (December 7 – December 18, 2009) at Central Ground Water Board, Southern Region, Hyderabad. Total 18 officers attended the course. The valedictory function was presided over by Shri Subrata Kumar, Member(T&TT).
10. A training course on "Administrative and Financial matters for Senior officers of the Board" was successfully completed on 18th December 2009 (December 14- December 18, 2009) at IIPA, New

Delhi. The course was attended by 18 officers of Central Ground Water Board.

11. A training course on "Analysis of Pumping Test Data" was completed on 19th December 2009 (December 14 – December 19, 2009) at Central Ground Water Board, Central Region, Nagpur. The course was attended by 20 officers.
12. A training on "Ground Water Management (Regulation & Control)" was successfully completed on 15th January 2010 at Central Ground Water Board, RGI, Bhujal Bhawan, Faridabad (January 11 – January 15, 2010). 11 trainees attended the course. The Chairman CGWB inaugurated and presided over the valedictory function.
13. A training course on "Mathematical Modeling of Ground Water System" was completed on 16th January 2010 (January 4 – January 16, 2010) at IIT, Roorkee. Total 14 officers attended the course. The Chairman CGWB presided over the valedictory function.
14. A training on "Water Well Construction – Techniques, Equipment and Management" was successfully completed on 26th February 2010 at Central Ground Water Board, North Central Region, Bhopal. 18 trainees attended the course.
15. A training Programme on "Geographical Information System and Mapping Tools" was completed on 5th February 2010 (January 25th – February 5th , 2010) at NITTT&R, Chennai. Total 20 officers attended the course.
16. A Training Course on "Ground Water Estimation and Management Software(GEMS) for Senior officers" was successfully completed on 18th February 2010 (February 16th – February 18th 2010) at Central Ground Water Board, NDC, Faridabad. 13 trainees attended the training course.
17. A Training Programme on "Application of Remote Sensing & GIS in Ground Water System" was completed on 12th February 2010 (February 1-12, 2010) at HRS, Dehradun. 19 trainees attended the training course.
18. A orientation course on "Economic Aspects" was completed on 26th February 2010 (February 22-26, 2010) at Institute for Resource Management and Economic Development, Delhi. 19 Sr. officers of the Board attended training course.
19. A Training Programme on "Management Principals and Practices" for officers of Central Ground Water Board is being conducted under Rajiv Gandhi National Ground Water Training & Research Institute on 30th March, 2010 (30th March, 2010 to 9th April, 2010) at IIPA, New Delhi. 22 trainees are attending the course.

Total 340 trainees from various disciplines have been trained in the above training courses conducted at various places during the year up to 31st March 2010.

REFRESHER COURSE FOR CHEMIST

21.3 TRAINING UNDER OTHER AGENCY

- Scientists from West Central Region, Central Ground Water Board, Ahmedabad attended two weeks training programme on ORACLE in CDAC, Noida from 19th to 31st January 2010.
- Scientist from Western Region, Central Ground Water Board, Jaipur attended a training programme on "Installation and operation of BOSS (Bharat Open Source Solution) software developed by CDAC" organized by "Rajbhasha Kiran" a monthly Hindi Magazine on 30th July, 2009.
- Scientist from North Eastern Region, Central Ground Water Board, Guwahati attended a training programme on "Right to Information" at Meghalaya Administrative Training Institute, Shillong from 3rd and 4th September 2009 .
- Scientist from Kerala Region, Central Ground Water Board, Trivendrum attended a training programme on "Comprehensive landslide Risk Management" at ILDM from 22nd September to 25th September 2009 .
- Scientist from South Western Region, Central Ground Water Board, Bangalore attended attended a training programme on Basic computers/MS office & Internet at Administrative Training Centre, Mysore From 20th to 25st July 2009.

22. SPECIAL STUDIES

22.1 WR, Jaipur

22.1.1 Urban Hydrogeolgical studies in Kota Urban & Industrial Area, Kota district

Kota urban lies in the north western part of Kota district. Area is underlain by sandstone belonging to Upper Vindhyan Group and a patch of limestone occurs in the north eastern part. Physigraphically, area is characterized by gentle plane with undulating plateau. The land slopes from south west to north east and is drained by perennial Chambal river and its tributaries. The soil of the area is brown to dark colour alluvium which is clayey loam to clay in composition and generally non-calcareous.

During premonsoon, 24 wells were inventoried and a total of 20 ground water samples collected from various GW Abstraction structures viz. hand pumps/tubewells for complete analysis and also industrial effluent samples for heavy elements determination. Depth to water level varies from 1.80 to 4.54 mbgl(pre-monsoon). Ground water quality is potable having EC from 270 to 1845 ms/cm at 25^0C and other chemical parameters are also within permissible limits of Drinking Water Standards.

During post-monsoon details survey, 27 Nos. of ground water samples were collected fromn various GW Abstraction structures. Depth to water level varies from 1.10 to 6.90 mbgl(post-monsoon). Ground water quality in general, is suitable for domestic purposes except in the close vicinity of industrial effluents disposal.

22.1.2 Compilation of Water Management Practices adopted by Urban Municipal Bodies in Rajasthan-Other item

Urban centers in Rajasthan are facing an ironical situation today. On one hand there is the acute water scarcity and on the other, the streets are often flooded during the monsoons. This has led to serious problems with quality and quantity of groundwater. Because of short duration of heavy rain, most of the rain falling on the surface tends to flow away rapidly leaving very little for recharge of groundwater. Most of the traditional water harvesting systems in cities have been neglected and fallen into disuse, worsening the urban water scenario. One of the solutions to the urban water crisis is rainwater harvesting - capturing the runoff.

In Rajasthan, *tankas*, *talabs* and *baodies* traditionally performed the job of collecting and storing runoff water. The *tankas* (underground tanks for drinking water) were one of the most reliable methods of water harvesting in desert towns. Its water was used judiciously to avoid shortage in summer. In the event of scarce rainfall, water from nearby *talabs*, *nadis* or village ponds was used to fill up the *tankas*. Rooftop harvesting was a common feature in the villages and towns across the Thar desert. The technique of rooftop harvesting involves collecting rain water that falls on sloping house roofs through a pipe into an underground tanker built in the courtyard. The locals created numerous other water bodies. These included *johad*, *bandha*, *sagar*, *samand* and *sarovar*. Wells including *kua*, *kohar* (owned by a community) and stepwells (*baodis* or *jhalaras*) were also important water sources. Stepwell is a unique form of underground well architecture very common in Rajasthan.

The photographs of various traditional water collection and management prevailing in Rajasthan are depicted in fig. 22.1, fig. 22.2, fig. 22.3, fig. 22.4, fig. 22.5 and fig. 22.6. Different type of tankas with sitting device meet the drinking water requirement during the summer. Johr meet the drinking needs of cattles.

22.1.3 Collaborative Studies

Hydrogeological Studies on Ground Water control measures to be adopted in Kasnau-Matasukh Mines, Nagaur district

Back ground details

Central Ground Water Board, Western Region, Jaipur has taken up regional hydrogeological studies of Kasnau – Matasukh Lignite Mines, Nagaur District for Rajasthan State Mines and Minerals Ltd. (RSMML) in Annual Action Plan 2005-06. The main objective of the study to understand the behaviour of the ground water regime in space and time owing to depressurization of confined aquifer for lignite mining activities. A preliminary study was carried out during the month of August' 05 and the following work plan is proposed to be undertaken under the study.

Drilling of one slim hole (dia 9 $^7/_9$") of about 400 m depth. The objective of slim bore hole drilling is to collect all hydrogeological and other relevant data and to ascertain the thickness of Tertiary formation in mining leased area.

1. Drilling and construction of 4 nos. exploratory wells (dia 10" to 14") and 8 nos. observation wells (dia 6") of depth between 200 and 250 m. The depth of EW and OW may vary depending upon the field condition. All

relevant hydrogeological and exploratory data would be collected including various logging of boreholes.

2. Drilling and construction of 4 – 6 piezometers (dia 6") in and around mining leased area for monitoring during the course of different tests and study. Besides, construction of a piezometer nests is also proposed at suitable location in the leased area.
3. Conducting of aquifer performance test and step drawdown test on exploratory wells. Duration of APT may vary between 3 and 30 days based on field conditions.
4. Drilling and construction of 2 recharge wells (dia 10 – 14") of depth 200 to 250 m for the purpose of recharge tests to establish the rate of recharge and consequent changes in the regime.
5. Collection and analysis of water samples during various tests and study.
6. Collection of data on land use, cropping pattern, hydrometeorological, hydrological, hydrogeological, population etc. from different departments.
7. Preparation of mathematical model based on regional hydrogeological studies for prediction of change in groundwater regime and depressurization of confined aquifer for lignite mining activity.
8. Preparation of report on "Regional hydrogeological studies in and around Kasnau – Matasukh Lignite Mines, Nagaur district, Rajasthan"
9. Any other work, which is not covered under item 1 to 9 and required during the studies, shall be taken up.

Execution of work

The study is a collaborative work of CGWB and RSMML. The role of RSMML and CGWB shall be as under for execution of work to accomplish the study.

A. Role of RSMML

The Rajasthan State Mines and Mineral Ltd. will execute the following:

1. Drilling, construction and testing of slim hole, exploration wells, observation wells, piezometers, recharge wells, Pumping test, recharge test, collection of data, mathematical modeling and preparation of report.
2. Collection of all existing and exploratory data and analysis.
3. Pumping and recharge tests and analysis of data.
4. Collection of water samples and analysis.
5. Mathematical modeling study.
6. Processing of analysis of data and preparation of report.

B. Role of CGWB

1. CGWB provide technical guidance and supervision of work of all the activities mentioned above.
2. Finalize the sites for EW, OW, Pz, recharge wells etc. for the studies in association with the hydrogeolotists engaged with RSMML.
3. Render guidance and supervision in preparation of the mathematical model and final report.

Time frame

The entire work is to be completed within 1 years time from the date start of the investigations.

- Construction : 2 month
- Test : 3 month
- Modelling stud : 1 month
- Processing, analysis and report writing:1 month

Other requirement

1. In view of the public litigation necessary and prior approval of the concerned authority shall be required before the commencement of work.
2. The RSMML shall also make necessary provision for disposal of poor quality water to be pumped during various tests (APT, SDT). Disposal of water may be done at a safe distance so as it may not influence the test by leakage etc.
3. RSMML shall engage an experienced hydrogeologist for collection and processing of all data, conducting and analysis of test during the study and preparation of final report under the overall guidance and supervision of CGWB
4. RSMML shall also obtaine necessary permission from concerned authority for construction of EW, OW, Piezometer, recharge well etc for the sites located out side their leased area.
5. Necessary funding for execution of entire work shall be arranged by RSMML.MoU of CGWB with RSMML signed. Strategies for lowering groundwater levels by de-watering will be finally suggested to the requesting agency.

Studies carried out during AAP 2008-09

- MOU between CGWB and RSMML for the study has been extended by the Competent Authority till December 2010. Regarding execution of the study, discussions were held with RSMML representative

- Shri Harshwadhan, Senior Manager & informed him regarding sites for construction of exploratory wells, observation wells and piezometers.
- MD, RSMML has been requested vide this office letter dated 28.7.08 for execution of the work plan since no work has been taken up by RSMML.
    - One EW site selected & pinpointed for exploration at Mata Sukh.
    - One observation well of 141 m depth completed at Matasukh, district Nagaur.
    - One PZ constructed for regional ground water study at Matasukh office premises and one EW abandoned due to mud loss at Kasnau drilled down to 72 m depth. Next site for EW released at Kasnau. One EW constructed

Studies carried out during AAP 2009-10

- Drilling for PZ & OW at Kasnau completed up to the depth of 123m and 150m respectively.
- EW at Kasnau and OW2 at Matasukh developed with air compressor.
- Site for OW at Kasnau released.
- Drilling of EW and OW at Tarnau, district Nagaur completed down to 235metres.
- Construction of two OW at Kasnau EW and one PZ at Kasnau Sainik camp.
- Drilling of Exploratory Well & Observation Well at TARNAU district Nagaur completed.

22.2 NCR, Bhopal

22.2.1 Feasibility studies for reclamation of ravines using remote sensing techniqes in badnagar block of Ujjain district:

An area of 600 sq km was covered for reclamation of ravines using remote sensing techniques in the Chamala Watershed in parts of (TS 46M/8 and 46N/5), Badnagar block Ujjain District. IRPS P6-LIS-III data were procured (1:50,000) from NRSA. The field mapping along 16 villages were carried out to identify the extent and nature of ravines along the Chamla river. The post monsoon DW of the studied area varies between 15.10-27.10 mbgl. The discharge of shallow tube wells of depth ranges 60-90m varies in the range of 1.60-4.30 lps. The shallow alluvium aquifer occurs in the depth ranges 15.30-17.0m Thickenss of alluvium in the area varies from 19.80-22.50 m. 20 Recharge pond with recharge shaft are identify at feasible location have to developed saturation of pharatic aquifers. These structures are posed at discharge area microstructures and at contact of river Chamla in the south of Badmnagar area.

22.3 NR, Lucknow

- Occurrence and distribution of pesticides residues in ground water in Loni block of Ghaziabad district and Khekra block of Baghpat district., U.P. Under this programme 99 no. of water samples of Loni block of Ghaziabad district and Khekra block of Baghpat district., U.P. were collected & extracted. The samples were analysed for pesticides residues in the Chemical Laboratory of C.G.W.B. at N.R., Lucknow on Gas chromatograph (SHIMADZU GC –17A) using Electron Capture Detector (ECD) The pesticide residues from water samples was separated by using organic solvents. Identification and quantification were accomplished using a known amount of external standards. For evaluating the water quality for domestic or municipal uses, the limits laid down by Prevention of Food Adulteration Act (25th edition 2004) and EEC (1988) are taken into account. These agencies permit the individual pesticide residue to be not more than 0.1 μg/l and Total pesticide residue as 0.5 μg/l in drinking water. The study reveals that Hexachlorocyclohexane (HCH) isomers (α, β, γ and δ) and DDT metabolite , i. e. 4,4'-DDT are localized and found with in the permissible limit . The other pesticide residue Chlorpyriphos is also present in few samples.
- Occurrence and distribution of pesticides residues in Gomti River, Lucknow. Under this study 9 water samples of Gomti river from Gau Ghat to Gomti barrage have been analysed for pesticides residues and only in one water sample DDT metabolite , i.e. 44 '- DDT has been detected.
- Occurrence and distribution of Arsenic in Ganga River water and ground water of the surrounding area along Ganga River in its stretch from Kanpur and onward in UP.
- During AAP 2009-10 the special study for Arsenic in Ganga River water and ground water of the surrounding area along Ganga River in its stretch from Kanpur and onward in UP was carriedout and the total 215 samples were collected from the area. The samples were analysed in the RCL, NR ,Lucknow on Shimadzu 6701 AA Atomic Absorption Spectrophotometer using Hydride Vapour Genrator. The range has been found from BDL to 688 –microgram /liter in the ground water of the area in Ganga river Arsenic has been found maximum upto 27 microgram /liter (at Sangam in Allahabad)and in ground water of the area maximum 688 microgram /liter (in Ballia district) has been observed during the study.

22.4 MER, Patna

22.4.1 CGWB-NGRI collaborative study on Ground water Modeling in Sone-Ganga interfluves region with a larger perspective on South Ganga Plain:

The objective of the study includes

a) Simulation of groundwater flow regime in the aquifer systems in the arsenic affected areas in Sone- Ganga interfluves region of Bhojpur and Buxar districts.

b) Interaction between contaminated shallow aquifer and the Ganga river as well as transfer of groundwater between various aquifer systems are to be ascertained.

c) In second stage the entire South Ganga Plain will be covered under groundwater flow modeling

The expected outcome of the study :

a. Valuable field data generated during the field work would be analysed to achieve the objective of the study.

b. It will help estimate the groundwater resource availability in fresh and arsenic contaminated aquifer.

c. Sustainable yield from the arsenic safe aquifers considering its annual recharge in intake areas as well as leakage from different aquifer system would be ascertained.

d. Finally to frame a groundwater development plan for supply of safe drinking water in a sustainable manner.

As part of the study, CGWB has completed the post monsoon survey in the study area. A total of 110 monitoring stations have been established in the study area. Ground Water samples have been collected for detailed chemical analysis. NGRI team has completed the Time domain electromagnetic and resitivity imaging in the entire study area.

22.4.2 Quaternary Geomorphological study around Sahoo–Porari village covering parts of Dharbhanga and Samastipur district:

An area of 1230 Sq. Km. around Sahoo – Porari village covering parts of Darbhanga and Samastipur district was covered under Quaternary geomorphological study. The study was undertaken with objective of identifying different hydrogeomorphic unit present in the area and to investiagte relationship between hydrogeomorphological units and incidence of high As concentration in the area. Study area in Darbhanga Falls in Biraul, Baheri, Behipur Ghansh , Haighat blocks and those of Samastipur district falls in Rosera and Shivajinagar blocks. Physiographically,the area forms part of a vast monotonous flat plain. Geomorphic features characteristic of the area are ox-bow lakes, small mounds and shallow depressions or the Chaurs. They are locally called 'Tal' and are shallow. Their areal expanse diminishes during the summer, however, some of them remain permanently water logged. The general elevation of the land surface varies from 38 – 46 m asl with general slope towards south. The area forms a part of the Bagmati sub basin of Ganga basin. The area is characterised by aggregation of alluvial fans of Burhi Gandak and Bagmati. The soils of the area are highly calcareous and are a mixture of clay, sand and silt in varying proportion. The quaternary alluvial sediments constitute potential aquifer in the area. These consist of sand, gravel and pebbles of various grades along with clay and silt deposit. Changes in depositional environment have resulted in vertical and lateral variation in texture and composition of the sediments. The aquifers are capped by a persistent clay layer of variable thickness

Ground Water occurs under semi confined to confined condition depending upon the nature of aquifer. The near surface sand, silt and silt clay mainly support open wells where ground water occurs under water table condition. The depth of open well varies from 5.5 to 11.70 m bgl. The depth to water level in pre-monsoon was found varying from 0.80 m at Mahwa to 6.03 at Sanker Rohar. The post-monsoon depth to water level varies from 0.43 m bgl at Mahwa to 4.87 m bgl at Kerian.

Total of 164 water samples were collected from different parts of the study area during different seasons of which 132 were collected for Arsenic, Fe & Mn and 32 for complete analysis. High arsenic concentration (> 50 ppb) has been found in Baheri, Benipur and Biraul blocks of Darbhanga district. Highest concentration of arsenic (220.5 ppb) in the area was found at Adherpur village in Baheri block.

22.4.3 Mining Hydrogeological Study - West Bokaro Coal Field (Hazaribagh District)

An area of 850 sq. km. has been surveyed under mining hydrogeological study covering part of Hazaribagh district. This coal field is known as West Bokaro coal field. Geologically the area is underlain by Chottanagpur granite gneiss, phyllite, mica-schist. It is unconformally overlain by Lower Gondwana Formation consisting of sandstones, shales and coal seams. Ground Water mainly occurs under water table condition in weathered residuum and in semi-confined conditions in deeper fractures. Exploratory wells of CGWB drilled in the Gondwana formation have revealed low ground water potential of the Gondwanas. Physiographically the area consists of plateaux, residual hills and intermontane valleys. The area is drained by river Barakar and its tributaries. Water level of the area varies between 6.30- 12.60 mbgl during pre-monsoon and 2.50-8.80 m bgl during the post-monsoon. A total of 30 samples have been collected during the survey from dugwells and shallow tubewells. The analytical results are awaited.

22.5 SWR, Bangalore

22.5.1 Remote Sensing Studies for impact assessment of artificial recharge structure in the special study area in parts of Chitraddurga district – 625 sq.km

In the present study, Using IRS-ID, LISS-III digital data, surface water body has been mapped. Geomorphology, Geology, Lineament and Landuse/landcover maps have been prepared. These layers were integrated to demarcate the area suitable for the constructing of artificial recharge structures. Surface water body and drainage map has been superimposed for finding the source for the recharge. Geomorphologically, the area mainly consists of pediplain shallow, moderate, and denudational hill. The groundwater prospect is moderate to very good in pediplains and recharge condition is also very good in this landforms. Granite gneisses, granite and metabsalat and tuff are the major formation in the study area. The high fracture aquifer is generally found in the gneissic formation. The lineament is generally trending NW-SE and NE-SW direction. NW-SE direction is parallel to general trend of the rock formation and parallel weaker zones. The landuse practice followed in the area is generally indicating the groundwater conditions in the area. Considering the features, which are favouring for the recharge, all layers were integrated and demarcated zones for the artificial recharge. The artificial recharge zones were superimposed and checked the source for recharge.

22.6 SECR, Chennai

22.6.1 Studies in Neyveli Hydrogeological Basin (MoU with NLC) – study continued from 2006 – 2011.

The studies in Neyveli Hydro geological Basin are being carried out as per the objectives of the MOU between CGWB and NLC to formulate optimum ground water development plan in the basin.

The increase in ground water draft from the basin has resulted in major changes in the hydrodynamics of the basin and consequent lowering of ground water levels and piezometric heads in the aquifers. In view of the above, there is an urgent need to have a study for better understanding of the hydrodynamics of the aquifer system in the basin with a view to formulate a long-term perspective plan for sustainable management of available water resources. With this perspective the collaborative study was taken up for sustainable development of available ground water resources with NLC.

Objectives of the project

- Deciphering geometry of various sedimentary rocks and cuddalore sandstone in particular and demarcate the lateral extension of aquifers above and below lignite seams.
- Assessment of distribution of potentiometric heads under different stress conditions and evaluation of aquifer parameters for each zone/ bed.
- Impact assessment of combined ground water withdrawal by different sectors in the entire basin.
- Assessment of fresh water/saline water interface movement, if any and suggestion of remedial measures.

Expected Outcome of the Study

To evolve a well-defined ground water development plan for basin and action plan for sustainable management of available ground water resources for arresting the landward movement of the fresh water-saline water interface, if any.

Findings

- The refinement of geometry of the aquifer system in the basin by exploratory drilling.
- Determined aquifer parameters by conducting long duration pumping test in different aquifers.

- The information generated through injection well tests would be useful for designing artificial recharge projects by injection well method.

The outcome of the Infiltration/recharge studies conducted recently by NLC at Perumal ari area and at Kil kavarapalayam by CGWB shows that the aquifer can accept the recharge for augmentation of ground water and scope for artificial recharge by Creating fresh ground water barrier to arrest the sea water intrusion along the coast.

22.6.2 R&D on "Specific yield studies for planning & designing of Artificial recharge structures in sub urban areas of Chennai, Tamil Nadu" in collaboration with Sathyabama University, Chennai.

"Specific Yield studies for planning and designing of artificial recharge structures, in sub-urban areas of Chennai, Tamilnadu" a collaborative project was taken up by CGWB and Sathyabama University under Hydrology Project – II as an R & D investigation under PDS.

Objectives of the study

Groundwater resource estimation requires realistic specific yield values for different hydrogeological units to get the realistic quantum of groundwater recharge and discharge. The other main aim of the study is to provide a descision support system for optimal design of rainwater harvesting structures based on Geological and Hydrogeological setting and rainfall. Further, the type of structures can be designed and validated for effective recharge structures. To study the groundwater quality by collecting water samples from the well field/tubewells giving emphasis to the environmental parameters like BOD, COD, E-Colliform and to monitor improvement in groundwater quality. Aslo, to study the intake capacity of filter unit of different dimensions and to arrive at specificiations.

Study area

The area under study covers parts of Tiruvallur and Chennai districts covering an area of 1000 sq. kms. It is bounded by North latitude 12 54'00" and 13 24'00" and East Longitude 80 10' 00" and 80 20' 00". The area covers Araniyar and Kortalaiyar river basins.

Progress

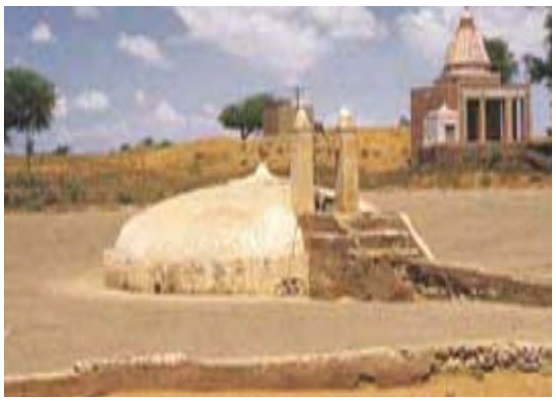
As on 30th March 2010, the following works have been completed;

- 5 well fields sites were finalized for construction of 1 PW & 6 OW.
- 4 well fields have been completed (valliyur, Kadambathur, Minjur & Ponneri).
- 15 infiltration tests were conducted within the project area by Satyabama University under the guidance of CGWB
- Slug tests were conducted at 2 well fields by Satyabama University under the guidance of CGWB
- Step Drawdown test was completed at Kadambathur well field & Long duration pumping test is being conducted.

Fig. 22.1

Traditional water collection and management prevailing in Rajasthan

Fig. 22.2



Tankas

Fig. 22.3

Johr(Pond)
Traditional water collection and management prevailing in Rajasthan

Fig. 22.4

Tanka with sitting device

Fig. 22.5

Well

Fig 22.6

Tanka with sitting device

23. TECHNICAL DOCUMENTATION AND PUBLICATION

Results of investigations carried out by The Central Ground Water Board were suitably documented in the form of reports and maps. All the field offices have been provided with report processing sections, which are responsible for the scrutiny and issuance of reports of various assignments carried out by its officers.

23.1 Reports

Details of various type of technical reports issued by respective regional offices of the Board were as follows:

23.1.1 State Reports

State Reports containing complete details of ground water surveys, exploration and other ground water related information are compiled and prepared for the status of ground water development in the State. Based upon reports, ground water development perspectives are worked out and future strategies are planned. During 2009-2010, Sikkim , Arunachal Pradesh state reports completed where as UT of Daman & Diu, Goa, Delhi and Uttarakhand state reports were under preparation.

23.1.2 District Reports

The Central Ground Water Board is compiling and issuing district reports of each district from time to time containing all the results of ground water surveys, exploration and other related studies. Further, groundwater development perspectives are also worked out for the benefit of State and other users agencies. The reports have been found very useful for their strategies for future. During 2009-10, 24 district reports were prepared and submitted. Region wise status of preparation of District Reports are presented in Table 23.1

Table 23.1: Status of District Reports Completed During 2009-2010

Sl. No	Regions	Nos.	Name of District Report
1	North Western Himalayan Region	2	Kargil, Poonch
2	North Western region	2	Ludhiana, Kurukshetra
3	West Central Region	2	Surat, Vadodra
4	North Central Chhatisgarh Region	1	Korba
5	Northern Region	1	Ambedkar Nagar
6	Mid Eastern Region	1	Khunti
7	Eastern Region	2	Malda, Coochbihar
8	South Eastern Region	3	Sundargarh,Nayagarh , Mayurbhanj
9	Southern Region	2	Nellore, Mehboobnagar
10	South Western Region	2	N.Goa & Bidar
11	South East Coastal Region	2	Tiruppur, Ramanathapuram
12	Kerala Region	2	Malapuram, Idukki
13	North Himalayan Region	2	Una, Mandi
	Total	**24**	

23.1.3 Ground Water Year Book

The Central Ground Water Board is compiling ground water year books to elucidate the changes in ground water levels and water quality. The accurate monitoring of the ground water levels and its quality both in space and time are the main requisite for assessment, scientific development and planning of this vital resource. During 2009-10, 23 reports were prepared . Region wise status of preparation of ground water year book are presented in Table 23.2

Table 23.2: Status of Ground Water Year Books Completed During 2009-10

Sl. No	Region	Ground Water Year book prepared	
		Nos.	State
1	North West Himalayan Region	1	Jammu & Kashmir
2.	North Himalayan Region	1	Himachal Pradesh
3	North Western region	3	Punjab, Haryana & Chandigarh
4	Western Region	1	Rajasthan
5	West Central Region	1	Gujarat
6.	North Central region	1	Madhya Pradesh
7.	North Central Chhatisgarh Region	1	Chhattisgarh
8.	Central Region	1	Maharashtra

Sl. No	Region	Ground Water Year book prepared	
		Nos.	State
9.	Northern Region	1	Uttar Pradesh
10.	Mid Eastern Region	2	Bihar, Jharkhand
11.	Eastern Region	1	West Bengal
12	North Eastern region	1	North Eastern States
13	South Eastern region	1	Orissa
14	Southern Region	1	Andhra Pradesh
15	South Western Region	2	Karnataka, Goa
16	South Eastern Coastal Region	1	Tamilnadu
17	Kerala Region	1	Kerala
18.	Uttaranchal Region	1	Uttarakhand
19.	SUO, Delhi	1	Delhi
	Total	**23**	

23.1.4 Ground Water information Booklets

During 2009-10, 156 Ground Water information Booklets have been completed/released in the states of Chhattisgarh, North Eastern States, Jammu and Kashmir, Madhya Pradesh, Maharashtra, Rajsthan, Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal, Sikkim, Andhra Pradesh and Gujarat . The details are given in Table 23.4.

Name of States	Nos.	Name of Districts
Chandigarh	2	Raigarh, J.C. Champa
North Eastern States	24	Aizal , Mamit ,Chandel , Bishnupur, Imphal West, Tamenglong,Jaintia Hill, Darrang, Tinsukia, Barpeta, Sibsagar , Nalbari, Bangaigaon, Changlong, Dibong valley, Tawang , Kurung Kume, Anjal , Lr. Dibong valley, East Kameng, Upper Subansiri, Upper Siang , Kolosib Champai districts
Jammu & Kashmir	11	Leh, Kargil, Anantnag, Baramula, Pulwama, Kupwara, Badgam, Kathua, Rajauri, Udhampur, Doda
Madhya Pradesh	24	Khargone , Khandwa, Betul, Shajapur, Shajapur, Chhatarpur, Hoshangabad, Shahdol, Mandsaur, Harda, Datia, Morena, Balaghat, Dewas, Neemuch, Damoh, Bhind, Sagar, Shivpuri, Narsinghpur, Tikamgarh, Ashok Nagar, Gwalior, Seoni
Maharashtra	12	Submitted
Rajasthan	9	Nagaur, Bikaner, Rajsamand, Bharatpur, Hanumangarh, Udaipur, Jhalawar, Banswara ,Dholpur
Tamil Nadu	10	Reports Issued
Uttar Pradesh	28	Rampur, Firozabad, Jhansi, .Ballia, Shrawasti, Bijnor , Siddharth Nagar , Baghpat , BaraBanki , Mainpuri, Pilibhit, Gorakhpur, Sant Kabir Nagar, Kanpur Dehat, Jyotiba Phule Nagar, Gautam Budh Nagar, Ghaziabad, Lalitpur, Sultanpur , Bareilly, Etawah, Buland Shahar Saharanpur, Gonda, Sitapur , Meerut, Allahabad, Hardoi
Uttarakhand	2	Nainital, Dehradun
West Bengal	2	Jalpaiguri, UT of A & N Islands
Sikkim	2	East Sikkim & South Sikkim
Goa	2	
Andhra Pradesh	18	Adilabad, Anantpur, Nizamabad, Karimnagar, Warangal, Nalgonda, Ranga Reddy, Khammam, Kadapa, Kurnool, Chittoor, East Godavari , Krishna, Nellore, Medak, Guntoor, Prakasam, Mahabubnagar
Gujarat	10	Anand, Rajkot, Surat, Porbandar, Navsari, Bharuch, Junagadh, Gandhinagar districts and UT of Daman, Diu
Total	**156**	

23.1.5 Ground Water Exploration Reports

During 2009-10, 14 Ground Water Exploration Reports have been completed / submitted of the states of Jammu and Kashmir, Punjab, Haryana, Chandigarh, Gujarat, Chhattisgarh, Uttar Pradesh, UT of A & N Islands, Nagaland, Andhra Pradesh, Tamilnadu, Kerala, Himachal Pradesh and Uttarakhand.

23.1.6 State Geophysical Reports

During 2009-10, 13 Ground Water Exploration Reports have been completed / submitted of the states of Jammu and

Kashmir, Punjab, Haryana, Chandigarh, Chhattisgarh, Maharashtra, Sikkim, U T of A & N Islands, West Bengal, NE State, Karnataka and Uttarakhand.

23.1.7 State Chemical Reports

During 2009-10, 7 Ground Water Exploration Reports have been completed / submitted of the states of Madhya Pradesh, Sikkim, U T of A & N Islands, West Bengal, Karnataka, Himachal Pradesh and Uttarakhand.

23.2 Bhujal News

Bhujal News, is a quarterly journal being published by Central Ground Water Board highlighting the latest advances in ground water research. Besides scientific papers, the journal also contains technical notes, news items , and regular columns. The journal has more than 1500 readers from all over the country. During the year 2009-10 up to 31st March 2010, the Vol. No 22, 2007 issued and Vol. 24 No. 1 January – March, 2009 (West Bengal Special issue) published.

24. VISITS BY SECRETARY, CHAIRMAN, DELEGATIONS AND IMPORTANT MEETINGS

24.1 Visit of Secretary, MOWR at Guwahati

Shri U.N.Panjiar, Secretary, MOWR visited Guwahati on 13th and 14th February,2010. Discussion was held in the VIP room of LGB AIR Port, Guwahati. Chief Secretary, Govt of Assam, Secretary, Water Resource Department, Govt of Assam, Chairman, Brahmaputra Board, Director, Central Water Commission were present in the meeting. Just after the meeting Secretary carried out an aerial survey by Helicopter of Majuli Island, Jorhat district, Matmara area, Lakhimpur district and Dhala area of Tinsukia district of Assam for taking immediate anti erosion measures.

24.2 Visit of Chairman, CGWB

i. The Chairman, CGWB visited Pune to attend a seminar organized by NSDI from 22-24th December 2009. The Chairman, CGWB also visited Hiware Bazar in Ahmednagar district on 23-12-2009 alongwith Shri. B. Jaya Kumar, Regional Director, CGWB, Nagpur and Shri. Sourabh Gupta, Scientist-D, CGWB, SUO, Pune to see the different techniques of Rain Water Harvesting and Water Management Practices adopted by the village Panchayat that was awarded the National Water Award - 2007 (Rs. 10 Lakhs) during Sept. 2007.

ii. The Chairman, CGWB visited Pune to deliver a Key Note address in National Conference on Ground Water Resources Development in Hard Rocks organized by Department of Geology, University of Pune on 12th February 2010. The Chairman also visited at CGWB, SUO, Pune & meeting was held with officers of SUO, Pune regarding activities of CGWB.

24.3 Various meetings

24.3.1 Meetings under Artificial Recharge to Ground Water/ Dug Well Recharge

- Scientist 'D' and Scientist 'B' attended Review meeting taken by Joint Secretary (A), MOWR to discuss on Physical and Financial Progress of Scheme of "Artificial Recharge of GW through Dugwells at New Delhi on 6.04.2009.
- Chairman, Member (SML) and Sr. officers of the Board attended review meeting of Physical & Financial progress and other issues relating to Artificial Recharge of Ground Water through Dugwells taken by Secretary (WR), Ministry of Water Resources, Shram Shakti Bhavan, New Delhi on 15.04.2009.
- A meeting was held under the Chairmanship of Dr. Vyavhare, Director, Soil Conservation and Watershed Management, Pune on 17.04.2009 to discuss the progress of the Dug Well Recharge Scheme. The representatives from GSDA, NABARD and Agriculture department attended the meeting. OIC, SUO Pune represented Central Ground Water Board.
- Additional Secretary(WR), New Delhi attended meeting with Chief Secretary, Govt. of Tamil Nadu on 9.04.2009 and Principal Secretary, PWD, Govt. of Tamil Nadu. Regional Director, Central Ground Water Board, South East Coastal Region, Chennai, Senior officers of NABARD and officers from nationalized banks participated in the meeting to review the progress in Dug Well Recharge Scheme.
- Scientist of Central Ground Water Board, South East Coastal Region, Chennai attended the 2nd Monitoring Committee meeting at Secretariat, Chennai on 15.04.2009 in respect of project on "Flood Risk Mapping Chennai city and comprehensive study through modeling to propose possible flood mitigation measures" and participated in the deliberaions.
- Regional Director, West Central Region, Ahmedabad attended the meeting with CEO, GSWMA on the scheme on Artificial Recharge to Ground Water through Dug Wells on 24.04.2009.
- Sri B.K.Kallapur Scientist-D attended DLIMC meeting of Dugwell recharge scheme in Chickballapur district at Chickbellapur on 11.5.2009.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai attended the meeting convened by Secretary, Ministry of Water Resources, New Delhi to review the progress of implementation of the Scheme "Artificial Recharge to Ground Water through Dug Wells" on 4.05.2009 and participated in the deliberations.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai had a technical discussion with Principal Secretary, PWD on 25.05.2009 regarding the Dug Well Recharge Scheme and other activities related to Ground Water Management and Regulation and land allotment for CGWB Divisional Workshop.
- A meeting was held under the Chairmanship of Dr. Vyahare, Director Soil Conservation & Watershed Management, Pune on 17.05.2009 to discuss the progress on the Dug Well Recharge Scheme. The representative from GSDA, NABARD and

Agriculture department attended the meeting . Dr. P.K. Jain, Scientist D and Shri S.C. Paranjape, AHG represented from CGWB.

- The Secretary, Ministry of Water resources chaired a meeting on the Scheme "Artificial Recharge to Ground Water through Dug wells" on 17th June 2009 at New Delhi. Dr. S.K. Gupta, Scientist D & H.O.O. Western Region, Central Ground Water Board attended and participated in the meeting. Issues related to credibility of subsidy amount into the accounts of farmers by Banks under the scheme. Progress of the scheme and IEC activities under the scheme were discussed.
- The NABARD has released subsidy to Lead Banks amounting Rs. 26.06 lacks on 4th June 2009 for 805 beneficiaries, Rs. 148 lacks for 4560 beneficiaries on 16th June 2009 and Rs. 130.08 lacks on 24th June 2009 for 4067 beneficiaries under the Scheme of Artificial Recharge to Ground Water through Dug Wells.
- Dr.K.Md. Najeeb Suptd Hg attended Review meeting of Dug Well Recharge Scheme on 5.06.2009 at Bangalore under the chairmanship of Addl. Chief Secretary and Development commissioner, Government of Karnataka.
- Shri M.Muthukannan Scientist-D attended DLIMC meeting of Dug Well Recharge Scheme in Bagalkot district at ZP Bagalkot hall on 12.6.2009.
- Shri. T.M.Hunse Regional Director attended meeting on 17.06.2009 at New Delhi called by NPMC, on review of release of Subsidy to beneficiaries, under Dug Well Recharge Scheme.
- Smt Bijimol Jose , Asst.Hydrogeologist attended DLIMC meeting of Dug well recharge scheme in Hassan district at ZP hall Hassan on 23.6.2009.
- State Level Task Force for the scheme " Artificial Recharge to ground water through Dug wells" was constituted under the chairmanship of Regional Director, CGWB with members from RDPR, NABARD, and SLBC. First meeting was Held on 24.06.2009 at Conference hall, Bhujal Bhawan, CGWB, SWR. Minutes of the meeting sent to the Members and Chairman, NPMC.
- Member(SML) attended review meeting taken by Secretary (WR) " Artificial Recharge to Ground Water through Dug Wells" at Ministry of Water Resources, New Delhi on 17.06.2009.
- Scientist of Central Ground Water Board, South East Coastal Region, Chennai attended the work related to NPMC and participated in the meeting on credit of subsidy in the beneficiaries banks under the Scheme of Dug Well Recharge at CGWA, New Delhi from 9.06.09 to 21.06.09.
- Shri A.D. Rao, Scientist D of Central Ground Water Board, Southern Region, Hyderabad attended meeting on "Artificial Recharge to Ground Water through Dug Wells" at New Delhi on 17.06.2009.
- Shri R.C. Jain, Regional Director, Central Ground Water Board, West Central Region, Ahmedabad attended three DLIMC meetings on "Artificial Recharge to Ground Water through Dug Wells" at Junagarh on 3.06.2009 & 25.06.2009 and at Panchmahals district on 24.06.2009.
- The Second State Level Meeting of the Task Force on the "Artificial Recharge on Ground Water through Dug Wells" was held on 9th July at Regional Office NABARD, Pune. The meeting was convened by Shri P.K. Parchure, Supdtg. Hydro geologist, Central Ground Water Board, Central Region, Nagpur. The meeting was attended by the officers from Soil & Water Conservation Department, Govt. of Maharashtra, NABARD, GSDA and Lead Banks entrusted with the disbursement of subsidy.
- Scientists from Central Ground Water Board, Southern Region, Hyderabad attended meeting taken by Hon'ble Chief Minister, Govt. of Andhra Pradesh on 15.07.2009 regarding implementation of Artificial Recharge through Dug Wells in Andhra Pradesh.
- Regional Director, Central Ground Water Board, West Central Region, Ahmedabad attended DLIMC meeting on Artificial Recharge through Dug Wells at Surat on 4th July 2009.
- Shri. B.K.Kallapur, Sci'D attended DLIMC meeting for scheme " Artificial Recharge to ground water through Dug wells" Kolar District at Kolar on 16.07.2009. Suptd Hydrogeologist attended Review meeting of Dug Well Recharge Scheme on 5.06.2009 at Bangalore under the chairmanship of Addl. Chief Secretary and Development commissioner, Government of Karnataka.
- Regional Director, CGWB, Western Region, Jaipur attended and participated in the meeting "Nodal Bank Branches" convened by NABARD, Jaipur on 14.07.2009. The agenda in the meeting were discussed regarding release of subsidy for scheme for Artificial Recharge to Ground Water through Dug Wells.
- Regional Director, CGWB, Western Region, Jaipur attended and participated in the State Level Task Force meeting held at NABARD, Jaipur on 16.07.2009 regarding effective implementation and to suggest the measures to overcome the bottlenecks in the implementation of scheme of Artificial Recharge to Ground Water through Dug

Wells in the State and release of subsidy to Beneficiaries.

- Chairman, Member (SML) and Senior officers of the Board attended the meeting taken by Secretary (WR) to review the progress of the Scheme of "Artificial Recharge to Ground Water through Dug Wells" at Conference Room, NABARD, Mumbai on 7th August 2009.
- Review meeting of the scheme on "Artificial Recharge through Dug Wells" in Karnataka called by Secretary, Ministry of Water Resources, Govt. of India was held at Mumbai on 7th August, 2009. Regional Director, South Western Region, Bangalore attended the meeting.
- Regional Director, CGWB,WCR, chaired the 2nd meeting of the State level task force on the scheme "Artificial Recharge to ground water through Dug wells" on 4.08.2009 at Ahmedabad.
- A meeting of core group formed by Uttarakhand state for Artificial Recharge and rainwater harvesting in Uttarakhand state has been held at CGWB office at Dehradun.
- Scientists of SWR, Bangalore attended a meeting on Restoration and Renovation of Tanks in Ranga Reddy & Warangal District, Andhra Pradesh on 2.9.2009.
- Second State Level Task Force meeting under Artificial Recharge to ground water through dug wells in Karnataka was held under the chairmanship of Regional Director, SWR on 7.9.2009 at department of RDPR, Govt.Of Karnataka for reviewing the progress of the scheme.
- Head of Office and Scientist-D attended a meeting on Dug Well Recharge convened by Commissioner, Panchayat Raj Department, Governemnt of Andhra Pradesh on 16th September, 2009. The meeting was attended by Sr. Officers of Government of Andhra Pradesh and NABARD. The modalities for implementing the Scheme were discussed at length.
- Suptdg Hydrogeologist, NWR, Chandigarh attended meeting with Chief Secretary, Punjab regarding Artificial Recharge to ground water through dugwell on agriculture land holding of farmers on 17.09.09
- Regional Director, South East Coastal Region, Chennai attended the SLTCC meeting on Artificial Recharge Schemes, Ground Water Resource Estimation and related issues at PWD, Secretariat, Chennai on 16.10.2009 and participated in the deliberations.
- Regional Director, South East Coastal Region, Chennai held discussions with District Collector, Namakkal on 7.10.2009 regarding progress of dug well recharge schemes and construction of Piezometers in Namakkal district.
- Regional Director, CGWB, Kerala Region, Trivendrum attended the District Level Committee meeting convened by the District Collector on the ongoing Artificial Recharge Schemes and new schemes proposed in Kasargod District at Collect orate, Kasargod on 15th October, 2009 and participated in the deliberations.
- 8th Meeting of the National Level Programme Monitoring Committee constituted under the Scheme of "Artificial Recharge to Ground Water through Dug Wells" was held at Central Ground Water Authority under the Chairmanship of Member(SML). The meeting was attended by Members of NPMC and other Senior officers of CGWB.
- Scientist D, Central Ground Water Board, North Western Region, Chandigarh attended a meeting on 5.10.2009 with Engineering-in-Chief, Public Health Engineering Department, Govt. of Haryana regarding Rainwater Harvesting and Artificial Recharge in Mewat and other areas of Haryana State.
- Regional Director, CGWA, New Delhi and Regional Director, NWR, Chandigarh attended meeting with Principal Secretary (Irrigation & Power), Govt. of Punjab on 15.10.2009 on Enactment of Legislation on Ground Water Authority by the State of Punjab on the lines of Model Bill circulated by the Ministry of Water Resources, Govt. of India. In the meeting, it was also decided that more schemes for Artificial Recharge to ground water in over exploited blocks of Punjab witnessing water level decline be prepared and submitted.
- OIC, SUO, New Delhi attended meeting regarding Artificial Recharge of Ground Water in NCR Region taken by Member Secretary, NCR Planning Board on 3.11.2009.
- OIC, SUO, New Delhi attended meeting with CEO, Delhi Jal Board regarding implementation of Artificial Recharge Projects under Central Sector Scheme in Educational Institute in South and South-West Districts of Delhi at Varunalaya, New Delhi on 6th November, 2009.
- 9th meeting of National Level Programme Monitoring Committee Constitute under the Scheme of "Artificial Recharge to Ground Water through Dug Wells" was held under the

Chairmanship of Member(SML) at CGWA, Curzon Barracks, New Delhi.

- Regional Director inspected the FPARP sites in Coimbatore district along with Professors of Tamil Nadu Agricultural University on 19.11.2009. Also, visited the sites selected for construction of Artificial Recharge structures in Karuvettar Water Shed of Namakkal district along with Shr. A.Subburaj, Sc`D' and officials of PWD, Sarabanga Basin Division, Namakkal.
- Regional Director CGWB, SECR, Chennai & Shri.A.Subburaj, Sc`D' inspected Artificial Recharge Structures which are under construction in Thalaivasal Block, Salem district and held discussions with officials of Saradha Ashram on 20.11.09 in connection with organization of workshop on "Water Quality" during January 2010.
- 10th meeting of NPMC to discuss progress of implementation of the scheme of "Artificial Recharge to Ground Water through Dug Wells" was held under the Chairmanship of Member(SML) at Central Ground Water Authority, Curzon Road Barracks, New Delhi on 8.12.2009.
- 3rd meeting for preparation of terms of reference (TOR) and request for proposal (RFP) for engagement of agency / agencies for impact assessment study under the scheme of "Artificial Recharge to Ground Water through Dug Wells" at Central Ground Water Authority, Cuezon Road Barracks, New Delhi on 8.12.2009.
- Regional Director, West Central Region, Ahmedabad participated SLSC meeting on the scheme "Artificial Recharge to Ground Water through Dug Wells at GSWMA, Gandhinagar on 1.12.2009.
- Scientists of Central Ground Water Board, SUO, Pune attended the meeting of District Level Implementation and Monitoring Committee (DLIMC) at Ahmednagar under the chairmanship of District Collector, Ahmednagar on 11-12-2009.
- Regional Director and Scientists of Central Ground Water Board, Western Region, Jaipur attended and participated in the State Level Technical Coordination Committee (SLTCC) chaired by Secretary, PHED & GWD, Govt. of Rajasthan, Jaipur on 7.12.2009 in connection with the implementation of Artificial Recharge Projects under Central Sector Scheme "Ground Water Management and Regulation".
- Regional Director of Central Ground Water Board, Western Region, Jaipur attended and participated in the District Nodal Officers meeting in respect of implementation of scheme on "Artificial Recharge to Ground Water through Dug Wells" on 22.12.2009. The meeting was chaired by the Secretary PHED and GWD.
- The SLTCC meeting for the State of Mizoram was convened on 12.01.2010 at Aizwal in the Chamber of Principal Secretary, Govt of Mizoram in the capacity of Member Secretary of the committee. The committee approved seven Detail Project Reports of Mizoram on Roof Top RainWater Harvesting and Artificial Recharge. The DPR along with the minutes of the meeting was sent to Member Secretary, CGWA.
- Dr. P. N. Rao, Scientist – D attended the SLSSC meeting on 25.01.10 convened by Engineer – in – Chief, RWSS, Government of A. P. for approval of Schemes/Projects under National Rural Drinking Water Programmes for the year 2009 – 10 and participated in the deliberations.
- Regional Director, Central Ground Water Board, Uttaranchal Region, Dehradun attended meeting with Head, Department of Hydrology, IIT, Roorkee to prepare proposal on waste water utilization for Artificial Recharge to Ground Water.
- Scientists of the Central Ground Water Board, Southern Region, Hyderabad attended the SLSSC meeting for approval of Schemes/Projects under National Rural Drinking Water Programme for 2009-10 convened by Rural Water Supply & Sanitation Department, Govt. of Andhra Pradesh on 11th February 2010 at Hyderabad.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai attended 2nd District level T.C.C. meeting at Collectorate, Coimbatore under the Chairmanship of District Collector on 20th February 2010.
- The third State Level Meeting of the Task Force on the Scheme "Artificial Recharge on Groundwater through Dug Wells" was held on 3rd February 2010 at Regional office, NABARD, Pune. The meeting was convened by Central Ground Water Board, Central Region, Nagpur. The meeting attended by the officers of CGWB, officers of NABARD, Soil Conservation and Watershed Development Department(Nodal Agency), Govt. of Maharashtra and Nodal/ Lead Banks entrusted with the disbursement of subsidy, besides officials from the CGWB.
- The Secretary, Ministry of Water Resources, Govt. of India had convened a National Level Meeting to review the progress of the scheme of "Artificial Recharge to Groundwater through Dug Wells" on 12th March 2010 at NABARD, Mumbai. Shri. B.

Jayakumar, Regional Director, CGWB and Shri. P.K. Parchure, Suptdg. Hydrogeologist, CGWB, CR, Nagpur and Dr. P. K. Jain, Sc-D & OIC, CGWB, SUO, Pune attended the meeting. The representative of Govt. of Maharashtra informed that the implementation of the scheme has now picked up well and they requested for extension of the scheme by another one year.

- 12th meeting of National Level Programme Monitoring Committee Constituted under the Scheme of "Artificial Recharge to Ground Water through Dug Wells" was held under the Chairmanship of Member(SML) at Central Ground Water Authority, Curzon Road Barrack, New Delhi on 10.03.2010.
- A meeting of State Level Co-ordination Committee (SLTCC) on Artificial Recharge Project under Central Sector Scheme of "Ground Water Management & Regulation" in the blocks of Nalhati-I & Murarai-I, Birbhum district, West Bengal was held on 16.03.10 in the office chamber of the Principal Secretary, WRIDD, Govt. of West Bengal, at Kolkata, to review the status of physical and financial progress of the scheme. The utilisation certificate, amounting Rs. 27.49558 lakhs, against the first installment of Rs. 33.32730 lakhs, was placed by the Implementing Agency in the meeting and the same was approved by the members. The payment of work, so far completed, is withheld due to inadequate fund, available with the agency. The committee, therefore, recommends the release of second and last installment of Rs. 77.76370 lakhs.

24.3.2 Meeting on Yamuna River Development Authority

- Sixth meeting of the Technical Advisory Group (TAG) of Yamuna River Development Authority under the chairmanship of Hon'ble Lt. Governor was attended on 29th April, 2009
- Sr. Officers of the Board attended meeting of Technical Advisory Group of Yamuna River Development Authority at Delhi taken by Principal Secretary, Govt. of NCT, Delhi at Delhi Sectt. on 15th April,2009.
- Regional Director attended 6th meeting of Technical Advisory Group of Yamuna River Development Authority at Raj Niwas, Delhi on 29th April, 2009. The meeting was taken by Lt. Governor of Delhi.
- Officer Incharge, SUO Delhi attended meeting on 25.05.2009 taken by the Principal Secretary, Urban Development Govt. of NCT Delhi regarding Technical Advisory Group of Yamuna River Development Authority at Delhi Secretariat, I.P. Estate, Delhi .
- Officer In charge, SUO, New Delhi attended meeting on 4.06.2009 taken by Principal Secretary, Urban Development, Govt. of NCT Delhi regarding Draft Committee of TAG under Yamuna River Development Authority.

24.3.3 Meeting on Farmers Participatory Action Research Programme

- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai visited PALMYRA, Auroville on 19th and 20th May, 2009 and inspected the field where Farmers Participatory Action Research Programme (FPARP) Scheme has been implemented by them and interacted with farmers about the benefit of the scheme.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai participated in the review meeting of Joint Secretary, Ministry of Water Resources at Coimbatore on 22.05.2009 along with Chief Engineer, Central Water Commission and took part in field inspection of FPARP demonstration sites in Coimbatore and Sathyamangalam area.

24.3.4 10th Meeting of the Central Ground Water Board

10th Meeting of the Central Ground Water Board was held on 24.07.2009 under the Chairmanship of Chairman, CGWB at Jamnagar House office, New Delhi which was attended by Member (SML), Member (SAM), Member (T&TT), Director (GW) MOWR, Consultant (MOWR), General Manager ONGC and other Senior Officers of the Board. The Chairman CGWB, in his opening remarks expressed concern over the depleting ground water levels and ground water quality. He emphasized upon the need for sustainable development and management of ground water resources in the country.

24.3.5 Meetings on Ground Water Assessment

- A meeting was held on 8th July 2009 with Director, Ground Water Surveys and Development Agency (GSDA) at Pune to discuss about various issues on Ground Water monitoring, development and management. The main discussion was about the difference in ground water recharge and draft figures as compared to 2004 figures. GSDA also

presented case studies in which they pointed that variation in recharge was mainly due to PD factor and decrease in draft due reduction in number of wells as per Revenue records and less number operational days during non-monsoon period. Shri Parchure, Supdtg. Hydrogeologist suggested that a rapid survey be made in select watersheds where the number of wells have drastically reduced and further suggested to check whether the decrease in draft is reflected in the water level hydrographs.

- Regional Director, Central Ground Water Board, West Central Region, Ahmedabad attended meeting with Managing Director, Gujarat Water Resource Development Corporation (GWRDC) regarding finalization of Ground Water Resource Estimation 2007 at Gandhinagar on 24th July 2009.
- Regional Director, Central Ground Water Board, South Western Region, Bangalore attended meeting of working group of GEC for re-estimation of Groundwater Resources of Karnataka was held at CGWB, SWR on 13.07.2009.
- Member(SAM) chaired the fourth and final meeting of the Working Group on methodology for assessment of development potential of deeper aquifer on 28th July 2009. The draft report of the working group was discussed and finalized. The meeting was attended by General Manager, NABARD, Regional Director, CGWB, State Govts of Haryana, Punjab, Uttar Pradesh, CGWB officers, Scientists from NIH, Roorkee and Indian Institute of Remote Sensing, Dehradun.
- Member(SAM) chaired the meeting on new and alternate methods of ground water resources assessment on 28th July, 2009. The meeting was attended by CGWB officers, Consultant (GW), Ministry of Water Resources, Scientists from NIH, Roorkee and Indian Institute of Remote Sensing, Dehradun. The concept paper on methodologies for ground water assessment was discussed in the meeting.
- The first meeting of Ground Water Estimation Committee was convened by Regional Director on 18th August, 2009. The meeting was chaired by the Additional Chief Secretary, Water Resources Department, Kerala State.
- Shri P.K.Parachure, H.O.O, CGWB, CR, Nagpur with officers of CR attended the State level meeting at Pune on 16th September 2009, convened by the Principal Secretary, Water Supply and Sanitation Departnment, Govt of Maharasthra, to review and finalise the Ground Water Resource Estimation of Maharasthra.

24.3.6 Regional Directors Meeting

- A Review meeting for Regional Directors was held during 28 – 29th October 2009 at Central Ground Water Board, Jamnagar House, New Delhi under the chairmanship of Chairman, CGWB. Members, Director (Admn.), FAO , Regional Directors, Superintending Engineers and other senior officers of the Board attended the meeting . The various items like Progress of work done during AAP 2009-10, Annual Action Plan 2010-11, following action on decisions taken in previous meeting, Administrative & Financial matters were discussed during the meeting. Director (GW & Esstt.) and Director (GW) from the MOWR also participated in the meeting of Regional Directors.
- A meeting for Regional Directors was held on 30th March, 2010 to review the activities / work plans of the Regional Directors of Central Ground Water Board in their Regions for 2010-11 taken by Secretary (WR) in the Conference Hall of the Ministry of Water Resources Shram Shakti Bhawan, New Delhi. Senior officers of the Board also attended the meeting . The various items like Progress of work done during AAP 2009-10, Annual Action Plan 2010-11, Administrative matters were discussed during the meeting.

25. CONSTRUCTION/ACQUISTION OF OFFICE BUILDINGS

The details of following construction work for own office building of Central Ground Water Board have been carried during 2009-10 up to 31st March 2010 is given in table 251.1

Table 25.1:Construction Work for Own office building during 2009-10

Region	Status
Bangalore	During 2009-10, Boundary wall at Bangalore has already been constructed and Divisional workshop is functioning on our own land. The construction work has been started. The funds to the tune of Rs. 2.00 Crores has been released against total estimate of Rs.4,04,60,000/-.
Guwahati	The construction work for 2 RCC Culverts and Store building likely to be completed by the end of this year 2009-10. Regarding construction of building for Regional & Divisional Office at Guwahati. The Ministry has accorded AA&ES for an amount of Rs.14,30,79,000/-. The CPWD has submitted their requirement of funds for Rs.1.75 Crores for 2009-10, out of which the Ministry has accorded sanction of Rs.29 Lakhs for 2009-10. The work likely to be start shortly.
Ahmedabad	Acquisition of land for construction of building of Region & Division, at Ahmedabad has been taken up. The land is under occupation of CGWB and CPWD has been asked for submission of preliminary estimate for construction of office building.
Bhubaneswar	The construction work of boundary wall around land of CGWB acquired for construction of Staff Quarter at Bhubaneswar. The entire funds as per estimate have been released. The work is in progress and likely to complete shortly.
Raipur	The land for construction of RGI building at Raipur has already been acquired. The possession process after demarcation of land is under progress with the State Authorities.
Faridabad	The building proposed to be constructed on the space available in the existing campus of "Bhujal Bhawan" for the Regional training centre at Faridabad. The modified preliminary estimate and its drawings has been re-submitted to Chief Engineer, CPWD, New Delhi for preparation of estimate.
Ambala	The land for construction of building of Division II at Ambala has been purchased. Ministry has released an amount of Rs.20 Lac for construction of boundary wall and earth filling work.
Jammu	The physical possession of land for Region office at Jammu has been taken over from Jammu Development Authority. The Regional Director, NWHR, Jammu has taken up the matter with the Chief Engineer, CPWD for preparation of Plan & Estimate.
Dehradun	The Chief Secretary of Uttaranchal State has expressed his inability to allot land. The Nagar Nigam, Dehradun has desired to allot a piece of land of 1600 sq.meter to CGWB, Dehradun. The land has been identified and the matter is at final stage.
Chennai	A proposal for sanction of an amount Rs.2,05,09,440/- towards the cost of land for construction of building for Divisional Store and Workshop to be purchased from State Government has been submitted to Ministry. Sanction is awaited.

26. DISSEMINATION AND SHARING OF TECHNICAL KNOW-HOW

26.1 Regional Workshop under IEC

❖ Under IEC activities, a workshop was organized on the theme "Roof Top Rainwater Harvesting and Spring Recharge" at TRC, Jammu on 10th February 2010 at 10.00 hrs. as per the directives received.
Shri Ashok Angurana, IAS, Principal Secretary, PHE, I&FC Departments, Govt. of J&K inaugurated the workshop as Chief Guest. In his inaugural address, he expressed his concern on the depletion of the water level due to decreasing rainfall & snowfall and insisted on the necessity of the roof top rainwater harvesting specially in the urban area. Dr. S.C. Dhiman, Member (SML), CGWB, who presided over the function introduced the theme of the workshop. Shri Dalip Bakshi, Chief Engineer, PHED, Jammu praised the work carried out by the CGWB in the state. Shri Ashwani Kumar Sharma, Chief Engineer, RTIC, Jammu expressed his concerned on the ground water quality in the state. Shri R.K. Gupta, Director, CWC was also presence in the function.

During the inaugural function Workshop volume containing all the papers presented in the workshop, Brochure on Rainwater Harvesting and booklet on Roof Top Rainwater Harvesting were released.

The focal theme for the workshop was **"**Roof Top Rainwater Harvesting and Spring Recharge"**.** The objective of the workshop was information dissemination, awareness creation and capacity building among the stakeholders like PHE, I&FC departments, CWC, GSI, NIH, University of Jammu and SKUAST, Kashmir. This workshop had provided a platform for interaction & sharing experiences by Scientists, Engineer and Officers from different organizations and to address various hydrogeological and hydrological issues including ground water quality and water use efficiency and snow water harvesting. During the workshop different aspects concerning the water conservation, methods and need of roof top rainwater harvesting, ground water exploration, Chemical quality of ground water in the state, snow water harvesting and all other aspects of development and management of ground water resources were discussed.

About 75 officers from the various Central & State Govt Departments like CWC, Professor & students of University of Jammu, Professor & students of SKUAST, Kashmir, Officers from PHED, Irrigation & Flood Control, Geology & Mining have participated in the workshop. During the workshop, exhibition on rainwater harvesting and water conservation was also organized and participants have taken keen interest in displayed charts and photographs depicting water conservation techniques.

❖ **U**nder the Information, Communication and Education (IEC) programme of Ministry of Water Resources, Govt. of India, Central Ground Water Board NCCR, Raipur organized a workshop on "Water Quality Management", on 22nd of January 2010 in Hotel Babylon Inn at Raipur. The programme was well conceived and was given wide publicity. For the purpose the information brochure was circulated in the 2nd week of Sept 2009, to all the prospective academic institutions, Universities, research organizations, Govt. organizations, PSUs, NGOs, individuals working in the concerned field in Raipur, Bilaspur, Durg and Bhilai along with all the Regional Offices & SUO of the CGWB. Technical papers/contributions were invited from the researchers, academicians and individuals of the above organizations for presentation in the workshop and publication in the workshop-volume. Very good responses were received from all the quarters and a number of technical papers were received for presentation/publication in the workshop. Out of the received technical papers 15 were selected for presentation/publication from varied fields related to the workshop theme. The whole workshop was divided into three technical sessions preceded by an inaugural function and concluded by valedictory function. Sh. C.K.Khaitan,Secretary,WRD, Govt. of Chhattisgarh , Sh. Dinesh Shrivastava, Secretary, PHED, Ms Shaheen Nilofer, Chief UNICEF, Chhattisgarh, were the chief guest , guest of honourand special invities, respectively in the inaugural function. The district report of Korba district was released in this occasion. The function was conducted by Sh. D.Chakraborty, Scientist 'C', CGWB, NCCR, Raipur.

26.2 Region-wise paper published and training taken by officers during 2009-10

Sl. No.	Regions	Paper presented /attended		No. of officers	
		National	International	Trainings	
				National	International
1	NWHR, Jammu	9	-	11	-
2	NWR, Chandigarh	3	-	7	-
3	WR, Jaipur	-	-	7	-
4	WCR, Ahemdabad	11	-	11	-
5	NCR, Bhopal	8	-	12	-
6	NCCR, Raipur	1	1(J)	8	-
7	CR, Nagpur	4(J)	-	8	-
8	NR,Lucknow	2	-	2	-
9	MER, Patna	15	-	11	-
10	ER, Kolkata	13	-	9	-
11	NER, Guwahati	30	-	4	-
12	SER, Bhubaneshwar	9	-	2	-
13	SR, Hyderabad	25+7(J)	-	7	-
14	SWR, Banglore	28+1(J)	-	16	-
15	SECR, Chennai	6+6(J)	-	10	-
16	KR, Trivendrum	6	-	5	-
17	UR,Dehradun	3+2(J)	-	7	-
18	NHR, Dharamshala	-	-	4	-
19	SUO, Delhi				
20	CHQ,Faridabad				4
	Total	169+20(J)	1(J)	141	4

26.3 Presentation of Technical Papers and Lectures

- Three scientific papers were presented by the officers in the Seminar on Sedimentation, Tectonics and Hydrocarbon Potential in Himalayan Foreland Basin organized by Department of Geology, University of Jammu at Jammu on 22-23 February 2010.
- Scientists of CGWB, CR, Nagpur have presented lectures on the scheme of "Artificial Recharge to Groundwater through Dug Wells" for the Workshop on Dug Well recharge organised by the State Nodal Agency at Jalalkhed in Nagpur district and Warud and Morshi taluka in Amravati districts on 5th and 17-18th March 2010 respectively. The aim of the presentation was to provide guidance to the farmers on the above scheme. About 150 to 200 farmers participated in the above Workshop and they have actively interacted with the CGWB.
- Shri S. Marwaha, Scientist 'D', CGWB, NWR, Chandigarh attended and presented paper in International Seminar at 8th IAH Assembly, 37th IAH Congress at Hyderabad on 'Impact of mining on ground water regime- a case study in Faridabad'on 7.09.2011.
- Shri S. Marwaha, Scientist 'D' CGWB, NWR, Chandigarh attended and presented paper on 'status of ground water in Punjab & Haryana and its legal perspective' in the workshop on Colloquium on Environmental degradation and its facet'organized by Chandigarh Judicial Academy on 12 and 13 September 2009.
- Shri S. Marwaha, Scientist 'D' CGWB, NWR, Chandigarh attended and presented paper on' Artificial Recharge Technologies for Water Conservation' in the Seminar on Water Conservation and its Management organized by Universal Rational Genre of Exponents (URGE) at CII, Chandigarh on 24.9.2009.
- Dr. Arun Kumar, Scientist 'B' CGWB, NWR, Chandigarh delivered lecture on Water quality scenario in Punjab and Haryana-an Over view in the Workshop on Ground water management in Haryana, Punjab and Chandigarh on 19.02.2010.
- Shri D.Tewari Scientist 'C' CGWB, NWR, Chandigarh delivered lecture in workshop on "Ground Water Monitoring, Design, Networking and Panchayat's Participation" on 16.03.2010 organized by CGWB, NWR at M.G.S.I.P.A, Institutional Area, Chandigarh.
- Dr. P.K. Jain Sc-D CR, Nagpur attended and presented paper on National Conference on Ground Water Resource Development and Management in Hard Rocks, February 2010 at University of Pune, Pune.

26.4 Participation/Organized Workshop, Seminars and Conference

- Member (SML), Regional Director and Senior officer attended a seminar on 27th April, 2009 on different aspects of Irrigation Water Management at IARI Conference Room, New Delhi. The seminar was conducted by the Project Director, Water Tech. Centre.
- One day workshop on "Rainwater and Crop Management in Saline Tract of Viarbha Region" as FPARP Extension Activity was organized on 11th April 2009 at Daryapur by Dr. Punjabrao Deshmukh Krishi Vidyapith, Akola in collaboration with Ministry of Water Resources, New Delhi and the participating farmers in the project. About 400 farmers participated in the workshop. Dr. V.M. Mayande, Vice-Chanceller, P.D.K.V., Akola was the Chairman

for the workshop. Shri B. Jay Kumar, Regional Director and other officer of Central Ground Water Board, Central Region attended this programme along with the other dignitaries.

- One day Workshop on "Ground Water Recharge Through Dugwells in the State of Karnataka " was conducted at CGWB, SWR, on 21.05.2009. District Level nodal officers nominated by Chief Executive officers for 20 districts of Karnataka state attended the workshop. The meeting was chaired by Dr. S.C. Dhiman, Member (SML), CGWB& Chairman, NPMC, Dugwell Recharge Scheme. He gave suggestions to overcome the bottlenecks to ensure the speedy implementation of the scheme. The meeting was attended by Shri.Rajeev Kumar, Director (GW), Ministry of water resources and officers from NABARD, State Level Bankers Committee to review the progress so far.
- Regional Director, Central Ground Water Board, West Central Region, Ahmedabad attended technical Seminar on Waste Water Management organized by Everything about Water Pvt. Ltd., New Delhi on 14.05.2009 at Vadodara.
- One day workshop on Rainwater and Crop Management in Saline Tract of Vidarbha Region as a FPARP Extension Activity was organized on 11th April 2009 at Daryapur by Dr. Punjabrao Deshmukh Krishi Vidyapith, Akola in collaboration with Ministry of Water Resources, New Delhi and the participating farmers in the project. About 400 farmers participated in the workshop. Dr. V.M. Mayande, Vice – Chancellor, Dr. P.D.K.V., Akola was the Chairman for workshop. Shri B. Jay Kumar, Regional Director, CGWB, Central Region, and Shri P.K. Parchure, Supdtg. Hydro geologist attended this programme with the other dignitaries.
- Member (SML) and othe Senior officers of the Board attended Workshop organized by Ministry of Rural Development Convergence issues under NREGA and Watershed Programme at Vigyan Bhawan, New Delhi on 6.05.2009.
- Scientists from Central Ground Water Board, North Western Region, Chandigarh attended workshop on Leveraging NREGA for sustainable development through Inter – Sectoral Convergence at Vigyan Bhawan, New Delhi on 6.05.2009.
- As per the Directives of Ministry of Water Resource a workshop on " Strategies for Water Conservation Artificial Recharge to Ground Water and improving water use efficiency in Ladakh Region of Jammu and Kashmir" was organized by CGWB, NWHR in Collaboration with 8 Mountain Division on 09.06.2009 at Kargil. During the course of workshop the following officers had delivered lectures/demonstration on various topics related to Ground Water.
- Chairman, Member (SML), Member(SAM) and TS to Chairman attended Conference of Principal Secretaries / Secretaries of Irrigation at ICAR, NASC Complex, Pusa, New Delhi on 24.06.2009.
- OIC, SUO, Delhi attended 60th International Executive Council Meeting & 5th Asian Regional Conference on Improvement in Efficiency of Irrigation Projects through Technology Upgradation and Better O & M at Committee Room, Central Board of Irrigation & Power, Malcha Marg, Chanakyapuri, New Delhi on 25.06.2009.
- Supdtg. Hydro geologist of Central Ground Water Board, Central Region, Nagpur attended one day National Workshop on "Environmental Flow and Water Resources Management " on 5th June, 2009 at NEERI, Nagpur. The main topic in the discussion was to review the status of environmental flow estimation methods in the Indian context and to keep provision of e-flow in surface water resource assessment
- Suptdg. Hydrogeologist, Central Ground Water Board, Eastern Region, Kolkata attended seminar on 'Use of Fly Ash in Agruiculture & Forestry', organized by Coal Ash Institute of India at CGCRI, Jadavpur, Kolkata on 6th & 7th August, 2009. Dr. Misra presented technical paper on 'Use of Fly Ash in Waste Lands and its possible effects on Ground Water Contamination'.
- Scientists of Central Ground Water Board, Eastern Region, Kolkata attended a one day workshop titled 'Open Source Demystified' on 19.8.09 at Kolkata. The theme of the workshop was implementation of free and open source software (FOSS) in office environment through incorporation of BOSS (Bharat Operationg System) platform, which is based on Debian Linux, developed by CDAC.
- Chairman, Central Ground Water Board, alongwith Regional Director and Scientists of the Board from different Regional offices & HQ participated in Joint International Convention organised by 8th IAHS Scientific Assembly and 37th IAH Congress with a focal theme "Water: A vital resource under stress-How science can help" organised by NGRI from 6-12 September, 2009 at Hyderabad. The Scientists of the Baord presented technical Papers in the Convention.Chairman, Regional Director, Ahmedabad also presided over one of the technical session.
- The scientists of the Board from different Regional offices attended Four-day pre-Conference training on "Introdution to ground water flow and solute

transport modelling" organised by NGRI & IAHS at Hyderabad from 1st to 4th September, 2009.

- Shri S.Marwaha, Scientist-D of Central Ground Water Board, North Western Region, Chandigarh presented paper at Two days Colloquim on Environmental degradation and its facet at Chandigarh on 12-13 September 2009.
- Dr R.P.Singh, Scientist-D presented technical paper in the workshop on Ganga and ground water contamination and its mitigation, organised by CGWB at BHU, Varanasi on 17-18th Sept 2009.
- H.O.O, CGWB, CR, Nagpur along with officers of CR participated in the National symposium on "Advances in Geospatial technologies with special emphasis on sustainable Rainfed Agriculture" organised by Indian Society of Remote Sensing(ISRS) during 17-19th September 2009 at Nagpur. Shri P.K.Parachure, chaired one of the technical session.
- Member(SML), Member(SAM) and two Scientist D attended Workshop on Scheme for promoting installation of Tubewells/Borewells and Construction of Dugwells in order to augment availability of water for agriculture and drinking water supply workshop chaired by the Joint Secretary (Admn.), MOWR.
- Member (SML) attended National Workshop to review the implementation of work programme towards a comprehensive assessment of Climate Change at Ashoka Hotel, Chanakyapuri, New Delhi on 14.10.2009.
- Chairman attended Inaugural function of Indo-German Workshop on "Sustainable Urban Development" organized by University of Rajasthan at Jaipur on 21.10.2009.
- Dr R.P.Singh, Scientist-D, presented papers at Two days Indo-German Workshop on Sustainable Urban Development held on 22-23 October 2009 at Jaipur.
- H.O.O and Scientists of CGWB, CR, Nagpur participated in the one day Workshop under Farmers Participatory Action Research Programme (FPARP) on "Insitu Soil Moisture Conservation Practices" organized by the Marathawada Agricultural University, Parbhani on 1st October, 2009. Shri P.K.Parachure was invited by the above University as Chief Guest of the Workshop.
- Regional Director and Supdtg. Hydrogeologist, South Western Region, Bangalore attended the Mass awareness programme as dignitaries, at Srinivasapur, Kolar district on 16.10.2009 which was organized by Department of of Mines and Geology, Govt. of Karnataka.
- Supdtg. Hydrogeologist of Central Ground Water Board, South Western Region, Bangalore imparted training on GEC methodology for ground water resource estimation to state/district level officers of Department of Mines and Geology, Govt. of Karnataka on 23.10.2009 at Bangalore.
- Regional Director CGWB, SECR, Chennai attended the Workshop and made presentation on "Water Management and Conservation" organized by WAPCOS at Coimbatore on 18.11.09
- Regional Director CGWB, SECR, Chennai attended Seminar on "Water Management" and made presentation on "Water Management" organized by Rotary Club of Vaniambadi Mid Town at Vaniambadi on 22.11.2009.
- Suptg HG, CGWB, SECR, Chennai attended workshop on Purpose Driven Studies (PDS) held at New Delhi on 23rd and 24th November 2009. Powerpoint presentation was made on the progress, road map, milestone and bottle necks of the R&D Project on Determination of Specific Yield for Planning and designing of Artificial Recharge Structures in Suburban areas of Chennai, Tamil Nadu.
- OIC, SUO, New Delhi and Scientist D attended NDWMA Workshop regarding Second India Disaster Management Congress at Vigyan Bhawan, New Delhi on 6th November, 2009.
- Central Ground water Board, NER organized Regional workshop on "Water Quality Management and its Related issues in North Eastern States" at Conference Hall, National Institute of Rural Development, Guwahati on 25th and 26th November, 2009. Delegates & officials from different organizations / Institutions, NGOs, Vos, i.e Directorate of Geology & Mining, Govt of Assam , Public Health Engineering Department, Mizoram, Govt of Mizoram, Central Water Commission, National Institute of Hydrology, Gauhati University, Students of Chemistry department, Gauhati University, etc participated. 21 papers were presented in different focal themes. In the inaugural Session Shri Rajan Nair, Chairman, Brahmaputra Board was Chief Guest, Dr.A.D Patgiri, Professor, Gauhati University and Shri A.B.Paul, Ex Chief Engineer, Public Health Engineering Depatment, Govt of Assam , Dr P.K.Haloi, Deputy Director, N.I.R.D were Guests of Honour. In the Valedictory function Shri Rajan Nair, Chairman, Brahmaputra Board, Shri A.B.Paul, Ex Chief Engineer, Public Health Engineering Depatment, Govt of Assam, Shri R.Lalfanliana, Chief Engineer, PHED, Govt of Mizoram was Chief Guest and Guest of Honour. Recommendations were accepted after fruitful

discussion. Shri G.C.Saha, Regional Director, CGWB, NER presided over both the sessions.

- Regional Director, Uttaranchal Region, Dehradun attended a Symposium on "Impact of Climate Change on Water Resources" at National Institute of Hydrology, Roorkee on 18th November, 2009.
- Scientist D, Central Ground Water Board, New Delhi attended one day Conference of Principal Secretaries/ Secretaries of the State Governments Head of WALMIs/IMTIs on Task Group Report regarding strengthening of WALMIs/IMDSTIs on 13.11.2009
- A National Conference on "Urban Water management-Challenges and Options" was organized by Centre for Sustainable Development, Bangalore during 13th- 15th December 2009. Regional Director & Suptd.Hydrogeologist were members of 'Technical and Review Committee'. Three technical papers were presented in the seminar by South Western Region on "'Water Management in Greater Bnagalore, present scenario and future prospects", "Potential of Rain ater harvesting in and around Bangalore" and "Ground water condition in Cochin-Ernakulam urban area". Regional Director chaired the technical session and wide coverage was given by the press to the technical papers presented by Central Ground Water Board.
- A workshop on "Dug Well Recrhage Scheme-Efficiency and Efficacy" was organized by South Western Region on 22.12.2009 at Bhujal Bhawan, Bangalore. Shri A. Ravikumar, IAS, Principal Secretary, RDPR, Govt of Karnataka was the Chief Guest. Shri Venkatesh Tagat, Chief General Manager, (Karnataka) NABARD and Shri H.M.Khyum Ali, Additional Director, DMG, Govt of Karnataka, were the Guests of honour. All District nodal officers, NGOs and geologists from all the districts participated in the workshop. A total of 105 delegates participated in the workshop. Twelve presentations were made wherein progress till date, success stories and details of activities taken up by NGOs under IEC were presented in detail. Also, some of the innovative site-specific designs of the structures adopted by implementing agencies were shown. The concluding session was chaired by Dr S.C.Dhiman, Member (SML), Shri C.S.Ramasesha, Ex-Commissioner, CGWB and Shri M.C.Reddy RD (Rtd) were guests of honour.
- Chairman, Member (SML), Member (SAM), OIC SUO, New Delhi and Senior officers of the Board attended the 5th Asian Regional Conference of Indian National Committee on Irrigation and Drainage on Improvement in Efficiency of Irrigation Projects through Technology Upgradation and Better Operation & Maintenance at Vigyan Bhawan, New Delhi from 9th to 11th December, 2009.
- Regional Director, CGWB,SECR, Chennai participated in the panel discussion on "Water and its linkages with Climatic Changes" organized by Centre for Climatic Change and Adaptation, Anna University on 21.12.2009.
- Central Ground Water Authority & Central Ground Water Board, Eastern Region, Kolkata had organized a day long Workshop on "Integrated Water Resources Management-Sikkim" on 27th November 2009 at Gangtok, Sikkim. The programme covered all the aspects of Integrated Water Resources Management in the technical sessions with presentation of ten technical papers by experts working in this terrain. In total, 150 participants (Scientist's, Professor's, Academician's, Technical experts, Administrators, NGO's, Water user agencies etc) attended and actively participated in the workshop. The workshop covered both through Electronic media and Print media.
- A one day workshop on "Water Conservation & Augmentation of Water Efficiency for the benefit of Armed Forces" was organized at Gangtok, Sikkim on 30.11.09 in collaboration with Defence Authority, Govt. of Sikkim. About 300 Defence personnel attended the Workshop and all the related issues on ground water conservation in the hilly areas were discussed at length. The Chairman, CGWB highlighted the measures, undertaken and initiated by CGWB in various water conservation techniques, whose implementation would be beneficial, if adopted, by the Defence Authority. Brig. S.B.Singh of the 17 Mountain Division, appealed to the army officers to make sincere efforts to adopt the measures, as suggested by CGWB, wherever feasible.
- Central Ground Water Board, Eastern Region, participated in 'Paribesh Mela' organised by Madhyamgram Municipality, North 24 Parganas district, in collaboration with Madhyamgram Green Mancha. The officers of CGWB demonstrated the models and charts, displayed in the CGWB stall, to the gatherings. Prof. Saughata Roy, Hon'ble Minister of State for Urban Development, Govt. of India, visited the CGWB Pavilion and commented as "Good & Educative".
- Regional Director, Western Region, Jaipur attended and participated in the Workshop at Alwar district regarding Water Management Strategy in Vijay Sagar, Kaduki Lake Catchment on 5th and 6th

December, 2009 and also made a presentation in this anent. The Member (SML) also participated in the aforesaid Workshop and rendered valuable suggestions on the subject in his address.

- South Western Region, Bangalore organized brain storming session on "**Knowledge economy in water sector**" in association with WAPCOS at Regional office Bangalore on 15.1.2010. Dr.Ram Mohan Mishra Joint Secretary, MOWR chaired the session. Director(GW), Regional Director, SWR and consultants, experts from water sector from State govt and NGOs and scientists from SWR attended the session. Altogether there were four presentations. Dr K.Md.Najeeb Suptd.Hg presented theme paper. All the participants had good interaction with Joint Secretary in chalking out common base for all water experts for sharing their expertise through a web site.
- One-day National Seminar on 'Rainwater Harvesting and Artificial Recharge to Groundwater with Special Reference to Coastal areas' was conducted on 21.01.2010 at Mangalore in association with Geo-Informatics Division , Dept of Marine Geology, Mangalore University. The inaugural function was Presided over by Prof. K.K.Achari, Vice-Chancellor, Mangalore University and Shri P. V. Sukumaran, DDG, Marine and Coastal Survey Division, GSI, was the Chief Guest. Dr. K. Chinnappa Gowda, Registrar, Mangalore University released the Digital Abstract Volume of the Technical Papers of the Seminar. Shri. T. M. Hunse, Regional Director, CGWB, SWR, delivered the Key note address. Dr. B. R. Raghavan, Head, Geo-Informatics Division , Dept of Marine Geology, Mangalore University and Dr. K.Md. Najeeb, Suptd. Hydrogeologist and TS to RD were present. A total of 40 Technical Papers were received for the seminar out of which 23 were presented in 8 sessions. Nine technical papers were presented by the CGWB officers. A total of 125 delegates participated in the seminar. Technical papers were received from different institutions spread over the country like NIT, Suratkal, Karnataka, Dept. of Geology, Presidency College, Chennai, Tamil Nadu, University of Kerala, Trivendrum, Kerala, University of Madras, Tamil Nadu, University of Mangalore, Karnataka, Mysore University, Karnataka, Centre for Earth Science Studies, Trivandrum, Kerala. One paper was received from Iran.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai participated the 3rd International Perspective on Current and Future State of Water Resources and Environment organized by Indian Institute of Technology, Madras during 4-6th January 2010 and presented papers.
- Scientists of Central Ground Water Board, South East Coastal Region, Chennai participated in the one-day seminar on "Rainwater Harvesting and Judicious utilization of Water" conducted by State Ground Water Unit and Soil Conservation, UT of Puducherry on 11.01.2010.
- An one-day Workshop on "Water Quality Management in Tamilnadu was organized by Central Ground Water Board, South East Coastal Region at Sri Sarada Ashram, Ulundurpet, Villupuram district on 21.01.2010 under IEC scheme. More than 750 participants attended and District Collector, DRO and various State officials took part in the deliberations.
- A two day Workshop on "Ground Water Resources Estimation" was organized by State Unit Office, Central Ground Water Board in association with Department of Civil Engineering, Indian Institute of Technology Delhi during 23-24th February, 2010 at CSMRS Auditorium, Hauz Khas, New Delhi. Dr. Mihir Shah, Member Planning Commission was the Chief Guest, Shri S. Manoharan, Sp. Secretary, MoWR and Prof. Surendra Prasad, Director, IIT Delhi were the Guests of Honour. Sh. B.M. Jha, Chairman, CGWB presided over the function. Member (SM&L), Member (SAM) and other Senior officers of the Board attended workshop.
- The International Workshop on "Mother Earths", organized from 13.02.10-15.02.10 by the Environment Science Department of University of Burdwan, was attended by the officers of CGWB, ER. Four technical papers were presented by the respective authors of the Region. Superintending Hydrogeologist & Head of the Office, ER, chaired one of the technical sessions.
- The workshop on "Agricultural Water Management Solution Project: West Bengal Stakeholder's Meeting, organized by International Water Management Institute at Kolkata was attended by the officers of CGWB, Eastern Region. The participants were from different State organizations, NGOs and farmers. In the workshop, problems in different levels have been identified and the probable solutions were provided by the participants.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai inaugurated the workshop on "Coastal Hydrogeology" conducted by Department of Applied Geology, A.C. Tech, University of Madras on 8th February 2010.
- A one day Workshop on "Dug Well Recharge-Efficiency and Efficacy" was organized by Central

Ground Water Board, South East Coastal Region under IEC activities at Vellore Institute of Technology, Vellore on 11th February 2010. Shri S. Manoharan, Spl. Secretary, MOWR, Govt. of India inaugurated the workshop.

- A prelude to the Workshop on "Ground Water Perspective, Policy and Planning" to be held on 6.03.2010 under IEC was organized by Southern Region office on 22.02.2010. Dr. A.K. Jain, IFS, Spl. Secretary, I&CAD, Govt. of Andhra Pradesh was the Chief Guest. Director, Ground Water Department, Senior officers of Ground Water Department, Officers from CGWB, Rural Water Supply & Sanitation, Govt. of Andhra Pradesh participated in the deliberations of the Workshop. A total 9 presentations on different themes on ground water were made in the Workshop. Shri A.D. Rao, Scientist D & H.O.O. made presentation on "Role of Ground Water in Agriculture and its contribution to GDP in Andhra Pradesh.
- Scientists of CGWB, Southern Region, Hyderabad participated in the 3rd International Conference on Hydrology and Watershed Management, organized by JNTU from 3rd February 2010 to 6th February 2010 at Hyderabad.
- Scientist of CGWB, Southern Region, Hyderabad participated in User Interaction Workshop organized by NRSC, ISRO on 3rd February 2010 at Hyderabad.
- Scientists of CGWB, Southern Region, Hyderabad and Visakhapatanam attended a one day workshop on "Users Conference on Public Weather Services for Andhra Pradesh" organized by Indian Meteorological Department at Andhra University, Visakhapatanam on 22.02.2010.
- Regional Workshop on "Water Management and Hydrochemistry in Uttarakhand" was held during February 18-19, 2010 at Wadia Institute of Himalayan Geology, Dehradun. A total 38 technical papers were received. The abstract volume of the Workshop was released on 18th February 2010 by Shri Harbans Kapoor, Hon'ble Speaker, Vidhan Sabha, Uttarakhand in presence of eminent scientists and technocrats.
- Chairman and OIC, SUO, Central Ground Water Board, New Delhi attended International Conference and Exhibition regarding AQUATECH INDIA 2010 at Pragati Maidan Exhibition Centre, New Delhi on 3rd February 2010.
- Member (SML), Central Ground Water Board attended Indo German Conference on Water and Waste Management at IIT Delhi on 3.02.2010.
- The Central Ground Water Board, Central Region, Nagpur organized one-day workshop on "Dug Well Recharge – Its Efficiency & Efficacy" at YASHADA, Pune on 4th February 2010 under IEC scheme of Ministry of Water Resources.
- The Central Ground Water Board, Central Region, Nagpur organized one-day workshop on "Ground Water Regulatory and Protection Measures" at VANAMATI, Nagpur on 18th February 2010 under IEC scheme of Ministry of Water Resources.
- Scientists of CGWB, SUO, Pune attended two days National Conference on Ground Water Resources Development in Hard Rocks organized by Department of Geology, University of Pune on 12-13th February 2010. Three papers were presented during technical session of the workshop.
- Superintending Hydrogeologist of Central Ground Water Board, Central Region, Nagpur attended a Workshop on "Contour Framing & Protective Irrigation in Saline Area" organized by Dr. Panjabrao Deshmukh Agriculture University, Akola district. He also delivered a talk on importance of Artificial Recharge to Ground Water.
- Central Ground Water Board, Southern Region, Hyderabad organized a Workshop on "Application of Remote Sensing & GIS in Ground Water Resource Management" on 10th March, 2010 at NGRI, Hyderabad.
- Central Ground Water Board, Southern Region, Hyderabad organized a Workshop on "Ground Water Perspective, Policy and Planning" on 20.03.2010 at Hotel Green Park, Hyderabad. Supdtg. Hydrogeologist & HOO presented a paper titled "Ground Water Issues and Management Strategies in Andhra Pradesh".
- Supdtg. Hydrogeologist & HOO, Central Ground Water Board, Southern Region, Hyderabad attended a Brainstorming Session on "Forecasting technological needs for Rainfed agriculture in India" organized by Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad on 19.03.2010.
- Workshop on "Artificial Recharge to Ground Water with special reference to Dugwell Recharge" was organized by Central Ground Water Board, Southern Region, Hyderabad on 25.03.2010 at Medak district, Andhra Pradesh.
- Chairman attended the Workshop and Release of World Bank Report on Addressing Ground Water Over-Exploitation in India held in Hotel Claridges, New Delhi on 5th March, 2010.
- Chairman Central Ground Water Board attended International Conference Environment Seminar on "Water Pollution" at CAG office, New Delhi on 15th March, 2010.
- Chairman,CGWB attended HP II Wrap up meeting and a Seminar taken by Secretary (WR) with World Bank Supervision Mission, Private Secretary / Secretary of States, Important Agencies and Head of

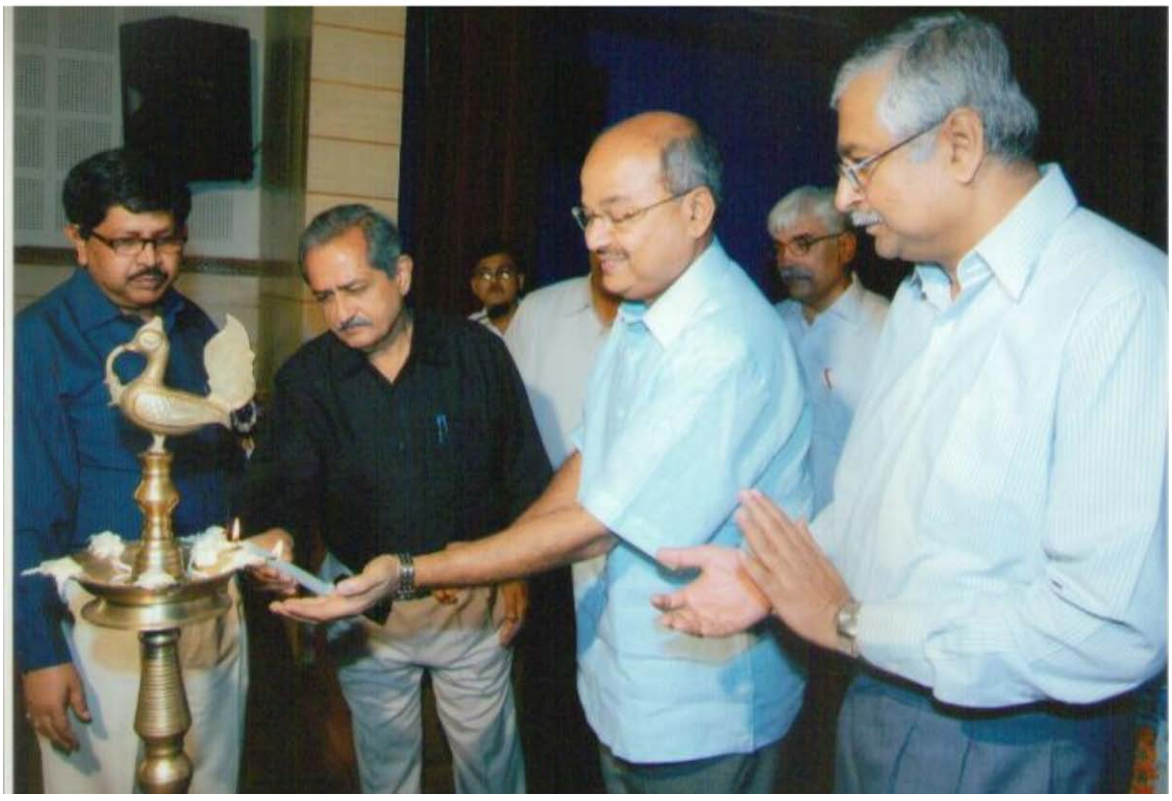
Central Agencies of HP II at Conference Room, Central Water Commission, New Delhi on 16th March, 2010.

- Regional Director, CGWB, Uttaranchal Region along with officers of the Region attended National Seminar on Remote Sensing organized by Uttrakhand Space Application Centre, Govt. of Uttarakhand.
- To observe World Water Day, a workshop on "Water Quality" was conducted along with CWC at Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Haringhata block, Nadia district, West Bengal on 26-03-2010.
- An one –day Workshop on 'Radon Contamination in GroundWater' was held in Bhujal Bhavan, CGWB, SWR, Bangalore on 26.03.2010. Dr. K.Satya murthy, IAS Cauvery Neeravari Nigama, GOK was the chief guest. Dr K.Shivanna Head of isotope department from BARC and Dr.P.K.Mehrotra , Director(WQ) from MOWR were guests of honour. Sri T.M.Hunse Regional Director welcomed the gathering and Dr K.Md.Najeeb Regional Director proposed vote of thanks. There were two technical session wherein radon contamination and isotope techniques for water management and related themes were discussed. Delegates from BARC, NGRI, DMG, CWC, Bangalore university and many other reputed organizations participated in the workshop.
- Member(SML), Central Ground Water Board attended one day workshop on "Dugwell Recharge : Efficiency and Efficacy" held at Jaipur and also held discussion with Nodal agencies of Rajasthan and Principal Secretary, Public Health Engineering department, Rajasthan on 18th March, 2010.
- Member(SAM), Central Ground Water Board attended one day workshop on "Conjunctive Use of Surface and Ground Water" organized by Central Ground Water Board, Northern Region, Lucknow in associated with UNICEF.
- One day workshop on Ground Water Management in Punjab, Haryana & UT Chandigarh was organised at Mahatma Gandhi State Institute of Public Administration, Sector 26, Chandigarh on **19.2.2010**. Dr. R.C.Sobti, Vice Chancellor, Panjab University, Chandigarh was Chief Guest while Shri A.S.Dullet, Chief Engineer (Canal), Department of Irrigation, Punjab and Shri H.K. Verma, Chief Engineer, Central Water Commission, Chandigarh (U.T.) were the Guests of Honour during inaugural ceremony of workshop. A total of eight number of papers dealing with ground water management, water quality and health aspects were presented by imminent experts from Central and State Government departments, R&D and Academic institutions.
- One day workshop on "Ground Water Monitoring, Design, Networking and Panchayat's Participation" was organised at Mahatma Gandhi State Institute of Public Administration, Institutional Area, Sector 26, Chandigarh on 16th March, 2010. The main objective of the workshop was to bring experts/scientists working on precarious environmental degradation of ground water to share a common platform so as to suggest suitable measures for policy makers. Eminent experts from various Government departments, Universities, research institutions, NGOs, stake holders had attended the summit and delivered lecturers on the burning issues involving ground water and related aspects.
- Workshop on "Capacity Building for Stakeholders in Water Resources Management in Gujarat and UT of Daman & Diu", organized at Gandhinagar on 19/1/2010. Shri NitinBhai Patel, Hon'ble Minister, Water Resources, Water Supply, Urban Development & Urban Housing Govt. of Gujarat was the Chief Guest. Other Prominent dignitaries included Shri B.N.Navalawala, Advisor (WR) to the Chief Minister, Gujarat and Smt. Rita Teaotia, Commissioner & Principal Secretary (Rural Development), Panchayats, Rural Housing & Rural Development Department, Govt. of Gujarat. Nearly 100 participants of various Govt departments, NGOs etc participated in the workshop.
- Workshop on "Dug well Recharge: Efficiency and Efficacy" organized at Gandhinagar on 22/02/2010. Shri Narottambhai T. Patel, Hon'ble Minister, Rural Development, Rural Housing, Panchayat, Food, Civil supplies and Consumer affairs, Govt. of Gujarat was the Chief Guest. Other Prominent dignitaries included Shri H.K.Das, Principal Secretary (Water Supply), Narmada Water Resources, Water Supply & Kalpsar Department, Govt. of Gujarat and Shri Ram Kumar, Chief Executive officer, Gujarat Watershed Management Agency, Govt. of Gujarat graced the occasion. Nearly 100 participants of various Govt. departments, NGOs etc participated in the workshop.
- Workshop on "World Water Day 2010 – Ground Water Management in Coastal Areas" organized by Central Ground Water Board, WCR, Ahmedabad along with Narmada, Water Resources, Water Supply & Kalpsar Department, Govt of Gujarat & Water Management Forum at Gandhinagar on 25/03/2010. Shri B.N.Navalawala, Advisor (WR) to the Chief Minister, Gujarat was the Chief Guest. Other Prominent dignitaries included Dr.M.S.Patel, Secretary (Kalpsar), Narmada Water Resources, Water Supply & Kalpsar Department, Govt. of Gujarat, Dr. D. K. Chadha, Former Chairman, CGWB and Shri R. G. Bhatt, Director; Water Management Forum graced the occasion. Nearly 85 participants of various Govt departments, NGOs etc participated in the workshop.

- A Seminar on "Ground Water Management & Governance for Sustainable Development" was held with Principal Secretary/Secretaries of water related Ministries, and officers/scientists of water related department at OTS, Jaipur on 8-9 March,2010. Principal Secretary, Water Resources, IGNP,PHED &GWD, Govt. of Rajasthan presided over the function. Scientists/officer from various state Govt/Central Govt. departments attended, participated and many of them presented technical papers in the technical session on 8-9 March,2010. Eminents scientists/officer from various state Govt/Central Govt. departments attended, participated and 24 No. of technical papers presented in the technical session.
- A National Workshop on "Dug Well Recharge-Efficiency and Efficacy" was held for Govt., non-Govt.organisations, Panchyat institutions and other stakeholders of Water Resources Development and Mission Advisors of Dug Well Recharge Scheme at Senate Hall, University of Rajasthan on 18 March,2010. Dr.S.C.Dhiman, Member(SML) presided over the function and Shri Yaduvendra, Secretary, PHED & GWD, Govt. of Rajasthan was the chief guest. Eminents scientists/officer from various state Govt/Central Govt. departments/Agriculrure Deptt. attended, participated and 16 No. of technical papers presented in the technical session.
- Workshop on "Preparing Strategies for Water Conservation, Artificial Recharge and Increasing Water Use Efficiency" was coordinated by CGWB, SUO,Jodhpur for Army Area at Military Station, Jodhpur on 15.10.2010. Officers of CGWB, WR and SUO presented various technical papers regarding various techniques of artificial recharge to ground water, present ground water scenario of Rajasthan and Jodhpur area. A paper on "Water Seepage in Jodhpur Urban Area-Causes, Remedial Measures" was also presented.

Sri M. N Gunavardhanan, Secretary, Water Resource Department, inaugurating the workshop on "Public Private Partnership in Ground Water Development and Management" at Chennai

Dr C.Mahnta, Professor, IIT, Guwahati,
address in the *Inaugural session*



Workshop on 'Conjunctive use of Surface and Ground Water' at Lucknow

Dr. S.C. Dhiman,, Member (SML) addressing the audience on the occasion of Workshop on "Roof Top Rainwater Harvesting and Spring Recharge" at Jammu

Prof. Anwar Alam, Vice-Chancellor, SKUAST-Kashmir lighting the lamp on the occasion of Work Shop on "Ground Water Quality Issues in J&K State" on 25th March 2010

Dr. R.C.Sobti, Vice Chancellor, Panjab University, Chandigarh, Chief Guest, Shri A.S.Dullet, Chief Engineer (Canal), Department of Irrigation, Punjab and Shri B.S.Sidhu, Director, Agriculture,

Dignitaries on the dice during the workshop

Workshop on 'Ground Water Management in Punjab, Haryana & UT Chandigarh'(Organised at Mahatma Gandhi State Institute of Public Administration, Chandigarh)
(19.02.2010)

Chief Guest & Dignitaries during inaugural ceremony of workshop

Dignitaries on the dice during the workshop

Workshop on 'Ground Water Monitoring, Design, Networking and Panchayat's Participation' (organised at Mahatma Gandhi State Institute of Public Administration, Chandigarh) (16.03.2010)

The dignitaries on the Dias at the inaugural session

Release of workshop volume by the dignitaries

Photographs of Workshop on " Capacity Building for Stake Holders in Water Resource Management in the State of Gujarat & UT of Daman& Diu-19th January 2010

Release of District Information brochures by the Dignitaries

Photographs of Workshop on "Dug well Recharge-Efficiency & Efficacy" 22nd January 2010

The dignitaries on the Dias at the inaugural session

Release of workshop volume on "Ground water Management in Coastal Areas-25th March 2010 by the dignitaries

Invitees attending the workshop

National Workshop on
"Dug Well Recharge: Efficiency and Efficacy", Jaipur - 18.03.2010

27. RESEARCH AND DEVELOPMENT STUDIES

An Indian National Committee on Ground Water (INCGW) is constituted by the Ministry of Water Resources, Govt. of India by order No. 38/1/2008-R&D/5709-II dated September 2008, with a view to accelerate the research & development programmes in ground water sector and giving due consideration to increase need of taking up research in the field of Ground Water. Chairman Central Ground Water Board is Chairman of INCGW. This committee has 15 members and examines the project proposals received on ground water issues for their suitability for funding and recommends for sanctioning by the Ministry of Water Resources. The committee has been entrusted with the following functions-

- To give advice to Central and State Governments and their agencies on matters related to ground water; to appoint expert panels to consider special problems to advice the committee.
- To prepare and periodically update the state of art in the country in different , branches of Ground Water; to disseminate information related to ground water by way of publishing journals, research news/digests; to support and conduct mass awareness programme like seminars/ conferences/ workshops; and to arrange R&D review sessions for ground water.
- To undertake studies on historical appreciation of development of ground water and introduce perspective planning for research in Ground Water.
- To recommend funding' for the infrastructure development of ground water research institutions; to recommend recognition of Centers of Excellence in ground water; to maintain effective cooperation with other National Committees /Boards, related Gal/State Ministries, CSIR Labs, IITs, Engineering Colleges and Polytechnics. Universities and other academic institution.
- To coordinate the R&D activities in ground water in general and to coordinate R&D programme of the MoWR in particular; to monitor the progress made by the executing institutions on research schemes; to identify areas which need immediate attention; to avoid overlaps in the research programmes of the different institutions, to invite and encourage R&D proposals in areas where work being done is inadequate; to encourage the national institutions, voluntary. professional bodies and non commercial NGO'S to take up R&D in Ground Water.
- To promote HRD programmes leading to specialization of research staff and recommend encouragement for the outstanding research personnel
- To promote and coordinate effective participation of India in the international programmes related to Ground Water and to act as national committee for such international bodies.
- To encourage indigenous industry through loans to take up technological development of Ground Water where required.

After transfer of related files from INCOH in May end, the working of INCGW started w.e.f. 1st June, 2009. During the year, eight new projects were received. Out of which, seven are under scrutiny and one proposal was rejected.

During the year, two meetings of INCGW were held on 6.11.2009 and 5.02.2010 respectively. During the first meeting of INCGW, four new proposals received in INCGW and seven revised proposals already considered in VIII meeting of Reseaerch Committee on Ground Water were considered. Out of which, six projects were approved. Following three approved proposals were forwarded to the MOWR for sanction:-

1. Vulnerability assessment and ground water management studies in aquifers of Pondicherry received from Dr. S. Chidambram .
2. Hydr-geo-chemical impacts of shrim farming on coastal watershed- PI- Dr. Nilarekha.
3. Development of Nano-Filtration Membrane Technology for drinking water purification & water reclamation for industrial use PI-Dr. Paramita Ray.

The remaining proposals were sent to the PI's for necessary revision as per the suggestion of committee members. Expert Panel for reviewing the new proposals and reports of the completed projects was also finalized during the meeting.

During the second meeting of INCGW, three new proposals were considered. The committee members offered suggestions for revising the proposals. One revised proposal titled "Study and Investigation on the Marble Waste Material (Marble Slurry) to remove the Arsenic from Drinking Water and Implementing Agency" : PI- Dr. R.N. Yadav was approved after revision for onward submission to the Ministry.

During the year, first R&D session of INCGW was organized at Chandigarh on 4.02.2010 to review the progress of the ongoing projects. The session was attended by approximately 100 participants from different central, state government and other institutions. During the session, progress of six ongoing schemes was reviewed by the committee members. The session was a huge success.

28. PUBLICITY AND PUBLIC AWARENESS

Central Ground Water Board/ Ministry of Water Resources participated in following Exhibition/Trade Fair during 2009-10.

i. Participation in International Trade Fairs -2009

Central Ground Water Board participated in the MOWR pavilion of IITF-2009 at Pragati Maidan, New Delhi during 14-27th November 2009. The exhibition demonstrated various live models on rainwater harvesting, artificial recharge to ground water, ground water development models. Various ground water related features and issues requiring awareness and public attention were displayed and literature was distributed to the visitors. The pavilion attracted the attention of large number of people.

ii. 3rd International Assam Trade Fair, 2009 at Guwahati

Central Ground water Board, NER participated in the 3rd International Assam Trade Fair, 2009 at Guwahati from 14th October, 2009 to 26th October, 2009. Models, Maps were displayed and distributed literatures related to Roof top Rainwater harvesting, water related issues for awareness of public. Our participation with above Trade Fair was very much successful and was appreciated by one and all.

iii. World Water Day-2010

Ministry of Water Resources observed the World Water Day – 2010 on 22nd March 2010 at NASC complex, PUSA, New Delhi by organizing National Ground Water Congress. During the week from 22nd to 27th March, workshops, seminars etc. were held all over the country by Central Ground Water Board and other organizations of the Ministry of Water Resources to raise awareness on water quality issues.

The theme of World Water Day 2010 was 'Communicating Water Quality Challenges and Opportunities' which envisaged raising awareness about sustaining healthy ecosystems and human well-being through addressing the increasing water quality challenges in water management and raising the profile of water quality by encouraging governments, organizations, communities, and individuals around the world to actively engage in proactively addressing water quality e.g. in pollution prevention, clean up and restoration.

Sh. Pawan Kumar Bansal, Hon'ble Minister of Water Resources and Parliamentary Affairs presented The National Ground Water Award of Rs. 10 lakh & Plaque and Citation to Vruksha Prem Seva Trust, Upleta, Rajkot. and twenty Ground Water Augmentation Awards of Rs.1 lakh each to the organizations/individuals doing exemplary work in the field of ground water augmentation, water conservation, reuse and recycling.

The Congress was attended by scientists, engineers, planners, policy makers and representatives of industries, NGOs, VOs and Stakeholders. The broad objectives of the Congress were to deliberate on various issues of ground water management; promote conservation and augmentation of ground water resources through artificial recharge and rain water harvesting; increase water literacy; propose national strategy for sustainable ground water security in terms of quantity and quality through social mobilization etc.

During the Congress, the deliberations and discussions were done in five technical sessions followed by panel discussions on following themes -

- Ground water Quality- Challenges and Opportunities.
- Information, Education and Communication (IEC) & e-Governance in ground water development and management.
- Ground Water Resources Management and Food Security.
- Ground Water Resources Management in the context of National Action Plan on Climate Change.
- Farmers' Participatory Action Research Programme & Water Use Efficiency.

Central Ground Water Board, a department under the ministry and NIC have jointly developed a web-enabled Ground Water Information System that will provide ground water related spatial and non spatial data in seamless manner to the users through internet. Sri Pawan Kumar Bansal, Hon'ble Minister of Water Resources and Parliamentary Affairs dedicated this Ground Water Information System to the Nation on this World Water Day. The key features of the system are:

- Web based geographical information systems for data disseminations to the stakeholders and end users.
- Tool for decision making, effective planning and management of ground water resources.
- Access to spatial and non-spatial ground water related data and information.

The functions/workshops/seminars were organized at all the 18 Regional Offices of the Board throughout the country during the week with the main theme –"Communicating Water Quality Challenges and Opportunities."

iv. Celebration of Hindi Saptah/Hindi Pakhwara

Hindi Saptaha/ Pakhwara was celebrated in different Regional offices/ HQ of CGWB from 14th September to 28th September 2009. Various competitions like Translation, Dictation, handwriting competition, Essay competition, Pick and speak, debate and Prasna Manch competitions were held. The officers and officials of the Board actively participated in all the competitions. The winners were also given prizes.

v. Vigilance Awareness Week

Vigilance Awareness Week was observed from 3.11.2009 to 7.11.2009 in CHQ, Faridabad, Regional offices and Divisions of Central Ground Water Board. Essay writing and debate competitions were conducted among the staff and prizes were also distributed.

vi. Communal Harmony Campaign

Communal Harmony Campaign has been organized in the Central Ground Water Board, Bhujal Bhawan, Faridabad during 19 to 25 November 2009 and various activities on the theme were organised for the officers & staff members.

vii. 2nd NATIONAL GROUND WATER CONGRESS

Central Ground Water Board organized a 2nd National Ground Water Congress and World Water Day 2010 at A.P. Shinde Symposium Hall, NASC Complex, ICAR, Pusa New Delhi on 22.03.2010 which was inaugurated by Shri U.N.Panjiar, Secretary (WR) and he released the Congress proceedings. More than 400 representatives from various Central/State Govt. organizations, NGO's/academic institutions participated in the congress. Shri Pawan Kumar Bansal, Hon'ble Minister of Water Resources distributed National Water Award and 20 Ground Water Augmentation Awards to the Awardees. He also launched the Ground Water Information System in public domain on this occasion in the presence of Prof. M.S. Swaminathan, Hon'ble M.P. and eminent Scientist and other dignitaries.

Sh. Arun Kumar, RD, NWHR delivering presidential address to the gathering on the occasion of Work Shop on "Ground Water Quality Issues in J&K State" on 25th March 2010 at Srinagar

Chief Guest Prof. Anwar Alam, Vice-Chancellor, SKUAST-Kashmir

Honourable Minister for Water Resources, Government of Kerala, Sri N.K Premachandran, inaugurating the function on World Water Day

29. FARMERS' PARTICIPATORY ACTION RESEARCH PROGRAMME (FPARP)

Ministry of Water Resources sanctioned Farmers' Participatory Action Research Programme at 5000 demonstration sites at a cost of Rs. 24.46 crore. This programme is being implemented in 375 districts of 25 States/UTs of the country with the help of 60 Agriculture Universities/ Indian Council of Agricultural Research Institutes / International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Water and Land Management Institutes (WALMIs) and Non-Government Organizations (NGOs) to increase yield and income per drop of water. Each programme covers a minimum of one hectare and is implemented in a participatory mode with the farm family having a sense of ownership of the programme.

519 demonstration were taken up during Kharif and 398 demonstrations were taken up in the Rabi crop season 2009-10. The performance of the programme is being monitored by the field formations of CWC & CGWB. The experience of implementation of the FPARPs have indicated an increase in yield and income with saving in water use.

Technologies demonstrated under the programme are:

- SRI (System of Rice Intensification) cultivation in Rice.
- Improved irrigation methods – Micro irrigation methods (Sprinkler/Drip).
- Multiple cropping.
- Water harvesting technologies (Low Cost Micro Rain Water Harvesting Structure i.e Jalkund, Storage tanks, Percolation tanks, Check dams, Recharging Wells, etc).
- Reclamation of soils through - Drainage/Bio-reclamation.
- Soil & Water conservation measures.
- Improvement of water use efficiency through suitably improved crop rotations.
- Bio-farming Technology.
- Propagation of Aqua Culture Activities e.g. Fish Culture.
- Crop diversification & multiple use of water.

30. ACTIVITIES IN NORTH EASTERN REGION

The Central Ground Water Board is conducting scientific and technical studies for ground water assessment, development and management in the North Eastern Region and has its annual work programme to carry out the work. The major achievements of the North Eastern Region in the year 2009-10 up to 31st March 2010 are given below in Table 30.1:

Table 30.1- Major achievements of the North Eastern Region

Sl. No.	Activities	Achievements
1.	Ground Water Management studies	15325 Sq. km (Pre-monsoon) 15325 Sq.Km. (Post-monsoon)
2	Ground Water Exploration	28 wells drilled in North Eastern Region
3.	Monitoring of Ground Water Wells	Monitored during April, August, November 2009 and January, 2010 through a network of 310 Ground Water Monitoring Wells. The water samples were collected during the pre-monsoon monitoring.
4.	Water Quality Analysis	340 samples analyzed for basic constituents and 208 samples have been analyzed for heavy metals such as Cu, Zn, Fe, Mn, CO, Cd, Cr, Ni, Pb etc.
5.	Short Term Water Supply Investigations	30 investigations
6.	Geophysical Studies	VES (Vertical Electrical Sounding) – 08 Borehole logging - 05
7.	Reports	1 State report completed, 1 district reports completed, 1 Ground Water Year Book of N E States issued, 1 Draft Ground Water Exploration Report submitted. 1 State Geophysical Report issued
8.	Estimation of Ground Water Resource of the entire Region based on GEC - 1997 Methodology	Completed
9.	Monitoring of Farmers Participatory Action Research Programme(FPARP)	• Field inspection of FPARP in Rabi 2008-09 implemented by AAU, Jorhat and NERIWALM, Tezpur, Assam was completed. • Prepared field inspection report and submitted. • Compiled information about FPARP implemented by AAU, Jorhat and sent submitted to Head Quarter office. • Release of balance payment of AAU, Jorhat, Assam. • Monitored two demonstration sites of Boro rice under FPARP, AAU, Jorhat
10.	Miscellaneous	• Central Ground Water Board, NER participated in the 3rd Asom International Trade Fair 2009 at Guwahati from 14th October 2009 to 26th October 2009. Models, Maps were displayed and distributed literatures relate to Roof Top Rainwater Harvesting, Water related issues for awareness of public. The participation of Central Ground Water Board in the pavilion of Trade Fair was very much successful and was appreciated by one and all. awarded 1st Prizewinner in the fare for its attracting display of working models and demonstrations. • Organized two days Regional workshop on "Water Quality Management and its related issues in North Eastern State" at National Institute of Rural Development, Guwahati on 25t & 26th November 2009. • Prepared one translide on success stories of Roof Top Rain Water Harvesting in NER & completed. • Organized Regional Seminar on "Rain Water Harvesting, Hydro Fracturing and other Techniques Enhancing Yield of Ground Water Structures" at Guwahati on 12th March, 2010. • Organized Regional Workshop on "Iron, Fluoride & Arsenic Contamination in Ground Water & Its Mitigation Measures in North Eastern States" at National Institute of Rural Development, Guwahati on 27th March, 2010.

31. PROGRESSIVE USE OF HINDI

- The provision relating to Section 3(3) of the Official Language Act, 1963 has been complied with.
- Letters received in Hindi were invariably replied in Hindi.
- Hindi Quartely Progress report has been sent regularly to the Ministry of Water Resources, Town Official Language Implementation Committee, Faridabad and Official Language Department (Regional Implementation Office).
- Quarterly meeting of the Departmental O.L. Implementation Committee are organised regularly and necessary action is taken as per the decisions taken in the meeting.
- Check points has been set up for the compliance of O.L. Act 1963 & O.L. Rule 1976.
- During 2009-10 a Hindi workshop for two days was organized from 3-4th September 2009 and 2nd February 2010 . 20 Officers/ officials were trained in the workshop.
- 'Hindi Pakhwara' was celebrated from 14 – 28th September 2009. Various competitions and other programmes were organized during the Pakhwara. The participation of officers/ officials in these competitions was encouraging.
- Incentive for original noting and drafting in Hindi is being implemented. 12 officials were awarded cash prize under this scheme.
- Ten sections of the office have been specified to work cent-percent in Hindi.
- 'Bhumijal News Letter' the quarterley magazine highlighting on the activities of Central Ground Water Board is being published.
- Director (Admn.) and Deputy Director(OL) were respectively awarded with prestigious "Rajbhasha Shiromani" and "Rajbhasha Gaurav" award during 10th All India Official Language Conference organized by Akhil Bhartiya Rastrabhasha Vikas Sangthan on 24-25th October 2009. Bhumijal News letter the in-house magazine of CGWB was also awarded on this occasion.
- The Board is committed towards the progress and implementation of Hindi and determined for its progressive use of Hindi as per the Annual Programme issued by Official Language Department.

32. VIGILANCE ACTIVITIES

32.1 Vigilance Activities

During the year 2009-2010, 22 complaints cases were brought forward with effect from the last year and 4 new complaints were received during 2009-2010 up to 31st March, 2010. Thus total 26 complaint cases were on the record. Out of these 4 complaints have been closed and 1 complaint case has been taken up as disciplinary proceedings. Therefore, 21 complaint cases have been carried forward w.e.f. 31.03.2010.

32.2 Disciplinary Proceedings

8 cases of disciplinary proceedings were brought forward w.e.f. 1.04.2009 and 1 case of disciplinary proceeding has been received during the year. Thus a total 9 cases of disciplinary proceedings were on the record. Out of these 3 cases of disciplinary proceedings have been finalized and 6 cases have been carried forward.

33. RTI ANNUAL RETURN INFORMATION SYSTEM

Ministry/Department/Organization: Ministry of Water Resources, Central Ground Water Board

Progress during 2009-10					
	Opening balance as on 1.04.2009	**Received during the year (including cases transferred to other public authority)**	**No. of cases transferred to other public authorities**	**Decisions where requests/appeals rejected**	**Decisions where requests/appeals accepted**
Requests	6	111	5	3	109
First Appeals	0	21	0	0	21

Number of cases where disciplinary action taken against any officer	**Nil**

No. of CAPIOs designated	**No. of CPIOs designated**	**No. of AAs designated**
17	**20**	**1**

No. of times various provisions were invoked while rejecting requests													
Relevant Sections of RTI Act 2005													
Section 8 (1)							**Sections**						
a	b	c	d	e	f	g	h	i	j	9	11	24	Others
-	-	-	-	-	-	-	-	-	-	-	-	-	3*

- Requests rejected due to non-receipt of registration fee.

Amount of changes collected (in Rs.)		
Registration Fee Amount	Amount Fee & Any other Charges	Penalities Amount
1090	14938	Nil

34. PERSONNEL MANAGEMENT

The sanctioned strength, filled up, vacancy position and category-wise personnel deployed in the Board are presented in table 33.1 .

Table 33.1- PERSONNEL DEPLOYMENT IN CENTRAL GROUND WATER BOARD DURING 2009-2010 (Up to 31st March, 2010)

GROUP "A"							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	403	300	103	20	0	43	12
Ministrial	6	6	0	0	0	0	0
Engineering	56	53	3	8	0	10	5
Total	**465**	**359**	**106**	**28**	**0**	**53**	**17**
GROUP "B"(Gazetted)							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	219	178	41	18	1	30	10
Ministrial	36	30	6	0	0	3	2
Engineering	110	68	42	4	0	14	9
Total	**365**	**276**	**89**	**22**	**1**	**47**	**21**
GROUP "B"(Non-Gazetted)							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	183	126	57	16	1	30	10
Ministrial	203	186	17	0	1	6	5
Engineering	70	54	16	6	1	10	3
Total	**456**	**366**	**90**	**22**	**3**	**46**	**18**
GROUP "C"							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	91	74	17	3	0	21	7
Ministrial	1249	954	295	95	15	162	65
Engineering	1657	1398	259	107	1	318	104
Total	**2997**	**2426**	**571**	**205**	**16**	**501**	**176**
GRAND TOTAL							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	**465**	**359**	**106**	**28**	**0**	**53**	**17**
Ministrial	**365**	**276**	**89**	**22**	**1**	**47**	**21**
Engineering	**456**	**366**	**90**	**22**	**3**	**46**	**18**
Total	**2997**	**2426**	**571**	**205**	**16**	**501**	**176**
Total Strength	**4283**	**3427**	**856**	**277**	**20**	**647**	**232**

35. PERSONS WITH DISABILITIES

The Persons with Disabilities for the Year 2009-2010 up to 31st March 2010 is given in table 34.1.

Table 34.1 : Persons with disabilities for the year 2009-2010

1.	Schemes/Policies run by the respective Ministry/Department for the benefit of Persons with Disabilities.					Nil
2.	Budget allocated and expenditure incurred under each scheme during the financial year.					Nil
3.	No. of persons benefited					Nil
4.	Per capita expenditure					Nil
5.	Sanctioned strength, the number of vacancies filled since 1996 and the number of persons with disabilities appointed in various posts in Group – A, B, C & D against the 3% vacancies to be reserved for them under Section-33 of the PWD Act.	Group	Sanction Strength	Number of vacancies filled since 1996	Number of persons with disabilities appointed against 3% reservation	Remarks
		A	465	81	-	Requisition for filling up two posts of PH (1-HH &1-OH) has been sent to the UPSC.
		B	1016	121	-	Requisition for filling up one post of VH has been sent to the UPSC.
		C	2802	399	2	Requisition for filling up 3 PH posts has been sent to the SSC.

36. BUDGET AND ACCOUNTING

Statement showing actual expenditure incurred by the Board during 2009-2010 has been shown in Table 35a, Table 35b, Table 35c, Table 35d and Table 35e.

Table 35a : Statement showing actual expenditure incurred by the Board during 2009-2010 (Up to March, 2010)

Sub-Head	Plan (Rs. In Lakhs)		Non-Plan (Rs. In Lakhs)	
	Funds	Expenditure	Funds	Expenditure
Salary	2382.00	2249.73	10780.00	10468.54
Wages	35.00	27.74	1.25	0.96
O.T.A	3.00	1.67	16.00	12.55
T. E	450.00	437.44	249.50	250.33
F.T.E	1.60	1.55	0.25	0.19
O.E	535.00	536.50	6.50	6.21
P.S	5.00	3.39	0.00	0.05
R.R.T	125.00	119.22	4.50	1.92
Publications	55.00	61.22	0.50	0.46
Subsidies	0.50	0.04	0.00	0.00
Susp. Stock	1000.00	989.93	0.00	0.00
W.O.L	0.50	0.48	0.00	0.00
M.V.	200.00	78.07	2.00	1.79
M & E	113.00	95.98	0.00	0.00
Works	2085.00	2150.86	0.00	0.00
Medical	90.00	86.32	140.00	130.99
Other Charges	2.50	2.34	0.00	0.00
B.C.T.T.	0.00	0.00	0.00	0.00
POL	980.00	950.41	3.00	2.88
O.A.E.	70.00	44.29	0.00	0.00
Adv./Publicity	0.00	0.00	4.25	0.01
Minor Works	65.00	63.71	0.00	0.00
Total	**8198.10**	**7900.89**	**11207.75**	**10876.88**

Table 35b: Rajiv Gandhi National Training & Research Institute for Ground Water

Sub-Head	Fund Allotment	Expenditures
Salaries	122.00	122.09
Wages	1.00	0.17
O.T.A	0.00	0.40
D.T.E	30.00	23.18
O.E	5.00	4.59
R.R.T	0.00	0.00
Publication	0.50	0.04
P.S	26.00	24.53
M.V	1.00	1.07
M & E	8.00	1.00
Medical treatment	4.50	0.40
P.O.L	2.00	1.94
Total (RGNTR&I)	**200.00**	**179.41**

Table 35c: Hydrology Project
Ext. Support 8.01 & Domestic Support 8.02

Sub-Head	Fund Allotment	Expenditures
Salaries	240.00	158.79
M/Treatment	6.00	0.21
D.T.E	9.75	7.77
F.T.E.	0.00	0.00
O.E	7.50	6.70
B.C.T.T.	0.00	0.00
O.A.E.	000	0.00
P.S.	15.00	8.11
M. V.	1.60	0.78
M&E	50.00	41.27
M/Works	65.60	19.79
Salaries	80.00	52.02
M/Treatment	2.00	0.03
D.T.E	3.25	1.66
F.T.E.	0.00	0.00
O.E	2.50	1.24
B.C.T.T.	0.00	0.00
O.A.E.	0.00	0.00
P.S.	0.15	0.00
M.V.	0.00	0.00
M&E	0.00	0.00
M/Works	8.40	0.00
Total (Hydrology Project)	**491.75**	**298.37**

Table 35d : Central Ground Water Board building for offices

Sub-Head	Fund Allotment	Expenditures
Major Works	370.00	349.30
M&E	100.00	26.67
Total	**470.00**	**375.97**
Total CGWB	**9359.85**	**8754.64**

Table 35e : DEDUCT RECOVERIES

Sub-Head	Fund Allotment	Expenditures
Central Ground Water Board		
Issue to works and other credits	1100.00	1010.07
Deduct Recoveries 17.01.70 issue to work		
Other Suspense Stock 17.02.70	100.00	0.00
Deduct Recoveries 01.03.70	0.00	0.00
Total Recoveries	**1200.00**	**1010.07**
NET CGWB	**8159.85**	**7744.57**

Annexure -1

LOCATION AND JURISDICTION OF REGIONAL AND OTHER OFFICES OF CENTRAL GROUND WATER BOARD

REGIONS	HEADQUARTERS	JURISDICTION
i)NORTH WESTERN HIMALAYAN REGION		
Regional Office	Jammu	J&K
Division Office	Div. VIII, Jammu	J&K
ii) NORTH HIMALAYAN REGION		
Regional Office	Dharamshala	Himachal Pradesh
Division Office	Div. XVII, Dharamshala	Himachal Pradesh
iii)NORTH WESTERN REGION		
Regional Office	Chandigarh	Punjab, Haryana, NCT of Delhi & UT of Chandigarh
State Unit Office	Delhi	NCT of Delhi
Division Office	Div. II, Ambala	Punjab, Haryana, NCT of Delhi & UT of Chandigarh
iv)WESTERN REGION		
Regional Office	Jaipur	Rajasthan
State Unit Office	Jodhpur	Western Rajasthan
Division Office	Div. XI, Jodhpur	Rajasthan
v)WEST CENTRAL REGION		
Regional Office	Ahmedabad	Gujarat, UT of Daman & Diu
Division Office	Div.I, Ahmedabad	Gujarat, UT of Daman & Diu
vi)NORTH CENTRAL REGION		
Regional Office	Bhopal	Madhya Pradesh
Division Office	Div.XII, Bhopal	Madhya Pradesh
vii)NORTH CENTRAL CHATTISGARH		
Regional Office	Raipur	Chattisgarh
Division Office	Div.XIII, Raipur	Chattisgarh
viii)CENTRAL REGION		
Regional Office	Nagpur	Maharashtra, UT of D & N. Haveli
State Unit Office	Pune	West Maharashtra
Division Office	Div. VI, Nagpur	Maharashtra, UT of D & N. Haveli
ix)NOTHERN REGION		
Regional Office	Lucknow	Uttar Pradesh
State Unit Office	Allahabad	Uttar Pradesh
Division Office	Div.III, Varanasi	Uttar Pradesh
x)UTTARANCHAL REGION		
Regional Office	Dehradun	Uttaranchal
Division Office	Div.XVI, Bareilly	Uttaranchal
xi)MID EASTERN REGION		
Regional Office	Patna	Bihar, Jharkhand
Division Office	Div. V, Ranchi	Bihar, Jharkhand
xii)EASTERN REGION		
Regional Office	Kolkata	West Bengal, Sikkim, UT of A & Nicobar Islands
Division Office	Div. XV, Kolkata	-do-
xiii)NORTH EASTERN REGION		
Regional Office	Guwahati	Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura
State Unit Office	Itanagar	Arunachal Pradesh
	Shillong	Meghalaya
	Agartalla	Mizoram, Tripura
Division Office	Div.VII, Guwahati	Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura
xiv)SOUTH EASTERN REGION		
Regional Office	Bhubaneshwar	Orissa
Division Office	Div. x, Bhubaneshwar	Orissa
xv)SOUTHERN REGION		
Regional Office	Hyderabad	Andhra Pradesh
State Unit Office	Vishakhapatanam	Coastal Andhra Pradesh
Division Office	Div. ix, Hyderabad	Andhra Pradesh
xvi)SOUTH WESTERN REGION		
Regional Office	Bangalore	Karnataka & Goa
State Unit Office	Belgaum	W. Karnataka & Goa
Division Office	Div. xiv, Bangalore	Karnataka & Goa
xvii)SOUTH EASTERN COASTAL REGION		
Regional Office	Chennai	Tamil Nadu, UT of Pondicherry
Division Office	Div. iv, Chennai	Tamil Nadu, UT of Pondicherry
xviii)KERALA REGION		
Regional Office	Trivendrum	Kerala & UT of Lakshadweep
Division Office	Div. iv, Chennai	Kerala & UT of Lakshadweep