Annual Report 2010-2011

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
2010-11

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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 and 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 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 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.

(ii) To regulate and control, development and management of ground water in the country and to issue necessary regulatory directions for the purpose.

(iii) Exercise of powers under section 4 of the Environment (Protection) Act, 1986 for the appointment of officers.

(iv) To resort to penal provisions contained in sections 15 to 21 of the said Act. the matters referred to in sub- section (2) of section 3 of the said Act.

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 and contamination. An annual target of 1.5 Lakh sq.km. is earmarked under this item of study. During the year 2010-11 up to 31st March, 2011, an area of 1.61 Lakh sq.km.

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 2010-11 up to 31st March, 2011, 818 wells (EW-365, OW-153, PZ-300) have been constructed, against a target of 800 wells. Out of 818 wells, 608 bore wells , 192 tube wells and 18 bore 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. 49 wells with high discharge ranging from 180 litre per minute to 2040 litre per minute have been constructed in the states of Andhra Pradesh, J&K, Karnataka, Kerala, Maharashtra, Madhya Pradesh, 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.

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 2010 & January 2011 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 2010-11 up to 31st March,2011, 1843 Vertical Electrical Soundings, 15.23 line kilometre resistively profiling and geophysical logging of 90 bore holes have been conducted in various parts of the country.

Hydrochemical Analysis

During 2010-2011, 14855 No. water samples have been analyzed for determination of basic constituents. Analysis of 601 No. water samples including the determination of 80 No. of organic parameters was carried out under specific studies and analysis 3424 No. water samples for involving the determination of Trace elements like As, Cd, Co, Cr, Cu Fe, Mn, Ni, Pb and Zn has been carried out.

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 2010-11 up to 31st March, 2011, 3 State Geophysical Reports, 2 Hydrogelogical Atlases, 3 State Chemical Quality Reports, 7 State Reports, 28 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 2010-11 up to 31st March 2011, the Vol. 24, No 2 & 3, April – September 2009 issue on Arsenic in Ground Water in India and Vol. 24, No 4, October- December,2009 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 195 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 Total Annual Replenishable Ground Water Resources of the Country have been reassessed as 431 Billion Cubic Metres (bcm) and the Net Annual Ground Water Availability is estimated as 396 bcm. Annual Ground Water Draft as on March, 2009 for all uses is 243 bcm. The Stage of Ground Water Development is 61%.

Artificial Recharge Studies

During 2010-11, Ten demonstrative recharge projects on "Artificial Recharge to Ground Water and Rain Water Harvesting" have been approved for taking up in the States of Madhya Pradesh, Andhra Pradesh, Karnataka, Jharkhand, Maharashtra, Gujarat, Uttar Pradesh & Chandigarh and being implemented.

The approved cost of ten projects is Rs.2788.175 lakhs for implementation by the departments of states under overall technical guidance of Central Ground Water Board for construction of 479 recharge structures in ten States.

R&D Studies

During the year, 14 new research proposals were received. Out of which, 11 were considered for further scrutiny and three proposals were sent back to Principal Investigators. During the year, two meetings were held. Third meeting of INCGW was held on 28-10-2010 at CGWB, New Delhi. Three revised proposals were considered during the meeting, out of which 1 proposal was approved subject to minor modifications, however other 2 were rejected. In addition to this, 11 new proposals were also considered, out of which 4 were approved subject to modifications.

Technical Examination of Major/Medium Irrigation Project proposals

As per the directives of the Planning Commission, the Board scrutinizes 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 groundwater. During 2010-11 (up to 31st March, 2011), 12 major and minor irrigation project proposals of Central Water Commission were examined.

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.

During 2010-2011, a total of 40 training courses were conducted under RGI. A total of 773 officers attended the various training courses organized in the year 2010-11 which included 16 trainees from African Countries.

Hydrology Project II

CGWB is participating agency in HP-II and has a budget provision of Rs 32.06 Crore and project has duration of 6 years staring from May 2006 to 2012. The Budget provision for the year 2010-11 is Rs 8.28 Crore and revised provision is 4.47 Crore. The expenditure incurred on the project till March 2011 in the FY 2010-11 is Rs 3.48 Crore.

During the year of the project, six domain specific training has been imparted, six Awareness raising programme held, 60 piezometers and 1 well field (7 wells under Purpose Driven Study on "Specific Yield Study in Chennai Sub-urban Area") have been constructed. Tender document for procurement of the hardware (7 Servers & 59 Workstations) has been published and bids evaluated. During this year, Proposal for procurement of Groundwater modeling softwares and All India Village boundaries GIS data (Digital) set from Survey of India have been undertaken. Inter laboratory Analytical Quality Control exercise for CGWB labs have also been undertaken. For hiring of Consultancy Services for "Development of e-GEMS", five firms have been shortlisted after evaluation of Expression of Interest (EOI) and Request for Proposal (RFP) has been prepared and got approved by MoWR.

Mathematical Modeling Studies

The Central Ground Water Board has undertaken ground water modeling studies during the year. Mathematical modeling have been taken up in Alwar District, Rajasthan; Lucknow urban area; Patna urban area; Ranchi urban area; Biharsharif – Rajgir Urban and Peri-Urban Areas ; Mining Hydrogeology, Ramgarh District; Sone-Ganga interfluves

region with a larger perspective on South Ganga Plain; Ground Water Modeling villages in Midjil and Kalwakurthy mandals in Mahabubnagar.

Remote Sensing Studies

During the year 2010-11, Central Ground Water Board has been taken remote sensing studies in Bhagalpur of Bihar, Mandsaur and Ujjain districs of Madhya Pradesh..

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 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 to ground water/rain-water harvesting.

IEC Activities

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

State/UT level painting competition on the theme of Water Conservation amongst the students of ivth, vth and 6th standard were organized at Regional offices of CGWB on 14.11.1010. The first, second and third prize winners from the State/UT level painting competition participated in the National Painting competition held at New Delhi on the 21st January 2011. In all 63 children representing 21 States/UT's participated in the competition held at CSMRS, Hauz Khas, New Delhi. The theme chosen for the purpose was "Water In Environment". In the National Painting Competition, one first prize worth Rs. 1,00,000/-, four second prizes worth Rs. 50,000/- each and eight third prizes worth Rs. 25,000/- each were awarded to the winners. Apart from the above, ten consolation prizes worth Rs. 10,000/- each were also given to the deserving children.

Budget

Expenditure of 9483.51 lakhs and 10045.88 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 RGI, Raipur.

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 2010-2011.

1.4 ACTIVITIES OF THE BOARD DURING 2010-11

The following activities had been undertaken during the period 2010-2011.

- 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 2010-2011

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 to 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 at their 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 out by the Board at various levels i.e. district, block, area specific etc. 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 2010-11, an area of 1.61 Lakh Sq.km. have been covered by the Board under Ground Water Management studies as against target of 1.59 Lakhs. km. State/District wise target vis-a-vis achievements during the year 2010-11 is shown in Table 2.1 and fig. 2.1.

Table : 2.1 TARGET AND ACHIEVEMENTS OF GROUND WATER MANAGEMENT STUDIES DURING 2010-11

Sl. No.	States	Districts	Target (Sq. km.)	Achievement (Sq. km.)
1	Gujarat	Kachchh	3642	3642
2	Karnataka	Gulbarga	3334	3334
		Kodagu and Hassan	3321	3321
		Chamarajanagar	2900	2900
3	Madhya Pradesh	Khandwa	7709	7709
		Burhanpur	3404	3404
4	Odisha	Parts of Bargarh	3000	3100
		Parts of Keonjhar	3000	3132
		Parts of Keonjhar	3000	3120
		Parts of Bargarh & Sonepur	3000	3252
		Part of Balasore (Remote Sensing Studies)	500	500
		Part of Angul (GW Pollution)	500	820
5A	Punjab	Patiala	3290	3290
5B	Haryana	Gurgaon urban agglomerate	1254	1254
6	Tamil Nadu	parts of Pudukottai and Ramanathapuram	3217	3217
		Thanjavur, Pudukottai & Trichy	3028	3028
		parts of Thirunelveli	3200	3200
		parts of Tiruvallur	3300	3300
7	Uttarakhand	Tehri Garhwal	3645	3645
		Udham Singh Nagar	3055	3055
		Bageshwar	2302	2302
8	Himachal Pradesh	Shimla district	5131	5131
		Nallagarh, Baritowala, Baddi and Parwanoo, Solan district(GW pollution study)	230	230
		Una district(data collection for GW Modeling)	1542	1542
9A	Assam	Tinsukia district,	3000	3000
		Majuli island, Jorhat	400	650
9B	Agartala	South Tripura	2624	2624

Sl. No.	States	Districts	Target (Sq. km.)	Achievement (Sq. km.)
9C	Meghalaya	West Garo Hills	3000	3400
		South Garo Hills	1000	1000
10	Andhra Pradesh	Warangal	2500	2500
		Parts of Srikakulam, Vizianagaram & Visakhapatnam	2550	2550
		Parts of Srikakulam, Vizianagaram & Visakhapatnam	2560	2560
		Parts of East Godavari	1642	1642
11	Rajasthan	Sawai Madhopur	5020	5020
		Parts of Bhilwara	6607	6607
12	Jammu & Kashmir	Jammu	2400	2400
		Udhampur	2800	2800
		Kargil	5000	5000
13	West Bengal	Parts of Nadia	3000	3000
		Parts of Birbhum	3000	3000
14	Uttar Pradesh	Parts of Jhansi	1840	1840
		Parts of Hamirpur	1229	1229
		Parts of Jalaun	1398	1398
		Parts of Lalitpur	1373	1373
		Parts of Banda	1513	1513
		Parts of Mahoba	1099	1099
		Parts of Chitrakoot	1491	1491
		Parts of Firojabad	2361	2361
15	Maharashtra	Parts of Thane	3000	3300
		Parts of Jalgaon	1900	1900
		Parts of Jalna	1200	1200
16	Bihar	Parts of Giridih	2423	2423
		Parts of Giridih	2419	2419
		Parts of Gaya	3000	3000
		Araria	2830	2830
17	Chattisgarh	Part of Raipur	3000	3000
		Part of Durg	3000	3000
18	Kerala	Pathanamthitta	2731	2731
		Parts of Kollam and Trivandrum	800	800
		Part of Trivandrum	500	500
		Part of Kasaragod	500	500
		Part of Mallapuram	500	500
		Part of Thrissur	1000	1000
19	Delhi	Part of Delhi	97	97
		TOTAL	**158811**	**160685**

SALIENT FEATURES OF DISTRICT GROUND WATER MANAGEMENT STUDIES:

2.1 NWHR, Jammu

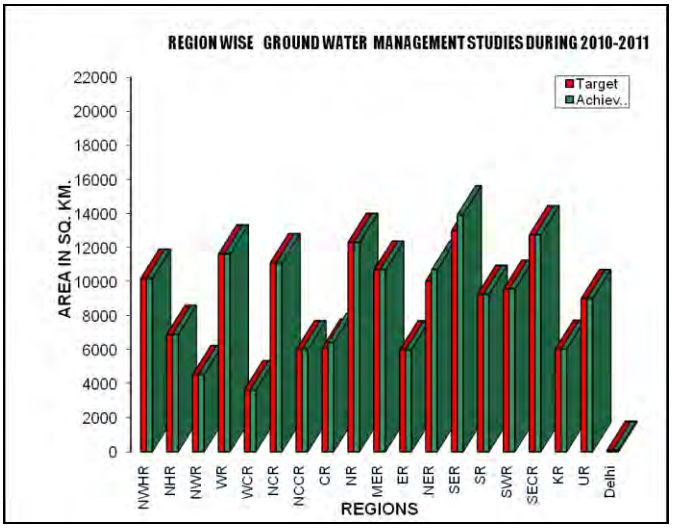
Three studies were carried out in Jammu, Udhampur & Kargil districts covering 2400 sq.km. ,2800sq.km & 5000 sq.km. respectively. All districts fall in Normal Category.

2.1.1 Jammu District

Geologically, the area of the district is divisible in two distinct units, the northern hilly area underlain by Siwalik rocks of Mio-Pliocene and the southern outer plain area underlain by the sediments of the Recent-sub Recent in age.

The occurrence of ground water is mainly controlled by topography, drainage and lithology. In hard rock area ground water occurs as small isolated bodies, whereas the same occurs as regional bodies in the outer plain area. The flow direction of ground water is broadly from north to south and corresponds roughly to the topographic slope.

Fig.2.1



The Siwalik group of rocks comprises Boulder Conglomerates, boulders, pebbles, gravels, sandstone, mudstone and clay with varying compactness forms the semi-consolidated formation. Ground water in these rocks occurs in weathered portions, cracks, joints and partition plains. The sediments of Kandi and Sirowal formation come under the un-consolidated formation. Ground water occurs under un-confined conditions in Kandi plains and both under water table and semi-confined to confined conditions in Sirowal plains.

The study of water Levels monitored during the month of May 2010 viz. Premonsoon survey reveals that in Sirowal formation the depth to water levels ranged mostly between 2 and 5 m, except for the patch in Pallanwala- Jourian area in Akhnoor Tehsil and a very small patch near Haripur –Dangre area in R.S. Pura Tehsil where water levels are within 2 m. Some patches have water levels between 5 and 10 m. In Kandi formation nowhere water levels are between 0 and 2 m but the parts adjacent to the Siwalik hills have water levels more than 20 m and within 10 – 20 m followed by 5-10 m. The post monsoon water level monitoring October-November 2010, shows that the area showing the water levels between 0 and 2 m and 2 and 4 m has increased and there is a considerable decline in the area showing deep er water levels in the range of 10 – 20 m and >20 m. The study of fluctuation between the two reveals that the rainfall has brought a great difference in the scenario of the ground water regime of Jammu district in the year 2010. The effect of heavy rainfall can be seen through rise in water levels, which range between 0 and 2 m, 2 and 4 m in almost whole of the Outer Plain area. viz. Kandi and Siwalik formations.

A total of 125 number of groundwater samples from dugwells and handpumps and 56 numbers from tube wells were collected for chemical analysis. 63 Samples were collected for heavy metal analysis. As such the ground water in the district is fresh with Electrical conductivity ranging from 190 micro-siemens/cm at 25^0C to 2800 micro-siemens/cm at 25° C. The shallow ground water is alkaline in nature and pH varies from 6.95 to 9.00. Deep ground water is also alkaline in nature and pH varies from 6.97 to 8.45. About 4.8% and 14.5% of the samples collected from deep and shallow aquifers are found to have Nitrate concentration more than 45 mg/l, the maximum permissible limit of BIS, for drinking water purpose. Ground water of the district is hard. The total hardness value varies from 70 mg/l to 1050 mg/l in case of shallow ground water samples. For deep aquifer water samples, total hardness varies from 120 mg/l to 500 mg/l. The Iron concentrations in the water samples collected from deep aquifer of the area are within the maximum permissible limit (1.0 mg/l) of BIS for drinking water purpose, except in two locations viz. Garar-1.34 mg/l & Chorli-2.42 mg/l. About 22.7% (28 out of 123 samples) samples collected from shallow aquifer are associated with iron concentration more than 1.0 mg/l. it varies from traces to 8.40 mg/l.

The dense network of canals and lack of proper drainage system resulted in water logging problems in canal command areas. Further water logging conditions created due to high intensity of irrigation without adequate drainage, which resulted in upward movement of water table.Based on depth to water level maps of the R.S. Pura and Bishnah tehsils, it is

observed that there is an improvement in the water logging conditions in the area.

A management plan adopting following measures management of aquifers, rain water harvesting, revival of ponds and lakes and need for artificial recharge to ground water, construction of gabbion structures, gully plugs, nallah bunds and check dams, rain water harvesting in urban areas, development of ground water sanctuaries along the seasonal nalas and khads, public awareness activities should be followed to mitigate the water supply problems in the district.

2.1.2 Udhampur District:

The area (2800 sq.km) under study falls in South-eastern part of Jammu and Kashmir State and is bounded in the west by Reasi district, in the north by Ramban district in the Northeast by Doda district, in the South-East by Samba district and in the South-West by Jammu district.

Ground water in the study area occurs under water table condition in alluvium and confined condition in the underlying rocks of the older age. The ground water occurrence is mainly controlled by topography, drainage, structure and lithology. In the study area ground water occurs in the pore spaces of saturated part of the alluvium and underlying Siwalik groups of the rocks. Springs are common in hard rock/sedimentary rock formation formed either along predominantly weathered zones at the contact of formations in low topographic areas. Rainfall snowmelt is the main source of recharge to ground water body.

Groundwater potential is considerably large where pebble, gravel fragments are dominated in terrace material. CGWB has drilled ten exploratory tubewells. The wells drilled in Udhampur district are mainly in the valley fill or in terrace deposits. The Udhampur terrace deposits are confined between Dudhar Khad to Bramin Di Khad in East-West direction and from Udhampur to Darshu in North-South direction. It also occurs from Manwal to Khoon. These comprises of boulders, cobbles, pebbles, sand and clay. Around Kishanpur-Manwal area, clay layer attain a thickness of 160 m. Groundwater in this formation occur in water table conditions. Perched water table conditions are generally reported in this formation. Depth of water in shallow aquifer varies between 5.35 m bgl (Raun, 43P/1-2B1) and 12.60 m bgl (Hartaryan, 43P/1-1A2) during pre-monsoon period. CGWB has drilled three exploratory tubewells in and around Udhampur. PHE has drilled many hand pumps in this area upto a maximum depth of 82.0 m. Discharge of these handpumps varies between 18 lpm to 32 lpm.

14 National Hydrograph Network Stations (NHNS) exists in the valley areas of Udhampur district to monitor the long term/short term water level behavior and quality of shallow aquifer. Depth to Water level in the district during May 10 was mostly observed between 2-5m bgl. In November 2010 except for the Dun Valley where water levels were observed in the range of 5-10 m bgl, water levels were between 2-5 m bgl.Apart from these NHNS, key wells were also established during the Pre Monsoon surveys which were again monitored in post monsoon season. The analysis of data collected during the two monitoring reveals that pre-monsoon water level variation depth to water level in unconfined/perched aquifer of terraces varies between 3.81 m bgl at Seen Brahamna to 08.10 m bgl at Nagrota Panjgarain. Post-monsoon water level variation during post-monsoon monitoring, it was observed that depth to water level in terraces formation varies between 3.51 m bgl at Rakh Badali to 0.96 bgl at Seen Brahamna.

Springs: A spring is a localized natural discharge of ground water issuing on the land surface through well-defined outlets (Karanth, 1987). Springs are formed where the water table is intercepted by the topography. In the study area, the springs are widely distributed, occurring in the different formations at varying altitudes. In the study area, occurrence of spring is controlled by lithological and structural character of rock formation. The discharge of the springs ranges from ,pre-monsoon 0.028 lps at Rangi to 1.95 lps at Mian-Da –Bagh. Post Monsoon the discharge ranges from 0.052 at Rangi to 2.31 lps at Mian-Da-Bagh.

2.1.3 Kargil District:

Studies were carried out in 5000 sq.km of area covering part of Kargil district including Zanskar region which is situated in the south of J & K state located.

Kargil district is a mountainous desert. The topography of the district is mountainous with little or no vegetation. The mountains are of sedimentary rocks and are in process of disintegration due to weathering. The district is divided into four high level natural valleys namely the Suru Valley, the Drass Valley, the Indus Valley and the Upper Sindh Valley of Kanji Nallah Valley. Zoji la and Fotul la passes situated at the height of 3567 and 4192 meters above the sea level are called gateways for Kashmir Valley and Leh District for entry in Kargil District. In Zanskar ranges, permanent glacial body exists because of higher elevation of these ranges. Deep gorges and valleys are being formed due to rapid flows of rivers in the district. The important major rivers draining the Kargil district are Drass, Suru, Zanskar and Indus. Suru valley constitutes a major part of the Kargil district which is surrounded by hills of soft mixture of clay and sand stone.

The district is underlain by consolidated formation in maximum part. Ground water in these formations occur in fissures and fractures developed due to repeated tectonic activity. The unconsolidated formations like alluvium, scree and talus formations present along the river valleys plays a vital role in term of occurrence and movement of ground water is concerned. Ground water resources of these formations can also be developed on sustainable basis. These moraine formations (Talus and scree formations) consist of boulders and clasts in a matrix of sand, silt, clay and gravel. The aquifer is made up of boulders and clastic material in clay, silt and sand matrix. Depth to water levels in moraine formations is very deep and varies between 60 to 75 m bgl. The valley fill deposits are mainly boulders and gravel mixed with silt and sand material. This is mainly transported material lying un-sorted in the recent river valleys. Ground water occurs as un-confined condition in this formation. Kargil town is located in terraces formed due to previous glaciation and is underlain by morain succession consisting of gravel, sand and clay alternate layers. Only few springs are present which are basically formed due to cutting of water table with land surface. State PHE department also constructed a number of hand pumps in Kargil district, which are yielding fresh water through out the year.

Springs: Ground water also emerges in the form of springs at contact of pervious and impervious beds, along fault planes and other structural features. A good number of springs are present in the district. Springs are formed when the topography, river terraces, the morainic masses and the alluvial fans intercept the water table.

During the present study, 54 key monitoring stations were inventoried and chemical quality parameters were analyzed, which include 50 springs, 04 handpumps. 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. Both cold and hot springs are present in the study area. The discharge of these springs varies from 01 to 38 lps. Most of the springs in study area falls in Fifth (5^{th}) order classification where discharge varies in the range of 01 to 10 liters/second. Three hot springs Zangla, Yrumdumvilla, Mulbek were inventoried during the course of study. The temperature of these hot springs ranges between 22° to 26°C respectively. From chemical quality point of view, ground water in the area is fresh and potable with electrical conductivity (EC) generally less than 700 µS/cm at 25°C.

2.2 NWR, CHANDIGARH

Two studies were undertaken in Normal areas of Patiala district (Punjab) and Gurgaon urban agglomerate(Haryana) covering an areas of 3290 & 1254 sq.km respectively.

2.2.1 Patiala District, Punjab

Patiala district covering an area of 3290 sq.km.is divided into eight-community development blocks viz. Patiala, Nabha, Sanaur, Bhunerheri, Rajpura, Ghanaur, Samana and Patran for the purpose of administration. The normal monsoon and annual rainfall of the district is 547 mm and 677 mm, respectively which is unevenly distributed over the area 29 days. A total of 60 No. of observation stations were established for monitoring the pre and Post monsoon water levels. 67 water samples were collected for quality analysis.

The district is occupied by Indo-Gangetic alluvial plain of Quaternary age, and falls in Ghaggar basin. The ground water occurs in alluvium formations comprising fine to coarse sand, which forms the potential aquifers. In the shallow aquifer (up to 50 m) ground water occurs under unconfined/water table conditions, where as in deeper aquifer, semi-confined/confined conditions exist.

The traditional dugwells tapping the shallow aquifer are not in use and most of them have been abandoned, however, this aquifer is being tapped through hand pumps and shallow tube wells, which are widely used for domestic purposes. The deep tube wells have been constructed by CGWB, which has drilled 5 exploratory boreholes, 1 slim hole and 6 Piezometers to delineate and determine potential aquifer zones, evaluation of aquifer characteristics. The deepest slim hole was drilled up to the depth of 308.30 at Dhappar (30^{o} 31'00" 76^{o} 48'24"). The permeable granular zones comprising fine to medium grained sand and occasionally coarse sand and gravel. Their lateral and vertical extent is limited. The borehole data reveals that clay group of formations dominate over the sand group in the district area. Ground water in the district occurs in the alluvium under water table and semi confined to confined conditions. The discharge of deep tube well in the area varies between 2400 and 2680 lpm. The transmissivity values ranges from 154 to 9410 m^2/day and storativity ranges from 1.95*10-3 to 4.7*10-3.

Studiy has indicated that there is complete replacement of shallow tube wells with the deeper ones except in the Ghanaur block. The minimum water level taken is 8.02 mbgl at Lachhru kalan and deepest water level noticed 44.30 m bgl at Jansua in the pre monsoon period and during the post monsoon the lowest water level was noticed at Bhagaura 7.59 m bgl and deepest was noticed at Jansua at 42.95 m bgl. Most of the area falls in the category of 20-30 mbgl, The maximum fluctuation from the pre monsoon & post monsoon period is 1.35 m but at Bhaguara the fluctuiation is 5.91 m which seems to be abnormally high. However on the basis of National hydrograph station, it is revealed that long term fluctuation shows the declining

trend. All the eight blocks of Patiala district are over exploited on the basis of Groundwater Resource Estimation as on 31/03/2004. The major problem in respect of ground water in the district is the overall decline in the water level. It is apprehended that the declining ground water trend will further aggravate with installation of more tube wells.

On the basis of water level trends all the eight blocks are suitable for rain water harvesting but Nabha and Samana blocks are most suitable for rain water harvesting. Area for taking up artificial recharge in the block of Rajpura and Samana has been identified.

2.2.2 Gurgaon Urban Agglomerate, Haryana

The total area of the district town and adjoining industrial area is about 350 sq.km. Within the municipal limits of the town there are number of hazardous industries such as electro-plating, chemicals, plastic, petroleum & automobiles etc. All the hazardous wastes generated by these industries are locally disposed and likely to pollute ground water and make it unfit for human consumption.

Major part of the Gurgaon district is underlain by Quarternary alluvium consisting of sand, clay and silt. Around 7 km east of the town, quartzite ridge trending NNE-SSW can be observed. Sandy layers at various depth form major water bearing horizons within the depth of 250 m bgl However, the thickness of sandy layer is very limited due to which the development of ground water has further restricted on large scale.Deep tubewells in the urban area have been installed by different agencies varying from 45 m to 90 m depth having dia of 15 cm and 20 cm As per analysis of the aquifer system it is observed that aquifer percentage within the alluvium column from 30 m to 90 m varies from 31 to 55% The yield of tubewells also varies in different areas ranging within 129 to 606 lpm. The depth to water level in the district varies from 3 to 55 m bgl. The water levels have shown major decline especially in central part of the town due to heavy withdrawal of ground water for industrial and domestic use. The present stage of ground water development (as on 31st March, 2004) of Gurgaon block is 311% which indicate that the entire block in which Gurgaon town is situated is over exploited i.e. ground water draft is more than the recharge. Ground water depletion in adjoining industrial areas of Gurgaon town is also becoming a serious concern, as water level trend of Shikohpur, Nathupur and Quaderpur are showing declining at rate of 0.37, 0.55 and 0.52 m/year respectively. During the last decade, the ground water has declined more than 10.0 m resulting in deepening of the tubewells and more consumption of energy for lifting the ground water from deeper horizons.

Analytical data of 48 handpumps indicate that in the northwestern part, the ground water is saline and not fit for drinking purpose. The study also reveals that due to lowering of water table in Gurgaon, saline water ingression of northwestern side is not ruled out. The heavy industrialization coupled with heavy urbanization is resulting in the form of ground water pollution. It is observed that at places the ground water is having high nitrate (more than 100 ppm) indicating ground water pollution. Further instances of high fluoride contents have also been observed making ground water unfit for drinking purposes.
The over exploitation of this vital resource along with the ground water pollution may lead to adverse environmental impact. Thus, there is an urgent need for protection of this vital resource by adopting the following measures.

i. Roof top rain water harvesting for factories institutional buildings, housing complexes and other big buildings has been made mandatory to augment the ground water recharge and may be included in building laws. The law should be strictly adhered.
ii. Water harvesting and artificial recharge structures should be constructed in Delhi ridge area, which is one of the major recharge zones for Gurgaon. The run off should be diverted to abandon mining pits. Small check dams can be constructed in hilly areas to hamper surplus run off.
iii. The industrial effluents causing ground water pollution should be treated before discharge.
iv. Strict regulatory measures are required for ground water pumpage, particularly for industrial use.
v. Industries should be persuaded to recycle the effluents to minimize consumption of water.
vi. Construction of new tubewells by individuals for domestic purpose should be regulated.
vii. The municipal sewage should be treated properly to avoid ground water contamination. The same may be utilized for horticulture and other industrial uses, thus reducing the pressure on ground water.
viii. Periodic monitoring of chemical quality should be carried out, particularly with reference to heavy metals, fertilizers, nitrates etc,
ix. Public awareness programme should be arranged to make the people and industry aware about the consequences of mining of ground water and need for effective/economic use of ground water.

2.3 WR, JAIPUR

Two studies were carried out in Sawai Madhopur district and in parts of Bhilwara district covering an areas of 5020 & 6607 sq.km. respectively.

2.3.1 Sawai Madhopur district

Sawai Madhopur district is located in the eastern part of the Rajasthan State and covers an geographical area of 5020.65 sq. km.

The soil type of the district is broadly classified in three categories viz. Recent alluvium, Older alluvium, Lithosoils and Regosoils of hills. Infiltration test results indicate that the infiltration rate of water is high in litohosols & rigosols of the hills as these type of soils are shallow with gravels very near the surface, light textured, fairly drained whereas it is low in recent alluvium specially in northern part of the Bamanwas block where soil have deep medium to heavy textures and black grey or dark brown in colour.
The district possesses well developed drainage system of Chambal, Banas & Morel. Tube wells/wells are the main ground water abstraction structures and irrigates about 96% of the total irrigated area. There were 37,500 wells during 2009-10 in the district, including 35,849 wells for irrigation & 1651 for domestic requirement. Out of these, wells used for irrigation were 31,285.

During the Pre and Post monsoon studies, the given target area has been covered and total 220 nos. of well (Dug wells, DCB's, and tube wells) were inventoried for detailed hydrogeological studies. Out of these, 204 nos. of key well were considered for the water level monitoring considering the hydrogeological formations which include the NHS and key well of Ground Water Department (GWD). The total 156 nos. of water samples (Pre & Post) were also collected for chemical analysis to understand the hydrogeochemistry of the area.

Development of barren land over the last decade has increased forest area from 15.72% to 18.04% in 2009-10. Net annual ground water availability has decreased from 2001 to 2007 due to below average rainfall and conversion of barren/agriculture land to urban area, which has resulted in sharp increase in ground water draft.
Bhilwara Supergroup, Delhi Supergroup and Vindhayn Supergroup of rocks are exposed in the district with Quaternary alluvium. About 45% area of the district is covered by consolidated formation, hence thickness of aquifer is limited to secondary porosities only. In alluvium area, considerable saturated thickness is limited to patches, especially near the river bed, west & south-west of Gangapur, Bamanwas and southern most part of Khandar tehsil near Chambal River.

Problems: Declining water level, Ground water salinity & drought condition are major problem in the district.

Decline in water levels : Ground water regime behaviour of the area varies widely. During pre-monsoon, 2010, water level in the range of 10 to 20 m covers about 58% area whereas water level between 20 & 40m covers about 23% area. During post monsoon water level in the major part (70% area) is between 5 & 20m whereas in 16% area water level is between 20 & 40m. Seasonal (pre-post) water level fluctuation during 2010 indicate rise in water level in 73% area of the district. Rise in water level > 4m is observed in about 30% area. Analysis of water level data for last two decades (1990-2010) shows that maximum decline in water level was recorded at Behraonda Khurd (Khandar block, Sandstone/shale) whereas rise in water level was recorded at Gangapur (Gangapur block, alluvium). Change in last decade (2000-2010) is indicated by maximum decline at Mainpura (Sawai Madhopur block, phyllite/schist) and rise in water level at Liwali (Bamanwas block, alluvium). Statistical analysis of water level shows that the area around Bhagwatgarh, Kiratpura & Sinoli have greatest variation in water level with respect to mean where water level is relatively deep. Hence area around these locations is most vulnerable during meteorological drought conditions.

Ground water investigations carried out in the area indicate that the specific capacity ranges from 0.030 m^3/min/m (Manchi) to as high as 0.255 m^3/min/m (Mahu) and optimum yield of the dug well varies from 0.04 m^3/min (Surwal) to 0.14 m^3/min (Piplai).

Ground Water Quality: Overall in the district, ground water quality has been deteriorated especially around Bamanswas whereas change in quality is also noticed in Gangapur & Bonli blocks. Sawai Madhopur & Khandar blocks are less affected. Groundwater quality improved at isolated locations in east (near Binega) & west (near Badh) of Gangapur town, Bonli village & south of Khandar block. Drainage system has no control over quality in phreatic aquifer.

The fluoride is within permissible limit (1.5 mg/l) in 79% area of the district whereas in 20% area it is in the range of 1.5 to 5 mg/l. Areas in the west & southwest of Khandar and north of Bamanwas blocks are fluoride affected (5 to 7.5 mg/l). Fluoride in post monsoon period as compared to pre monsoon indicate increase in the area from 3981 to 4049 km^2 & 752 to 805 km^2 in the range of <1.5 mg/l & 1.5-3 mg/l respectively. However, there is decrease in the area from 230 to 166 km^2 in the range of 3-5 mg/l and higher values of fluoride (>5 mg/l) observed during pre monsoon does not reflected in post monsoon. This indicates that quality of ground water in terms of fluoride has improved. In major part of the district except in Bamanwas & Gangapur blocks nitrate is within permissible limit (<45ppm).

Quality of ground water in the deeper aquifer is generally fresh with very limited and small pockets having brackish to saline. In Banas River basin, areas having fresh ground water occur around Banas, Lewali & Phulwara. As per ground water resource assessment as on 31.3.2009 indicates that the overall stage of ground water development of the district comes out is 128.12% and categorized as "Over-exploited". This reflects excessive withdrawal of ground water in comparison to recharge, resulting in depletion of ground water levels, deterioration in chemical quality of ground water and reduction in yield of wells and tube wells. If this situation continues for some more years, aquifers in the district will be damaged and result in acute problem of ground water even for drinking water supply; therefore, early implementation of regulation on ground water use in the area is necessary.In the area, gross ground water draft is more than net ground water availability and no surplus ground water resources are available in the major part of the area except phyllite zone of Bonli block & alluvium zone of Khandar block where ground water development activities can be taken up. The confluence of Morel & Banas River tracts is highly productive & suitable for high capacity tube wells with discharge over 1000 lpm and at places >2000 lpm. The rest of the fresh water zone in alluvial area is suitable only for medium to low capacity tube wells. Maximum thickness of alluvium increases along the river course towards down reaches of the river.

Recommendations: In Rajasthan, watering of crops is done mainly by flood irrigation. Shifting from flood irrigation to drip and sprinkler irrigation system, common ground water supply etc. Definitely save ground water draft.The suitable artificial recharge structures like subsurface barriers across the river bed should be constructed so the ground water run off may be arrested and impounded in the subsurface reservoir for meeting various sectoral needs.Various government departments have initiated water conservation measures to harvest rainwater, reduce soil erosion and check runoff velocity. Impact of these water harvesting structures indicate that there is increase in cropping area, cropping intensity, crop production, enhancement in labor

employment, minimizes erosion from nalah bank, and change in cropping pattern & cropping intensity. Harvested water provides supplementary irrigation during long dry spell & additional water sources to wild life in Ranthambore Tiger Reserve. Such programme may be taken up in the entire district for further development of surface water and ground water resources to enhance agricultural production.To ensure sustainable water management and assured irrigation facilities the dug well recharge scheme is implemented for accelerated groundwater recharge. Dug well located in the catchment area of dams, near canals, downstream of ani-cuts and low lying areas (depression) of the agricultural fields etc. forms the potential site for groundwater recharge.

The government should take initiative to harvest rainwater run-off in office buildings to encourage public. In addition to these, commercial establishment like hotel, resorts, coaching institutes, colleges etc. should also be encouraged to install such structures to utilize rainwater runoff. School buildings may be encouraged to adopt rainwater conversation by constructing tanka (Tank) that can be utilize as platform for cultural programme with installation of hand pump so that water can be abstracted to keep toilets clean & hygienic.

There is a plenty of scope for artificial recharge at suitable sites along Morel & Banas Rivers & their tributaries in the over exploited blocks by construction of small check-dam & subsurface barriers across the courses of flow as evident from the water conservation scheme implemented in Ranthambore Tiger Project area, which fulfil water requirement for the wild life through out the year.

2.3.2 Asind,Banera,Hurda, Mandal, Raipur,Suwana, Sahada and Kotri blocks of Bhilwara district

Bhilwara district is located in the southeastern part of the State. Study was taken in 8 blocks(Asind, Hurda, Raipur, Sahada, Mandal, Suwana, Kotri and Banera) having an area of 6607 Km^2.

A total of 125 nos. of well (Dugwell, DCB's, and tubewells) were inventoried during Pre and Post monsoon studies for detailed hydrogeological studies. Out of these, 117 nos. of key well were considered for the water level monitoring considering the hydrogeological formations. The total 209 nos. of water samples (Pre &Post) were also collected for chemical analysis. Banera block of Bhilwara district has been selected for detailed ground water study.

The major problem in the area is availability of water during summer and over exploited groundwater resources in potential aquifers. As the major part of the district is characterized by hard rock area (Schist and gneisses of Bhilwara Supergroup) 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 fit for the drinking and irrigation purposes except in few locality.

The mean annual rainfall (1986-2009) of the area is 644.70 mm whereas normal rainfall (1901-70) is lower than average rainfall and placed at 603.30 mm. The district consists of fairly open plains & hills in the south and northeastern part and falls in the Banas (6474.0 Km^2) and Luni Basin (133.0 Km^2).

Principal aquifers are gneiss and schist of Bhilwara Supergroup. Groundwater occurs under unconfined to semi confined condition. Weathered zone below the water table acts as good storage. The joints, fissures and other plains of structural weakness, opening and interconnection etc. control occurrence & movement of groundwater.

Weathered gneiss with schist occupies most of the northern part (Hurda, Asind block), western part (Raipur block) and south eastern part (Suwana and Kotri block). This formation exhibits irregular joints and are intruted by granite, amphibolite, pegmatite and quartz vein. The contact between these provide good channel for groundwater circulation. Average Depth to water level in this formation generally varies between 6.20 (kotri) and 23.0 mbgl (Banera). Wells tapping this formation yield between 20 & 40 m^3/d.

Phyllite and schists are predominating aquifer in the eastern part (Banera block) and central part (Mandal block) of the area. These formations are intercalated with quartzite and basic intrusives. Average Depth to water level in this formation ranges from 17.80 mbgl (Suwana) to 20.87 mbgl (Sahada). Total depth of the well tapping these formations varies from 15 to 50 m. while yield of wells vary from 25 to 55 m^3/d.

During pre monsoon shallow water level (>10 m) exist Kotri block while remaining area water level was between 15 and 20m bgl except in Banera block whereas it was more than 20 mbgl. Post monsoon data shows depth to water level generally raises and ranges between 10 and 12 mbgl, except sharp rise in water level observed in Asind block (5.0 mbgl). Seasonal fluctuation of Pre and Post monsoon 2010 indicates rise in water level in all the blocks of the study area due to widespread and good rainfall. Out of this rise in water level more than 10 m was observed in the area falling in Hurda, Asind and Banera block. Except Suwana block where rise in water level was observed minimum (2.73 m) remaining blocks viz. Sahada, Raipur, Mandal and Kotri show 5 to 10 m rise in water level.

Chemical analysis of ground water samples indicates that in the district groundwater is alkaline and in major part of the area it is hard to very hard. The southern, eastern & western part of the area, groundwater quality in shallow aquifer is fresh with EC less than 2000 mmhos/cm at 25^0 C. Here water of high EC more than 4500 mmhos/cm at 25^0 C occurred in isolated patches (Pur, Sangwa in Suwana block, Raipur, Sardarnagar in Banera block). Fluoride concentration in groundwater exceeding permissible limit (1.5 mg/l) has been reported from almost all the blocks ranging 0.5 to 2.82 ppm). Higher value of fluoride (>4 ppm) have been observed at Sodar, Sareri in Hurda block, Motipur in Asind block. Wilcox diagram of the area indicates that majority of samples fall in C2S1, C3S1 and C3S2 category which suggest that ground water is good to moderate for irrigation purpose. Generally, the ground water is fresh and potable in the area for drinking and domestic use.

As per the groundwater resource estimation 31.3.2009, the stage of groundwater development in the district reached up to 135.55% and the district as whole is categorized as “Over Exploited” with decline in pre and post monsoon water level. Out of eight blocks of the study area only one block Mandal (109.95%) falls in critical category while all blocks come under Overexploited category.

For detailed ground water study, Banera block covering an area about 687.80 Km^2 has been selected. In this study for the benefit of the stake holders of villages and for the development and management of groundwater resources smallest unit i.e. Gram Panchyat has been taken up. All the study has been carried out on gram Panchyat level. To monitor the groundwater regime one key well is selected in each gram Panchyat. In this study, emphasis is given to integrated water resource management where the water resources availability has been calculated in the block both for groundwater as well as surface water. The water resource availability has been assessed in the block on water shed basis as well as on administrative boundaries (Gram Panchyat) and calculated season wise for monsoon and non monsoon period.

Hence, there is an urgent need for integrated approach for conservation and management of water resources in the area. Following water management strategies may be applied to the area:

1. As the area is drained by Banas and its tributaries like Khari, Kothari river, emphasis must be given on the implementation of artificial recharge to ground water technique like construction of small check dam, SSB and small anicuts after conducting the runoff study to harness the water during the rains.
2. There are number of village ponds in all the blocks which can be revived and used to recharge the groundwater of the area and for other domestic purposes.
3. There are many textile industries located in Bhilwara and Gulabpura town which consume huge quantity of water resulting in drinking water problem. Regular monitoring and check on untreated disposal of waste can prevent groundwater to get polluted.

4. Taking advantage of uneven topography of the area percolation tanks, earthen dams, small check dams may be constructed to store rainwater. This will increase recharge to groundwater which ultimately result in increase of yield of wells.
5. Alluvial tracts along the river channels of Banas, Kothari and Khari are most feasible locations where shallow wells can be constructed to harness the shallow water table aquifer being potentially recharged by the flash flood and surface runoff. These well can be used for water supply, wherever feasible.
6. In the district, new improved irrigation techniques such as drip and sprinkler irrigation to be encouraged.
7. Surface runoff can be harnessed by constructing tanks at feasible sites in the area occupied by hard rock terrain for supplementing irrigation potential to increase the agriculture production.
8. In the overexploited blocks, construction of new bore well and tubewell should be banned immediately.
9. To increase the awareness of people/ villagers on water conservation and management issues, mass awareness programme should be conducted.

2.4 WCR, AHMEDABAD

Studies were carried out in the coastal area in parts of Mandvi, Mundra, Anjar and Gandhidham Talukas of Kachchh District covering an area of 3642.39sq.km.

2.4.1 Parts of Kachch District

The study area(3642.39sq.km) is located in the central and eastern part of Kachchh district. There are 511 small and large size tanks/ponds in the area with few being used for irrigation.Long-term average annual rainfall for New Kandla IMD station is 401.40 mm. Most of the rainfall (about 401mm) is received during south-west monsoon between June and September. The overall drainage pattern is radial because of central upland which acts as drainage divide.

Hydrogeology:

Hydrogeological units in the area can be grouped as Mesozoic formations, Deccan trap (Hard rock), Tertiary formations & Quaternary sediments

Mesozoic Formations

These formations belonging to the Bhuj (Umia) series forms the most prolific aquifer system in the north eastern and north central parts and a small patch in the north of Mandvi taluka. This aquifer is extensively developed in Gadhsisa-Mau, Anjar-Khedoi-Shinugra and Ratnal areas. Bhuj Sandstone comprises of fine to coarse grained sandstone interbedded with siltstone and shale. The sandstone, which mainly forms the aquifer, is soft, friable and highly porous/permeable. The unconfined or the phreatic aquifer system in this formation extends down to a depth ranging from 20 m to about 100 mbgl depending on the presence of aquitards/confining layers. Groundwater in central parts occurs mainly in unconfined to semi-confined conditions. Due to excessive development resulting in decline of water levels, most of the dug wells have gone dry, particularly in Anjar-Khedoi-Shinugra, Gadhsisa areas. In these areas, the ground water is mainly developed through medium and deep depth tubewells ranging in depth from 80 to 200m. These tube wells tap aquifer zones in the depth range of 40 to 200m. The aggregate thickness of granular zones ranges from 30 to 100m. The discharge of tube wells ranges between 40 and 360 m^3/hr with drawdown ranging between 3 and 12m. The piezometric heads / water levels in Bhuj Sandstone range from 13 to 117 m bgl. The quality of ground water in general is fresh with TDS < 2000 ppm.

Deccan Trap

It occurs as almost one continuous belt from Anjar to Mandvi north of the Manchhar series rocks. Ground water in Deccan traps occurs in the weathered mantle and along the interflow zones, joints and fissures. Groundwater development is limited in this formation due to poor water bearing characteristics. Dug wells tap the weathered portions & joints. They are 4 to 23mbgl deep with depth to water 1.05 to 11.25 mbgl. The Ground water quality is variable with very good at few locations and saline to brackish at some places.

Tertiary Formation (Manchhar Series)

This formation occurs in an East-West trending belt bounded by Recent alluvium in the south and Deccan Trap rocks in the north comprises of buff light grey, reddish, yellowish clays, mottled sandstone and sandy clays with gypsum. The mottled sandstone forms productive aquifer at places. Wells range from 7 to 24m in depth with depth to water 3 to 15 m bgl.

In parts of Mandvi and Mundra taluka this aquifer unit is extensive and has good ground water development by means of dug wells and tube wells. Due to excessive development most of the dug wells have gone dry, at present this aquifer is mainly exploited through tube wells for irrigation purpose by farmers. Ground water occurs under water table conditions down to 25 m and under confined conditions in deeper levels i.e. below 30mbgl to a

maximum depth 170 mbgl. Depth to water level ranges from 1.5 to 12.88 m bgl in dug wells and between 30 to 106 mbgl in tube wells tapping deeper aquifers. The fluoride content in groundwater exceeding permissible limit (1.50ppm) has been observed in many places.

Quaternary Sediments

Alluvium (Pleistocene to Recent)

Alluvium occurs in streams, & coastal tracts spread over almost whole study area. The alluvium comprises of brown loamy, kankary. silt, clays, sand, gravel, loam & kankar with a total thickness of about 6 m. However, in southern parts of the study area parallel to the coast, the thickness is considerably high. Depth of dug wells varies between 4 to 21 mbgl with depth to water level in the range of 1.3 to 17.45 mbgl. A few Tube wells in the depth range of 30 to 115 mbgl are also present tapping recent alluvium aquifer with depth to water level in the range of 17 to 37 mbgl. The quality is highly variable factored by distance from coast and fresh water bodies.

Aquifer Geometry-Shallow and Deeper

The study area has both shallow and deep aquifers. The shallow aquifers have been considered up to the depth of 25 mbgl and are developed mainly by dug wells covering all the hydrogeological units. Due to heavy exploitation, most of the dug wells have dried up. The dug wells inventoried during course of study are mostly situated near favourable situations such as water bodies, river beds etc.The deeper aquifers are the main user aquifer in the study area and are developed by dug-cum bore wells and tube wells. The depth of the deeper aquifers is 30-200m. Deeper aquifers are mostly tapped in Manchhar series and Bhuj series rocks.

Depth to water level

The depth to water level in the shallow aquifer varies between 1.3 mbgl to 39.65 mbgl in the alluvium formation. In basaltic aquifers it ranges between 1.05 to 11.25 mbgl. Aquifer tapping Manchhar series have the depth to water level between 1.5 to 30.08 mbgl.The depth to water level in the deeper aquifers tapping Manchhar series ranges from 33.61 to 105.78 mbgl.The depth to water level in the deeper aquifers tapping Bhuj series ranges from 34.65 to 117.9 mbgl.The depth to water level in the shallow aquifer during the post monsoon period varies between GL to 34.85 mbgl in the alluvium formation. In basaltic aquifers it ranges between 1.75 to 11.25 mbgl. Aquifer tapping Manchhar series have the depth to water level between GL to 15.93 mbgl. The depth to water level in the deeper aquifers tapping manchhar series ranges from 30.13 to 86.79 mbgl.The depth to water level in the deeper aquifers tapping Bhuj series ranges from 23.93 to 117.89 mbgl.

Water level fluctuation

Wide fluctuation in the water levels is observed in response to the monsoon. During the study period the area received good monsoon. Except a few places, there is general rise of few meters to 27.71 m considering all the aquifers. The wells tapping shallow aquifers in alluvium formation shows rise in water level in the range of 0.38 to 11.41m compared to pre monsoon water levels. The shallow aquifers tapping basaltic formation shows rise in the range of 0.05 to 6.67m compared to pre monsoon water levels. The shallow aquifers tapping Manchhar formation shows fluctuation in the range of -0.15 to 19.33m compared to pre monsoon water levels. The deeper aquifers tapping Manchhar formation show rise in the range of 0.21 to 17.5 m compared to pre monsoon water levels. The deeper aquifers tapping Bhuj formation show fluctuation in the range of -7.97m fall to 27.71 m rise compared to pre monsoon water levels.

Ground Water Quality

143 ground water samples were collected during the pre monsoon period. The samples were also collected from the key wells and the nearby running wells encompassing all aquifer systems existing in the area. The study area being coastal tract of Kachchh has in general poor ground water quality. The quality has wide variation depending upon the depth, aquifer system, distance from the coast, distance from the water bodies etc.The TDS varies from 300 ppm (Nabhoi Nani, Ta- Mandvi) to 46667 ppm (Dholupir Bambhdai, Ta- Mandvi).50% wells in the study area have TDS value more than 2000 ppm.Fluoride concentration also shows wide variation in the area. 42 samplesin the study area have fluoride concentration more than 1.5 ppm. 5 samples have nitrate value more than 100 ppm. 33 samples have SAR value more than 18 which indicates its use “doubtful for irrigation purpose”. Shallow ground water in the study area shows wide variation in relation to formation, vicinity from coast and water bodies etc. The TDS ranges from 300 to 46667 ppm. 47 samples from shallow aquifer have TDS value more than 2000 ppm. 27 samples show Fluoride concentration more than 1.5 ppm. Deeper aquifers tapping Manchhar and Bhuj formation have variable ground water quality. The Bhuj aquifer has good quality potable water, where as Manchhar series aquifer is moderate to poor in quality and is used mostly for irrigation purposes. The TDS in the deeper aquifer varies from 530ppm (Shinugra, Taluka-anjar) tapping Bhuj aquifer to 6373 ppm (Layja nana village, Taluka-Mandvi) tapping Alluvium/Manchhar series aquifer. Samples from deeper aquifers indicate nitrate within permissible range in all the. 26 samples from deeper aquifer show TDS value more than 2000 ppm. Fluoride concentration ranges from 0.3 to 6 ppm in deeper aquifer samples with 11 samples showing its value more than permissible limit. SAR value of the samples range between 2.7 to 35.2. 16 samples from deeper aquifer have SAR value

more than 18 indicating it to be doubtful for irrigation purpose.

To ascertain the extent of sea water intrusion a chemical signature in the form of Chloride/Carbonate ratio was used. It has been observed that 50 out of 61 samples show the value more than 1 which indicates sea water intrusion has taken place in the area. The severity and extent is under study and will be elaborated after analysis of the chemical data. Further studies using multidisciplinary approach like geophysical studies is needed to be done in the study area.

Finding:

- The area is facing ground water depletion and deterioration in quality. Sea water ingress has taken place in the coastal aquifers.
- Although Ground water conservation structures are constructed in the coastal area, looking at the post sea water ingress scenario the approach has to be modified and intensified.
- Rain water harvesting and artificial recharge structures need to be constructed in the northern part of the study area which is the main recharge zone.
- A number of storage tanks and percolation tanks (97 nos.) of storage capacity varying between 0.025 to 0.29 M m^3 are present in the study area. They can be repaired/restored or renovated to increase their storage capacity which in turn would improve the ground water resources within the area.
- Farmers are to be encouraged to utilize sprinklers and drip irrigation technique for efficient ground water management.
- Recharging through suitable rain water technique near or within the agricultural land and dwelling units should be made compulsory which will ultimately benefit the farmers and local population.
- Cropping pattern need to be suitably changed to use the less water intensive and salinity resistant crops.

2.5 NCR, BHOPAL

Three studies were undertaken two in Khandawa (Drought & Normal categories) and one Burhanpur (Tribal & Normal categories) covering an area of 7709 & 3404 sq.km respectively.

2.5.1 Khandwa, Pandhana, Chhegaon-makhan & Punasa blocks of Khandwa district (including conjunctive use studies for proposed Indira Sagar Dam)

Khandwa district is located in the south western part of Madhya Pradesh having an undulating topography.The study area can be divided in two physiographic units viz the northern upland and the central low lands . The area is showing Dendritic drainage pattern.

The area is mainly covered by Deccan Trap Basaltic flows consisting vesicular amygodial, massive fractured & weathered Basalts, Bagh beds consisting sandstones & shales in Punasa block, and Vindhyan sand stones & shale along the Narmada river course. Alluvial deposits are also observed along the nala & river course at some places. About 30 Basaltic flows which are distinguished by either presence of Red bole, vesicular zones or break in slopes, their thickness varies from 7 to 55 m .

During the study 95 Nos. of key-wells were monitored, the depth of dugwells varies from 5.20 mbgl to 21.25 mbgl. Depth to water ranges from 3.00 mbgl (kalmukhi) to 18.61 mbgl (Banjari) during pre monsoon and from 3.0 mbgl to 7.20 mbgl (Dongargaon) during post monsoon. Long term annual rising trend showing in Pandhana and Chhegaon Makan blocks & declining trend in Khandwa and punasa blocks. The ground water occurs in phreatic and semi confined conditions in the area and average yield varies from 140 to 650 lpm. 33 water sample were collected for chemical analysis, the ground water is potable at most places, however, at places the electrical conductivity is high.

Conjuctive use of Punasa -Dam -(Indira Sagar Dam):

Indira Sagar power station is situated 10 km away from village punasa in Khandwa District (M.P). it is a multipurpose project the river Narmada with installed capacity of 1000 megawatt (8x125 mw) it designed annual energy generation capacity is 1980 MUs.

Gross reservoir capacity of Indira Sagar project is 12.2 billion cubic meter which is (a) sufficient for the drinking water requirements of 125 crores peoples of India for whole year (b) The largest reservoir of India which is 125 times larger than Bhakhra dam reservoir. It caters 564 villages and irrigation 2.70 Lakh Hactares land annually.

2.5.2 Ground Water Management studies (focusing on GW quality studies including Fluoride problem) in Harsud, Balri & Khalwa blocks district Khandwa Distt. Madhya Pradesh.

The study was undertaken in parts of Khandwa district covering an area of 3791sq.km.Geologically, the area comprises Narmada valley granitoids of Palaeo-proterozoic age, Bijawar group of Palaeo to Meso-Proterozoic age, Rewa group of Vindhyan Supergroup of Neo-Proterozoic age, Bagh group of Late Cretaceous age and Basaltic flows of Deccan Trap of Late Cretaceous to Palaeogene age.

The pre monsoon depth to water level in the district ranges between 1.20 m bgl and 12.73. In general depth to water level remains less than 10 mbgl in major part of the area under study during pre monsoon. During post monsoon, the general depth to water level in the district ranges between 0.30 m bgl to 8.08. In general depth to water level remains less than 5 mbgl in major part of the area under study during post monsoon. Water level fluctuation ranges from 0.25m to 8.83m in the area under study. The general trend of water level fluctuation is increase in intensity from south to north or from Khalwa block to Baldi block from. Pre monsoon water table elevation ranges from 253.08 m amsl to 458.85 m amsl. The major rivers Narmada and Tapi are effluent in nature. The ground water flow direction is broadly SSE-NNW in the area under study in the part of Narmada catchment towards Indra Sagar Reservoir and Narmada river whereas it is towards river Tapi broadly in NE-SW direction in the Tapi catchment in part of Khalwa block. In general hydraulic gradient varies from 6.66m/Km in hilly and forested area south of Khalwa block to 2.30 m/Km in northern part of the area under study North of Khalwa block. The gradient of water table is still gentler in further north of the district. The gentle hydraulic gradient in north than the south suggests that permeability in north is higher than southern hilly areas. Post monsoon water table elevation follows more or less the same pattern as that during the pre monsoon.

Perusal of long term trend analysis indicates, that the National Hydrograph Stations of the district under study show block-wise rising trend during pre monsoon period averaging 0.167 and 0.330 m/year for Harsud and Khalwa blocks respectively. Similarly, block-wise they show rising trend averaging 0.275 and 1.07 m/year for the above two blocks. There is no hydrograph station in Baldi block as major part of this block falls in the submergence area of Indra Sagar.

CGWB exploration data in the study area of Khandwa district in the depth range of 175 to 213 m bgl indicates that in none of the wells basement has been encountered. Discharge from these wells has ranged from negligible to 1044 lpm. 'Transmissivity' value has ranged from12.0 m2/day to 112.0 m2/day, whereas the 'Storativity' value has been estimated as 1.10×10^{-2}.

As per GWRE 2009, all the blocks fall in safe category. The present average stage of ground water development for the three blocks has been estimated to be 47% as compared to 39 % during the base year 2004. There is no change in the category since 2004. It will result into creation of additional Irrigation Potential of 39629 Ha in the three blocks under study.Net ground water availability for irrigation at 70% development is estimated to be 62.27 MCM which may support 3842 dug wells and 2113 tube wells. It will result into creation of additional Irrigation Potential of 10379 Ha in the three blocks under study.

Ground water quality in the area may be concluded to be potable except for nitrate that necessitates safeguarding shallow aquifer from contamination of domestic and agricultural waste. There is need for fluoridation of water also as the fluoride concentration for majority of samples is too low below 0.50mg/l.

2.5.3 Burhanpur District

The study area (3404 sq.kms.) exhibits an undulating topography and can be divided into two physiographic units Viz. the northern and southern uplands and the central low lands. The highest elevation in the district is 778 m.amsl in the western part on the Satpura Range. The Tapti river carves out a narrow valley bifurcating the Satpura range. The lowest elevation is 249 mamsl southwest of Burhanpur town along the major Tapti River. The Utaoli, Sukhi, Khaknar nala, Khokari and Dewri are the main tributaries of Tapti River. The drainage pattern of the area can be classified as Dendritic.

The thickness of the alluvium ranges from 30 m to more than 200 m. Alluvium comprising of sand, clay and gravel occurs along the Tapti river course and forms unconfined, semi confined to confined aquifers. The yield of the borewells constructed in the formation ranges from 4 lps to 16 lps.

A major portion of the district is underlained by Deccan Trap basaltic lava flows. Groundwater occurs in the weathered, vesicular, jointed and fractured basalts. In general in the area the phreatic aquifer is encountered up to a depth of 30 m under unconfined conditions. The semi confined and confined aquifers are encountered between 45 to 190 m bgl. Potential aquifers are encountered where the basalt is highly fractured and jointed. The yield of the borewells in Deccan traps ranges from negligible to 10 lps.

Depth to water levels ranges from 2.90mbgl to 35.50 mbgl during pre monsoon period and from 0.80 mbgl to 30.60 mbgl during post monsoon period. The water levels are deeper south of Burhanpur near Shahpura. During pre monsoon period, many of the domestic and irrigation dug wells go dry.

The water levels in the observation wells monitored during 1991 and during 2010 shows that the water levels have declined during pre and post monsoon in all the observation wells except three wells. The decline in long term water level ranges from 0.023 m/year (Sirpur) to 0.32 m/year (Nachankheda) during pre monsoon and from 0.04 m/year

(Icchapur) to 0.35 m/year (Sirpur) during post monsoon period. The decline in ground water levels and yield of the dugwells/borewells can be attributed to the increased groundwater withdrawal for irrigation mainly for banana and sugarcane. This is prominently observed in Burhanpur block in the area south of Burhanpur town. Due to the construction of percolation tank and stop dam in and around villages viz.Bhambada, Dahinda, Dhulkot etc., the dugwells and borewells in the villages which used to go dry during summer are yielding water throughout the year.

The chemical analysis of the groundwater samples reveal that the following ranges: pH 7.14 to 7.99, Ec (µmhos) 350 to 3530, Total Hardness as $CaCO_3$ (mg/l) 155 to 1395, Bicarbonate (HCO3) 122 to 744, Chloride (Cl) 14 to 535, Sulphate (SO4) 2 to 300, Nitrate (NO3) 1 to 605, Fluoride (F) 0.03 to 1.13, Calcium (Ca) 24 to 378, Magnesium (Mg) 4 to 125, Sodium (Na) 2 to 230, Potassium (K) 0.1 to 556. On comparison of chemical quality of groundwater samples in the area with BIS standards for drinking water it is observed that majority of groundwater samples are within the permissible limits.

2.6 NCCR, RAIPUR

Two studies conducted in Raipur(Normal category) and Durg district(Tribal category) covering an areas of 3000 & 3000 sq.km each.

2.6.1 Raipur District (focus on urban hydrogeology)

Studies conducted in five administrative blocks namely Bhatapara, Simga, Palari, Tilda and Dharsiwa blocks of Raipur district covering an area of 3106 sq. with the thrust on the urban hydrology of Raipur urban agglomerate having an area of around 250 sq. Km. . Due to the rapid growth of the city, there has been a considerable stress on its natural resources including the ground water resources. The Raipur town gets a part of its water supply from the Kharun River and the rest is met through the ground water. At present about 25% of the water demand of the urban area is met by ground water only. The entire study area is drained by Kharun River and its tributaries.

The study area is underlain by consolidated Precambrian sedimentaries of Chhattisgarh Supergroup of rocks and is basically consist of limestone, shale and dolomites. Dug wells are selected to study the ground water behaviour in the phreatic aquifers and at the same time bore wells are monitored to study the ground water behaviour in the semi-confined/confined aquifer. There are two different aquifers present in the area which are being used for abstraction of water for different purposes. The semi-confined aquifer is the one which is being heavily exploited for irrigation as well as for domestic purposes and resulting in deep water level in some parts of the area. The area which are covered by the canal command, showed shallow water level during even the pre-monsoon period as compared to the non-command area where the water level goes beyond even more than 25m bgl. This shows a good sign that the aquifer is very much responsive and artificial recharge in the areas with same geological conditions will be very much successful in improving the ground water conditions in the area as well as the sustainability issues of the ground water abstraction structures in the area can be solved.

The detail hydrogeological studies were carried out in and around the Raipur urban area covering an area of around 250 sq. km. Physiographically Raipur is situated in the South Central part of Chhattisgarh basin having gentle undulating topography. Drainage is moderate in the area due to flat terrain and underlying layers of laterite and sandstone which has moderate permeability.

Raipur Urban Agglomarates

Urban area of Raipur covers an area around 300 sq. km. Kharun along with Chhokra nallah and other small nallah systems drain the area. Drainage is moderate in the area due to flat terrain and underlying layers of laterite and sandstone which has moderate permeability.

As a result of urbanization, rapid change in land use pattern of Raipur has been observed. Most of the area which was earlier occupied by agricultural land and water bodies has been converted into industrial and residential colonies. So there is significant reduction of area suitable for recharge.

Urban requirement is met through surface and ground water resources. As per the data obtained from Raipur Municipal Corporation (RMC Water Works Department, 2011)), total water supply by RMC is 150 MLD, i.e. 54.75 MCM. Out of it 127 MLD (i.e. 46.35 MCM) is supplied from surface water sources. The rest 23 MLD (i.e. 8.4 MCM) is supplied through ground water sources. RMC supplies a total of 54.75 MCM against a demand of 62.05 MCM. Remaining 7.3 MCM is met entirely through private bore wells. Thus the total annual ground water draft is estimated as 15.7 MCM.

The total annual available resources were estimated to be 19.80 MCM.Total annual ground water draft is estimated as 15.7 MCM. The stage of ground water development is nearly 80% for RUA .With the stage of ground water development more than 70% and water levels in most of the wells showing falling trends, RUA can be categorized as semi-critical. With increasing ground water draft the situation may worsen.

The urban agglomerates generate large quantities of waste both liquid and solid. The city has not been provided with facilities for proper treatment/disposal of the wastes. Abandoned quarries and local depressions are converted into waste disposal sites which contaminate the aquifers. Some residential colonies have come up on the old land fill sites which pose serious health hazards.

2.6.2 Durg district (Conjunctive use of surface and groundwater)

The study of conjunctive use of surface and groundwater was undertaken in Tandula Command Area of Seonath sub-basin covering 3000sq.km of area. 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 given below in Table. 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.

Table : Basic details of Tandula Reservoir Complex

Name of the Resevoir	Catchment (Sq. Km)	Live Storage (TMC)	Dead Storage (TMC)	Gross Storage (TMC)
Tandula	827	10.68	0.35	11.03
Gudhli	194	3.41	0.18	3.59
Kharkhara	372	4.92	1.14	6.06
Total	1393	18.91	1.67	20.58

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.

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 up to October 2010.As per the data of department of Revenue, in the previoust 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.

During pre-monsoon period, the water level varies from 1 to 16 mbgl with the modal class being 5-7 mgl. Similarly, during post-mosoon period, the water levels vary from 1 to 11 mbgl with the modal class of 3-5 mbgl.

Water table contour map is 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

Three studies were carried out in parts of Thane, Jalgaon & Jalna Districts covering an areas of 3300,1900 &1200 sq.km. respectively. All the three areas fall in Normal Category.

2.7.1 Parts of Thane district (focus on seawater ingress)

Studies were carried out in parts of coastal areas of Talasari, Dahanu, Palgarh, Vasai talukas and parts of Wada and Vikramgarh talukas of Thane district covering an area of 3300 sq.km. against the target of 3000 sq.km. The theme of the study was to assess the impact of sea water ingress due to over development of aquifers and to suggest the remedial measures to overcome the problem. The detailed study was done in coastal tracts of Datirva–Kelve– Mahim – Shirgoan - Trapur- Dahanu stretches covering 500 sq. km.

The area is mainly occupied by Basalt and coastal alluvium. To study the hydrogeology of the area 68 key observation wells (KOW) were established in addition to the already existing 14 GWMS. The depth of the KOW ranged from 2.60-12.20 m bgl, whereas the diameter ranged between 1.50 and 12.00 m. The premonsoon depth to water level ranged from 1.20 to 9.35 m bgl, whereas in postmonsoon it ranged from 0.11-5.65 m bgl and the seasonal fluctuation ranged from -0.67 to 6.72 m.

A detailed study in the coastal areas indicate that depth of water level varies between 0.50 and 1.85m bgl, whereas the depth of dugwells ranges from 3.5 to 8.5m. The ground water is exploited through circular dug wells and shallow hand pump fitted slim holes or bore wells. The potable ground water is confined to phreatic aquifers, comprising of coastal alluvium. The thickness of alluvium is restricted down to 5 to 8m and it diminishes to the east of the coast. The coastal alluvium is underlain by fine grained, massive basalt of Deccan Traps. Ground water for irrigation is exploited through large diameter open wells to a limited extent.

Discharge in these wells range from 12 to 18 cum/hr and the wells have a drawdown of 1.55 to 3.2m for 3 to 5 hrs of pumping. The TDS is observed to range from 300 to 500mg/l in fresh water pockets. Thick clay bed is encountered below 8 to 10m depth and ground water is limited to upper alluvial patches. Deeper zones of saline or brackish water are not reported and periodic change in water quality with respect to salinity in phreatic aquifer is also not reported.
As part of disaster management measures, few sites were selected for exploratory drilling after detailed hydrogeological study of the area and interaction with Tarapur Atomic Power Station (TAPS) officials. Locations of tentative sites selected for drilling bore wells for disaster management were also provided to TAPS officials.

The effect of tidal waves on ground water levels or quality is not observed. Sea water ingress is not reported in the area. Due to very less exploitation of ground water, limited thickness of coastal alluvium followed by thick clay bed and massive basalt the sea water intrusion is not occurring in the coastal area of Thane district.

Ground water quality is generally good and is potable in almost all the areas. Saline to brackish water is reported in deeper zones (>8-10m) in areas close to sea coast which is not being pumped. Water contamination due to industrial activity is reported in Palgarh-Mahim-Harnvad areas at moderate depths of 40-60m.

Conclusuion & Recommendations

The effect of tidal waves on ground water levels and its quality is not observed. Due to very less exploitation of ground water, limited thickness of coastal alluvium, which, is followed by thick clay bed, and massive basalt the seawater ingress is not occurring in the coastal area of Thane district.

Few ground water potential zones are identified based on well inventory and local hydrogeological studies. The areas identified for development by borewells are located at:

1. Masvah-Dahisar-Pargoan-Ghatimpad areas in valley portions.
2. Manor-Khamoli areas.
3. Ashgarh-Vadhana-Kasa areas.

In these locations 60-80m deep borewells can be drilled at specific sites based on the local hydrogeological conditions. The bore wells would yield about 3lps of discharge, which may sustain 5- 6 hrs of continuous pumping.

Large diameter shallow dugwells (6-8 m depth) are recommended in coastal alluvial patches about 3-5km away from coastal areas near Manda-Mahim-Kelve-Makunsar-Pagda-Shirgoan-Vangoan-Tanashi-Vasagoan-Sakhare areas. These wells can be utilized for horticulture. However, care should be taken to restrict ground water extraction from these wells limited to 2-3 hrs daily pumping in two intervals with 6-8hrs of gap in a day. The yields of these dugwells may range between 43 and 48 m^3/hr.

As Vasai-Virar areas are almost over exploited, therefore no further ground water extraction can be taken up in these coastal zones to avoid seawater ingress.

2.7.2 Raver & Yaval Talukas, parts of Jalgaon District (focus on over exploitation)

Studies carried out in 1990 sq.km in Raver and Yaval taluka of Jalgaon district (Over-Exploited talukas).

The district forms the northern part of Tapi basin. Tapi River is the main river flowing in the southern part of these taluks and its main tributaries in northern flank are Suki, Bhokri, Mor and Bhaunak of Jalgaon district. Geomorphologically, it is part of Tapi Alluvium plain lying at the foot of the Satpura range.

Geologically, Raver and Yaval taluka of Jalgaon district is composed of Upper Cretaceous-Eocene Deccan traps in the northern part and thick deposit of Alluvium of Pleistocene to Recent age in the middle and southern part. There are small pockets of Deccan traps exposed in Raver taluka in the form of inliers near Raver town and Khanapur village.

In the present study, an area of 1900 sq. km. was covered against the targeted area of 1900 sq. km The major part of these talukas is covered by Tapi alluvium underlain by Deccan lava flows at different depths. Tapi alluvium is the main water bearing formation at variable depths. During premonsoon survey, 50 key wells (dugwells) were established to monitor the water level in the area. As the theme of this study was OE talukas, emphasis was given to select those key wells, which have been monitored during previous studies to correlate the change in ground water regime. In Raver taluka 24 key wells were established, whereas in Yaval taluka 26 key wells were established. The talukawise brief write up is given below.

Raver Taluka

The depth of the dugwells in Raver taluka varies from 6.68 mbgl (Lalmati, Hilly area) to >60 mbgl and diameters vary from 2.30 to 6.15m. Deeper depths are observed in the areas occupied by alluvial formation. Pre-monsoon water level ranges from 4.29 mbgl (Nimdya, Hilly area) to 53.48 mbgl (Maskawad Sim, Alluvium) and Post-monsoon water level ranges from 2.54 mbgl (Nimdya, Hilly area) to 50.20 mbgl (Maskawad Sim, Alluvium). The water level fluctuation was observed to be ranging from 1.11m (Sudgaon, Alluvium) to 22.86m (Kumbharkheda, Alluvium).

Yaval Taluka

The depth of the dugwells in Yaval taluka varies from 4.00 mbgl (Langda Amba, Hilly area) to >60 mbgl and diameter vary from 2.20 to 6.15m. The deeper depths are observed in area occupied by alluvial formation. Pre-monsoon water level ranges from 2.20 mbgl (Langda Amba, Hilly area) to 59.70 mbgl (Faizpur, Alluvium) and Post-monsoon water level ranges from 1.72 mbgl (Langda Amba, Hilly area) to 54.41 mbgl (Faizpur, Alluvium). The water level fluctuation ranging from –11.97m (Sanghvi Budrukh, Alluvium) to 15.03m (Hambardi, Alluvium).

The fluctuation of pre and post monsoon water level shows rise in water level in 96% of wells whereas 4% wells show decline in water level. The rise in water level ranges from 1.11 to 22.86 m. This may be due to good rainfall received in these talukas in 2010. Change in cropping pattern (from banana to onion, turmeric, papaya, pulses etc) and modern irrigation practices (sprinkler and drip) have also led to more availability of ground water.

To know the long term water level trend, the water level of 34 wells were compared with previous data and it is found that 59% of wells show rise and 41% of wells show decline in water levels during pre-monsoon and similarly 41% of wells show rise and 59% of wells show decline in water levels during post-monsoon. This indicates that during the postmonsoon season, the demand of ground water is increasing with time especially for irrigation purpose, thus leading to the decline.

Conclusion & Recommendations

During the field study, several discussions were held with the farmers regarding the status of water levels and yield of their wells. Most of the farmers informed that the recharge caused by good rainfall received during 2010 have resulted in rise of water levels and it could sustain good agricultural activities.

Over the years, the water levels have gone down in these talukas and yield of wells have reduced due to which farmers have to lower their pumps to deeper depths. As the depths are more they require more energy to lift the water for irrigation. Therefore, appropriate ground water recharge facilities are required to arrest the declining water levels in these OE areas on regular basis. Modern irrigation practices like drip and sprinkler irrigation should be adopted instead of flood irrigation to minimize the ground water use.

2.7.3. Jalna Taluka, parts of Jalna District (Focus- Low Yielding Aquifers)

Study area(1239 sq.km.) is occupied by basaltic lava flows of Deccan Traps of Upper Cretaceous to Eocene age. The lava flows are piled over one another. The individual flow thickness ranges between 20 to 30 meters. Alluvial deposits along the rivers overlie the Deccan Traps. The alluvium consists of clay, silt and sand and the thickness ranges between 10 to 20 meters.

Ground water occurs under unconfined and semi-confined to confined conditions. The unconfined condition prevails through out the area in all type of formations, where as semi confined to confined conditions exist only in Deccan trap areas. The semi confined to confined condition is observed in many of the boreholes drilled by GSDA in the area. The deeper bore wells in Deccan trap area have shown the shallow depth to water level, as the numbers of fracture zones encountered are more, whereas in shallow bore wells the water level are relatively deeper as the number of fracture zones encountered are less indicating existence of confined aquifers in the area. Such type of situation was observed around Raipur village.

40 key wells have been established during May 2010 and water levels were monitored for the premonsoon and postmonsoon season. The premonsoon water level varies from 3.90 m bgl (Malegaon) to 17.75 mbgl (Takarwan). Post Monsoon water level varies from 2.23 m bgl (Samangaon) m bgl to 5.44 m bgl (Jalna). In the premonsoon monitoring a majority of the area had depth to water levels between 8.00 and 12.00 mbgl in the river valley parts of the area. Depth to water levels in the range of 12.00-16.00 mbgl were observed in small parts of the area. The depth to water level around Jalna and Takarwan was found to be more than 16.00 mbgl, where wells are tapping massive jointed basalt and jointed basalt. In post monsoon season, majority of the areas have depth to water levels in the range of 4-6 m bgl. In some patches, depth to water levels ranges from 2.00-4.00 mbgl. These areas occur along the Dudhna River and are occupied by highly weathered basalt, at the foot hills of moderately sloping grounds. Majority of the area had water level fluctuations ranging from 6.00-8.00 mbgl, followed by 4-6 m and 2-4 m, whereas in few isolated patches they were above 8 m.

During the post monsoon season 4 pumping tests were conducted in detailed study area in order to estimate the hydrogeological parameters of the wells in the shallow aquifer. The attempts were made to conduct pumping tests in recharge area, intermediate zone and discharge area. The yield of the well is rated by its Specific Capacity, which is defined as the discharge per unit time for unit drawdown. Specific Capacity varies between 496.59 m^3/day /m at Warud to 1191.17 m^3/day /m at Nirkheda.

Yield of dugwells in the area varies according to the nature of formations tapped. The yield ranges from traces to 432 m^3/day. The aquifers in the area are poor to moderately

yielding having low storage capacity. The wells sustain pumping for about one hour on an average. Therefore, more emphasis needs to be given to hydrogeological study/scientific input while selecting sites for the wells, to encourage ground water development in the area.

Ground water has special significance for agriculture and development in the area. Although the ground water development in the area is on lower side, major parts of the area are experiencing declining ground water levels.

2.8 NR, LUCKNOW

Eight studies were carried out in parts of Jhansi, Hamirpur, Jalaun, Lalitpur, Banda, Mahoba, Chitrakoot and Firozabad districts covering an areas of 1840, 1229, 1398, 1373, 1513,1099, 1491 & 2361 sq.km. respectively.

2.8.1 Mauranipur, Bangra & Gursarai blocks of Jhansi district.

Study area consisting of Bangra, Gursarai & Mauranipur blocks, Jhansi district occupies an area of 1840 sq. km. falls in Bundelkand region of Uttar Pradesh. Drainage in the three blocks mainly consists of Dhasan and its ephemeral tributaries such as Sukhnai, Kurar, & Lakheri. Dhasan river marks eastern boundary of Gursarai and Mauranipur blocks. The drainage pattern is dendritic.

The area experiences sub-humid climate characterized by a hot dry summer and cold winter. The average annual rainfall in the study area is 850.1 mm. During monsoon period surplus water is available for deep percolation to ground water.

Due to hard rock and uneven topographic features, large number of tanks, sagars and tals are available in the study area, which are the main source of water for drinking as well as irrigation. Induced recharge from surface water bodies is also taking place.

Geologically the area is characterised by Bundelkhand massif consisting of granite, schist, gneisses and quartz reefs overlain by thin cover of alluvium. The alluvium consists of clay, silt sand and gravel. The northern part of the area is occupied by the alluvium of Quaternary age which together with the underlying weathered zone of granite-gneissic basement forms a more or less continuous aquifer. The northern aquifer system has moderate yield potential through dugwells and tubewells. Whereas, in southern parts of the area, the Bundelkhand granite-gneissic complex of Archaean age and overlying residual soils largely forms the aquifer system. This aquifer has limited to moderate yield potential through dugwells and borewells. Ground water occurs under phreatic conditions in these aquifers. In the granitic terrain ground water occurs fractures and in fine interstices of the weathered rock material.

Ground water occurs mostly under phreatic condition in weathered zone and in the secondary porosity in deeper fractured zones. The depth to water level of shallow wells varies from 4.36 to 16.37 mbgl, during pre monsoon (2010) and 2.37 to more than 16.50 mbgl in post monsoon. The water levels of deep tubewells vary from 7 to 19mbgl.

The long term water level trend for ten years (2000 –2009) of ground water monitoring wells shows that in general there is a decline in water levels during pre or post monsoon periods. Decline during pre monsoon period varies from 0.07 to 0.59 m/year and during post monsoon period decline varies from 0.05 to 0.76 m/year. GWD data indicates that blockwise declining trends in water levels during premonsoon vary from 0.11 m/year to 0.25 m/year and during post monsoon period long term water level trends vary from 0.09 m/year to 0.29 m/year. It is observed that there is high seasonal fluctuation in water levels. The water gets recharged quickly during monsoons and then flows off as base flows.

Ground water is slightly alkaline in nature as indicated by pH values and Electrical Conductivity ranges from 469-839 µ-Siemens/cm at 25°C, indicating that the ground water is fresh. All the basic parameters are within permissible limit and thus the ground water quality is suitable for drinking and irrigation purposes.

Overall stage of ground water development in the area is 85.3%. the ground water resources in the area are under stress as indicated by the category of all the three blocks. Mauranipur block is “Over Exploited” with stage of ground water development as 108.38%, Bangra block with stage of ground water development of 90.20% falls under “Critical” category of blocks and only Gursarai block falls under “Safe” category of blocks with stage of ground water development of 64.19%.

In the study area there is lot of variation in geological formations and chances of ending up into a successful bore well are very low. Due to the limited hydraulic continuity it is also very common to get dry or low discharge borehole even within a very short distance from a successful borehole. Better aquifers are already utilized and the remaining ones are not dependable and construction of tube-wells is risky. The yield of deep tube well constructed up to 150.00 mbgl in hard rock area by CGWB varies from 200 to 300 lpm for normal draw down. Stripped plains or valley fills are mainly run-off zones and these consist of loose sediments, weathered material and fissured rocks. These formations

have a potential of yielding 150 to 200 lpm through a borewell of 70 to 100 metres depth. Along Lineament/ fracture zones, the yields are significantly higher and wells are likely to be sustainable for longer duration.

Keeping in view the copious precipitation exceeding about 1000 mm annually, it is recommended to harness the rain water and arrest the rapid surface runoff, creating subsurface storage through artificial ground water recharge/ conservation structures as also exercise effective watershed management involving afforestation, soil conservation, optimization of land and water use and horticulture/ agriculture.

It is also recommended that the existing tanks/ponds may be rejuvenated by undertaking de-silting and minor repairs which will enhance the storage capabilities augmenting ground water recharge.

Watershed development has been recommended as most economical method of recharging rain water into the ground, the conservation of rain water, soil and vegetation by watershed based interventions will improve sustainability of stream flows to provide efficient surface irrigation. Through watershed management, development of surface water resources, improving water use efficiency, enhancing biomass productivity of forest and livestock sector are the most important options of the new strategies. The watershed management, development of surface water resources, reviving of traditional dug-wells and tanks, desilting ponds, command area development and efficient micro irrigation systems should be given high priority of the investment sectors.

2.8.2 Sumerpur and Maudaha blocks of Hamirpur district.

Studies were carried out in Sumerpur and Maudaha blocks of Hamirpur district covering an area of 1229 sq.km. These two blocks Sumerpur and Maudaha for present study area lies in eastern part of the Hamirur district. The area is part of Yamuna sub basin lies between River Betwa and Ken both are right bank tributaries of river Yamuna.

The area is part of Bundelkhand Plateau with isolated hillocks and intervening low relief undulating plains. The major rivers are Betwa and Ken which are right bank tributaries of Yamuna river. The Chandrawal river tributary of Ken flows through the area. The area is marginal alluvial plain with the thickness of alluvium increases from south to north. The land surface along the main stream are deeply weathered resulting into badland topography and ravines. The topography and soil of the area causes heavy run off of water during rainy season.

The area is part of Bundelkhand plateau underlain mainly by Granite. The quaternary alluvium overlies the granite. The thickness of the alluvial varies from 20 to 120 m in the area. The general geological sequence of the formation in the area is as follows.

The exploratory works carried out in the district shows that maximum alluvial thickness is in northern parts in Sumerpur block, ie. 120 mbgl and minimum is in Maudaha block at Khanna ie 35 mbgl . The alluvial material is generally composed of Clay, Clay mixed with kankar, sand and gravel. The maximum alluvial thickness has been observed in Sumerpur block along Betwa and Yamuna river. The important aquifer in the area is porous sandy layer present with in alluvial deposits. The thickness of the aquifer is highly variable in the area. It composed of sand, gravel and mixed zone of clay and sand. The ground water occurs in unconfined condition in phreatic aquifer and in semi-confined to confined condition in deeper aquifer.

During pre monsoon period 26 numbers of key wells along with four ground water monitoring station were fixed for water level monitoring in the area. The areas where dug wells are dry the State ground water department piezometers were monitored. The depth to water level monitored in pre and post monsoon period.

The depth to water level in pre monsoon period varies from 6.20 to 28.75 mbgl where as in post monsoon period it varies from 1.0m to 23.5 mbgl. The depth to water level; is shallow in south and south western part in Kargaon, Sayar, Gusiyai, Khanna ad Ichhauli.where as in deep water level occurs in north and north eastern part along river Ken. Betawa and Yamuna. In general, major part water level fluctuation occurs between 0 to 2.00 (Plate 5). The fluctuation more than 3 meters in southern part of the area, i.e in Kapsa, Ratwa and Khanna.

The study of long term water level trend data show declining trend for last ten years (2001-2010). In Maudaha block in pre- monsoon period decline varies from 0.10 to 1.46 m/year whereas in post monsoon period decline is 0.97 m/year. In Sumerpur block the decline in pre monsoon period varies from 0.74 to 1.40 m/ year, whereas in post monsoon period it varies from 0.57 to 0.97 m/year. The rise in pre mosoon period is at Kapsa ie. 0.12 m/year and at at Khanna in post monsoon period rise is 0.20 m/year.Tehra in same block rise in post monsoon period ie.0.27 m/year. In Sumerpur block only at Tehra in post monsoon period rise of 0.27 m/year.

A total 28 samples were collected from Hand Pump I.M.II and Dug Well from entire area in pre monsoon period five samples were collected in post monsoon period from

Maudaha block from inland salinity affected area. The results of the chemical analysis shows all chemical constituents are within permissible limit in general except at few locations having high E.C. and Chloride. The pH varies from 7.80 to 8.20. The E.C. varies from 657 to 7092 µs/cm at 25 ºC. In general E.C. varies from 657 to 1200 Us/cm at 25 ºC. At few location of Maudaha block, i.e. Khuneta, Khhana, Icchauli, Gusiyari, Ratwa it varies from 2000 to 7092 Us/cm at 25 ºC. The EC of Hand Pump water is higher than the Dugwell. The value of Flouride at one location at Sumerpur is 1.80mg/l i.e. above permissible limit.The value of chloride is also higher in Location having High E.C. value. At Gusiyari, Ichhauli and Khuneta in Hand Pump Chloride value is above 1000 mg/l.

The stage of ground water development in Sumerpur block is 57 % where as in Mauhaha block it is 54 %. These two blocks are in safe category (as on 2009).

2.8.3 Dakor & Konch blocks,Jalaun district.

Studies were carried in parts of Jalaun district with specific reference of Dakor and Konch blocks covering an area of 1398 sq.km.

Physiographically, the area forms a part of Bundelkhand region in the marginal plains of U.P. and most of the area of these blocks is covered under Banda Alluvium. Topographically the area is generally flat and have very low topographic gradient in the area. Drainage in the district Jalaun is marked by three important rivers Betwa, Yamuna and Pahuj but in the study area Betwa marks the boundary with the district Hamirpur in the South east direction and River Pahuj drains the North eastern part of Konch block.

Exploration activity indicates bedrock encountered in boreholes rests in depth range of 70.0 to 148.00 m below ground level. Bed-rock occurs comparatively at shallow depth in southern part of the district in comparison to northern part. Besides it is also depicted that there is almost a thick clay layer. Thickness of this layer increases from 30.0 m to 72.00 mbgl. Granular zones comprising fine to coarse sand and gravel has been encountered between this depth range.

All the sample analysed fall under the category type 5 and type-8. Hence two distinctive type of water in the area could be identified. Type –I Ca, Mg rich Carbonate or bi-carbonate type of water and other category is Na, K rich Carbonate or bi-carbonate type of water. Where type-I indicate recharging water with permanent hardness, this type of water is not fit to be used in boilers, preventing and restricting its use for industrial purpose. Type-II indicates base - exchange reaction and Na transfer from clay into water.

Mammoth amount of ground water which is being exported to the other area by the farmers on charge basis need to be incorporated in calculation of ground water resources of the area at the time of resource assessment to get a better accounting of ground water .

Ground water is the source of one fourth of the domestic water supply demand in rural area and around half of urban and industrial demand. While ground water development has had important implication for the agriculture as ground water accounts for 70-80% of value of farm produce and economy of the area. The over use of ground water is emerging a serious concern for agriculture, An attempt is required at this stage to introduce to farmers the concept of water use efficiency. There is a need of development of incentive system with suitable buy back mechanism for the harvest to encourage farmers to move away from water stress crop.

2.8.4 Bar and Jakhaura block, Lalitpur district

The study (1373sq.km.)was carried out in Bar and Jakhaura blocks of Lalitpur district in hard rock area of Bundelkhand Region, where ground water occurrence is limited and restricted to favorable geological conditions only.

The field investigation includes validation of remote sensing data interpretation at ground level and collection of data field evidences in the form of periodic monitoring of ground water levels by way of establishing 42 nos of key wells in different hydrogeological units, and collation of information on activities being carried out in the area for identification of feasible sites for ground water exploitation. The area forms mainly the part of Yamuna sub-basin in parts of Lalitpur district of U.P.

The pre monsoon depth to water level ranges from 2.80 to 11.90 mbgl,. Area having water level less than 5 mbgl covers maximum area and central parts between 5 & 10 mbgl wheras one places more than 10 mbgl has been found in isolated pockets in Jakhaura block. The seasonal water level fluctuation lies between 0 .00 m and 2.00 m.

The stage of groundwater development varies from 66.76% (Jakhaura block) to 51.86 % (Bar block). Average stage of ground water development is 59.31%. Two blocks namely Bar and Jakhaura fall in ‘Safe category’. The level of development indicates that there is a vast scope for ground water development.The ground water is suitable for drinking and domestic uses and ‘As’ content has been found within permitted limit of BIS (10 ppb).

Recommendations:

a. Construction of large dia wells up to the depth of weathered mantle with infiltration galleries across the strike.
b. Construction of shallow to moderate deep tubewell with the help of imageries and hydrogeological / Geophysical investigations.
c. Construction of sub-surface dams in selected areas to arrest the discharge into major & minor rivers.
d. Construction of small tanks, bandhs, check dams and reservoirs at suitable sites perticularly in the run-off area with the aim to check the surface water, run-off store water and to reduce the soil erosion.
e. Proper utilisation of natural barrier e.g. quartz reefs, hillocks etc. for the development of surface water reservoirs.
f. Promotion of surface water irrigation system e.g. canals network and conjunctive use of surface water and ground water resources for agricultural purposes.
g. Desiltation of existing reservoirs and lakes at proper time. The reservoir siltation problem needs immediate attention.
h. Afforestration Programmes should be promoted in the area to reduce surface run-off and ultimately enhance ground water recharge.
i. Farmerr Participatory Action Research Programme should be initiated with the academic agriculture institute or university to educate the farmers for promotion of modern techniques of drip irrigation and sprinkler irrigation system for cash / high input crops in the undulating agriculturable areas with the basic aim of judicious scientific utilisation of irrigation water.

2.8.5 Naraini & Mahua blocks, Banda District.

Studies were conducted in Naraini & Mahua Blocks of District Banda covering 1513 Km^2 area. Depth to water level varies from 2.9-to 14.30mbgl during pre-monsoon and from 1.00 to 13.00 mbgl during post-monsoon having depth of wells from between 5.15 & 16.80 mbgl. Problematic areas for ground water exploitations for sustainable Development

are Piprahi, Kalyanpur, Pukari (Kartal Road), Kartal, Kalinjal of Naraini block and Shivhar, Indrapurwa, Mahua areas of Mahua block.

2.8.6 Kabrai & Jaitpur blocks, Distt. Mahaoba

Studies were carried out in Jaitpur and Kabrai blocks of Mahoba distt. covering an area of about 1099 km^2.26 representative key wells were inventoried and water level was monitored during pre and post monsoon period. In addition to these key wells the water level of piezometers of State Ground Water Department were also collected. In Kabrai block, depth to water level ranges from 4.96 to 14.00mbgl during pre-monsoon and from 2.45 to 10.68 mbgl during post-monsoon having seasonal fluctuation of 0.73 to 4.15m. In Jaitpur block, depth to water level ranges from 6.60 to 13.10mbgl during pre-monsoon and from 4.45 to 12.70mbgl during post-monsoon having seasonal fluctuation of 0.27 to 2.15m.

2.8.7 Manikpur & Mau blocks, District Chitrakoot

Chitrakoot district lies in the southern part of U.P. and is part of Bundelkhand Plateau. The total geographical area of the two blocks is 1491 sk.km.
The hydrogeological condition of the area is mainly controlled by geological and structural set-up. The major part of the North of Mau block is occupied by alluvium of Quarternary age, whereas Manikpur and South of Mau block is occupied by Bundelkhand Vindhyan group of rocks.Ground Water occurs in confined condition in phreatic aquifer and semi confined to confined condition in deeper aquifer. During pre-monsoon period 89 key wells including NHS and State piezometers were fixed for water level monitoring in the area.

The depth to water level of key wells in pre-monsoon varies from 0.185 mbgl to 55.70 mbgl and from 0.85 to 52.70 mbgl in post-monsoon period in Manikpur block. In Mau block the same varies from 3.10 mbgl to 24.0 mbgl in pre-monsoon and 3.25 mbgl to 25.0 mbgl in post-monsoon period. The water level fluctuation between pre and post monsoon in the study area varies from 0.80 to 5.8 mbgl in Manikpur block and from 0.07 to 8.5 mbgl in Mau block. The fluctuation is more than 3 m in southern part of the blocks.The long term water level trends of NHS of CGWB indicate falling trend during last ten years. The Manikpur block indicate falling trend of the magnitude 0.12 m/yrl to 1.12 m/yr and the same varies between 0.39 to 1.63 m/yr in Mau block. The trend of post monsoon water levels of NHS of CGWB indicate fall of magnitude 0.35 to 1.11 m/yr in both the blocks.

The ground water samples from different abstraction structures were collected and analysed. Summary of the result of analysis is as follows.

Parameters	Maximum	Minimum
PH	8.10	7.80
Ec	196 m Siemens/ cm	818 m Siemens/cm
NO3	44 mg/l	00 mg/l
F	0.11 mg/l	1.19 mg/l
HCO3	55 mg/l	183 mg/l

2.8.8 Parts of Ferozabad district(Inland salinity infested area in marginal alluvial plain)

Studies were undertaken in inland salinity infested area in marginal alluvial plain of Ferozabad district covering an area of 2361sq.km with the aim to search the fresh ground water pockets. The area is drained by river Yamuna and its tributaries Sirsa, Sengar and Arind Nadi. Geomorphologically, the area is subdivided into flood plan, younger alluvial plain, older alluvial plain, Salt encrustation and ravines. The thickness of alluvial sediments gradually increases towards Central and Northeastern parts. The first unconfined aquifers exist from gl to 80mgl followed by two aquifers occurring at depths of 100-140m and 180-300m. A total 16 no. of key wells were established for monitoring of the water levels. Pre-monsoon depth to water level varies from 2.72m to 17.35mbgl and post-monsoon depth to water level varies form 0.61m to 15.62 mbgl as observed in dugwells and 12.52 to 51.44 mbgl as recorded in piezometers. The water levels are shallow in canal command areas ands deeper in other areas. Annual ground water availability as per estimates on 31.03.2004 has been worked out to be 70536.72 Ham The overall stage of ground water development has been worked out to be 80.49%. Only one block Ferozabad has been categorized as critical, and three blocks namely Madanpur, Sikohabad and Tundla have been categorized as semi-critical and rest four blocks fall under safe category. A total 43 no. water samples were collected from different sources in the district to know behavior of ground water quality in the area. Fluoride concentration at 5 locations have been reported to be more than the maximum permissible limits.

2.9. MER, PATNA

Four studies were carried out in parts of Giridih, Giridih, Gaya districts and in Araria district covering an areas of 2423,2419,3000 & 2830 sq.km. respectively.

2.9.1 Parts of Giridih district (focus on delineation of Artificial Recharge areas)

Studies were taken in an area of 2423 sq. km area covering six blocks namely Dhanwar, Jamua, Bengabad, Gawan, Tisri and Dewri with special emphasis for the delineation of areas

suitable for artificial recharge including Giridih open cast mines. The pre-monsoon depth to water level of the area was found ranging from 2.64 to 10.70 m bgl. The deepest water level (> 10 m) was observed in Gawan and Dewri blocks while the shallowest water level was observed in Tisri block. Areas with post-monsoon water level > 5 m bgl have been considered as suitable for recharge based on which recharge worthy areas have been delineated in parts of Bengabad, Jamua, Dhanwar and Gawan blocks.

The water level lies between 4.02 to 14.0 m bgl during pre-monsoon period in and around the mining area. The mine discharge has been estimated as 17600 gallons per day from the single quarry. A total of 8 water samples were collected from the above specified area for quality studies. As part of the study detailed hydrogeological survey was also carried out for Giridih town and 19 open dug wells in the depth range of 2.90 to 15.53 m bgl were monitored. Wide variation in the water level (2.22 to > 15.50 m bgl) was recorded in these wells. Analysis of the long term water level trend of the HNS well located in Giridih town reveals a falling trend both during the pre-and the post-monsoon season at the rate of 0.173 m / year and 0.039 m / year respectively.

To evaluate the quality of ground water, samples have been collected from 28 dug wells and 31 representatives hand pumps (bore wells). The ranges of chemical constituents in study area is given below:

Chemical Constituents and quality parameters	Dug well samples	Bore well (hand pump) samples
pH	7.8	7.8
EC (micro siemens/cm at 25^0c)	232 – 2230	102 – 2450
TH as $CaCo_3$ (ppm)	90 - 470	25 – 755
Na (ppm)	15 - 192	7 - 76
Cl (ppm)	14.18 – 205.6	7.1 – 454

2.9.2 Parts of Giridih District (with special emphasis on delineation of of AR areas)

Stduies were carried out in six blocks viz. Giridih, Birni, Gandey, Pirtanr, Dumri & Bagodar falling in southern part of the Giridih district covering an area of 2419 sq.km.

The major part of the area is drained by the Barakar River flowing almost west to east. It presents rugged and rolling topography. Geologically, it can be characterized by the Granite Gneiss with up to 15 m of weathering. The rocks of Lr. Gondwana formation occurs in and near Giridih town and in the Gandey block comprising shale, sandstone and coal seam

The major part of the area is characterized by the hard rock (Granite Gneiss) and capped with up to 15 m thick laterite. The water level monitoring carried out during pre (May) and Post-monsoon (Nov.) period. About 60 % of the area has shwon pre-monsoon water level between 6 to 12 m bgl. The maximum water level is 14.95 m bgl at Mohanpur, block Giridih. In about 80% of the area, the water level reamins between 3 and 6 m bgl. The deeper water level observed almost along the Giridih-Dumri Road. Only two well at Fatehpur and Madhban has shown water level less than 3 m bgl. More than 50% of the area experiences the fluctuation between 2 to 4 m.

The minimum and maximum values of chemical constituents is given below in Table. The fluoride concentration is yet to be tested. However the state agencies have not reported yet the fluoride concentration beyond permissible limit. EC has been found ranging from 171 to 1514 µS/cm 25^{0}C. The range of the major parameters is as under

Parameter	Min.	Max.
EC (µS/cm) at 25^{0}C.	171	1514
TH (ppm)	55	600

The water supply to the urban area is being made through the surface water. From six blocks, falling in this part of the Giridih districts, the water supply scheme are operational or under construction in 04 town. At present, the Giridih town is facing shortage of water and 'rationing' is going on during summer in water supply. During the study a sample draft survey was also carried out in Gandey Block where dug wells are the main source for irrigation during non-monsoon period.

2.9.3 Parts of Gaya district (focus on delineation of Artifical Recharge areas)

Studies were carried out in an area of 3000 sq. km spreading across 15 blocks in parts of water scarce Gaya district.

Hydrogeologically the area can be divided into two main units viz, (a) Fissured formations, and (b) Porous formations representing the Granite Gneissic complex and the Quaternary alluvium. Water level monitoring data indicate that the ground water levels vary from 4.18 m bgl to 19.24 m bgl during pre-monsoon and 2.43 m bgl to 12.48 m bgl during post-monsoon periods. Ground water level was deep (> 10 m) in the central part (Gaya sadar block) of the area where the demand was more in pre-monsoon period. Ground water levels of 8-10 m,bgl were observed in the northwestern part adjoining Arwal district and Belaganj block. The majority of the area had water level between 6-8 m,bgl. During post monsoon period the water level in the majority of the area rested between 4-6 m, bgl. About 40% area showed water level between 6-8 m, bgl . Ground water levels of 8-10 m,bgl were observed in the central, south-western and some areas in the north-eastern part (Gaya, Belaganj, Konch, Gurua blocks). The groundwater level fluctuation between pre- and post-monsoon 2010 indicates that it ranges between more than 6 m and -1.20 m. The dynamic ground water resource as per 2004 estimation is 80072.7 ham and the stage of ground water development ranges from 24.4% (Paraiya block) to 73.4% (Tekari block). Out of 15 blocks, 7 blocks have stage of development more than 50%. The gross ground water draft for the area has been estimated as 22141.6 ham. Ground water is by and large potable except for reported fluoride contamination at some places. For artificial recharge schemes in the area roof top rain water harvesting should be done in Gaya urban and Bodh Gaya town areas whereas check dams , contour bunding (Ahar), subsurface dyke may be taken up in rural areas. The abandoned dugwells in the area may be used as recharge wells/recharge shafts. The Phalgu river which serves as an active unconfined aquifer and life line for Gaya urban area and Bodh Gaya town should be protected from unlawful sand mining and contamination.

2.9.4 Araria district(Kosi flood plain)

Studies were conducted in Araria district covering an area of 2830 sq km.The district falls in the eastern parts of the well known Kosi megafan, which forms the biggest fluvial depositional geomorphic feature in the North Bihar Plains in middle Ganga Basin. The area is frequently inundated with the flood water of the Kosi River. This part of the Ganga plain bears few typical hydrogeological characteristics, controlling the groundwater occurrence and movement in the region.

During study, 43 key wells were established during the groundwater management study of the district. It is observed that the maximum water level in the district rests within 5.5 m and 5.04 m below ground level during pre-monsson and post-monsoon respectively. In the western and southern parts, the water level remains shallow (< 2 m bgl), while in the central and north-eastern parts of the district, it is deeper, varying from 2 to 6 m bgl. Maximum water level exists in the south-western parts of Araria district head quarter (Rajakhor) and in the north-eastern parts of the district. Ground water fluctuation between pre- and post-monsoon periods is observed to remain within 0.25-0.7 m only.

The shallow water level in the southern and western parts of the district may have been responsible for the perennial waterlogging condition existing along the same areas. Flood and canal water irrigation might have aggravated the the waterlogging condition in those areas. The important outcomes from the study are (a) ground water development in the district is in a sub-optimal stage and there exists ample scope for development of the resource, (b)flood and canal water irrigation deteriorates water-logging condition in the district & (c) scope for conjunctive use of surface water and groundwater can be explored.

2.10 ER, Kolkata

Two studies were carried out in parts of Nadia and Birbhum districts covering an areas of 3000 sk.km & 3000 sq.km. respectively.

2.10.1 Karimpur I & II, Tehatta I & II, Kaliganj, Nakasipara, Chapra, Krishnaganj, Santipur, Krishnanagar I & II, Nabadwip, Hanskhali Blocks, Krisnanagar, Nabadwip and Santipur Municipal areas of Nadia District (high arsenic in ground water in shallow aquifers, potentiality of deeper aquifers and R & D study on impact of artificial recharge in diluting arsenic concentration of shallow aquifers in collaboration with PHED, Govt. of West Bengal)

Study area(3,000 sq.km.) is covered by a huge thickness of alluvial sediments composed of sand of various grades, silt, clay and occasional gravel forming Quaternary Formation. One major granular zone predominates almost down to the depth of 150 mbgl. From 150 to 250 mbgl, mainly clay beds are predominant with intercalacations of fine sand layers. Coarse sand and gravel exist from 250 to 270 mbgl at few places.

Ground water occurs under unconfined to semi-confined condition within depth of 150 m bgl. Deeper aquifer below 150 m bgl is under confined to semi-confined condition. The depth to water level in shallow aquifers widely varies from 2.7 to 9.25 m bgl during pre-monsoon period and 0.8 to 9.25 m bgl during post-monsoon period. Arsenic content in ground water is more than permissible limit in shallow aquifer within the depth of 80 m bgl. Therefore, deep drilling may be carried out beyond 80 m bgl to 300 m bgl to tap arsenic free aquifer. Cement sealing technology may be adopted to separate the upper arsenic contaminated aquifer from deeper arsenic free aquifer. Arsenic removal plants may be installed in arsenic contaminated tube wells. To overcome the depletion of ground water level and thereby to augment the ground water resources, the concept of artificial recharge by rainwater harvesting may be utilized in the area with suitable structures. The scope for artificial recharge in shallow aquifer has to be assessed. Rain water harvesting structures like tanks, de-siltation of existing tanks with recharge shafts, roof top rain water harvesting with recharge structures and conservation of rainwater will minimize the use of ground water and the same are recommended.

2.10.2 Murarai I, Nalhati I, Rampurhat I, Khoyrasol, Md. Bazar, Dubrajpur, Suri I, Rajnagar Blocks of Birbhum district(high fluoride concentration in ground water)

An area of 3,000 sq. km. in parts of Birbhum district is covered. Geologically, the hard rock area consists of crystalline metamorphic rocks (granite gneiss, amphibolites, gabbro and schists) of Archean to Proterozoic age, Gondwana Super Group of rocks (Sandstone, shale and coal seams) of Permo – Triassic age and Rajmahal basalts of Jurassic age. Ground water occurs in 20 m weathered formation followed by fractures/joints in hard rocks.

During the study, 40 number of key observation wells (dug wells having 12 to 15 m bgl depth and tube wells having 60 to 100 m bgl depth) have been established. Pre-monsoon depth to water level ranges from 4.65 to 11.90 m bgl in dug wells and 11.16 to 17.25 m bgl in tube wells. Post-monsoon depth to water level ranges from 2.15 to 9.21 m bgl in dug wells and 7.40 to 12.50 m bgl in tube wells. Annual water level fluctuation in dug wells varies from +2.60 m to +4.70 m and that of in tube wells varies from +1.80 to +2.45 m. Maximum fluoride concentration in Khoyrasole, Nalhati I, Rajnagar and Rampurhat I Blocks ranges from 2.44 mg/l to 16.20 mg/l. Fluoride affected sources in Khoyrasole, Nalhati I, Rajnagar and Rampurhat I Blocks are 1.26%, 0.92%, 0.94 %, 1.14 % respectively.

2.11 NER, GUWAHATI

Five studies were conducted in Tinsukia district, Assam ; Majuli island, Jorhat district, Assam; South Tripura district, Tripura; West Garo Hills District, Meghalaya; and South Garo Hills district, Meghalaya covering an areas of 3000,650,2624,3400 & 1000 sq.km respectively.

2.11.1 Tinsukia district,Assam (Impact of agriculture & industrial practices in connection with ground water quality and development plan for drinking water supply)

Tisukia district (3000 sq.km.) is located in the northeastern corner of Assam bordering part of Arunchal Pradesh and Nagaland. The district falls in Brahamputra basin.

In spite of having vast ground water resources, Tinsukia district is still in a nascent stage in terms of ground water development. A network of drinking water supply utilizing ground water sources has been developed by PHED, Govt. of Assam at block levels, the command area of which is yet to be expanded to about $3/4^{th}$ of the total area. The farmers have either very little or no access to irrigation facilities in any form. Shallow tube wells constructed down to the depth of 30 to 60 mbgl and deep tube wells, 120 to 250 mbgl generally yield 30- 150 m^3/hr. In general, the deeper water level is witnessed throughout the foothill region which forms the recharge zone and characterized by higher topographic gradient and highly permeable nature of underlying sediments.

Margharita block, out of seven blocks of Margherita sub-division in Tinsukia district is well known for its coal and oil industries. Industrialization and subsequent growth of population are categorically responsible for deterioration of

water quality in pockets whose impact can be observed specially on the surface water bodies around the open cast coal mining areas. It is reported that along NH-38 from Margherita in the west to Tipong in the East, presence of very high concentration of acidic effluents, particularly iron in ground water in shallow depth occurs, which are infiltrated from surface. The ground water of the area is of acidic nature with pH ranging from 4.7 to7.5. It is in between 4.5 to 5.5 in Nepali basti (Tikak colliery), Hamukjan and Ledo village. The lowest value of pH in ground water was observed at Ledo Bazar near Patkai stadium which is 4.4 during the month of November 2011. Based on the observation, lower values of pH are recorded in the area in between Borgolai and Lekhapani where open cast mining of coal mining is in progress . Ground water collected from shallow tube wells with depth range less than 30 m show low pH values.

As per Coal India Limited, mine water discharge is of the order of 6000 m^3/day in dry season and 11000 m^3/day during monsoon season. This water is discharged in the nearby drainage after treatment. Coal India Ltd. has installed two ETPs (Effluent Treatment Plants) at Tirap and Tipong colliery having a capacity of 600 gallon per minute respectively. Mine water is treated using soda and lime ash. Similarly, Digboi Refinery, the oldest operating refineries in Asia is also equipped with modern ETP, pollution control laboratory and follows strategy for maximizing reuse of treated effluent in the refinery ensuring adherence to such exacting standards.No adverse affects has so far been reported or observed on the agricultural practices on groundwater in the district as a whole.

Recommendations

- For proper and justified utilization of the vast ground water resources, evolution of a suitable policy for development of the ground water resources is necessary towards up gradation of agriculture based socioeconomic conditions in the district. The resources can well be utilized through construction of different type of ground water abstraction structure for drinking and domestic as well as irrigation purposes.
- Ground water development in the foot hill region may be planed through construction of large diameter dug wells and dug cum bore wells. Due to deeper water levels and higher drawdown shallow tube wells are not recommended in this zone. However, construction of deep tube wells down to depth of 150-200 m may be recommended by deploying percussion or reserve rotary rig depending upon the nature and size of boulders.
- Detail mapping has to be carried out for demarcating the area where ground water flow is obstructed by natural barriers. In such area open well may be highly productive for sustainable ground water development.
- Change of existing cropping pattern may be adopted by enhancing cropping intensity to make proper use of the vast groundwater resources. Instead of paddy, sugarcane and other high water consuming crop like maize, wheat, bazra, jowar, oil seeds can be grown during pre-kharif and rabi season.
- Social awareness is to be created at all levels to educate people about adverse environmental, social and economical impact due to use of polluted surface water, especially adjacent to industrial/ colliery area, for drinking and irrigation purpose which may trigger problems at later stage.

2.11.2 Majuli island, Jorhat district, Assam (Ground Water quality specially enrichment of Arsenic)

Majuli is one of the largest inhabited river islands of the world that support a population of 135,378 in the Jorhat district of Assam. The island is located at the central part of the Brahmaputra basin and an area of 650 sq.km has been covered.

Fifteen deep tube wells with depth ranging from 66m to 98m and 10 Dug wells have been recorded and studied as key observation wells for the study in the island by covering 650 sq km as non eroded area. Forty hand pumps (STW) are included as key observation wells in the study area and sampling has been done for incorporating for the Arsenic contents in the groundwater.

Geologically, the island is occupied by unconsolidated alluvial sediments of Quaternary age. The vast alluvial plain of Brahmaputra valley, of which the island forms a part, was developed of foreland depression lying in between the Himalayan Orogenic Belt in the North and Southern Crystalline Massifs. The Sediments owe its origin and development with the different phases of upliftment, glaciation and erosion of Himalayas and basement tectonic of crystalline massifs. The newer alluvium is generally confined to topographical lows, flood banks of major rivers and alluvial terraces. These deposits are distinguishable by their characteristic grey colour and generally well sorted alternate layers of clays, silts, sands and gravels.

Based on the ground water condition in the adjacent area, behaviour and occurrences of ground water beyond the island i.e. South of Brahamaputra river bordering the island, the regional groundwater condition of the area have been discussed under two categoriesi.e.(a)Shallow aquifer group occurring within the depth of 50 m and (b)Deeper aquifer group beyond a depth of 50 m to 200 m below ground water level.

Twenty four groundwater samples were collected from shallow groundwater structure mainly hand pumps and were

analyzed for Arsenic concentration. The range of in Arsenic in the present study area is from 6-90 ppb. Concentration of arsenic has been found beyond permissible limit ((>10 ppb as per BIS, 1991 (REV; 2007)) at all location except at one location (Kamalabari Ghat, HP). However physical manifestation of arsenic effect has not been reported in the area.

Highly silty nature of sediments prevails in shallow depth. It is a fact that inundation by flood for several times in a year is common and is responsible for high erosion and deposition activity in the island area. Arsenic is found high in such situation.In order to delineate and confirm the concentration levels of arsenic in the aquifer zone in the island, groundwater samples were collected from the existing ground water abstraction structures, such as deep tube well (DTW), hand pumps (SHP, T.P, M-II, M-III) and dugs wells etc.

Recommendation

- Deeper aquifers should be explored. Ground water of deeper aquifers should be analyzed for assessment of arsenic content. Alternate sources of drinking water is to be be studies. Awareness campaign should be arranged for health hazards due to excessive arsenic contamination.Geophysical resistivity survey is to be carried out for determination of sedimentary layers within shallow and deeper depth for bringing out contrast of clay, silty clay, silt and sand.Sampling should be done of litho-types through manual boring for 50 m depth for co-relation and depositional trend of sediments. Role of pesticides used for agricultural activity is to be determined.
    - More than 80% populace in the study area is agrarian with no industrial development. Ground water development in the island is negligible. The farmers have either very little or no access to irrigation facilities in any form. A network of drinking water supply utilizing groundwater sources has been developed by PHED, Majuli subdivision, Govt. of Assam at panchayat and village of which is yet to be expanded to about 3/4th of the total area.

Constraints

In the island, CGWB has not carried out any groundwater exploration due to the problems of approachability. Truck mounted rig can not be transported by water route to Majuli Island.

2.11.3 South Tripura district, Tripura (Impact of Agriculture / Industrial Practices on Ground Water Quality – Aquifer of the Brahmaputra Basin and Developmental Plan for drinking water supply)

The South Tripura district is divided into 11 blocks with Udaipur as its headquarter coveing an area of 2624sq.km. The total population of the area is 8,62,252 (2011). The climate has moderate temperature with high humidity. The average annual rainfall in the area is 2443mm and is mainly from SW monsoon. Physiographically, the area can be divided into two parts - anticlinal hill ranges and synclinal flat bottomed valleys. The common drainage patterns are sub-parallel to parallel and dendritic. The major perennial rivers in the area are Gomti, Muhuri, Fenny. In general, soils of the area are acidic in nature with pH ranges from 4.50 to 6.5.

Geologically, the area is underlain by Quaternary & upper Tertiary groups of sediments. Four hydrological units/ water bearing formations occur which are identified as alluvium, Dupitila, Tipam, and Bokabil formations. The sandstones of Tipam constitute the principal aquifer in the study area. The aquifer system of the area is divided into two groups, viz, shallow aquifer and deeper aquifers. Shallow aquifer occurs within 30mbgl and deeper aquifer occurs between 30 to 300 mbgl. In shallow aquifer ground water occur under unconfined and semi-confined conditions. Depth to water levels in confined aquifer varies from 1.24 to 10.06 mbgl during pre- monsoon period and from 1.08 to 7.44 mbgl during post-monsoon period. The seasonal fluctuation in water level varies from 0.40m to 3.31m. In deeper aquifers ground water occurs under semi-confined to confined condition and the piezometric head varies from 0.45to 19.98 mbgl during pre-monsoon period and from 0.28magl to 17.74mbgl during post-monsoon period and the fluctuation ranges from 0.25 to 2.68 m.

Artesian zones mostly occur in Matabari, Kakraban, Bagafa, Rajanagar and Satchand blocks. The artesian (flowing) wells tapping granular zones between 75-171m bgl have piezometric head of which varies from 0.05 to 0.45 magl and and discharge varies from 0.03-1.25lps during pre-monsoon period and from 0.08- 1.50 lps during post-monsoon period. However, discharges of these wells are decreased over time. Ground water quality in the study area is in general suitable for domestic, irrigation, and industrial purposes. However, concentration of iron in ground water is more than the permissible limit in shallow aquifers (varying from 0.05-8.53 ppm) as well as in deeper aquifers (ranging from 0.04 to 7.41 ppm). The enrichment of iron in ground water of the area is due to the ferruginous nature of Tipam sandstone. The ground water while using for drinking purposes is to be treated before use. Fluoride content in the ground water in the area is within the permissible limit.

The stage of ground water development in the study area is 15.77%. All the 11 blocks of the study area falls under SAFE category.

Recommendations for state Govt. and User agencies

Artesian /confined aquifers should be developed through proper construction of wells.Artificial recharge for deeper

aquifer should be adopted.The site selections for deep tube wells need to be done with the help of scientific studies.In hilly areas, roof top rain water harvesting should be adopted and local population need to be encouraged to follow this in each house along with surface storage methods.All types of leakages/ free flow of taps should be restricted during water supply.Modern techniques of irrigation like sprinkler, drip etc. should be encouraged, where ever it can be practiced.

2.11.4 West Garo Hills District, Meghalaya (Development of Water supply through Springs)

West Khasi Hills district is the largest district of Meghalaya covering 23% of the total area of the state. An area of 3400 sq.km has been under survey out of 5247 sq.km of total area of district.

Geomorphologically the district is an undulatory terrain with the E-W trending Khasi hill ranges of Central Upland zone. The average altitude of the Central Upland is about 1,400 m AMSL. Broadly, the district can be differentiated into Denudational Low and High Hills (covering about 1300 sq. km), Dissected Plateau (covering about 2800 sq. km area) and Structural Hills (covering about 1100 sq. km area).

The area under study falls in Meghalaya Plateau which is constituted mainly of Precambrian rocks of gneissic composition.

Hydrogeologically, the district can be divided into two units, namely consolidated and semi consolidated formations. About two third of the district is occupied by consolidated formation. Consolidated formations are like the Archaean Gneissic Complex, acid / basic intrusive and Precambrian quartzites and phyllites of Shillong Group of rocks. At hydrogeologically feasible location, well drilled down to a depth of about 80 -150 m below ground level may yield a moderate discharge of 5-15 m^3/hr in Archaean and Precambrian Group of rocks, whereas in the acid and basic rocks may discharge of 5-10 m^3/hr. Water level is found to occur between 2 to 15 m bgl. The southern and south-western part comprises sedimentary formations. It includes limestone, sandstone and shale, inter-bedded with the coal seams. Ground water is found to occur under confined to semi-confined conditions with low yield of 5-15 m^3/hr. Water level is found to rest at 2 - 4 m bgl.

Spring is a discharge of ground water appearing at the ground surface as flowing water. The study was carried out to know the genesis of springs and their present status of utilization for rural drinking and agricultural purposes, quality aspect and further scope of development. During the study 48 springs covering all the blocks were studied. The discharge of the springs was monitored in different seasons. It is observed that topographic, contact and fracture springs are prevalent in this district.

During the study it is observed that the rural people are presently dependent on spring water for drinking and irrigation purposes. Springs are susceptible to contamination by surface water, especially during rainstorms. Proper spring development helps in protecting the water supply from surface contamination and stores it in a sanitary spring box.

Chemical quality of the spring water samples were collected and analysed. It shows that except iron, all other parameters are within desirable limit for all useful purposes.

Findings

- Spring catchment area need to be protected/ developed to make more scope for rainfall recharge. It is observed that peoples are destroying the spring catchment by construction of house or through agricultural practice where by the soil is eroding. As soil is act as the womb for water storage of the springs, any loss in soil thickness will be reflected in the spring discharge.
- It is observed that though a large number of rural villagers are utilising the naturally available springs in this district to fulfill their various needs, but there is hardly any action from any level, whether government or public, for spring catchment area development. On the contrary, at Mawnai village in Mairang block, it has been observed that a spring catchment area is traditionally developed by the villagers for its sustainable use. In the upstream of the spring two small pond like structure has been constructed to store the rainwater. On way the stored water is recharging the ground water and the nearby spring in the downstream is getting direct benefit and thereby running throughout the year.
- Ground water quality in the study area is good and range of all chemical constituents is within the permissible limit set by BIS (1991), except iron. The iron content ranges from 0.03 to 0.93 mg/lit except in Mawkirwat block where in one place i.e. at Sakwing village it is 2.00 mg/lit which is much higher than the permissible limit for drinking purpose.
- Spring tab chambers of the district are not properly cleaned periodically. As a result algal growth (moss) has developed inside the wall of the spring tab chamber.

Recommendation

1. Each spring, whether seasonal or perennial, should be given due importance. During lean period when rural villagers suffer from water crisis, a very low discharge spring can cater a part of their daily water requirement.

2. Long term spring discharge trend analysis shows that except Nongstoin block, in the other three blocks under study, the spring discharge shows a declining trend. It is observed in some localities that in the upstream side of the spring catchment area deforestation, construction of house as well as agricultural practice are going on and thereby loss of soil cover is prevalent. Spring catchment area should be protected and developed properly.
3. Spring water should be tested before and after heavy rains each year for bacteria, pH, turbidity, and conductivity. During survey it is noticed that spring tab chambers are not properly cleaned periodically. As a result algal growth (moss) has developed inside the wall of the spring tab chamber. Therefore, time to time bacteriological test and periodical chlorination of each spring are needed. Now-a-days PHED, Govt. of Meghalaya is having district level chemical laboratory which facilitate the analysis of spring water from adjacent villages.
4. The sustainability of spring depends on awareness of community as well as their active participation in spring development for their periodical maintenance and monitoring. It may not be possible for any government to take necessary attention in time for individual springs. Therefore, formation of a village committee with proper training is needed.

2.11.5 South Garo Hills district, Meghalaya (Hydrogeology of Coal mining belt)

The South Garo Hills district lies in the southern western part of the state of Meghalaya having an area of 1887 sq.km with the district headquarter at Baghmara. .An area of 1000 sq.km has been covered under study.

Agriculture and its activities are by and large confined to the valleys and slope. The climatic conditions vary substantially from place to place due to wide differences in altitude. The average annual rainfall in the district recorded at Baghmara is 2186.6 mm. Some of the main rivers in the district are: Simsang, Rompha, Rongdi, Rongdik, Dareng, Bhugai and Khakija.

The district has a variety of rocks formation ranging in age right from the Archaean to Recent. Hydrogeologically, the area can be divided into three units, namely consolidated, semi consolidated and unconsolidated formations. Consolidated formations are found in the northern part of the district. Tertiary sedimentary rocks represent the semi consolidated formation. They are exposed over a major part of the district. These formations mainly consist of sandstone/ siltsone and shale/ claystone etc. The unconsolidated formation is mainly represented by recent alluvium occurring near the southern fringe of the district and is the continuation of the alluvial plain of Bangladesh. The depth to water level ranges from 1 to 3.5 mbgl in the district depending on topographical settings. The discharge of springs is mostly within 30 lpm in the majority of cases during both pre and post monsoon season. The stage of ground water development for the district is 0.08%.

Coal occurrences in the Garo hills are mostly confined in the Tertiary formation and are located along the southern extremity of Shillong plateau as scattered patches and bounded by latitudes $25^0$12’ to $25^0$44’ and longitude $89^0$58’-$90^0$58’. In South Garo Hills district, the main coal mines are Siju (Nongal area) and Balphakram- Pendengru. The Balphakram-Pendengru coalfield lies between latitudes $25^0$12’30” to $25^0$17’30” N and longitudes $90^0$47’30” to $90^0$57’30” E. There are eight coal seams ranging in thickness from <1 to >3 m. Based on the geological mapping a total resource of 107.03 million tones has been estimated as inferred category. The Siju coalfield is concealed under a capping of overlying Siju Limestone. It falls within the latitudes $25^0$18’ to $25^0$27’ N and longitudes $90^0$25’ to $90^0$42’ E. Quantitatively the coal shows moisture content from 1.7 – 11.3% and that of ash from 1.5 to 18.7 %. The total resource of 125 million tones has been estimated as inferred category.

The mining activities are small scale ventures controlled by individual owner of the land. Meghalaya State falls under the provision of the sixth schedule of the Indian constitution, and so, the land is solely owned by the people. The government has little control on the land. As a result, coal is being indiscriminately mine in unscientific manner causing enormous damage to the environment.

The State Govt. had not taken up any studies on coal mining in the district. However earlier studies carried out in the Jaintia Hills district, which is one of the major coal producing area of the State revealed that majority of the rivers and streams in the mining areas are affected by contamination of “Acid Mines Drainage” (waste water produced in coal mining operation which owe their origin to the oxidation of sulphur bearing material dumped near coal mines). The influx of acid water oozing out from mines into the river and stream is mainly responsible for degradation of water quality and aquatic habitat.

In the coal mining areas, depletion of forest cover, pollution of air, water and soil, degradation of agricultural fields, and scarcity of water and other natural resources are some major environmental issues. The rivers are the greatest victims of the coal mining. Hence there is urgent need for initiating activities for eco-restoration of the affected areas. Following

measures can be taken up to mitigate the environmental problem and improvement of water quality:

1. Preservation of non polluted water sources.
2. Active mining area and overburden dumps be isolated from surface water upstream by constructing drains all around the mining area. This will prevent pollution of nearby streams.
3. Earthen bunds should be constructed all around the outer edges of abandoned benches before reclamation so as to prevent carryover of the solid material by the surface run-off .
4. Scientific method of coal mining and disposal of mine water as well as spoils.
5. Filling of mine pits, channelling of seepage water for checking "Acid Mines Drainage" contamination of water bodies.
6. Extensive afforestation and vegetation on coal mines areas is an important step of ecorestoration.
7. Conservation of top soil is essential for plant growth and agricultural productivity.
8. Creating generate awareness among local people about the damage that coal mining activities causes to the area.

2.12 SR, HYDERABAD

Four studies were carried out in Warangal district; Greater Hyderabad district; parts of Srikakulam, Vizianagaram & Visakhapatnam Districts; and parts of East Godavari district covering an areas of 2500,2550,2560 & 1600 sq.km respectievely.

2.12.1 Warangal District (Strategies for Ground Water augmentation in water stress area)

The study area (2500 sq.km) is drained by Akeru River, a tributary of Krishna river. It is underlain by granites and granite gneisses of Archaean age. Thickness of weathering ranges from 0.50 to 30.0m.. The depth to water levels during pre-monsoon and post monsoon seasons vary from 4.4 to 23.0 mbgl and 1.9 to 14.27mbgl respectively. Yields of dug wells range from 21 –140m3/day and bore wells from 20-140m3/day. In general, ground water quality is good. No. of Key Observation wells established-65;No. of Wells inventoried-140 dug wells, 60 bore wells;No. of Tests conducted – 14;No. of Water samples collected -100 (including Pre and Post-monsoons).

2.12.2 Parts of Srikakulam, Vizianagaram & Visakhapatnam Districts (Coastal Aquifer Management including climatic change affects)

Study area(2550sq.km) covers Municipal Corporation of Hyderabad (MCH), ten peripheral municipalities, Secunderabad Cantonment and Osmania University and its adjoining areas in parts of Ranga Reddy, Medak districts. During the study, 225 borewells and 74 dug wells as key wells established, monitored 225 borewells, 74 dug wells and 56 NH stations and 410 ground water samples including of 205 in Pre and 205 in Post monsoon, was done.

Presently ground water is being exploited through shallow and deep bore wells with depth ranging from 100-300 m. The thickness of the weathered zone varies from 5-25 m and discharges generally vary from negligible to 5 lps.

In the urban areas, there is a drastic change in land use pattern and many of the recharge areas and hills were cleared up at many places for construction activities. Infiltration of rain water into the sub-soil has decreased drastically and recharging of ground water has diminished. During the last 4 decades there was an increase of residential area (10-44 %) and reduction of vacant land (38 to 2 %) and open spaces, parks and play grounds together account 6.81% only. As per the projection, by the year 2011, HUDA will be in shortage of 119 MGD water.More than 50% of surface tanks were physically extinct and many under the verge of extinction or highly mismanaged.

Discharge of untreated industrial and domestic effluents has led to the degradation of the water quality in surface and ground water. Major ground water quality problem is encountered in areas surrounding the landfill sites in Jawahar Nagar, Auto Nagar and Gandhamguda and the industrial areas of Kukatpalli, Jeedimetla, Patancheru, Bolarum, Katedan and Cherlapalli.

The shallow fractures are more prevalent, which need to be harnessed through rooftop rain water harvesting. Hyderabad often faces serious floods during monsoons. The storm runoff generated within an area can be utilized for groundwater recharging by diverting it into suitably designed structures. There is no engineered landfill site in Hyderabad Urban Agglomeration. Presently, waste disposal facility is located at Jawaharnagar in Shamirpet Mandal of Ranga Reddy district only, where contamination of ground water is observed. Efforts should be made to identify the sites based on scientific surveys and wastes be collected and treated properly before disposal.

2.12.3 Parts of Srikakulam, Vizianagaram & Visakhapatnam Districts (Coastal Aquifer Management including climatic change affects)

The study area (2560sq.km) is with a coast line length of around 192 km.

During the study, 59 Key Observation wells established and inventoried 120 wells. Saline Water ingress is observed in the study area. Coastal plains generally consist of generally

brackish to saline waters except in beach ridges and sand dunes where moderate shallow water aquifer is noticed at Kaviti, V.Kothur, Polaki,Gara and Icchapuram mandals. Three aquifers were deciphered namely (i) Alluvial aquifer (ii) Charnockite aquifer and (iii) Gneissic aquifer.In Itchapuram, Kaviti, Kanchili, Sompeta Baruva mandals (Bahuda basin), alluvial aquifers exist. The thickenss of alluvium ranges from 3-5 m. and the discharges varies from 2-5 lps in these areas. The thickness of alluvium ranges from 15-20 m. and the discharges varies from 10--15 lps in these areas. Tekkali mandal has been categorized as Gneissic aquifer. The thickness of alluvium ranges from 15-20 m. and the discharges varies from 10--15 lps. Chemical quality variations of some of the constituents like E.C., Chlorides, Nitrates are observed at higher values at Polaki,Sompeta, Kaviti and V.Kothur mandals.

2.12.4 Parts of East Godavari(Coastal Aquifer Management including Climatic change effects)

The study area consists of 13 administrative mandals in East Godavari district covering an area of 1642 Sq.Km. Study has indicated that area is underlain by coastal deltaic alluvium of Recent age. Ground water occur under unconfined and confined conditions

Three aquifers are identified within the depth range of 100m bgl (1st Aquifer – unconfined - extends down to 18.00m bgl;2nd Aquifer – confined - from 20 to 62m bgl & 3rd Aquifer – confined - lies between 66 to 95m bgl)

The pre-monsoon water levels varies from 0.48 to 6.83m bgl. Electrical Conductivity of ground water varies from 380 to >20,000 ms/cm at 25°CPremonsoon) and 330 to 6480 ms/cm at 25°C during post monsoon. High values of Electrical Conductivity observed both in pre and post monsoon periods at certain places viz., N.Rameswaram(3030), Pallamkuru(3300), Toorangi(4240), Toorpupalem(5670), A.Kothapalli(9400), Kandikuppa(13570) & Dindibeach road(>20,000). Salinity in the coastal area decreases during post monsoon period. Quality of ground water is fresh in the top unconfined aquifer. Conjunctive use of ground and surface waters may me planned to prevent the adverse effects of surface water irrigation in the command area.

2.13 SER, BBSR

Four studies were carried out in parts of Bargarh district(drought category),Keonjhar district(mining area),Keonjhra district(industrial area) and Bargarh& Sonepur districts(canal command area) covering an areas of 3100,3132,3120 & 3252 sq.km. respectively.

2.13.1 Parts of Bargarh District (Drought area) :

The study area (3100sq.km) falls in the western part of Bargarh district comprises 6 blocks i.e.Padampur, Paikamal, Jharbandh, Gaisilet, Sohela and Bijepur.

The area is characterized by a complex geological set up with a variety of rock type belonging to Archean, Precambrian and permocarboniferous age. Different rock types exist in the area are khondalite, charnockite, amphibolite and dolerite dyke, quartz vein of Archean age, sandstone, shale,phyllite and conglomerate of Chandarpur group, shale and quartzite of Raipur group, sandstone, shale and pebbles bed of Gondwana Super Group and sand, silt and laterite of Recent to sub-recent age.
Hydrogeologically, groundwater occurs under water table conditions in weatherd portion and under semi-confined to confined conditions in consolidated formations. Laterite and alluvium of recent age is a good repository of ground water where grou8ndwater occurs under water table conditions.

During pre-monsoon, the water level in the study area lies in between 3.7 mbgl and 11.37 m bgl. In major part of the area water level lies in between 6 to 8 mbgl. Water level is deeper in areas in patches in northern part of the study area which lies in between 8 -10 mbgl. During post monsoon, the water level in the study area lies in between 1.12 mbgl and 6.55 mbgl. All observation wells show rise in water level.

2.13.2 Parts of Keonjhar District (Mining areas):

The study area(3132sq.km) falls in northern parts of Keonjhar district covering Patna, Saharpada, Keonjhar, Jhumpudra, Champua and Joda block**.**

Major parts of the study area are underlain by rocks belonging to Older metamorphic Group; Iron ore Group;Singhbhum granite & Proterozoic rocks. Older metamorphic group constitutes Tonalite gneiss, amphibolite, schist & micaceous quartzite. Iron ore Group constitutes Iron ore group lavas, BHJ,BHQ, Shale, tuff & phyllite etc. Proterozoic rock constitutes Malangtoli lava volcanics; Kolhan group-orthoquartzite in valley-shales;Gabbro-Anorthosite&ultramafics.
The consolidated formations (hard rocks) form the main hydrogeological unit in the study area. These rocks lack primary porosity and are rendered porous and permeable by weathering and fracturing. The top weathered zone developed over these rocks form phreatic aquifer. However the success of bore wells is site specific (under suitable topographic and hydrogeological conditions). Depth to water level in pre-monsoon period ranges from 1.16m to 16.25m bgl; average being 6.92m bgl. Depth to water level in post monsoon period ranges from 0.56 m to 11.68m bgl; average

being 4.33 m bgl. Water table fluctuation ranges from 0.33 to 7.74m; average being 2.59 m. No appreciable long term change in ground water level/ground water regime.

Ground water quality in most of the study area is good for domestic use except for few isolated places where fluoride and nitrate concentration are more than the permissible limit. Ground water is generally good from irrigation point of view (mostly C1S1 and C2S1 Class under USSL Classification).

Area is having huge ground water resource potential out of which only small part is being utilized. The stage of development of Joda block is 62% due to high utilization of ground water in mining and industrial sector.

Artificial Recharge Projects should be implemented religiously by mining and industrial sectors in their respective campus and surrounding areas particularly in these two sub basins (a) Karo Nadi sub basin and (b) Kundra Nadi sub-basin. Rainwater harvesting and water conservation structures should be constructed at suitable location after scientific survey at micro-basin level in the hard rock terrain.

2.13.3 Parts of Keonjhar District (Industrial areas):

The study area(3120sq.km) falls in south-eastern parts of Keonjhar district covering Hatadihi, Anandpur, Ghasipura, Ghatagaon & Harichandanpur blocks. The average rainfall of the study area is 1365.6mm.

Area is mainly drained by the river Baitarani and its tributeries (Baitarani basin). The major tributeries are Remal, west Bagira nadi, Musal nadi, Musai nadi, Kusai nadi and Salandi Nadi. The drainage pattern is controlled by Baitarani river system and the overall drainage pattern is parallel to sub parallel type.

90% of all the blocks of the study area except Ghasipura, Anandapur and Hatadihi are occupied by the Singhbhum granite. The weathered residuum ranging in depth from 2.81 to 14.78 m below ground level constitute the shallow aquifer zone. The weathered zone forms the main repository of ground water and aids in circulation of ground water through interconnected fractures and fissures to deeper fracture zones. Shallow aquifers have well-developed joints and fractures which constitute the shallow aquifer zone. There are generally one to two sets of fracture zones within 51 m depth below ground level. The discharge of the wells within 51m bgl depth is negligible to 9 lps. This variation in yield depends on topographic setting, proximity to the major lineaments, thickness of weathered residuum and number of saturated and interconnected fractures encountered. The weathered residuum ranging in depth from 15.1 to 22 m below ground level constitute the shallow aquifer zone. So, far as deeper aquifers are concerned, there are generally two sets of fracture zone within 200m bgl depth is negligible to 14 lps.

The depth to water level in pre-monsoon (2010) lies between 4 to 6 mbgl in major part of the study area and in post monsoon lies between 2 to 4 & 4to6 mbgl. The shallowest water level of the order of 0-2m bgl is observed in Hataihi 7 Harichandanpur blocks and deeper water level of the order of>8 to 10 mbgl is observed as one patches in Ghasipura & Hatadihi blocks in post monsoon. In premonsoon the deepest water level in the order of 4-6m bgl is observed in Ghatagaon, Anandapur, Ghasipura and Hatadihi blocks. Area has huge ground water resource potential out of which only a small part is being utilized. The stage of ground water development varies from 12.89 to 44.84%. Therefore, all the blocks fall under safe category.

Artificial Recharge Projects should be implemented religiously in and around boula chromite mining belt. Rainwater Harvesting and water conservation structure should be constructed at suitable location after scientific survey at micro-basin level in the hard rock terrain.

2.13.4 Parts of Bargarh & Sonepur District(Canal Command Area)

The study area encompasses 6 blocks (Ambabhona, Bhatli, Attabira, Bargarh, Barpali & Bheden) of Bargarh district and 2 blocks (Binka & Dungripalli) of Sonepur district covering an area 3252 sq.km .

Geologically major parts of the area is underlain by hard crystalline rocks of Archean/Pre-cambrian age which includes granite, granite gneiss, charnockite, schists, amphibolites, phyllites and schists, metavolcanics, quartzite, sandstone, shale, feldspathic grit of Chndarpur Group.

A total of 107 key observation wells were monitored both during pre-post monsoon periods during 2010.The data indicate that premonsoon water level in this area varies from 8.60 mbgl at Dechuan in Ambobhora block to 0.55 mbgl at Tuniamunda in Dungripali block and the post monsoon water level varies from 5.75mbgl at Kusumdihi in Ambabhona block to 0.72 mbgl Berangapali in Barpali block.

Based on water level fluctuation method the groundwater resources of the study area is estimated as 138.33MCM and based on rainfall infiltration method it is calculated as 217.36MCM. As per GEC-97 norms the average annual rainfall recharge is194.35 MCM in the study area. To evaluate Net Ground Water Resources through almost all sources, GEC-97 methodology was adopted, which becomes equal to 262.44 MCM . Considering the existing number of

groundwater structures in this area as observed from published report, the gross draft is calculated as 66.94MCM. Thus the average 'Stage of Ground Water Development in this area is 26.18%. Depending on the long term trend of ground water levels for both pre & post monsoon periods and considering the stage of development for individual blocks, all the blocks are categorized as safe.

2.13.5 Remote Sensing Studies: Hydrogeomorphological Mapping and Delineation of Ground Water Potential Zones using Remote Sensing Technique in Nilgiri Subdivision, Balasore District

Hydrogeomorphological Mapping and Delineation of Ground Water Potential Zones using Remote Sensing Technique in Nilgiri Subdivision, Balasore District was conducted. The study area Nilagiri subdivision, consisting of two blocks, Nilagiri and Oupada covers an area of approximately 500 km^2. The area is characterized by a tropical monsoon climate. Agriculture is the primary occupation of the people. Increasing population, urbanization and expansion in agriculture has lead to the unscientific exploitation of groundwater, a precious resource, creating a water stress condition. This alarming situation calls for cost and time effective technique for proper evaluation of groundwater resources and management planning. An attempt has been made to study the different geomorphic and hydrogeological parameters such as geology, geomorphology, land use and land cover, drainage, lineament, slope, DEM (Digital Elevation Model) using Remote Sensing. Thematic maps are prepared and analysed. Relationship of each layer to the ground water regime has been evaluated through detailed analysis of the individual parameters.

Small rivers, rivulets originate from the hills in the northern part and join the river Suno, which is a major tributary to the river Budhabalanga. The drainage pattern is mainly structurally controlled and dendritic in the foothills. Numerous springs also flow from the hill ranges.

Depending upon geology, water bearing and water yielding properties, two major hydrogeological units have been identified in the district viz. consolidated and unconsolidated.

In the present study, the aim is to identify and map the prospective ground water zones n the area by qualitative assessment of the controlling and indicative parameters. Qualitative interpretation of features of ground water interest is largely possible through remote sensing and ground checks. Remotely sensed data are used for lithological and structural mapping of water bearing formations, geomorphological mapping etc.

IRS-ID LISS III has been used for the present study. The ASTER and DEM map is downloaded from the internet and used for creation of contour map for the study area.

The various hydro geomorphologic units delineated from satellite data. High pass and edge detector convolution filters for spatial enhancement were applied on Land sat data. ASTER DEM was used in conjunction with processed land sat FCC to identify various geomorphic units like structural hills, Dyke ridge, Buried pediment shallow, Buried pediment deep, Older alluvial plain, lateritic plain based on their shape, size, tone, texture, association with the surroundings, spectral signatures of different earthly objects, growth of vegetation etc. The various hydrogeoorphic units are mapped based on the satellite imagery interpretation and reviewing of literatures and studying the maps and toposheets available earlier. The geomorphic features are later verified in the field.

The indicators of groundwater occurrences are related to the geologic and hydrogeomorphic parameters such as Geology, Geomorphology, Land use, Drainage Density, Lineament Density, Slope and DEM. An attempt has been made to delineate the different hydrogeomorphic units depicting all detail structural elements like lineaments, fractures, joint traces of the area with the application of remote Sensing data along with other collateral data and hydrogeological data. In the present study satellite data has been proven to be very informative and useful for hydrogeomorphological mapping, especially in bringing out hydrogeomorphological characteristics of various geomorphic units. The methodology developed may be applied similar terrain conditions with some local considerations and modifications. Further incorporation of geophysical data can enrich the interpretation.

2.13.6 Pollution studies on Ground Water Quality at Angul-Talcher Section, in Angul district

Pollution studies were carried out at Angul-Talcher Section of Angul district. The study area covers the mining areas of Angul district between Angul and Talcher. The total study area covers about 820 sq. Kms.

68 wells were inventoried in the area. In general the water level in the area ranges between 1.88 mbgl (Gunchapal) to 10.8 mbgl (Ghantapada). The area shows a general declining water level trend during the pre-monsoon. On the basis of location, hydrogeology, 17 representative samples were collected for determination of EC and pH. These water samples includes 14 from phreatic aquifer (dug wells), 2 from deeper aquifer (borewells/tubewells) and one surface water sample from Nandira Jhor which is the main drainage channel which collects the mine discharged water. The

water samples were analysed in the chemical lab of CGWB, SER, Bhubaneswar. Only major ions other than Fe could be analysed. Any other parameter relevant to a pollution study is not analysed to lack of facility. Study of local geology, geomorphology, collection of relevant informations etc were carried out.

The EC in the water samples ranges from 240 to 4900 µS/cm. the majority of the samples have normal EC and classified under Ca-Mg-HCO3 type. The F in the 5 samples mostly in the phreatic aquifer is more than 1 ppm and only 1 sample at Bhogabareni shows F excess of the permissible limit of drinking water.

2.14 SWR BANGALORE

Three studies were undertaken in Gulbarga(drought category), Hassan (farmer's distress) and Kodagu & Chamarjanagar districts (tribal category) covering an area of 3334 sq.km, 3321 sq.km & 2900 sq.km respectively.

2.14.1 Chincholi and Chitapur Taluks, Gulbarga District

Forms part of Krishna basin and is distributed among seven watersheds in the area. Topographically the study area is moderately plain country having scattered hills at places. The drainage pattern is dendritic in the area. Normal annual rainfall for Chincholi and Chittapur taluks is1033 mm and 794.2 mm respectively. Geologically, Granites and Gneisses are predominately exposed in the southern parts of the taluk and show moderate weathering. These are followed by limestone, belonging to the Bhima group. The limestone are overlain by Deccan traps in the north.Depth to water level during pre & post monsoon varies from 0.70 to 23.10 and 0.00 to 12.0 mbgl respectively.Seasonal fluctuation ranges from 0.10 to 13.40m. In general ground water in the study area is potable, except at places where inland salinit y was observed. Both the taluks have been categorized as safe, considering the present stage of ground water development.

Special studies

As a part of detailed study, an area of about 1000 sq.kms was selected. 95 dug wells were inventoried in the area and the data collected. Four pumping tests were conducted in the area. Village-wise hydrogeological data have been collected. Geologically, the study area comprises of granites and gneisses followed by limestones in southern part and basaltic flows in the north. Highly vesicular laterites are exposed in the northeastern parts of the area. The depth of the dug wells ranges from 8.40 to 15.30 mbgl in granites and gneisses and in limestones it ranges from 3.70 to 25.30 mbgl. In case of basalts the depth ranges from 2.50 to 19.0 mbgl. The maximum depth to water values in the area was 11.60 m bgl. In general the ground water quality is good and potable. However in some villages nitrate and fluoride has been reported. Due to occurrence of compact lithological formations, the percolation of surface water is poor, and the recharge component is also poor. As the density of ground water structures is poor, there is scope for the development of the same.

2.14.2 Somvarpet and Virajpet taluks of Kodagu District and Arkalgud Taluk of Hassan district

During the course of study, 192 groundwater abstraction structures were inventoried and water levels were also monitored from 89 key observation wells. 81 number of ground water samples were collected for regional quality analysis and 25 samples for special quality study in canal command areas. Hydrogeological tests were conducted to determine aquifer parameters. Meteorological, agricultural and irrigation data were also collected from various state agencies. A special emphasis was given for the canal command area to demarcate the quality and water logging problematic areas.

Ground water occurs under both phreatic and semi-confined to confined conditions in fractured formations Granitic gneisses and charnockites in weathered, jointed and fractured form are the main aquifers and hydrological tests indicate that weathered and fractured granite gneisses are more prospective from ground water point of view than charnockites.Premonsoon (May 2010) water level ranges between 1.30 to 20.20 mbgl and the postmonsoon (November 2010) water level varies from 0.06 to 17.95 mbgl. Seasonal fluctuation of water level between May 2010 & November 2010 shows only rise within a range of 0.02 mbgl to 11.33 mbgl.62% of borewells from the study area have yields from 3 to 10 m^3/hr and higher yields upto 55 m^3/hr are also recorded in few villages in eastern part of Arkalgud taluks. Depth analyses of existing bore wells indicates that productivity of weathered and fractured zones is insignificant below 80 m. The ground water in the study area is potable, calcium-bicarbonate type with mostly low to medium salinity hazard, and low sodium (alkali) hazard for irrigation use. In non-command area minor irrigation tanks are suitable to harvest rainwater and augment ground water recharge.

Underground check dams across small nalas are recommended to check base flow and induce recharge to ground water. Desilting of filled up existing irrigation

tanks are recommended for maximum storage of water to create additional irrigation potential. In order to obtain higher discharges for irrigation, Dug-cum-Borewells should be located on low lying valleys and lineaments. In the canal command area, possibility of water logging condition and salinity problems can be avoided by observing following practices. Conjunctive use of surface and ground water in the canal command areas of Somvarpet and Arkalgud taluks. Optimization of ground water potential and applied irrigation by surface water is recommended to avoid water logging/salinity problems and to achieve maximum crop yield. Pick up weirs may be constructed regularly down stream of the ayacut of the distributaries so that return flow from applied irrigation can be recycled.Few villages in Arkalgud taluk were identified for further Ground Water Exploration along with Geophysical survey.

2.14.3 Gundlepet, Chamarajanagra and Yelandur taluks of Chamarajanagar district

The study area is covered by 2900 sq.km. falling in Gundlupet, Chamarajnagara and Yelundur taluks of Chamarajnagara districts and falls in the southern tip of the Karnataka state. Geologically, the area is mainly underlain by Charnockites, Peninsular Gneissic complex of Archaeans age and Sargur schist belt.

65 key wells were observed. Pre-monsoon water level is ranging from 3.48 mts to 60.06 mts. The shallowest water level is recorded at Gopalapura and the deepest water level is monitored at Veeranapura. In Gundlupet taluk, most of the area falls in less than 20mts and above 20 mts water level falls in the eastern parts of the taluk. In Chamrajanagara taluk, the less than 20 mts zones are falling all along the forest area. Almost all the plain area in Chamarajnagara taluk, the water level zones are falling above 30mts. The deepest water level zones are falling in western parts of the study area. In Yelandur taluk, all the area is falling under below 20mts zones.

Post monsoon water level ranges from from 1.25 mts to 63.10 mts recorded at Kestru and Anukurki respectively. In Gundlepet taluk, entire area is showing rising in water level when compared to premonsoon water level. 50% of the area shows water level of less than 10 mts. In Chamrajanagara taluk, all along forest area as well in plain area, depth to water level is less than 20 m. The deepest water level is found in western part of the study area. In Yelandur taluk, water level is below 10m in the entire taluk.

Water samples were collected from key observation wells for the chemical analysis. EC and pH were collected using portable instruments in field. The electrical conductivity varies from 130 to 2850 mhos.cm and the minimum EC is observed in B.R.Hills and the maximum EC is observed in Bannahalli. Based on the contour map, the high EC values are observed in eastern, southern and western parts of the study area. Generally high EC observed in areas underlain by Amphibolites schist.

During the fieldwork, a spring has been identified in Gundlepet taluk. This spring should be protected and used for the strategic time for drinking water purposes.Alluvial aquifer was mapped in parts of Chamarjanagara and Yelendur taluks.

2.15 SECR, CHENNAI

Four studies were undertaken in parts of Pudukottai and Ramanathapuram Districts(Normal category); Thanjavur, Pudukottai & Trichy districts(Normal category); parts of Thirunelveli district(Normal category) and in parts of Araniyar and Kortalaiyar rivers basin in Tiruvallur district covering an areas of 3217sq.km ,3028 sq.km ,3200 sq.km. & 3300 sq.km respectively

2.15.1 Parts of Pudukottai and Ramanathapuram Districts

Studies were carried out in parts of Pudukottai and Ramanathapuram Districts(Normal category) covering an area of 3217 sq.km. The objective of study was to Delineate of alluvial and tertiary fresh water aquifer units, define recharge & discharge area and formulation of Aquifer Management Plan.

Geologically the entire district is comprised of sedimentary formations of Quaternary, Tertiary except 1 % of hard rock formations of Quartzite and Gneissic formations. Quaternary deposits occur at the top and they range in thickness from 0 to 40 m from west to east. They consist of Sand, Clay, Silt, Kankar, pebbly clays and laterite etc. Tertiary deposits occur below the Quaternary and they range in thickness from 200-250 m. They consist of sandstone and mottled clay. Cretaceous formation underlain the Tertiaries and the rock types include chiefly limestone. The granular zones occurring at different depths are grouped into three namely viz.(i)Shallow aquifer occurring down to 30-50 m depth(ii)Medium aquifer occurring down to 70 to 100 m depth and (iii)Deeper aquifer occurring down to 150 to 350 m depth.

The chemical quality of ground water of shallow aquifer is generally poor in major part of the district, where as in the west, north-western, northern parts and in isolated pockets the quality is good. The deeper aquifers are also saline except Tiruvadanai area. Brine concentration in formation water of

coastal part of the study area ranged up to 11.5^0 Be. The brine concentration decreases with increase in depth.

In coastal areas of about 10 km distance from sea only shallow wells are suggested as the quality of ground water detriorates when the water level goes down below mean sea level.

2.15.2 Parts of Thanjavur, Pudukottai & Trichy districts(Conjunctive use of surface and ground water studies in Irrigation Scheme of Cauvery Delta)

Studies were carried out in parts of Thanjavur, Pudukottai & Trichy districts (Normal category) covering an area of 3028 sq.km.Study area is underlain by semi-consolidated formations of Mesozoic and Tertiary ages and unconsolidated alluvial sediments and coastal sediments of Quaternary age.

Ground water occurs under phreatic conditions in the weathered mantle and semi-confined in fractured zones at deeper levels, where as in sedimentary formations comprising sand stones, lime stones, shales and unconsolidated alluvium, it occurs under the phreatic and confined condition depending upon the storage and conduit characteristics of the confining layers.The depth to water level is within 10 m bgl in the major part of the study area throughout the year. Deeper water levels are observed in isolated pockets in the northern part of Thanjavur, Thiruvaiyaru, Budalur, Peraurani, Orthanadu and southern part of Aranthangi. Shallow water levels in the range of 5 m bgl in the northern and southern part of study area.Long-term water level data (1989-98) indicates that water levels have risen in major part of the area of the study area. The water levels have risen by more than 4 m, 2 to 4 m, and less than 2 m in 46.15 percent, in 7.69 percent and in 30.77 percent of the wells analysed. Declining trend has been observed as isolated pockets in 15.38 percent of the wells analysed.

The quality of ground water in the water table in the eastern and southeastern coastal area there is saline water at the top, the quality of ground water in the porous formation is generally good and fit for both domestic and irrigation. The Specific Electrical Conductance is more than 2500 µS/cm at 25°C in 50 percent of the samples analysed. A gradual increase in conductance is observed in the area from northeast to south west and the chloride, calcium and magnesium in shallow ground water exceeding desirable limit for drinking uses.

Numerous rivers and canals flowing through levees and recharge the shallow and filter point aquifers. During peak summers the filter point aquifers get dried up, as there is no flow in these rivers and canals. The exposures of upper Miocene for formations on the surface in the west of Grand Anicut Canal and east of Thanjavur – Pudukkottai road gets direct recharge from the rainfall. The medium and deeper aquifers are over lined by intercalated clay beds. Further, the areas other than levee complexes in the Cauvery sub basin are covered by impervious clay blanket which does not facilitate recharge of medium and deeper aquifers at a faster rate.

The major source for irrigation in the study area is through Canals. Canal irrigation constitutes 88% and remaining portion compensated by ground water.On several occasions in the past it has been recorded that the canal water was being released during August or September, which becomes inadequate for raising even a single crop. In the absence of an assured irrigation even raising a single crop becomes great difficult. North East monsoon rainfall pours huge with incessant in short spell of rainy days during October, November and December, which led to mostly unutilizable for irrigation because all the surface water bodies and ground water reservoirs are up to the capacity due canal flow. Overall, the all available surface water is being fully utilsed for irrigation.

In majority of the study area, the ground water quality is good. Few saline pockets are observed in blocks of Sethubhavachatram, Avudayar Koil and Manalmelgudi blocks. High EC values are recorded in Madahgam, Mimisal, Kottaipattinam and Naagudi. Water logging has been observed in localized pockets in Avudayarkoil, Manalmelgudi and Aranthangi blocks. The water logging portions are occurring all along the coastal tract.

Out of 10 blocks, 6 blocks already exhausted all the ground water resources. 4 blocks namely Manalmaelgudi, Aranthangi, Avudayar Koil and Budhalur of Pudukottai and Thanjavur districts respectively are 'SAFE' as per 2009 estimation.

Stage of ground water development is too low in Manalmaelgudi (4%), Avudayar Koil (2%) and Aranthangi(36%) blocks of Pudukottai district. The blocks forms coastal tract and ground water can be developed in an optimum manner keeping in view of the coastal hydrodyanamics. Stage of ground water development in Budhalur block is 47%, where the ground water development through irrigation can be adopted.

2.15.3 Parts of Thirunelveli district (Delineation of water scarcity areas suitable for artificial recharge using Remote Sensing)

Studies were undertaken in parts of Thirunelveli districts (Normal category) covering an area of 3200sq.km.A total of 120 key wells inventoried.Groundwater occurs under phreatic conditions in the weathered formation and phreatic to semi-confined condition in the fractures formations.

Depth to water level ranges from 2.25 to 22.10 m bgl during Pre monsoon, May, 2010 and from 1.60 to 16.70 m bgl during Post monsoon, January 2011. Seasonal fluctuation data indicate rise in 96 % of key wells. Fluctuation ranges from 0.35 to 10.35 m.

The groundwater flow direction in the study area is from western/northwestern towards the eastern/southeastern direction. Groundwater table of the study area ranges from >190 to 50 m amsl. Lineaments and Dykes play a major role in groundwater occurrence and its quality. W-E oriented dykes in these regions acts as a carrier and wells falling in it proximity have high yields. Few lineaments observed in the area West-East oriented lineament/dyke near village Kumbanaeri and surrounds: About 200-250m north and south of this dyke has very good potential and potable quality. Few wells in this zone have discharge of 4-5 lps and can sustain pumping for 8-10 hrs for a drawdown 1-1.5 m. Further few single wells in this zone irrigate upto 10 acres of land. North-South dyke (N20˚E) oriented dyke near village Marudappapuram have quality problems in the upstream side. EC Value ranges from 3700 to 4600µS/cm at 25^0 C. The dyke cuts across the Chittar River near the village Arunachalapura-Nettur.

The quality of groundwater near the vicinity of the river is potable. The EC value ranges from 1000 to 1200 µS/cm at 25^0 C. The dyke near the river Chittar acts as a carrier to the vicinity of about 1 to 1.5 km on both the sides. North-South dyke (N40˚W) oriented dyke near village Andarkulam (East of Sendamaran) have quality problems in the upstream side. EC Value (µS/cm at 25^0 C) ranges from 3000 to 4000. While wells in the downstream side have EC ranging from 1300-1600. The dyke here acts as a barrier thereby hindering the normal groundwater flow in the study area. The groundwater flow direction in the study area is from western/northwestern towards the eastern/south-eastern direction.

The EC value (µS/cm at 25^0 C) of ground water during Pre monsoon (May 2010) ranges from 193 to 4380. The lowest value of 193 is observed in Kadayam village, which is located near the Western Ghats. The highest EC value of 4380 is observed in Kurvikulam village located on the north-eastern side of the study area. About 65 samples of the total 120 keywells have EC values less than 1500 and it covers an area of 2025 sq.km. 55 locations have EC values more than 1500. About 1174.58 sq.km of area is affected by high EC values. High EC values are observed in the north-eastern side i.e., Kurvikulam, Alangulam, Melaneelithanallur and Eastern side of Sankarankoil blocks.Presence of many N-S, NE-SW dykes hinder the groundwater flows, thereby causing stagnation of the groundwater leading to drastic change in groundwater quality. Ultimately making the water non-potable.

The overall category of the study area has changed from safe during the year 2004 to semi-critical during the year 2009. On the basis of this survey carried out in the study area, six regions have been demarcated for optimal development

1. **Region near Karisalkulam-Sembakulam**. Falling in the quadrant of 58G12C2 – C3 covering an area of 22 to 25 km^2 have high GW potential.
2. **Downstream of Ramanadi & Gatana Reservoir**: Groundwater levels are very shallow and almost prone to water logging conditions. Groundwater of these regions can be pumped to other water scare areas.
3. **Regions between the Chintamani and Sivagiri** are of high potential. Depth of weathering in this area is about 09-15 mbgl and pre monsoon groundwater level ranges between 11 and 15 m bgl. Groundwater is this belt can be developed more. Groundwater level can be lowered for another 5 m. The area is near the foot hills so immediate recharging takes place after the monsoon (induced recharge).
4. **Region near village Valasai and surrounds:** regions near Valasai-Kambaneri have very good potential and potable quality. This area gets direct recharge through W-E oriented lineament exposed in the Western Ghats. About 200-250 m north and south of the lineament has areas high potential groundwater source.
5. Development of groundwater in the blocks Tenkasi, Pappakudi and Kadayam is low. They are in the safe category. Groundwater in these blocks especially Tenkasi can be pumped to other regions where water is scares.
6. Regions adjacent to Chittar River like V.K.Pudur, NE parts of Tenkasi area can be developed. These areas are prone to water logging conditions.
7. Artificial recharge structure suitable for the study area is percolation ponds/tanks in the Western Ghats i.e., in the bazada zone. In blocks Melaneelithanallur, Kurvikulam & Sankarankoil have numerous tanks, repair, renovation and restoration of these tanks would increase the groundwater potential of the area.

2.15.4 Parts of Araniyar and Kortalaiyar rivers basin in Tiruvallur district (Hydrogeological and hydrochemical regimes of shallow and deeper aquifers)

Studies were undertaken in parts of Araniyar and Kortalaiyar rivers basin in Tiruvallur district(3200sq.km) to study the hydrogeological and hydrochemical regimes of shallow and deeper aquifers. A total of 103 key wells inventoried. Groundwater occurs under water table, semi-confined and confined conditions.

Depth to water level ranges from 8.00 to 22.50 m bgl during Pre monsoon, May, 2010 and from 0.70 to 13.50 m bgl during Post monsoon, January 2011. During pre monsoon, in the major part of the area the DTW is between 5 and 10 mbgl, in isolated pockets, water levels deeper than 10 m were observed in and around Tiruthanni, Ramkrishnarajupet and Thiruvalagadu blocks .During post monsoon, in the major part of the area the DTW is between 2 and 5m bgl, the deeper water levels in the range of 10m and above have been observed in isolated pockets in the northwestern part of Tiruthanni, Ramkrishnarajupet and Thiruvelangadu blocks. A comparison of the water levels recorded during the two seasons show that there is a rise in depth to water levels of the range of 2-4m.

Large scale ground water development in the form of marketing is taking place from select pockets around Ambattur, Porur (Kundrattur) and Poonamallee areas. In the crystalline areas like Tiruthanni, Ramkrishnarajupet and Pallipattu blocks, a sharp decline in depth to water levels has been noticed due to scanty rainfall over the years and excess withdrawal of groundwater by indiscriminate pumping of bore wells.A number of recharge structures have been built but due to lack of scientific approach most of them have been constructed at wrong locations.

The quality of ground water is generally good except in the areas occupied by Gondwana sandstone, where the quality is poor and rich in iron content.

In the industrial belt of Ambathur and Manali, excessive urbanization and industrialization has caused a sharp decline in the chemical quality while in the Minjur area excessive pumping from the well fields during the yesteryears has caused a saline intrusion with the sea moving 6km inward according to UNDP studies.

2.16 KERALA REGION, TRIVENDRUM

Two studies conducted in Raipur(Normal category) and Durg district(Tribal category) covering an areas of 3000 & 3000 sq.km each.

2.16.1 Pathanamthitta district

Pathanamthitta District has an area of 2731 sq km accounting for 7.02% of Kerala state. It has five taluks Adoor, Kozencherry, Thiruvalla, Mallapally and Ranni spread over 9 blocks. Physiographically the district is divided into three divisions namely the coastal plains, the midland in the centre and the highland towards the east. Thumbimalai has the highest elevation of about 1520 m amsl. *Pamba* River system with its two major tributaries viz. *Achenkovil* and *Manimala* Rivers, drains the northern and central parts of the district. The southern part of the district is drained by *Kallada* River. The normal annual rainfall in the district is 3133.9 mm.

Around 2.13% of the total area of the district have irrigation facility with 0.9% of the total area being irrigated through wells. The irrigation projects are 1) Kallada irrigation project ii) Pamba irrigation project with command area 693 ha iii) Minor irrigation schemes (canals and tanks- 777 ha) and iv) Lift irrigation schemes(199 ha).

Consolidated rocks such as charnockites and gneisses of Archaean age encompasses about 70% of the district. They are traversed by pegmatite, quartz veins and dykes. The semi consolidated *Vaikom* sedimentary formations of Tertiary occur as small hillocks on the eastern border of Pulikeezh block covering 1.4% of the district area. Major lineaments in the midlands trend N-S, NNW-SSE, NE-SW and NW-SE. The N-S lineament is the most promising, whereas NNS-SSE is trending lineaments are characterized by tight joints.

The yield of bore wells varies from place to place and depending on the lineament tapped and tectonic history of the area. The bore wells in hard rocks yield up to 17 lps of fresh water. Tube wells in sedimentary formations have similar yields, but the quality is often brackish. The thickness of weathered zone in the district ranges from 3 to 20m. Deep seated fractures in the crystalline rocks form potential aquifers. Productive fractures have been encountered down to a maximum depth of 145 m bgl. The thickness of fracture zone varies from 0.50 to 10 m with yield range of 20 to 1380 lpm. The transmissivity of the aquifer ranges from <1 to 80 m^2/day.

Analysis of long term trend analyses of water level data does not indicate that significant fall/rise in water level over the years either in pre monsoon or in post monsoon period.

The groundwater in phreatic aquifer is potable in the entire district. In the deeper aquifers, the ground water in the sedimentary formation is mostly brackish whereas it is fresh in crystalline formation.

The stage of groundwater development is about 31.75 %. As all the blocks in the district fall under safe category, there is possibility for developing additional irrigation potential through wells. The study indicates that there is scope for construction of about 41,000 groundwater abstraction structures for developing 70% of the balance resource available for irrigation in the district.

For development of groundwater, 3 m diameter dug wells with cement rings can be constructed down to 6-8m in

Pulikeezh block. In mid-land area large diameter dug wells down to 8-12 m can be constructed. Bore wells down to 200 m can be constructed along potential lineaments.

Findings and Recommendations

1. No major changes in rainfall pattern observed in the last decade when compared to normal.
2. Both rise and fall in water levels observed in the district. Water level decline areas roughly correspond with areas of increased ground water exploitation.
3. Extraction of ground water from deeper aquifers for domestic and irrigation uses has increased in the recent past.
4. All blocks are in safe category as in March 2009.
5. Ground Water is generally potable in both phreatic and semi-confined aquifers. Bacteriological contamination is reported in wells in hydraulic connection with major streams.
6. No definite pattern of quality degradation in either phreatic or deeper aquifers is has been observed in the last decade.
7. There is scope for ground water development as well as for ground water augmentation using surplus monsoon run-off in the district.
8. Groundwater level gets depleted during summer months due to subsurface out flow through the sloping bed rocks. To arrest the subsurface out flow, subsurface dams can be constructed at suitable locations.
9. Artificial recharge structures like check dams, contour bunds, trenches, gulley plugs, terraces etc are feasible in the mid land area of Parakode , Kulanada, Elanthoor, Pandalam, parts of Ranni and Konni blocks and in Adoor and Pathanamthitta Municipalities to improve groundwater availability in summer.
10. Roof top rain water harvesting can be implemented for the assured source of drinking water for the isolated habitations in the eastern and western borders.
11. Existing dug wells and failed bore wells can be used to recharge ground water in mid lands and eastern hilly terrains.
12. The alternating hills and valleys present ideal sites for construction of subsurface dams for conservation of groundwater, which will mitigate the water scarcity of the upstream side.
13. Detailed mapping should be carried out to explore deeper fracture zones using remote sensing techniques and geophysical investigations.
14. There is feasibility for development of springs to meet the drinking and domestic water requirements, especially in the hilly regions of the district.

2.16.2 Parts of Kollam and Trivandrum districts (focus on Impact of clay mining activities on Ground Water Regime)

The studies undertaken in 800sq.km of area forming parts of Trivendrum (500sq.km) and Kollam (300sq.km.) districts.

The important clay mining areas are located in Azhoor, Mangalapuram and Andoorkonam Panchayaths in Thiruvananthapuram district and in Nedumpana and Vellichikkala Panchayaths in Kollam district.

After carrying out reconnaissance survey in the area, detailed study was mainly concentrated in the clay mining areas of Thiruvanathapuram district where the impact is being felt. Detailed hydrogeological survey carried out to evaluate the ground water scenario of the region. The main objective of the study was to collect a baseline data on the groundwater regime and quality in the study area such as Nature and depth of water bearing formations, Depth to water level, seasonal/annual water level fluctuation, ground water flow direction, quality of both surface and ground water, mapping of ongoing and abandoned clay mines and to study the impact of clay mining on ground water.

Physiographically, the study area falls mainly in the midland and lowland of Kerala. The coastal plain forms a narrow strip of land in the western portion of the study area and the general width is less than one kilometer. The area is drained by Vamanapuram River and its tributaries. *Kadhinamkulam Kayal* and *Mungottu Kayal* are the important backwaters in the study area.

The area has a typical tropical monsoon climate with the rainy season extending from May to November. The average annual rainfall as observed at the nearest meteorological station at Trivandrum is 1838.7 mm.

Groundwater occurs in all the geological formations ranging in age from Archaean to the Recent. Groundwater occurs in the porous granular formations such as alluvium, laterite, and the tertiary sediments, weathered and decomposed crystalline rocks as well as in the fissures, joints and fractures in the fresh crystalline rocks. The aquifers in the study area can be grouped into four distinct geological formations in which they occur namely alluvial aquifers, laterite aquifers, The tertiary sedimentary rock aquifers and the weathered, fissured and fractured crystalline formations

The range of depth to water level in wells tapping different aquifers is given in table below:

Depth to Water Level

Sl. No.	Aquifer	Depth of the well	DTWL(mbgl) Pre monsoon	DTWL (m bgl) Post monsoon
1	Alluvium	3.66-7.55	1.89-3.04	1.5-2.5
2	Laterites	4.25 -25.65	4.32-24.82	4.0-20.5
3	Weathered crystallines	7.80- 16.40	4.03-12.30	3.5-10.20

The groundwater in the area is generally potable except in few locations such as areas adjacent to the clay mining area. Along the coast, water is generally alkaline in nature. The groundwater is suitable for domestic and drinking purposes. Ground water in the vicinity of clay mining areas has been found to have low pH, indicating its acidic natur

Findings

1. The major aquifer system in the study area is alluvium, laterites and weathered Khondalites.
2. The depth to water level in the study area ranged from 1.89 to 24.82 m.bgl during pre-monsoon period and from 1.50 to 20.50 m.bgl. during post-monsoon period.
3. The productive clay horizon is encountered between 15m to 30m bgl. Lithomaric clay horizons are encountered in hard rocks below 35 m.
4. Clay mining in the area has resulted in various environmental problems including fall in agricultural production, loss of fertile soil, water level decline in wells adjacent to mining sites specially during summer season and deterioration in water quality.
5. The Indiscriminate clay mining activities without adequate depth control has affected the local hydrogeological conditions. Present study revealed that the ground water regime in panchayats of Azhoor, Andurkonam, Veillur, Melthonnakal, Sasthatvattam has been affected.
6. Conversion of irrigated paddy fields to clay mines has adversely affected the recharge into the aquifers.
7. The study has revealed that a substantial volume of ground water is being pumped out for fresh excavations which is increasing the stress on the ground water regime.
8. Hydrochemical analysis of ground water samples from mining area showed pH values in the lower side and high sulphate contents. This is attributed to the presence of iron sulphide in the china clay beds usually within a depth range 15 to 30 mbgl. The wells with depth greater than 20 mbgl exposed the iron sulphide minerals to oxidizing conditions which made them soluble in water thus lowering the pH.
9. The excessive removal of clays leaves has left vast areas of fallow lands unsuitable for any agricultural activity.

Recommendations

1. In order to prevent further deterioration of the environment in general and ground water regime in particular in the clay mining areas, clay mining needs to be regulated by allowing only location specific extraction of clay under well conceived guidelines.
2. The depth of mining may be restricted to the depth of pre-monsoon water levels in the area
3. Measures may be taken to augment the ground water resource by using the stored water in the excavated pits for irrigating the agricultural crops in the area. This will enhance the net agricultural productivity of the area in addition to augmentation of the ground water resource.
4. A Continuous water quality monitoring system should be established in the areas where clay mining activities are in progress. This is of utmost importance since indiscriminate mining to deeper levels may expose new subsurface geological formations which in turn impart marked changes in the water quality conditions of the areas and adjoining wells of future.
5. The feasibility of converting abandoned mine-pits to fish farm ponds , irrigation ponds or rainwater harvesting structures may be explored.
6. Afforestation of the reclaimed area should be promoted.
7. Environment rehabilitation should be made an integral part of all mining projects in such areas.

2.16.3 Coastal area of Trivandrum district (focus on preparation of base line data on Ground Water regime and quality in the proposed Vizhinjam Harbour and Container Terminal/other allied infrastructure areas).

The Study area is located on the southwestern part of Thiruvananthapuram district covering 500 sq.km. The project area is spread over four Panchayats, namely, Vizhinjam (now City Corporation area), Kottukal, Venganoor and Balaramapuram falling in Nemon and Athiyannur Blocks.

The projected water requirement for the proposed Vizhinjam Harbour Project is as under

- During construction - 100 m^3/day
- Short term - 410 m^3/day
- Medium term - 600 m^3/day
- Long term - 1000 m^3/day

This water requirement is to met either from the existing sources or supply from other areas.

The main objective of the study is to collect the following data from the area to facilitate possible impact of this project in the ground water regime of the area once the project becomes fully operational.

1. Nature and depth of water bearing formations
2. Depth to water level data (Pre monsoon)
3. Depth to water level data (Post monsoon)
4. Seasonal/Annual water level fluctuation
5. Long term water level trend
6. Ground water flow direction
7. Quality of both surface and ground water
8. Present water demand and availability
9. Existing Hydro Environmental problems in the area, if any.

Physiographically, the study area falls in the midland and lowland areas of Kerala. The coastal plain forms a narrow strip of land along the western boundary of the study area the width of which is less than half a kilometer. The coastal plain extends from Pozhiyur in the South to Sankhumugham in the North. A small part of the area in the eastern side falls within the high land region.The main drainage courses in the area are the Neyyar and Karamana rivers and some of their tributaries. Neyyar dam, constructed across Neyyar river constructed in its upper reaches caters to the water requirement for irrigation in the area.

The major litho units in the area belong to the Khondalite suite of rocks of late Archaean - Proterozoic age. Among the khondalite suite, garnet-biotite gneiss form the major rock type. Khondalites, leptinites and patches of charnockite and pyroxene granulite are exposed at places. All these rock units have been weathered and lateritised. The thickness of weathering ranges from less than 1 m to more than 20 m. In the coastal tracts, crystallines are overlain by sandstone and clay sequence of Tertiary age.

There are different sources of surface water resources available in the form of rivers/streams, lakes, backwaters,

tanks, ponds, springs etc. The *Vellayani lake* in Nemom block is the only fresh water lake in the area. The Neyyar irrigation project is the major irrigation

project. Puvar is the back water system and is brackish to saline nature. There are more than 500 tanks in the area, some of which are used for irrigation, domestic, and drinking purposes.

There are two distinct rainfall seasons viz. the SW monsoon (May to September) and NE monsoon (October to November). The average annual rainfall of the district is 1623.9 mm.

Beach sands & river alluvium, laterites, sandstones (Tertiaries) and weathered / fractured / jointed crystallines constitute important aquifer systems in the area. Tertiary Sandstones form the potential aquifers in the area. Ground water occurs in phreatic to confined conditions in these aquifers and is being developed through dug wells and tube wells.

Groundwater in shallow crystalline formations such as khondalites and charnockites occurs in water table conditions. The wells located in charnockites vary in depth from 6 to 13 mgbl. The deeper fractured hard rocks form localized aquifers.

In laterites, the depth to water level generally ranges from 3.45 to 20 mbgl and the depth of the well range from 4 to 22 mbgl. Deeper water levels (>50 m bgl) are observed in and around Pulluvila, Chani, Karumkulam areas.

The Recent alluvial deposits are composed of sand and clays and form the most potential aquifer in the area. Groundwater occurs under water table and semi confined conditions. These are developed by shallow tube wells and filter point wells. The depth to water generally varies from 1.5 to 5 mbgl and the depth of dug-wells wells ranges from 2 to 6 mbgl. The average yield is about 10 to 60m^3/day.

Groundwater abstraction in the study area is mainly by means of dug wells, bore wells and tube wells. Filter points are also used for ground water extraction in Recent alluvial deposits and Tertiary sedimentary aquifers.
As per the latest assessment of dynamic ground water resources carried out jointly by CGWB and the State Ground Water Department (2004), Athiyanur block is categorized as over-exploited and Parassala as critical. Trivandrum and Perumkadavila blocks are under safe category.

Ground water in the area is, in general, potable and suitable for irrigation and industrial application. Brackish ground water exists in isolated patches and in areas surrounded by backwaters. This study is to be continued in AAP 2012-13.

2.16.4 Bauxite & clay mining areas of Kasargod district (focus on preparation of base line data on Ground Water regime and quality in the proposed bauxite and clay mining areas of Kannur and Kasargod districts.

The study area is a part of Kanhangad block and Kanhangad municipality of Kasaragod district. The proposed clay mine is in the Karinadlam area of Kinanur – Karindhalam panchayat. Clay is already being mined in and around Nileshwar town area.

The study area experiences wet type of climate. The major rainfall contribution is from south-west monsoon (85.3%) during June to September. The average annual rainfall is 3500 mm. Physiographically the study area can be divided into coastal plains, mid-lands and high lands. More than 90% of the study area falls in mid land area.Major part of the study area is drained by Karingote river, which originates at Padinalkad Ghat of Coorg district of Karnataka at an altitude of about 1525 m.amsl. The river is tidal up to 2.4 km upstream from the sea. Asmelkara in the northern part of the study area is drained by Nileshwar river, which originates in Kinanur at an elevation of 137 m.amsl.

Geologically majority of the area is occupied by Charnockites which are lateritised at top. The thickness of lateritisation exceeds 20 m at places. Laterite is followed by lithomargic clay. In the western part of the study area, tertiary formations are encountered which are also lateritised at top. Alluvium occurs along the coast and on river banks.

Ground water occurs under phreatic condition in laterites. The depth to water (DTW) ranges from 2.80 m to 19.77 m.bgl in pre-monsoon period and during August 2010 it ranges from 1.04 to 18.00 m.bgl. In post-monsoon period (November 2010) the DTW ranges from 1.43 to 18.27 m.bgl and during January 2011, from 2.01 to 18.61 m. bgl; The seasonal fluctuation (2010) ranges from 0.51 m to 5.08 m.

The chemical quality of ground water is generally good to excellent for domestic, industrial and irrigation purposes. The EC of 17 water samples collected were below 200 µs/cm at 25^{o}C.

2.16.5 Parts of Malappuram district (Base line data collection on Ground Water depth to water level and quality along the upstream and downstream areas of the proposed Chamravattom Barrage cum regulater).

Studies were carried out for base line data collection on ground water depth and quality along the upstream and downstream areas of proposed Chamravattom bridge-cum-regulator in Malappuram district.

The Chamravattom project envisages construction of a bridge-cum-regulator across Bharathapuzha at Chamravattom for storage of water for drinking and irrigation uses as well as to prevent tidal water ingress into the river during summer. The project involves construction of a regulator for storage of water +4.00 m. The length of bridge proposed is 978 m with a span of 12 m. having 70 numbers of shutters of 12.00 x 4.00 m size. The ayacut area (gross) achieved will be 4394 hectares.

The main objective of the project is to evolve enough storage for irrigating a gross ayacut area of 4394 hectares. The project is proposed to stabilize the ayacut maintained by nine lift irrigation schemes in the area. The shortage of perennial source for drinking water will be solved by the project and also the river when bridged will be an important link connecting the coastal towns of Ponnani and Tirur. The water spread area is about 800 hectares.

The project area is located about 6 km upstream of confluence point of the river Bharathapuzha and the Arabian sea at Ponnani. The latitudes and longitude of the site are 10^{o}51' and 75^{o}57' east. The project site is in Ponnani and Tirur taluks of Malappuram district.

The study area covers 500 sq.km on both upstream and downstream sides of Chamravattom project and includes Tirur block, Kuttippuram block, Ponnani block, Ponnani Municipality of Malappuram district and part of Thrithala block of Palakkad district.

The study area experiences wet type of climate. The normal annual rainfall in the area is 2703 mm.Physiographically the study area comprises mostly the coastal plain and the midlands in the eastern parts. The area is spread on both banks of Bharathapuzha.

Geologically, the western part of the study area is covered by Recent alluvial deposits which are underlain by Tertiary formations. The eastern and northern parts of the area are underlain by laterites.The alluvial formations can be divided into three viz; Coastal alluvium seen all along the coast of the study area, the river alluvium sear by the banks of Bharathapuzha from the coast (Ponnani) to the eastern part of the study area especially between Chamravattom and Kuttippuram area and valley fills seen all along the midland area along the valley.Laterites are seen along northern and eastern part of the study area and along elevated areas. The thickness of laterites goes up to 20 metres at places. The laterites are derived from both Tertiary formations and crystalline rocks. The crystalline rocks are seen only in limited places of the present study.

The alluvium and laterites forms the aquifer system in the study area. In a small area in the eastern part of the study area, hard rocks also form aquifer. The alluvial aquifers are the most potential aquifers in the area. The coastal alluvium forms potential aquifers and can sustain medium to heavy duty dug wells. Filter point wells are feasible wherever the saturated thickness exceed five metres. River alluvium of considerable thickness is seen in and around Thirunavaya, Kuttippuram area by the northern side of Bharathapuzha.Laterites form important aquifers in the

eastern and northern part of study area. The laterites are highly porous and due to this, they get fully recharged by the al few rains in the monsoon season. Subsequent rains contribute little to the aquifer system and flow of as rejected recharge. The laterites form highly potential aquifers along topographic lows and valleys.

Ground water occurs under phreatic, semi-confined to confined condition in the weathered and fractured portion of crystalline formations which are encountered only in a small part of the study area.

A total of 60 key wells (37 in alluvium, 20 in laterite and 3 wells in crystalline formation) were established in the study area for regular monitoring of water level. The depth to water in key wells in Alluvium ranges from 1.02 to 6.81 m.bgl in pre-monsoon period and 0.50 to 5.24 m.bgl in post-monsoon period (November 2010). The DTW of key wells ranges from 0.83 to 5.5 m.bgl in January 2011. The fluctuation in water level between pre-monsoon (May 2010) period and post-monsoon period (November 2010) ranges from 0.10 m to 2.25 m. The yield of dug wells tapping alluvium ranges from 50 to 300 lpm. The DTW of key wells in laterites ranges from 4.30 to 13.89 m.bgl in pre-monsoon period and 1.44 m to 11.57 m.bgl in post-monsoon period (November 2010). The fluctuation in water level between pre-monsoon and post-monsoon ranged from 1.44 to 4.03 m. The yield of dug wells tapping laterite ranges from 30 to 300 lpm. The DTW of key wells ranges from 9.95 to 15.41 m.bgl in pre-monsoon period and 8.03 to 13.02 m.bgl in post-monsoon period (November 2010).

The ground water in the study area, in general, is good to excellent for domestic, industrial and irrigation purposes. The ground water from alluvial formation has higher total dissolved solids and major ion constituents to that of laterite area. This is due to the proximity of back water channel and tidal influence in the area occupied by coastal alluvium

2.16.6 Coastal tracts of Thrissur district(focus on iron concentration in groundwater in the coastal tracts)

The coastal tract of Thrissur district forms the western part of the district covering an area of 1000 sq.km.

Around 30 ground water samples were collected from various abstraction structures during April 2010 representing the pre-monsoon water quality. Well inventory data such as type of well, diameter, height of measuring point, geology, aquifer materials etc were recorded during the data collection. Water samples collected from the wells in study area for analysis of Iron. The chemical quality data of ground water samples of observation wells maintained by the State Ground Water Department and Kerala Water Authority are also intended to use. The Survey of India (SOI) toposheets, satellite imageries (FCC), secondary data from various State Govt. organizations were also used in the study.

The iron contamination in ground water has been reported by many State Government agencies like State Ground Water Department and Kerala Water Authority. Results of Chemical Analysis of the water samples collected during the study are awaited from the Chemical Laboratory, CGWB, KR for further follow up studies and analysis.
Based on the existing data collected, setting up of site specific iron removal plants in the area has been recommended

2.17 UR, DEHRADUN

Three studies were undertaken in Tehri Garhwal (Normal Category), Udham Singh Nagar(Normal Category) and Bageshwar (Normal Category) districts covering an areas of 3645,3055 and 2302 sq.km respectievely.

2.17.1 Tehri Garhwal District

Studies were carried out in Tehri Garhwal Districts (Normal category) covering an area of 3645 sq.km. The geology of the district consists dominantly of metasedimentary and metamorphic rocks of the Lesser Himalayan and Central Himalayan zones. The formations exposed in District Tehri Garhwal include Deoban Formation, Berinag Formation, Rautgara Formation, Chandpur Formation, Nagthat Formation, Blaini Formation and high grade metamorphic rocks of Central Crystalline Group intruded by granites of variable ages. Detailed studies were carried out in and around Tehri Reservoir, Chamba block with the help of Remote Sensing and Geographic Information System. Logistic support for the study was provided by the Indian Institute of Remote Sensing, Dehradun. During the studies, 45 cold water springs were surveyed. Discharge of the springs and temperature of water and atmosphere were measured both in pre-monsoon and post-monsoon.Apart from the springs, depth to water level was measured in 71 India Mark-II hand pumps during the pre-monsoon and post-monsoon surveys. Temperature of water of hand pump along with atmospheric temperature was also recorded.

A total of 96 water samples were collected out of which 67 samples were collected in pre-monsoon and 29 in post-monsoon. The samples collected include 27 samples from springs/seepages, 58 samples from hand pumps, 2 samples from Universal Stand Post (piped water supply) and 9 samples from surface water (including Bhagirathi River, Bhilangana River, Alaknanda River, Bhaldiana Lake/Tehri Reservoir and Kempty Falls).

The minimum spring discharge during pre-monsoon period was negligible (<0.001 lps) in a seepage at Nagni followed by 0.19 LPM at Muneth. The maximum spring discharge during pre-monsoon survey was 54.5 LPM at Silasu Bridge on Kempri-Nainbag road. During the post-monsoon survey, the minimum spring discharge of 0.41 LPM was observed near Aindi followed by 1.32 LPM at Nandgaon. The highest post-monsoon discharge of 100 LPM was recorded near Phakot, Narendrangar block.

The water temperature collected from springs, hand pumps, rivers/streams and lake shows variation from 13.0 to 35.5°C during pre-monsoon survey. Similarly, the water temperature during post-monsoon was found to be varying from 7.0 to 30.0°C.

Depth to water level in hand pumps measured in pre-monsoon were varying from 0.62 m bgl at Dhaudapani (Narendranagar block) to 70.07 m bgl at Arakot (Chamba block). During the post-monsoon survey and detailed study, depth to water level in hand pumps was found to be ranging from 0.90 m bgl at Dhaudapani to 63.38 m bgl at Arakot. Analysis of depth to water level data has revealed minimum rise of 0.47 m at Chaudana while maximum was 38.75 m at Motna near Bhaldiana Lake/Tehri Reservoir. Decline in water level in hand pumps varied from 0.01 m at Durgapur (near Thatyur) to 26.42 m at Jakhnidhar, the block headquarter.

Hand pumps are extensively used by the local populace for drinking and domestic work and are rapidly replacing traditional sources of water supply like springs and gadheras. A total of 1766 villages were fully covered through the hand pumps thereby benefitting a population of 543843.

The success story of rain water harvesting has been brought out through the works of two Non Government Organizations (NGOs) viz. Social Upliftment for Rural Youth Association (SURYA), Badshahi Thaul (Chamba block) and Mount Valley Development Association (MVDA) based at Doni (Bhilangana block).

As a part of the distribution of popular material to users and stakeholders (under the provision of the IEC Scheme), 50 calendars and 50 posters (in Hindi) on Water Conservation and Rain Water Harvesting were distributed to Gram Pradhans, Social Workers, School Teachers, Women Representatives of Gram Sabha and Gram Panchayat and villagers in all the nine Developmental Blocks of District Tehri Garhwal.

Besides, 20 booklets on Ground Water Management and Rain Water Harvesting entitled (1) ty cpk,a] thou cpk,a ,oa (2) Hkwty iquHkZj.k ,oa lao/kZu] mRrjk[k.M) were distributed to villagers, representatives from Gram Panchayats and Teachers of Government Primary, Upper Primary and Higher Secondary Schools and of Government Intermediate College and Government Girls Intermediate Colleges. Fifteen stickers on water conservation and rain water harvesting (in Hindi) were pasted in India Mark-II hand pumps at Almas, Durgapur, Pantwari, Shrikot, Thatyur, Manjgaon, Kandikhal, Lamkande, Anandchowk (Sendul), Dhaulagiri, Arakot, Kund etc.

2.17.2 Udham Singh Nagar District

Studies were carried out in Udham Singh Nagar Districts (Normal category) covering an area of 3055 sq.kmand falls in the Tarai region of Kumaon Divison.

Area has a dense network of the drainage pattern. The rivers of the district belong to the Ganges drainage system. Of these, Sarada, Kosi, Gola and Phikka River and their tributaries are Sawaldeh, Bour, Nandhour, Bhak, Kailash etc. drain the district. The overall drainage pattern in the study area is sub dendritic to sub parallel.The major rivers Kosi, Gola, and Sarada provide ample water to meet the irrigation demand, besides major reservoirs like Tumaria, Gularboj and Haripura, Dron, Baghul, Nanak Sagar and Sarada Sagar. Prominent canals like Kosi, Gola and Sarada irrigate a large area of the Tarai belt. Rainfall, spatially, is highly variable depending upon the altitude. The average annual rainfall in the district is 1296.85 mm.

Udham Singh Nagar district may be broadly divided into two physiographic units from north to south viz. Bhabar and Tarai respectively. Since the area is located in the Himalayan foothills, a very thick column of alluvium is deposited at the southern side, which further is classified into two distinct divisions: (a) Piedmont fan deposits known as Bhabar and (b) The Tarai Alluvium. Bhabar Zone (or Bhabar Formation) mainly comprises alluvial deposits lying on the sloping plains in the Himalayan foothills. Bhabar Formation primarily consists of unconsolidated sediments like sand, gravel, boulder and clay. It is exposed in northern parts of Bazpur, Sitargunj and Khatima blocks. The extreme northern portion of the Bhabar Zone is marked by the contact with Siwalik Ranges, whereas the southern limit is defined by the contact between Bhabar and Tarai, which forms the spring line or a zone of marshy conditions.

Bhabar is the main intake area close to the Himalayan foothills. Generally the water table is as deep as 75 m bgl - the water table also shows higher seasonal fluctuation. Considerable amount of water is also discharged by perennial springs at the southern limit of Bhabar during in monsoon seasons. The formation is favorable to percolate the water laterally from the Bhabar to Tarai and the Older

Alluvium further south. The hydraulic gradient is approximately 2.97 m/km.

A total of 11 dug wells and 73 India Mark-II hand pumps were surveyed. The pre monsoon depth to water level was minimum in a hand pump at Dhimari, which was recorded as 0.14 m bgl. The maximum depth to water level was again found in a hand pump, which was 14.17 m bgl at Jaspur. During the post-monsoon survey, the minimum and maximum depth to water levels was recorded in identical locations, viz. at Dhimari and at Jaspur. The minimum depth to water level in post-monsoon was 0.08 m bgl while the maximum was 14.12 m bgl. During the course of the survey, a total of 59 water samples were collected, out of which 12 samples were collected from tube wells and rest 47 samples were from hand pumps. The samples were sent to the Chemical Lab, CGWB, NWR, Chandigarh for complete chemical analysis. As on 31st March 2011, the analysis results from NWR, Chandigarh are awaited.

2.17.3 Bageshwar District

Studies were carried out in Bageshwar Districts (Normal category) covering an area of 2302 sq.km. The drainage in the district is constituted by three major rivers viz. Saryu, Gomti and Pindar.

District Bageshwar is mainly represented by the rocks of Lesser Himalaya and Central Himalaya. The rock units exposed in various parts of the district include quartzite, mica-talc schist, phyllite, limestone, slate, gneiss and granite gneiss. Ground water occurs mainly within the fractured, fissured and jointed crystalline and metasedimentary rocks. Ground water emerges as springs and seepages under favourable physiographic conditions such as in gently sloping area, broad valley of rivers and along the lithological contacts.
A total of 42 India Mark II hand pumps and 20 cold water springs were surveyed and established. The depth to water level was found to be varying from 1.80 m bmp at Garur (Garur Block Headquarter) to a maximum of 59.80 m bmp at Bhatkhola. Discharge of springs was found to be ranging between 0.0135 lps (0.81 lpm) and 2.950 lps (177 lpm) in the area. During post-monsoon survey, depth to water level in hand pumps was found to be varying from 1.89 m bmp at Garur to 36.70 m bmp at Kanda. The spring discharge was found to be varying from 0.0058 LPs (0.346 lpm) to a maximum of 30.0 lps (1800 lpm) in Kapkot behind the tehsil office at Chhadi.

During the pre-monsoon survey, a total of 88 water samples were collected. Out of these, 58 samples were earmarked for analysis of fluoride, 25 samples for iron and 5 samples for trace element analysis. During the post-monsoon survey, a total of 29 water samples were collected from hand pumps for analysis of iron. Detailed study in Garur Valley was undertaken with special emphasis on possibility of ground water exploration and chances of fluoride and iron contamination in the area. It was observed that spring discharge of 1800 lpm in Kapkot Block suggest possibility of moderate scale of ground water development. The spring water was found to be flowing into Saryu River and ground water development was found to be possible by suitable methods of water conservation for public use viz. both for drinking and irrigation purpose. The excess water can be used for recharging the shallow aquifers.

2.18 NHR, DHARAMSHALA

Three studies were undertaken in Shimla district(Normal Category); Nallagarh, Baritowala, Baddi and Parwanoo, Solan district (Normal Category); and part of Una district(Normal Category) covering an areas of 5131 sq.km, 230 sq.km. & 1542 sq.km respectively.

2.18.1 Shimla District

The Shimla district is located in the southeastern part of the Himachal Pradesh. The climate of the district is sub-tropical in the valley and tends to be temperate in the hilltops.

Shimla district presents an intricate mosaic of high mountain ranges, hills and narrow deep valleys with altitude ranging from 1000 to 3000 m amsl. In the areas underlain by high hill ranges of Himalayas, the valleys are narrow and deep with steep slopes trending in NW-SE direction. The terrain is moderately to highly dissected with steep slopes. The altitude is higher in northeastern parts and decreases towards south and west. Shimla district is covered by the catchment area of the rivers Satluj of Indus basin and Pabbar and Giri Rivers of Ganga basin. The district drains itself into these rivers.

Geologically, the rock formations occupying the district range in age from pre-Cambrian to Quaternary period. The major rock formation encountered in the district are Granites of lower Himalayas, Vaikrita Group, Jotogh Group, Rampur Group, Kullu Group, Shimla Group and the Quaternary alluvium in isolated pockets.Geologically, the rock formations occupying the district range in age from pre-Cambrian to Quaternary period. The major rock formation encountered in the district are Granites of lower Himalayas, Vaikrita Group, Jotogh Group, Rampur Group, Kullu Group, Shimla Group and the Quaternary alluvium in isolated pockets.

The overall groundwater quality in the district is fresh and suitable for domestic and other uses.

2.18.2 Ground Water pollution studies around industrial areas of Nallagarh, Baritowala, Baddi and Parwanoo of Solan district:

Ground Water pollution studies around industrial areas of Nallagarh, Baritowala, Baddi and Parwanoo of Solan district covering an area of 230 sq.km. Baddi Barotiwala

Industrial area is an important industrial area of Solan district of Himachal Pradesh and plays an important role in not only in economy of the state but also generating employment. A total of 56 samples were collected in the study area, from deep and shallow aquifers, surface water and drain samples from industries. The ground water samples were taken from dug wells, hand pumps and tube wells. Some of the important findings are as below:

Electrical conductivity of ground water is generally low. In study area, EC of 2300 micro mhos/ cm at 25°C is found in Surajpur (HP). In deeper ground water , higher concentration ie 1000 micro mhos/ cm is observed in Haripur (TW) and in drain samples collected from Haripur Sandholi nala.Fluoride concentration in spring, shallow and deep ground water samples are observed with in maximum permissible limit (1.5 mg/l) of BIS for drinking water purpose, except Surajpur (HP). Water sample collected from Surajpur, has reported 10 mg/l of fluoride. The effluents/drain samples also found to have fluoride concentration within the limits.About 33.3% of the samples have reported Iron concentration more than 1.00 mg/l, maximum permissible limit of BIS (Rev.2007) in shallow ground water , high values are reported at Bauni (1.73 mg/l), Surajpur (1.60 mg/l), Sattiwala (2.56 mg/l), Bhuranwala (2.87 mg/l), Kulhariwala (1.44), Dasora (1.54 mg/l) and Haripur Sandholi (1.76 mg/l). From deep ground water 2.22 mg/l is reported from Johranpur. More than 50% of drain samples have reported high Iron concentration. Samples from Balad nala have reported high iron concentration.As per the hardness classification, it is clear that about 90% of the samples collected are belonging to
very hard category. In case of spring samples all are of very hard category.In the study area, over all Nitrate concentration is less than 45 mg/l which is within the permissible limits according to BIS norms for drinking water. Maximum Nitrate concentration is recorded in Barotiwala hand pump (48 mg/l).The concentration of Copper, Zn, Ni, Cr and Cd are within permissible limits. The concentration of Mn, Pb at few places is reported more than permissible limits. The high con. of Mn is reported from Haripur Sandoli (DW). In drain samples, about 36% of samples are associated with higher concentration.

Maximum concentration is reported from Balad nala (8.72 mg/l).High concentration of lead can cause burning of mouth severe inflammation of gastrointestinal tract. The chronic toxicity produces nausea, paralysis and mental confusion. The concentration of Pb is within permissible limits of BIS for drinking purpose except in Batedh (TW).

2.18.3 Una District- data collection for Ground Water Modeling

Data collection of Una district(1542sq.km) was conducted for ground water modeling as the ground water exploration activity is concentrated in the Una valley.

Ground Water Management and Rfegulation Studies at Southern Region

Dug well in Jalna taluka, Jalna district having water level at GL

Dug well showing fractured aquifer system in RHS area of Jalna District

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 2010- 11 (up to 31st March, 2011), 818 wells (EW-365, OW-153, PZ- 300) have been constructed, against a target of 800 wells. It is heartening to report that out of 608 wells, 192 wells and 18 wells were constricted in hard rock, alluvium and bouldary formation respectively. 103 wells and 295 wells were constructed for exploration in tribal and drought prone areas respectively. The Board has so far has drilled a total of 30202 bore holes to identify areas worthy for ground water development in the country till March, 2011.

49 wells with discharge ranging from 180 LPM to 2040 LPM have been constructed in the states of Andhra Pradesh, Jammu & Kashmir, Kerala, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, West Bengal and Tamilnadu. 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 2010-2011 in the country is presented in Table 3.1 & Table-3.2. Region wise & Division wise status of bore holes drilled during 2010-2011 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 2010-2011

Sl No.	State/UTs	EW	OW	PZ	SH	DW	Total
1.	Andhra Pradesh	18	04	96	0	0	118
2.	Arunachal Pradesh	0	0	0	0	0	0
3.	Assam	20	06	0	0	0	26
4.	Bihar	03	0	07	0	0	10
5.	Chhattishgarh	22	08	26	0	0	56
6.	Gujarat	12	04	17	0	0	33
7.	Haryana	01	0	23	0	0	24
8.	Himachal Pradesh	6	0	0	0	0	06
9.	Jammu & Kashmir	9	0	1	0	0	10
10.	Jharkhand	12	04	2	0	0	18
11.	Karnataka	43	14	2	0	0	59
12.	Kerala	25	10	0	0	0	35
13.	Madhya Pradesh	43	15	29	0	0	87
14.	Maharashtra	34	21	08	0	0	63
15.	Orissa	44	15	16	0	0	75
16.	Punjab	03	04	1	0	0	08
17.	Rajasthan	20	07	34	0	0	61
18.	Tamilnadu	08	10	28	0	0	46
19.	Uttar Pradesh	26	20	07	0	0	53
20.	Uttarakhand	02	0	0	0	0	02
21.	West Bengal	13	10	0	0	0	23

Sl No.	State/UTs	EW	OW	PZ	SH	DW	Total
	TOTAL(A)	**364**	**152**	**297**	**0**	**0**	**813**
	UNION TERRITORIES						
1	Delhi	01	01	03	0	0	05
	TOTAL(B)	**01**	01	**03**	**0**	**0**	**05**
	GRAND TOTAL(A+B)	**365**	**153**	**300**	**0**	**0**	**818**

Table 3.2 Division wise wells constructed by central ground water board during the year 2010-2011

Sl No.	DIVISION	EW	OW	PZ	SH	DW	Total
1	I- AHMEDABAD	12	04	17	0	0	33
2	II- AMBALA	05	05	27	0	0	37
3	III- VARANASI	21	14	1	0	0	36
4	IV- CHENNAI	22	13	28	0	0	63
5	V- RANCHI	15	04	09	0	0	28
6.	VI-NAGPUR	34	21	08	0	0	63
7.	VII-GUWAHATI	20	06	0	0	0	26
8.	VIII- JAMMU	09	0	11	0	0	10
9.	IX-HYDERABAD	18	04	96	0	0	118
10.	X- BHUWANESWAR	44	15	16	0	0	75
11	XI- JODHPUR	20	07	34	0	0	61
12.	XII BHOPAL	43	15	29	0	0	87
13	XIII- RAIPUR	22	08	26	0	0	56
14.	XIV- BANGALORE	54	21	02	0	0	77
15.	XV- KOLKATA	13	10	0	0	0	23
16	XVI- BAREILLY	07	06	06	0	0	19
17	XVII- DHARAMSALA	06	0	0	0	0	06
TOTAL		**365**	**153**	**300**	**0**	**0**	**818**

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

A total of 10 exploratory tubewells were drilled during the 2010-11 against the target of 11. Out of 10 wells, 8 were drilled in Jammu province one in Kashmir valley and one in Kargil. District wise summarized details of ground water exploration Pumping Test Conducted in 2010-2011is given in table 3.1 and 3.2 .

Table 3.1:District wise details of ground water exploration in Jammu & Kashmir

Sl. N0	Location	District	Depth drilled m bgl	Zone Tapped (m)	SWL (mbgl)	Discharge (m3/hr)	DD (m)	T (m2/day)	Aquifer
	Jammu Province								
1	Meitra Army Camp –II	Ramban	142.0	-	33				
2	Lower Kharote	Kathua	102.00	70.00-76.00 78.50-80.50 82.50-83.50 94.00-100.00	53.37	33	0.44	458.399	Boulder
3	Khalka Bardal	Jammu	93.40	73.00-79.00 80.00-89.00					Sand, Boulder
4	Chanderkote	Ramban	173.37	Fractured formation	38.33	1.21	4.6		
5	Karorma Bhalwal	Jammu	108.50	101.50-107.50					
6	Kharkar	Kathua	100.00	55.50-59.50 68.50-72.50 77.00-79.00 80.50-83.50 86.50-87.50 92.50-94.50	62.0				
7	Dalogra	Rajouri	107.79		8.09		8.81		
8.	Lam Base	Rajouri	118.00	-	-	meagre	-	-	-
	Kashmir Province								
9.	Hanjan	Kulgam	80.00	24.00-30.00 39.00-45.00	28.80	1.5			Boulder
	Ladakh								
10.	Khumbathang	Kargi	87.15	81.12-87.15	57.61	3.0	0.34		Hard Rock

Table 3.2: Details of Pumping Test Conducted in 2010-2011

Sl. No.	Location	District	Duration of test (Minute)	SWL (m bgl)	Discharge (Lps)	Draw Down (M)	Sp. Cap. (lpm/m)
1	Jadh	Jammu	360	45.37	13.75	2.33	354.077
2.	Sunail-III	Jammu	500	64.22	4.76	0.48	595.93
3.	Lower Kharote	Kathua	500	61.41	9.16	3.22	170.807
4.	Khumbathang –I	Kargil	300	57.31	3	0.34	682.3
5.	Khumbathang -II	Kargil	300	57.61	1.5	12.06	7.462

3.2 WR, JAIPUR , RAJASTHAN

Ground water exploratory drilling were undertaken in Jodhpur, Dausa , Tonk , Hanumangarh, Ganganagar, Bikaner, Bharatpur , Alwar and Jaisalmer districts during the AAP 2010-11. District wise summarized details of ground water exploration and pumping test conducted is given in table 3.3 & 3.4.

Table 3.3 :District wise summarized details of groundwater exploration in the State

Sl. No	District	Depth Drilled(m) Depth of Well(m)	Zones Tapped (mbgl)	SWL (mbgl)	Discharge (lpm)	Formation
1	Bikaner	91.1-203 96-184	96-184	15-131	50 to 2000	Alluvium, Tertiary Sst.
2	Hanumangarh	55.8-200 36-120	40-102	8.98 to 30.7	165-1000	Alluvium
3	Ganganagar	11.4 ----	------	------	------	Alluvium
4	Tonk	154-202 154-202	Naked hole	5.58 to 30.3	30-300	Phyllite
5	Dausa	72-137.3 70-137.3	59-68	22.93 to 25.73	50-600	Alluvium,Quartzite,schist Gneiss/phyllite
6	Bharatpur	89-126.25 51-91.1	38-84	18 to 33.3	70-880	Alluvium/ quartzite/sst.
7	Jaisalmer	91.5-202 72.5-172	45 to 165	17.35-106.35	40-1100	Tertiary Sst.
8	Jodhpur	136-203.7	90 to 164	33-102	Meager To 330	Sst/limestone/ ganite/rhyolite/ shale

Table 3.4: Results of pumping test in Rajstahan

Sl. No	Location	District	SWL (m)	Discharge (lpm)	Duration (min)	Drawdown (m)	Transmissivity (m2/day)
1	Shergarh (EW)	Hanumangarh	17.64	350	600	11.21	73.73
2	Chandrana (EW with OW)	Dausa	8.57(EW) 9.05(OW)	220	300	31.50(EW) 3.25(OW)	17
3	Sainthal	Dausa	18.56	180	500	6.50	24.15
4	Boyal(EW)	Jodhpur	11.83	940	540	3.02	-----
5	Tanot	Jaisalmer	5.17	1134	400	5.27	-----
6	Jelu	Jodhpur	32.85	180	300	25.61	-----
7	Longwala	Hanumangarh	31.51	870	600	3.31	1224

Sl. No	Location	District	SWL (m)	Discharge (lpm)	Duration (min)	Drawdown (m)	Transmissivity (m2/day)
8	Panchla	Jodhpur	64.79	300	400	32.41	-----
9	Goluwala	Hanumangarh	21.90	660	600	6.89	397.30
10	Nimbo Ka Talab	Jodhpur	87.87	367	600	8.86	-----
11	Ayalki	Hanumangarh	24.33	1135	600	4.28	1428
12	Mukhaniyo Ki Dhani	Jodhpur	106.0	132	300	27.36	------
13	Shahadpura	Dausa	30.77(EW) 31.45(OW)	100	300	32.0(EW) 0.30(OW)	2.514

3.3 NWR, CHANDIGARH, (Punjab & Haryana)

Ground water exploratory drilling were undertaken in Gurudaspur, Jalandhar of Punjab , Yamuna Nagar, Palwal, Panipat, Karnal, Sonepat of Haryana, total 32 wells have constructed including 4 EW, 4 OW and 24 PZ. Details of Piezometers construction through outsourcing is given in table 3.5 .

Table 3.5: Piezometers construction through outsourcing

Sr. No.	District	Site location	Depth drilled	Length of casing		Slot length	SWL	Discharge
				m.agl	m.bgl	m.	m.bgl	lps
1.	Sonepat	Murthal	104	0.60	71	6	28.60	0.8
2.	Sonepat	Barauli	106	0.60	70	6	7.14	6.67
3.	Sonepat	Manauli	95	0.60	50	8	5.67	5.5
4.	Sonepat	Janti khurd	88	0.60	57	5	8.80	6.28

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

Against the target of 51 wells (13-EW, 10-OW & 28-PZ) for groundwater exploration/piezometer construction during the AAP 2010-11 by deploying 6 Rigs (2-DTH, 4-DR) , 33 (12 EW, 04 OW & 17 PZ) wells have been constructed. Ground water exploration was carried out in Hard rock formations of Banaskantha, Panchmahals and Kachchh districts and alluvial formation in Banaskantha district. Piezometer Construction was taken up in Ahmedabad, Banaskantha, Vadodara districts and coastal Saurashtra (Bhavnagar & Amreli districts). The details are given in table 3.6, 3.7, 3.8.

Table 3.6 :District wise Summarised Details of exploratory wells in Gujrat

Sl No	District	Depth Drilled (mbgl)	Zones tapped / fractures encountered	SWL (mbgl)	Discharge (lpm)	Formation
1	Ahmedabad	450.6 - 358	349 to 379	113 to 114	84 to 132	Unconsolidated formation / Quaternary & Miocene

Table 3.6 :District wise Summarised Details of exploratory wells in Gujrat

Sl No	District	Depth Drilled (mbgl)	Zones tapped / fractures encountered	SWL (mbgl)	Discharge (lpm)	Formation
2	Amreli	258 - 185.9	148 - 221	10.8 - > 100 m	1113	Deccan Trap
3	Banaskantha	101 - 202	14 - 140	14.7 -16.6	150 - 720	Granite- Gneiss
4	Kachchh	450	183 to 246	2.80	8.4	Deccan Trap
5	Mahesana	150	84 - 143	81.5	84	Alluvium (& Sandstone?)
6	Panchamahals	202-200	19 - 149	11.64- 22.8	3.6- 2.25	Metasediment - Quartzite-schist gneiss etc

Table 3.7: Details of piezometer constructed in Gujarat

Sl. No	District	Depth Drilled (mbgl)	Zones tapped / fractures encountered	SWL (mbgl)	Discharge (lpm)	Formation
1	Ahmedabad	26.9-3.5	12m -27m	2.79-3.54	81 -170	Alluvium
2	Amreli	23-43.5	9m - 42 m	2.35-36.6	15-182	Alluvium
3	Banaskantha	30-120	16 m - 119m	12.5-50.21	30-300	Alluvium
4	Bhavnagar	52	18m -34 m	24.8	30	Alluvium
5	Vadodara	46.26	17 m -44m	15.78	42	Alluvium

Table 3.8 :Salient Features of Pumping test results

Sl. No.	Districts	SWL in m bgl	Disch in lpm	T in m^2/day	Sp.Cap in lpm/m	Duration of pumping (in minutes)
1	Dohad (Limbadiya)	8.77	198	25.60	5.262	1000
2	Dohad (Sevaniya)	4.22	235.2	-	16.598	1000
3	Panchmahal (Bakrol)	2.98	72	0.79	0.7492	1000
4	Panchmahal (Saraswa)	12.02	220	-	4.169	1000

3.5 NCR, BHOPAL (Madhya Pradesh)

Ground Water Exploration has been undertaken in Betul, Panna, Damoh & Sagar district of Madhya Pradesh and constructed EW- 43, OW-15, PZ-29, Total-87 wells. District wise summarized details of Ground Water Exploration in the State is given in table 3.9.

Table 3.9 : The Summarised details of the Exploration in Madhya Pardesh.

Sl. No.	District	Depth Drilled (mbgl)	SWL (mbgl)	Discharge (lps.)	Formation
1.	Chhatarpur	19.3-256.2	11-100	0.2-14	Bijawar Limestone and Sandstone/ Shale
2.	Panna	62-202.30	4 - 36	0.50– 7.50	Sandstone and Quarzite
3.	Damoh	61.7-303.5	4-23	0.1-5.5	Vindhyan Sandstone
4	Sagar	50.6-203	4.5-33.1	0.12-3.5	Basalt, Vindhyans and Sandstone
5.	Ujjain	38.4-203	0.6-16.5	1.1-3.5	Vesicular Basalt

3.6 NCCR, RAIPUR, Chhattisgarh

Ground Water Exploration has been undertaken in Mahasamund, Raipur, Durg and Korba district of Chhattisgarh and constructed 56 wells, out of which 22 were exploratory wells (EW), 08 were observation wells (OW) and 26 were piezometers (PZ). Summarized details of Ground Water Exploration in Chhattisgarh is given in table 3.10.

Table 3.10: District wise summarized details of ground water exploration

Sl. No	District	Depth Drilled (mbgl)	Zones tapped/ Fractured encountered (mbgl)	SWL (mbgl)	Discharge (lps)	Draw Down (m)	Aquifer parameter T m2 /day	Formation
1	Durg	21.6-151.9	14-17,27-28, 35-40, 50-58, 78-80	6-40	0.5-13	3-37	5-94	Limestone, &Shale
2	Mahasamund	61-183	34-45,50-54,70-87,107,119	6-20	0.2 -19	14-37		Limestone, Shale & Granite – Gneiss
3	Raipur	110-202	61-65,83-86	4-13	0.2-4.5	30-42		Sandstone,shale and limestone
4	Korba (Hard rock)	62 -200	22-23, 43-44,62-65, 77-80, 88-94,166-167	6-13	0.5-6	25-35	3-8	Granite – Gneiss
5	Korba (Soft rock)	58-201	30-40, 50-70, 140-157	7-13	1	10-30		Sandstone , Shale and Coal seam

3.7 CR, NAGPUR (Maharasthra)

Ground Water Exploration has been undertaken in Amravati, Jalgaon, Beed, Parbhani, Satara and Thane districts for the construction of exploratory bore wells. Altogether 63 wells (34EW, 3 2 OW & 8PZ) have been constructed**.** District-wise summarized details of Ground Water Exploration and high yielding wells is given in table 3.11 and table 3.12.

Table 3.11: Summarized Details of Exploratory Wells drilled in Maharasthra

Sl. No.	Salient Features	Amravati	Jalgaon	Parbhani & Beed	Satara	Thane
1	No. of Wells	EW-2, OW-2	EW-5, OW-3, Pz-2	EW-7, OW-6, Pz-2 & 1EW in Beed	EW-10, OW-8, Pz-2	EW-9, OW-2, Pz-2
2	Depth range (mbgl)	94.00-203.00	55.90-235.00	37.10-200.00	7.70-200.00	80.00-200.00
3	Depth of casing (mbgl)	16.50-52.50	7.00-39.60	3.50-6.10	5.70-16.50	4.50-5.70
4	Number of zones encountered	2-3	1-2	1-6	1-3	1-2
5	Zone Range (mbgl)	48.00-133.00	16.00-153.00	3.5-180.40	10.00-133.40	27.00-195.00
6	SWL range (mbgl)	12.35-32.10	7.71->100.00	0.84 m agl – 22.00	3.17 – 64.50	2.30l – >50.00
7	Yield range (lps)	2.16-10.98	Traces-7.76	Traces-9.84	0.14-10.00	Traces-13.50
8	No. of wells with yield >3 lps	3	4	4	9	2
9	EC range (µmhos/cm) at 25oC.	400-4000	600-3510	310-1780	NA	NA
9	Formation	FVB & FB	FB, Sand & Gravel	FVB	FMB, VB, WVB	FMB, VB, WVB

(Here, F- Fractured, W- Weathered, V- Vesicular, M- Massive, B- Basalt)

Table 3.12: District-wise break up of High Yielding Exploratory Wells.

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	2	2	100%	184.00-203.00	3.77-10.98
2	Jalgaon	5	1	20%	201.00	5.94
3	Parbhani	7	2	29%	123.00-200.00	4.43-5.15
4	Satara	10	6	60%	40.00-200.00	3.00-10.00
5	Thane	9	2	22%	169.00-172.00	5.77-13.50

3.8 NR, LUCKNOW, Uttar Pradesh

Ground Water Exploration has been undertaken in Ghazipur, Ballia, Muzaffar Nagar, Bulandashar, Mathura, Varanasi, Kaushambhi , Allahabad, Mahoba, Chitrakut districts of U.P and constructed 26 EW, 20 OW, 7 PZ (Total 53 Wells). District wise Summarized details of Ground Water Exploration in the State is given in table 3.13.

Table 3.13: District wise Summarize details of Ground Water Exploration

SL No.	District	Depth Drilled in m.	Zone tapped/ Fracture encoun-tered	SWL (mbgl)	Discharge (m^3/hr)	Draw-down (m)	Formation
1.	Ghazipur	67 - 354	55 - 334	4.75 – 8.12	37.4 – 154.5		Alluvium
2.	Baliya	92 - 344	54 - 297	5.35 – 7.5	39.0 – 90.0		Alluvium
3.	Muzaffar Nagar	52 - 450	42 - 300				Alluvium
4.	Bulanshahar	60 - 311	43 - 229	9.1 – 9.15	129.9	4.1	Alluvium
5.	Mathura	32 - 151	17 - 43	1.0 – 8.5			Alluvium
6.	Varanasi	170 - 200	96 - 189	17 – 18.5	81 - 100	3.2 – 3.6	Alluvium
7.	Mahoba	74 - 200	18 - 124	2.5 – 7.5	5.34 - 56		Granite
8.	Chitrakoot	75	68 - 74		18		Sandstone

3.9 M E R, Patna, (Bihar & Jharkhand)

Ground Water Exploration has been undertaken in Begusarai , Bhagalpur, Darbhanga, Patna districts of Bihar State and Bokaro, Khunti , Ranchi districts of Jharkhand state and constructed 26 EW, 20 OW, 7 PZ (Total 53 Wells). District wise Summarized details of Ground Water Exploration in Bihar & Jharkhand States is given in table 3.14 & 3.16 and Piezometerdrilled in Bihar & Jharkhand States is given in table 3.15& 3.17. Summarized Pumping test results of the exploratory wells tested in Bihar & Jharkhand given in table 3.18 & 3.19.

Table 3.14:Details of Exploratory Wells drilled in Bihar (2010-11)

SL. No	Location	District	Depth Drilled (m)	Zones Tapped (m)	Depth of Construction (m)	Formation
1	Teghra	Begusarai	227.5	127-133 146-152 170-182	186	Quaternary Alluvium
2	Mamlakkha	Bhagalpur	132	108-126	129	Quaternary Alluvium
3	Sankar Rohar	Darbhanga	202.56	92-98 110-116 140-158 170-176	179	Quaternary Alluvium

Table 3.15:List of Piezometers drilled in Bihar

S.I. No	Location	District	Depth Drilled (m)	Zones Tapped (m)	Depth of Construction (m)	Formation
1	B.N.College campus, Patna	Patna	194	132-138 152-156 162-166 180-184	186	Quaternary Alluvium
2	Mamlakkha	Bhagalpur	30	16-22	24	Quaternary Alluvium
3	Mamlakkha	Bhagalpur	132	112-124	127	Quaternary Alluvium
4	Sankar Rohar	Darbhanga	93.74	42-48	51	Quaternary Alluvium
5	Sankar Rohar	Darbhanga	202.56	170-182	185	Quaternary Alluvium
6	Samarpura, Baheri, Darbhanga	Darbhanga	202.74	128-140	144	Quaternary Alluvium
7	Samarpura, Baheri, Darbhanga	Darbhanga	56.10	40-49	53	Quaternary Alluvium

Table 3.16: List of exploratory wells drilled in Jharkhand state

Sr. No.	Location	District	Depth drilled (m bgl)	Depth of casing (m bgl)	Depth of fracture zones encountered (mbgl)	Dis-charge (lps)	Static water level (mbgl)	Formation
1	Primary School campus, Marmakudar	Bokaro	153.50	24.27 (7'')	-	Low discharge	-	Granite Gneiss
2	Primary School campus, Marmakudar	Bokaro	199.05	18.28 (7'')	-	Low discharge	-	Granite Gneiss
3	Idgadih, Chandankiyari	Bokaro	184.00	12.14 (7'')	-	Low discharge	-	Granite Gneiss
4	Primary school campus, Pindrajora	Bokaro	180.00	6.00 (7'')	-	Low discharge	-	Granite Gneiss

Table 3.17: List observation wells and Piezometers drilled in Jharkhand state

Sr. No.	Location	District	Type of well	Depth drilled (m bgl)	Depth of casing (m bgl)	Depth of fracture zones encountered (m bgl)	Discharge (lps)	Static water level (m bgl)	Formation
1	Idgadih, Chandankiyari	Bokaro	OW	184.45	12.00 (7'')	-	Low discharge	-	Granite Gneiss
2	Primary school campus, Pindrajora	Bokaro	OW	160.05	6.00 (7'')	-	Low discharge	-	Granite Gneiss
3	Kunjla Khunti	Khunti	OW	105.20	17.78 (8'')	22-26 60-61	5 lps	3.79	Granite Gneiss
4	Forest Ranger Campus, Tamar	Ranchi	Pz	74.70	2.50 (7'')	15.50-17.50	1.8	7.75	Granite Gneiss
5	Judges Colony, Khunti	Khunti	OW	130	17.70	10-13 96-97	4.5		Granite Gneiss
6	Pindrajora	Bokaro	PZ	53.25	5.40	5.5-6.5 11-12 30-31	2.5		Granite Gneiss

Table 3.18: Summarized Pumping test results of the exploratory wells tested in Bihar

Sl. No	Location	District	SWL (m bgl)/	Discharge (m3/day)	Drawdown (m)	T (m2/day)	S
1	Tajpur	Jamui	5.64 (8/8/2010)	450	22.06	55	5.9*10-5
2	Barauni Flag	Begusarai	7.51 (20/5/2010)	4310	9.11	7888	9.2*10-5
3	Churamanpur	Buxar	7.23	4736	3.62p	7884	1.8*10-5
4	Numer	Jamui	4.36 (16/12/2010)	432	11.48	34	8*10-4
5	Ramankabad	Munger	2.93 (12/3/2011	330	22.49	33.5	1.36*10-3

Table 3.19: Summarized Pumping test results of the exploratory wells tested in Jharkhand

Sr. No.	Location	District	Type of well	SWL (mbgl)	Discharge (m3/day)	Drawdown (m)	T (m2/day)	S
1	DAV School, Doranda	Ranchi	PZ	22.01	417.312	10.66	23.51	0.0013 (PZ – II) 0.010 (PZ – III)
2.	NIFFT campus, Hatia	Ranchi	PZ	11.61	287.712	22.05	65.85	-
3	War Memorial premises, Dipa Toli	Ranchi	PZ	12.93	760.32	12.04	39.22	--
4	Pandripani	Simdega	EW	6.25	313.632	40.37	3.27	-
5	Joram	Simdega	EW	4.38	872.64	24.12	87.68	-
6	Lachragarh	Simdega	EW	7.69	324.00	30.88	3.66	-
7	Harmu Housing Colony	Ranchi	PZ	23.69	1211.328	9.41	113.17	-

3.10 ER, KOLKATA, (West Bengal)

Ground Water Exploration has been undertaken in Jalpaiguri, Birbhum, Nadia, North 24 Paragana, Dakshin Dinajpur, Bankura & Hugli districts of West Bengal and constructed 23 wells(13 EW, 10 OW) . District wise Summarised Details of Ground Water Exploration and pumping test in the State is given below table 3.20 & 3.22. Ground Water Exploration (Through Outsourcing is given table 3.21.

Table 3.20: District wise Summarized Details of Ground Water Exploration

Sl. No	District	Depth drilled (mbgl)	Zones tapped / fracture encountered (m bgl)	SWL (m bgl)	Discharge in m3/hr	Formation	Remarks
1	Jalpaiguri	100.00	72-96	1.13	97.2	Boulder Formation	Disposition & potentialities of aquifers
2.	Birbhum	85-215	38-250	11-17	7-126	Alluvium	Identify extension of Fluoride contaminated aquifers & to delineate Fluoride free aquifers.
3.	Nadia	302-325	146-260	4.30-4.36	90-123	Alluvium	Delineate extension of arsenic free aquifers
4.	North 24 Parganas	40.09	22.50-26.50	6.5	23.40	Alluvium	Delineate extension of arsenic free aquifers
5.	South 24 Parganas	Basanti Block 325.02	18-310.00	1.82-9.82	0.58-79.20	Alluvium	Delineate potable aquifer disposition for drinking water supply,
6.	Dakshin Dinajpur	81-136	59-128	13.47	0.3-15.84	Alluvium	Identify extension of Fluoride contaminated aquifers & to delineate Fluoride free aquifers
6.	Hugli	Goghat I Block 225	40-219.00	14.55-17.9	15.84-36	Alluvium	Aquifer disposition & potentiality of shallow as well as deeper aquifers.

Table 3.21: Ground Water Exploration (Through Outsourcing):

Target	District	Location	Depth drilled/ Well constructed (mbgl)	Zones tapped/ fractures encountered (mbgl)
100 nos	Murshidabad	Purapara, Khargram Block	51.81 / 46.90	34.40 – 44.40
		Joypur, Khargram Block	50.59 / 46.00	33.00 – 43.00
		Gatla, Khargram Block	50.60 / 45.00	33.00 – 43.00
	Nadia	Babla, Santipur Block	50.60 / 43.00	30.48 – 40.48
		Bathna, Santipur Block	51.81 / 47.90	34.40 – 44.40
		Kritibas, Santipur Block	51.81/ 48.00	34.40 – 44.40

TABLE 3.22: DETAILS OF PUMP TESTS CONDUCTED

Sl. No.	Location / Block/ Dist.	Geology	SWL (mbgl)	Discharge (lps)	Draw Down (m)	Duration of pumping (min)	T (m^2 / day)	Storativ-ity (S)
1.	Margram , Rampurhat-II, Birbhum	Alluvium	13.73	3.67	9.96	350	72.47	$4.81x10^{-8}$
2.	Rameshwarpur, Pandua , Hugli	Alluvium	21.75	2.75	2.27	300	621.67	$2.16x10^{-5}$
3.	Margram , Rampurhat-II, Birbhum	Alluvium		6.63	0.54	360	1748.06	
4.	Tinna , Pandua, Hugli	Alluvium	17.10	4.40	2.03	300	496.93	$1.10x10^{-4}$
5.	Mandlai, Pandua Block, Hugli dt.	Alluvium	16.44	5.5	2.51(EW) 0.59 (OW)	300	483.13	$7.76x10^{-5}$
6.	Karbola, Bhangar II Block, South 24 Parganas dt.	Alluvium	5.50	4.4	1.22	360	695.71	0.00813
7.	Karbola , Bhangar II Block, South 24 Parganas dt.	Alluvium	5.12	5.15	0.76	360	2670.40	
8.	Pairachina , Pandua block, Hughli district	Alluvium	2.70	9.97	2.82	400	1313.24	0.000158
9.	Chaumaha, Barasat II block	Alluvium	4.02	3.33	11.43	240	175.68	

3.11 N ER, GUWAHATI (North East States)

Ground Water Exploration has been undertaken in Cachar and Karimganj , Marigaon district , Sonitpur, Kamrup, Lakhimpur & Dhemaji districts of Assam and constructed 26 wells(20 EW, 6 OW) . District wise Summarised Details of Ground Water Exploration in the State is given below table 3.23.

Table 3.23: Summarised Details of ground water exploration in Assam

District	Depth drilled (m) bgl	Zones tapped/ fractures encountered	S.W.L (m bgl)	Dicharge m^3/hr.	Drawdown (m)	Aquifer parameters (T&S)	Formation
Marigaon	52-125				-		Alluvial
Cachar	132.50						
Karimganj	182.30						
Lakhimpur	61-68	39-66	3-5	15-54	2.12	T= 1581.87 m^2/day, S=1.52x10^{-4} (Charaidolon)	-- do --
Sonitpur	85-137	36-94	3.29-7.26	15-37	0.3-2.0 M	T= 1247-1983 m^2/day, S=1.14-1.52x10^{-4}	-- do --
Kamrup district Assam,	35-106	11 – 91	1-9	1-16	3.9-15	T= 7.56-657 m^2/day	Alluvium / Valley fill/ granite-gneiss

3.12 SER, BHUWANESHWAR, (Orissa State)

During the Year 2010 – 11, ground water exploration was taken up in the different districts of Orissa covering the consolidated, semi-consolidated and un-consolidated formations. Against a drilling target of 44 exploratory wells, 19 observation wells and 20 Pz, 43 numbers of exploratory wells, 14 observation wells and 16 Pz were drilled in Deogarh, Sonepur, Cuttack/Jajpur, Mayurbhanj, Nuapada and Sundargarh/Dhenkanal districts. Out of these 73 wells drilled, 40 exploratory wells and 12 observation wells were drilled in the consolidated formation and 3 exploratory well and 2 observation well was drilled in the unconsolidated formation. District wise Summarized details of Ground Water Exploration in Orissa is given 3.24.

Table 3.24:District wise Summarized details of Ground Water Exploration in Orissa

Sl No	District	Depth Drilled	Zones tapped / Fractures Encountered	SWL	Discharge	Drawdown	(T)	Formation/ Aquifer
		mbgl	mbgl	mbgl	lps	m	m^2/day	
1.	**Keonjhar EW: 7,OW: 2 Pz: 3**	56.1-196.6	9,10.5,22.8,53.2,61.5,72.7,102.3116.2,118.3,120.3,176.2	4-12.4	0.5-8	3.25-22.55	6.14-36.99	Granite Gneiss, Granite&Quarzofeldspathic
2.	**Jajpur/Cuttack-Alluvium EW: 2,OW: 2**	166.2- 3.5	16 – 28, 64-75,		15-20			Recent Alluvium
3.	**Nuapada EW: 6,OW: 3 Pz: 4**	62.3-184.1	25.70, 27.80, 31.80,58.3,69.5,75.5,80, 98.2,158	3.14-7.14	0.2-6.5	11.3-31.9	3.04-41.6	Granite
4.	**Mayurbhanj EW: 9,OW: 3 Pz : 4**	56.4-178.4	24,26,35,45,50,91,102,111	4.91-5.89	0.5-12	11.5-19.3	0.1873-71.73	Granite Gneiss,
5.	**Sonepur EW: 10,OW:: 2 Pz :4**	46 -200.2	14-20,26-32,32-45,104-105	2.1-11.1	0.44-12.2	3.22-16.83	1.32-48.18	Granite
6.	**Sundargarh/ Dhenkanal EW: 8,OW: 2 Pz :1**	57 – 184.6	24-26,46-49,77-78,102-103	1.81-12.7	0.5-7.5	-	9.26-11.33	Khondalite, Charnockite

3.13 SR, HYDERABAD, Andhra Pradesh

Ground water exploration was undertaken in Ranga Reddy / Karimnagar, Nizamabad/Adilabad /Hyderabad, Krishna/Ranga Reddy, Warangal and East Godavari districts of Andhra Pradesh and constructed 118 wells (18 EW, 4 OW, 96PZ). District-wise targets and achievements is given in table 3.25.

Table 3.25:District-wise targets and achievements

S No	District	Target				Achievement			
		EW	OW	PZ	Total	EW	OW	PZ	Total
1	Ranga Reddy / Karimnagar(Normal-Pz-35 m)	-	-	20	20	-	-	20	20
2	Nizamabad/Adilabad /Hyderabad (Normal-200 m)	6	2	25	33	7	2	31	40
3	Krishna/Ranga Reddy (Normal-200 m)	3	2	15	20	1	-	11	12
4	Warangal (Normal-EW-200m Pzs-35 m)	6	2	25	33	7	1	34	42
5	East Godavari (Normal-100/150 m)	3	1	2	6	3	1	-	4
	Total	18	7	87	112	18	4	96	118

3. 14 SWR, BANGALORE, Karnataka

Ground Water Exploration was undertaken in Chamarajanagar, Hassan, Chikkaballapur & Gulbarga district of Karnataka and constructed 59 wells(43 EW , 14 OW & 2 PZ). District wise summarised details of ground water exploration is given in table 3.26:

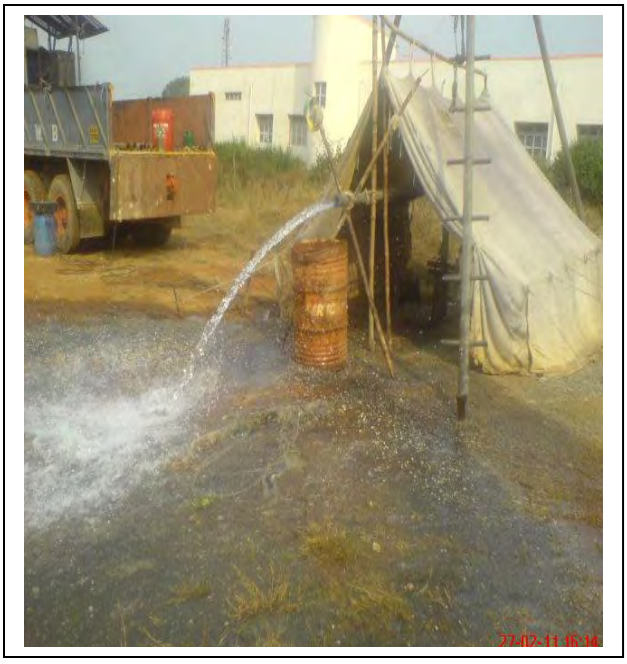
Table 3.26:District wise summarized details of Ground Water exploration in the state (in range)

District	Depth Drilled in mbgl	Zones Tapped/ Fracture Encountered (m)	SWL (mbgl)	Discharge (m3/hr)	Draw Down (m)	Aquifer Parameter T (m2/d)	Formation
Chamarajanagar	77.25– 176.85	18.10-156.65	7.16-38.37	0.288-78.192	1.21-17.10*	-	Gneiss
Hassan	123.80 – 207.28	13.20 – 163.44	4.03 - 21.00	0.28 to 57.88	1.13 – 18.17	5.04 – 577.60	Granitic Gneiss
Chikkaballapur	184 to 500.70	From 29 to 381 mbgl	5.22 to > 100	4.33 to 42.29	3.3 m to 15.78 m	12 – 35.6	Granitic gneiss
Gulbarga	206.0-302.30	-	1.7 to >200	Neg to 33.45	-	-	Basalts , L.st, Shale and Gr.Gneiss

Ground Water Exploration at Devinagar Tanda EW, Parbhani district

Drilling operations at Southern Region at Hyderabad

Auto flow well at Gaur EW, Purna Taluka, Parbhani district



Drilling at Anugavalli, Hassan District, Karnataka

3.15 SECR, CHENNAI, Tamil Nadu

Ground Water Exploration was undertaken in Cuddalore,Kancheepuram, Tiruvallur & Vellore, Salem, Coastal sedimentary tracts of Neyveli Hydrogeological Basin and Coastal sedimentary tracts of Neyveli Hydrogeological Basin of Tamil Nadu and constructed 46 wells(8 EW, 11 OW & 27 PZ). District wise Summarized details of ground water exploration in the State is given in table 3.27. Construction of Peizometers through outsourcing in Tamil Nadu is given in table 3.28.

Table 3.27: District wise Summarized details of ground water exploration

District	Depth drilled/constructed depth (mbgl)	Zones tapped/Fractures Encountered (m)	SWL (mbgl)	Discharge (m3/hour)	Formation
Salem	62 to 200	8 .0 – 8.5 to 118.18 - 119.18	3.35 to >50	<1 to 59	Gneiss
Tiruvallur	30 to 200	22 – 22.5 to 55 to 55.5	3.67 to 32.4	Neggligible to 35.4	
Vellore	60 to 200	5.5 – 5.75 to 169 - 170	1.65 to 28.5	Neggligible to 36.4	Gneiss
Ariyalur	400	124-132, 210-228, 260-278, 300-315, 325-337, 380-389	4.4 m agl (Flowing Well)	90	Cuddalore S. St.
Cuddalore	70 to 186	75 – 81 to 180 - 186		41 - 44	Cuddalore S. St

Table 3.28:Construction of Peizometers (Through Outsourcing) :

	Depth (m)	Target (Nos.)	Achievement (Nos.)
Construction of piezometers (outsourcing)	60	108	108
	200	75	75
Total		183	183

3.16 KR, TRIVENDRAM, Kerala

Ground Water Exploration was undertaken in Pathanmitha, Palghat & Trissur districts of Kerala and constructed 35 wells(25 EW & 10 OW). District wise summarized details of ground water exploration in the state is given in table 3.29.

Table 3.29: District wise summarized details of ground water exploration in the state

Sl. No.	District	Depth drilled (m bgl)	Zones tapped/ fractures encountered (m bgl)	SWL (mbgl)	Discharge m3/hr	Draw down (m)	Aquifer parameters (T &S)		Formation
							T	S	
1.	Pathanamthitta	23-200	10-176	1.6- >50	Negligible-46.008	3.5 -29.85	2 - 106	0.00044-0.0068	Hornblende biotite gneiss. Charnockite Alluvium Biotite gneiss
2.	Thrissur	95.25 - 101	20 - 89	3.3 -14.45	Negligible -0.5	7.48 - 27.76	20 - 33	0.00017-0.001	Hornblende biotite gneiss. Charnockite Biotite gneiss
3.	Palakkad	50-101	25-82	3.70-8.65	2.00 – 6.00	13.39-14.89	105	-	Hornblende biotite gneiss. Charnockite

Free flow exploratory tube well drilled at Karaikurichy in the Neyveli Hydrogeological Basin, Ariyalur district tapping Cuddalore sandstone

High yielding piezometer drilled at Mallapanur in Salem District (31 lps)

3.17 NHR, DHARAMSALA, Himachal Pradesh

Ground Water Exploration was undertaken in Kangra/Solan, Hmirpur/Bilaspur, & Kangra/Mandi district of HimachaL Pradesh and constructed 6 wells(6 EW). District wise summarized details of Ground Water Exploration in the State is given in table 3.30.

Table 3.30:District wise summarized details of Ground Water Exploration in the Himachal Pradesh

S. No	District	Depth Drilled (m)	Zones tapped/ Fracture encountered (m)	SWL (mbgl)	Discharge (lpm)	Drawdown (m)	Aquifer parameter (T &S)	Formation
1.	Kangra	45-63	17-18 to 54-57	4.72	60-480	32.32	79.27	Valley Fills / Morainic Deposits
2.	Hamirpur	47.30	11-12 to 45-47	-	-	-	-	Valley Fills
3.	Mandi	50.00	10-14 to 33.36	3.26	999.24	4.83	658.81	Valley Fills

3.18 UR, DEHRADUN, Uttarakhand

Ground Water Exploration was undertaken in Dehradun & Pauri Garhwal district of Uttarakhand and constructed 2 wells (2 EW). District-wise Summarized Details of Ground Water Exploration in the State is given in table 3.30.

Table 3.30: District-wise Summarized Details of Ground Water Exploration in the State (in range)

Sl. No.	District	Depth Drilled (m)	Zones Tapped (m)	SWL (mbgl)	Discharge (m3/hr)	Drawdown (m)	Formation
1.	Dehradun	133.0	63-66, 69-71,74-77,88-94, 100-106,108-111 115-118,121-126	54.27	11.4	0.70	Doon Gravels
2.	Pauri Garhwal	28.0	10-18	5.07	114.0	3.70	Flood Plain of River Alaknanda

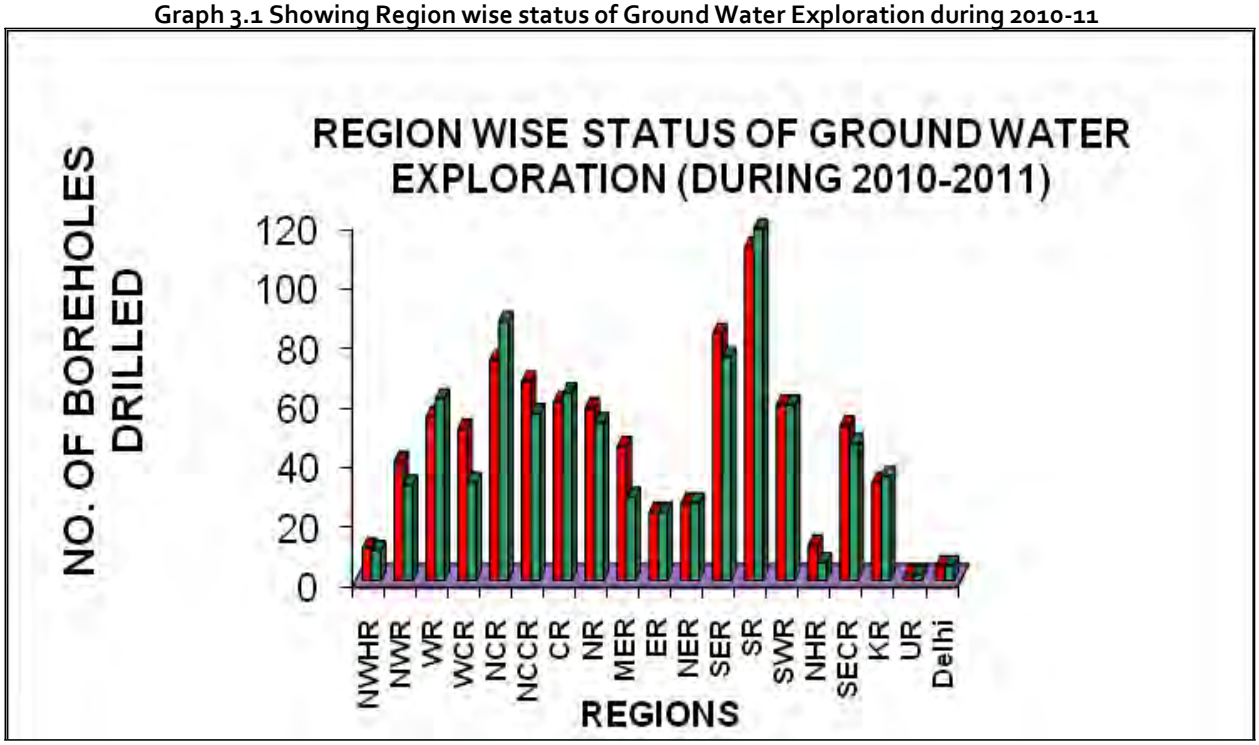
3.19 STATE UNIT OFFICE, DELHI

Ground Water Exploration was undertaken in West and South West Delhi district of Delhi and constructed 5wells (1EW, 1 OW and 3 PZ). District-wise Summarized Details of Ground Water Exploration in the State is given in table 3.31.

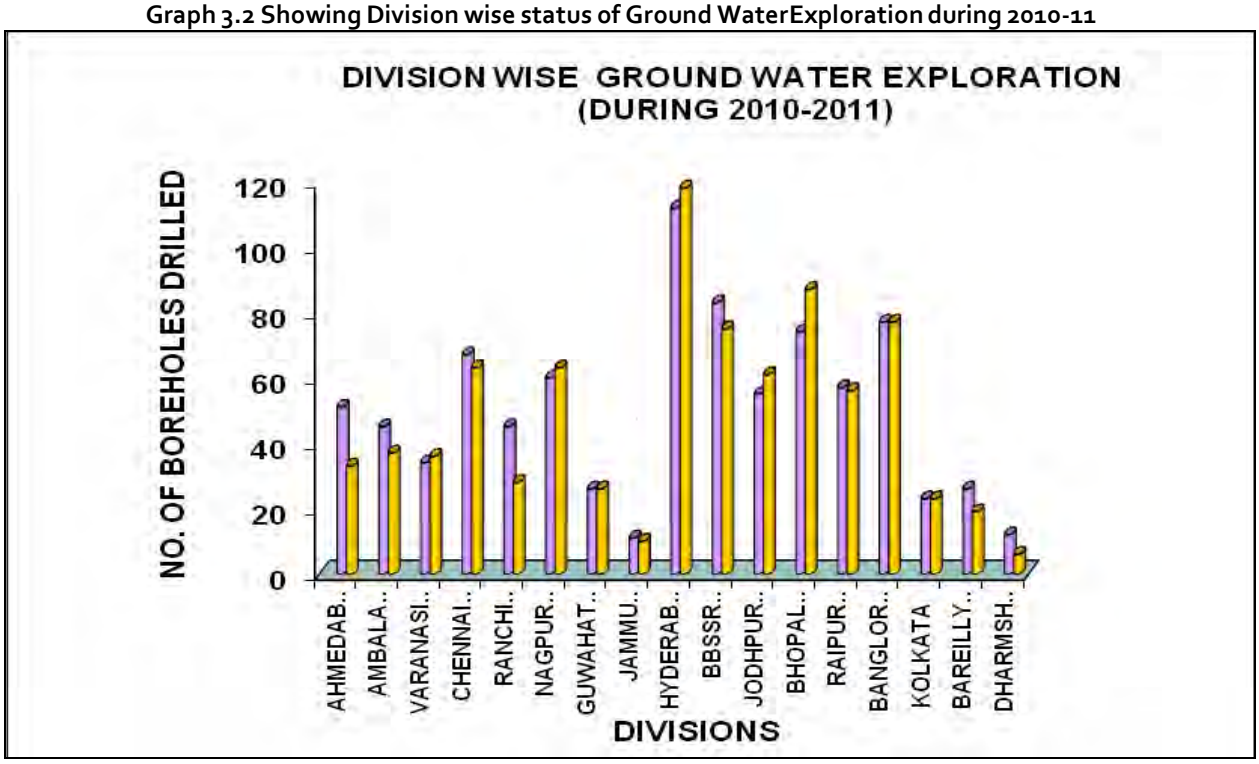
Table 3.31:District wise summarized details of Ground Water Exploration in Delhi

Sl No.	District	Depth Drilled in (m)	Zones tapped	SWL (m bgl)	Discharge m3/hr	Formation
1.	West	62.27-184.48	25.50-27.50,30.50-33.50, 45.50-48.50	17.15-18.50	15-22	Older alluvium
2.	South West	96.25-146.24	57.50-59.50, 69-71,77-80	64.10-65	6-9	Older alluvium

Graph 3.1 Showing Region wise status of Ground Water Exploration during 2010-11



Graph 3.2 Showing Division wise status of Ground WaterExploration during 2010-11



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 conducting, 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 155 wells were developed and tested during the year 2010-2011. Region wise achievement has been presented in Table 4.1

Table 4.1: Regionwise/Statewise Pumping Tests Conducted in the Year 2010 – 2011

Sr. No.	Regions	State/ Union Territories	No of wells tested during 2010-11 Upto March,2011		
			No. of E. wells constructed during 2010-11 and tested	No. of E. wells constructed in earlier Year and tested	Total No. of wells tested
1	NWHR, Jammu	Jammu & Kashmir	1	3	4
2	NWR,Chandigarh	Haryana	0	1	1
		Punjab	1	3	4
		Delhi	0	0	0
3	WR, Jaipur	Rajasthan	11	4	15
4	WCR, Ahmedabad	Gujrat	1	3	4
5	NCR, Bhopal	Madhya Pradesh	0	3	3
6	NCCR, Raipur	Chhattisgarh	2	9	11
7	CR, Nagpur	Maharashtra	3	2	5
8	NR, Lucknow	Uttar Pradesh	1	5	6
9	MER, Patna	Bihar	0	3	3
		Jharkhand	0	9	9
10	ER,Kolkata	West Bengal	0	8	8
11	NER, Guwahati	Assam	7	4	11
		Arunachal Pradesh	0	0	0
		Meghalaya	0	0	0
		Tripura	0	0	0
12	SER ,Bhubneswar	Orissa	8	14	22
13	SR, Hyderabad	Andhra Pradesh	2	23	25
14	SWR, Bangalore	Karnataka	2	4	6
15	SECR, Chennai	Tamilnadu	3	1	4
16	KR, Kerala	Kerala	5	3	8
17	NHR, Dharamshala	Himachal Pradesh	13	5	6
18	UR, Dehradun	Uttarakhand	0	0	0
TOTAL			**48**	**107**	**155**

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 2011, a total of 13656 wells have been drilled, out of which 10761 successful exploratory wells were offered for handed over and only 5711 wells have so far been accepted /taken over by State Governments while 4043 successful wells are yet to be accepted/ taken over by them and only 1007 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 31-03-2011 is presented in table 5.1

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Table 5.1: Handing over of wells drilled by CGWB (As On 31.03.2011)

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	1251	902	728	139	35
2	Arunachal Pradesh	32	28	14	3	11
3	Assam	355	304	120	88	96
4	Bihar	276	223	61	143	19
5	Chhattishgarh	589	533	160	311	62
6	Goa	58	49	0	49	0
7	Gujarat	918	599	431	104	64
8	Haryana	366	197	145	49	3
9	Himachal Pradesh	184	170	77	65	28
10	Jammu & Kashmir	329	262	160	72	30
11	Jharkhand	301	252	75	149	28
12	Karnataka	1227	1066	471	489	106
13	Kerala	421	307	238	49	20
14	Madhya Pradesh	929	618	492	69	57
15	Maharashtra	1140	949	794	126	29
16	Manipur	25	15	14	0	1
17	Meghalaya	80	69	14	18	37
18	Mizoram	3	3	3	0	0
19	Nagaland	11	7	5	1	1
20	Orissa	1321	1257	405	798	53
21	Punjab	172	148	79	58	11
22	Rajasthan	1108	804	251	525	28
23	Sikkim	31	10	6	0	4
24	Tamilnadu	919	666	496	149	21

25	Tripura	60	54	36	12	6
26	Uttarakhand	56	46	23	10	14
27	Uttar Pradesh	821	675	190	342	143
28	West Bengal	429	377	135	184	58
Total		**13412**	**10590**	**5623**	**4002**	**965**
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	149	131	61	31	39
5	Pondicherry	30	13	13	0	0
Total		**244**	**171**	**88**	**41**	**42**
GRAND TOTAL(A+B)		**13656**	**10761**	**5711**	**4043**	**1007**

6. WATER SUPPLY INVESTIGATIONS

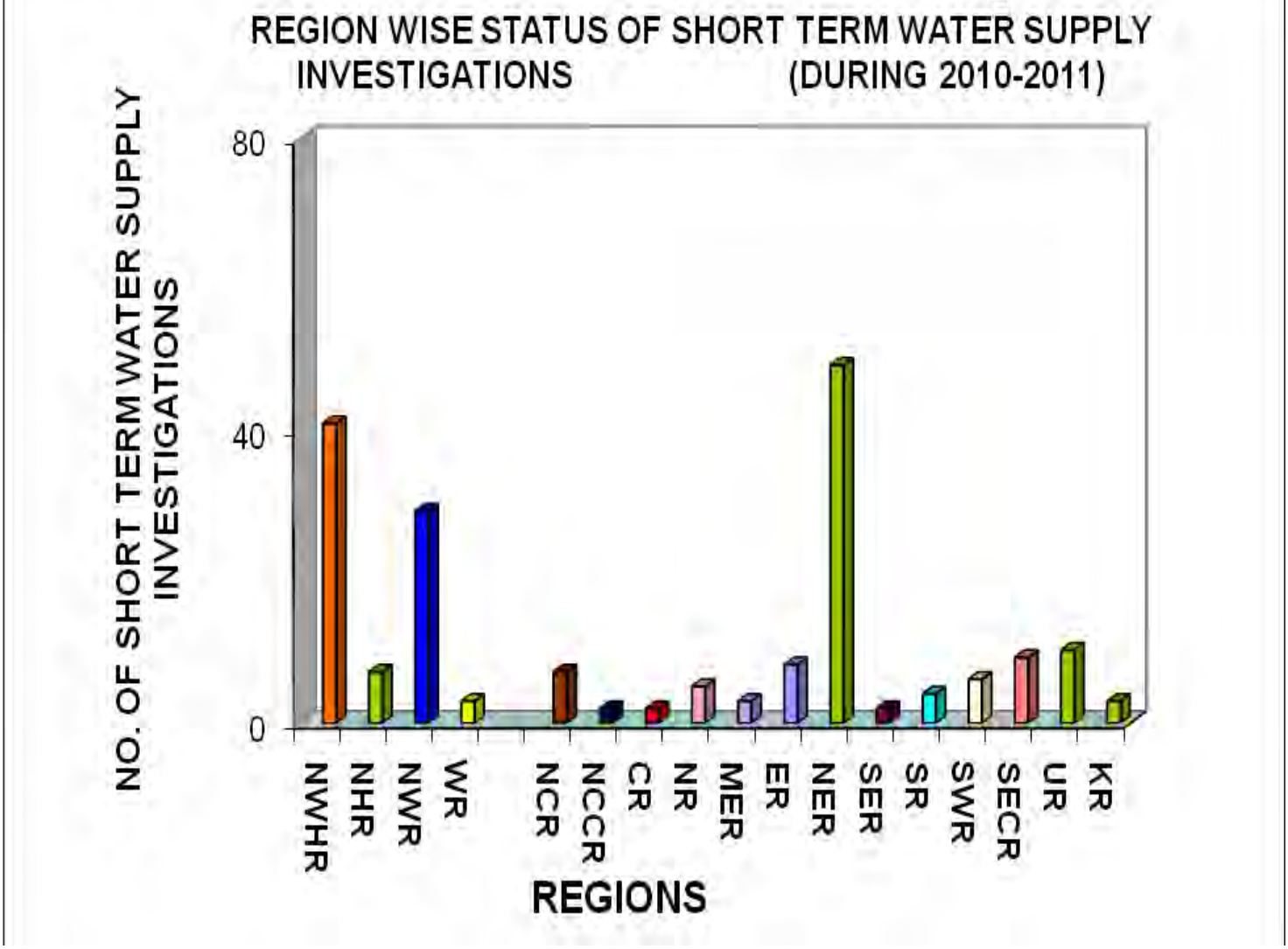
The Board provides assistance to defence and Govt. Agencies establishments to solve their immediate water supply problems by selecting suitable sites for construction of ground water abstraction structures. During 2010-11, 190 Water Supply Investigations were carried out and region wise/state wise status is given in table 6.1 and fig. 6.1.

Table 6.1 : Region/Statewise Water Supply Investigations Taken up During 2010-2011

Sl. No.	Regions	States	Number of Water Supply Investigations
1	NORTHERN WESTERN HIMALAYAN REGION	Jammu & Kashmir	41
2	NORTHERN HIMALAYAN REGION	Himachal Pradesh	07
3	NORTH WESTERN REGION	Punjab	18
		Haryana	05
		Chandigarh	02
		Delhi	04
4	WESTERN REGION	Rajasthan	03
5	WEST CENTRAL REGION	Gujarat	0
6	CENTRAL REGION	Maharashtra	02
7	NORTHERN REGION	Uttar Pradesh	05
8	UTTARANCHAL REGION	Uttaranchal	10
9	EASTERN REGION	West Bengal	08
10	NORTH CENTRAL REGION	Madhya Pradesh	07
11	NORTH CENTRAL CHATTISGARH REGION	Chhattisgarh	02
12	MID EASTERN REGION	Bihar & Jharkhand	03
13	NORTH EASTERN REGION	Assam,Meghalaya,Arunachal Pradesh	49
14	SOUTH EASTERN REGION	Orissa	02
15	SOUTERN REGION	Andhra Pradesh	04
16	SOUTH WESTERN REGION	Karnataka	06
17	SOUTH EASTERN COASTAL REGION	Tamil Nadu	09
18	KERALA REGION	Kerala	03
Total			190

Graph 6.1 Showing Short term Water Sypply Investigations during 2010-2011

Fig. 6.1



7. HYDROLOGICAL AND HYDROMEOTEROLOGICAL 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 various reports.

7.1 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 2010-11 and utilized the same to estimate district mean monthly, seasonal and annual rainfall. The data is being analyzed and used to compute the ground water level monitoring data.

- Percent deviation of rainfall of May 2009-May 20010, Aug 2009-Aug 2010, Nov 2009- Nov 2010 and Jan 2010 to Jan 2011 with respect to respective month of the same period were calculated.
- Analyzed rainfall data along with graphs and also prepared a write up on hydrometeorology part of used Ground Water Year Book.

7.2 WESTERN REGION (Rajasthan)

The following work has been carried out during 2010-11.

- Filling up the gaps of rainfall data of period 1991 to April, 2010. Completed entries of rainfall data of year 2009-10
- Entered rainfall data of May, 2010 received from IMD

7.3 NORTH CENTRAL REGION (Madhya Pradesh)

During the year 2010-11, the existing hydrometeorological data such as maximum & minimum temperature, wind velocity, Relative humidity and rainfall have been collected for Sidhi & Singrauli District. The normal isohyetal map & different seasonal rainfall have been also worked out for the above districts. A detailed note on climatology of Singrauli & Sidhi district has been prepared for the district reports of the respective district. The monsoon rainfall of 2010 has been also collected for all existing station of M.P. Monsoon isohyetal map of MP prepared.

The departure of monsoon rainfall from the normal also worked out isohyetal map of 2010 and departure of rainfall of M.P. also prepared. A detailed note on rainfall distribution over M.P. during the 2010 monsoon trend has been prepared for the Ground Year Book 2010.

7.4 CENTRAL REGION (Maharashtra)

7.4.1 Climatological Input for District & RHS Reports:-

Climatological inputs were provided for the compilation of District Reports of Bhandara and Ratnagiri districts. These Climatological chapters include detailed analysis of rainfall of all rain gauges in the district with isohyetal maps, temperature, relative humidity and wind speed and direction. The following maps were also prepared.

- 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, analysis of 20 years of rainfall data (1990-2009) of all district headquarters of Maharashtra is under progress.

7.4.2 Development of hydrometeorological data base: -

Updated and maintained hydrometeorological database of Maharashtra, which includes:

- Monthly RF data upto 2009 for 34 Observatory Stations Maharashtra was entered in Hydromet database.

7.4.3 Hydrometeorological Data Analysis for Ground Water Year Book

The hydrometeorological data for Ground water Year Book for 2009-10 was analysed and were prepared for inclusion in the yearbook.

7.5 NORTHERN REGION (U.P.)

Hydrometerological studies with findings/conclusion :

1. Measurement of daily rainfall data of Bhujal Bhawan rain gauge station

2. Compilation & computation of monthly & annual rainfall data for the period 2004-2008 for Kanpur & Kannauj district
3. Computation & computation of monthly & Annual rainfall data for 2004 to 2008 for all the seventy district of Uttar Pradesh for preparation of State Report and for 2009 for preparation of Year Book.
4. Preparation of Isohytal Map from mean Annual Rainfall of the period 2004 – 2009 for State report
5. Preparation of Histograms of mean Annual rainfall of all seventy districts of UP
6. Write up of Hydro meteorological Chapter for Year Book, State Report & two district reports

7.6 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.

7.7 SOUTH WESTERN REGION (Karnataka)

During this year, rainfall data pertaining to the year 2010 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 2010.

Rainfall Distribution During 2010:

The Rainfall pattern for various geomorphological units for different seasons is described in the following paragraphs.

South west Monsoon Season (June – September)

During the period from 1st June to 30th September 2010, the state as a whole recorded an actual amount of 890mm of rainfall as against the normal rainfall of 833 mm with percentage departure from normal being **7%** and state falls under normal category. Taluk-wise rainfall category during Southwest monsoon is shown in Fig 9.

South-Interior Karnataka: The Cumulative rainfall was excess in Bangalore rural, Tumkur, Chitradurga, Davanagere and Mandya districts and normal in Bangalore urban, Ramanagara, Kolar, Chikkaballapura, Chamarajanagara and Mysore districts. Among the 63 taluks, rainfall was excess in 32 taluks, normal in 30 taluks and deficit in one taluk. Last year for the same period rainfall was excess in 44 taluks, normal in 17 taluks and deficit in 2 taluks.

North Interior Karnataka: The Cumulative rainfall was excess in Bellary, Koppala, Raichur, Bidar, Bagalkote, Gadag and Yadgir districts and normal in Gulbarga, Belgaum, Bijapur, Haveri and Dharwad districts. Among the 69 taluks, rainfall was excess in 42 taluks, and normal in 27 taluks. Last year for the same period rainfall was excess in 34 taluks, normal in 30 taluks and deficit in 5 taluks.

Malnad Region: The Cumulative rainfall was normal in all the 4 districts of this region. Among the 25 taluks, rainfall was excess in 8 taluks, normal in 13 taluks and deficit in 4 taluks. Last year for the same period rainfall was excess in 12 taluks, normal in 10 taluks and deficit in 3 taluks.

Coastal Region: The Cumulative rainfall was and normal in all the 3 districts of this region. Among the 19 taluks, rainfall was excess in one taluk, normal in 16 taluks and deficit in 2 taluks. Last year for the same period rainfall was excess in one taluk, normal in 16 taluks and deficit in 2 taluks.

Northeast Monsoon Season (October – December)

South Interior Karnataka: The Cumulative rainfall was excess in Chitradurga & 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.

District-wise cumulative rainfall during 2010 annual period is shown in Table 7.1

Table 7.1: District-wise cumulative rainfall during 2010 (annual)

Sl.	District	Norm	Actua	%
1	Bangalore	867	882	2
2	Bangalore	790	961	2
3	Chitradurga	570	1060	8

4	Davanagere	657	1031	5
5	Kolar	723	936	2
6	Shimoga	1819	2049	1
7	Tumkur	719	1051	4
8	Ramanagara	853	854	0
9	Chikkaballapur	744	884	1
1	Chamarajanaga	816	809	-
1	Chikkamagalur	1904	2103	1
1	D.Kannada	3911	4149	6
1	Hassan	987	1291	3
1	Kodagu	2642	2274	-
1	Mandya	722	893	2
1	Mysore	766	1029	3
1	Udupi	4182	4848	1
1	Bellary	636	872	3
1	Bidar	885	1153	3
2	Gulbarga	842	963	1
2	Yadgir	832	968	1
2	Koppala	583	774	3
2	Raichur	681	712	5
2	Bagalkote	586	647	1
2	Belgaum	823	893	8
2	Bijapur	631	565	-
2	Dharwad	786	842	7
2	Gadag	630	754	2
2	Haveri	777	992	2
3	Uttara Kannada	2885	3237	1
	STATE	**1151**	**1343**	**1**

7.8 SOUTH EAST COASTAL REGION (Tamil Nadu)

To ascertain interaction between surface water flow in the river and ground water levels in parts of Palar basin in Tamil Nadu.

Background information:

Total study area : Drainage area of Palar in Tamil Nadu State (10146 sq.km)

Administive Units (Block): The Palar basin area in Tamil Nadu is distributed in 11 blocks of Kancheepuram district, 13 blocks of Tiruvannamalai district and 16 blocks of Vellore district either fully or partly.

Findings

The ground water level data of Arcot, Devadanam, Walajabad and Chengalpattu has been correlated with the respective flow data measured at different parts of Palar River. Based on the analysis and behaviour of hydrographs during the period of peak flow years, it is observed that the surface water flow in the river system is immensely contributing to the ground water regime in addition to the natural recharge. This is observed in the post monsoon hydrographs, where steep rise in the graph recorded corresponding to the peak river flow years. In order to separate the natural recharge from rainfall and volume of recharge from river, a detailed study is required at least for 1 year. During the detailed study more ground water control wells need to be established radially on either side of river to ascertain the extent of impact.

The pre monsoon ground water hydrograph of all the wells also revels that the pre monsoon water level of wells remain shallow during the next few consecutive years and become deep during the years when the river was dry. The recharge contributed from the river flow to the ground water system is minimizing the risk of de-saturation of phreatic zones during the lean /drought years.

The composite hydrograph plotted with discharge data of 4 stations for the period of 1979 – 2006 reveals that there was significant flow in the entire basin only in 11 years out of 27 years and the same was recorded in all the 4 gauging sites. Rest of the years some of stations recorded either minimum flow or nil discharge. Maximum discharge recorded during the year 1996-97 and nil discharge notice in many years. Years between 1986 to 1991 and 1999 to 2004 are considered to be the dry years, as the flow in the basin was recorded almost dry in all the 4 stations. Out of 27 years, 8 years the river discharges a good amount of flow into sea as surplus flow the same was recorded at Chengalpattu.

Further, it is suggested that mathematical modeling with minimum 3 years of observed data will give an exact picture on the quantum of impact of river flow on the ground water regime and forecast for the extreme conditions (surplus flow or drought periods).

The present interim report prepared based on the available data only. The data available is not sufficient to give clear picture of the system and a detailed study is required.

Hydrometeorological study in respect of Pathanamthitta district.

Variablity of rainfall over Pathanamthitta district has been analysed to understand the behavioral pattern of rainfall over the district. The analysis and findings of the study is as given as below.

The climate of the district is characterised by hot summer and rainfall both in the SW and NE monsoon seasons. The year may be divided into four seasons. Mid-December to February is the comparatively cool period of the year. March to May is the hot season. The southwest monsoon season, which follows, lasts till September. October to December constitutes the northeast monsoon season.
Annual rainfall as well as seasonal rainfall (SW and NE monsoons) data from Twenty seven stations over the period 1901-2007 have been utilised for the present study.

The normal annual rainfall over the district varies from about 2627 mm to about 5391 mm. It is the minimum around Adoor Estate (867 mm) in the Western part of the district. It gradually increases and reaches the maximum around Kallelei Estate (9464 mm) in the eastern part.
The probability of occurrence of normal annual rainfall over the district has been studied. It is observed that the chances of receiving normal annual rainfall vary from 55% at Adur to 75% at Kalleli Estate. These chances are the maximum (60-70%) in an area in the eastern and central part around Pathanamthitta.

The probability of receiving excess rainfall (i.e. 25% or more in excess of the normal) varies from 12% to 23% at almost all the places. The coefficient of variation of annual rainfall from the normal, on the whole, is rather high all over the istrict. It ranges from 23% at Triveni to 34% at Adur. It is the maximum (30-35%) in the northern part around Triveni. In the rest of the district, it is in the range of 10-15%.

A study of the negative departures of the annual rainfall from the normal reveals that the probability of occurrence of moderate drought ranges from 5% at Triveni, Vazhathumozhi to 8% at Adoor. Severe and acute drought conditions were not experienced at any of the stations.

The frequency of occurrence of various kinds of drought at each station has been studied on the basis of number of years per one drought. It has been observed that the frequency of occurrence of drought is rather high (5 years or less, per drought) over the southern part around Adur. Over the remaining major part of the district the frequency is slightly less or rare and is in the range of 5 to 10 years per drought.

The percentage departures of the 50-year normal annual rainfall from the 25-year normal annual rainfall over the selected rain gauge stations district have been computed to study the long term trend of the normals (Table 7.2).

Time-series and trend analyses of annual rainfall have been carried out. The trend of annual rainfall ranged from –3.4652 mm/ to9.1314 mm/year.

Contribution of seasonal rainfall to the annual rainfall is studied. In Pathanamthitta district the contributions of individual seasons are as follows: SW Monsoon-57%, NE Monsoon-26%, Summer-13% and Winter 4%).

Table 7.2: Comparative Study of 25-Year & 50-Year Normals Of Annual Rainfall Over Pathanamthitta District

Sl. No.	NAME OF STATION	NORMAL RAINFALL (mm)		DEPARTURE (%)
		25-YEAR	50-YEAR	
1	Adur	2515	2391	-5
1	Anatodu	2050	1926	-6
2	Angamuzhi	2004	1856	-4
3	Chittar	1853	1756	-3
4	Konni D.F.O.	2366	2153	-5
5	Laha Estate	2215	2056	-3
6	Muzhiar	2456	2296	-4
7	Maniyar	1925	1645	-6
8	Pamba	2586	2394	-5
9	Pathanamthitta	2140	2031	-6
10	Punnamedu	2560	2680	7
11	Sitatodu	2890	2986	8
12	Triveni	2790	2680	7
13	Vallathumuzhi	2966	3050	9

8. GROUND WATER LEVEL SCENARIO

8.1 INTRODUCTION:

Monitoring of ground water regime is an effort to obtain information on ground water level 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 15653 observation wells located all over the country is being monitored (Fig 8.1) . Ground water samples are collected from these observation wells once a year during the month of April/ May to obtain 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 and depiction of bar diagramme is given in fig. 8.1 & their distribution in fig 8.2. Strenthening of observation wells since 1985 (5461 nos) to 2011(15653 nos) is presented in fig. 8.3.

TABLE 8.1: DISTRIBUTION OF OBSERVATION WELLS

Sl. No.	Name of the State	Total No. of Ground Water Monitoring Wells (as on 31.03.2011)		
	States	**DW**	**PZ**	**Total**
1	Andhra Pradesh	580	402	982
2	Arunachal Pradesh	12	0	12
3	Assam	292	10	302
4	Bihar	329	12	341
5	Chhattisgarh	461	248	709
6	Delhi	25	137	162
7	Goa	43	59	102
8	Gujarat	637	376	1013
9	Haryana	198	266	464
10	Himachal Pradesh	89	0	89
11	Jammu & Kashmir	178	19	197
12	Jharkhand	215	12	227
13	Karnataka	1134	373	1507
14	Kerala	658	267	925
15	Madhya Pradesh	870	376	1246
16	Maharashtra	1075	227	1302
17	Manipur	13	10	23
18	Meghalaya	31	5	36
19	Nagaland	12	7	19
20	Orissa	973	137	1110
21	Punjab	159	202	361
22	Rajasthan	722	396	1118
23	Tamil Nadu	566	589	1155
24	Tripura	32	9	41
25	Uttar Pradesh	818	247	1065
26	Uttarakhand	39	94	133
27	West Bengal	468	420	888
	UTs			
1	Andaman & Nicobar	64	0	64
2	Chandigarh	1	27	28
3	Dadra & Nagar Haveli	7	0	7
4	Daman & Diu	9	5	14
5	Pondicherry	4	7	11
	Total	**10714**	**4939**	**15653**

8.2 Ground water level scenario - pre monsoon,2010

Perusal of depth to water level data and the map depth to water level for the period Pre Monsoon (May 2010) (Fig. 8.4) indicates 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 2-10 meter below ground level (m bgl). 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 western Rajasthan and north Gujarat 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 (in isolated pockets) water level in the range of 2-5 m has also been observed. In the east coast i.e. coastal Andhra Pradesh, Tamil Nadu and Orissa, water level in the range of 2-5 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 5-10 m bgl, with patches 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 in these areas.

A comparison of depth to water level during May 2010 with decadal mean of the May (2000-2009) (Fig. 8.5) reveals that, in general, there is decline in water level various states of India except in the states of Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh and Tamil Nadu where majority of wells analysed showing rise in water level mostly in the range of 0-2 m. Isolated pockets of fall in mainly in the range of 0-2 m is also observed in these states. 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 Uttar Pradesh, Rajasthan, Gujarat, Haryana, Delhi, Maharashtra, Tamil Nadu and West Bengal.

8.3 Ground water level scenario - August, 2010

A perusal of depth to water level map of India for August 2010 (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. In the eastern part of the country in the Brahmaputra valley water level generally less than 2 m bgl, except in isolated pockets where depth to water level is in the range of 2 to 5 m bgl. However, in Upper Assam, isolated pocket of deeper water level, 5-10 m bgl has been observed. In major parts of Indus basin, depth to water level generally ranges from 5-20 m bgl. In the western part of the country covering states of Gujarat and Rajasthan deeper water level is recorded in the range of 20-40 m bgl. Relatively deeper water level in the range of 20-40 m bgl and > 40 m bgl has been observed in Rajasthan, Punjab and Haryana and also in central and north Gujarat. In Maharashtra water level recorded is mostly in the range of 2-5 m bgl except western Maharashtra where water level is generally less than 2 m bgl. In the east coast i.e. coastal Andhra Pradesh and Tamil Nadu, generally the water level ranges between 5-10 m bgl. In Orissa water level generally is less than 2 m bgl with isolated pockets showing water level in the range of 2-5 m bgl. West Bengal recorded water level in the range of 2-5 m bgl except in coastal parts where water level is 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 water level is more than 10 m bgl. The peninsular part of country generally water level ranges between 5-10 m bgl except in isolated patches where water level is more than 10 m bgl. Isolated patches of deeper water level in the range of 20-40 m bgl have also been observed in various parts of the country.

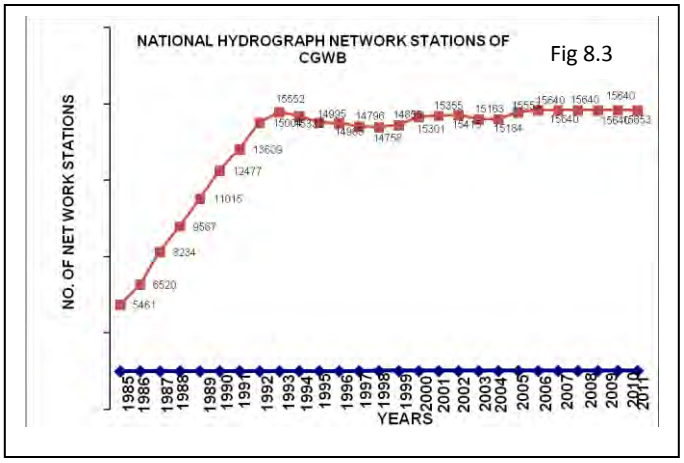
A comparison of depth to water level during August 2010 with decadal mean (2000-2009) (Fig. 8.7) reveals that in general, there is decline in the water level in north and eastern part of the country. In general there is rise in water level in central and western parts of the Country. About 59.51% of wells showing rise in water level. Out of which 54.39% wells are showing rise in water level less than 2 m. Only 5% wells are showing rise in water more than 2 m. About 40.5% wells are showing decline in water level in the range of 0-2 m. Remaining 3.6% wells are showing decline in water more than 2 m. Decline in water level more than 4 m is mostly prominent in the states of Rajasthan, Punjab, Haryana, Delhi, Orissa and west Bengal states. Rise in water level more than 4 m is observed mostly in the Gujarat, Western Rajasthan, Central Maharashtra and in parts of Andhra Pradesh states.

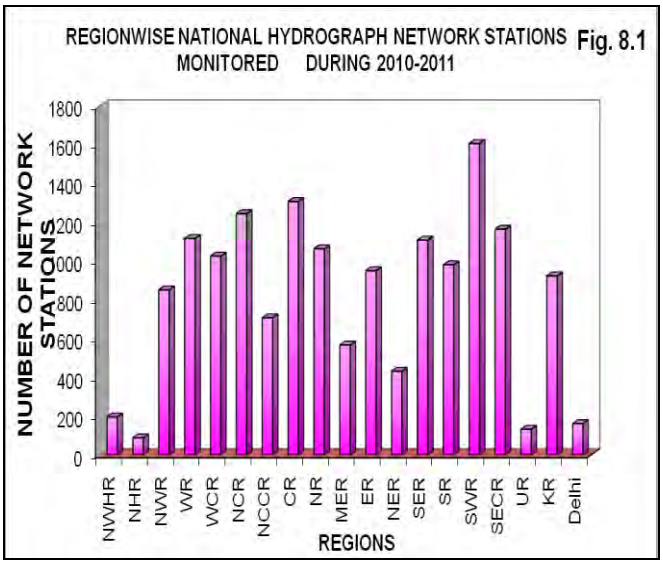
8.4 Ground water level scenario - Post-monsoon, 2010

Perusal of the ground water level data for the period November 2010 (Fig. 8.8) indicates 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 also been observed. In major parts of north-western states depth to water level generally ranges from 10-20 m bgl. In the western parts of the country deeper water level is recorded in the depth range of 20-40 m bgl. In North Gujarat, part of Haryana and western Rajasthan water level more than 40 m bgl is recorded. In the west coast water level is generally less than 5 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 m bgl. 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 2-5 m bgl, except in isolated pockets where water level more than 5 m bgl has been observed. Similarly pockets of shallow water level less than 2 m bgl is also observed along the west coast. The peninsular part of country generally recorded a water level in the range 2-5 m bgl. In some patches water level ranges from 5-10 m bgl.

A comparison of depth to water level during November 2010 with decadal mean November (2000-2009) (Fig. 8.9) reveals that in general, there is decline in the water level in northern, western and eastern part of the country. In general there is rise in water level in central and Southern parts of the country except in the Tamil Nadu state. About 52.25% of wells showing rise in water level. Out of which 41.29% wells are showing rise in water level less than 2 m. About 7.36% wells are showing rise in water in range of 2-4 m. About 3.6% wells are showing rise in water in range of >4 m. About 47.75% wells are showing decline in water level, out of which 35.09% wells are showing decline in water in the range of 0-2 m. Remaining 13.66% wells are showing decline in water level more than 2 m. Decline in water level more than 4 m is mostly prominent in the states of Rajasthan, Punjab, Haryana, Delhi, Orissa and west Bengal states. Rise in water level more than 4 m is observed mostly in the Gujarat, Western Rajasthan, and central Maharashtra and in parts of Andhra Pradesh state.





8.5 Ground Water Level Scenario - January,2011

Perusal of the ground water level data for the period January 2011 (Fig. 8.10) indicates 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. Isolated pockets of shallow water level less than 2 m bgl have also been observed. In major parts of north-western states depth to water level generally ranges from 10-20 m bgl. In the western parts of the country deeper water level is recorded in the depth range of 20-40 m bgl. In North Gujarat, parts of Haryana and western Rajasthan water level more than 40 m bgl is recorded. In the west coast water level is generally less than 5 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 m bgl. However South-eastern part of West Bengal recorded water level in the range of 10-20 m bgl. In central India water level generally varies between 5-10 m bgl, except in isolated pockets where water level less than 5 m bgl has been observed. Similarly pockets of shallow water level less than 2 m bgl is also observed along the west coast. 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.

A comparison of depth to water level during January 2011 (Fig. 8.11) with decadal mean January (2001-2010) reveals that in general, there is decline in the water level in northern, western and eastern part of the country. In general there is rise in water level in central and Southern parts of the country. About 61.55% of wells showing rise in

water level. Out of which 44.09% wells are showing rise in water level less than 2 m range. About 11.30% wells are showing rise in water in range of 2-4 m. About 6.16% wells are showing rise in water in range of >4 m. About 38.46% wells are showing decline in water level, out of which 27.28% wells are showing decline in water in the range of 0-2 m. Remaining 11.18% wells are showing decline in water level more than 2 m. Decline in water level more than 4 m is mostly prominent in the states of Rajasthan, Punjab, Haryana, Delhi, Bihar, Jharkhand and west Bengal states. Rise in water level more than 4 m is observed mostly in the Gujarat, Western Rajasthan, and Central Maharashtra and in parts of Andhra Pradesh state.

8.6 Pre - Post water Level fluctuation Scenario - 2010

Water Level of Post Monsoon 2010 when compared to Pre Monsoon 2010 (Fig. 8.12) reveals that, in general there is a rise in water level in almost all states of India except in Rajasthan, Punjab Haryana and Tamil Nadu. Isolated pockets of fall in water level in the range of 0-2 m have been observed in Rajasthan, Punjab Haryana and Tamil Nadu. Fall in water level more than 2 m is also observed in Rajasthan and Tamil Nadu states. Out of the total observation wells only 9.6% wells are showing fall in water level. Out of this 8% wells are showing fall in water level in less than 2 m range and remaining 1.6% wells are showing fall in water level in more than 2 m range. Most of the North and North east states showing rise in water level in the range of 0-2 m. Eastern Uttar Pradesh, Bihar and Jharkhand states are showing rise in water level in the range of 2-4 m. Gujarat, Maharashtra, Andhra Pradesh, Orissa, Karnataka and North Tamil Nadu State are showing rise in water level more than 4 m.

Fig. 8.2

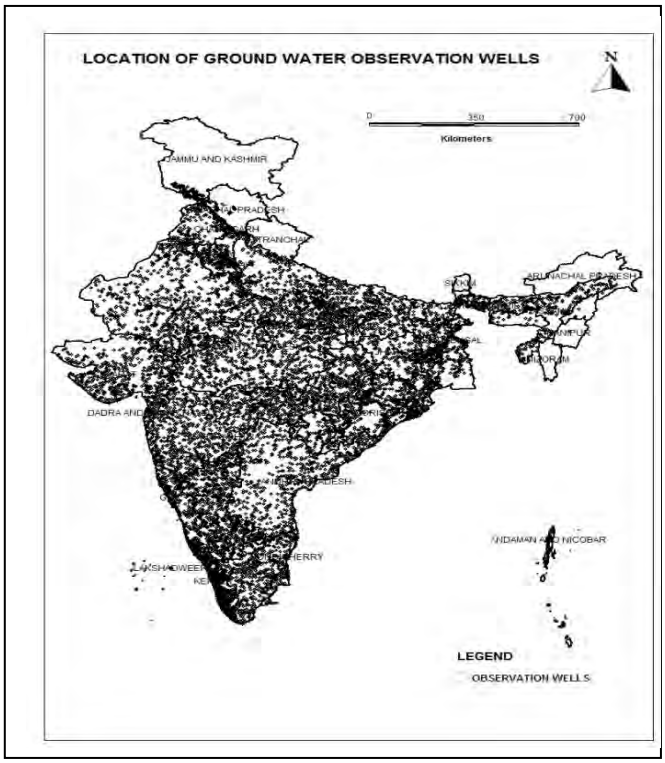


Fig. 8.4

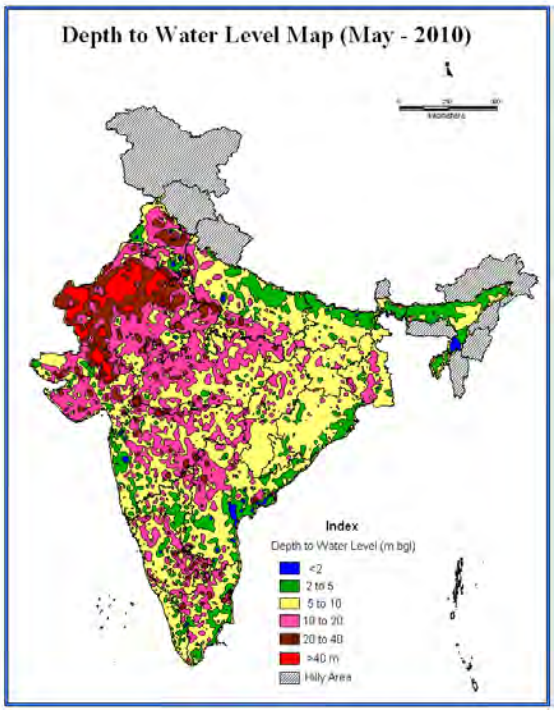


Fig. 8.5

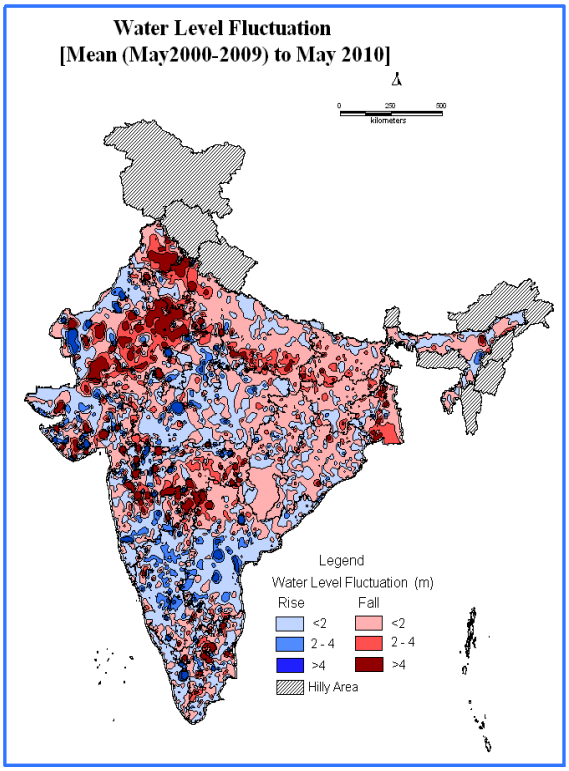


Fig. 8.6

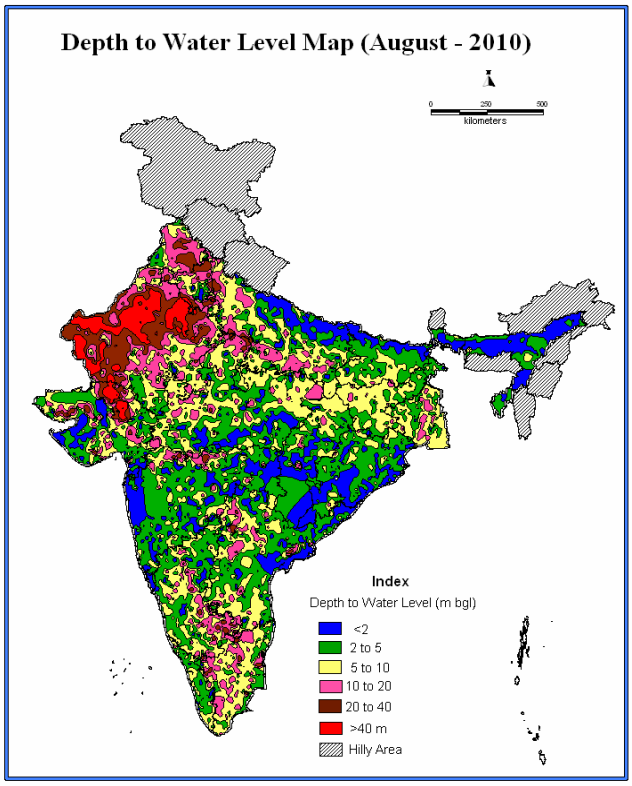


Fig. 8.7

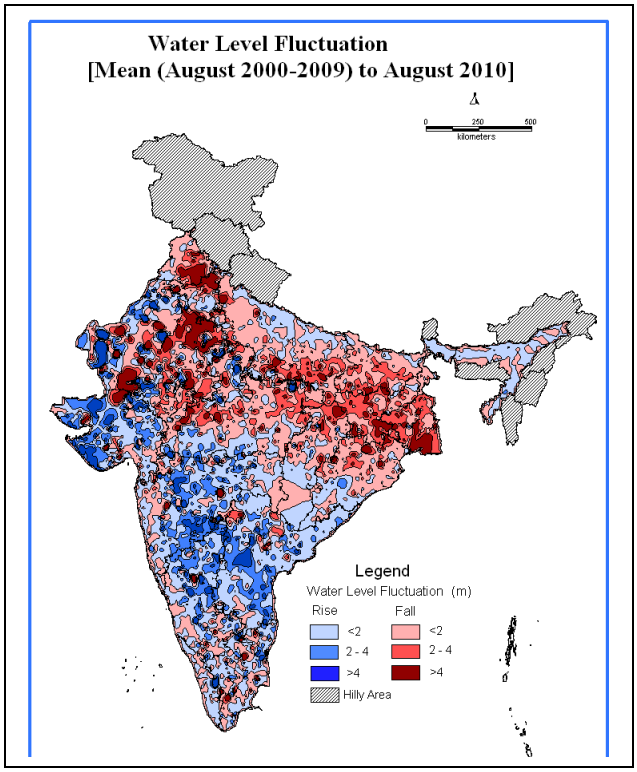


Fig. 8.8

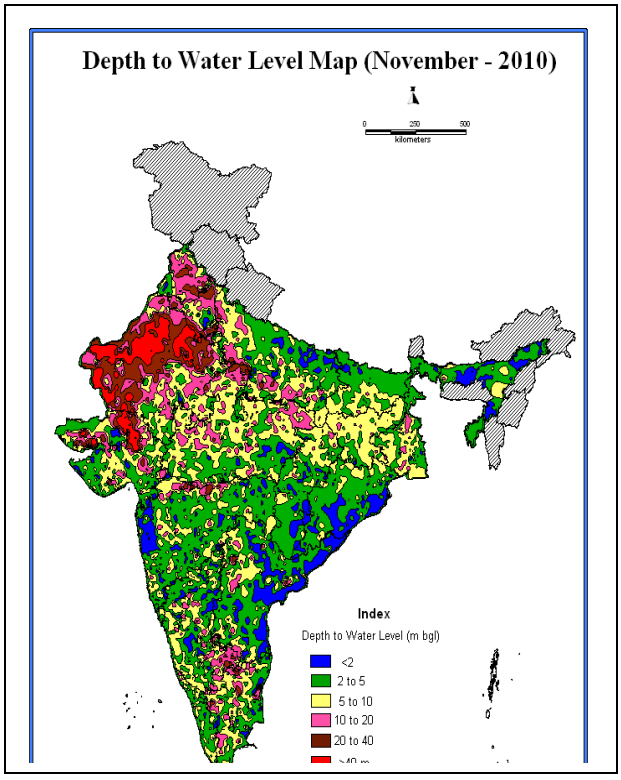


Fig. 8.9

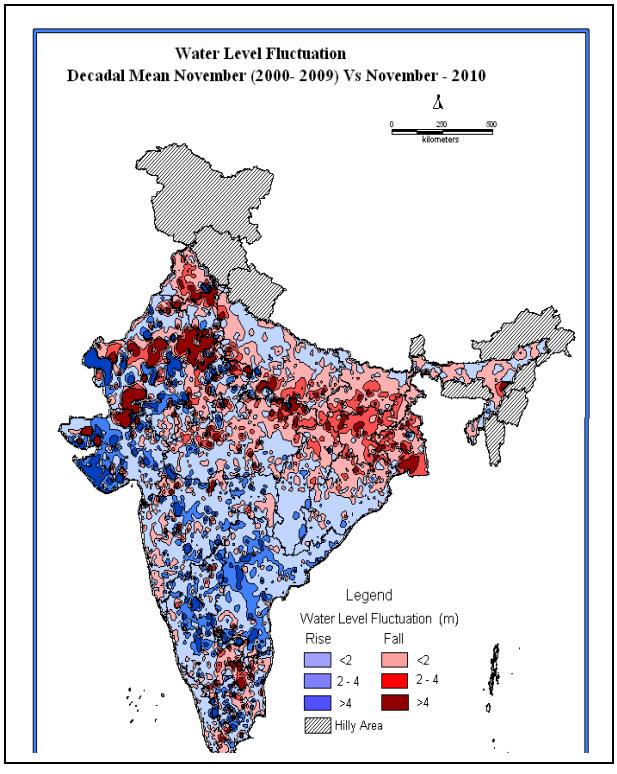


Fig. 8.10

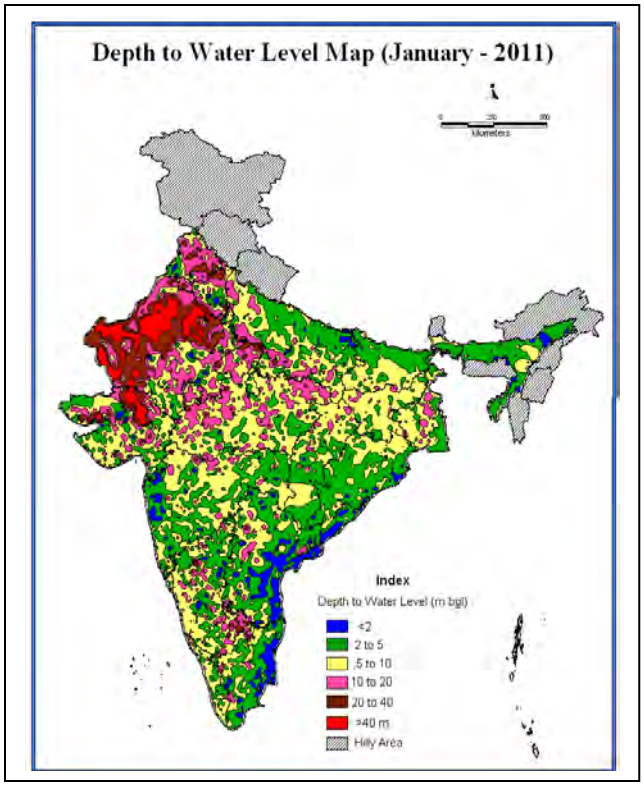


Fig.8.11

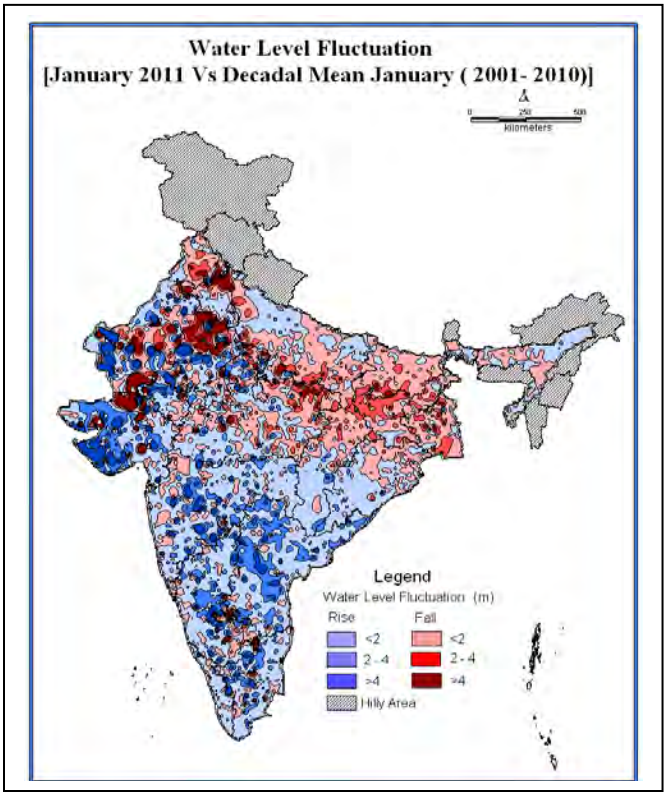
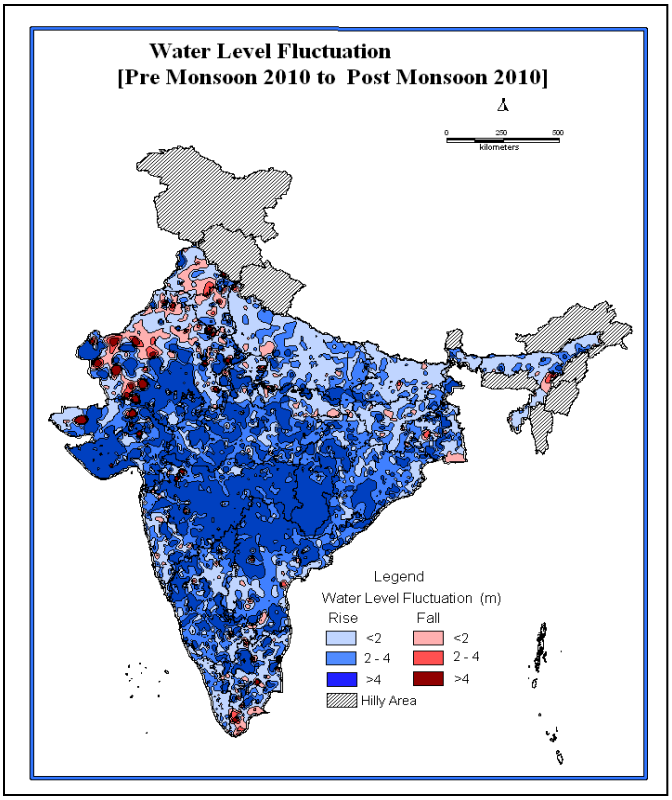


Fig. 8.12



9. GEOPHYSICAL STUDIES

The Board has made extensive use of both the surface and the subsurface (well logging) geophysical techniques in the search of groundwater and proper construction of water wells. The findings as a practice are combined with the hydro geological and geomor-phological investigations to place them on firm footing. The techniques have become an integral part of the ground water exploration programme.

The geophysical techniques in vogue have been used under all types of geological and geographical settings that the country is bestowed with, i.e., Archaean to Recent formation containing aquifers in the hilly terrain, piedmont areas, sprawling plains and plateau, deserts and coastal tracts. The techniques have been used to assess the disposition of capable aquifers under vulnerable conditions as interspersed with saline zones and the encroachment of saline and polluted water.

An effective and wide application has been made of the conventional surface electrical resistivity technique for source finding and of borehole geophysics for well construction. These surveys were undertaken to support, supplement and corroborate the hydrogeological surveys, ground water exploration and short-term water supply investigations as an integral manually and computer software like 'SCHLUM and IPI2WIN etc., The field VES data along with the interpreted results were also entered in GEMS.
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 as well as snow harvesting sites in Himachal pradesh, flood plain studies and in farmer distress villages etc. Geophysical studies were also conducted in the hilly terrains of Meghalaya by deputing a team of six geophysicists from southern region in this AAP.

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

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 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

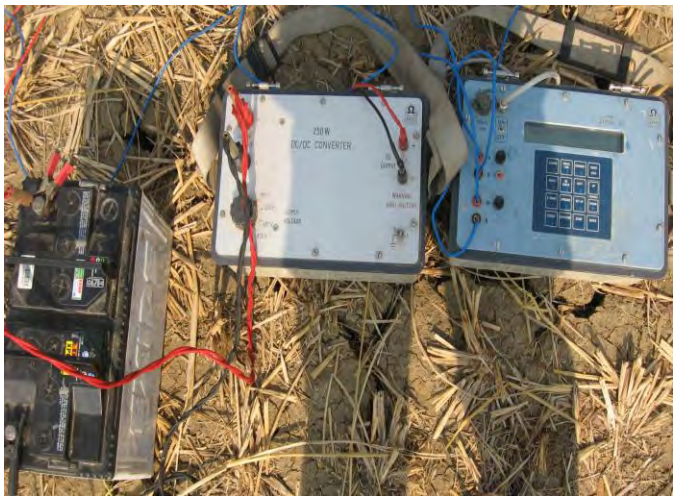
Central Ground Water Board entrusted with a target of 2100 nos. of VES and need based Resistivity Profiling. Against this target, a total no. of 1843 VES and 15.23 LKm of Resistivity profiling were carried out. Apart from this a total no. of 90 boreholes were logged geophysically with different parameters viz. SP, PR, 16" & 64" Normals and Natural Gamma. 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. Details of Geophysical surveys & geophysical bore hole logging carried out in different regional offices are furnished below in Table 9.1.

Table 9.1: Geophysical Surveys & Bore Hole Logging During 2010-2011

Region	No. of VES	Resistivity Profiles (line km)	No. of boreholes logged
NWHR, Jammu	52	-	2
NWR, Chandigarh	81	-	31
WR, Jaipur	99		15
WCR, Ahmedabad	Nil	-	1
NCR, Bhopal	65	-	Nil
NCCR, Raipur	122	0.7	-
CR, Nagpur	150	-	3
NR, Lucknow	12	-	3+1(by NWR, NR)
MER, Patna	165	-	9
ER, Kolkata	116	5.4	10
NER, Guwahati	5	-	5
SER, Bhubaneswar	109	-	3
SR, Hyderabad	500	0.13	2
SWR, Bangalore	206	-	2
SECR, Chennai	101	-	3
KR, Trivendrum	60	-	-
UR, Dehradun	Nil*	-	Nil*
NHR, Dharamshala	-	-	-
SUO, Delhi	-	-	-
Total	**1843**	**15.23**	**90**

*No geophysicist posted in the region.
**Logger not working.



Geophysical Study in Mid Eastern Region, Patna

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 Spectrophotometer (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 2010-2011, 14855 No. water samples have been analyzed for determination of basic constituents. Analysis of 601 No. water samples including the determination of 80 No. of organic parameters was carried out under specific studies and analysis 3424 No. water samples for involving the determination of Trace elements like As, Cd, Co, Cr, Cu Fe, Mn, Ni, Pb and Zn has been carried out. 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 2010-2011 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	642	8379	501	501	234	1869
NWR*	1094	14262			340	1028
WCR	814	13024			342	1574
WR	1288	20542			128	1024
NCR	1256	16328			530	1199
NCCR	306	3978			114	684
CR	710	9750			300	1500
NR	1190	15896	80 (organic)	960(organic)	416	1949
ER	1094	13551			205	205
MER	855	8293			190	409
NER	264	2006	20	20	347	347
SER	918	11142				
SR	1462	19006			3	3
SWR	862	7260				
SECR	1101	14013			268	2120
KR	810	8387				
UR**(Analysed at NWR Lab)	213	2761				
NHR**	189	2457			7	56
SUO Delhi** (Analysed at NWR Lab)	99	1335			8	48
TOTAL	**14855**	**188274**	**601**	**1481**	**3424**	**13967**

* The samples shown by UR & SUO Delhi also analysed by NWR Lab. ** Regions don't have their own chemical laboratory,

Hydrochemical studies carried out in the regions with findings/conclusions:

10.1 North Western Himalayan Region, Jammu

10.1.1 Ground water management studies

Jammu district:

A total of 178 numbers of groundwater samples were collected (123 samples from shallow aquifers and 55 from deep aquifers). The analysis of chemical data reveals that water is alkaline in nature. pH varies from 6.95 to 9.00 in shallow ground water samples, and 6.97 to 8.45 in samples from deep ground water structures. Majority of water samples of the area are fresh but at few places high values of EC are observed (Suchetgarh 2800 µmhos /cm at 25oC, Shallow ground water, Upper Kanhal 1270 µmhos/cm at 25oC, Deep ground water).

Maximum concentration of carbonate 66 mg/l is reported in the water sample collected from Joian (Shallow aquifer). The Nitrate concentration in ground water samples is low in shallow ground water samples, and ranges from traces to 194 mg/l (Mule Chak). In deep ground water samples it varies from traces to 92 mg/l (Shastri nagar). About 4.8% and 14.5% of the samples collected from deep and shallow aquifers are found to have Nitrate concentration more than 45 mg/l, permissible limit of BIS, for drinking water purpose. All the samples collected from the study area are observed to have Fluoride concentration below the BIS permissible limit (1.50 mg/l) for drinking water.

Total Hardness value range from 70 mg/l (Pangli Colony) to 1051 mg/l (Mule Chak) in shallow aquifer and 120 mg/l (Pangiari) to 500 mg/l (Upper Kanhal) in deep aquifer. The concentration of alkaline earth elements (Ca, K & Mg) are more with respect to alkali elements (Na & K). But high value of Sodium are observed at few locations namely Suchetgarh (320 mg/l) & Bisnah (330 mg/l).

The Iron concentration was found to be higher than the permissible limit (1.0 mg/l) of BIS in the two water samples collected from deep aquifer (Garar-1.34 mg/l & Chorli-2.42 mg/l). About 22.7% samples collected from shallow aquifer are associated with iron concentration more than 1.0 mg/l and varies from traces to 8.40 mg/l (Muthi).

Udhampur district: 77 numbers of water samples were collected pre and post monsoon from Udhampur district. The chemical data reveals that water is alkaline in nature. pH varies from 7.17 (Sail Sallan spring) to 8.60 (Ghordi Spring)and 18.2% of water samples have pH values more than 8.20 due to presence of Carbonate.

Majority of samples have EC values less than 500 µmhos/cm at 25oC and values range from 140 µmhos/cm (Dhanu Spring) to 1040 µmhos/cm (Nagrota Panjgrain Spring). The concentration of Nitrate varies from traces to 38 mg/l (Jaghanoo Spring) Fluoride concentration varies from traces to 0.81 mg/l (Nagrota Panjgrain Spring).

As per the BIS classification for drinking water of hardness, 18.2% have moderate hardness, and 44.1% of samples have high values of total hardness. Maximum observed value for total hardness is 345 mg/l (Darsuh spring).

Zanskar area of Kargil district:

54 No. of groundwater samples were collected Zanskar area of Kargil district. Ground water of the area is alkaline in nature (pH value 7.35 to 8.60) and EC value range from 55 µmhos/cm at 25ºC (Chila) to1200 µmhos/cm at 25°C (Khangral).

The Chloride concentration varies from 3.50 mg/l (Unmoli) to 14 mg/l (Zangli-II Hot spring). The concentration of nitrate is less than the maximum permissible limit (45 mg/l) of BIS. And the highest value observed is 17 mg/l in the water sample collected from Pharona spring. Fluoride above the desirable limit of BIS is observed at two locations, namely, Zangala-II and Karpokar (1.45 mg/l and 1.32 mg/l respectively).

Total Hardness varies from 25 mg/l (Chilla) to 715 mg/l (Khangral) and 27.8% samples have very high total hardness as per BIS categorisation for water to be used for drinking purposes. 20.4% samples of the area are associated with iron concentration more than 1.0 mg/l. The water sample collected from Zangala-II (hot spring) is Mg-SO_4 type.

10.1.2 Other Activities

Participation Analytical Quality Control exercise:

Participated in H P –II AQC 2010, organised by North Central Region, Bhopal. Synthetic two numbers of samples were analysed for Specific Conductance, Total Hardness, Ca, Na, K, Cl ,SO_4, NO_3 and F and results were sent with in stipulated time.

10.1.3 Pollution studies

Bari Brahmana industrial area, District Samba, Jammu and Kashmir

The study was carried out in 5 Sq Km area of Bari Brahmana area with pre and post monsoon of water sampling.

Ground water in study area is fresh and potable. Most of the ground water is hard to very hard category causing gastro-intestinal problems. Analytical results has not indicated pollution to good water. However, there is need to have monitoring stations in the area to have impact of industrial effluents in the ground water..

Baddi Barotiwala industrial area, District Solan, Himachal Pradesh

The study was taken up in Baddi Barotiwala industrial area, Solan district, Himachal Pradesh. A total of 55 numbers of samples were collected from spring, shallow, deep ground water aquifers and effluent/drain.

The highest E.C in shallow aquifer is found to be 2300 µmhos/cm at 25ºC in Surajpur (hand pump) while EC of 1000 µmhos/cm is observed in Haripur Tube well sample and drain sample from M/s Haripur Sandholi.

Fluoride concentrations in spring, shallow, deep ground water samples as well as in effluents water are within the permissible limit (1.5 mg/l) of BIS for drinking water purpose with only one exception at Surajpur H/P (10 mg/l). Maximum concentration of Nitrate 48 mg/l is recorded in the water sample collected from Barotiwala Road (H/P).

About 80.9% samples from shallow aquifer, 90.0% of samples collected deep aquifers and 100% of spring water samples fall in very hard category of total hardness.

The concentration of Copper, Zinc, Nickel, Chromium and Cadmium are within the maximum permissible limit of BIS In shallow ground water high value of Iron are reported are Bauni (1.73 mg/l), Surajpur (1.60 mg/l), Satiwala (2.56 mg/l, Bhuranwala (2.87 mg/l), Kulhariwala (1.44 mg/l), Dasora majra (1.54 mg/l), Haripur Sandholi (1.76 mg/l). From deep ground water, 2.22 mg/l of iron is reported from sample Johanpur. More than 50% of drain /effluent samples reported iron high concentration of Iron. Samples collected from Balad Nala Drain have iron concentration 2.01 mg/l, 1.48 mg/l, 6.7 mg/l. Sample collected from Sirsa River after Sandholi nala confluence, also reported 5.60 mg/l iron.

The high concentration of Manganese in shallow ground water collected from Haripur Sandholi (Dug well) is 16.42 mg/l, In effluents samples, about 36% of samples are associated with higher concentration and highest value of 8.72 mg/l is reported from Balad nala (Drain). High concentration of lead is observed in Tube well water of Batech (0.062 mg/l).

10.2 North Western Region, Chandigarh

A total number of 1434 water samples of Punjab, Haryana State and Chandigarh as well as New Delhi State, Uttrakhand and Jammu & Kashmir collected under NHNS, Exploration, Reappraisal pollution and other studies were analysed in the chemical laboratory of NWR. The total number of constituents was 15242.

10.3 Western Central Region, Ahmedabad

During the AAP 2010-2011, 814 samples were subjected to basic analysis comprising of 13024 constituents. The analysis of heavy metal and iron were carried out for 342 samples. Thus in total 1156 samples were analysed for 14598 constituents in the Regional Chemical Lab of WCR. 643 water samples collected from CGWB observation wells spread over 26 districts of Gujarat and UT of Daman & Diu were analyzed for different chemical parameters. The major quality findings are described as under:

In general EC values are high to very high in the many parts of the state. A total number of 75 samples are having EC > 3200 uS/cm, out of a total of 460 samples analyzed which shows the salinity problem in the area. The data reveals high salinity problem in Northwestern parts of the state having EC>15000µS/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 at places in Ahmedabad, Amreli, Anand, Banaskantha, Bharuch, Bhavnagar, Dohad, Jamnagar, Junagadh, Kacchh, Khera, Mehsana, Navsari, Patan, Porbander, Rajkot, Sabarkhantha, Surat, Surendranagar, and Vadodara districts. In most other parts of the state water is almost fresh with respect to EC and salinity. High Nitrate > 100mg/L, have been found in 77 number of samples out of 460 total number of samples analyzed indicating high nitrate pollution which may be due to use of nitrogen containing fertilizer, domestic and agriculture waste and manmade anthropogenic activities. Nitrate value as high as 500 mg/L is found 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 the 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 where nitrate concentration is less than 45mg/L, there is no problem with respect to nitrate pollution.

High Fluoride >1.5mg/L, which is mainly attributed due to geogenic conditions, have been observed in 33 water samples out of 460 water samples analyzed. Fluoride values to the extent of 11.0 mg/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 Halwad, 2.25 mg/l Muli, 5.50mg/l Miani, 4.50mg/l Ratanpur- Surendranagar) have been observed indicating prevalence of fluoride problem in these areas. Apart from above locations another 20 samples at different locations have been found to contain fluoride values in the range of 1.5mg/L-3.00mg/l which indicates fluoride problem exists in patches.

Ground Water Management Studies in parts of Kachch district. A total number of 157 water samples from selected GWMS were collected separately for iron analysis after filtration and hydrochloric acid treatment. Out of these 52 samples have been found to contain iron contamination with permissible limit of BIS. Iron value as high as 2.40 mg/l Mandal 2 (Ahmedabad), 2.70mg/l Chalala (Amreli), 1.34 mg/l Sukhsar (Dohad), 2.65 mg/l Haryana, 3.75 mg/l Kalyanpur 2, 1.45 mg/l Sethwadala, 16.0mg/l Sumana (Jamnagar), 1.18 mg/l Gagodar (Kacchh), 1.30 mg/l Wankaner (Rajkot), 1.29 mg/l Poshina 2, 1.18 mg/l Shamlaji (Sabarkhantha) are observed to have high magnitude of iron problem.

10.4 Western Region, Jaipur

Hydrochemical studies with findings/conclusions

The chemical quality of ground water in the state exhibit considerable variation from fresh to highly saline. In southern part of the state ground water quality is good i.e. potable. Owing to aridity most part of western Rajasthan and some part of eastern Rajasthan are having saline ground water. High salinity is generally confined to aquifers in alluvium, blown sand and the semi consolidated formation comprising tertiary and Mesozoic formations and to a lesser extend to the aquifers in Marwar super group of rocks. Instances of growing levels of nitrates in ground water are noticed due to haphazard disposal of wastes, particularly faecal disposals in urban areas.

About 36% of water samples have fluoride concentration beyond maximum permissible limit of 1.5 mg/l. High fluoride concentration hazards has been observed in the districts of Nagaur, Bhilwara, Jalore, Barmer, Pali, Sirohi, Jaipur, Jaisalmer, Bharatpur, Dungarpur, Churu, Ganganagar, Hanumangarh, Sawai Madhopur, Bikaner, Jodhpur, Jhunjhunu, Dholpur, Sikar and Karauli (22.22 to 69.05 %).

Around 42% of samples have nitrate values beyond the permissible limit of 45 mg/l. The districts of Churu, Barmer, Nagaur, Sirohi, Jodhpur, Jalore, Karauli, Jaisalmer, Banswara, Jaipur are much affected with nitrate pollution as 50 to 91.48 % of stations have nitrate values beyond limit of 45 mg/l. Similarly the districts of Jhalawar, Baran, Sikar, Bikaner, Jhunjhunu, Bhilwara, Pali, Hanumangarh, Rajsamand and Ganganagar are slightly less contaminated (30 to 47.06 %).

About 31 % of samples have TDS value beyond the permissible limit of 2000mg/l. In Barmer, Churu, and Nagaur, Jaisalmer, Jodhpur districts high TDS values have been observed as more than 50 % stations have high TDS value, while in Bharatpur, Jalore, Ganganagar, Jaipur, Dholpur districts 36.36 to 47.62 % of stations have TDS values beyond permissible limit. 20 % of collected samples have iron value beyond the permissible limit of 1.0 mg/l in the state. Iron contamination is mostly observed in the districts of, Baran, Bundi, Rajsamand ,Sirohi, Hanumangarh, Kota, Tonk, Ajmer,Chitorgarh, Jaipur, Dholpur, Ganganagar, Pali, Jalore,

Udaipur, Sawai Modhopur (21% to 55%). Percentage distribution of major constituents in Rajasthan, 2010-11 is given in table10.8.

10.5 North Central Region,Bhopal

1786 water samples were analysed. Out of these, 1256 water samples have been analysed for determination of basic constituents and analysed 530 water samples for heavy metals involving the 1199 No. of constituents.

10.5.1 Ground Water Quality of Urban Area, Madhya Pradesh-2010

(A) Indore Urban Annlomerates :

Analytical data indicated that the pH value ranges from 6.98 to 7.31 . The electrical conductivity lies between 755 to 1975 µs/cm at 25°C. The electrical conductivity values more than 1500 µs/cm at 25°C was recorded at three places such as Nateshwar Temple (1975), Phootikothi (1740) and Gandhi Hall area (1540).

The chloride values were found between 46 to 287 mg/l. Fluoride concentration varies from 0.29 to 1.17 mg/l which is well within the safe limit for drinking water. Nitrate values have been recorded between 0.5 to 122 mg/l. The highest value of 122 mg/l of dug well at Police Training Centre. The high concentration of nitrate above the permissible limit of 45 mg/l for drinking water was found at 4 places may be attributed due to local habitation around the source.

The concentration of Total Hardness (TH) in the study area was found ranging between 180 to 750 mg/l. only three wells were having higher values more than 600 mg/l with highest values of 750 mg/l at Phootokothi (tube well) followed by 625 mg/l at Gautam Ashram and 610 mg/l at Nateshwar temple.

Overview of the analytical data of the urban area of Jabalpur city indicates that quality of ground water is generally good and safe for drinking purpose.

(B) Jabalpur Urban Agglomerate:

The analytical results indicate that the ground water of study area was pH value betweens 7.20 & 8.33. The electrical conductivity of water samples was found between 166 to 1468 µs/cm at 25°C.

The chloride values were found between 18 to 174 mg/l. Fluoride concentration varies from 0.17 to 4.97 mg/l. Fluoride values more than 1.50 mg/l were found at Jabalpur Municipal Complex (4.97), Bhanpur Tallaiya (3.53) Garha (3.01) and near Medical College (Digambar Jain Mandir 2.97). Nitrate values have been recorded between 3.0 to 131 mg/l. The highest value of 131 mg/l was found at Medical College (Digambar Jain Mandir). The high concentration of nitrate above the permissible limit of 45 mg/l for drinking water was found at 8 locations which can be attributed to local habitation around the source. The concentration of Total Hardness (TH) in the study area was found ranging between 90 to 410 mg/l. As per limit of TH for drinking water, all wells were found to be within the permissible limit of 600 mg/l.

Overview of the analytical data of the urban area of Jabalpur city indicates that quality of ground water is generally good and safe for drinking purpose, except at some locations where the values of fluoride and nitrate were found above the permissible limit recommended by the BIS (Bureau of Indian Standards).

(C) Bhopal Urban Agglomerate:

The pH values range varies in between 7.12 to 8.28. Based on the distribution of EC, it was observed that Bhopal city had EC ranging from 600 to 1500 (Avg. 954) µS/cm at 25^0C indicating the quality of ground water quality is potable. EC values greater than 1500 µS/cm at 25^0C were noticed only in two wells namely Annanagar (1666) and Semra Kalan (1899). This deteriorating effect in water quality due to high EC values in above two wells may be attributed with anthropogenic cycle of salts accumulation (secondary salinization) in ground water characterized by erroneous agricultural or economic activities done by men.

The anion chemistry shows that bicarbonates and chloride are the dominant anions in the ground water of Bhopal city. Bicarbonate contributes on an average 40 to 60% to total anions in ground water. The undesirable effects beyond the desirable limit of bicarbonate (200 mg/l as per BIS, 1991) have not been reported though its concentration in wells sampled from Bhopal city varied from a minimum of 49

mg/l for Kaliasote to a maximum value of 555 mg/l for Semra Kalan locality. The chloride concentration in the analysed samples varies from 18 to 277 mg/ l.

There were only three locations where concentration of NO_3 ions greater than 100 mg/l were detected i.e. Patel Nagar (138mg/l), Kaliasote (126 mg/l) and Berkhera (125 mg/l). Fluoride concentration lies within the BIS permissible limit (1.5 mg/l). Total hardness within permissible limit (600 mg/l) except in isolated pockets.

10.6 North Central Chattisgarh Region, Raipur

A total of 420 nos of water samples were analyzed out of which 306 analyzed for basic parameter analysis and 114 for heavy metal analysis.

Hydrochemical Studies and Findings:

The pH value shows that the ground water is neutral to alkaline in nature where as in some coal mine areas it is acidic in nature . The electrical conductivity value in most of the samples is less than the 1000 µs/cm at 25° C, which indicate that the ground water is of low mineral content in Chhattisgarh. Exceptionally higher value of EC is recorded in samples of Hemunagar in Bilaspur district (1900 µs/cm at 25° C) and Kudurmal at Korba(1700 µs/cm at 25° C) where as the lower value is recorded at Koraba (52 µs/cm at 25° C) in Korba district. Total hardness is observed within the permissible limit with a few exceptions at 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/l. In few water samples of Korba, Bastar, Raipur, Kanker, Jashpur and Surguja districts it is found to be more than the 1.5 mg/l.

Pollution Study on Korba Industrial Area

Analytical results of 53 Nos of water samples indicated that the pH value ranges from 6.0 to 8.2. In study area low conductivity value observed in major part of the city but at few locations high E.C. is also observed. The chloride concentration varies from 7.0 mg/l to 178 mg/l in all the water samples in the study area. The high Fluoride concentration at various locations in Dengu nala & Belgiri nala surfaces water samples is due to discharge of effluents of Aluminum plant & Thermal power plant into nala that finally joins the Hasdeo River. In few dug well water samples high concentration of Nitrate, beyond the BIS permissible limit (100mg/l) has been observed at the study area. Highest concentration of phosphate 1.6 mg/l observed at Ash pound of thermal power plant and it is also observed in nearby ground water samples.

Overall, sodium concentration, Calcium concentration and magnesium concentration are found within permissible limit of BIS. On the perusal of chemical analysis results the iron content has been found almost in all the water samples. In case of deep aquifer, the iron content was observed more than permissible limit (1mg/l), Manganese is observed at seven water samples more than the BIS recommended value, Zn is found to be 5mg/l, at two locations Surakachar SW and Jamnipali HP, in rest of the samples Zn concentration observed less than the BIS recommended limit. Presence of Cr is observed only at two locations i.e. Sonpuri (0.15mg/l) and Satnamnagar (.05mg/l.) No lead pollution is observed in study area.

10.7 Central Region, Nagpur

A total of 1010 ground water samples (BA = 710+ HM 300) were analysed.

Other Activities:

Water Quality Maps: Water Quality Maps for TDS, TH, Cl, NO_3 & F of Maharashtra & U/T of DNH were prepared based on HS 2009 data for inclusion in the yearbook.

Ground Water Quality Database: Compilation, validation and computerization of all ground water quality analytical data generated were carried out. Updating the ground water quality database for the year 2009 in GEMS software was carried out.

Activities under Hydrology Project-II : Submitted Information/Evaluation Report in the questionnaire format pertaining to Chemical Laboratory, CGWB, CR, Nagpur required for Evaluation of HP Water Quality Monitoring laboratories under HP-II to Regional Director (HP), CGWB, Faridabad

Participated in Inter-Laboratory AQC Exercise and analyzed two synthetically prepared unknown samples received from NCR, Bhopal Laboratory.

10.8 Northern Region, Lucknow

Hydro chemical studies with finding/conclusions

In general, shallow ground water in the state of Uttar Pradesh is fresh except at few places where concentration of ions has been found above permissible limits (BIS-1991).

The pH value of ground water in the state varies from 7.14 - 8.88 & lies within the permissible limit and water is found to be slightly alkaline in nature.

Electrical conductivity ranges from 240 to 8500 µS/cm at 25^0C. High EC (>3000 µS/cm at 25^0C) is observed in the shallow ground water of Hamirpur, Agra, Mathura, Fatehpur & Kanpur Nagar districts. Excessively high values of EC (>4000 µs/cm at 25^oC) is observed at Akola (8500 µS/cm at 25^oC) in district Agra; Chandaus (4500 µs/cm at 25^oC) in Aligarh.

The concentration of nitrate has been found to vary widely in the state. It ranges from nd-361mg/l. High values of $N0_3$ (>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 (>100 mg/l) are observed at Amraudha (361 mg/l) & Akbarpur (145 mg/l), Kalyanpur (237 mg/l) in district Kanpur. & Bangarmau (332 mg/l) in Unnao district.

Fluoride values range from nd-2.54 mg/l and fluoride >1.5 mg/l is observed in the shallow ground water at Mahrauni (2.4), Mandwara (2.31) in Lalitpur districts & Tahipur (2.08) in Varanasi districts

The total hardness of ground water ranges from 60-2560 mg/l in the state. Values of total hardness >600 mg/l are observed in the shallow ground water from Agra,Mathura, Aligarh, Firozabad, Kanpur Nagar, Kanpur Dehat & Mahamayanagar districts. A maximum value of 2560 mg/l total hardness is observed in the ground water from Akola (Agra district).

10.9 Eastern Region, Kolkata

Hydro Chemical Studies With Finding/Conclusions:

1. Finding on the basic of Arsenic Determination:
   a. Andaman NHS samples (58 number) show arsenic concentration within permissible limit (i.e.<0.05 mg/l).
   b. Pollution Cluster samples (35 samples) from Howrah, Haldia, Durgapur and Asansole area also show arsenic concentration within permissible limit (i.e.<0.05 mg/l).
   c. Landfill area in Dhapa (33 samples) shows no incidence of arsenic contamination.
   d. Ground water exploration samples (41 samples) show arsenic concentration from BDL to 44 ppb.
   e. In Ground water management studies of Nadia District (51 samples) incidence of arsenic concentration more than permissible limit has been encountered at Bamanpara (63 ppb), Ghutugachi (107 ppb), Maheshchandpur (65 ppb), Bholadanga (55 ppb) and Gobrapota (67 ppb). Other samples show arsenic concentration from 3 to 43 ppb.
2. Finding on the basis of Fluoride Determination:
   a. Ground water exploration in Birbhum and Dakshin Dinajpur District shows fluoride concentration is within permissible limit and it ranges from 0.62 to 0.94 mg/l except at one exploration site in Birbhum district, where it shows 5.9 mg/l.
   b. Ground water management study in hard rock parts of Birbhum District shows fluoride concentration above permissible limit at Junidpur (10.7 mg/l) and at Damra (8.29 mg/l).
3. Chemical analysis of ground water samples from Andaman and Nicobar Islands collected during AAP 2010-11, revealed the following observations:
   a. EC ranges from 313 to 2920 micromhos/cm at 25^0C.
   b. pH ranges from 7.54 to 8.7.
   c. Fluoride is within permissible limit except at Sippighat (F=1.84 mg/l).
   d. Nitrate ranges from 1 to 22 mg/l.
   e. Phosphate ranges from bdl to 2.78 mg/l at Port Blair.
   f. Iron exceeds permissible at Austinabad (1.18 mg/l) and Saitankhari (7.87 mg/l).
4. Chemical analysis of ground water samples collected during pre-monsoon NHS monitoring from Kolkata City collected during AAP 2010-11, reveals iron concentration ranging from 0.17 mg/l to 6.20mg/l. Fe crosses more than permissible limit at Ballygange (5.3 ppm), Dum Dum (3.3 ppm), Garden reach (6.2 ppm), Jhautala (1.23 ppm), New Alipore (1.53 ppm). EC, pH, Cl, HCO^3, TH, Ca, Mg, Na, K,

SO_4, F parameters show concentration within permissible limit.

5. In Howrah District it reveals that EC values are more than permissible limit in three locations, viz., Baganda (6950 micromhos/cm at 25^0C), Bauria (3650 micromhos/cm at 25^0C), Uluberia (3610 micromhos/cm at 25^0C). Except at Goalpota, iron concentration is more than permissible limit in all the NHS wells. Chloride is more than permissible limit at Uluberia, Bauria, Dakhin maju, Baganda. Maximum value of chloride is reported from Baganda. All other parameters are within permissible limit.
6. In Bankura District, it reveals that EC values are more than 2000 micromhos/cm at 25^0C reported from Hijula, Padampur and Ghugimora. Fluoride concentration has been reported more than permissible limit at Bhalukhan (3.00 ppm), Jafardanga (2.1 ppm). High iron concentration has been reported from Hijula (11.4 ppm).Ramsagar (4.9 ppm), Basudevpur (2 ppm). All other parameters are within permissible limit.
7. In Jalpaiguri District, it reveals that EC, pH, TH, Ca, Mg, Na, K, F, SO_4,Fe,TDS are within permissible limit.
8. In Purulia District, EC value is more than 2500 micromhos/cm at 25^0C reported from Bagmundi, Sindri and Dubra. High concentration of fluoride has been reported from Narayanpur (2.4 ppm). High concentration of iron has been reported from Deuli (3.8 ppm), Sindri (3.5 ppm), Bispuria (1.8 ppm), Sarbori (1.6 ppm). All other parameters are within permissible limit.
9. In Hugli District , iron value is more than one ppm reported from Deyparaman DLOI. All other parameters are within permissible limit.
10. In South 24 Parganas District, EC value is more than 2000 micromhos/cm at 25^0C reported from Ramdhari (2580 micromhos/cm at 25^0C), Chandipur(2050 micromhos/cm at 25^0C), Paschim Narayanpur (2750 micromhos/cm at 25^0C), Panikhali Bazar (2110 micromhos/cm at 25^0C), Uttar Hazipur (2240 micromhos/cm at 25^0C), Rajar Taluk (6140 micromhos/cm at 25^0C) . High concentration of chloride has been reported from Ramdhari (763 ppm), Falta (447 ppm), Katalia (557 ppm), Chandipur (550 ppm), Paschim Narayanpur (525 ppm), Mathurapur (369 ppm), Rajar Taluk (1580 ppm), Uttar Hazipur (383 ppm). High concentration of iron has been reported from Rajpur (17.3 ppm), Buraghat (2.98 ppm), Bhangar (1.4 ppm), Chandipur (3.2 ppm). All other parameters are within permissible limit.
11. In North 24 Parganas District, high concentration of iron has been reported from Gopalnagar (1.8 ppm), Sodepur (14 ppm), Berachapa (1.5 ppm), Baduria (2 ppm), Gaighata (2.7 ppm), Chandpara (2.1 ppm), Habra (5.9 ppm), Bayermari (5.3 ppm), Murarisha (3.5 ppm), Rajarhat (3.6 ppm), Haroa (9.2 ppm), Halisahar (6.2 ppm), Kochua (1.7 ppm), Dutta pukur (15 ppm), Dhamakhali (4.9 ppm), Bhagaband (2.7 ppm), Bhebia (1.6 ppm), Baidyapur (2 ppm), aminpur Bazar (4.6 ppm), Krisnachandrapur (2.8 ppm), Gobrapur (5.7 ppm), Khalisadi more (2.2 ppm), Chatra (7.5),Guma (2.4 ppm), Santoshpur (8.3 ppm), Sarupnagar (4.1 ppm). High concentration of fluoride have been reported from Noapara (2.12 ppm), Chatra (2.00 ppm), Guma (1.80 ppm), Santoshpur (1.70 ppm), Khalisadi more(1.9 ppm). All other parameters are within permissible limit.
12. In Murshidabad District, EC value is more than 2000 micromhos/cm at 25^0C reported from Hurshi (2260 micromhos/cm at 25^0C), Begunbari (2130 micromhos/cm at 25^0C). High concentration of iron have been reported from Chandipur (1.6 ppm), Saktipur (1.12 ppm), Salar (14.4 ppm), Gokarna (5.04 ppm), Gangedda (2.8 ppm). All other parameters are within permissible limit.
13. In Nadia District, EC value is more than 1100 micromhos/cm at 25^0C reported from Uttar Kechuadanga (1320 micromhos/cm at 25^0C), Narayanpur(1440 micromhos/cm at 25^0C), Karimpur(1500 micromhos/cm at 25^0C) . High concentration of fluoride has been reported from Uttar Kechuadanga (1.53 ppm), Hanspukuria (1.54 ppm), Dienagar (1.64 ppm). All other parameters are within permissible limit.
14. In Burdwan District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 are within permissible limit.
15. In Cooch Behar District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe,TDS, HCO_3, CO_3 are within permissible limit. High concentration of iron has been reported from Bara Pinjorir hat (1.26 ppm), Cooch Behar (1.01 ppm).
16. In Darjeeling District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 are within permissible limit.
17. In Purba Medinipur District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 are within permissible limit. High values of EC (1780 micromhos/cm at 25^0C) and chloride (269 ppm) have been reported from Kolaghat.
18. In Paschim Medinipur District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 are within

permissible limit. High values of Fe is reported from Gopiballavpur (6.62 ppm), Salboni (5.5 ppm), Lodhasuli (9.17 ppm), Balibesia (4.55 ppm), Sankrail (6.17 ppm), Sonkara (5.98 ppm), Sarasanka (2.28 ppm) areas.

19. In Birbhum District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 are within permissible limit. High values of Fe is reported from Illambazar (3.2 ppm), Bolpur (1.9 ppm), Sambati (2.1 ppm), Labpur (2.3 ppm), Ahmedpur (4.00 ppm), Sainthia (1.8 ppm) areas.
20. In Malda District, Ec, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 are within permissible limit. Although higher values are observed at Sujapur (Ec-2010 micromhos/cm at 25^0C), Malatipur (F-1.64 ppm), Bhaluka (Fe-1.02 ppm), Gazole (Fe- 1.86 ppm), Bot-Tille (Fe-1.26 ppm) and Nimasarai (Fe-2.34 ppm).
21. In Uttar Dinajpur District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 values are within permissible limitin most of the samples. High Ec value have been reported from Durgapur (1450 micromhos/cm at 25^0C), Kaliganj (1010 micromhos/cm at 25^0C) area. High iron concentration has been reported from Itahar (1.39 ppm), Barakamat (3.34 ppm) area.
22. In Dakshin Dinajpur District, EC, pH, TH, Ca, Mg, Na, K, F, SO_4, Fe, TDS, HCO_3, CO_3 values are within permissible limit in most of the samples. High fluoride value has been reported from Joredighi (1.58 ppm) Bordangi (1.94 ppm), Samjhia (1.78 ppm). High iron concentration has been reported from Lalpur (2.54 ppm), Tapan (2.20 ppm) and Gangarampur (3.26 ppm) area.

10.10 Mid Eastern Region, Patna

During the year, 855 samples have been analysed. Total number of constituent determined was 8293. 184 sample were analyzed for heavy metals.

Hydrochemical studies with findings / conclusions

10.10.1 Bihar:

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. The value of electrical conductivity indicates wide variation in dissolved constituents in groundwater . The maximum conductivity value (4190 micro Siemens/Cm) has been observed at Sahpur Patori, Samastipur district whereas minimum conductivity value (100 micro Siemens/Cm) has been observed at Bathnaha Araria district. In general, the quality of groundwater in terms of Total Hardness as $CaCO_3$ has been found as hard to very hard. Ground water in major part of the state has been found suitable for irrigation.

10.10.2 Jharkhand

The groundwater in the state of Jharkhand is mildly alkaline in nature. Most of the samples contain no carbonate but are characterised by the presence of bi-carbonate. The maximum concentration of HCO_3 was found as 976 mg/l at Tandwa (Hazaribag,Chatra, Koderma district). The maximum conductivity value, 3500 micro Siemens/Cm, has been found at Jarmundi, Dumka district, whereas minimum value was found as 113 micro Siemens/Cm at Balumath in Hazaribagh district. The value of electrical conductivity indicates wide variation in dissolved contents in groundwater of Jharkhand. Generally, the quality of ground water in terms of total hardness as $CaCO_3$ has been found as hard to very hard.

10. 11 North Eastern Region, Guwahati

Hydro Chemical Studies with Finding / Conclusions

10.11.1 Assam

In the state, 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 few pockets. EC value ranges from 44 to 784 micro Siemens /cm at 25°c.

In the study area pH ranges between 5.70 & 9.50. At Hamren of Karbi Anlong district pH value is found to be 4.16 (beyond permissible limit). Fe concentration exceeds permissible limit in pockets in some districts. Fe concentration in the study area ranges from below detection limit (BDL) to 14.69 ppm. The Cl concentration of the ground water in the study area ranges between 3.54 to 113 ppm. The maximum concentration of Cl was 113 ppm. It is observed that Fluoride content in the study area increases with depth. Fluoride concentration varies from 0.02-1.78 ppm.

In Greater Guwahati, out of 20 samples it was found all samples having Arsenic concentration of less than 10 ppb.,

which is permissible limit for Arsenic. The Arsenic concentration in the Greater Guwahati ranges from below detection limit to 07 ppb.

In general the ground water quality in the state of Assam is found suitable for various purposes of drinking domestic, plantation and agricultural uses.

10.11.2 Meghalaya

In general, chemical quality of ground water in the state of Meghalaya is found good and portable. EC value ranges from 33 to 647 micro Siemens /cm at 25°c, which states about freshness and potable nature of water. The pH value in the study area varies from 6.48 to 7.95. Carbonate concentration is found below detection limit in ground water samples. Bicarbonate varies from 6.15 to 196 ppm. Chloride content ranges from 3.54 to 42 ppm. . The fluoride concentration in the study area ranges from BDL to 0.54 ppm in deeper

aquifers, which is well within the desirable limit of 1.0 ppm. Calcium and Magnesium presence in the water sample is within the permissible range- Ca (02-46) & Mg (1.2-10.93) ppm. The total hardness of the analyzed water samples varies from 15 to 180 ppm.

In Meghalaya, concentration of iron ranges from below detection (BDL) limit to 3.30 ppm except Umjarian-15.6 ppm. The quality assessment of ground water in the study regions shows that except few samples, all elements of water samples fall within the desirable limits of BIS.

10.11.3 Tripura

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 waters are slightly alkaline in nature. The pH values of the ground water ranges from 6.42 to 8.50. Specific conductance of ground water in the state varies from 40-741 micro Siemens /cm at 25°c. Carbonate content varies from 09-18 ppm in ground water but for a few samples where it occurs in negligible quantities. Bicarbonate is the chief source contributing to the alkalinity of the waters. Bicarbonate content of the ground water in the state ranges from 24 to 264 ppm. Sulphate concentration is comparatively low and ranges from BDL to 33 ppm. This low concentration of Sulphate indicates that water is of recharging type. Chloride content of the water in general ranges from 10 to 113 ppm. Calcium and Magnesium in the form of carbonate and bicarbonate presence is within the permissible range. Thus the ground water of the state is generally soft. Fluoride concentration ranges from 0.01-0.98 ppm. Iron concentration ranges from 0.04 to 6.12 in the state expect for a few high values e.g. 10.0 ppm in the water sample collected from Gaptoli.

10.11.4 Arunachal Pradesh

In general chemical quality of ground water in the state is found potable. EC value ranges from 73 to 837 micro Siemens /cm at 25°c, which states about freshness and potable nature of water. The pH value in the study area varies from 7.24 to 8.88, except Hukanjuri (pH= 3.95) of Tirap District which show acidic nature of water at that point. Carbonate concentration is found below detection limit (BDL) to 18 ppm in ground water samples of Arunachal Pradesh. Bicarbonate varies from 1.7 to 190.65 ppm. Chloride content ranges from 10.63 to 70.90 ppm. which is well within the permissible limit . The fluoride concentration in the study area ranges from BDL to 0.25 ppm in deeper aquifers. Calcium and Magnesium presence in the water sample is within the permissible range- Ca (12-44) & Mg (2.5-52.5) ppm. The total hardness varies from 40 to 270 ppm.

Concentration of iron ranges from below detection (BDL) limit to 3.70 ppm. The quality assessment of ground water in the study regions shows that except few samples, all constituents of water samples fall well within the desirable limits of BIS.

10.12 Southern Region, Hyderabad

Samples collected from exploration sites of Nizamabad,Adilabad, Guntur, Hyderabad,Krishna, Prakasam, Ranga Reddy, Warangal districts were analysed.

Hydro chemical studies with finding / conclusions:

Water quality problems like high pH and Carbonate are observed at Nandigonda of Warangal District ; Salinity (EC),Total Hardness,Calcium, Magnesium, Chloride at Singaraikonda of Prakasam District; Sodium, Bicarbonate, Sulphate and Fluoride at Kanchikacherla of Krishna District; Potassium at Pedda Kondamagundla of Guntur District. Nitrate is high at Kumari of Adilabad District. Out of all samples, 14 samples were observed to contain Fluoride more than 1.5 mg/l. Highest concentration of Nitrate observed was 307 mg/l at Kumari of

Adilabad district and 16 samples have nitrate more than 45 mg/l. High salinity >3000 µS/cm at 25^0 C was observed at 7 sites.

10.13 South Eastern Region, Bhubneshwar

The parameters determined are- 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

A total of 862 ground water samples were analyzed during the AAP 2010-11. Thirteen basic chemical constituents viz., Electrical conductivity, pH, Carbonate, Bi- carbonate, Chloride, Nitrate, Sulphate, Flouride, Calcium, Magnesium, Total Hardness, Sodium and Potassium. In addition, specific analyses of NHS groundwater samples were carried out for five chemical constituents viz., EC. pH, Flouride, Nitrate, Chloride.

In addition to the above, process initiated for procurement of RAD-7 for analysis of Radon in ground water samples. Correspondence made with KSPCB regarding empanelment for upgradation of chemical laboratory to environmental one as per new guidelines.

10.15 South East Coastal Region, Chennai

Hydrochemical studies with findings/conclusions

A total of 1369 samples were analyzed for basic parameters and heavy metals involving 16,133 constituents under National Ground Water Monitoring Wells (NGMWs), Exploration, Ground Water Management Studies (GWMS), Pollution studies and others for the period 2010-11.

The quality of shallow ground water in Tamil Nadu state and U. T. of Puducherry has been evaluated by sampling and analysis of water sample collected from NGMWs was monitored for water quality during May 2010 representing pre-monsoon water quality.

In general, the ground water quality in the state is fresh in about 16% of the NGMWs, as indicated by the EC value less than 750 µs/cm at 25^{0}C. In about 52% of the NGMWs the EC varies between 751and 2250 and 13% of the NGMWs are between 2251and 3000 indicating that the ground water is slightly mineralized and about 19% of NGMWs 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 54% of the sample analyzed and 36.5% of the samples are between 251 and 1000 mg/l and 9.5% 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 89% of the samples and 11% of the samples shows more than 1.5 mg/l, which are from the districts Viz., Dharmapuri, Krisnagiri, Salem, Namakkal, Erode, Coimbatore, Pudukottai, and Virudhunagar. Nitrate content is less than 45mg/l in about 64% of the samples analyzed and 17% is within the permissible limit of 46-100 mg/l and 19% of samples shows more than 100 mg/l which are from the districts of Salem, Namakkal, Erode, Kancheepuram, Kanyakumari and Dindigul.

Compilation of Chemical studies

- Report on Assessment of Groundwater Quality in and around Ambattur industrial area, Thiruvallur district, Tamil Nadu submitted and issued.
- Report on Hydrochemistry of Pallikaranai landfill site – A sub urban area of Chennai is submitted.
- Interim report on Ground water pollution in Kodungaiyur landfill site is submitted

10.16 Kerala Region, Trivendrum

Hydro chemical studies

Apart from NHS samples, water samples from the following studies were also analysed.

i) Exploration programme, Pathanamthitta district and Trichur district
ii) RHS Malappuram district and special studies Chamravattom area, Malappuram district Bauxite and Clay mining area, Kasargod district.
iii) Ground Water management studies of Pathanamthitta district and Trivandrum district.
iv) Short Term Water Supply Investigation Scheme, Ernakulam district.
v) Lakshadweep Islands

The parameters determined in water samples of the above mentioned studies are pH, Electrical-conductivity, Total hardness, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulphate, chloride, fluoride and nitrate. Except in the water samples collected from the Lakshadweep Islands , the water samples collected from the other studies are found to be within the permissible limits of drinking water specifications. The findings in respect to the water quality parameters of Lakshadweep Islands are summarised below. The samples are collected during the months of April 2010 and November2010 representing pre monsoon and post monsoon water samples.

10.17 Uttarakhand 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 189 samples were collected under Ground Water Observation, exploration, reappraisal studies and analysed for 2457 determination of basic parameters. 7 number of ground water samples collected for determination of Heavy metals were also analysed.

10.19 State Unit Office, Delhi

During the AAP: 2010-11, a total of 107 water samples were collected and sent to Chemical Laboratory of North Western Region (NWR), Chandigarh. Out of 107 water samples, 96 samples were collected from Net Work stations. 11 form exploration wells.

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. HIGH YIELDING AQUIFERS EXPLORED

During 2010-11, 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 180 litre per minute to 2040 litre per minute have been constructed in the states of Andhra Pradesh, J&K, Karnataka, Kerala, Maharashtra, Madhya Pradesh, 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 2010-11 is given Table 11.1 .

Table 11.1: High Yielding Wells Constructed During 2010- 2011

Sl. No.	Name of States	Description
1.	Andhra Pradesh	• An exploratory well drilled in Devokpet, Nizamabad district recorded a yield of 240 LPM during drilling at the fracture zone encountered at 93 mbgl. This well can cater to drinking water requirements of a population of about 2400 (@ 60 lpcd for ten hours of pumping a day) in the area.
2.	Jammu & Kashmir	• An exploratory well drilled (2004-05) and APT conducted on 9th October 2010 in Kargil district has yielded discharge of 200 LPM in the area. 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.
3.	Karnataka	• An observation well drilled in Hosahudiya, Chikkaballpur taluk, Chikkaballpur district down to a depth of 342.6m bgl has encountered a high discharge of 705 litre per minute in fractured granite gneiss formation. 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. • An exploratory well drilled in Chamrajnagar taluk, Chamrajnagar district down to a depth of 129.10m bgl has yielded a high discharge of 738 litre per minute in the formation Granite Gneiss. This well can cater to drinking water requirements of a population of about 7380 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Chamrajnagar taluk, Chamrajnagar district down to a depth of 104m bgl has yielded a high discharge of 552 litre per minute. This well can cater to drinking water requirements of a population of about 5000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Kollegal taluk, Chamrajnagar district down to a depth of 132.15m bgl 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. • An exploratory well drilled in Ayyanapura of Chamarajanagar district down to a depth of 156.55 m bgl with casing of 27.0 mbgl has yielded high discharge of 1140 LPM. This well can cater to drinking water requirements of a population of about 11400 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Somenahalli, Hassan Taluk, Hassan district to a depth of 200.20m bgl has yielded a high discharge of 201 litre per minute . 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 exploratory well drilled in Chikkaballpur taluk , Chikkaballpur district down to a depth of 336.5m bgl has yielded high discharge of 180 LPM. This well can cater to drinking water requirements of a population of about 1800 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Chamarajanagar taluk, Chamarajanagar district down to a depth of 80 m bgl has yielded high discharge of 1260 LPM. This well can cater to drinking water requirements of a population of about 12600 (@ 60 lpcd for ten hours of pumping a day) in the area.

Sl. No.	Name of States	Description
3.	Karnataka	• An exploratory well drilled in Ayyanapura of Chamarajanagar district down to a depth of 77.25 m bgl with casing of 24.50 mbgl has yielded high discharge of 1138 LPM. This well can cater to drinking water requirements of a population of about 11400 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Byle of Hassan district down to a depth of 126.05 m bgl with casing of 22.7 mbgl has yielded high discharge of 270 LPM. This well can cater to drinking water requirements of a population of about 2700 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Hassan taluk in Hassan district down to a depth of 123.8 m bgl has yielded high discharge of 828 LPM. This well can cater to drinking water requirements of a population of about 8300 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Chamarajanagar taluk, Chamarajanagar district with depth of 123m bgl has yielded a high discharge of 1138 LPM. This well can cater to drinking water requirements of a population of about 11300 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Patna taluk in Hassan district with depth of 162m bgl has yielded a high discharge of 300 LPM. 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 in Alur taluk, Hassan district with depth of 163m bgl has yielded a high discharge of 404 LPM. 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 in Chikkaballpur taluk , Chikkaballpur district with depth of 367m bgl has yielded a high discharge of 270 LPM. This well can cater to drinking water requirements of a population of about 2700 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Chamarajanagar taluk, Chamarajanagar district with depth of 103m bgl has yielded a high discharge of 722 LPM. 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 in Patna taluk in Hassan district with depth of 170m bgl has yielded a high discharge of 404 LPM. 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 in Chikkaballpur taluk, Chikkaballpur district with depth of 251m bgl has yielded a high discharge of 540 LPM. This well can cater to drinking water requirements of a population of about 5400 (@ 60 lpcd for ten hours of pumping a day) in the area.
4.	Kerala	• An exploratory well drilled in Chelakara, Trissur district down to a depth of 101m bgl has yielded a high discharge of 900 litre per minute in Hornblende Biotite 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 in Kongad, Palakkad district down to a depth of 50m bgl has yielded a high discharge of 360 litre per minute in Hornblende Biotite Gneiss formation. This well can cater to drinking water requirements of a population of about 3600 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Adoor, Pathanamthitta district down to a depth of 123m bgl has yielded a high discharge of 600 litre per minute in Gneiss formation. 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. • An exploratory well drilled in Desamangalam, Trissur District with depth of 101m bgl has yielded a high discharge of 600 LPM and formation tapped is Charnockite. 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.

Sl. No.	Name of States	Description
4.	Kerala	• An exploratory well drilled in Ramavarmapuram, Trissur District with depth of 90m bgl has yielded a high discharge of 1440 LPM and formation tapped is Charnockite. This well can cater to drinking water requirements of a population of about 14400 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Pathanamthitta Municipal Stadium, Pathanamthitta District with depth of 150m bgl has yielded a high discharge of 354 LPM and formation encountered is Garnet biotite gneiss. Charnockite. This well can cater to drinking water requirements of a population of about 3500 (@ 60 lpcd for ten hours of pumping a day) in the area.
5.	Maharashtra	• An exploratory well drilled in Wadgaon in Sonpeth taluka of Parbhani district down to a depth of 200m bgl has yielded a high discharge of 265.8 litre per minute in the formation is fractured weathered basalt. The water-bearing zone was encountered between 24.00 & 29.00 m.bgl. The static water level is 8.25 m.bgl. This well can cater to drinking water requirements of a population of about 2600 (@ 60 lpcd for ten hours of pumping a day) in the area.
6.	Madhya Pradesh	• An exploratory well drilled down to a depth of 213m bgl at Surajpur Kalan in Bada Malhera block of Chhatarpur district has yielded high discharge 480 LPM in Bijawar formation. The water level recorded was 11 m bgl. 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 in Malar in Buxwaha block of Chhatarpur district down to a depth of 214.53 m bgl has yielded high discharge 300 LPM in Vindhyan Shale formation. The water level recorded was 30 m bgl. 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 in Darganwa in Bada-Malhera block of Chhattarpur District down to a depth of 80.30m bgl has yielded a high discharge of 840 LPM in Bijawar formation. The water level recorded was 34.70m bgl for a drawdown of 4.18m in 100 minute of pumping during APT. 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 exploratory well drilled in Garguan in Budamalehera block District Chhetarpur District has yielded a high discharge of 840 LPM in Bijewar 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 exploratory well drilled in Kusmi, Jabara block, Damoh District has yielded a high discharge of 360 LPM in Vindhyan formation. This well can cater to drinking water requirements of a population of about 3600 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled down to a depth of 269.9m bgl. at Konda-Kalan in Damoh District has yielded a high discharge of 180 LPM in lime stone formation of Vindhyan group. This well can cater to drinking water requirements of a population of about 1800 (@ 60 lpcd for ten hours of pumping a day) in the area.

Sl. No.	Name of States	Description
7.	Orissa	• An exploratory well drilled in Denkanal Sadar block, Dhenkanal district with depth of 129.7m bgl has yielded a high discharge of 450 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 4500 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Mahanga block, Cuttack district with depth of 81.95m bgl has yielded a high discharge of 1020 LPM in Alluvium formation. This well can cater to drinking water requirements of a population of about 10200 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Denkanal Sadar block, Dhenkanal district with depth of 139.7m bgl has yielded a high discharge of 360 LPM in Khondalite and Granulite formation. This well can cater to drinking water requirements of a population of about 3600 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Tarva block, Boudh district with depth of 160m bgl has yielded a high discharge of 420 LPM in Granite 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 in Ghatgaon, Keonjhar District with depth of 111.2m bgl has yielded a high discharge of 240 LPM in Granite formation. This well can cater to drinking water requirements of a population of about 2400 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Gobindapur, Dhenkanal Sadar district with depth of 130m bgl has yielded a high discharge of 384 LPM in Khondalite & Granulite formation. This well can cater to drinking water requirements of a population of about 3800 (@ 60 lpcd for ten hours of pumping a day) in the area. • An observation well drilled in Ghatgaon, Keonjhar district with depth of 121.30m bgl has yielded a high discharge of 480 LPM in Granite & P 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. • A piezometer drilled in Keonjhar block, Keonjhar District with depth of 56.10m bgl has yielded a high discharge of 360 LPM in Granite formation. This well can cater to drinking water requirements of a population of about 3600 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Ghatgaon of Keonjhar district down to a depth of 105m bgl has yielded a high discharge of 300 litre per minute in the formation Granite Gneiss. 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.
8.	Rajsthan	• An exploratory well drilled in alluvial formation on the right bank of Banganga river at Hingota weir, Weir block, Bharatpur district down to a depth of 102m bgl has yielded (fresh/potable ground water, having EC about 88ms/cm at 25^{o}C) high discharge of 880 LPM in area, where quality of ground water in general is brackish to saline. This well can cater to drinking water requirements of a population of about 8800 (@ 60 lpcd for ten hours of pumping a day) in the area.

Sl. No.	Name of States	Description
9.	Tamilnadu	• The piezometer drilled in Macheri block, Mallpanur in Salem district down to a depth of 85 m bgl has yielded high discharge 1860 LPM in Granite Gneiss formation. • Piezometer constructed in hard rock areas of Salem district at Magudamchavadi down to a depth of 64m bgl has yielded a high discharge of 1560 litre per minute in the formation of Granitic Gneiss. • An exploratory well drilled down to a depth of 400m bgl at Karaikurichy in the Neyveli Hydrogeological Basin, Cuddalore district tapping Cuddalore sandstone has yielded high discharge 1140 LPM and is under free flow condition during development. This well can cater to drinking water requirements of a population of about 11000 (@ 60 lpcd for ten hours of pumping a day) in the area.
10.	West Bengal	• An exploratory well drilled in Bhajanghat, Nadia District has yielded a high discharge of 1500 LPM. This well can cater to drinking water requirements of a population of about 15000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Chapla, South 24 Parganas District has yielded a high discharge of 1320 LPM in Granite formation. This well can cater to drinking water requirements of a population of about 13200 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Putikhali, Nadia district has yielded a high discharge of 2040 LPM. This well can cater to drinking water requirements of a population of about 20000 (@ 60 lpcd for ten hours of pumping a day) in the area. • An exploratory well drilled in Lohapur, Birubhum District has yielded a high discharge of 1320 LPM. This well can cater to drinking water requirements of a population of about 13200 (@ 60 lpcd for ten hours of pumping a day) in the area.

12. 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 32.06 Crore and project has duration of 6 years staring from May 2006 to 2012. The Budget provision for the year 2010-11 is Rs 8.28 Crore and revised provision is 4.47 Crore. The expenditure incurred on the project till March 2011 in the FY 2010-11 is Rs 3.48 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 Decision Support System and Purpose Driven Studies have been taken up. In this year of the project, six domain specific training has been imparted, six awareness raising programme held, 60 piezometers and 1 well field (7 wells under Purpose Driven Study on "Specific Yield Study in Chennai Sub-urban Area") have been constructed. Tender document for procurement of the hardware (7 Servers & 59 Workstations) has been published and bids evaluated. During this year, proposal for procurement of groundwater modeling softwares and All India Village boundaries GIS data (Digital) set from Survey of India have been undertaken. Inter laboratory Analytical Quality Control exercise for CGWB labs have also been undertaken. For hiring of Consultancy Services for "Development of e-GEMS", five firms have been shortlisted after evaluation of Expression of Interest (EOI) and Request for Proposal (RFP) has been prepared and got approved by MoWR.

13. STUDIES ON ARTIFICIAL RECHARGE TO GROUND WATER

13.1 Demonstrative Projects on "Artificial Recharge to Ground Water & Rain Water Harvesting"

During 2010-11, Ten demonstrative recharge projects on "Artificial Recharge to Ground Water and Rain Water Harvesting" have been approved for taking up at following areas.

1. Artificial recharge to groundwater in Ratlam District, Madhya Pradesh.
2. Artificial recharge to groundwater in Shajapur District, Madhya Pradesh.
3. Artificial recharge to groundwater in Bangalore Rural District, Karnataka.at Kayyur –Cheemeni, Kasargod dist. Kerala
4. Rainwater harvesting in premises of Kakatiya University, Warangal dist. Andhra Pradesh
5. Artificial recharge structures in Indira Nagar & Gomti Nagar regions of Lucknow city
6. Artificial recharge structures in the premises of Panjab University, Chandigarh.
7. Artificial recharge structures in Watrak (Mohar) watershed (Sabarmati Basin) area of Kheda & Sabarkanth district, Gujarat
8. Artificial recharge structures in Saraswati River Bed at Madhu Pavdi check dam, Siddhpur, district Patan, Gujarat
9. Artificial recharge structures in Raj Bhawan, Nagpur
10. Artificial recharge structures in Ranchi Urban Area, Jharkhand

The approved cost of ten projects is Rs.2788.175 lakhs for implementation by the departments of states under overall technical guidance of Central Ground Water Board for construction of 479 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 Madhya Pradesh, Andhra Pradesh, Karnataka, Jharkhand, Maharashtra, Gujarat, Uttar Pradesh & Chandigarh 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 to 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 to 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, 2011, 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, 2011 given in table 13.2.

Check Dam constructed in Malur taluk under Demonstrative Projects at SWR, Bangalre

Artificial Recharge to Ground Water under CSS at Chittoor district

Artificial Recharge and Rainwater harvesting Studies under CSS (XI th Plan) at Rajbhavan at Nagpur

Earthen Structure **at Rajbhavan (Governors's Bunglow) at Nagpur**

Table 13.1: Demonstrative Artificial Recharge Projects sanctioned under CSS "Ground Water Management and Regulation" XI Plan As on 31.03.2011

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 Recharge 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	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	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	1	0	40.000	28.000	Released first installment on 26.10.2009
10.		Artificial Rechargeb to Groundwater in Karuvatur watershed Namakkal district .	30	7	275.350	192.745	
11.		Artificial Ground Water Recharge through road side and open space rainwater harvesting structures in Coimbatore city .	215	159	100.000	70.000	
12.	Andhra Pradesh	Construction of Artificial Recharge structures in Chittoor district.	29	0	130.020	91.014	
13.	Karnataka	Demonstrative Artificial Recharge Project in Malur Taluk, Kolar district.	52	0	109.158	76.410	
14.	Uttar Pradesh	Artificial Recharge to Groundwater in Sataon block of Rae Bareli district.	28	0	720.063	504.440	Released as 1st installment on 30.03.10
		Total	**596**	**223**	**2074.853**	**1250.387**	

During 2010-11 Total 6 projects						
Sl. No	**State**	**Number of structures**	**Demonstrative Recharge Project**	**Approved/ Cost Rs. (in Crores)**	**Released Cost Rs. (in Crores)**	**Remarks**
1	Madhya Pradesh	28	Artificial recharge to Groundwater in **Ratlam District**, Madhya Pradesh.	3.02680	2.11876	Released as 1st installt. Vide Ministry letter dated 11.05.2010
2		12	Artificial recharge to Groundwater in **Shajapur District**, Madhya Pradesh.	1.29180	0.90426	
3	Karnataka	56	Artificial recharge to Groundwater in **Bangalore Rural District**, Karnataka.	0.96585	0.67610	Released as 1st installt. MoWR. dt 20.10.2010
4	Andhra Pradesh	33	Rainwater harvesting in premises of **Kakatiya University**, Warangal dist. Andhra Pradesh	0.75180	0.52640	Released as 1st installt. MoWR. Lt dated 03.11.2010
5	Uttar Pradesh	116	Artificial recharge structures in Indira Nagar & Gomti Nagar regions of **Lucknow city**	10.6064	7.2850	Released as 1st installt. MoWR. Lt dated 12.11.2010
6	Chandigarh	54	Artificial recharge structures in the premises of **Panjab University**, Chandigarh.	7.7603	5.43221	Released as 1st installt. MoWR. Lt dated 15.11.2010
7	Gujarat	96	Artificial recharge structures in Watrak (Mohar) watershed (Sabarmati Basin) area of Kheda & Sabarkanth district, Gujarat	1.6671	1.16697	Released as 1st installt. MoWR. Lt dated 9-12-2010.
8	Gujarat	20	Artificial recharge structures in Saraswati River Bed at Madhu Pavdi check dam, Siddhpur, district Patan, Gujarat	1.4953	1.04671	
9	Maharashtra	49	Artificial recharge structures in Raj Bhawan, Nagpur	0.1515	0.10605	
10	Jharkhand	15	Artificial recharge structures in Ranchi Urban Area, jharkhand	0.1649	0.11543	
	Total	**479**		**27.88175**	**219.37789**	

Table 13.2: **State wise details of funds released in the scheme as on 31st March, 2011**

Sl. No.	States	Fund released as subsidy to Beneficiaries (Rs. In Crores)	Fund released to State/Min. for IEC activities (Rs. in Crores)	Total fund released as on 31.03.11 (Rs. in Crores)	Dug well recharge structures constructed as on 31.03.11
1.	Andhra Pradesh	0.00	0.00	0.000	0
2.	Gujarat	48.41	3.25	51.66	7984
3.	Karnataka	26.68	2.00	28.68	11007
4.	Madhya Pradesh	40.14	2.00	42.14	14639
5.	Maharashtra	14.04	2.00	16.04	38023
6.	Rajasthan	30.48	2.00	32.48	4396
7.	Tamil Nadu	103.83	5.75	109.58	21055
	Ministry		0.242	0	0
	Total (in Rs. Crores)	**263.58**	**17.242**	**280.822**	**97104**

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 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 in judicious 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:

Identify, acquire and review all available data including previous studies.

(a) 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.

(b) Identify regional and local boundaries for groundwater flow and develop a conceptual geological model.

(c) 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.

(d) Apply the groundwater model to evaluate groundwater flow condition and flow rates for different hypothetical future scenarios in the area.

Status of work done

Preparation of database and transfer into mudflow files in respect of top & bottom of layer 1 & 2; water level, hydrological properties etc. Re-estimation of cell-wise values & transfer cell to cell data of top, bottom, water level, recharge, groundwater draft, hydraulic properties for layer 1 & 2 in modflow for modeling of groundwater systems. Attempts were made to run steady state model.& submitted Interim Report for the work done till September, 2010 **.**

14.2 Ground water modelling studies in Lucknow urban area

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Lucknow city, the capital of Uttar Pradesh, lies on the banks of river Gomti and occupies an area of 340 sq km in parts of three blocks namely Sarojini Nagar, Chinhat , Kakori , falls in Survey of India toposheet Nos. 63B/13 & 63B/14 (Scale 1:50,000).The population density of 6600 persons per sq km with a high decennial growth has put on tremendous stress on ground water resources for drinking and other purposes.

The total population of the city area is 22.45 lacks in the year 2001 against the population of 17.31 lacks in the 1991. Projected population for 2011 will be 33.90 lacs. The alarming increase in the population of the city is putting an immense pressure on the available water resources. Thus swelling demand of water supply is attracting water Planners & Managers for its critical examination. The climate of the city is sub-tropical. The annual normal rainfall at Lucknow city is around 1000 mm .

Lucknow city occupies the inter-fluvial region of Gomti and Sai rivers of the Central Ganga Plain in Ganga basin. It is almost a flat country with conspicuous natural depression in north-eastern part around Jankipuram. The general slope of the area is from NNW to SSE.

The drainage system of the area is controlled mainly by river Gomti. 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 .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.

In the area three geomorphic units can be deciphered .They are Younger Flood Plai, Older Flood Plain and Interfluve Plain or Upland

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.

As per WHO norm of 250 lpcd the total requirement of Lucknow city is 849.75 MLD (say 850 MLD) thus a deficit in water supply is 370 MLD approximately in the year2011. Considering the water requirement of 150lpcd which is being taken as a norm , the total requirement is 509.85 MLD in the year 2011 leaving behind a gap of 29.85 MLD..

The present supply from surface water is met through river Gomati through its water works at Aishbagh & Balagunj. Lucknow Jal Sansthan supplies the water supply to Lucknow city. Another water works is under construction stage at Gomti Nagar . Total Surface Water Supply is 242 MLD and Total Ground water supply is 238 MLD.

Ground water occurs in the pore spaces of unconsolidated alluvial sediments in the zone of saturation under pheretic and semi confined conditions. In deeper aquifers it occurs under semi confined to confined conditions.

Aquifer Groups

Sl. No.	Aquifer Group	Depth range (mbgl)
1.	First Aquifer Group	00.00-150.00
2.	Second Aquifer Group	160.00-240.00
3.	Third Aquifer Group	260.00-370.00
4.	Fourth Aquifer Group	380.00-480.00
5.	Fifth Aquifer Group	483.00-680.00

Depth to water in Lucknow city is being monitored monthly by C.G.W.B. through 19 piezometers since 2003. It is found that out of 10 piezometers in Cis-Gomti area, 8 have shown a falling trend in Pre-monsoon period for the period 2003 to 2010. The minimum fall is observed at Sarojininagar-0.41 m/year and maximum at Narhi-0.94 m/year. The rising trend is seen at Arya Nagar and Campbell road where the extraction of ground water is minimum. All piezometers in Trans-Gomti area show a falling trend in Pre-monsoon period. The minimum fall is observed at LU New Campus (0.33 m/year) and maximum at Gomti nagar (1.69 m/year).

It is found that out of 10 piezometers in Cis-Gomti area, 8 have shown a falling trend in post-monsoon period. The minimum fall is observed at Sarojininagar-0.14 m/year and maximum at Narhi-1.07 m/year. The rising trend is seen at Arya Nagar and Campbell road.

All piezometers in Trans-Gomti area show a falling trend in post-monsoon period. The minimum fall is observed at Bhujal Bhawan, Aliganj- 0.44 m/year and maximum at Gomti Nagar.

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 the 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 .

The ground water level of a ground water reservoir fluctuates according to inputs to it and withdrawal from it.

The chemical analysis data of the ground water samples reveals that most of the chemical parameters are well with in permissible limits of Bureau of Indian Standards (BIS).

14.3 Special Studies Patna Urban Area

Under the groundwater modeling study of Patna urban area, the following work has been completed

i) All the data files e.g (top and bottom of each layers, pumping wells, boundary conditions for each layer, storage and conductivity, recharge, hydraulic heads of each layer) have been prepared in excel file and have been imported in MODFLOW.
ii) Steady state calibration has been carried out taking piezometric level data of 2008-09.
iii) Model is being validated with data of 2009-2010.
iv) Monthly monitoring is continuing for additional data sets for model validation.

14.4 Special Studies Ranchi Urban Area

A total of 40 dug wells and 13 peizometers were monitored monthly in Ranchi Urban area for study of the ground water regime.

In shallow aquifers during pre-monsoon period water level varies from 2.04 (Dindyal Nagar) to 15.95 m bgl (Daily Market). During post-monsoon, water levels varies from 0.25 (Tiril) to 11.81 m bgl (Church Compound).

In deeper aquifer during May 2010 the depth to piezometric surface registered wide variation within the Urban Area. The minimum water level has been recorded as 5.49 m bgl at Bariyatu, where as maximum water level has been recorded as 22.08 m bgl at Kanke. During November 2010 also depth to piezometric surface registered wide variation throughout the area. The minimum water level has been recorded as 3.9 m bgl at Zilla School, where as maximum water level has been recorded as 19.84 m bgl at Kanke.

All the relevant data have been prepared in excel file compatible for import in MODFLOW.

14.5 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:

i) Valuable field data generated during the field work would be analysed to achieve the objective of the study.
ii) It will help to estimate the groundwater resource availability in fresh and arsenic contaminated aquifer.
iii) 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.
iv) Finally to frame a groundwater development plan for supply of safe drinking water in a sustainable manner.

As part of the, joint study, the following works were carried out during 2010-11.

CGWB team:

Pre and Post-monsoon monitoring completed. Available data has been organized in excel file in format compatible for import in MODFLOW. Data collection from different Govt agencies

NGRI team:

Time domain electromagnetic and resitivity imaging commenced. NGRI team leader visited Patna and held discussions with CGWB team.

A joint field survey was also carried out in the study area. Surveying carried out through DGPS and 55 monitoring stations connected through DGPS. One drilling through NGRI carried out at Sinha (Bhojpur district) for 150 feet.

14.6 Impact Of Climate Change On Ground Water Regime - Gaya peri-urban area

In this study, the historical rainfall data of Gaya for the period 1901-000 (Source IMD) has been analysed. The monthly data has been grouped for monsoon 2 (June to September) and non-monsoon periods. The decadal trend of the monsoon season has been found to exhibit a decline of 2.2 cm. For the non-monsoon season, there is no change in the overall rainfall regime during the past 100 years. The available records of the water level have been studied and attempt has been made to quantify the impact of climate change on the declining water levels for Gaya peri-urban area.

14.7 Ground Water Regime Study in Biharsharif – Rajgir Urban and Peri-Urban Areas Biharsharif (Nalanda district), Bihar state –400 sq. km.

The study area falls under Phalgu-Mohane-Sakri sub basin. This is a depressed land and is often inundated during south west monsoon. The area in and around Biharsharif town is underlain by alluvium of Recent age overlying crystalline metamorphic quartzites of Archean age.

Biharsharif, the major town falling in the study area is thickly populated. The pressure of population has greatly affected land utilisation of the area. The land use figures reveal that maximum land is given to crops around Biharsharif town. The secondary activities are poor or non existent except for some local trade. The study area is an alluvial plain formed by the sediments brought by the master stream, the river Ganga and its tributaries from the south.

The hydrogeological survey around Biharsharif reveals great accumulation of groundwater forming a thick zone of about 600-700 m. The average relief in and around Biharsharif does not go beyond 70 m. The general slope of the land is towards north. The climate of Biharsharif plain is generally hot and dry except during the monsoon period when the humidity suddenly goes high. The average annual rainfall in Biharsharif is 1000-1100 mm. The lower rainfall is on account of local relief condition.

The rivers around Biharsharif are all rainfed with smaller catchment except in the monsoon when the rivers have very little water. Since the area around Biharsharif has a fertile soil and little surface water irrigation facilities, large scale of exploitation of ground has taken place and the water table has gone down.

The groundwater occurring in the inter granular spaces in sands, gravels, pebbles and cobbles of the alluvium and fractures in quartzite of the area mainly due to direct precipitation and the inflow of ground water from the recharge zone (marginal alluvial tracts) bordering hills in the south. The near surface ground water occurs under water table conditions. The pre-monsoon depth to water level varies between 2.25m bgl to 8.61 m bgl and post-monsoon depth to water level varies between 2.22m bgl to 7.04 m bgl.The temperature of ground water of shallow aquifer ranges from 25 ºC to 29ºC. However, the average depth to water level in dug wells is 4.76. The ground water of the area flows in a northerly direction.

14.8 Mining Hydrogeology, Ramgarh District:

The area of Patrau coal field comprises of barakar sandstone with coal seams,Mica schist, phyllite and Chotanagpur Granite Gneiss**.** Four types of geological formations are present in the Patratu coal field area. Premonsoon water level is deepest (9.50mbgl) in Bhurkunda area and Shallowest (2 mbgl) in Sayel area. Post-monsoon water level is deepest (8.50mbgl) in barwatola area and Shallowest (1.40 mbgl) in Patel Nagar.In Patratu Coal field Open cast mine area is about 25^2 km. The hydrologic impacts to ground water is dewatering of local aquifers caused by pumping from the mine and a resulting cone of depression. Active mine areas are having deeper water levels and abandoned mine area is having shallow water level. Ground water quality of the area is within permissible limit as prescribed by BIS. Naikkari river passes through the area and suspended sediments is high and it seems to be polluted in terms of physical characteristics.pH-8.22. Ground water of the area is Alkaline in nature and pH varies between 8.22-9.09.

14.9 Ground Water Modeling villages in Midjil and Kalwakurthy mandals in Mahabubnagar district

About study area

MBNR-D-44-Tarnikal watershed (Madharam basin) having an area of 95.30 km2, consist of 9 villages in Midjil and Kalwakurthy mandals in Mahabubnagar district is study area. The area lies between 16°37′46″ to 16°47′41″ North Latitude and 78°21′16″ to 78°26′02″ East Longitude falling in Survey of India Toposheet No. 56 L/5 and L/6.

Objectives of the study

To fine-tune/improve the existing groundwater estimation parameter norms/methodology for quantitative assessment of ground water resources of the watershed by

- Estimation of natural recharge and return irrigation by using tracer techniques.
- Estimation of ground water draft using conventional and remote sensing data.
- To simulate/generate groundwater models for sustainable development of groundwater resources of the basin.
- To recommend suitable rainwater harvesting techniques and artificial recharge structures for sustainability of ground water abstraction structures.

Activites during the year

- Monitoring of Ground Water Levels
- Ground water levels were monitored from the established 10 key wells during pre and post monsoon season.. The depth to water level (DTW) varies between 11.52 meter below ground level (m bgl) to 48.55 mbgl during pre-

monsoon season and between 7.94 mbgl to 11.02 mbgl during the year 2010.

- Simulation of Groundwater Model for Sustainable Development of Groundwater Resources

Conceptual model

The conceptual model for simulation of groundwater flow for sustainable development of groundwater resource for the above area was taken up. The data generated during 3 years field work and various hydrogeological data collected was used in conceptualization of model. The most popular and comprehensive deterministic ground water model MODFLOW Code has been used.

MODFLOW, is a family of compatible codes based on finite difference solutions for 3-d flow through porous medium. During the process the following steps were followed.

1) MODEL CREATION

- Conceived the pseudo 3-D model with 2 layers (1- unconfined and 2- leaky confined representing fractured zone).
- Divided the area into 500 m X 500 m equal grids and created 38 rows and 19 columns with 722 cells. Out of these 722 cells, 377 cells were active and remaining 345 were non active.

Data entry

- Prepared the base map and divided it into 38 rows and 19 columns and descretised top elevation cell wise by observing the values from toposheets and actual measured values in field with the help of DGPS.
- The minimum and maximum elevations were assigned 450 m amsl and 600 m amsl. However, the elevation in 4-5 cells which is above 600 made non active for the smooth running of the model. The grid map of the model for layer 1, bottom of the layer 1 and top of the layer 2 is prepared and the map for layer 1 is given in figure-2.
- Map for initial heads were prepared and discretized with the help of actual pre-monsoon water table data (pre-monsoon 2007) and adjusting with the top of elevations. Cell wise data is entered and generated the initial heads for layer 1 and layer 2.
- Assigned the general head boundary (head dependant boundary) of 433 m amsl to the 37th row and 5th column (i.e., at the confluence of stream with Dindi river).
- Cell wise and layer wise aquifer parameters namely hydraulic conductivity, effective porosity,vertical leakance based on the field data (aquifer tests) has been discretised into the model.
- Ground water draft has been computed from the field data and the same is descritized in to the model.
- Average annual recharge during the normal annual rainfall year has been computed cell by cell and discretized.
- With all the above data inputted into the model and the model was run under steady state conditions using pre-processor (Modflow) and the output files are generated.

A steady state calibration was achieved by methodology adjusting model input parameters until simulated heads atched the observed heads of 2007 (pre-monsoon) (Figure-3). The figure 4 shows machine contoured surface simulation head by the model. The model is calibrated under steady state conditions till a discrepancy error is zero is obtained. Steady state heads are given in the following figure.

STEADY STATE CALIBRATION

For the steady state stress period 1 day is considered. The Hydraulic conductivity values accepted by the model for layer 1 and layer 2 is 1.5 and 1.8 m/day in x,y and z direction respectively. Accepted vertical leakance for layer 1 varies from 0.0001 to 0.1 (from cell to cell) and for layer 2 it is 0.0001, the effective porosity values are 0.044 for layer 1 and 0.043 for layer-2. the wetting factor of 0.1 is accepted for both layer 1 and layer 2. the recharge for each was 0.16 x10-3 (m/day) for both layers. The draft for each cell was 40m3/day/cell for both layers. The total input is 14240 m3/day/cell and the constant head in wells is 11200 m3/day/cell and the remaining 3039 m3/day was outflow from head dependant boundary base flow). The model has been calibrated till discrepancy error is 0 %. The accepted steady state model results are as given below:

Parameters	Accepted values	
	Layer 1	Layer 2
Active cells 377 non-active cells		
Hydraulic conductivity (x,y,z)	1.5	1.8
Vertical leakance	0.0001 to 0.1	0.0001
Effective porosity	0.044	0.043
Bulk density	0	0
Wetting factor	0.1	0.1
Recharge	0.16 x 10 -3	0.16 x 10 -3
Draft (wells)	-40 m3/day/cell	-40 m3/day/cell
Total in	14240 m3/day/cell	For the entire model area and for both layers.
Outflow from head dependant boundary	3039 m3/day/cell	
Constant head in wells	11200 m3/day/cell	
Total out	14240 m3/day/cell	
Percent Discrepancy	0.0%	

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 14.1.1997 for the purpose of regulation and control of ground water development and management in the country.

The Central Ground Water Authority was re-constituted vide S. O. 1121(E) dated 13th May, 2010. As per the Notification issued, the Authority consists of Chairman & 14 members with Member (SML), CGWB as Member Secretary.

The Authority can invite the following as special invitees if required for the meetings.

1. The Joint Secretary, (Soil and Water Conservation), Dept. of Agriculture & Cooperation, New Delhi.
2. The Joint Secretary (Water Supply), Ministry of Urban Development, New Delhi.
3. Director, National Institute Hydrology, Roorkee.
4. Director, NGRI, Hyderabad.

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, development and management 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 of the appointment of the 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 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.

Web site of CGWA: The detailed activities and achievements of CGWA have been put on the websites of CGWB at http:// cgwb.gov.in/ GroundWater/ gw-regulation.htm.

PUBLIC NOTICES:

During this period, the following two Public Notices were issued:

(i) Public Notice No. 1/2010 : Sub: Attention of large and medium Industries using ground water in the over exploited and critical areas in the country (except in the water logged areas)

(ii) Public Notice No. 2/2010: Sub: Declaration of Gurgaon district as "Notified Area" for regulation of ground water development and management. (Any Suggestion or objections were called)

(iii) Public Notice No. 3/2010: Sub: Declaration of areas as "Notified Area" for regulation of ground water development and management (In Andhra Pradesh, Gujarat, Haryana, Karnataka, Punjab, Rajasthan, Tamil Nadu) Any Suggestion or objections were called).

DIRECTION ISSUED:

Vide letter dated 24.5.2010, directions were issued to Principal Secretary (I&P) , Department of Irrigation & Power, Govt. of Punjab, Chandigarh for regulating ground water development and management.

ACTIVITIES CARRIED OUT UNDER IEC, SCHEME OF MINITSRY OF WATER RESOURCES

(i) First Painting Competition on Water Conservation:

Under the Information, Education and Communication(IEC) Scheme of Ministry of Water Resources, Central Ground Water Authority organized nation wide painting competition on

saving and protecting the precious resource and to create awareness in children who are the future citizens. The target group was school children of IVth, Vth and VIth standards. The painting competition was held in three stages – the School Level, followed by the State Level and finally terminating at the National Level.

Fifty winners from the school level competition were selected in each state for participation in the state level painting competition which was held on 14 November on the occasion of 'Bal Diwas' birth day of Pandit Jawaharlal Nehru, the first Prime Minister of the country. In each state cash prizes worth Rs. 33,000/- was distributed among the first, second, third and ten consolation prize winners.

The school level painting competition had a participation of more than 2,60,000 students from the entire country. Encouraged by the response received for the painting competition in the very first year, Ministry of Water Resources decided to undertake the activity on a regular yearly basis

Children participating in State Level Painting Competition at Bangalore

The first, second and third prize winners from the State/UT level painting competition participated in the National Painting competition held at New Delhi on the 21st January 2011. In all 63 children representing 21 States/UT's participated in the competition held at CSMRS, Hauz Khas, New Delhi. The theme chosen for the purpose was "Water In Environment". In the National Painting Competition, one first prize worth Rs. 1,00,000/-, four second prizes worth Rs. 50,000/- each and eight third prizes worth Rs. 25,000/- each were awarded to the winners. Apart from the above, ten consolation prizes worth Rs. 10,000/- each were also given to the deserving children.

(ii) Mass Awareness Programme (MAP) & Water Management Training Programme (WMTP)

Under the IEC Scheme of Ministry of Water Resources, 40 Mass Awareness Programmes and 40 Water Management Training Programme were organized all over the country.

The advertisement through mass media transport vehicles viz bus back panel, hoardings, Delhi Metro, Railway Stations Airports etc were done all over the country.

Children participating in State Level painting competition at Kolkata

PriZes distributed by Hon,ble Minister (WR) to Children participating in State Level Painting competition at NWR, Chandigarh

Hon,ble Minister (WR) observing paintings made by children participating in State Level Painting competition at Chandigarh

Children participating in State Level Painting competition at CR,Nagpur

Children participating in State Level Painting competition at Chandigarh

Participants with prizes in State Level Painting competition Guwahati

Children participating in State Level Painting competition at Trivendrum

16. GROUND WATER MANAGEMENT STUDIES IN DROUGHT PRONE AREA

Ground Water Management Studies were under taken in drought prone area of 19139 sq. km. in Gujarat, Orissa, Uttar Pradesh and Karnataka States of the country under. In addition to this, 295 bore holes (171 EW, 58 OW & 66 PZ) by departmental rigs were drilled in drought prone areas of Karnataka, Kerala, Madhya Pradesh, Maharashtra Orissa, Rajasthan and Uttar Pradesh States.

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 & depicted in Fig 17.1 & 17.2 respectively.

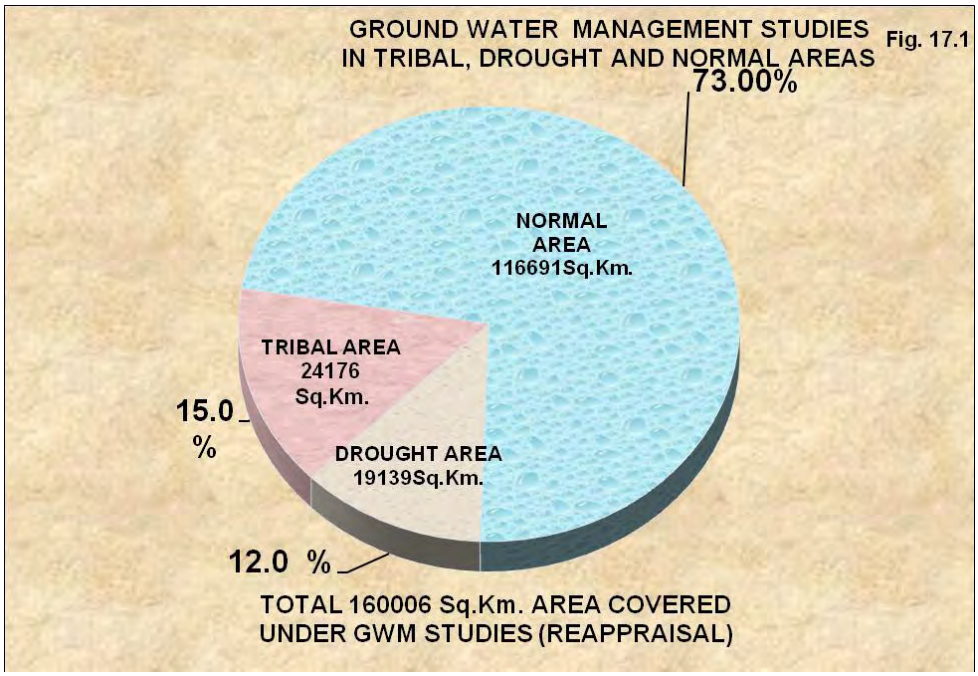
Table 16.1 : Area covered under ground water management studies in drought prone areas (2010-2011)

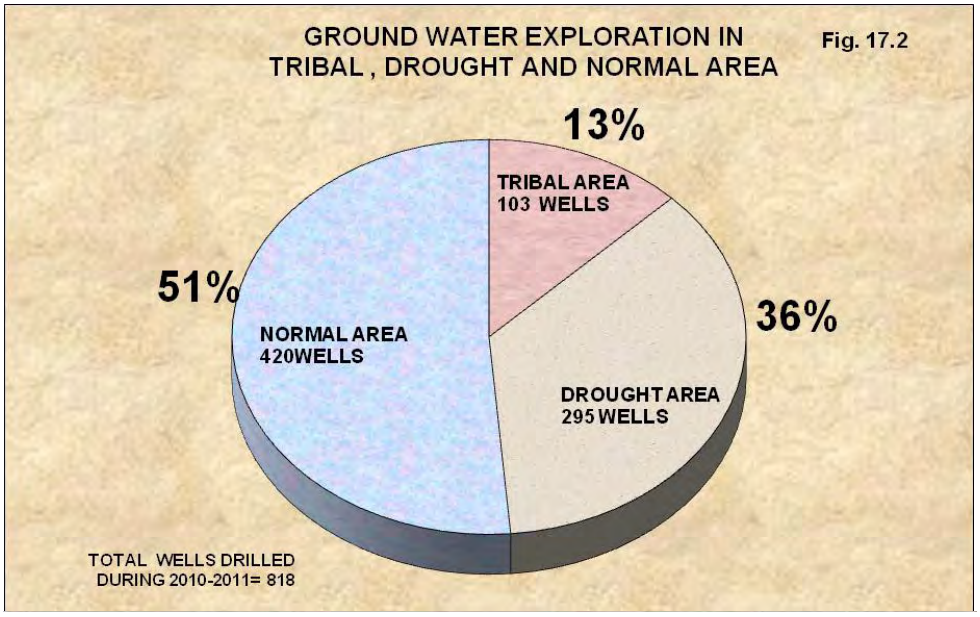
Sl. No.	Regions/ State	Districts	Achievement Sq.Km.
1.	**WESTERN CENTRAL REGION** Gujarat	Kachch district	3642
		Total	**3642**
2.	**SOUTH EASTERN REGION** Orissa	Parts of Bargarhsonepur	3152
		Parts of Bargarh	3100
		Total	**6252**
3.	**NOTHERN REGION** Uttar Pradesh	Mahoba	1099
		Chitrakoot	1491
		Total	**2590**
4.	**SOUTH WESTERN REGION** Karnataka	Gulbarga	3334
		Kodagu & Hassan	3321
		Total	**6655**
	GRAND TOTAL		**19139**

Table 16.2 : Exploratory wells drilled in "drought prone" area (2010-2011)

(By Departmental Rigs)

Sl. No	States	EW	OW	PZ	T
1	Karnataka	35	10	2	47
2	Kerala	14	3	-	17
3	Madhya Pradesh	43	15	29	87
4	Maharashtra	10	8	2	20
5	Orissa	41	13	16	70
6	Rajasthan	12	5	16	33
7	Uttar Pradesh	16	4	1	21
	Total	**171**	**58**	**66**	**295**


GROUND WATER MANAGEMENT STUDIES
IN TRIBAL, DROUGHT AND NORMAL AREAS
Fig. 17.1
73.00%
NORMAL
AREA
116691Sq.Km.
TRIBAL AREA
24176
Sq.Km.
15.0
%
DROUGHT AREA
19139Sq.Km.
12.0 %
TOTAL 160006 Sq.Km. AREA COVERED
UNDER GWM STUDIES (REAPPRAISAL)


GROUND WATER EXPLORATION IN
TRIBAL , DROUGHT AND NORMAL AREA
Fig. 17.2
13%
TRIBAL AREA
103 WELLS
51%
NORMAL AREA
420WELLS
36%
DROUGHT AREA
295 WELLS
TOTAL WELLS DRILLED
DURING 2010-2011= 818

17. GROUND WATER MANAGEMENT STUDIES IN TRIBAL AREAS

The Central Ground Water Board, in its 2010-2011 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 24176 sq. km. was covered in Madhya Pradesh, Chhattisgarh, West Bengal and Jharkhand States under tribal areas and 103 bore hole (EW- 55, OW-18, PZ- 30) were drilled in Chhattisgarh, Jharkhand, Karnataka, 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 2010-2011

Sl. No	Regions/state	District	Achievement (Sq.Km.)
1.	Madhya Pradesh	Khandwa and Burhanpur	6193
2.	Chhattisgarh	Durg	3000
3.	West Bengal	Birbhum	989
4.	Jharkhand	Girdih	4842
5.	Orissa	Keonjhar	6252
6.	Karnataka	Chamarajanagar	2900
GRAND TOTAL			**24176**

Table 17.2 : Exploratory Wells Drilled in "Tribal" Area during 2010-2011
(by Departmental Rigs)

Sl. No	States	EW	OW	PZ	T
1.	Chattisgarh	22	8	26	56
2.	Jharkhand	12	04	2	18
3.	Karnataka	08	04		12
5.	Maharashtra	9	2	2	13
5.	West Bengal	4	-	-	01
Grand Total		**55**	**18**	**30**	**103**

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) .

As per 31.03.2009, the Total Annual Replenishable Ground Water Resources of the Country have been reassessed as 431 Billion Cubic Metres (bcm) and the Net Annual Ground Water Availability is estimated as 396 bcm. Annual Ground Water Draft as on March, 2009 for all uses is 243 bcm. The Stage of Ground Water Development is 61%. 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 5842 assessment units (Block/Mandals/Talukas) in the country, 802 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 in pre-monsoon & post-monsoon both. In addition 169 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 either in pre-monsoon or post-monsoon periods or both. There are 523 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 and apart from these, there are 71 blocks completely underlain by saline ground water. 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			
					Irrigation	Domestic and Industrial uses	Total	Stage of Ground Water Developme nt(%)
1	2	3	4	5	6	7	8	9
	States							
1	Andhra Pradesh	33.83	3.07	30.76	12.61	1.54	14.15	46
2	Arunachal Pradesh	4.45	0.45	4.01	0.002	0.001	0.003	0.07
3	Assam	30.35	2.537	27.81	5.333	0.69	6.026	22
4	Bihar	28.63	2.42	26.21	9.79	1.56	11.36	43
5	Chhattisgarh	12.22	0.64	11.58	3.08	0.52	3.60	31
6	Delhi	0.31	0.02	0.29	0.14	0.26	0.40	138
7	Goa	0.221	0.088	0.133	0.014	0.030	0.044	33
8	Gujarat	18.43	1.08	17.35	11.93	1.05	12.99	75
9	Haryana	10.48	0.68	9.80	11.71	0.72	12.43	127
10	Himachal Pradesh	0.59	0.06	0.53	0.23	0.08	0.31	58
11	Jammu & Kashmir	3.70	0.37	3.33	0.15	0.58	0.73	22
12	Jharkhand	5.96	0.55	5.41	1.17	0.44	1.61	30
13	Karnataka	16.81	2.00	14.81	9.01	1.00	10.01	68
14	Kerala	6.62	0.59	6.03	1.30	1.50	2.81	47
15	Madhya Pradesh	33.95	1.70	32.25	16.66	1.33	17.99	56
16	Maharashtra	35.73	1.93	33.81	15.91	1.04	16.95	50
17	Manipur	0.44	0.04	0.40	0.0033	0.0007	0.0040	1
18	Meghalaya	1.2343	0.1234	1.1109	0.0015	0.0002	0.0017	0.15
19	Mizoram	0.044	0.004	0.039	0.000	0.0004	0.0004	1
20	Nagaland	0.42	0.04	0.38	-	0.008	0.008	2.14
21	Orissa	17.78	1.09	16.69	3.47	0.89	4.36	26
22	Punjab	22.56	2.21	20.35	33.97	0.69	34.66	170
23	Rajasthan	11.86	1.07	10.79	12.86	1.65	14.52	135
24	Sikkim	-	-	0.046	0.003	0.007	0.010	21
25	Tamil Nadu	22.94	2.29	20.65	14.71	1.85	16.56	80
26	Tripura	2.97	0.23	2.74	0.09	0.07	0.16	6
27	Uttar Pradesh	75.25	6.68	68.57	46.00	3.49	49.48	72
28	Uttarakhand	2.17	0.10	2.07	1.01	0.03	1.05	51
29	West Bengal	30.50	2.92	27.58	10.11	0.79	10.91	40
	Total States	**432.43**	**33.73**	**398.70**	**221.29**	**21.83**	**243.14**	**61**
	Union Territories							
1	Andaman & Nicobar	0.310	0.012	0.298	0.0006	0.010	0.011	4
2	Chandigarh	0.022	0.002	0.020	0.000	0.000	0.000	0.000
3	Dadara & Nagar Haveli	0.059	0.003	0.056	0.001	0.007	0.009	15
4	Daman & Diu	0.012	0.001	0.011	0.008	0.003	0.011	99
5	Lakshdweep	0.0105	0.0070	0.0035	0.0000	0.0026	0.0026	74
6	Puducherry	0.171	0.017	0.154	0.121	0.029	0.150	98
	Total Uts	**0.59**	**0.04**	**0.54**	**0.13**	**0.05**	**0.18**	**34**
	Grand Total	**431.03**	**35.03**	**396.06**	**221.42**	**21.89**	**243.32**	**61**

Table 18.2: CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN INDIA AS ON 31st MARCH, 2009

Sl.No.	States / Union Territories	Total No. of Assessed Units	Safe		Semi-critical		Critical		Over-exploited		Remarks
			Nos.	%	Nos.	%	Nos.	%	Nos.	%	
	States										
1	Andhra Pradesh	1108	867	78	93	8	26	2	84	8	38- Salinity Affected
2	Arunachal Pradesh	16	16	100	0	0	0	0	0	0	
3	Assam	23	23	100	0	0	0	0	0	0	
4	Bihar	533	529	99	4	1	0	0	0	0	
5	Chhattisgarh	146	132	90	14	10	0	0	0	0	
6	Delhi	27	2	7	5	19	0	0	20	74	
7	Goa	11	11	100	0	0	0	0	0	0	
8	Gujarat	223	156	70	20	9	6	3	27	12	14 - Salinity Affected
9	Haryana	116	18	16	9	8	21	18	68	59	
10	Himachal Pradesh	8	6	75	0	0	1	13	1	13	
11	Jammu & Kashmir	14	14	100	0	0	0	0	0	0	
12	Jharkhand	208	200	96	2	1	2	1	4	2	
13	Karnataka	270	154	57	34	13	11	4	71	26	
14	Kerala	152	126	83	22	14	3	2	1	1	
15	Madhya Pradesh	313	224	72	61	19	4	1	24	8	
16	Maharashtra	353	324	92	19	5	1	0	9	3	
17	Manipur	8	8	100	0	0	0	0	0	0	
18	Meghalaya	7	7	100	0	0	0	0	0	0	
19	Mizoram	22	22	100	0	0	0	0	0	0	
20	Nagaland	8	8	100	0	0	0	0	0	0	
21	Orissa	314	308	98	0	0	0	0	0	0	6 - Salinity Affected
22	Punjab	138	23	17	2	1	3	2	110	80	
23	Rajasthan	239	31	13	16	7	25	10	166	69	1 - Salinity Affected
24	Sikkim	4	4	100	0	0	0	0	0	0	
25	Tamil Nadu	386	136	35	67	17	33	9	139	36	11 - Salinity Affected
26	Tripura	39	39	100	0	0	0	0	0	0	
27	Uttar Pradesh	820	605	74	107	13	32	4	76	9	
28	Uttarakhand	17	11	65	5	29	1	6	0	0	
29	West Bengal	269	231	86	38	14	0	0	0	0	
	Total States	**5792**	**4235**	73	**518**	9	**169**	3	**800**	14	
Union Territories											
1	Andaman & Nicobar	33	33	100	0	0	0	0	0	0	
2	Chandigarh	1	1	100	0	0	0	0	0	0	
3	Dadra & Nagar Haveli	1	1	100	-	-	-	-	-	-	-
4	Daman & Diu	2	0	0	1	50	0	0	1	50	
5	Lakshdweep	9	5	56	4	44	0	0	0	0	
6	Puducherry	4	2	50	0	0	0	0	1	25	1-Salinity Affected
	Total Uts	**50**	**42**	84	**5**	10	**0**	0	**2**	4	
	Grand Total	**5842**	**4277**	73	**523**	9	**169**	3	**802**	14	71 - Salinity Affected

Blocks- Bihar, Chattisgarh, Haryana, Jharkhand, Kerala, M.P., Manipur, Mizoam, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, UP, UttaraKhand, WB, **Taluks** (Command/Non-Command) –Karnataka, **Mandal** - Andhra Pradesh

Taluks - Goa, Gujarat, Maharashtra, NCT Delhi

Districts (Valley) - Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Meghalaya, Manipur, Mizoram, Nagaland, Sikkim, Tripura

Islands - Lakshdweep, Andaman & Nicobar Islands

Region - Puducherry

19. TECHNICAL SCRUTINY / EXAMINATION OF SCHEMES / PROPOSALS

19.1 MAJOR AND MEDIUM IRRIGATION SCHEME / PROPOSALS

As per the directives of the Planning Commission, the Board scrutinizes 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 made to protect quality and quantity of groundwater. During 2010-11 (up to 31st March, 2011),

Twelve major and minor irrigation project proposals of Central Water Commission listed below were examined and are listed below.

1. Virat Sagar Dam, Uttar Pradesh
2. ERM of Maniyari Tank, Chhattisgarh.
3. Upper Pravara Irrigation, maharashtra.
4. Borward Parisar Sinchar Yojna, Maharashtra.
5. Waghur irrigation, Maharashtra.
6. Relining of Indira Gandhi Feeder & main canal, Rajasthan.
7. Urmadi irrigation, Maharashtra.
8. Bina Complex Irrigation and Multipurpose, Maharashtra.
9. Sri Rameswar Lift Irrigation, Karnataka.
10. Dr. B.R. Ambedkar Pranhita-Chevella Sujala Sravanthi, Andhra Pradesh.
11. ERM of Rangwan High Level Canal System , Madhya Pradesh.
12. ERM of Urmil Canal System, Madhya Pradesh.

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 2010-11.

20.1 MER, Patna

Remote sensing study covering an area of 700 sq. km was carried out in Bhagalpur district with objective of deciphering relationship hydro-geomorphological units and incidence of high Arsenic concentration. Study was carried out in the area falling along the river Ganga in Bhagalpur district. The study area covers part of Sabour, Khalagaon,Pirpaiti, Sonhaula and Goradih blocks of the district. The area forms a part of the mid-Gangetic alluvium plain. Physiographically the Bhagalpur district can be divided into two units the marginal alluvial tract of South Bhagalpur and the flat Indo-Gangetic alluvium of the north and central Bhagalpur. There are some detached hard rock bodies of Pre-cambrian age, which stand out as prominent peaks (inliers) within the alluvial plains. Study area covering parts of Sabour block forms the low land while parts of Kahalgaon ,Sabour,Pirpaiti form Diara land south of the river Ganga Parts of Navgachia forms diara land north of river Ganga. The diaras are nothing but heap of sands brought by the mighty river Ganga.

The purpose of this survey was to determine the existence and intensity of arsenic contamination in aquifers being tapped and its correlation with the wetlands and related channel flows, eg. river meanders, abandoned channels, interfluves, braided streams, alluvial deposits, and other fluvial features and understand and make predictions, if any, about the possibility of arsenic contamination with associated geomorphologic units. The district is principally drained by the river Ganga, which enters the Bhagalpur district at Sultanganj. The river Ganga flows in N- E direction. The river Ganga has two major tributaries joining from south; Badua and Koa. The district towards the south of the river Ganga falls in the Badua- Koa Sub-Basin and the area to north of Ganga falls in the Baghmati - Kosi sub-basin. These two sub-basins are parts of Mid-Ganga basin in Bihar. The northern boundary of the district is marked by the river Kosi (Ghugri) known to be heavily laden with silt and sand. A number of ephemeral streams from Chotanagpur plateau such as Gahra, Chanan, Kadwa, Gerua and Bhena join the mighty river Ganga. During the course of study, key open dug wells including the network station of CGWB of varying in depth from 5.5 m to 11.50 m were established in the entire study area to for spatial and temporal assessment of ground water level for quaternary shallow aquifer. These wells were established in different hydrogeological terrain and distributed throughout the study area. The pre-monsoon water level data of the NHNS for the year 2010 reveals that the depth to water level in the study area range from 4.98 to 7.83 m bgl, with the deepest of 7.83 m bgl at Kahalgaon, whereas post-monsoon depth to water level in the area varies from 4.1 to 5,25 m bgl. To study the ground water chemistry, presence of arsenic in particular and its relation with the geomorphic unit, a total of 74 water samples from tube wells(depth ranging from 21 to 37m) and open dug wells(depth ranging from 8.92 to 11.4m) were collected from different parts of the study area for Arsenic, Fe & Mn and for complete analysis.Out of 74 sample 45 were collected for trace element analysis and 39 were collected for complete analysis.

20.2 NCR, Bhopal

20.2.1 (A)Feasibility Studies for Reclamation of Ravines using Remote Sensing Techniqes in Sitamau Taluka of Mandsaur District:

Hydrogeological studies were carried out in Sitamau taluka of Mandsaur district covering an area of 800sq km. studies to study the possibilities of reclaiming ravines affected areas. The entire study area is covered by basaltic lava flows of Deccan traps. Depths to water levels were found varying 7 to 23 mbgl during pre monsoon season and from 3 to 11.80 mbgl during post monsoon season. Each Lava flows is characterized by lower massive part becoming gradually vesicular towards top. Vesicles are of small size and are invariably found filled with secondary minerals, thereby reducing the primary porosity of the rock to almost nil. Ground water occurs under unconfined to semi confined conditions and movement and storage of ground water is controlled by the jointed, fractured and weathered part of the rock. Weathering index increase in the vicinity of the rivers. The advancement of ravines may be controlled by raising the bunds of the fields by minimum thirty centimeters, check dams should be constructed in IInd / IIIrd

orders streams to check the flow velocity and enhance the recharge to Ground water. A forestation would be another controlling factor.

20.2.2 (B) Feasibility Studies for Reclamation of Ravines using Remote Sensing Techniques in Badnagar Block, Ujjain District:

An area of 600 sqkm wa studied for reclamation of ravines using remote sensing techniques in the Chamla Watershed, Badnagar block, Ujjain district. RPS P6-LISS-III data were procured (1:50,000) from NRSI,Hyderabad. The field mapping along sixteen villages were carried out to identified the extent and nature of Ravines along the Chamla river. The Post-monsoon year (2009)depth to water level of the studied area varies from 15.10 mbgl-27.10 mbgl. The discharge of shallow tube well of depth 60-90 m are in the range of 1.60-4.30 lps. The shallow alluvium aquifer occurs at depth of 15.30-17.0 m. Thickness of alluvium in the area varies from 19.80-22.50 m. Twenty Recharge ponds with recharge shaft are constructed at feasible location to develop saturation of Pheratic aquifer. These structure are proposed at discharge area of micro-watershed structure at contact of river Chamla in the south of Badnagar Block.

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 Hydrology Project

- One Awareness Raising Training Programme on Hydrology Project Data Users Group was conducted at Kollam on 3rd March,2011.
- Awareness raising training programme under HP-II was held on 20.10.2010 at Goa Science Centre, Panjim, Goa. Theme of the training programme was " Water Use and Quality criteria with special reference to Goa". Sri S.T.Nadakarni, Chief Engineer, WRD, Govt. of Goa was the Chief Guest. Sri Panigrahi A.B, Regional Controller of Mines, Indian Bureau of Mines, Goa was the Guest of Honour. Dr K.Md.Najeeb, Regional Director presided over the programme and delivered Key note address. Training was imparted to 80 heads and presentation were made from officers of State departments and academic institutions.

21.2 Rajiv Gandhi National Ground Water Training and Research Institute

The RGNGWTRI, Raipur has imparted trainings to ground water professionals and sub-professionals of central and state government organizations on major core areas namely survey, exploration and assessment of water resources, ground water management by regulation and control, mathematical modeling and augmentation of resource by artificial recharge of ground water.

During 2010-2011, a total of 40 training courses were conducted (10 trainings at RGI, Raipur, 06 trainings at CHQ, Faridabad (including one on mathematical modeling under International Training Program for the participants from African countries, 06 trainings at four Regional Offices and 18 Orientation training program conducted by Regional Offices (one by each Regional Office) for capacity buildings of State government departments dealing with ground water. A total of 773 officers attended the various training courses organized in the year 2010-11 which included 16 trainees from African Countries.

The details of the various trainings are given in Tables 21.2A , 21.2B & 21.2C.

Table 21.2A : Trainings organized at RGI, Raipur in 2010-11

Sl. No.	Name of the course	Total participants
1.	Application of Geophysical Techniques for Ground Water Development and Management	16
2.	Training course on Artificial Recharge Techniques in different Hydrogeological conditions	18
3.	Water Well Construction – Techniques, Equipment and Management	21
4.	Refresher Course on Ground Water Resource Estimation	18
5.	Refresher Course on Ground Water Resource Estimation	15
6.	Administrative Training for staff of CGWB	19
7.	Managerial soft skills and Management Principles and Practices	15
8.	Hydrogeological Investigations, Development & Management of ground water in Hard Rock Terrain - Techniques, Equipments and Practices	14
9.	Application of Geophysical Techniques for Ground Water Development and Management	15
10	Training Course on Material Management, Preparation of EOI, Tender document and Bidding Process	16

Table 21.2B: Training courses organized at Faridabad in 2010-11

Sr. No	Name of the course	Total Participants
1	Refresher course for Chemists on "Analysis of Basic Water Quality Parameters in ground water and Data Validation" (NR, Lucknow)	23
2.	Hydrogeological Investigations, Development & Management of ground water in **Alluvial Terrain** - Techniques, Equipments and Practices (NWR, Chandigarh)	20
3.	Refresher course for Chemists on "Analysis of Basic Water Quality Parameters in ground water and Data Validation"(NR, Lucknow)	22
4.	Analysis of Pumping Test Data (CR Nagpur)	22
5.	Analysis of Pumping Test Data (CR Nagpur)	18
6.	Training on Administrative & Financial matters for Senior officers of CGWB (CGWB, SWR Bangalore)	20

Table 21.2C:Training courses conducted by CGWB Regional Offices

Sr. No	Name of the course	Total participants
1.	Ground Water Management (Regulation & Control)	18
2.	Appreciation Course on Ground water Estimation and Management Software (GEMS) for Senior Officers	15
3.	Appreciation Course on Ground water Estimation and Management Software (GEMS) for Senior Officers	21
4.	Training on Mathematical Modeling of Ground Water system	19
5.	Training on Mathematical Modeling of Ground Water system	12
6.	International Training course on Ground Water Management and Modelling -for eight African Countries-IAFS:2008, funded by MEA, GOI	16

Field demonstrations to the trainees at Dharamshala

Organising one week orientation training at Guwahati

Trainees attending WMTP at Kodungallur, Tamil Nadu

A View of Trainees at Water Management Training – Madurai, Tamil Nadu

Water Management Training at CR, Nagpur

Water Management Training Programme and Mass Awareness Programme held at Bangalore

Releasing of Training Module by Chief Guest Shri. C. Kamaraj, IAS, District Collector, Madurai along with Shri D.S.C. Thambi, Regional Director, SECR

Water Management Training Programme at Jalgaon

Water Management Training Programme at Jalgaon

22. SPECIAL STUDIES

22.1 Collaborative Study done Under Memorandum of Understanding between CGWB and RITES

The Memorandum of Understanding (MOU) was signed on 01-06-2010 between Central Ground Water Board (CGWB), Bhujal Bhawan, NH IV, Faridabad (Haryana), and RITES Ltd., Rites Bhavan, Plot No.1, Sector-29, Gurgaon-122001 (Haryana), with an objective of finding a solution to the problem of heavy seepage in the tunnel no. 3 on Udhampur – Katra section of the Udhampur Srinagar Baramulla Rail Link (USBRL) project in J&K.

1. Title of the study

"Ground Water Modelling of the area around Railway tunnel no. 3 on Udhampur – Katra section of the USBRL project, J&K.

The objective of the collaborative study is to simulate ground water flow regime in the aquifer systems in the tunnel no. 3 on Udhampur – Katra section of the USBRL project in J&K and to establish ground water interaction and quantification of recharge and seepage to tunnel. This problem of heavy seepage is related to ground water. RITES is engaged in doing different steps towards the solution of this problem including remote sensing studies, geophysical studies viz; ground penetration radar, resistivity profiling survey, drilling and pumping test. To reach at a suitable solution, ground water modelling is a proper tool.

Sh. K. P. Singh, Sc. 'B' (GP) & Sh. Ashwin Atey, AHG were nominated from CGWB, NWHR, Jammu to collaborate in the collection of ground water data (i.e. hydrogeological, geophysical, etc.) of the study area, drilling of wells, conducting pumping tests, conducting resistivity profiling and vertical electrical soundings, interpretation of the time draw down data of pumping tests to find out aquifer-aquitard hydraulic parameters, leakage between aquifers. The various activities done are as below:

a) The 3D resistivity imaging survey was attended by Sh. K. P. Singh, Sc. 'B' (GP) on 14-06-2010 which was being conducted by Sh. Vinod Kumar, Asstt. Manager, RITES, at Kambaldanga, above the tunnel no. 3 alignment, using the Super Sting R8IP Earth Resistivity / IP Meter.

b) The pumping tests were conducted on 12-07-2010, 14-07-2010 & 09-08-2010 in the well having depth of 60 m, at chainage 12790. Depth to water levels were also recorded in OW-I (at a distance of 10 m), OW-II (at a distance of 30 m) & OW-III (at a distance of 78.5 m).

Table 22a: Results of Pumping Test Conducted at Kambaldanga, District Udhampur

Particulars	12-07-2010	14-07-2010	09-08-2010
SWL (m bgl)	24.17	24.71	31.12
Discharge (lpm)	--	36	150
Pumping duration (minutes)	9.0 (well dry)	40	80
Water level, when pump stopped (m bgl)	30.93 (After 15 minutes of well dry)	41.14	53.85
Recovery duration (minutes)	120	240	180
Recovery Water Level (m bgl)	24.76	25.06	31.86

The Transmissivity value obtained on the basis of pumping test data of 09-08-2010 is 1.882 m^2/day.

c) The chemical analysis of the ground water sample collected on 14-07-2010 from the well at chainage 12790, is given in table 22 b.

Table 22b:: Results of Chemical Analysis of Sample Collected from Kambaldanga, distt Udhampur

Sl. No.	Water Quality Parameters	Value	Desirable limit	Permissible limit
1	pH	7.75	*6.5 - 8.5*	*No Relaxation*

2	Specific Conductance (µmhos/cm at 25°C)	510	*500 (TDS)*	*2000 (TDS)*
3	Carbonate (mg/l)	0	-	
4	Bi-Carbonate (mg/l)	348	-	
5	Chloride (mg/l)	11.0	*250*	*1000*
6	Nitrate (mg/l)	9.26	*45*	*100*
7	Fluoride (mg/l)	0.08	*1.0*	*1.5*
8	Sulphate (mg/l)	Not detected	*200*	*400*
9	Calcium (mg/l)	86	*75*	*200*
10	Magnesium (mg/l)	18	*30*	*100*
11	Sodium (mg/l)	8.6	-	
12	Potassium (mg/l)	1.0	-	
13	Total Hardness as $CaCO_3$ (mg/l)	270	*300*	*600*
14	Iron (mg/l)	2.02	-	

d) The Slug Test was conducted on 27-10-2010, in the bore hole drilled down to the depth of 29 m bgl, near a nalla by the side of road. The bore hole got filled upto 17.75 m bgl and water was filled upto 0.60 m bgl. The salient features of slug test is as below:

- Water filled in borehole from 17.75 m bgl to 0.60 m bgl.
- Time taken to fill the bore hole upto 0.60 m bgl is 7 minutes 18.97 secs (~ 7.19 minutes).
- Volume of water injected @ 6.875 lps = 2,965.88 litres.
- Water level at 220 minutes, after the injection of water in borehole = 11.65 m bgl.
- The Transmissivity value so obtained is 1.95 m^2/day

22.2 Gist of collaborative studies In CIAE (I.C.A.R.) Research Farm area, Nabibagh, Bhopal (M.P.)

A collaborative hydrogeological, hydrochemical and water management studies was taken up during AAP 2010-11 in Central Institute of Agriculture Engineer (CIAE) campus area, Nabibagh Bhopal. Campus/ Research farm of CIAE, Nabibagh area is located on Bhopal- Berasia road in Bhopal district and it is spread over an area of about 93 hectares.

Objective of studies was to establish hydrogeological/ hydro chemical conditions of the area and to assess run-off conversation practices adopted by institute and irrigation water utilization by micro-Irrigation through sub surface irrigation network area adopted by CIAE. Management of groundwater resource of the area is to be combined for future ground water development and rain water harvesting and recharge.

During studies available hydrogeological/ hydrometerological data was consulted and collected. Site plan of area finalized with CIAE. Water samples for chemical analysis collected from ground water sources and water bodies of the area to ascertain chemical quality of surface and ground water systems. Resistivity survey was also carried out for evaluation of weathering depth in campus area. R.L. survey for determining of ground water abstraction structure above mean sea level was carried out by CGWB surveying wing and data is being processed. Data of water bodies of various ponds in campus area which are main sources of irrigation water requirement has been collected. Roof area of various buildings of CIAE campus is also collected for planning for roof top rain water harvesting structures.

Geologically almost entire area in incepting western part is occupied by basaltic lava flows. Outcrop of Vindhyan sandstone is occurring in western boundary of area at surfaces. As per CGWB exploratory well data, Vindhyan sandstone is encountered at depth of 23.73 mbgl below basalt. In campus there are 5 open wells with depth ranging from 13.43mbgl to 16.00 mbgl and tapping weathered/vesicular basaltic rocks. Depth to pre monsoon (may 2010) water level in dug wells ranges from 9.00 mbgl to 14.10 mbgl .Post monsoon depth to water level varies from 8.00 mbgl to 13.65 mbgl. Diameter of open wells found between 3.60 m and 6.70 m.

In CIAE campus area there are about 8 bore wells all tapping basaltic aquifer system. Reported depth of bore wells is from 75 mbgl to 90 mbgl. Depth to pre-monsoon water level was recorded between 12.66 mbgl and 20.37mbgl .

The overview of chemical quality data indicate that quality of ground water observed through water samples collected during pre monsoon (year 2010) is by and large is good and there is moderate mineralization as indicated by EC in one sample heaving 1139µs/cm at 25°C. Concentration of other parameters of anions and cations (HCO3, Cl, SO4, HO3, F, T.H., Ca, Mg, Na & K) are within permissible range. Chemical quality of ground water during post monsoon season (October 2010) indicated effects of rains on quality of ground water. It is also observed that quality of ground water does not seem to be affected by input of fertilizer in study area.

22.3 Micro level hydro-chemical studies-block Talwandi Shaboo, district Bathinda, Punjab

The studies in collaboration with Department of Environment, Punjab University was taken up and field work was carried out along with the research scholars of the University. A total number of 38 water samples were collected and analyzed for detailed, trace elements, DO and pesticides in Talwandi Saboo block of Bathinda District. As per the results of chemical analysis, it is gathered that out of 38 samples, trace element Cadmium (Cd) is absent in all samples. The concentration of Copper (Cu), Mangenese (Mn) and Zinc (Zn) are found to be within permissible limits in all the samples. The concentration of Iron (Fe) in 4 samples namely Malkana, Kotbhaktu (Canal Water), Koriyana and Zajjal was found to be beyond the permissible limit of BIS. Out of 38 water samples, the concentration of Lead (Pb) was found in 20 samples, with a maximum of 0.2598 mg/l at Zajjal. Arsenic (As) was found in 23 samples and maximum concentration was found in Kotbhaktu (0.007 mg/l). The results of Pesticide analysis are under process.

22.4. Impact of Dying industries on ground water quality in Balotra area, Barmer district, Rajasthan.

The study area lying around Balotra town of Barmer district, under taken in AAP 2010-11 to study the impact of effluent dying industries in the Luni river causing quality deterioration of ground water.

The average rainfall in the Barmer district is 277 mm.The area investigated is underlain by the Quaternary sediment deposited over the Rhyolite belonging to the Malani suit of igneous rocks. The bed rock in the area is encountered ranging from 80 to 90 mts. bgl. By and large, bed rock topography resembles that of land surface. Ground water in the study area occur usually under water table condition and places under very feebly confined conditions.It occurs in ;sand, sandy clay, silts clay and sandy gravel including pebble and kankar. The different type of water bearing sediment gradually merge into each other. The depth to water level in the area ranges from 5.00 to 75 mbgl (reported). Maximum water level observed at Kitnod was 49.95 mbgl however reported DTW in tube well Majiwala was 75-80 mbgl. The discharge of tubewells ranges between 100 to 400 lpm which runs for 10 to 20 hour/day.

During the pre-monsoon period 20 water samples were collected for complete chemical analysis, 25. for heavy metal analysis and 17 samples for iron ion analysis from 20 locations. During the post monsoon period, 16 water samples were collected for complete chemical analysis; 16 for heavy metal analysis and 16 Nos. for iron ion analysis. These samples were collected from the ground water abstraction structures, industrial effluents, Luni river pounded water and inflow and outflow samples from the treatment plants operating in the area.The investigated area is almost plain with few sand dunes here and there which are alligned in NE-SW direction. The only major drainage course in the area is the Luni river which is ephemeral in nature and flows westward besides these few local nala draining in to Luni river.

The EC value ranges from 1720 to 60 600 micromhos cm at 25oC during pre-monsoon period and Chloride value ranges from 326 to 29282 ppm, Nitrate value ranges from 0 to 143 ppm, Fluoride values ranges from 0.55 to 4.9 ppm . During the post monsoon period EC value ranges from 1780 to 53 350 micromhos/cm at 25oC, chloride values 454 to 17040 ppm, Nitrate value 10 to 180 ppm and fluoride value from 0.3 to 5.12 ppm.It has been observed that Balotra town and adjacent area, the quality of ground water is highly saline owing to natural factor of Pachpadra brine lake and it has been further deteriorated owing to highly saline effluent discharge in to Luni river by industries.

The saline water in the Balotra area becomes less saline as we move towards east in Bithuja and south east at Kitnod it becomes almost fresh in the tube wells. It is clear that saline-fresh water interface exists between Balaotara/Bithuja and Balotra-Asotra-Kitnod zone. The shallow aquifer at Bithuja is saline and deeper aquifer is relatively less saline whereas at Balotra shallow & deep both aquifer are highly saline. The declining water level at Bithuja and Kitnod due to heavy exploitation of ground water for domestic and industrial use has caused saline fresh water interface to progress toward east i.e Bithuja and south east toward Asotra-Kiytnod. Heavy discharge of saline water effluent at Balotra, has further added to above mentioned progression of saline fresh water interface, thus increasing the saline area around Balotra

The heavy metal analysis of the water samples collected from the Balotra-Bithuja area including water samples of effluents and Luni river, it can be concluded that heavy metal pollution is limited to Copper, Chromium and Manganese which may be due the colour dyes used by the dying industries discharging effluent into Luni river which is not removed even by the treatment plants operating in the area.

22.5 Impact of Dying Industries on ground water quality in Pali area, Pali District, Rajasthan

The study area lying around Pali town is part of Luni basin on Bandi river bank has been under taken in AAP 2010-11 to study the impact of dying industry disposal of effluent in Bandi river causing quality deterioration to ground water. The area shows gentle undulating topography with dendritic pattern of drainage. The area is underlain by Rhyolite and granite and locally gravel/conglomerate bed is found on river bed.During the pre-monsoon studies 13 Nos. of water samples were collected for complete chemical analysis, 13 Nos. of water samples for heavy metal chemical analysis and 13 Nos. of water samples for iron ion analysis.During the post monsoon period total 24

locations water samples were colleted for complete chemical analysis, heavy metal chemical analysis and iron ion analysis.The results of chemical analysis of the water samples collected has been analyzed.

Ground water in Pali city and adjoining areas has very high electrical conductivity and other metal contents. The quality is deteriorated surrounding Pali city , especially in down stream, down to confluence of Bandi and Luni river . Deterioration of ground water quality and it's aerial expansion has been reported. It was observed that few unregistered dyeing units (not registered in Pollution control board) directly despose the effluent into the Bandi river and also contributed by leakage in pipe line carrying the effluent from units to treatment plant. Study area having mixed type of fresh and saline ground water .

The aquifer is saturated by saline water in down stream where as the fresh water aquifer is unsaturated particularly in up stream side. In upstream side water level is moderately deep where as in down stream it is shallow. In canal command area both fresh and saline water is seen.

22.6 Arsenic in and around Ganga river from Kanpur to Bijnour in UP

Study is based on the chemical analysis of 60 nos.of water sample collected from IM II, private hand pump & Ganga River from the districts adjoining river from Bijnour to Kanpur.

The Ganga basin, its physiographic, occurrence of arsenic in soil, mobilization of Arsenic in environment, Chemistry of arsenic in water and toxic effects of arsenic on human health are discussed in brief before discussion of findings.

From the chemical analysis data it is observed that Ganga river was found to contain 3 nos water samples [21%] and ground water in the area has 4 nos of water samples [11%] to contain Arsenic content more than 10 ppb the limit prescribed by WHO, ICMR & BIS. The highest concentration [75 ppb] of arsenic in Ganga river was found at Makanpur ghat LB in Unnao near Bilhour & in ground water in the adjoining areas of river Ganga was found to contain As from 0 to 100 ppb in the area of study maximum observed at Makanpur ghat LB in Unnao near Bilhour followed by Gava opp Anupsahar in Moradabad district.

22.7 Occurrence and distribution of pesticide residues in ground water in Bisrakh block of G B Nagar district, U.P.

'Pesticide' is a general term for substances which are used to poison pests (weeds, insects, molds, rodents, etc.). The pesticides most acutely dangerous to man are insecticides and rodenticides. Herbicides are the most widely used type of pesticide. Not every pesticide is acutely toxic to humans or other non-target species. Pesticides enter surface and ground water primarily as runoff from crops and are most prevalent in agricultural areas. Pesticides are also used on golf courses, forested areas, along roadsides, and in suburban and urban landscape areas. As the chemical pesticide percolate through the soil zones and reaches the ground water body, the degradation of ground water quality starts and sometimes attains to such a label which is considerable to be objectionable with regards to drinking water standards.

The special study entitled," Occurrence and distribution of pesticide residues in ground water in Bisrakh block of G B Nagar district, U.P." has been carried out.

Under this programme water samples from Bisrikh block were collected and extracted. The pesticide residues from water samples were separated by using organic solvents. Identification and quantification were accomplished using a known amount of external standards. Studies have established 92% recovery.

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 in ground water of Bisrakh block of Gautam Budh Nagar, Uttar Pradesh, the pesticide residue Hexachlorocyclohexane (HCH) isomers (α and β) were localized and the highest Total HCH value being 0.000149 µg/l (Salarpur). The DDT metabolite i.e. 4.,4' –DDT was also localized with the highest value 0.000125 µg/l was recorded in Hosiyarpur. The Chlorpyrifos was also present in 67% samples with the highest value of 0.005371 µg/l found at Hoshiyarpur. Aldrin could be detected in 17% of water samples. The report is under process.

22.8 Hydrogeological study In Kolkata Municipal Corporation area with special reference to declining of piezometeric level of Ground Water, West Bengal

The Present area of Kolkata Municipal Corporation is 187.33 sq. km, comprising of 141 Wards and 15 Borough.

Kolkata Municipal Corporation Area is covered by Quaternary alluvial sediments. Two regionally extensive clay beds are present throughout KMC area within the depth of 400 m bgl. The depth of occurrence of the basal clay varies from place to place but in general it occurs from 300 to 450 m bgl and the top clay bed (10 to more than 60 m thick) overlies the entire alluvium sequences in KMC area. Between these two clay beds occurs a group of granular zones made up of fine to coarse sand, gravel and occasional pebble intervened by clay lenses.

In general ground water in KMC area occurs under confined to semi-confined condition. In Ballyganj, Tollyganj, Tiljola, Dhakuria, Kasba, Santoshpur, Garia, Behala, Barisha & Thakurpur area and in the levee deposits on the bank of Hugli River, ground water occurs under water table condition in shallow aquifer over the top clay blanket.

Piezometric surface indicates that water level is deepest around Park Street forming a trough in Central Kolkata around Park Street, Rajabazar, Fort William etc., due to excessive withdrawal of ground water as well as due to interference effect of closely spaced tube wells running simultaneously. The long term trend of ground water level in this part indicates a falling trend in both pre and post monsoon period. There is a decline of 7 to 11 m in ground water level in last 45 years since 1958 to 2003.

In general, the presence of the thick clay layer at the top of the sedimentary sequence in KMC area acts as a protective cover to the ground water occurring below from any kind of pollution from the surface. In the eastern part of KMC area near Tangra-Topsia-Tiljala, toxic trace elements like Cr, Co are found in excess of 0.01 mg/l in the shallow aquifers within 20 m bgl. Sporadic occurrence of arsenic above toxic limit (0.05 mg/l) has been reported in some parts of the Corporation area.

A total of 305.20 million litres per day of ground water is being withdrawn in KMC area through KMC owned 264 nos large dia (300 mm) tube wells fitted with 20 HP submersible pump, 10,000 nos hand pump fitted small dia (40 mm) tube wells and 5840 nos of Private owned small dia (40-200 mm) tube wells with 1 to 2 HP pump.

At present, total supply of water from both surface and ground water sources by KMC is 1305.3 million litres per day. In addition, people use ground water to the tune of 160.9 million litres per day by their own tube wells.

Withdrawal of ground water in KMC area by KMC owned tube wells has increased progressively from 121.5 million litres per day in 1986 to 209.7 mld in 1998 and it continued up to 2004. As a result, the area of the ground water trough mentioned earlier increased. From 2005, KMC started replacing gradually the ground water supply by surface water supply. As a result, there is a reduction in the quantum of ground water withdrawal by KMC tube wells since 2005 onwards. In 2006, withdrawal of ground water by KMC owned tube wells come down to 144.3 million litres per day. The impact is very positive on ground water regime in certain parts. It has been observed that the piezometric level has raised from 0.4 to 0.3 m during 2007 to 2010 in Baghbazar, Park Street and Jadavpur area. This may be due to the less withdrawal of ground water from those areas. However, the overall scenario is still under threat. Due to critical ground water condition in KMC area, indiscriminate withdrawal of ground water is to be restricted. If necessary, the area is to be notified by legal means.

There is a good scope for rainwater harvesting in KMC area. A net quantum of 247 million cubic meter of available rainwater may be utilized by both conservation and artificial recharge.

22.9 Special studies on 'Scope of Water Conservation in Sagar Islands, South 24 Parganas district, West Bengal'

Salient features:

Sagar Island is made up of alluvial deposit laid down by River Ganga and it's tributaries. Fresh GW aquifers occur within depth span of 245–325 m bgl which lie below saline water aquifers separated by 20-25 m thick impervious clay. Occurrences of fresh ground water at deeper aquifers restrict large scale GW development, since it is beyond capacity of common people. Domestic water supply is met from Government owned deep tube wells (DTW) which is not sufficient. Surface water is not suitable for irrigation and domestic purposes since river, nalas are saline due to tidal effect.

Before introduction of Rain Water Harvesting (RWH), there was no irrigation facilities and agricultural lands were mono-cropped.

Findings/Impact of RWH in Sagar Islands

Benefits in Agricultural Sector:

Drainage Channel: 9 no; 176 ha benefitted & 431 no. Beneficiaries; Protective Bundh: 12 no; 92 ha benefitted & 210 no. Beneficiaries; Reservoir Pond: 6no; 90.56 ha benefitted & 275 no. Beneficiaries.

Mono cropped land has been transformed into Double and Triple cropped land. Along with paddy, varieties of pulses, oilseeds, cotton, fruits, jute, tobacco and vegetables introduced. Sweet betel vine has taken a key role in present economy of the Island.

Land use under agriculture sector after introduction of 'rain water harvesting' system in the Sagar Islands:

i) Net cropped area – 15544.25 ha.
ii) Single cropped area – 11477 ha.
iii) Double cropped area – 3273 ha.
iv) Triple cropped area – 794 ha.
v) Cropping Intensity – 131%.
vii) Net Irrigated area under 'Rain Water Harvesting' - 3614 ha.

After introduction RWH, out of 15544ha Net cropped area, 3614ha area has been brought under assured irrigation.

Benefits in Domestic Sector

In interior villages where ground water supply not available from DTW, new people use conserved rain water stored in the Reservoir Pond for domestic purposes.

Socio-economic set up

Development of agricultural growth has led to the development the economy of the common people. Life style has been enriched. Island has become self dependent .

22.10 Impact of Urbanization on Ground Water in Siliguri town, Darjeeling district, WB.

The area of the Siliguri Municipal Corporation is about 41.90 sq. km. with a population of 4,72,374 (as per 2001 census) and density of 11,224 persons/sq. km. The area is underlain by unconsolidated formation consisting mostly of piedmont zone and alluvial plain forming the vast tract of Terai formations consisting of coarse sands and gravels intercalated with thin clay layers. Ground water occurs in the extensive thick granular zones in unconfined to semi confined condition down to the depth of 300 mbgl. This zone constitutes the most promising aquifer in the region with yield prospects of 50-150 m^3/hr.

The ground water level trend of NHNS in Siliguri Municipal area reveals that there is no significant change in ground water regime in the shallow aquifer in the area over the years. River Mahananda flowing along the eastern part of the town contributes to shallow ground water regime. The urban water supply is met from the ground water as well as surface water sources. Considering the potentiality of both shallow and the deeper aquifer, no significant impact has been noticed in ground water regime over the years in response to the massive urbanization.

22.11 Study on extension of fluoride rich ground water & possibility of construction of suitable artificial recharge structures to provide fluoride free water to the users in parts of Birbhum district, WB, (Nalhati I and Murarai I blocks)

Based on the study and hydrogeological condition, the fluoride affected belts in Nalhati I and Murarai I blocks are described as follows ,

West of Nalhati town: Nalhati, Basanta, Banior, Bautia, Bhabanandapur, Nasipur, Dadpur

South west of Nalhati town: Takipur, Lohapur, Nagora area

Murari I block: Maheshpur- Mitrapur area

The area is underlain by basalts and laterite. The depth of the dug wells lies between 9 & 11 mbgl whereas the tube wells are within the depth of 70 mbgl. Fluoride contamination F in ground water (1.85 - 6.7 mg/l) is reported from tube wells within the depth range of 44-70 mbgl. However, the present study reveals that the occurrences of F in ground water is sporadic in nature and no such adverse affects of F in human body is reported. The local water supply authority PHED, Govt. of West Bengal has already adopted a few measures to combat the challenges which includes sealing off the affected wells and arrangement of alternative water supply from the river bed tube wells (18-19 m depth) supply. On the other hand, extensive boro cultivation from ground water has resulted in decline of water level in the area.

State Water Investigation Directorate, Govt. of West Bengal with the financial assistance of MOWR, Govt. of India and technical assistance from CGWB, ER has constructed piezometers, nallah bunds, check dams, gully plugs etc at Sanketpur, Banior, Chandipur, Barsor mouza in Nalhati I and Murari I blocks of Birbhum district under Central Sector

Scheme. The monitoring of water level from the piezometer and comparison with the rainfall reveals 2.30 m accretion in ground water level as an impact of artificial recharge structures.

22.12 Special studies in and around Rajarhat New town/Salt Lake area to demarcate Saline/Fresh water interface, West Bengal

I4 no VES adopting Schlumberger's Array of configuration with AB/2, 200 m has been conducted in the study area. The interpretation of the curves reveal the occurrences of silty clay down to 20-30 mbgl, followed down by fine to medium grained sands within the depth range of 30-75 mbgl with moderate resistivity of 20-25 Ώm which is followed down by fine to medium to coarse sands with resistivity of 25-40 Ώm within the depth range of 75-200 mbgl. Ground water up to 75 m depth is brackish in nature whereas the deeper aquifer beyond 75 m depth is fresh. The thickness of the top brackish layer increases from 35 m to 80 mbgl in the eastern part of the Rajarhat New town area.

22.1.13 Evaluation of the impact of existing landfills on surface & ground water quality in Eastern Kolkata

Due to rapid urbanization, the major part of the original geomorphologic units has been obscured. Most of the marshy lands have been filled up. Depth to water table varies from -1.71 to 2.03 m amsl during pre-monsoon period and -5.34 to 2.47 m amsl during post-monsoon period. Depth to piezometric surface (shallow tube well in the depth range of 0-50 mbgl) varies from -6.92 to -0.78 m amsl during pre-monsoon period and from -5.46 to -0.13 m amsl during post-monsoon period. Depth to piezometric surface (deep tube well in the depth range of 100-180 mbgl) varies from -12.78 to -9.36 m amsl during pre-monsoon period and from -14.09 to -8.51 m amsl during post-monsoon period. Gradient of ground water in deeper aquifer varies from 0.0000075 to 0.305 degree during pre-monsoon period. In general, the presence of the thick clay layer at the top of the sedimentary sequence in the study area acts as a protective cover for any kind of contamination from the surface. Thirty three (33) water samples collected from surface water sources i.e. bil, pond; shallow aquifer (dug well, shallow tube well) and deeper aquifer (deep tube well) for Basic, Heavy Metal, TOC and Arsenic analysis during the investigation. No Arsenic contamination is observed in surface water sources, shallow and deeper aquifers. Heavy metal analysis and TOC analysis are in progress. Iron concentration in ground water varies from 0.31 to 6.03 mg/lt. EC varies from 1020 to 4660 µs/cm at 25˚C.

22.14 Collaborative Studies with NGRI, Hyderabad

Tracer studies for determination of return irrigation from paddy field (Irrigated crop) and natural irrigation from non-paddy field are taken up by injecting tritium tracers at Madharam village in second phase. The first phase is completed during the year 2009-10.. The details are given in Table-1 and 2 below.

Table : Details of Tritium Injected Sites (2010).

Site.	Location Village	Soil Type	Depth of collection (cm)	Remarks
1.	Irrigated field site, Near Madharam village	Loamy soils	200	Injections made at 3 locations

Date of injection: 1.7. 10 Date of collection: 26.11 10 (at 2 locations)

Depth of injection: 60 cm Effective rainfall: 707 mm Irrigation: not measured.

Table : Results of Natural Recharge Measurements (2010).

Location No.	Site name	Displacement of tracer peak (cm)	Average MV of displaced zone (%)	Recharge (mm)
1.	Irrigated field site, Near Madharam village – Location 1	75.0	27.8	208.5
2.	Irrigated field site, Near Madharam village – Location 2	85.0	25.1	213.0

Results of phase-I (2009-10)

Study indicates that the natural recharge caused by rainfall is about 98.7 mm (15%) in recharge area (upper reaches) and about 10.6 mm (2%) in discharge area (lower reaches) with a mean of 55.1 mm (8.4 %). The recharge from irrigation return and effective rainfall together is about 127.8 mm (19.4 %) in recharge area and 256.2 mm (39 %) in transient area with a mean of 107.25 mm (26.8 %.) The net average recharge by groundwater irrigation return is about 18.4% of applied 5750 m3 of ground water/acre.

Depth moisture measurements using Neutron moisture probe (2010-11)

Neutron moisture probe was used for measuring depth moisture measurements at 2 slim hole sites (one in the rainfed field and another in the irrigated field) made near Madharam village in the watershed area. Slim bore wells were drilled at the selected sites through DTH drilling machine having a drilling bit diameter of 3" and drilling rod diameter of 1.5". PVC access tubes of 2.5" diameter were inserted in the bores up to the drilled depth. The access tubes of 20' length were joined together using adhesives. The tubes inserted were sealed at the bottom with PVC caps with adhesives. A calibrated Neutron probe was used to monitor moisture from the ground surface to the access tube depth. The depth moisture measurements were taken for every 20/40 cm section at regular interval of time for different time intervals. The measurements were made in the month of July, August, September and November months of 2010. The results are being analyzed for evaluating moisture flux and moisture transport mechanism.

22.15 Optimum Groundwater Development Plan for the Multi layer coastal aquifer system in Neyveli Hydrogeological Basin, Tamilnadu.

The Neyveli Hydrogeological Basin (Project study area) lies in the coastal sedimentary tract of Tamil Nadu covering an area of 1500 sq. kms. It is bounded by Kaluveli Lake in the North and Gadilam River in the South. The Western margin is in crystalline contact and the Eastern side is bounded by the Bay of Bengal.

A collaborative project entitled "Optimum Ground Water Development Plan for Multi-Layer Coastal Aquifer System in Neyveli Hydrological Basin" was initiated on mutually agreed terms and conditions and the MOU between CGWB and NLC was signed. The project work (2006-2011) started from May-2006 and would be completed by 2011. Interim report of the Project study was submitted on September 2010.

Scope of the Project

Formulation of optimum Ground Water Development Plan for sustainable development of ground water in Neyveli Hydrogeological Basin is ultimate scope of the project. It is proposed to compile the existing data, identify the data gaps and generate scientific database to understand and simulate the hydrodynamics and to test the optimal ground water development strategy.

Objectives of the Project

The main objective of the project study is to;

- Decipher the geometry of various sedimentary rocks, cuddalore sandstone in particular and demarcate the lateral extension of aquifers above and below lignite seams.
- Assess the distribution of potentiometric heads under different stress conditions and evaluate the aquifer parameters for each zone/ bed.
- Assess the impact of combined ground water withdrawal by different sectors in the entire basin.
- Assess fresh water/saline water interface movement, if any and to suggest remedial measures and finally,
- To simulate ground water for varying stress conditions to get more realistic picture for predictive ground water management strategies.

Expected outcome of the study

A well-defined ground water development plan for Neyveli Hydrogeological Basin and action plan for sustainable management of the available ground water resources would be the outcome of this project study.

Summary

The regional impact of continuous pumping stress by various agencies in the Neyveli hydrogeological basin is being monitored continuously in order to plan an effective ground water management system for the present and future.

The data gaps were identified and new data base has been created for effective outcome. The exploration studies of confined aquifers carried out in Jayankondam region by NLC (under Advance Action Plan) and CGWB for Jayamkondam lignite project have brought more information on the potentiality of the aquifers.

The data generated from the collaborative study, are to be used to develop a comprehensive groundwater model. The model thus developed would be utilized to evolve a optimum groundwater development plan for Neyveli Hydrogeological Basin.

Thus, a well defined regional ground water development plan for the basin and action plan for sustainable management of the available resources would emerge out of the MoU between NLC and CGWB.

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Special Studies- Madhram watershed, Mahabubnagar district

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 2010-2011, Maharashtra , Uttar Pradesh, Karnataka, Kerala, H.P., Goa and Delhi states reports completed.

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 2010-11, 28 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 2010-2011

Sl. No	Regions	Nos.	Name of District Report
1	North Western Himalayan Region	2	Leh, Anantnag
2	North Western Region	1	Moga
3	West Central Region	2	Tapi, Kachcha
4	North Central Chhatisgarh Region	2	Durg, Dantewada
5	Northern Region	2	Faizabad, Mahoba
6	Mid Eastern Region	2	Gumla, Dumka
7	Eastern Region	1	Purulia
8	South Eastern Region	4	Dhenkanal,angul, cuttack,sundargarh
9	Southern Region	1	Bolaram
10	South Western Region	1	Kolar
11	South East Coastal Region	2	Tirunelveli, Pudukottaio
12	Kerala Region	2	Two islands of Lakshadweep Kalpeni and Minikoy
13	North Eastern Region	1	Sibsagar
14	Central Region	2	Ratnagiri, Bhandara
15	North Himalayan Region	1	Sirmaur
16	Delhi	2	North East & Central
	Total	**28**	

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 2010-11, 23 reports were prepared . Region wise status of preparation of ground water year book are presented in Table 23.2

23.1.4 District Ground Water Brochures

The Central Ground Water Board prepares district ground water brochures periodically containing summarized results of ground water surveys, exploration and other related tendes. Further, it has ground water development prospects, , quality hazards, ground water related issues of concerned with suitable recommendation of ground water management stretagies. District brochures as uploaded in CGWB web sites for public utility.

During 2010-11, 60 District Ground Water Brouchures were prepared . Region wise status of preparation of District Ground Water Brouchures are presented in Table 23.3

Table 23.2: Status of Ground Water Year Books Completed during 2010-11

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
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**	

Table 23.3:Region wise status of preparation of District Ground Water Brochures

Name of States	Nos.	Name of Districts
Chhattigarh	4	Bilaspur,Janjgir,Mahasamund, Raigarh,
North Eastern States	2	Kamrup, Lakhimpur
Madhya Pradesh	6	Bhopal,Indore, Morena, Umaria, Sheopukalan, Jabalpur
Maharashtra	6	Gadchizoli,Gondia ,Bhandara, Ahmednagar, Aurangabad, Jalna
Rajasthan	5	Karauli, Sikar, Pali, Jaisalmer, Ganganagar,
Uttar Pradesh	21	Basti, Bahraich, Balrampur, Lucknow, Moradabad, Kushi Nagar, Aligarh, Faizabad, Maharajganj, Kanpur, Deoria, , Mahamayanagar, Etah, Lakhimpurkheri, Auriya, Kannauj, Kaushambi, Muzaffarnagar, Mahoba, Banda and Jaunpur
Bihar	5	Siwan, Nawada, Gopalganj, Muzaffarpur and Lakhisarai
Jharkhand	4	Godda, Deoghar, Jamtara, Palamu
Karnataka	2	Bellary, Bagalkot
Goa	2	North and South Goa
Gujarat	2	Tapi and Valsad
Uttarakhand	1	Paurigarwal
Total	**60**	

23.1.6 Ground Water Exploration Reports

During 2010-11, 3 Ground Water Exploration Reports have been completed / submitted of the states of Tamil Nadu, Madhya Pradesh and Bihar.

23.1.7 State Chemical Reports

During 2010-11, 3 State Chemical Reports have been completed / submitted of the states of Himachal Pradesh, Bihar, Jharkhand.

23.1.8 Hydrogeological Atlases

During 2010-11, 2 Hydrogeological Atlases have been completed / submitted of the states of Meghalaya and Lakshadweep.

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 2010-11 up to 31st March 2011, the Vol. 24, No 2 & 3, April – September 2009 issue on Arsenic in Ground Water in India and Vol. 24, No 4, October- December,2009 issue published.

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24. CONSTRUCTION/ACQUISTION OF OFFICE BUILDINGS

The details of following construction work for own office building of Central Ground Water Board have been carried during 2010-11 up to 31st March 2011 is given in table 24.1.

Table 24.1:Construction Work for Own office building during 2010-11

Region	Status
Hyderabad	The proposal for releasing of additional requirement of funds to the tune of Rs. 46 lac as 10% cost escalation has been sent to the Ministry.
Division- XIV, Bangalore (for construc-tion of Work-shop & Store Building)	Against the total estimate of Rs.4,04,60,000/-, the funds to the tune of Rs.1,50,82,649/- after revalidation of earlier sanction released during 2010-11. Work is under progress.
Store Building & Workshop at Guwahati Construction of Region & Division building	The funds to the tune of Rs. 420 Lac released during 2010-11. The work of Workshop & Store completed & shifted from rented premises to own Building w.e.f. 01-01-2011. Out of total allocation of Rs. 420 Lac, the CPWD has surrendered Rs. 200 Lac during 2010-11.
Ahmedabad	Ministry has conveyed for making the provision EFC Memo. The AA&ES is awaited from Ministry.
Division- XIV, Bangalore (for construc-tion of Work-shop & Store Building)	Against the total estimate of Rs.4,04,60,000/-, the funds to the tune of Rs.1,50,82,649/- after revalidation of earlier sanction released during 2010-11. Work is under progress.
Purchase of land for Staff quarters at Bhubanesh-war	The construction work of Boundary Wall is almost at completion stage. The CPWD has revised the existing cost of the project which is under consideration. Sanction is awaited from Ministry.
NHR, Dharamshala	The matter is under consideration with the State Authorities.
Regional Training Center (RGI) at Raipur	The CPWD has submitted Preliminary Estimate of Rs. 11.00 Crore. The same has already been submitted to Ministry for AA&ES. By making the provision in the EFC Memo for 11th Plan. Sanction is awaited from Ministry.
RGNGWT&RI, Raipur	The CPWD has submitted estimate of Rs. 4.41 Crore for construction of Boundary Wall around the land. AA&ES received from Ministry. As per requirement from CPWD the funds to the tune of Rs. 10 lacs released.
Division-II, Ambala	The entire amount released/ authorised during 2010-11. Work is almost at completion stage.
Region & Division at Jammu	The CPWD has submitted an Estimate for Construction of Boundry Wall which is submitted to Ministry. The MoWR has suggested a barbed fencing wire around the land instead of C/o Boundary Wall. The RD, NWHR, Jammu has been asked to get the PE revised from CPWD.
Dehradun	Dehradun Nagar Nigam has agreed to allot land to CGWB. The matter for physical allotment is under consideration of the Nagar Nigam.
Division-IV, Chennai	Approval of Rs. 2.06 Crore towards the total cost of land received from MoWR. Funds to the tune of Rs. 2.06 Crore released. Physical possession of land from State Government is under process.
Division-XI, Jodhpur	The JDA has offered allotment of Land on a Total cost of Rs. 1.66 crore. The proposal with revised EFC Memo has been submitted to Ministry. Sanction is awaited.

25. DISSEMINATION AND SHARING OF TECHNICAL KNOW-HOW

25.1 Region-wise paper published and training taken by officers during 2010-11

Sl. No.	Regions	Paper presented /attended		No. of officers	
		National	International	Trainings	
				National	International
1	NWHR, Jammu	7	-	4	-
2	NWR,	38	-	9	-
3	WR, Jaipur				
4	WCR,	2	-	7	-
5	NCR, Bhopal				
6	NCCR, Raipur	5(J)	-	3	-
7	CR, Nagpur				
8	NR,Lucknow				
9	MER, Patna	5	7	-	-
10	ER, Kolkata	7	-	11	-
11	NER, Guwahati	13	-	6	-
12	SER,	14	-	2	-
13	SR, Hyderabad	36	-	7	-
14	SWR, Banglore	37	1(J)	13	-
15	SECR, Chennai	2	2	7	-
16	KR, Trivendrum	4+1(J)	-	5	-
17	UR,Dehradun				
18	NHR,	-	-	2	-
19	SUO, Delhi	1	-	1	-
20	CHQ,Faridabad				11
	Total	166+6(J)	9+1(j)	77	11

25.2 Presentation of Technical Papers and Lectures

- Regional Director, Southern Region, Hyderabad delivered a lecture on "Hydrogeological analysis for designing Artificial Recharge Structures" in the Training Workshop on "Use of Ground Water Prospects and Sustainability Maps" organized by Rural Water Supply & Sanitation Departemnt, Government of Andhra Pradesh, on 17.06.2010 in N.I.R.D, Hyderabad.
- Regional Director delivered a special lecture on "Rainwater Harvesting and Water Conservation" in Hindi to the officials of C-DOT, Bangalore on 17th June, 2010.
- Regional Director, Southern Region, Hyderabad delivered a lecture on "Design and Installation of Ground Water Monitoring Stations – Sample collection and Preservation" on 1st July, 2010 in a training organized by ESCI, Hyderabad.
- Scientist-D Southern Region, Hyderabad delivered a lecture on "Ground Water Pollution-Case Studies" in the "Training on Water Quality Monitoring for Irrigation and Drinking Water" organized by ESCI, Hyderabad on 2nd July, 2010.
- Scientist-D, Southern Region, Hyderabad delivered a lecture on "Ground Water Resources Availability and Management" in a training organized by ESCI on 5th July, 2010.
- The Regional Director, Central Ground Water Board, Uttaranchal Region, Dehradun delivered a lecture on Rain Water Harvesting and Artificial Recharge at Indian Institute of Remote Sensing, Dehradun on 23rd August 2010.
- Scientist-B, Central Ground Water Board, Uttaranchal Region, Dehradun delivered a lecture on "Geology of Uttarakhand, Ground Water Availability and Quality Problems" organized by Uttarakhand Pey Jal Nigam and held at Uttarakhand Space Application Centre, Dehradun on 5th August, 2010.
- Suptdg. Geophysicist, Southern Region, Hyderabad delivered two lectures as Faculty in Training on "Application of Geophysical Techniques for Ground Water Exploration and Management" during 2-17 August, 2010 organized by CGWB, NCCR, Raipur.
- Scientist-C, Central Ground Water Board, South East Coastal Region, Chennai delivered a lecture on "Water Quality and Health" and to the foreign trainees who visited Chemical Laboratory of SECR, Chennai as part of the "Oversees Teachers Programme" conducted by NITTTR, Chennai on 16th August 2010.
- Suptd. Hydrogeologist, Eastern Region, Kolkata delivered lecture to the trainees IPHE, at Salt Lake office, IPHE, on "Hydrogeological condition suitable for recharge" on 6.9.10.
- Suptd. Hydrogeologist, South East Coastal Region, Chennai delivered a lecture on "Ground Water Resources Development and Management" to the foreign trainees at NITTTR, Chennai as part of the "Oversees Teachers Programme" conducted by NITTTR, Chennai on 15.09.2010.

- Scientist of South East Coastal Region, Chennai delivered a lecture on the topic "Atomic Absorption and Inductively Coupled Plasma Atomic Emission Spectrometry in Environmental Chemical Analysis" and "Speciation Analysis of Trace Element in Environmental Water Samples" at Chennai on 18.09.2010 & 25.09.2010 during the Refresher Course for College Teachers conducted by University of Madras.
- Regional Director, Central Ground Water Board, Central Region, Nagpur delivered a lecture on Ground Water Hydrology at National Water Academy, CWC, Khadakwasla, Pune on 2nd September 2010.
- Scientist D of Central Ground Water Board, Southern Region, Hyderabad delivered a lectured on "Water Security" to the 4th & 5th batches of trainees of Rural Water Supply and Sanitation, Govt. of A.P. on 18th and 20th September 2010 respectively.
- Central Ground Water Board, Faridabad delivered a power point presentation on Result Frame Work Documents (RFD) 2010-11 of CGWB at the Chamber of Additional Secretary (WR), Shram Shakti Bhawan, New Delhi on 22nd September 2010. Joint Secretary (A), Chairman CGWB and Members of the Board also attended the presentation.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai delivered a lecture on "Ground Water Regulation and Management in Coastal Areas" on 5th October 2010 during one week training course on "Ground Water Management (Regulation and Control) conducted by RGI at Central Ground Water Board, Faridabad.
- Regional Director and Scientists of Central Ground Water Board, Southern Region, Hyderabad attended a lecture delivered on "Flow Properties of fractured Crystalline rocks" by Prof. Oliver Bour, Dept. of Geosciences, University of Renner, France at NGRI, Hyderabad on 07.10.2010 and participated in the discussions.
- Scientist of Central Ground Water Board, North Central Chhattisgarh Region, Raipur presented a paper titled "Sustainable Development of Ground Water to solve Drinking Water crisis in Peninsular India" organized by Indo-Italian Workshop at Nagpur on Sustainable Development of Ground Water on 22.10.2010.
- Regional Director, CGWB, SR, Hyderabad, made a power point on presentation on "Possible Impact of Climate Changes on Water Resources of Andhra Pradesh" in a Workshop organized at Central University, Hyderabad on 09.11.2010.
- Regional Director, CGWB, SR, Hyderabad delivered a key note address on "Intervention on ground water management" in the workshop organized by NABARD, Hyderabad on 15.11.2010.
- Scientist Central Ground Water Board, South East Coastal Region, Chennai delivered a lecture on Artificial Recharge and Rain Water Harvesting on 11.11.2010 for the participants of overseas training programme of National Institute of Technical Teachers Training and Research at Chennai.
- Scientist Central Ground Water Board, North Central Chhattisgarh Region, Raipur presented a scientific paper titled "Present design for risk mitigation in roof top rain water harvesting system" for 4th World Aqua Congress held at New Delhi during 8-10th December 2010.

25.3 Participation/Organized Workshop, Seminars and Conference

- ❖ Regional Director of Central Ground Water Board, South Western Region, Bangalore attended conference on "Science and Technology for Sustainable Development" on 15th April, 2010 at IISC, Bangalore. The Conference was organized by Karnataka State Council for Science & Technology and IISC. A stall was put up by Central Ground Water Board on working models of water conservation at the exhibition during the conference from 15.04.2010 to 17.04.2010.
- ❖ Regional Director,Central Ground Water Board, South Western Region, Bangalore attended "World Earth Day-2010" which was celebrated on 22nd April, 2010 at Bangalore University. Regional Director delivered keynote address on the theme during the occassion.
- ❖ Supdtg. Hydrogeologist, Central Ground Water Board, Sout East Coastal Region, Chennai attended one day symposium on Earth Day 2010 conducted by School of Earth and Atmospheric Sciences, Department of Geography, University of Madras and made presentation on "Water Resources and Sustainable Management" on 22nd April, 2010.
- ❖ Member(SML), Central Ground Water Board attended the conference of State Secretaries, Incharge of Rural Drinking Water and Sanitation at Vigyan Bhawan, New Delhi organized by

Department of Drinking Water Supply on 6th May, 2010.

- Member (SAM) attended Workshop on "Ground Water for Emergency Situation in Coastal Orissa" organized by UNESCO at Bhubaneswar on 10th & 11th May, 2010.
- Member (SML) attended a Workshop on 28th May, 2010 on "Achieving Drinking Water Security in Water Stressed and Quality Affected Areas" for officials working in Rural Water Supply, Irrigation, Ground Water and Agriculture Department of Govt. of Rajasthan at Udaipur organized by Department of Drinking Water Supply. A presentation was made by him on "Planning for Sustainability".
- Regional Director participated in the National Seminar on Water Auditing held at Jaipur, Rajasthan during 18th to 19th May,2010. He presented a paper entitled "Sustainability of water stressed aquifers in Gujarat"
- Scientist, CGWB, Eastern Region, Kolkata, delivered lecture on "Basic Hydrogeology in Hard rock terrain and behavior of springs in hilly terrain, especially in Sikkim" in the workshop organized by RM&DD and State Institute of Rural Development (SIRD) jointly with the technical support agencies namely ARGHYAM Bangalore, ACWADAM Pune, WWF Sikkim and TMI (The Mountain Institute).
- Scientists of Central Ground Water Board, Uttaranchal Region, Dehradun submitted two technical papers on (i) "Ground Water Prospects in Kamola Watershed, Garhwal Himalaya, District Uttarkashi" (ii) "Hydrogeological Aspects of Bhabhar and Tarai formations, District Udham Singh Nagar" in the National Seminar on "Water Auditing" organized by University of Rajasthan, Jaipur from 18- 20th May, 2010.
- Superintending Hydrogeologist attended Workshop on "Integrated Water Resources Management" on 26.04.2010 and participated in the deliberation at Anna University convened by Centre for Water Resources.
- Member(SML) and Office Incharge, Central Ground Water Board, SUO, New Delhi attended the Seminar on "Water Management in Forces" at Palam, Delhi Cantt on 7th June, 2010.
- Member (SML) attended Seminar on "Water Management in Forces" at Palam, Delhi Cantt on 8th June, 2010.
- Suptdg. Hydrogeologist and Scientist 'B' CGWB, ER, Kolkata attended and participated in group discussions in the Workshop on " Importance of Adequate and Safe Water, Sanitation and Hygiene for Health and Nutritional Benefits to Communities" for the Launch of District Level Planning and Motivation programme at Hotel Hyatt Regency, Kolkata on 14th June 2010. organized by Public Health Engineering Department, Govt. of West Bengal.
- Chairman, CGWB, Regional Director and Scientist D attended National Seminar on Water Resources Management and Mining Sector in India organized by CII at India Habitat Centre, New Delhi on 2nd July, 2010.
- Regional Director, Suptdg. Hydrogeologist and Scientist 'C', CGWB, ER, Kolkata attended the two days National Workshop on "Arsenic Contamination in Ground Water –Source, Migration and Mitigation" on 23-24th July 2010 at the auditorium of Indian Institute of Social Welfare & Business Management (IISWBM), Kolkata organized by IISWBM sponsored by Dept. of Science and Technology, Govt. of India. Two technical papers were submitted on "High Incidence of occurrence of arsenic in ground water in West Bengal" by Regional Director, Suptdg. Hydrogeologist and Asstt. Chemist and "Present scenario of mitigation of arsenic in ground water of West Bengal" by Scientist 'C' and Asstt. Chemist. Suptdg. Hydrogeologist presented a paper on "High Incidence of occurrence of arsenic in ground water in West Bengal" in the Workshop.
- Regional Director, CGWB,NER presented a paper on "Arsenic Contamination in Shallow Aquifers of North Eastern Region" in the seminar on Arsenic contamination in Ground Water Source, Migration and Mitigation: on 23-24th July, 2010 organized by Indian Institute of Social Welfare and Business Management, Kolkata.
- Regional Director, Scientists of Southern Region, Hyderabad participated in a Workshop on Ground Water Resource Estimation organized by on 6th and 7th July, 2010 at Mahabubnagar. Regional Director, delivered a lecture on "Ground Water Resource Estimation".
- Scientists of Southern Region, Hyderabad participated in the Workshop on Ground Water Resource Estimation organized by on 12th and 13th July, 2010 at Tirupathi. Scientist-D delivered a lecture on "Ground Water Resource Estimation".
- Regional Director, Central Ground Water Board, Uttaranchal Region, Dehradun attended National Seminar on Data Users organized by the Department of Science and Technology at Survey of India, Dehradun on 26th July, 2010 and delivered

a lecture on Ground Water Management in Uttarakhand.

- Regional Director and Scientists of Central Ground Water Board, Northern Region, Lucknow attended workshop on "Developing Drinking Water Security Plan for Bundelkhand Region" organized at Jhansi by MoRD, Govt. of India and two papers were presented by Scientists and field demonstrations were also made.
- Suptd. Hydrogeologist, CGWB, Eastern Region, Kolkata attended workshop on "Mitigation of Arsenic in aquifers of West Bengal" at IISWBM, Kolkata on 6.09.10.
- A Workshop held during September 2010 on Ground Water Draft Bill under the chairmanship of Commissioner at Bareilly. The various state Governments officers and NGO and officers from Academic fields also participated in the workshop.
- Regional Director, South East Coastal Region, Chennai participated in the Workshop on GIS for Rural Water and Sanitation sponsored by Department of Drinking Water and Sanitation, Ministry of Rural Development and organized by TWAD Board at Chennai on 9th September 2010.
- Scientist of Central Ground Water Board, South Western Region, Bangalore participated as resource person in the workshop on " Recent Trends in Water Quality and Sustainable Management " organized by Karnataka State Council of Science& Technology on 16.09.2010 at Davanagere and delivered a presentation on "Ground Water Situation in Karnataka State".
- Supdtg. Hydrogeologist, Central Ground Water Board, Bhujal Bhawan, Faridabad attended the Stockhlm World Water Week 2010 from 5th to 11th September 2010 and presented a poster entitled "Alternative Arsenic-safe aquifers for sustainable Drinking Supply in Gangetic Plains – A case study from Bihar State, Eastern India" in Workshop: Management of Ground Water Abstraction and Pollution.
- Scientists of Central Ground Water Board, North Central Region, Bhopal attended workshop on "Water And Climate Change" at Bhopal on 11-10-2010 organized jointly Water Resources Dept, Govt. of MP and EPCO, Bhopal. The Principal Secretary, WRD, The Principal Secretary, Housing and Environment and Managing Director EPCO addressed the workshop.
- Scientists of Central Ground Water Board, Central Region, Nagpur attended the Indo-Italian Workshop on 'Sustainable Development of Ground Water Resources" organised jointly by CNR-IGAG, Italy and NEERI, Nagpur at NEERI Auditorium, Nagpur on 20-10-2010. Shri. P.K. Parchure, Supdtg. Hydrogeologist delivered the ***concept presentation*** on "Ground Water Resources and Recharge" in the first technical session. He also participated in the discussions during concluding session for drafting the recommendations of the above Workshop.
- Central Ground Water Board, South Western Region, Bangalore participated and presented three technical papers in the International Conference held during 4-5 October 2010 at Central College, Bangalore. The conference on " Water, Plumbing, Sanitation and Health –Issues & Challenges, WPSH-2010" was organized by Bangalore University. Regional Director, CGWB, SWR presided over in the valedictory function of the conference. Regional Director and Scientists of CGWB, SWR contributed the papers.
- Regional Director and Supdtg. Hydrogeologist of Central Ground Water Board, South East Coastal Region, Chennai attended workshop cum group discussion on "Modelling Hydrological System" organized by Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore on 4th October, 2010. Regional Director delivered an inaugural speech in the workshop.
- Regional Director Central Ground Water Board, South East Coastal Region, Chennai attended workshop on October 21, 2010 at New Delhi to review the progress of R&D Study under Hydrology Project II Purpose Driven Studies (PDS) of Implementation Agencies.
- Supdtg. Hydrogeologist of Central Ground Water Board, South East Coastal Region, Chennai attended workshop on "Programme on Seawater Farming" organized by M.S.Swaminathan Research Foundation on 21st October 2010 at Chennai.
- Scientists of Central Ground Water Board, Northern Region Lucknow participated in the workshops on 'Draft State GW Act' at Agra and Lucknow during October 2010.
- Regional Director, Central Ground Water Board, Uttaranchal Region, Dehradun attended Indo-Italian workshop on "Climate Change" organized by Department of Hydrology, IIT, Roorkee on 22nd October 2010.
- Organized a two days long Regional Workshop on "Integrated Water Resources Management" held

on 1st & 2nd November 2010 at Pinewood Ashoka Hotel, Shillong, Meghalaya. Shri W M S Pariat, Chief Secretary, Govt. of Meghalaya inaugurated the Workshop as the Chief Guest. Shri B. Warjri. Addl. Chief Secretary, Govt. of Meghalaya; Smt. S. Swer, Padmasri; Dr. Arvind Kumar, President, India Water Foundation; Shri R. M Mishra, Commissioner & Secretary (WR), Govt. of Meghalaya graced the occasion as the Guests of Honour. Shri G.C.Saha, Regional Director, Central Ground Water Board, North Eastern Region presided over the function. The resource persons inspected the Rainwater Harvesting Structures, Jalkunds and Soil & Water Conservation structures on the way.

- Regional Director Central Ground Water Board, South East Coastal Region, Chennai attended one day user Interaction workshop on "Flood Risk Mapping for Chennai City and its suburbs" using ALTM data organized by the Institute of Remote Sensing, Anna University on 22.11.2010.
- The Regional Director, Central Ground Water Board, West Central Region, Ahmedabad presented a paper entitled "Role of Managed aquifer Recharge in reversal of Ground Water Depletion in the arid and semi arid regions of Gujarat-India" in the workshop "Climate Change and its Impact on Water Resources-Adaptation Issues" held at Panjab University, Chandigarh during 23 - 24 November 2010.
- Superintending Hydrogeologist and HOO of Central Ground Water Board, Central Region, Nagpur attended International Conference on Ground Water Resources Management and Treatment Technology" organised by NEERI during 19-21 January 2011. He chaired a session on "Ground Water Resource Management" on 20th January 2011. He also attended the inaugural programme and other ground water related presentations made during the conference.
- Organized a National Workshop on "Regulation and Protection of Ground Water Resources" at Bhujal Bhavan, Bangalore, on 12th January 2011 under IEC activity. Proceeding of the workshop comprisisng of 15 technical papers was released during the inaugural function. Technical sessions were held & 100 delegates from various Central, State Government Departments & Educational Institutions Viz., NGRI, CWC, KSNDMC, KSPCB, University of Agricultural Science (UAS), Bangalore University, Geological Society of India, NGO representatives and Scientists from CGWB attended the deliberations.
- CGWB, SWR participated in Bharat Nirman Exhibition, organized by Press Information Bureau, Bangalore at Hunsur, Mysore district during21.01.2011 to 23.01.2011. Working models of Rainwater Harvesting, Point Recharge and Dug Well Recharge methods were exhibited at the stall. During the three days exhibition, more than 500 people from different walks of life including students visited the stall. Also, brochures and stickers on water conservation were distributed to the visitors.
- The National workshop on "Role of Traditional Methods and Recent Technologies in Ground Water Augmentation and Management" was conducted at YASHADA, Pune on 12th February 2011 under the IEC activities of Ministry of Water Resources. During the workshop, 8 scientific papers covering various themes of workshop were presented by GSDA, Archeology Department, (Government of Maharashtra), North Maharashtra University (NMU), Jalgaon and CGWB. About 40 participants from various State and Central Govt. Ofiices, Pune University etc attended and took active participation in the workshop.
- A one day workshop organized on "Pollution of Ground Water by Industrial Cluster-Mitigation and Management" under IEC scheme of Ministry of Water Resources, Govt. of India by CGWB, North Central Chhattisgarh Region, Raipur on 23rd February 2011 at Raipur. Very good responses were received from all the quarters and 13 papers were received from varied fields related to ground water. Workshop volume and a report on "Geogenic arsenic contamination in ground water, Ambagarh Chowki block, Rajnandgaon district" were released during the workshop.
- Supdtg. Hydrogeologist & HOO of Central Ground Water Board, Central Region, Nagpur attended the 14th National Conference on e-Governance at Aurangabad held on 10th & 11th February 2011. The conference was inaugurated by Honorable Governor of Maharashtra Shri K. Shankanarayan and other dignitaries. Supdtg. Hydrogeologist and scientist of CGWB participated in all the 4 plenary sessions covering various themes of the conference.
- Regional Workshop titled "Water Quality, Assessment, Control and Assurance" was organized at Kolkata on 22.02.2011. Eminent scientists, academicians and workers from

various Govt., Academic, Semi Govt. organizations including NGOs have participated in the workshop and opined their scientific views and findings. 18 research papers were received and out of them, 9 research papers were presented. Shri S. Biswas, IAS, Secretary WRIDD, Govt. of West Bengal was the chief guest, while Dr. S. Kunar, Member (SAM), CGWB, Faridabad, Shri D.Mukherjee, IAS, Director, Education, Govt. of West Bengal were the guests of honour.

- Workshop on "Challenges ahead in the ground water sector of Tamil Nadu "was organized by SECR, at Trichirappalli on 09.02.2011. Dr. P. Devadass Manoharan, Vice Chancellor, Anna University, Trichirappalli was the Chief Guest. Morethan 100 delegates from various Central and State Agencies including professors and students from various Universities and colleges attended the workshop. There were two interactive technical sessions followed by Recommendations. The event was a grand success.
- Scientists of Central Ground Water Board, South East Coastal Region, Chennai attended the workshop on "Isotope Tracers for Water Resources Management" organized by Centre for Water Resources, Anna University, Chennai on 25.02.11.
- One day National Seminar on "Sustainability of Ground Water Resources" was organized at Shakaraghatta, Shimoga, on 09.02.2011. The seminar was organized by Central Ground Water Authority and Central Ground Water Board, SWR, Bengaluru in association with Department of Applied Geology, Kuvempu University, Shankaraghatta, Shimoga. The seminar was attended by more than 100 delegates from different institutions and departments viz., MGD, NIH, PRED, ZP, Research Institutes, Universities, etc. A seminar volume containing 24 technical papers on different aspects of water Resources was released during the inaugural session.
- One day Regional Workshops have been organized on different themes at various places "Integrated Water Resources Management" on 4th March, 2011 at Guwahati; "Ground Water Development and Management Prospect" on 7th March, 2011 at Bhubaneswar; "Rejuvenation of Springs by Artificial Recharge and Catchment area treatment with special reference to Rainwater Harvesting" on 9.3.2011 at Gangtok; "Conjunctive use of Surface and Ground Water" on 15th March, 2011 at Khajuraho, Chhattarpur; "Spring Recharge & Rejuvenation of Natural Springs by Artificial Recharge and Catchment Treatment" at Palampur; Ground water salinity, Assessment, Management and Mitigation" during 18-19 March 2011at CSSRI Karnal.
- Scientists of Central Ground Water Board North Central Region, Bhopal attended workshop on "Innovation for sustainable water management" at WALMI, Bhopal on 25th March, 2011 which was organized by Central Water Commission and WALMI, Bhopal.
- National Seminar on "Application of Remote Sensing and GIS Technology in Water Resources Management" held at Wadia Institute of Himalayan Geology, Dehradun during 15 – 16th March, 2011.
- Regional Director and Scientists of Central Ground Water Board, South Eastern Coastal Region, Chennai attended Regional Consultative Workshop-12th Plan Approach conducted by the Confederation of Indian Industries (CII) at Chennai on 12.03.2011.

Inauguration of the National Seminar on
" Sustainability of Ground Water Resources" held on 9.2.2011 at Shimoga

Release of seminar volume by Dr P.K.Mehrotra, Director(GW), MOWR, Sri R.N. Sawkar , Geological Society of India and Dr K.Md.Najeeb Regional Director during inaugural function of National Workshop on "Ground Water Regulation and Management" held on 12.1.2011

Chief Guest Shri S. Biswas, IAS, Secretary, WRIDD, Govt. of West Bengal inaugurating the Regional Workshop on 22.02.2011 at Indismart Hotel, Sector-V, Salt Lake, Kolkata-91 organized by CGWB, ER, Kolkata.

Address by Sri S. Kunar, Member, CGWB, at Kolkata

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,
NATIONAL WORK SHOP ON DEVELOPING WATER USE EFFICIENCY AT JAIPUR ON 28.02.11

Lighting of Lamp in Productive use of Ground Water Management through Peoples participation by Sri U.N.Panjiyar, IAS, Secretary, MoWR, Govt. of India at MER, Patna

Address in Productive use of Ground Water Management through Peoples participation by Sri U.N.Panjiyar, IAS, Secretary, MoWR, Govt. of India at MER, Patna

Dr. A.P.J Abdul Kalam, Former President of India is being shown the GW Model on different aquifers by Shri. D.S.C.Thambi, Regional Director, SECR, Chennai at the event titled "Siruthuli Peruvellam" on 17.07.2010 organised by Siruthuli (NGO), Coimbatore, Tamil Nadu

Shri D.S.C.Thambi, Regional Director, CGWB, SECR interacting with Dr A.P.J.Kalam, Former President of India on the Rainwater Harvesting Scheme being executed in Coimbatore City under Demostrative Project on Artificial Recharge through working model.

Two days Workshop on Integrated Water Resources Management" at Shillong, Meghalaya

WORKSHOP ON AUGMENTATION AND PROTECTION OF GROUND WATER(24/02/2011)

26. RESEARCH AND DEVELOPMENT STUDIES

An Indian National Committee on Ground Water (INCGW) is constituted by the Ministry of Water Resources, Govt. of India vide 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.

During the year, 14 new research proposals were received. Out of which, 11 were considered for further scrutiny and three proposals were sent back to Principal Investigators.

During the year, two meetings were held. Third meeting of INCGW was held on 28-10-2010 at CGWB, New Delhi. Three revised proposals were considered during the meeting, out of which 1 proposal was approved subject to minor modifications, however other 2 were rejected. In addition to this, 11 new proposals were also considered, out of which 4 were approved subject to modifications. Two ongoing schemes were also approved.

Fourth meeting of INCGW was held on 2-2-2011 at CWRDM, Kozhikode. During the meeting, 6 new proposals were considered, out of which 1 proposal was approved and PI's of remaining were advised to incorporate modifications as suggested by the committee. One ongoing scheme was approved for closure.

Second R&D session of INCGW was organized on 2-2-2011 at CWRDM, Kozhikode to review the progress of ongoing schemes. The Session was inaugurated by Dr. Nivedita P. Haran, Additional Chief Secretary, Department of Revenue, Government of Kerala and was presided over by Chairman, Central Ground Water Board and INCGW. The session was attended by approximately 60 participants from different central, state government organizations and educational institutions. One day study tour was also arranged. During the session, progress of two ongoing schemes was reviewed. The session was a huge success.

Out of 4 proposals which were approved during the first meeting of INCGW and had been forwarded to Ministry for sanction, the following 3 proposals were approved during the meeting of Standing Advisory Committee of MoWR & funded by Ministry and remaining 1 was deferred till next meeting.

1. Vulnerability assessment and ground water management studies in aquifers of Pondicherry" received from Dr. S. Chidambaram. Cost of the scheme is Rs. 26,01,900 for duration of three years.
2. Hydro-geo-chemical impacts of shrimp farming on coastal watershed –PI- Dr.Nilarekha. Cost of the scheme is Rs. 36,07,933 for duration of three years.
3. Development of Nano-Filtration Membrane Technology for drinking water purification & water reclamation for industrial use" PI- Dr.Paramita Ray. Cost of the scheme is Rs. 24,21,840 for duration of three years.

Four proposals approved during the previous meetings were forwarded to the Ministry for sanctioning.

27. PUBLICITY AND PUBLIC AWARENESS

Central Ground Water Board/ Ministry of Water Resources participated in following Exhibition/Trade Fair during 2010-11.

i. Participation in International Trade Fairs -2010

Central Ground Water Board participated in the MOWR pavilion of IITF-2009 at Pragati Maidan, New Delhi during 14-27th November 2010. 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. Bharat Nirman Exhibition organized by PIB

CGWB, SWR participated in Bharat Nirman Exhibition, organized by Press Information Bureau, Bangalore at Taluk stadium, Pandvapura, Mandya district from 22.08.2010 - 24.08.2010. Working models of rainwater harvesting and Dug Well Recharge methods were exhibited at the stall. In addition, documentary films and slide shows regarding rainwater-harvesting projects have been displayed through LCD projector and posters advertising water conservation. During the three days exhibition, more than 500 people from different walks of life visited the stall and shown keen interest on the working models for rainwater harvesting. Scientists of CGWB, SWR participated as the resource persons .

iii. Painting Competition at State & National Level under IEC:

On receipt of instructions from Ministry of Water Resources, letters have been issued to 500 schools of Assam to organize painting competition amongst IVth , Vth , VIth standard students and two best entries to Regional Office. Venue of State Level Painting Competition decided at Sankardev Kalakheshtra , Guwahati for 14th November, 2010 function. Hon'ble Governor of Assam has agreed to grace the occasion as Chief Guest and to distribute prizes to students. Moreover Hon'ble Chief Minister, Govt of Assam, Minister of Water Resources, Govt of Assam, Minister of Education, Govt of Assam have been invited to be Guest of Honour on the occasion. Jury committee has been already constituted jointly with BEE, MOP for selection of best three paintings.

iv. Organized Painting competitions at State and school level under IEC activities

Regional offices of Central Ground Water Board organized State level Painting competition on the theme " Save Water- Every drop counts" at Bangalore, Nagpur, Hyderabad, Assam, Trivandrum, Chandigarh, Jaipur, Bhopal, Tamilnadu, Jammu, Shimla, Dehradun and Ahmedabad under the IEC activities in association with Bureau of Energy Efficiency, Power Grid Corporation, Ministry of Power, Govt. of India on 14.11.2010. The function was attended by the participating students, parents/guardians and officials from POWERGRID, CGWB/Ministry of Water Resources and Govt. media persons.

v. First National Level Painting Competition on Water Conservation held at New Delhi

Central Ground Water Board organized First National Level Painting Competition on Water Conservation on 21st January 2011 at CSMRS, New Delhi under the auspicious of Ministry of Water Resources, Government of India. First National Level Painting Competition was inaugurated by Shri Salman Khurshid, Hon'ble Minister of Water Resources, Shri Pawan Kumar Bansal, Hon'ble Minister of Parlimentary Affairs, and Shri Vincent H. Pala, Hon'ble State Minister of Water Resources & Minority Affairs. On this occasion, welcome address was given by Shri D.V. Singh, Secretary, Ministry of Water Resources. 63 winner students IV to VI standards from all over the country (three from each Regional offices) participated in National Level Painting Competition. Painting experts Jury selected 23 students for 1st, 2nd, 3rd and consolation award. Hon'ble Minister of Water Resources Shri Salman Khurshid distributed the certificates and cheques to the winners. Shri Sudhir Garg, JS(A), MoWR, Shri U.N. Paniyar, Former Secretary(WR) and other officers from CGWB and CSMRS were also present in the function. The 1st prize winner was from the Andhra Pradesh State.

Vote of Thanks was given by Dr. S.C. Dhiman, Chairman,CGWB.

vi. Manasa 2011

In response to invitation from Department of Geology, University of Mysore for participation in the event "Manasa 2011,. Central Ground Water Board, South Western Region, Bangalore exhibited working models on Rain water harvesting at "Manasa 2011" in Mysore from 15th - to 24th February 2011. The models were displayed at the department of Geology, University of Mysore. Further, calendars, brochures and pamphlets were also distributed. Scientists from CGWB, SWR were associated in this programme.

vii. Science Expo – 2011

Central Ground Water Board, Northern Region, Lucknow actively participated in Science Expo – 2011 during 19th - 23rd January 2011 at Regional Science City, Aliganj, Lucknow along with 21 distinguished Scientific Institutions of India. The Expo was inaugurated by Hon. Minister of Science & Technology, UP, Shri Abdul Mannan on 19th January 2011. Prof. S.W. Akhtar, VC, Integral University; Dr. N.C. Mehrotra, Director, BSIP; Dr. V.P. Kamboj, Ex. Director, CDRI, Shri B.M. Meena, Principal Secretary, CST, UP and Shri S. Kumar, Project Coordinator, RSCL were guest of honor. Many other distinguished guests/scientists were also present.

viii. 3rd NATIONAL GROUND WATER CONGRESS

Central Ground Water Board organized 3rd National Ground Water Congress and World Water Day 2011 at NASC Complex, ICAR,New Delhi during 22-23rd March, 2011. World Water Day was inaugurated by Shri Salman Khurshid, Hon'ble Union Minister of Water Resources & Minority Affairs and attended among others by Shri Vincent H. Pala, Hon'ble Minister of State for Water Resources & Minority Affairs, Prof. M.S. Swaminathan, Hon'ble M.P., Shri D.V.Singh, Secretary, Ministry of Water Resources and eminent Scientists and dignitaries. Hon'ble Union Minister of Water Resources & Minority Affairs released the volumes i) Collection of National/State/UT level Painting Competition on Water Conservation ii) Technical paper on water for cities responding to the urban challenges iii) Ground Water scenario in major cities of India and iv) Coastal Aquifer Systems of India. Hon'ble Union Minister of Water Resources & Minority Affairs presented National Water Award and 14 Ground Water Augmentation Awards to the Awardees on the occasion of World Water Day. More than 400 representatives from various Central/State Govt. organizations, NGO's/academic institutions participated in the congress. Valedictory addressed delivered by Shri Vincent H.Pala, Hon'ble Minister of State for Water Resources & Minority Affairs Shri G. Mohankumar, Additional Secretary(WR), Shri Sudhir Garg, Joint Secretary(WR) and officers from MOWR and CGWB were also present.

ix. Celebration of Hindi Saptah/Hindi Pakhwara

Hindi Saptaha/ Pakhwara was celebrated in different Regional offices/ HQ of CGWB from 14th September to 29th September 2010. 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.

x. Vigilance Awareness Week

Vigilance Awareness Week was observed from 3.11.2010 to 7.11.2010 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.

xi. Communal Harmony Campaign

Communal Harmony Campaign has been organized in the Central Ground Water Board, Bhujal Bhawan, Faridabad during 19 to 25th November 2010 and various activities on the theme were organised for the officers & staff members.

Shri S. Gupta, Member (SML), Shri G.C.Saha, Regional Director (NER) and Shri C.P.Srivastava, RD (ER) were present in the valedictory programme of World Water Week (21-25 March 2011) at Kolkata.

World Water Day Celebrated In Jodhpur

PROGRAMME ORGANISED DURING WORLD WATER WEEK, ‘‘RUN FOR WATER’’ FLAG OFF BY Mrs.Jyoti Khandelwal MAYOR JAIPUR ON 28.3.2011

Children participated in “Jaljatra” during the occasion of Mass awareness Programme at Budge Budge – I Block, South 24 Parganas District, West Bengal on 28.01.2011.

28. 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 2010-11 up to 31st March 2011 are given below in Table 28.1:

Table 28.1- Major achievements of the North Eastern Region

Sl. No.	Activities	Achievements
1.	Ground Water Management studies	10674 Sq. km area has been covered
2	Ground Water Exploration	26 wells drilled in North Eastern Region
3.	Monitoring of Ground Water Wells	Monitored during April, August, November 2010 and January, 2011 through a network of 310 Ground Water Monitoring Wells.
4.	Water Quality Analysis	365 samples analyzed for basic constituents and 380 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	52 investigations
6.	Geophysical Studies	VES(VerticalElectrical Sounding) – 366 Borehole logging - 05
7.	Reports	• Finalised Hydrogeological Atlas of Meghalaya and submitted. • District report of Sibsagar, Assam completed • Ground Water Year Book, 2009-10 completed • State Chemical Quality Report issued
8.	Preparation of a film on ground water issues.	Doccumentary film completed
9.	Estimation of Ground Water Resource of the entire Region based on GEC - 1997 Methodology	Draft Reports on Dynamic Ground Water Resource Estimation for seven states of North Eastern Region as on 31.03.2009 has been completed and submitted within stipulated time by the team of officers.
10.	Acquisition of Land & Building	Construction of the Divisional workshop at the CGWB plot Betkuchi , Guwahati by CPWD has been completed and Divisional Workshop has been completely shifted to the Departmental Building. The rented plot at Ganeshguri has been vaccated and possession given to the owner.
11.	I.E.C Activity	1.Completed the following programmes under I.E.C: i. 3 Nos MAP ii. 3 Nos WMTP iii. I No WRD iv. 1 No WWD v. I No Translide vi. Printing of Brochure of Kamrup district vii. Printing of Activities of CGWB viii. Extension of Electronic display Board on Guwahati Railway station 2. Completed one Week Orientation Training under RGI 3. Completed three days Training on "Building capacities of State PHED engineers on sustainability of drinking water sources". 4. Completed State Level Painting Competition of school children of IV, V and VI standards of all schools of all the districts of Assam State.
12.	Artificial Recharge Studies	Target Achieved & total 16 nos RTRWH structures completed. No modified DPR received from Govt. of Mizoram. Convened SLTCC meeting at Dimapur under the Chairman-ship of Commissioner & Secretary, Geology & Mining, Govt of Nagaland, Kohima and cleared DPR forwarded.

29. 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 2010-11, Parliamentary committee of official Language made the inspection of CGWB, New Delhi on 10.06.2010. The committee expressed its satisfaction on the efforts made towards propagation of Hindi & its implementation.
- Incentive for original noting and drafting in Hindi is being implemented. Nine 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 regularly.
- 'Hindi Pakhwara' was celebrated from 14 – 28th September 2010. Various competitions and other programmes were organized during the Pakhwara. The participation of officers/ officials in these competitions was encouraging.
- 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.

30. VIGILANCE ACTIVITIES

30.1 Vigilance Activities

During the year 2010-2011, 21 complaints cases were brought forward with effect from the last year and 16 new complaints were received during 2010-2011 up to 31st March, 2011. Thus total 37 complaint cases were on the record. Out of these 6 complaints have been closed and 2 complaint cases have been taken up as disciplinary proceedings. Therefore, 29 complaint cases have been carried forward w.e.f. 1.04.2011.

30.2 Disciplinary Proceedings

6 cases of disciplinary proceedings were brought forward w.e.f. 1.04.2010 and 2 cases of disciplinary proceeding have been received and one case droped during the year. Thus a total 7 cases of disciplinary proceedings were on the record and carried forward w.e.f. 1.04.2011.

31. RTI ANNUAL RETURN INFORMATION SYSTEM

Ministry/Department/Organization: Ministry of Water Resources, Central Ground Water Board

Progress during 2010-11					
	Opening balance as on 1.04.2010	**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	1	289	21	4	255
First Appeals	0	23	0	0	23

Number of cases where disciplinary action taken against any officer	**Nil**

No. of APIOs designated	**No. of PIOs designated**	**No. of AAs designated**
9	**13**	**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
-	-	-	-	-	-	1	-	-	3	-	-	-	-

Amount of changes collected (in Rs.)		
Registration Fee Amount	Additional Fee & Any other Charges	Penalities Amount
15	15296	Nil

32. PERSONNEL MANAGEMENT

The sanctioned strength, filled up, vacancy position and category-wise personnel deployed in the Board are presented in table 32.1 .

Table 32.1- Personnel Deployment in Central Ground Water Board During 2010-2011 (Up to 31st March, 2011)

GROUP "A"							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	404	295	109	21	0	43	13
Ministrial	6	4	2	0	0	0	0
Engineering	56	48	8	0	0	2	0
Total	**466**	**347**	**119**	**21**	**0**	**45**	**13**
GROUP "B"(Gazetted)							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	219	170	49	18	1	25	11
Ministrial	36	29	7	0	0	2	1
Engineering	110	55	55	9	0	6	2
Total	**365**	**254**	**111**	**27**	**1**	**33**	**14**
GROUP "B"(Non-Gazetted)							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	183	121	62	14	0	27	10
Ministrial	203	174	29	0	0	1	1
Engineering	265	220	45	4	0	2	2
Total	**651**	**515**	**136**	**18**	**0**	**30**	**13**
GROUP "C"							
Section	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
Scientific	91	69	22	3	0	17	5
Ministrial	1136	910	226	0	0	0	0
Engineering	1462	1143	319	10	0	12	18
Total	**2689**	**2122**	**567**	**13**	**0**	**29**	**23**
GRAND TOTAL							
Groups	**Sanctioned**	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
GROUP "A"	**466**	**347**	**119**	**21**	**0**	**45**	**13**
GROUP "B"(Gazetted)	**365**	**254**	**111**	**27**	**1**	**33**	**14**
GROUP "B"(Non-Gazetted)	**651**	**515**	**136**	**18**	**0**	**30**	**13**
GROUP "C"	**2689**	**2122**	**567**	**13**	**0**	**29**	**23**
Total Strength	**4171**	**3238**	**933**	**79**	**1**	**137**	**63**

33. PERSONS WITH DISABILITIES

The Persons with Disabilities for the Year 2010-2011 up to 31st March 2011 is given in table 33.1.

Table 33.1 : Persons with disabilities for the year 2010-2011

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.

34. BUDGET AND ACCOUNTING

Statement showing actual expenditure incurred by the Board during 2010-2011 has been shown in Table 34a, Table 34b, Table 34c, Table 34d and Table 34e.

Table 34a : Statement showing actual expenditure incurred by the Board during 2010-2011 (Up to March, 2011)

Sub-Head	Plan (Rs. In Lakhs)		Non-Plan (Rs. In Lakhs)	
	Funds	Expenditure	Funds	Expenditure
Salary	2100.00	2049.76	9924.48	9729.06
Wages	35.50	36.14	0.50	0.45
O.T.A	2.00	2.37	7.00	6.91
D.T. E	460.00	497.24	190.00	195.03
F.T.E	0.00	0.00	0.60	0.60
O.E	525.00	543.10	5.50	6.20
P.S	25.00	15.13	0.45	0.13
R.R.T	90.00	107.05	4.30	2.52
Publications	45.00	43.51	0.70	0.18
Subsidies	0.20	0.07	0.00	0.00
Susp. Stock	900.00	917.25	0.00	0.00
W.O.L	3.00	0.14	0.00	0.00
M.V.	123.00	153.45	1.50	1.22
M & E	30.00	24.77	0.00	0.00
M.Works	3554.40	3547.82	0.00	0.00
Medical	86.00	84.96	113.85	100.87
Other Charges	8.00	8.47	0.00	0.00
B.C.T.T.	0.00	0.00	0.00	0.00
POL	1000.00	1031.68	2.75	2.71
O.A.E.	15.00	24.90	0.05	0.00
Adv./Publicity	0.00	0.00	0.50	0.00
Minor Works	40.00	41.02	0.00	0.00
Total	**9042.10**	**9128.83**	**10252.18**	**10045.88**

Table 34b: Rajiv Gandhi National Training & Research Institute for Ground Water

Sub-Head	Fund Allotment	Expenditures
Salaries	205.00	210.22
Wages	0.00	0.00
O.T.A	0.00	0.00
D.T.E	50.00	44.74
O.E	10.0	6.87
R.R.T	6.00	0.99
Publication	2.00	1.29
P.S	43.00	37.47
M.V	4.00	3.56
M & E	12.000	10.01
Medical treatment	2.00	1.59
P.O.L	6.00	2.44
Total (RGNTR&I)	**340.00**	**319.18**

Table 34c: Hydrology Project
Ext. Support & Domestic Support

Sub-Head	Fund Allotment	Expenditures
Salaries	187.78	172.32
M/Treatment	1.12	0.09
D.T.E	10.32	7.79
F.T.E.	15.00	8.34
O.E	21.75	13.50
B.C.T.T.	0.00	0.00
O.A.E.	000	1.62
P.S.	12.00	8.08
M. V.	15.00	0.00
M&E	45.62	6.90
M/Works	81.00	79.87
Total H.P.Ext. Sup.	**389.59**	**298.51**
H.P.(D/S)		
Salaries	62.59	32.06
M/Treatment	0.38	0.19
D.T.E	3.78	2.42
F.T.E.	0.00	0.00
O.E	7.25	5.91
B.C.T.T.	0.00	0.00
O.A.E.	0.00	0.06
P.S.	0.00	0.00
M.V.	0.00	0.00
M&E	0.00	0.00
M/Works	9.00	8.65
Total H.P. Dom. Sup.	**83.00**	**49.29**
Total (Hydrology Project)	**472.59**	**347.80**

Table 34d : Central Ground Water Board building for offices

Sub-Head	Fund Allotment	Expenditures
Major Works	920.00	660.56
M&E	80.00	51.30
Total	**1000.0**	**711.86**
Total CGWB	**10854.69**	**10507.67**

Table 34e : Deduct Recoveries

Sub-Head	Fund Allotment	Expenditures
Central Ground Water Board		
Issue to works and other credits	1100.00	1024.16
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**	**1024.16**
NET CGWB	**9654.69**	**9483.51**

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
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
State Unit Office	Ranchi	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	Naharlugan	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
State Unit Office	Delhi	Delhi


भूजल की रक्षा जीवन की सुरक्षा
केन्द्रीय भूमि जल बोर्ड
चण्डीगढ़
स्वच्छ जल
स्वस्थ जीवन