Annual Report 2008-2009

CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

Annual Report
2008-2009

CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
GOVERNMENT OF INDIA

ANNUAL REPORT 2008-2009

CONTENTS

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, deep 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, water balance studies, conjunctive use studies and artificial recharge studies. The Board also organizes training of personnel of different disciplines of Central and State Government Organisations in ground water related activities.

OBJECTIVES

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

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

ORGANISATIONAL SETUP

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

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

The Sustainable Management and Liaison wing looks after sustainable management of ground water related policies, issues etc., augmentation of ground water resources including artificial recharge and monitoring of artificial recharge studies, urban ground water management, 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, work related to monitoring of ground water regime and development, conjunctive use of surface and ground water, Aquifer mapping and assessment of aquifer characteristics based on exploration and surveys, Hydro-chemical analyses and studies, pollution studies, short term water supply investigations, drought management, data collection, 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. 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.

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 having problems of water quality due to geogenic sources. An annual target of 1.5 Lakh sq.km. is earmarked under this item of this study. During the year 2008-09 up to 31st March, 2009 an area of 1.62 Lakh sq. km was covered during pre-monsoon period and Post-monsoon studies have been completed in 1.55 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 2008-09 up to 31st March, 2009, 761 wells (EW-404, OW-159, PZ-197, SH-01) have been constructed, against a target of 800 wells.

60 wells with discharge ranging from 90 LPM to 3000 LPM have been constructed in the states of Andhra Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh. 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 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 2008 & January 2009 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 2008-09 up to 31st March,2009, 1932 Vertical Electrical Soundings, 10.88 line kilometer resistively profiling and geophysical logging of 88 bore holes have been conducted in various parts of the country.

Hydrochemical Analysis

There are 16 Regional Chemical Laboratories in the Regional offices of the Board. Chemical analysis of water samples collected during various studies are analyzed in these laboratories. All the Laboratories are equipped with Atomic Absorption Spectrophotometer to carry out the analysis of toxic elements and heavy metals. 2 chemical laboratories are also equipped with Gas Chromatograph (GC) to take up the analysis of organic pollutants

(Pesticides etc). 19258 samples have been analyzed during the year up to 31st March, 2009, out of which 15671 samples were analysed for basic constituents, 2625 samples for heavy metals such as Cu, Zn, Fe, Mn, CO, Cd, Cr, Ni, Pb etc, analysis of 858 No. water samples for specific studies and 104 samples for organic and specific constituents.

Artificial Recharge Studies

The Board is carrying out demonstrative artificial recharge studies in high water demand areas with over-exploited / critical stage of ground water development. Artificial Recharge studies have been completed in most of the Regions and impact assessment of ongoing & completed Schemes, monitoring & report submission are in progress.

During 2008-09, A demonstrative scheme on "Rain Water Harvesting and Artificial Recharge to Ground Water" has been taken up in the (1) Lingala, Pulivendula Vemula and Vemalli blocks in Kadapa district, Andhra Pradesh (2)Gangavalli block in Salem district, Tamil Nadu (3)Mallur block in Kolar district, Karnataka (4)Bel watershed, Amla & Multai blocks in Betul District, Madhya Pradesh.(5) Upper reaches of Choti Kali Sindh river in parts of Sonkatch & Bagli blocks in Dewas district, Madhya Pradesh. 191 artificial recharge structures have been completed during the year.

The Scheme of the Ministry of Water Resources on "Artificial Recharge to Ground Water through Dug Wells" in 7 states namely Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Tamilnadu, Gujarat and Madhya Pradesh has been launched. The scheme has been approved for a cost of Rs. 1798.71 Crores with net cost of subsidy to Government in terms of civil works of Rs. 1499.27 Crores.

R&D Studies

Central Ground Water Board, is assisting Ministry of Water Resources in carrying out R&D studies as a member of a sub-committee of Indian National Committee on Hydrology (INCOH), with a view to accelerate the research & development programme in ground water sector. This Committee examines the project proposals received by INCOH in the field of ground water for their suitability for funding by MOWR and also monitors the research schemes funded by INCOH. During the year total 19 projects were received. Out of 19 projects, 2 proposals were approved and recommended by R&D(GW) sub committee, 2 proposal approved in principle and sent to PI for revision and remaining 15 proposals are under scrutiny.

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 2008-09 up to 31st March, 2009, 213 District Ground Water brochures, 2 State Reports , 13 District Reports, 8 Ground Water Exploration Reports and 21 Ground Water Year Books issued /complete.

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 2008-09 up to 31st March 2009, the Vol. No 22, 2007 issue has been finalized and under printing.

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 126 investigations during this year.

Dissemination and Sharing of Technical Know-how

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

Re-Assessment of Dynamic Ground Water Resource

The Dynamic Ground Water Resource of the country has been jointly estimated by State Ground Water Departments and Central Ground Water Board, based on the methodology recommended by Ground Water Estimation Committee-1997 (GEC-97). The Ground Resource was estimated as on March, 2004. The National level report on "Dynamic Ground Water Resources of India" was finalized and approved by the R&D Advisory Committee in its seventh meeting held at New Delhi on 19th August, 2005. As per the report, the Annual

Replenishable Ground Water Resource for the entire country is 433 billion cubic metre (bcm), Net Annual Ground Water Availability is estimated as 399 billion cubic metre where as the Annual ground water draft for irrigation, Domestic & Industrial was 231 billion cubic metre and their Stage of Ground Water Development for the Country as a whole is 58%.

Technical Examination of Major/Medium Irrigation Project proposals

As per directives of the steering committee on Irrigation projects constituted by Planning Commission, the major and medium irrigation project reports and proposals sent by State Governments through Central Water Commission (CWC)/Command area Development (CAD) Authority were scrutinized and cleared by CGWB from Ground Water Development and impact assessment point of view. Suggestions were made for modification / addition of ground water development in these schemes. During the year 2008-2009, Sixteen major irrigation project proposals of Central Water Commission were examined and area specific recommendations were made.

Human Resources Development

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

Fifteen training courses out of proposed 16 training programmes have been conducted successfully during the year 2008-09 under Rajiv Gandhi National Ground Water Training and Research Institute. Total 308 trainees from various disciplines have been trained in the training courses conducted at various places.

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 expenditure incurred on the project till March, 2009 is Rs 211.65 lakhs.

Mathematical Modeling Studies

The Central Ground Water Board has undertaken two studies in Ranchi and Patna urban area on ground water modeling during the year. Mathematical modeling have been taken up in Madaram watershed for creating the data base for simulation of mathematical model and Kottukal thodu water shed of Neyyar basin for groundwater flow and the impact of various stresses on the flow regime.

Remote Sensing Studies

During the year 2008-09, the application of Remote sensing in drought prone water scarce area of Purulia district; parts of Sengar river watershed, Kanpur Dehat district; Lakhimpur district of Assam; taken up in Yamuna flood plain area, Haryana; Remote sensing studies in Gangavalli and Thalaivasal blocks, Salem district; study was taken up to delineate the different geomorphic units using Remote Sensing techniques in 7 blocks in the district Bhadrakh.

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 organized Mass Awareness programmes and Training's on Rain Water Harvesting including Roof Top Rain Water Harvesting at different locations of the Country, with the aim of educating the common people about judicious and optimum utilization of ground water. During the year, various activities under the IEC programme of Ministry of Water Resources were taken up by Central Ground Water Board through its Regional Office, 19 Mass awareness programs were organized during the year for ground water conservation, artificial recharge and ground water

protection and 19 Ground water management training programs were also organized in different parts of the country for designing rain water harvesting structures for augmenting the water and 19 Workshops were organized.

Central Ground Water Authority has notified 43 Blocks/ Mandals / Talukas etc. in the country for regulation of groundwater development in the states of Haryana, Punjab, Uttar Pradesh, Rajasthan, West Bengal, Gujarat, Andhra Pradesh, Madhya Pradesh, NCT Delhi and Union Territory of Diu. So far, 65 Blocks/ Mandals / Talukas in the country have been notified for registration of groundwater structures in the states of Haryana, Punjab, Uttar Pradesh, Gujarat, Andhra Pradesh, Karnataka, Kerala, Tamilnadu, Madhya Pradesh, Maharashtra, NCT Delhi and Union Territory of Pondicherry. During the period (April 2008 to March 2009), 369 industries have been accorded NOCs. The process of registration was discontinued as per the decision taken in the 25th meeting of CGWA held on 7th August, 2008. So far, 36 District Collectors / Deputy Commissioners have been appointed as authorized officers in notified areas during 2008-09 upto 31st March, 2009.

Budget

Expenditure of 5114.33 lakhs and 5951.37 lakhs of rupees were incurred by the Board during the year under various Plan and Non-plan sub-heads respectively to carry out various activities mentioned above.

1. INTRODUCTION

1.1 HISTORY OF CGWB

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

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

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

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

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

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

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

1.2 MANDATE AND OBJECTIVES

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

"Develop and disseminate technologies, monitor and implement national policies for the scientific and sustainable development and management of India's ground water resources including their exploration, assessment, conservation, augmentation, protection from pollution and

distribution based on principles of economic and ecological efficiency and equity".

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

1.2.1 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.

1.2.2 Formulate perspective plans, basin or sub-basin wise, for harnessing ground water resources in a phased or need based manner and resolve regional imbalances.

1.2.3 Monitor ground water development in the country and promote its sustainable management on principles of ecology, economics, efficiency and equity.

1.2.4 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.

1.2.5 Plan augmentation, conservation, protection and regulation of ground water resources keeping in view the existing and future ground water demand scenario.

1.2.6 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.

1.2.7 Forecast the manpower, equipment, energy and financial requirements for the ground water sector, in the context of demand projections.

1.2.8 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.

1.2.9 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.

1.2.10 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.

1.2.11 Establish benchmarks and methodologies for ground water studies in coordination with the State Governments.

1.2.12 Promote environmental awareness and water quality consciousness.

1.2.13 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, 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 2008-2009.

1.4 ACTIVITIES OF THE BOARD DURING 2008-2009

The following activities had been undertaken during the period 2008-2009.

1.4.1 Ground Water Management Studies

1.4.2 Ground Water Exploration aided by Drilling.

1.4.3 Monitoring of Ground Water Observation Wells.

1.4.4 Short Term Water Supply Investigations.

1.4.5 Periodic Assessment of Ground Water Resources.

1.4.6 Technical Documentation and Publication of Maps & Reports.

1.4.7 Publication of Quarterly Journal "Bhujal-News".

1.4.8 Taking over of Wells by State Govt.

1.4.9 Organizing Exhibitions, Seminars, Workshops etc.

1.4.10 Hydrochemical Analysis.

1.4.11 Geophysical Studies.

1.4.12 Hydrological and Hydro meteorological Studies.

1.4.13 Mathematical Modeling Studies.

1.4.14 Artificial Recharge studies.

1.4.15 Organizing training of Central and State Government personnel.

1.4.16 R & D Studies.

1.4.17 Basic Research in Hydrogeology/ Special studies

1.5 ANNUAL ACTION PLAN 2008-2009

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

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

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

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

2. GROUND WATER MANAGEMENT STUDIES

Ground Water Management Studies are being carried by the Board at district level to evaluate the changes in quantity & quality in the ground water regime owing to development and also to identify related issues for future management strategies. A major part of replenishment of ground water is through infiltration from rainfall. Return flow from irrigation and seepage from surface channels and reservoirs also contribute substantially to the ground water recharge. The effect of ground water withdrawals and out-flows are directly measurable through water table. Since all these inputs and outputs frequently change with time, the ground water situation is being periodically reappraised. As the development of resource leads to changes in its regime and water quality therefore planning for further development of the resource is to be done on the basis of findings of the studies, which provide valuable information for reorienting ground water development programme keeping in view the emerging scenarios. During the year 2008-2009, an area of 1.60 Lakh Sq.km. have been covered by the Board under Ground Water Management studies as against target of 1.59 Lakh Sq km. State/District wise target vis-a-vis achievements during the year 2008-2009 is shown in Table 2.1 and Graph 2.1.

Table : 2.1 TARGET AND ACHIEVEMENTS OF GROUND WATER MANAGEMENT STUDIES DURING 2008-09

Sl. No.	States	Districts	Target (Sq. km.)	Achievement (Sq. km.)
1	Jammu & Kashmir	Kathua	1700	2691
		Pulwama	1210	500
2	Himachal Pradesh	Chamba	3000	3000
		Bilaspur	1167	1167
3	Punjab	S.A.S. Nagar(Mohali)	1093	1093
		Hoshiarpur	3000	3000
4	Haryana	Flood plain area of Yamuna River (Yamuna Nagar,Karnal,Panipat, Sonipat and Faridabad)	3000	3540
		Fatehabad	2520	2520
5	Rajasthan	Parts of Bikaner	10128	10128
6	Gujarat	Mehsana	3000	3000
7	Madhya Pradesh	Shahdol	5834	5834
		Kshipra watershed (Indore, Dewas, Ujjain & Ratlam districts)	3920	3920
		Anuppur	570	570
8	Chhattisgarh	Durg	3000	3000
		Korba	3000	3000
9	Maharashtra	Part of Jalgaon and Aurangabad	3000	3156
		Part of Wardha	3000	3015
		Part of Nagpur	1500	1500
		Ahmednagar	3500	3590
10	Uttar Pradesh	Shahjahanpur	2470	2470
		Kannauj & Kanpur Nagar	2011	2011
		Unnao	750	750
		Lucknow & Barabanki	2878	2878
		Parts of Unnao	1496	1496
		Kanpur dehat	300	300
		Lucknow Urban Area	340	340
		Parts of Faizabad	500	500
		Parts of Balrampur	1000	1000
		Parts of Hamirpur	2272	-
11	Uttarakhand	Pauri Garhwal	5400	5400
		Udham Singh Nagar	600	600
		Pithoragarh	4100	4100

Sl. No.	States	Districts	Target (Sq. km.)	Achievement (Sq. km.)
12	Bihar	Parts of Munger	300	300
		Parts of Buxar,Bhojpur,Siwan, Saran and Patna	2500	2500
		Parts of Patna, Vaishali, Samastipur, Begusarai, Lakhisarai and Munger	2500	2500
		Parts of Khagaria, Munger, Bhagalpur,Purnea and Katihar	2500	2500
13	Jharkhand	Palamu	2700	2700
14	West Bengal	Purulia	4500	4500
		Partsc of Malda & Murshidabad	1000	1000
		Hugli	2500	2500
		North 24 Parganas	720	720
15	Sikkim	Parts of South & East districts of Sikkim State	400	400
16	Assam	Goalpara	1824	1824
		Sonitpur	3000	1600
		Dibrugarh	3000	3000
		Nagaon	3000	3973
17	Tripura	West Tripura	1301	1301
18	Arunachal Pradesh	Papumpare	2875	2875
19	Orissa	Dhenkanal	3000	3500
		Jajpur	3000	3000
		Parts of Kendrapara & Jagatsinghpur	3000	3815
		Parts of Jharsuguda & Sambalpur District	3000	3000
		Bhadrak	510	510
18	Andhra Pradesh	Khammam	2400	2400
		Nizamabad	3000	3130
		Prakasam	3000	3000
		East Godavari	1600	1600
		Ranga Reddy	110	110
		Mahabubnagar	95	95
19	Karnataka	Chikamagalur	2836	2836
		Kopal & Belgaum	2706	2706
		Parts of Chikmagalur, Shimoga & Davanagere	1100	1100
		Mangalore.	92	92
		Chitradurga	354	354
20	Tamil Nadu	Parts of Thanjavur & Pudukkottai	3411	3411
		Chennai City	993	993
		Parts of Thanjavur & Tiruvarur	3132	3132
		Salem	410	410
		Chennai sub-urban area	200	200
21	Kerala	Wayanad	1000	1350
		Palakkad	2000	2000
		Kannur	3000	3000

SALIENT FEATURES OF DISTRICT GROUND WATER MANAGEMENT STUDIES:

2.1 NWHR, JAMMU

Ground Water Management Studies was carried out in Kathua district (2691 sqkm) and in Pulwama (500 Sqkm).

2.1.1 Kathua District

Ground water management studies was carried out in Kathua district, Covering an area of about 2691 sq km. The southwestern boundary is contiguous with the international border with Pakistan. The survey was aimed at understanding the hydro-geological set up of the area with a special emphasis to demarcation of artesian aquifers in outer plain of Kathua district.

The district is traversed by a series of north west – south east trending parallel hill ranges such as Sunderi Kote Dhar, Banjal Gala Dhar and the Kaplas ranges over the northern margin and existence of outer plain over the southern margin. The northern hilly parts constituting about 67% of the total area of the Kathua district is a rugged mountainous terrain varying in heights between 440 and 1500 m amsl. The annual rainfall in the district is approx. 1672 mm. Most of the higher areas in the Basohli and Billawar Tehsils experiences snowfalls for most part of the year. The District experiences rainfall during winter and early summer. Ravi river along with its tributaries namely Ujh, Taranah and Bein drains the district from north east to west. Most of the nallahs in the hill are ephemeral in nature and carry huge amount of load during monsoon period.

Hydrogeologically the area is divided into three formations such as unconsolidated, semi consolidated and consolidated formations. The northern hilly terrain of the district comprises of the semi-consolidated and consolidated formation. The southern outer plain comprises of unconsolidated formations such as Kandi and Sirowal formations. In the hilly terrain, the highly dissected topography, steep slopes and impervious nature of the rocks, collectively result into more of surface run off than the downward percolation. Groundwater in this terrain occurs mostly in the form of seepage & springs depending upon the local hydrogeological conditions. In the southern plains, which are about 50 km in length and is 10-20 km in width, groundwater occurs as a regional groundwater body. Wells and tube wells are the main ground water structures used for ground water development. The ground water occurs both under water table and confined conditions and free flow artesian condition is observed in the southern part of Kathua district with in the Sirowals that also form prolific aquifers. Depth to water table varies inversely proportional to the distance from the outer Siwalik hills. In this belt dug wells have water under water table conditions while tube wells yield water under both water table as well as confined conditions. The water level ranges from 1.56 m to 30.20 m bgl in outer plain and hilly areas. In dun valley water level ranges from 3.25 m to 25.83 m bgl during pre-monsoon. The water level varies from 1.02 m bgl to 25.23 m bgl in outer plain where as in Dun valley it ranges between 0.65 m & 25.23 m bgl during post monsoon.

Apart from the open wells about 34 springs in the area were monitored both for quantity and quality analysis. The discharge of the spring ranges from 0.03 lpm to 510.6 lpm respectively. From the present study it has been observed that auto flow conditions exists in three zones in southern part of Kathua district along the international border with Pakistan These zones are mainly along the perennial nalas and rivers are presently in alluvium of Sirowal formation. General discharge of auto flow tube wells varies from 300 to 2700 lpm. The quality of ground water in general is good with low salinity and suitable for domestic and irrigation use.

2.1.2 Pulwama District:

Ground Water Management Studies carried out in Pulwama district and covered an area of 500 sq km during pre-monsoon period. The study was aimed with a view to re-apprise the present ground water condition and to delineate the extension of artesian aquifers, to determine the aquifer characteristics and to ascertain the changes in ground water regime.

2.2 NWR, CHANDIGARH

Ground Water Management Studies was carried out 9613 Sq.Km covered in S.A.S. Nagar (Mohali) and Hoshiarpur districts of Punjab State and Fatehabad district and Flood plain area of Yamuna River of Haryana State.

2.2.1 S.A.S. Nagar District, (Mohali) Punjab

The Ground Water Management Studies was carried out 1093 Sq.Km area in SAS Nagar district. A total of 27 dug wells and 4 Piezometers have been established and monitored to carry out the study. 37 no. of water samples were collected from shallow and deep aquifer for the purpose of detailed chemical analysis and in addition to that 14 samples were also collected for heavy metal analysis, 14 samples were collected landfill area of Mohali City.

The water level in the district ranges from 2.90 m at Jaintimazri to 46.08 m at Kishanpura falling in Sialba Mazri block. Maximum decline of water level is encountered in northeastern part in Sialba Mazri block. Shallow tubewells are the most important groundwater abstraction structures in the district. The shallow tubewells are in the depth range of 20-76m bgl tapping shallow granular zones. The granular zones are composed of sandy clay, sand and kankar. The discharge ranges from 153 to 1784 lpm with moderate drawdown.

Drinking water supply in rural and urban areas is mainly based on ground water. Punjab State Tubewell Corporation and Public Health Department has drilled boreholes in the depth range from 43 to 182m bgl to cater the domestic and irrigation needs of the district. The discharge of these wells ranges from 206 to 2873 lpm. 96% of the total irrigated area is by shallow and deep tubewells and rest by canals etc.

Majority of the ground water samples collected from the district show mixed type of chemical character. Since all the physical and chemical parameters are below the permissible limit prescribed by BIS the ground water in the area is suitable for drinking purposes.

2.2.2 Hoshiarpur District, Punjab

The Ground Water Management Studies was carried out in Hoshiarpur district falls in the eastern part of the Punjab State, covering an area of 3365 sq.km. Administratively the district has four tahsils, five sub-tahsils and ten blocks.

Topographical gradient of the area as deduced from DTM, SRTM data of the Hoshiapur indicate southwest direction in general. The upper part of the district acts as recharge area for Bist Doab. The district is drained by the river Beas, Black Bein and White Bein. Besides, a number of small streams flow down the Siwalik hills which are debouching into plains spread in numerous branches locally known as choes giving rise to fan shaped structure. During the monsoon period, these choes carry quantity of water as flash flood along with considerable sand and silt. In general the soils are yellowish brown to dark brown in colour. These range from calcerous sand to fine sandy loam to silt.

Hydrogeologically, unconsolidated alluvial sediments lying south of Siwalik foothills mainly occupy the district. The alluvial sediments are classified as piedmont and fluvial deposits. The piedmont deposits lie along Siwalik Hills, which comprises boulders, pebbles, gravel, sand and clay. It is further divided into Kandi and Sirowal, which are contemporaneous, and merge imperceptibly with each other. The fluvial comprise of silt, sand, gravel and clay in association with Kankar. Ground water is generally fresh at all levels. Ground water exploration was carried out at 40 sites which includes 5 piezometers. The boreholes at Patti Khas, Naloian, Jian, Hariana and Niala were abandoned due to insufficient thickness of aquifers. The study of exploratory boreholes drilled by of Central Ground Water Board indicated presence of three aquifer groups upto 425m depth below ground level. A total of 3 distinct aquifer groups as under were deciphered. The stage of ground water development for the district is 94 % and two blocks fall in over-exploited categories.

2.2.3 Fatehabad District, Haryana

Fatehabad district has five developmental blocks having geographical area of 2254 sq.km. Topographical gradient of the area as deducted from DTM, SRTM data of the Fatehabad indicate southwest direction in general.

Fatehabad is traversed by high density of canal and natural drainage following the natural topographical gradient of the district. Ghaggar river and Rangoi nala makes the major natural drainage, where as BML and its supporting distributaries make canal network of the district. Canal and drainage density is relatively less in the southeastern part of the district. Hydrogeologically, Ground water movement is followed by the topographical gradient of the area. In northern part of the area water level are more than 30m and in the southern part of the district water level are shallow, less than 5m.

A total of 79 samples were collected from shallow and deep aquifer for detailed chemical analysis and 17 samples were collected for heavy metal analysis. Besides 75 on the spot values were taken for Electrical Conductance of the groundwater in the area. Preliminary analysis of water sample indicate Northern and Central part of the district comprising parts of Fatehabad, Ratia and Tohana block have relatively fresh water upto a relatively deeper level in comparison to the southern part of the district where fresh water is available in the form of thin water floating lens over highly saline water. Northern part of the district has relatively fresh floating lens over highly saline water. Northern part of the district has relatively fresh water because of the perinneal recharge from the Ghaggar river flood plain. Presence of the fresh water has a reasonable fair spatial correlation with the canal/drainage density of the area. In general area with fresh quality of water shows higher level of ground water development in comparison to southern parts where ground water development is low on account of its poor quality of water.

2.2.4 Flood Plain Area of Yamuna River, Haryana

In the present study, an effort has been made to assess the ground water potentials in flood plains of river Yamuna, in Yamuna Nagar, Karnal, Panipat, Sonipat and Faridabad districts of Haryana state. The area fall in active floods and abandoned channels of the river Yamuna within a radius of 5 kms, from its right bank identified both with the help of remote sensing maps received from HARSAC, Hissar and field checks has been done to demarcate the potential for ground water recharge and development. Yamuna Flood plains extend from Buriya in Yamuna Nagar district in north to Hassanpur in Faridabad district in south. The total flood plain area along River Yamuna in Haryana state is nearly 500 Km^2.

The flood plain area along River Yamuna is underlain by alluvium of Quaternary and Recent Age. The older alluvium is generally characterized by dark coloured and rich in concretions and nodules of impure calcium carbonate known as kankars. The older alluvium forms slightly elevated terraces generally above the flood level, the river generally having cut through it to a lower level. The older alluvium constitutes of poorly sorted silt, sand, gravels and clays. The most conspicuous component of older alluvium found in various proportions is Kankar. The unsorted newer alluvium, occurring mainly along the flood plains of rivers, is light coloured and poor in calcareous matter. It contains lenticular beds of sands, gravels and clays. Sub surface geology inferred with the help of exploratory boreholes drilled in area reveals that clays are light coloured, soft and silty and sands are mostly medium to coarse grained.

Seismic surveys in the area reveal that the alluvial thickness to be more than 3000 m. Central Ground Water Board has established the occurrence of three major aquifer groups down to the depth of 463 m in Yamuna Nagar district. The first aquifer group consisting of coarser sediments extends down to 167 m and is underlain by 10 - 15 m thick clay bed. The second major aquifer group occurs at a depth ranging between 65.0 and 294 m of varying thickness of 26 to 152 m. It constitutes of comparatively lesser coarse material than the first group and is characterized by the presence of kankars. Third group of aquifers characterized by very fine sand beds alternating with clay beds and occurs at depths ranging between 197m and 385m.

Water level in the area varies between less than 3 m and 20m in 5 km belt along the Yamuna River. The variation in water level is attributed mainly due proximity to the river and stage of ground water development in particular area.

Though the area along the river has high rate of ground water development, water levels are shallow as compared to the areas away from river, which indicates that river is constantly contributing to the ground water body in area along the river.

The principal aquifer material in the area constitutes of medium to coarse grained sands mixed with silts. Gravels, pebbles are also commonly present. The shallow aquifers hold water under water table conditions. The shallow tubewells generally tap a single aquifer encountered within the depth range of 10m to 30m with discharge ranging between 5$m^3$and 40 m^3 and drawdown of 1.0 and 3.5 m.

Areas identified for Ground Water Recharge

The major source of ground water recharge other than rainfall is inflow/ bank storage during floods in Yamuna River besides subsurface flow from adjoining areas and return flow from irrigated fields. It can further be augmented by adopting the following measures;

- Periodic release of water in Dhanoura Escape, Indri escape and construction of recharge trenches along it.
- Construction of suitable recharge structures along the abandoned channel i.e. Budha nallah in Yamuna Nagar, Pran Nallah and Purani Yamuna in Karnal and Panipat districts will help rise in water level and enhance the ground water resource in the area.

Areas identified for ground water development

- Water Table aquifer as well as deeper aquifers (mostly confined) are quite potential
- Suitable recharge structures (Trenches) to be constructed in the Pran Nadi and Purani Yamuna for augmenting the recharge.
- Heavy duty TWs to be constructed on the eastern bank (west of Yamuna) of Pran nadi and Purani Yaumna which Will be tapping the water table as well as deeper aquifers
- Water available (500 MCM) due to lowering of water table to be supplied to nearby towns/cities/industries

Two potential zones have been delineated (1) between Pran Nadi and Yamuna river in Karnal district and (2)

between Purani Yamuna and Yamuna River in Karnal and Panipat districts.

2.3 WR, JAIPUR

Ground Water Management studies were carried out in Lunkaransar and Nokha blocks of Bikaner district during 2008-09 covering a total of 10128 sq. km area, with the objective to evaluate changes in ground water regime owing to developmental stresses, to identify issues of concern and to suggest future management strategies.

2.3.1 Lunkaransar block, Bikaner district

Lunkaransar block is located in the northeastern part of the Bikaner district of Rajasthan having geographical area of 6328.02 Sq.km. The area is characterized by arid climate, low and erratic rainfall with high evaporation losses. The major part of the area is covered by sand dunes with flat to undulating alluvial plains. The average annual rainfall in the area is 257 mm. The maximum temp. ranges between 38 and 46^{o} C in the summer and in winter it drops to 8^{o} C. The area has no major river system except Lunkaransar lift canal (surface water) which passes through the area. Agriculture activity in the area is by and large depending upon the monsoon rainfall and rabi cultivation is restricted to localised area where irrigation facility (through canal) is available. Bajra and wheat are main crops in the area.

There are two main water bearing formations in the area - Quaternary Aquifer & Tertiary Aquifer. Quaternary Aquifer comprising of sand , clay, kanker and gravel and located in the northern part of the block.Groundwater occurs under water table condition. Depth to water level varies from 20 to 66 mbgl. Tertiary Aquifer comprises Nagaur and Jodhpur sandstone as main water bearing formations. Southern part of the block is occupied by these formations. Depth to water varies between 35 and 50 mbgl.

The water level data reveal that water tables are deep in the alluvial formation and shows negative fluctuation due to large scale groundwater pumping in the eastern part of the area. Positive water fluctuation has been observed mainly in saline zone and along the Lunkaransar Canal, which is attributed due to recharge from canal and salinity. Depth to water during pre-monsoon ranges from 22-75 mbgl, post monsoon level ranges from 22-73 mbgl. Total 45 nos. of water samples were collected to analyze the chemical quality of the area.

The Kanwarsen lift command area lies in Ganganagar and Bikaner district covering Suratgarh, Lunkaransar and Bikaner blocks . The native groundwater in the command area is saline. The main hydrogeological formations in the command area are older alluvium, tertiary sandstone and Nagaur sandstone. A network of Piezometers and key wells has been established for periodic monitoring of water levels and their fluctuations. It is evident from the water level data that the depth to water level in command area is deep and ranges between 25 to 60 mbgl. The water level fluctuation reveals rising trend in water level (0.25-5.4 m) during period 1995-2005, which is attributed to seepage from canal and return flow of irrigation, while comparing this fluctuation with recent period i.e. 2005-2008, it is inferred that during this period negative fluctuations were observed and in most of the observation wells showed the declining trend, which indicate the improvement in water logging condition. This may be attributed to less release of water in canal and low water allowance. Waterlogging about the KS Lift canal between RD 250 and RD 280 occurs in discontinuous areas of low lying land less than 3 hectare. The presence of hard pan layer restrict the downward movement of water and a perched water table forms above the layer is the reason for Waterlogging in the Lunkaransar. For the last 3-4 years it is observed that there is tremendously decrease in the size of water logging area due to use of sprinkler and drip irrigation system in the area as well as less availability of water for irrigation due to mearge discharge in KS lift canal fro the source. As per the data, K.S. Lift Canal, Lunkaransar, the total water logged affected area remains only 255.57 Hac. up to year 2004.

Following recommendations have been made on the basis of the study and field observations:

- Proper delineation of aquifer (perched and deep) and their extension lateral and vertical may be defined through geophysical method so that a comprehensive water management plan may be prepared.
- Increase the density of existing piezometers and Construction of shallow piezometers in the affected area to study the groundwater system behaviour.

2.3.2 Nokha block, Bikaner district

Nokha block is situated in the south eastern part of Bikaner district covering an area of 3800 sq.km. The climate is arid with annual normal rainfall being 269.0mm. Geomorphologically, the area is characterised by flat to undulating topography with sand dunes of different types and magnitudes with flat to undulating interdunal

plains.The block has no river system except a few rare short intermittent and ephemeral channels. Runoff is of short duration and part of it is stored in small tanks and the rest seeps into sand and alluvial veneer. There are few small ponds in the area where rainwater is collected. Soils of the area are generally desertic type with poor fertility status with very low water retention capacity.

Practically the whole of the surface geology in the study area is concealed under a thick cover of wind blown sand. The principal water bearing formation in the area is the semi-consolidated formations including Palana and Marwar Super Group of rocks. Ground water occurs under water table condition. Depth to water level varies from 30.28mbgl at Mainsar to 115.65mbgl at Munjasar during pre-monsoon and 30.60mbgl to 116.48 mbgl during post-monsoon. Seasonal water level fluctuation in the area varies from 0.10m to 2.96 m of rise and 0.10m to 1.20 of decline.

Palana sandstone is overlain by Quaternary deposits and is underlain by rocks belonging to Nagaur Group of Marwar Super Group. The yield of tubewells varies from 100 m^3/day to 1000 m^3/day or more. The depth of tubewells ranges from 200 to 300m.

The quality of ground water in the area is generally fresh except southern part of the block in Bilara limestone formation. The pH ranges from 7.10 to 8.12 and EC from 500 to 9920ms/cm at 25°C. The concentration of chloride varies from 57 to 2663ppm, nitrate from 2 to 900ppm and fluoride from 0.10mg/l to 2.30mg/l.

The overall stage of ground water development of the block is 131.78% as per the Ground Water Estimation as on 31.03.2004 and categoried under over-exploited category.Less recharge and excessive withdrawal of ground water has resulted in declining trend in water level and depletion of this precious resource.

2.4 WCR, AHMEDABAD

2.4.1 Mahesana district

Ground Water Management studies were taken up in parts of Mahesana district covering an area of about 3000 Sq. Km. Detailed hydrogeological study was carried out exclusively in Kadi taluka comprising 831 sq.km. The Rupen, Khari and Puspavati rivers constitute the drainage network in the study area. These rivers are ephemeral in nature and mainly flows in response to the rainfall. The study area experiences an average annual rainfall of 602mm. It experiences a semiarid climate. Extreme temperatures, erratic rainfall and high evaporation are the characteristic features of this type of climate. Alluvial plain is the single most prominent geomorphic unit and covers the entire part of the study area and is part of the North Gujarat alluvial plain. The area is characterized by gently sloping, slightly rolling to undulatory topography with gradual slope toward southwest.

Pre-Cambrian hard rock, post-Miocene alluvium and Mesozoic sedimentary formations form multiple aquifer system in the district. Within alluvial plains, two major aquifers have been identified upto the explored depth of about 600m below surface. The upper unit is mainly phreatic, but at places becomes semi-confined to confined and has been designated as aquifer "A". The lower unit comprises a few hundred metres of alternating arenaceous (sandy) and argillaceous beds and forms the confined aquifer system. It is sub-divided into aquifer B, C, D and E contained in post Miocene deposits and aquifer F and G in Miocene sediments. Himatnagar sandstone (Cretaceous) forms local aquifer in north-eastern part and has been designated as aquifer 'H'.

Ground water is extensively developed by dug wells, dug-cum-bore wells and tube wells in the study area. Ground water occurs under unconfined condition in the upper unit i.e. the phreatic aquifer where as in the lower unit of the alluvial formations (deeper aquifer) comprising of few hundred meters of alternate sandy and clayey horizon in semi-confined to confined conditions. Ground water development from phreatic aquifer is low to moderate due to limited saturated aquifer thickness and at place due to low yield and/or salinity. The depth of dug wells and dug-cum-bore wells tapping the unconfined aquifer varies between 6.70 mbgl to 32.90 mbgl. The depth to water level during the pre monsoon period ranges between 2.50 mbgl to 20.98 mbgl where as during the post monsoon period it varies between 1.64mbgl and 12.98 mbgl. The fluctuation in water level (pre-post) ranges from 0.62m to 9.02m. The depth of tube wells tapping the deeper aquifer varies between 115mbgl to 390mbgl and the water level varies between 40 mbgl to 165 mbgl during the pre monsoon period where as during the post monsoon period it varies between 35mbgl and 160 mbgl. The fluctuation in water level (pre-post) ranges from 0.71m to 10.93m. Deeper water level is noticed particularly in Unjha and Mahesana taluka. The yield of the dug wells varies between 200 lpm to 300 lpm where as the yield of the tube wells in general is high and ranges from 400 lpm to 900 lpm. Ten pumping test were conducted in large diameter wells. The specific capacity value calculated varies between 0.01909m^3/min/m draw down to 0.0653m^3/min/m draw down. The optimum yield value varied between 79.248 m^3/day and 219.12m^3/day.

Ground water is the main source of irrigation in the study area. Drinking water supply in the study area, both urban and rural, is both surface water and ground water dependent. Major part of the study area is covered by Narmada Canal Based Regional Water Supply Scheme and Dharoi Regional Water Supply Scheme.

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

Many check dams, check dam cum recharge tube wells, percolation tanks in village ponds have been constructed by the irrigation department, GWSSB at different locations on Khari river, Rupen river. 247 percolation tanks have been constructed by the Jilla Panchayat Irrigation division in the entire Mahesana district. Recharge due to these percolation tanks contribute to the rise in water level in the nearby areas.

Impact of water conservation structures (Check dams) and artificial recharge structures spread over the study area was studied by establishing observation wells around the study area. Impact of recharge by Sujalam Sufalam spreading canal which is primarily constructed for the recharge purpose, was also studied by means of inventory of wells. It was observed that there is a marked rise in the water level of the order of 2 to 4 meters near to the water conservation and recharge structures constructed. Many of the dug wells those were dry since last 10 to 15 years have started yielding near to the Sujalam Sufalam spreading Canal owing to good recharge.

Detailed area

Kadi taluka was selected for detailed study with aerial extent of 831 sq.km approximately. The taluka has witnessed rapid growth in population since last two decades which has led to great demand on freshwater which in-turn has added more stress on the fresh water resources and thus resulting in fast depletion in the ground water level consistently over a period of time.The stage of ground water development is 173.37% (GEC 2004). More over most of the villages in the taluka experiences problems related to the quality of ground water, as the concentration of fluoride is very high.

The detailed study area comprises of alluvium constituting sand, silt and gravel beds ranging from few meters to hundreds of meters. Ground water development is mainly through dug wells, dug-cum-bore wells and tube wells. The dug wells and the DCBs tapping the unconfined aquifer are mostly concentrated towards the southern part of the taluka. The depth of dug wells varies between 7mbgl and 22mbgl. The depth to water level varies between 2.50mbgl to 11.20mbgl. The depth of tube wells range from 135mbgl to 310mbgl and the depth to water level ranges from between 45mbgl to 115mbgl. The irrigation water demand is mainly met through ground water resources. However irrigation water demand is also met through canal irrigation during the period mid October to the month of February and sometimes even up to March depending on the availability of sufficient storage in the reservoir, which in turn depends on the rainfall. Hence in canal command areas rise in water level in post monsoon period is observed which is attributed to recharge from rainfall facilitated by less withdrawal from the ground water abstraction structures owing to canal irrigation.

The quality of ground water in the taluka in general is potable. However in the southern parts of Kadi taluka, shallow aquifers are brackish to saline, with EC more than 3000µS/cm. Slight deterioration in groundwater quality is observed in the canal command areas. The quality of groundwater in deeper aquifers, down to 300 m depth, is generally potable in most parts of the taluka. High fluoride concentrations both in shallow and deep aquifers have been reported at many places in the taluka.

There is no scope for further ground water development in this taluka as ground water overexploitation conditions are very clear. (Stage of development is 173.37%). This overexploitation has also resulted in steep decline of water levels with time particularly in confined aquifers, which is an alarming situation. Artificial recharge and optimized irrigated agriculture in areas of intensive irrigation is required for sustainable development.

The main Artificial Recharge techniques considered feasible include construction of percolation tanks, check dams with recharge wells. Govt. of Gujarat has taken up such initiatives for recharge purpose and augmentation of ground water resources and to arrest the declining trend in water levels. 35 percolation tanks and 2 check dams have been constructed in the taluka by the Jilla Panchayat

Irrigation division, Mahesana. There is an urgent need to adopt water efficient irrigation techniques like drip irrigation & sprinkler irrigation in a big way together with Artificial Recharge projects to improve deteriorating ground water condition.

2.5 NCR, BHOPAL

Ground Water Management Studies were carried out in Shahdol, Anuppur and mapping of flood plain aquifer in parts of Kshipra basin (parts of Indore, Dewas & Ujjain districts), covering area of 10324 sq.km.

2.5.1 Kshipra Watershed in Indore, Dewas & Ujjain districts

Mapping of flood plain aquifer in parts of Kshipra basin (parts of Indore, Dewas & Ujjain districts) were carried out in an area of 3920 sq km. 83 nos of Key observation wells were selected in the area, pre & post monsoon water level measured and water samples were collected from the representative wells for water quality analysis. Depth to water ranges from 6.04 m (Pigdamabar) to 19.00 mbgl (Dekchiya) during pre-monsoon and 2.00 mbgl (Umariya) to 14.64 m bgl (Sodang) during post monsoon period. Depth of the dug wells ranges from 7.00 m to 19.30 m bgl and diameter ranges from 2.70 m (Gujarpura) to 10.00 m (Hatod).

Major part of study area of Kshipra basin is covered by Deccan Trap basaltic flows. There are 7 flows identified in Indore & Dewas district but only 5 prominent flows identified in and around Ujjain in the study area. The elevation of these flows in the Ksipra basin as identified is from 423-450 m amsl, 430-457 m amsl, 457-483 m amsl, 503-534 m amsl and above 534.84 m amsl respectively. The flows have varying thickness in Ujjain district. The flows consist of different units like weathered, vesicular, fractured and massive basalts consisting of spheroidal weathering, calcitic and secondary mineral filling in vesicular basalt. Different flows are marked by marker horizons known as 'red bole' in the area. In general, ground water occurs under pheratic conditions and sometimes cumulative aquifers give good results and are feasible for groundwater development in the study area. At places, alluvium is found in the valley and stream along courses of kshipra and its main tributaries having variable thickness (8-26 m).

2.5.2 Beohari, Jaisinghnagar & Gohparu Blocks of Shahdol district

In the study area of 3587 sq km,the depth to water level in pre monsoon ranges from 5.40mbgl at Chitrau to 11.35 mbgl at Karki. Post monsoon water level ranges from 2.60 m bgl at Kushwah to 10.80 m bgl at Sansui in dug wells. Depth ranges of dug wells is from 5.10 to 11.50 m. About 90% of the area is covered by Barakar sandstone (Gondwana formations). Boreholes drilled by CGWB at Bijaha village and Khasarwah village are free flowing wells. Bore holes drilled by PHED (Govt. of M.P.) at Muhuatola (2) , Girvi Bagli and Akhetpur are auto flowing wells. Discharge of the free flowing wells ranges from 0.5 lps to 10 lps. Chemical quality of the water of these wells is good. All the auto flowing bore holes occur in the Barakar sandstone. In the study area, number of springs are also occurring in sandstone formation. At place villagers are using the water of these springs for irrigation purposes.

2.5.3 Sohagput and Burhar blocks of Shahdol district and Kotma block of Anuppur district

The study covering an area of 2247 sq km, is part of the Son sub-basin of Ganga basin. Physiographically, the area under investigation can be divided into three physiographic divisions:Highlands of mountain ranges(The Maikal Range),The hills of Eastern Plateau, and Low lands of rivers, The Upper Son Valley.

During course of study, 76 key observation wells were established and inventoried for pre and post monsoon water level. 51 water samples were collected from representative wells for information about ground water quality. Depth to water level (pre-monsoon) ranges from 5.10 m bgl to 13.90 m bgl. Depth to water level (post-monsoon) ranges from 0.95 m bgl to 11.10 m bgl. Water level Fluctuation ranges between pre-post monsoon water level ranges from 0.50 m to 9.30 m.

The general geological succession in the area is crystalline rocks, Gondwanas and Alluvium confined to the river channels. Major part of the study area is underlain by Barakar sandstone of Lower Gondwana Super Group. Barakar formation conformably overlies the Talchir formation.

In the Kotma Block of the study area, depletion in water level is recorded in last decade during pre and post monsoon season, perhaps due to heavy pumping from different coal mines in the area. Special study of coal mines have been carried out in the Kotma Block. The area of coal mining in the Kotma Block can be divided into two parts (a) Jamuna-Kotma area and (b) Hasdo area. 11 number of water samples collected for analysis of chemical quality of mine water. Feasibility of artificial recharge structures etc. in the coal mining area through necessary filtration has been studied.

2.6 NCCR, RAIPUR

Ground Water Management Studies were carried out in parts of Korba and Durg District. Toal area covered under Ground Water Management Studies was 6000 sq.km.

2.6.1 Korba district

The Studies were taken up in Pali Paudi and Katghora blocks of Korba district covering an area of about 3000 sq. km. It is a tribal dominated area(45% of the total population). The study area has subtropical climate characterized by hot summer and cold winter season. The normal average rainfall ranges from 1089-1473 mm. Temperature varies from 2° C to 45.3° C. The area is drained by Hasdeo river and its tributaries like Teti, Aharan, and Tan, Chornai rivers that comes under Mahanadi basins. The drainage pattern is dendritic to sub-dendritic in nature. Nearly 65% of the study area is forest covered.

The main Geomorphological features and landforms developed in the district are structural plain, plateau, and denudation hill. The study area covered by rocks of Chhota Nagpur gneisses, Chhattisgarh and Gondwana Supergroup of Archean to Corboniferous age. The formation comprises Granite, granite gneisses, sandstone and shale with coal seams. Ground water occurs in unconfined, semi-confined to confined conditions in these formations.

For groundwater regime monitoring in the study area a total of 150 observation wells were established which included both dug wells and bore wells. The pre-monsoon water level ranges between 2.68 mbgl to 15.30 mbgl whereas post monsoon water level ranges between 0.45 mbgl to 9.52 mbgl. Total 49 no. of ground water samples were collected from dug wells and hand pumps for analysis of basic parameters and 8 acidified samples were collected for determination of trace element particularly iron to assess the groundwater quality. The chemical analysis of these samples reveals that by and large ground water is potable in nature. No significant change has been observed in the ground water regime when compared with the previous reappraisal hydrogeological survey.

2.6.2. Durg district

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

Tandula reservoir complex embodies three reservoirs; salient features are given in following table.

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**

In addition to this, Tandula Reservoir also gets feed from Pt. Ravishankar Reservoir (Gangrel) through the Mahanadi Feeder Canal. Tandula reservoir has a command area of nearly 3000 sq. Km.

A total of 94 key wells were established for the study. The key wells are well- distributed representing head and tail areas of the canals, different geological formations, rural and urban areas etc. All the key wells were monitored during pre-monsoon, post-monsoon period. and January 09. As per the data of department of Revenue, in the present year (2008-09), 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 2008-09.

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

During pre-monsoon period, the water levels vary from 1 to 16mbgl with the modal class being 5-7 mgl Similarly, during post-mosoon period, the water levels vary from 1 to 11 m bgl with the modal class of 3-5 mbgl. Water table contour map was prepared based on the reduced levels collected by hand held GPS. There are two perennial rivers on both sides of the study area with a water divide at the

center 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

GWMS were carried out in parts of Jalgaon, Aurangabad, Wardha, Ahmednagar & Nagpur district

2.7.1 Jalgaon and Aurangabad districts

An area of about 3156 sq kms in parts of Jalgaon and Aurangabad district falling in Tapi basin was covered. A total of 82 Key wells were established. The depth of dug wells varied from 5.50 m to 28.05 m. The pre-monsoon DTW ranged from 2.30 m.bgl to 25.05 m.bgl, while the post-monsoon water level varied from 1.80 m.bgl to 22.40 m.bgl. The area is totally covered by basaltic lava flows with intrusion of dykes variable thickness.

The quality of the ground water is potable, in general. The electrical conductivity of ground water varies from 190 to 2100 micromhos/cm during the premonsoon and from 180 and 1710 micromhos/cm during post-monsoon season. During the study, it was observed that there is a deeper water level in Waghur sub basin and parts of Titur watershed. The area is mainly irrigated by dams located on Girna, Bori and Titur rivers. Ground water irrigation in the area is mostly based on drip pattern. Pumping tests conducted on the wells to assess specific yield.

2.7.2 Wardha district

Ground Water Management Studies have been taken up over an area of 3015 sq.kms in Farmers' distress area in parts of Wardha districts. The area covers southern part of the district and includes 19 watersheds in Hinganghat, Samudrapur, Deoli and parts of Wardha Talukas.

The main crop grown in the area are cotton Jowar, Tuwar and Soya bean during Kharif season. Some of the farmers having irrigation facilities like dugwells; ponds etc. grow wheat and gram during Rabi season. The Normal Annual Rainfall over the area ranges from 846.5 to 1037.2 mm (1998-2007). The area is underlain by Deccan Trap Basalt and recent alluvium. The main water bearing formation of the area is fractured basalt. Alluvium is spread along fringes of the Wardha and Wunna River.

Dugwells are the most common ground water abstraction structures. Ground water occurs under unconfined conditions in fractured, weathered massive basalt and weathered vesicular basalt. The yield of the wells depends mainly on the nature of the hydrogeological conditions. Lower yields are observed in weathered and fractured vesicular basalt.

During premonsoon, a total number of 61 key wells were established and collected 57 water samples. As a part of post monsoon studies, repeat water level measurement were also been taken up. The depth of water level ranged from 2.1 to 12.3 m.bgl. The yield of the dugwells range from 70 to 300 m^3 / day. The depth to water level during post monsoon ranged from 1.0 to 11 m.bgl. The seasonal fluctuation ranges from 0.35 to 8.10 m.

The quality of ground water in the area is generally good. The ground water is alkaline in nature with average pH of 7.6. The electrical conductivity (EC) ranges from 560 to 1700 µS/at 25^{o}C.

Since, the focus of the study is on Farmers' distress, few farmers were contacted during the premonsoon survey to understand their problems related to water availability for irrigation. For this purpose, the District Administration was also contacted to understand the problems being faced by the farmers in the area. Interaction were also held with Ground Water Surveys and Development Agency (GSDA) officers in this regard. Subsequently, discussions were also held with Gram Panchayat officials and selected farmers. From these discussions it was gathered that the distress among the farmers in this area may be due to Indebtedness,Rising cost of cultivation,Poor credit availability due to complexities involved in process, Absence of surface irrigation facilities & repeated crop failure due to irregular rainfall.

2.7.3 Nagpur district (Coal Mining area)

Ground Water Management Studies over an area of 1500 sq. km. were carried out in parts of Nagpur district falling in Godavari Basin, to study the Hydrogeology of Coal Mining areas. The selected area comprises of the watersheds that cover the Gondwana Sedimentary formations. The study was carried out based on watershed as a unit hydrogeological feature. The watersheds WGKK-1 (195.68 sq km), WGK-5 (183.15 sq km), WGKK-2 (145.61 sq km), WGKK-3 (137.91 sq km), WGKKC-1 (154.59 sq km), WGK-7 (124.0 sq km), WGKKC-2 (360.52 sq. km), WGK-3 (115.74) sq km and part of WGK-4 watershed were taken as the study area. The area forms a part of Godavari basin and drained by Kanhan river and its tributaries namely Pench and Kolar river.

The Granites, the Basalts and the Gondwana are the main water bearing formations of the area. The Gondwana

comprise of Talchirs, Barakar, Kamthi and Motur formations. The Kamthi formations form the most potential aquifer of the Gondwana formations. The water bearing properties of the basaltic and granitic aquifers is controlled by depth and degree of weathering, fractures and joints. A number of underground and opencast coalmines have been operating in the area from Saoner to Kandri. The watershed WGK-3 has been taken as the detailed study area targeted for carrying out the ground water modelling study. The reason for this is that it has three opencast mines namely Kamptee O/C and Gondegaon O/C. Another O/C mines namely Inder was earlier Underground and now being converted to O/C. This watershed has a pronounced mine water dewatering effect. All other coal mines in the area are underground in nature.

During the premonsoon season, about 100 key wells (dugwells) were established to monitor the water level in the area out of which 31 lie in WGK-3 alone. The depth of the wells varies from 4.77 to 30.65 m.bgl. 28 shallow aquifer water samples from some of the key wells were collected for determination of chemical quality. 10 water samples were also collected from the deeper aquifer (hand pumps). In addition to the key wells 11 exploratory wells of CGWB were taken for water level monitoring out of which 10 are in WGK-3 watershed. The monitoring of all these wells was done during May 2008 (pre-monsoon) and November 2008 (post-monsoon). A monthly water level monitoring was started in WGK-3 watershed since May-2008. Pre-monsoon water level (May2008) ranged from 2.25 m.bgl to 20.5 m.bgl and Post-monsoon water level (Nov2008) ranged from 0.45 to 18.85 m.bgl with the water level fluctuation ranging from -0.5 to 5.35 m. A digital water level recorder at Shivnagar Kandri, close to the Kamptee opencast mines, is measuring water level at 2 hrs intervals since March 2009. The collection of informations on mine discharge, ground water draft in various villages, unit draft of abstraction structures, pumpage of water from Kanhan river, measurement of base flow is done. VES surveys are also carried out in the WGK-3 watershed.

2.7.4 Ahmednagar District

An area of about 3590 sq. Km. was covered under Ground Water Management Studies in parts of Ahmednagar District and covers Rahuri, Nevasa Pathardi, Shevgaon, Shrirampur, talukas.

During Pre-monsoon 115 key wells were established and collected 66 water samples for the study of chemical quality of the ground water. During post monsoon 300 ground water structures were examined for the detailed study of the area. The depth range of the dug wells varies from 5.0 to 29.0 m bgl. The DTW during pre monsoon ranges between 2.3 to 20.8 m bgl. The DTW during Post- monsoon ranges between 0.5 to 17.45 m bgl. The fluctuation of the water levels ranges between 0.6 to 14.6 m. The area is drained by Godavari river and their tributaries namely Pravara & Mula. Most part of the area is rain fed and the irrigation in these areas is mainly through ground water structures (dugwells and Borewells) and rain water abstraction structures (percolation tanks, Nala bunds, KT weir etc) The area is underlain by Deccan traps of Upper Cretaceous to Eocene age and Alluvium of recent age along the river course and valley portions. At places the thickness of the alluvium cover ranges from 5.0 to 15.0 m. The Alluvium and weathered, vesicular, fractured & jointed basalts forms an aquifer zones in the covered area. In general the quality of water is good to brackish. The yield cum draft of the dug wells in Deccan traps formations ranges between 5 to 100 cubic meter/day where the pumping hours are in the range of 2 to 8 hours/day with the pump sets of 3 to 10 HP. while the yield cum draft of the dug wells in Alluvium areas between 100 and 300 cubic meter/day where the pumping hours are in the range of 8 to 16 hours/day.

2.8 NR, LUCKNOW

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

2.8.1 Hardoi & Shahjahanpur District (Flood Plain Mapping)

The study area in parts of the Ganga Flood Plains and in its' surroundings and encompasse total 2470 sq.km. area. It incorporates the Mallawan, Madhoganj, Bilgram, Sandi, Harpalpur and Bharkhani blocks of Hardoi district and the Mirzapur and Kalan blocks of Sahajahanpur district of U.P.

The Ramganga, Kunda, Garra and Sai are the major tributaries of the Ganga forming a dendritic drainage pattern in the alluvial plains of Quaternary age. It receives about 911 mm. normal rainfall annually. The net irrigated area is 157129 hact. with irrigational intensity of 132.68%. The total population of the area is 12 lac 43 thousand and 983, which is mainly dependent on the ground water for its irrigational and drinking water needs.

The area has three tier sub-surface aquifer system upto the inventoried depth of 450 m bgl , of which the top "Phreatic Aquifer System" upto an average depth of 50 m bgl is generally of unconfined nature having ground water under water table condition. The deeper systems are of semi-confined to confined nature and have ground water under

piezometeric pressure head. The Phreatic aquifer system has the depth to water level ranging from 2.12 to 13.80 m bgl. during pre-monsoon, and 1.10 to 12.98 m bgl during Post-monsoon seasons respectively. The seasonal water level fluctuation in the area ranges from 0.20 to 2.65 m.

As per estimation of Ground Water resources as on 31.3.04 the area is bestowed with the net annual ground water availability of 56932 hact. m. out of which the net ground water availability of 8176 hact. m. is for the future irrigational needs. The present annual ground water draft for all uses is 47343 hact. m. with the level of development ranging from 67.94 to 95.67%. The Kalan block is falling under critical, whereas the Mallawan, Madhoganj, and Harpalpur blocks are semi critical, and remaining four blocks are categorized as 'safe'. The semi-critical and critical blocks needs water conservation and artificial ground water recharge measures need to be adopted.

The additional ground water potential existing in the shallow depth to water areas and in flood-plains may also be utilized to meet out the irrigational and drinking water needs of the local populace. In general, the ground water quality of the area is good and potable.

2.8.2 Kanpur Nagar & Kannauj District (Flood Plain Mapping)

The Ground Water Management Studies was carried out in parts of Kanpur Nagar and Kannauj covering an area of 2011 Sq.Km in eight blocks adjoining river Ganga. The objective of the study is to mapping flood plain and surrounding area of blocks along Ganga river and potentiality assessment of shallow and deeper aquifers and preparation of development plan for drinking water supply and irrigation needs.

The study area lies in blocks Sarsaul Kalyanpur, Chaubepur, Sivrajpur, Bilhaur (in Kanpur Nagar) Kannauj, Talgram, Jalabad (in Kannauj). The area lies in Central Ganga alluvial Plain having flat relief with gentle slope from north west to south east direction. The altitude varies from 120 to 140 masl.

The average annual rainfall is 835 mm. More than 85% of rainfall occurs in monsoon period (June to September). The major rivers in the area are Ganga, Kali, Pandu, Ison. The study area is part of Ind Gangetic Plain. The silt clay, gravel and sands of different grades are main sedimentary constituents in the area. The water occurs in phreatic condition in shallow aquifer and under confined condition in deeper aquifer. The exploration by CGWB in the area reveals four aquifer group down to basement. The basement rock granite encountered at Trilokpur (591,0 mbgl) and at Pank (503.0 mbgl). The quality of water in II aquifer (125-250 m) is brackish. Hence deep tube wells tapping granular zones between 250-400 m has yield between 1800-3000 lpm for draw down from5 to 10 m. The value of transmissivity varies from 1600 to 2498 m^2/day.

During pre-monsoon period key wells were established in the study area for water level measurement. About 80 numbers of key wells were established and water level was measured in pre-monsoon and post-monsoon period. The depth of dugwells varies from 4.25 m to 25.0 m bgl. The depth of piezometers are around 50.0 mbgl. The depth to water level in pre-monsoon period varies from 1.89 to 38.20 mbgl whereas in post-monsoon period it varies from 1.00 m to 37.90 mbgl. The fluctuation in water level varies from 0.13 to 5.70 m. Depth to water level is shallow (less than <10 m) in Canal Command area i.e. Kalyanpur, Chaubepur, Sivrajpur and Bilhaur blocks. The depth to water level is deep (310 m) in urban area (Kanpur city, kannauj) and in older alluvial of Kannauj, Talgram, jalalabad and Sarsaul blocks.

For the assessment of water quality in the study area water samples were collected from dug well, Handpumps, borewells, tubewells and Ganga river for complete analysis. In Kanpur city, water samples samples were collected from Handpump, borewells and tubewells for analysis of Trace element (cromium).

Out of total water requirement of Kanpur City i.e 520 MLD, 300 MLD water is provided by surface water scheme from the Ganga river and 120 MLD water is provided from deep tube wells from Jal Sansthan. Hence there is deficit of 100 MLD water. In Kannauj city, total water requirement is 13.66 MLD which is fulfilled by 17 number of tube wells.

During Ganga Action Plan, three Sewage treatment plants were installed at Shekpur near Jajmau in Kanpur City to treat domestic sewage and effluent from Tennary. The total capacity of these plant is 162 MLD domestic sewage and 9 MLD of Tennary effluent. After treatment, water is utilized for irrigation. The cromium sludge is dumped at dumping sites at Ruma and Kumbhi.

The depth to water levels during pre-monsoon period (2008) and post-monsoon (2008) in the Ganga river flood area, varies from 2.86 mbgl to 15.68 m bgl and from 1.82 to 14.51 mbgl respectively. Fluctuation ranges from 0.25 to 3.44 m.

To assess the quality of ground water, 43 nos. of water samples were collected from flood area of Ganga river

from different hand pumps and deep shallow and deeper tube wells for domestic purpose during pre-monsoon & post-monsoon period. The water samples are collected from State tubewells in the flood area (Fatehpur chourasi, Gang Moradabad, Sofipur, Sikandarpur.

2.8.3 Unnao District (Flood Plain Mapping)

The Ground Water Management Studies were carried out Under Flood Plain Mapping in parts of Unnao district along Ganga river from Gunj Moradabad block to Sumerpur block, covering an area of 750 sq.km.

The area forms part of the Central Ganga plain and is covered by alluvial deposits of quaternary age. The upper layer of alluvium is composed of sandy loam and clayey loam. The alluvium occupies in Ganga river area get flooded by Ganga river during monsoon period. The drainage channels Kalyani river Khar Nadi anjd Morani Nadi are tributaries of the Ganga. Danger of floods exists in parts of Sikandarpur, Sumerpur, Sifipur, Fatehpur Chourasi etc. area along the Ganga. The average annual rainfall is 852 mm and temperature maximum 43^{o}C or even more.

The sub-surface geology of the area is revealed from the data of the exploratory boreholes (CGWB) and state tubewells drilled upto 455 mbgl. Deep drilling for exploration has revealed the presence of three aquifer's at various levels. The top aquifer extends upto the depth of 90 mbgl. Second aquifer is between 100 and 250 m bgl and lower aquifer (bottom) encountered below 250 m and recorded to be continuing to the achieved drilled depth of 455 mbgl.

The Ground water occurs in the pore spaces of the unconsolidated alluvial material in the zone of saturation. The near surface clay and kankar beds support mainly open wells where ground water occurs under water table condition. Kankar occurring at shallow depths, yield sufficient water to sustain moderate capacity tubewells. Most of the shallow tubewells top water only from Kankar beds and fine sandy aquifers.

The depth to water levels during pre-monsoon period (2008) and post-monsoon (2008) in the Ganga river flood area, varies from 2.86 mbgl to 15.68 m bgl and from 1.82 to14.51 mbgl respectively. Fluctuation ranges from 0.25 to 3.44 m.

To assess the quality of ground water, 43 water samples were collected from flood area of the Ganga river from different hand pumps and deepshallow and deeper tube wells for domestic purpose during pre-monsoon & post-monsoon period. The water samples are collected from State tubewells in the flood area (Fatehpur chourasi, Gang Moradabad, Sofipur, Sikandarpur.

2.8.4 Lucknow & Barabanki districts (Flood Plain Mapping)

The Ground Water Management Studies were carried out in parts of Lucknow & Barabanki districts and area covered was 2878 sq.km. The river Gomti is main drainage which has a total length of about 260 km, out of which about 53 kms lies in Lucknow district and about 95 kms in Barabanki district. Geomorphologically Gomti watershed is a part of Madhotanda spring line representing gently slopping land. The normal annual rainfall of Gomti basin is about 994 mm. About 90% annual rainfall takes place during the south-west monsoon period from June to September.

The river Gomti is a ground water fed perennial river having limited discharge during non-monsoon period. The discharge substantially increasesduring monsoon period even occasionally overflowing its narrow banks leading to flood in the nearby low lying areas. The river Gomti covers around 127.50 Sq.km. & 227.50 Sq.km. area under younger Alluvial plain (including active flood plain) in Lucknow and Barabanki districts respectively. The active flood plain can be observed in Shahjahanpur, Lakhimpur, Hardoi, Sitapur, Sultanpur and Jaunpur districts also. Gomti is the deficit river basin, having problem of over exploitation of ground water resources in some administrative blocks of the region. The river Gomti is a perennial river but development of drilling technology and withdrawal of ground water for various uses, has caused in depletion of water levels in the basin and resulted in drying of base flow of the river. Lucknow city falling in Gomti basin area is facing problem of Urban/Industrial water supply.

88 observatory wells established in the Basin & water sample collected from the representative well for chemical analysis. Depth to water level during Pre-monsoon season is ranging between 1.80 m bgl at Gosaiganj proper to 32.45 mgbl at Dilkusha (Sarojini Nagar block). Depth to water level during post-monsoon season varies from 1.05 mbgl at Nurpur Behtaof Gosaiganj block to 32.47 m bgl at Nashi (Sarojini Nagar block). Dia meter of dug wells vary from 0.61 to 1.95 m. in the basin area. Long term water level trend analysis in Gomti basin has been done using water level data of CGWB, for last one decade (1999 to 2008). Out of 26 stations 6 are showing rising trends and remaining 20 are showing declining trend during pre-monsoon. Rate of decline ins water level vary from 0.03 m/year at Khawas Khera (Lucknow district) to 0.56 m/year

at Deviganj (Kalkeshwar Temple) in Barabanki district. Rise is water levelsduring pre-monsoon season vary from 0.04 m/year at Chaubisi (Barabanki distt.) to 0.33 m/year at Utrathia NHS of Lucknow district.

CGWB has drilled 32 Exploratory wells in Gomti basin varying from 161.78 m bgl at Tulsi Park-II to 753.00 mbgl at Lucknow University. The yield of Exploratory wells was recorded from 60 Lps at Lucknow University to 1700 lpm at Mahanagar Extension (Hanuman Temple). The Draw-down in exploratory wells was observed from 3.52 m. at Indira Nagar Sector-B to 32.77 m at Patang Park-II (T)

2.8.5 Unnao District (Naturally contaminated – Fluoride)

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

2.8.6 Kanpur Dehat District (Remote Sensing Studies)

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

For the study about 300 Sq Km area has been identified in lower parts of Sengar River Water Shed in Kanpur Dehat District. The Sengar river originates from Hardua village in Aligarh district. The river drains a total catchment area of about 6.60 lakh hectares in Aligarh, Hathras, Etah, Firozabad, Etawah, Auraiyah and Kanpur Dehat districts before finally debouching in to river Yamuna at Amraudha village of Kanpur Dehat district.

Hydro-morphological map of the area was prepared using historical data viz. Survey of India topographic maps and land set images on 1:50000 scale showing drainage and extension of ravine land. Various features identified and mapped are drainage pattern which is basically dendritic type, high degree of meandering, point bars, and features of fluvial erosional action viz. sheet erosion, rill erosion, gully erosion and ravines along the Sengar River. The area in general forms an undulating topography with mounds and incised valley slops which is underlain by Quaternary alluvial sand comprising dominantly of silty clay and fine sand intercalations. The area was entirely covered by field survey to monitor Pre and Post monsoon depth to water level in selected dug wells established for computing water level fluctuation in the area to assess the storage capacity of the aquifer for artificial recharge. The pre-monsoon DTW levels varies from 9.20m bgl to >30.0m bgl and post monsoon DTW varies from7.0m bgl to 27.80m bgl thus, the ground water level fluctuated between -2.76m to 3.69m pre to post monsoon period giving limited scope for rain water harvesting.

2.8.7 Lucknow urban area (Ground Water Modeling Study)

Rising population, urbanisation and associated anthropogenic activities have left a debilitating effect on the qualitative and quantitative aspects of the ground water resources in the city area. Lucknow being the capital and an important city naturally calls for such types of studies to be undertaken to understand and address the problem realistically. A lot of exploratory and related hydrogeological data is already available for the city.CGWB has already constructed a number of Piezometers in the city to facilitate ground water level monitoring. The water level data of more than 5- years is available with the office. The present study in and around Lucknow city is to be carried out with a view to (i)Studying the ground water regime in the area with a view to make predictions in response to ground water withdrawals, rainfall and ever increasing urbanization. (ii)Quantitative estimation of the ground water resource potential of shallow as well as deeper aquifers in the urban area of Lucknow.

2.9. MER, PATNA

The Ground Water Management Studies were carried out in Palamu (Jharkhand) & parts of Munger, Buxar, Bhojpur, Siwan, Saran, Patna, Vaishali, Samastipur, Begusarai, Lakhisarai, Khagaria, Bhagalpur, Purnea and Katihar districts (Bihar) and area covered 10500 sq.km.

2.9.1 Parts of Palamu District (fluoride affected Area)

Study was carried out in 2700 Sq Km area covering eight blocks namely Daltonganj sadar, Chatarpur, Hussainabad,

Hariharganj, Lesliganj, Patan, Bishrampur, Satbarwa and Chainpur blocks. The study area forms a part of Chhotanagpur Plateau. A broad spectrum of Archean, Proterozoic to Quaternary deposits comprising crystalline rocks, sedimentary rocks and Recent sediments occuring in the area. Altogether 50 numbers of dug wells were inventoried in sedimentary and Pre-Cambrian terrain for monitoring and water quality determination. In the sedimentary portion of the study area 22 numbers of dug wells were inventoried. Depth of dug wells vary between 7.70 m to 13.00 m bgl. Pre-monsoon depth to water level varies between 5.02 and 12.00 m bgl During post-monsoon season water levels vary between 2.90 and 10.80 m bgl. In the Pre-cambrian terrain of the study area 28 numbers of dug wells were inventoried with depths in the range of 6.10 to 14.00 m. During Pre-monsoon season depth to water levels was found varying between 4.65 and 10.50 mbgl Post-monsoon was recorded between 2.40 and 7.80 mbgl.

Eighty-four ground water samples were collected from from dug wells as well as hand pumps of which 26 water samples were collected from sedimentary terrain. Ground water of the area is potable and most of the constituents are within permissible limit as per BIS (Bureau of Indian standards) except Fluoride concentrations at Kundri in Patan block that is 2.97mg/l. Of the 58 ground water samples collected from the Pre-cambrian terrain, fluoride concentration was found above permissible limit in 26 ground water samples spread over Daltonganj sadar block, Chatarpur block, Bishrampur block and Satbarwa block. Maximum concentration was found as 6.98 mg/l at Chuku village in Daltanganj sadar block.

2.9.2 Parts of Munger District (fluoride affected Area)

An area of 300 sq km covering parts of Kharagpur block of Munger district of Bihar was taken up for study with emphasis on fluoride contamination in the area. The western part of the study area is bordered by Khargpur hills which consists mainly of quartzites and phyllites. The study area is underlain by Chottanagpur Gneissic Complex suite of rocks mainly granite gneiss which is overlain by older alluvium in major parts and by colluviums in areas bordering Kharagpur hills. The thickness of the alluvium varies from 7 to 50 m with higher thickness in the eastern part. The depth to water level was found varying between 2.7 and 9 m bgl during the pre-monsoon while during the post-monsoon the water level varied between 0.7 and 5.70 m bgl. Under the study a total of 30 key wells were established for water level monitoring in the study area. Total 51 ground water samples were collected of which 22 were from dug wells and 29 from hand pumps. Repeat sampling was done from 9 locations. Concentration of fluoride has been found above permissible limit at Khaira, Ramankabad, Nazari, Bhusi Chak, Kathi, Teghra and Raghunathpur village. Fluoride contamination has been found both in the marginal alluvium as well as in the underlying granitic rocks. At Khaira and Raghunathpur villages, fluoride contamination was found above 2 ppb in samples from dug wells also. Highest concentration of fluoride (8.04 ppm) has been found at Khaira village from a hand pump tapping zones within 25 m. At Khaira village there is significant population affected by fluorosis. Here knock-knee and mottling of teeth has been observed in young ones while the aged persons have been found suffering from skeletal fluorosis.

2.9.3 Mapping of Flood Plain Aquifer along Ganga River and its development plan

Flood plain studies were taken in 20 km wide stretch along the river Ganga, covering an area of 7500 sqkm. The study area was divided into three segments under Groundwater Management Studies as below:

- **Segment 1** -Western part of the state, comprising parts of Buxar, Bhojpur, Siwan, Saran and Patna.
- **Segment 2** -Central part of the state, comprising Patna, Vaishali, Samastipur, Begusarai, Lakhisarai and Munger.
- **Segment 3** -Eastern part of the state, comprising Khagaria, Munger, Bhagalpur, Purnia and Katihar.

The study involves detailed hydrogeological study- involving analysis of lithological logs, Water level measurements, Water sample collection for analysis of major and trace elements , Yield survey and unit draft survey, Conducting pumping tests, Ground truth collection for satellite imagery interpretation, Geophysical survey by vertical electrical sounding (VES). Satellite imageries were also interpreted from LISS-III False Colour Composite for the western and central part.

The survey conducted includes:-

Number of wells monitored – 303, Number of groundwater samples collected for major parameters – 127 &Trace elements – 148, Water level of hydrograph network stations analyzed – 52, VES carried out – 53 nos, Analysis of lithological logs – 44, Reinterpretation of pumping test data – 22

Approximation of ground water availability in area of 7500 sq. Km skirting the river Ganga on both her banks has been done for the depth of 50m below ground. The availability

has been worked out for a thickness of 30m of aquifer is approximately 18,000 MCM for assumed specific yield of 8%.

2.10 ER, KOLKATA

The Ground Water Management Studies were carried out in Purulia,Malda,Murshidabad,Huhli, N-24 Parganas (West Bengal) & parts of South & East districts of Sikkim State and area covered 9120 sq.km(including 2000 sq.km. covered in ground water modeling study).

2.10.1 Purulia district (Remote sensing techniques)

Ground Water Management Studies in drought prone water scarce area covering 4500 sqkm of Purulia district were carried out by using remote sensing techniques with the objective to assess the scope for GW development vis-à-vis possibility of rain water harvesting in water scarce hard rock terrain, to study the impact of already constructed RWH structures under CSS and to ascertain the magnitude & extent of ground water contamination with fluoride.

The area under study belongs to the peripheral part of Chhotanagpur Plateau predominantly composed of granite gneiss (Precambrian) with small patches of Gondwana formation in Neturia area. Here, ground water, in general, occurs in the weathered zone within 10 m bgl and/ or shallow fracture zones forming unconfined to semi-confined aquifers. A total of 120 key dug wells were monitored and it has been observed that depth to water level varies from 3.67-9.76 m bgl in pre-monsoon and 1.32-7.31 m bgl in post monsoon period. A comparative study on water level shows that there has been no significant change in water level over last 25 years. During lean period most of the dug wells and the surface water bodies become dry.

Ground water is being extracted through dug wells and shallow hand pumps fitted tube wells of 10 m depth. River bed tube wells and collector wells, installed by PHED, down to the depth of about 3 m in the beds of Kangsabati and Dwarakeswar at few places are in use for meeting the domestic water requirement through a supply network. PHED data shows that about 10% of the total population of the study has been covered under PHED Water Supply Scheme.

Geophysical survey reveals that, in general, four sub-surface layers have been identified, namely weathered, semi-weathered, partially weathered and fresh rock layer. Weathering is varying within the depth range of 5.70 to 46.80 mbgl, semi-weathered rock occurs within the depth range of 5.80 to 89.60 mbgl and partially fractured rock is lying within the depth range between 10.50 & 122.80 mbgl. The fractures are identified to be within the depth range of 40-50, 70-80 and 120-150 mbgl. The most dominating fractures are within 70-80 mbgl.

The geophysical survey revealed the average thickness of alluvium in the Dwarakeswar river bed is 7.40 m in Hura block and 3.0 m near Sialbari area of Kashipur block, beyond which the fractures are identified in the depth span of 8-10, 12-15, 20-35 and 40-50 mbgl in Hura block, 12-15 and 20-40 mbgl in Kashipur block and 50-60 & 90-100 mbgl in Raghunathpur block.In the Futiary river bed, the average thickness of alluvium has been identified down to the depth of 9 m and the fractures in the depth span of 12-20 and 40-50 mbgl in Hura block. The geophysical studies reveals the presence of promising ground water bearing zones which may be harnessed through dug wells and shallow hand pump fitted tube wells for domestic water supply.

Ground water sampling has been done to determine the concentration of fluoride and other parameters in ground water with respect to the Purulia South and Purulia North Shear Zones. From the available data, it has been observed that a maximum of 3.7 mg/l of fluoride is present in ground water.

Based on the findings of hydrogeological and geophysical surveys, sites for ground water abstraction structures, e.g. tube wells and intake wells have been selected to cater to the need in future due to ever increasing population growth and urbanization.

Since the average annual rainfall in the area is around 1400 mm (1369.80 mm annual rainfall in the last 20 years & 1245.30 mm during 2007), rain water harvesting for conservation and through artificial recharge to ground water may be attempted for augmentation of ground water. Sites for artificial recharge structures through nullah bunding, gully plugging, renovation of tanks/ ponds, abandoned dug wells etc., have been selected. Roof top rain water harvesting technique may also be adopted in some schools on experimental basis.

2.10.2 Malda & Murshidabad districts (Flood Plain Aquifer Mapping)

Ground Water Management Studies were carried out along the Ganga River from Manikchak of Malda district to Jalangi of Murshidabad district under Flood Plain Aquifer Mapping. The objective of the study is precise

identification of the aquifers,delineation in the terms of mapable units both laterally and vertically and to determine hydrological characteristics and water quality of these aquifers.

With the frequent shifting of the Ganga river due to flood, wide variation in depositional features occur. Hence, in order to prepare the base map of the study area, thematic maps, based on IRS LISS-II & III data, collected from Department of Science & Technology, Govt. of West Bengal, were consulted. A careful scanning of the maps indicate that during a span of 7 years (1997-2004), the course of the river Ganga, has undergone a considerable lateral shifting, resulting in the changes in the configuration of the present flood plain areas. Considering the configuration that emerges in the IRS maps during 2004, the base map of the flood plain area has been prepared.

In order to know the variation in ground water condition, as well as in quality, the key observation wells (of 10-36 m depth) have been set up across the river at about 3-5 km interval and along the river about 10-15 km interval. Depth to water level has been monitored from the key wells during pre and post-monsoon periods. It is observed that water level in the key wells of Malda district, in general, ranges from 2.50-7.34 mbgl during pre-monsoon period and 2.44-6.64 mbgl during post-monsoon period, whereas the same in the key wells in Murshidabad district, generally, ranges from 4.13-9.16 mbgl and 2.72-6.65 mbgl during pre and post-monsoon periods respectively. The magnitude of recession of water level as recorded is comparatively less in Malda district with respect to Murshidabad district during the period May, 2000 to May, 2008.

Based on the data collected and the details of the exploration, carried out by CGWB in the study area, it has been observed that thickness of alluvium varies from place to place. In the left bank of the River Ganga in Manikchak, Englishbazar, Kaliachak I, II & III blocks of Malda district, the hard rock is encountered at the depth between 60-120 mbgl, whereas in the right bank of the river in Murshidabad district, thickness of alluvium is limited within 50 mbgl in Farakka area and the thickness increases towards east. From the bore hole data of the piezometers, constructed by CGWB, on the both banks of the river Ganga from Farakka to Jalangi, it is revealed that a clay layer of thickness, ranging from 3-15 m, is encountered at the top. In the left bank of the river Ganga in Malda district, the top clay is followed by fine sand of thickness 10-20 m, which is underlain by thick layer of medium to coarse sand of 20-60 m thickness with thin clay layers at places. In the right bank of the river in Murshidabad district, except in Farakka area, below the top clay, sand zone occurs down to 90 mbgl. Within this sand zone, fine to very fine sand, sometimes mixed with clay occur at near surface depth, underlain by medium sand down to 60 mbgl. The coarse sand & gravel occur within 60-90 mbgl. In the Farakka area, the fine to medium sand occurs down to about 40-60 mbgl overlain by a very thin clay layer.

Hydrological test data of shallow wells (within 30 m depth) have been compiled and it has been observed that the aquifers are highly potential having yield potential to the tune of 50-100 m^3/hr. The Transmissivity (T) and 'S' value have been derived and are found to the tune of 600-2624 m^2/hr and $1.3X10^{-2}$ to $4.0X10^{-4}$ respectively.

The water samples collected from the shallow aquifer of study area in pre monsoon period have been analysed. The ground water of shallow aquifer in general is normal to slightly alkaline. The occurrence of high arsenic is reported in the shallow aquifers of the area under study, but arsenic concentration in the samples collected from the study area is found to be below permissible limit.

2.10.3 Hugli district

Ground Water Management Studies in (Goghat-I & II, Arambagh, Khanakul-I & II, Pursura, Tarakeswar, Haripal, Polba-Dadpur, Chanditala-I & II, Jangipara blocks) were carried out in 2000 sq.km . Ground Water Modelling Study has been initiated in selected areas to study the impact of agriculture practices on ground water regime . The Objectives of the study is to establish a Ground Water Flow model for the area, so that impact of agricultural draft on groundwater regime may be understood; to estimate optimum additional groundwater irrigation potential; For better understanding of aquifer disposition and anisotropy in the area.

The area under study is mainly covered by Recent Alluvium, except in parts of Goghat-I & II blocks where Older Alluvium occupies the area. The nature of aquifer material is not uniform both in horizontal and vertical extension in the area. However, in general, the topmost aquifer is restricted within 60-80 mbgl and the second aquifer system starts below 90 mbgl. Individual aquifer is separated by thin clay layers, which are not regionally extensive. Monitoring of pre-monsoon water levels indicate that deepest water level (>15 mbgl) occur in Goghat-I block with depth to water level gradually reduces to east up to Pursura-Tarakeshwar area. In the other areas depth to water level, in general, lie in the range of 3-4 m.

Jangipara block, situated at southern part of Hugli district, has been selected for groundwater modelling study, covering an area of 163.24 sq. km. The area has been selected because the area is mostly agriculture based and has led to extensive development of groundwater. Field survey indicated that about 900 Deep Tubewells are in operation in the block. There is no groundwater development in the block for industrial purpose.

The Jangipara area, under Ground Water Modelling study, is surrounded by Tarakeshwar and Haripal blocks in the north, Chanditala-II block in the east and Howrah district in the south and west. In the west, Damodar river forms a natural boundary. The activities taken up for modelling studies include estimation of draft component, digitization of various maps, Preparation of Geological map, geomorphological map,collection of rainfall map, Monitoring of key wells, tubwells etc, Prepartion of lithologs of exploratory wells, Geophysical studies, Initiated Data entry to the Visual Modflow (V.4.2) software etc.

A three layer model has been conceptualised for the area within the depth of 70 m bgl, based on results of exploratory drilling and geophysical survey. The study area has been discretized to convert continuous spatial data into discrete data. This has been achieved by overlaying a grid over base map. A grid of dimension of 26 x 34 (884) has been created consisting of square cells of 500m width and 500m height. The grid size has been determined considering the inhomogeneity of the subsurface geology as well as availability of data. The study is under progress.

2.10.4 North 24 Parganas district

Ground Water Management Studies in parts of North 24 Parganas district to study ground water quality by using Ground Water Modelling Study covering an An area of 720 sq km in parts of Amdanga, Barasat I, Barasat II and Habra II block has been undertaken for the study. Out of the total area, about an area of 500 sq.km, has been selected for detailed study area with the objective To establish a Ground water flow model for the area, so that impact of ground water development can be visualized in the long run, For better understanding of Ground water management and development in arsenic infested areas, To visualize the aquifer disposition and anisotropy in the area and estimation of optimum additional ground water draft and additional ground water potential

The activities under the study onclude detailed hydrogeological over an area of 750 sq km, monitoring of key wells & monitoring wells, digitization for preparation of various layers, Geophysical studies, Determining aquifer parameters, Exploratory drilling etc. The modeling area (500 sq. km) is bounded mainly by the natural physiographic boundaries. Nawai drainage in the west and Bidyadhari drainage in the east and Suti drainage in the south form the natural boundaries.

The Quaternary alluvium is characterised by clay, silt, sand of various grades and occasionally gravel (colour of sand - grey to yellow). The thickness of sand varies laterally as well as vertically. Clay and sand horizons occur in alternate sequence. Groundwater occurs in a thick zone of saturation in the unconsolidated formations of quaternary alluvium down to a depth of 350 m. Ground Water occurs under water table conditions in shallow aquifer and in confined condition in deeper aquifer. T values CGWB exploratory wells tapping aquifers down to 60 mbgl in the range of 1334 m2/day to 3179 m2/day and S values range from 0.138 to 0.332. Wells tapping aquifer from 80- 150 mbgl have T values range from 2524 m2/day to 5725 m2/day and S values range from 4 X 10-4 to 2.8 X 10-5. Pre monsoon depth to water level varies from 7 to 9 mbgl in 60% area and 5 to 7 mbgl in 40% area. Water level in the range of 3-5 mbgl and 9-11 mbgl has also been found in patches in the study area. Post monsoon water level varies from 4 to 6 mbgl in 70% area, 2 to 4 mbgl in 15% area, 6 to 8 mbgl in 15% area. Water level in the range of 8 to 10 mbgl have been observed in patches. Pre and post monsoon fluctuation varies from 1.5 to 2.5 meter in 80% area and 2.5 to 3.5 meter in rest of the area. Yield of Heavy duty tube wells tapping deeper aquifer: 50- 150 m^3/hr with drawdown of 4-5m. Yield of Low duty tube wells tapping Shallow aquifer: 20- 40 m^3/hr with drawdown of less than 4m. A total number of 4 geological horizons (Quaternary Alluvium) have been delineated based on geophysical logging and lithology. Regional groundwater flow is from the north-west to the south-east direction.

A four layer model down to 150 mbgl has been conceptualized for the area, based on the panel diagram in the study area. Layer -1 is (0-20 mbgl) sandy clay, layer-2 is (20 to 60 mbgl) sand, layer-3 is (60 to 80 mbgl) clay and layer-4 is (80 to 150 mbgl) sand. Boundary condition for top layer has three drainage boundary in east, west and south direction and lateral flow boundary towards northern direction. Sandy layer (within depth of 15 mbgl) is present in patches in the study area. Therefore, top layer is considered as sandy clay layer.

2.10.5 Parts of South & East Sikkim

Hydrogeological survey was carried out over an area of 400 sq.km in Maniram, Rumtek & Pakiang areas in parts of

South & East districts of Sikkim State for development of water supply through springs.

A total of 29 springs were monitored in parts of Maniram in Namchi Sub-division of South Sikkim district and Rumtek and Pakyong area in Pakyong Sub-division of East district. In course of survey, the discharge of the springs was measured twice, in June'08 and March'09. The area of study is

- Maniram, Phalidanda-Maniram G.P., Namchi Sub-division, South Sikkim- Mainly Perennial, Discharge 18-50 lpm during June'08,1-8.57 lpm during March'09.
- Rumtek, Ranka G.P., East Sikkim-Mainly Perennial, Discharge 3.50-16 lpm during June'08,1.2-8.57 lpm during March'09.
- Pakyang, Pakyang Sub-division, East Sikkim-Original Springs, Discharge 37.50 lpm during June'08,8.50-48 lpm during March'09

The analysis of spring water samples through analysis kit reveal that Specific Conductance ranges from 20-300 µs/cm at 25°C, pH: 6.79-7.94, Arsenic: Below detectable limit

Water Scarcity is an inherent and common problem in the area. During lean period the discharge of springs decreases considerably resulting in acute drinking water crisis. The scope of large scale ground water development through tube wells is also limited. Spring water is vulnerable to surface pollution, bacteriological contamination, turbid, etc., which needs filtration, chlorination and/ or boiling before using for drinking purpose. The rocks prevailing in the area are very hard and massive.

Ground water development through bore wells in this hilly tract may be attempted after delineating the hydrogeologically favourable areas with the help of detailed structural and remote sensing studies and geophysical surveys. Dug wells and bore wells, located on flat areas near the spring, may yield appreciable amount of water. In the eastern most and north-eastern fringe of Rumtek area in East Sikkim along Rani Khola, where the thickness of the loose weathered overburden is considerably high, ground water development by deploying suitable rig may be planned. The perennial springs are to be developed in a proper scientific manner and planning for sustainable ground water supply. The precaution may be taken up during development of springs such as -The spring source needs to be cleaned periodically; Spring water may be tapped at a relatively higher altitude than the habitation & needs to be collected in a chamber/ artificial tank in the topographically low land; Wastage of spring water before collection in chamber/ storage tanks as well as during pipe line supply needs to be minimized;Treatment (both chemical & anti-bacterial) requires to be carried out before use the water for drinking purpose. Roof top rain water and rain water conservation may be adopted, especially in the areas where ground water is scarce Spring water conservation structures, like gabions, nala bunds, cement plugging, etc, may also be attempted in favourable hydrogeological set up.

2.11 NER, GUWAHATI

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

2.11.1 West Tripura district(Mapping of artesian belt)

During present survey artesian zones are delineated in Bishalgarh, Dukli, Melaghar, Boxanagar, Mohanpur, Jirania, Teliamura, Khowai and Kalyanpur blocks. Valley-wise and block-wise comparative statement of artesian zones have been compiled.

Physiographically, West Tripura district can be divided into two main valleys, viz, Agartala valley and Khowai valley. In Agartala valley, artesian zones are available in Mohanpur, Bishalgarh, Dukli, Jirania, Melaghar and Boxanagar blocks and in Khowai valley artesian zones are available in Teliamura, Kalyanpur, Padmabil and Khowai blocks. In Agartala valley almost 99% of artesian wells tap shallow granular zones (within 50mbgl) but in Khowai block almost all artesian wells tap deeper granular zones (between 60 – 200 mbgl). Valley-wise and block-wise details are given below

i) Agartala valley

Bishalgarh and Dukli blocks: Artesian zones are found along Rangapania river and its tributaries. Artesian wells in this zone are observed in Chechrimai, Charilam, Sutarmura, Rangmala, Dhariatal, Lalsinghmura, Amtali, Banstali, and Dhakarbari Grampanchayats. Another artesian zone is available along Fatikcherra stream in Pandabpur Madhupur, Gakulnagar, Nehalchandranagar Grampanchayats. Apart from these, 2/3 very small artesian zones located in intermontane valleys of Kaiyadhepa, Aurobindanagar, Rajnagar, Manoharpur and Gabtali grampanchyats.

In comparison to the last re-appraisal study of 2003-04, it is found that artesian wells are not showing flow condition as before in Chandranagar–Raghunathpur section (a part of artesian zone along Rangapania river) and in Bikramnagar, Gazaria gram panchayats. It is observed that a large no. of shallow tubewells have been constructed for irrigation during this period in these areas and are causing of ceasation of free flow.

Melaghar and Boxanagar blocks**:** Artesian wells are found around Rudrasagar lake (Chandinamura, Jubarajghat, Kemtali gram panchayats) and along the drainage (streams/ nalas) contributing to the lake. On both sides of streams/ nalas flowing through Chowmohani, Khaschowmohani, Kumariakucha, gram panchayats artesian wells are found. A small artesian zone was found in Dhupuria bandh area of Boxanagar block. In comparison to the last re-appraisal survey it is found that only 2/3 wells are now available in Nalchar area. This is due to depletion of discharge of the artesian wells for areas brought under irrigation. In Boxanagar block, variation of discharge as per lithology and depth has been observed.

Mohanpur block**:** Artesian zones are found along Lohar nadi (river), at various locations in Rajghat, Fatikcherra, Berimura, Gochamura area. In comparison to the last reappraisal survey no remarkable difference has been observed.

Jirania block**:** A continuous artesian zone extending from east of Jirania upto Kashipur area of Agartala was found. The zone was delineated on both sides of Haora river. In comparison to the last reappraisal survey there is also not much difference observed in this zone.

ii) Khowai valley

Teliamura Block: Artesian wells are observed in depressed areas in Teliamura town and Maiganga – Baishghar area. Both the zones are situated along Khowai river. In comparison to the last re-appraisal survey only one artesian well has been found in Teliamura town, because the area has been brought under piped water supply two years ago. Also it is observed that due to very low discharge of the wells people are not interested in constructing artesian wells.

Khowai, Padmabil and Kalyanpur Blocks**:**A continuous artesian zone was found to be extending from Kalyanpur to Bangladesh border. The zone was found on both sides of Khowai river. In comparison to the last reappraisal survey there is not much difference observed in this zone.

Deep artesian wells**:** DWS, Govt. of Tripura has constructed many heavy-duty deep tubewells for drinking and domestic purposes in West Tripura district, amongst them 2 deep tubewells in Rainbazar and Bridhanagar area of Jirania block and 4 deep tubewells in Khowai area of Khowai block are found to be in flowing conditions. These tubewells tap zones between 120 – 200mbgl. The piezometric head varies from 0.10 to 3.40 magl and discharge from 0.20 lps to more than 3 lps.

2.11.2 Bishalgarh Block, West Tripura District(Ground Water Resources Estimation)

Groundwater resource estimation of Bishalgarh block, West Tripura district has been done. Groundwater year considered was from April 2007 to March 2008. Data collected during the study are Rainfall data for 2007-08, Groundwater structures for irrigation, Land irrigated by surface water sources & groundwater sources and Area under ponds and tanks etc, Surface water structures for irrigation. Approach / Methodology used was GEC'97 methodology

It has been seen that discharge of shallow tubewells for irrigation varies from 2–5 lps and tubewells run for an average of 8hrs daily for 120 days in a year. While calculating unit draft of a shallow tubewell discharge in lower side i.e., 2 lps has been considered. River lift irrigation projects along Rangapania river is working. 47 such schemes are available and irrigating 2520 ha land. Deep tube well (irrigation) projects are working. 20 such schemes are available and irrigating 450 ha land.

There are some artesian zones available in the block, but in some area, like Raghunathpur and Durganagar, after inception of shallow tubewells for irrigation artesian wells ceased to flow.The depth to water level varies from 2.17 to 6.36 mbgl during April 2007 (pre-monsoon) and from 2.68 to 4.93 mbgl during November 2007 (post-monsoon). Average water level fluctuation is 1.38m.

The ground water estimated through the studies are, Total groundwater recharge - 11633.81 ham, Net groundwater availability - 10470.43 ham,Allocation for domestic and industrial use up to year 2025 -1116.72 ham,Net groundwater available for future use - 8977.97 ham, Stage of development- 7.10%,Category –SAFE. The Stage of development is low. Large amount of groundwater is available for future development. Groundwater is good for drinking, domestic and irrigation purpose except concentration of iron exceeding permissible limit.

2.11.3 Papumpare Districts, Arunachal Pradesh (Development of water supply through springs)

PapumPare District covers an area of 2875 sq. km in Lesser Himalayan zone. The district is a part of Brahmaputra river basin. The district can be broadly grouped into six geomorphic units, viz., high relief structural hills, low relief structural hills, dissected and highly dissected hills, intermontane valleys, piedmont and alluvial plain. The altitude of the district generally increases towards north from about 300 m in the south to 2700 m above MSL in the north. Geologically, the district is underlain by the Siwalik Super group in central, southern and southwestern part which is in contact with narrow and elongated Gondwana Group of sediments by Main Boundary Fault. The climate of the district is in general sub-tropical. However, depending upon the elevation from the sea level, the climatic condition varies. In the southern part, i.e., in lower altitude the climate is wet and humid. Annual rainfall in Papum Pare district varies from 2200 mm to 6800 mm. However, during the rainy season the disruption of supply line in the upstream area create water scarcity. Moreover, during the lean period the discharge of source diminished rapidly. The district helmets are scattered in such a way that it becomes difficult to supply water to the populations and the population are found to drink water from springs in a traditional way.

The study was carried out with an objective to examine the possibilities of sustainable development of spring for drinking water supply. Inventory of springs were carried out in different geological set up. Spring number and yield vary depending on geologic and hydrogeological conditions. It is observed that hydrogeologically the Kimin Formation of the Siwalik Group is more impermeable than the overlying permeable Older Alluvium in and around Itanagar Capital Complex. The older alluvium facilitated the downward movement of recharge water and impermeable Kimin Formation acts as subsurface barrier and then the concentrated discharge of groundwater appears as spring. In general most of the springs oozing out at the contact of the Siwalik Group and Older Alluvium can be classified as stratigraphic or contact spring. Contact springs are also observed in the northern part of the district, i.e., near Sagalee where granite/granite gneiss underlain the Older Alluvium. Few fracture springs are also observed in the Siwalik Group and in the fractured Precambrian Bomdila Group near Kimin. Spring near Gumtu can be classified as topographic in nature. Most of the springs in Papum Pare district are associated with a shallow flow system which can be inferred from positive correlation of spring discharge with seasonal precipitation. However, one example of deep flow system is found at Barapani area of Naharlagun township where spring discharge show little seasonal variation.

It is found that out of 62 inventoried springs 29% are of 6^{th} order, 56.45% are 7^{th} order, 9.85% are of 8^{th} order and only 4.83% are of 5^{th} order springs as per Meinzer classification. Diurnal variation of two springs in Naharlagun area was also measured. It is found that the discharge of the spring in the C-Sector, Barapani is fairly consistent throughout the year. During the peak monsoon period when the discharge of the spring at D-colony, Naharlagun show a sudden leap the Barapani spring discharge maintains uniformity. Thus it can be inferred that this spring discharge fluctuations is not associated with rainfall or seasonal. This spring is in fact periodic spring. During the survey it is found that out of 62 inventoried springs 43 are perennial and in the Capital Complex the mean spring discharge varies from 2776 LPD to 99884 LPD, in Gumtu area the mean discharge is 80,957LPD, in the Doimukh-Sagalee road section mean discharge varies from 523 LPD to 1, 37,143 LPD and in Kimin-Ziro road section it is 323 LPD to 2, 56,634 LPD.

Periodic spring like that one in Barapani area, Naharlagun is a more sustainable supply source of water than a high discharge ephemeral spring. The perennial spring should be developed in a balanced way. Since in most cases the flow is porous and shallow, the area around the spring should be cleaned and should be dug to ensure a good flow. During the survey it is found that in the same location water oozing out from number of sources and in that case efforts should be made to divert the water to one opening by digging far enough back into the hill. Digging should continue until the impermeable layer is reached. An impervious layer makes a good foundation for the spring box and provides a better surface to arrest underflow.

Proper gravel packing is necessary to reduce siltation in the spring box. For spring in level ground like those at Barapani and D-colony, digging should be carried out to form a basin and the basin should be lined with gravel so that water should flow through it before it reaches the spring box. Wherever possible, trench of proper size should be constructed above the stream to catch surface flow from rains. Moreover, wherever possible horizontal boring may be carried out to fit slotted pipe to enhance the discharge. Proper sanitary protection measurement is to be undertaken to avoid bacteriological pollution. To make spring water supply sustainable and for proper management of spring, community participation should be encouraged.

2.11.4 Lakhimpur District, Assam(Remote Sensing studies)

Procurement of satellite imagery of Lakhimpur district from NRSC. Base map layer has been prepared along with preparation of drainage, geology and soil thematic layers of Lakhimpur district, Assam.

2.11.5 Dibrugarh District, Assam:

The study area comes under Burhi-Dihing sub-basin, Brahmaputra basin, Dibrugarh district Assam. The area of flood plain is 1080 sq. km. (Including parts of Tinsukia district)and area of flood plain prone to flood is 960 sq. km. (Including parts of Tinsukia district)

Dibrugarh district is a valley underlain by unconsolidated alluvial sediments deposited over a semi-consolidated Tertiary group of rocks. The area can be divided into two groups of water bearing granular zones – (a) shallow zones to a depth of 50 m bgl and (b) deeper zones between 50 m to 200 m depth.

Top clay layer followed by mono aquifer with a thickness of 15 to 45 m occurs down to a depth of 50 m below ground level constitute shallow aquifer group in most part of the district. But in flood prone area, i.e north of Dibru river, top clay layer is absent exposing sand with occasional silt down to a depth of 50 m. Ground water occurs under unconfined to semi-confined condition. Grain size of aquifer material is fine to medium. In and arround Namrup, Joipur area cobble, pebble and boulders are likely to encounter and its presence is marked from near surface near Dilli river and is to be encountered at depth while approaching from eastern foothill belt (near Dilli river) to areas towards west at Jaipur.

Deeper aquifer group, extending below 50 m depth is seen in the northern part of the district. It is mainly a single aquifer system. But in the southern part, this single aquifer system is separated into a multiple aquifer system by thick clay partings. Thickness of aquifer increases from east to west. Grain size of aquifer material in general is medium to coarse but fine to medium is also present. Pre – monsoon depth to water level ranges from 0.16 to 4.23 m bgl. Post – monsoon depth to water level ranges from 0.14 to 5.693 m bgl. Water level fluctuation ranges from 0.36 to 3.55 m.

Most part of the district except Namrup area is feasible for construction shallow/ deep tubewell by deploying Rotary Rig. In and arround Namrup area covering Dillighat, Nagamati,Nagahat, Charaipung etc bordering Dilli River/ Dilli R.F where boulder will encounter and therefore Percussion Rig is suitable. Depth of encountering boulder will vary from place to place. Dilli River bouldery formation starts almost from surface (as seen in the Dilli River section) and is found to encounter approx. from 120 m bgl onwards as recorded at Dirialgaon at Jaypur. In rest part of the district Direct Rotary rig need to be deployed.

Quality of ground water is good except high iron content in localised condition. At Dibrugarh town area no iron problem is reported upto 100 m depth. In southern part of the district at Naharkatia, Jaipur and Namrup variation of iron content witin 3-4 ppm is found within 10-15 m depth. Otherwise, whole district experience iron content witin 2 ppm witin shallow depth.

2.12 SR, HYDERABAD

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

2.12.1 Nizamabad district:

Ground Water Management Studies were carried out covering an area of 3130 Sq.Km. A total of 13 Mandals were covered viz., Dichpally, Dharpally, Sirikonda, Sadashivnagar, Machareddy, Madroi, Domakonda, Bhiknoor, Lingampet, Nizamabad, Jakranpally, Kamareddy and Bheemgal. The area is underlain by granites, gneisses of Archaean age and basalts belonging to Deccan Trap.

The aquifer system in the area consist of weathered and semi-weathered phreatic aquifers and fractured aquifers. The thickness of weathered zones is upto 20 m at places. In all, 60 domestic wells and 100 irrigation wells were inventoried. The depth range of bore wells is 60-90 m, yielding 2-6 lps which sustain 4-6 hrs. of pumping. The total ground water draft in the area is in the order of 42,753 ha.m which is 2317 ham more than the replenishable ground water resource of 40,436 ham. The stage of ground water development is 108%. Out of 13 Mandals, Machareddy and Thadvai mandals are falling in safe category, while all other mandals are in Semi-Critical & Over-Exploited category.

The study area reveals that, there is a need to avoid clustering of bore wells and to advocate change in cropping pattern, desilting of tanks and also to take up construction of artificial recharge structures and recharge

through dug wells on scientific lines to improve the ground water situation in the area.

Detailed Surveys in Donakonda Mandal:

The detailed area covering Domakonda Mandal is 160 sq.km. There are 15 gram panchayats covering 22 revenue villages. The area is drained by Manjira and Peddavagu Sub-basins of Godavari river basin. The main crops grown in the area paddy, sugarcane, sunflower, maize, grams and groundnut.

The entire area is occupied by granites and gneisses of Archaean age, intruded by dolorite dykes. Most of the dug wells are dry. The main existing aquifer system in the area is under semi-confined-confined conditions tapping shallow and deep bore wells. Deep water levels, i.e., >30m are observed in villages Mutyampeta, Domakonda and Tujalpur during both pre and post-monsoon periods with falling trends over a long-term period. The net ground water availability is 2382 ha.m whereas the draft is 3074 ha.m, and the stage of development is 141%, thus falling in over-exploited category. The quality of groundwater is good for drinking and irrigation purposes.

The study area reveals that there is a need to avoid clustering of wells making WALTA Act to be enforced strictly. There is an urgent need for adopting artificial recharge measures in the area like desilting of tanks, construction of artificial recharge structures and existing dug well recharge to arrest further decline of water levels and stabilise the existing ayacut under bore wells.

2.12.2 Prakasam District:

Ground Water Management Studies in farmers distressed drought prone areas of Prakasam district were carried out in targeted area of 3000 km, covering North and North Eastern parts of the district. This includes coastal and upland Mandals from Kothapalem to Chirala – Marturu-Santhanuthalapadu and Addanki Mandals. Ground water in the study area occurred under phreatic and semi-confined conditions in weathered and fractured zones. The depth to water level varies from 3-5 in post-monsoon and 5-7 m in pre-monsoon and are deep in western upland granite terrain. Ground water is exploited through 40-50 m deep bore wells in granitic terrains and shallow filter point wells of 10-12 m deep in coastal alluvium at eastern end. The discharge varies from 3 to 5 lps and commercial crops are grown in the area.

The studies were carried out with special emphasis in fluoride-infested area, with a view to find out reasons for high fluoride occurrence in ground water and also to suggest remedial measures for arresting farmers suicides in the area. Ground water samples, soil samples and rock samples were collected for detailed chemical analysis to find out the source and genesis of fluoride in ground water. High fluoride ground water patches were identified in Memdlamudi, Addanki, Korsipadu, Santhanuthalapadu, Martur Mandals, where fluoride concentration varies from 2 to 4 mg/l. It is observed that there are safe ground water sources within the fluoride rich patches. Government of Andhra Pradesh is contemplating to supply surface water from Gundlakamma river shortly.

The study area witnessed very high number (35) of farmer suicides. Through interaction with families of deceased farmers, public representatives and Government officials, it is understood that insufficient and unseasonal rains, heavy investments in agricultural practices, uneconomical market conditions, accumulated debt burden from private money lenders and high farm input costs are the main causes. Non-availability of institutional finance has forced the farmers to go in for moneylenders whose pressurization for repayment has led to large-scale suicides among farmers. Improvement in irrigation facilities, timely distribution of loan, seeds, pesticides, fertilizers etc. could mitigate the farmers' problems. Co-operative farming by combining small land holdings may improve the lot of farming community. There is need to increase surface water storage facilities in BC soil Mandals and also to construct rain water harvesting structures, where more suicides have occurred, at feasible locations, in western and middle parts which may improve ground water resource potential.

2.12.3 East Godavari District

Ground Water Management Studies were carried out in the Godavari deltaic aquifers in East Godavari district covering 13 mandals in an area of 1642 sq.km.

The studies are taken up in project mode with the objectives of delineating the Aquifer Geometry of the area upto 200 m bgl, to explore the ground water potential to a depth of 200 m bgl, to build up data base on fresh water/saline water interface and modeling of the ground water system.The entire area is underlain by coastal and deltaic alluvium of Recent age. Ground water occurs in unconfined to confined conditions and tapped by shallow tube wells and filter point wells. The discharge of the wells varies from 8 to 25 lps.

As a part of the studies, 64 key observation wells were established and monitored during pre-monsoon and post-

monsoon seasons. The Pre monsoon water levels vary in between 2.15 m at Sakhinetipalli and 7.95 at P. Gannavaram. In general, the field Electric Conductivity varies from 360 micro siemens/cm at 25° C to 2750 micro siemens/cm at 25° C with an exceptionally high concentration of more than 3000 at N. Kothapalli, A. Kothapalli, Kesava Dasu Palem, Toorangi and Nagaram. The Post monsoon water levels vary in between 0.85 m at Muramalla and 6.34 m bgl at Lankala Gannavaram.The field Electric Conductivity varies from 200 to 2970 micro siemens/cm at 25° C with an exceptionally high concentration of more than 3000 at N. Kothapalli, A. Kothapalli and Nagaram. The Fluctuatuion between pre-monsoon and post-monsoon water levels varies from 0.10 m at Peruamallapuram to 3.49 m at G. Pedapudi.

Geophysical surveys were also carried out to know the thickness of weathering and quality of the formations. Water samples were collected from these wells for detailed chemical analysis.

2.12.4 Khammam District

Hydrogeological studies were carried out in an area of 2565 sq.km covering 8 mandals viz., Palvoncha, Burgampahad, Aswapuram, Manuguru, Pinapaka, Bhadrachalam, Dummugudem and Cherla Mandals of Khammam district, Andhra Pradesh.

The area is underlain mainly by gneisses and granites, which form part of Peninsular Gneissic Complex of Dharwar Craton. The Gondwana formations occupy the Northern part of the study area. Along the Godavari River, alluvium comprising sand, silt and clay with occasional gravel beds is deposited.

In the crystalline rocks, the ground water occurs under unconfined conditions in the weathered formations and under semi-confined to confined conditions in the major joints, fractures and faults, etc. The depth of weathering varies from place to place ranging between 2 and 17 m and the potential fractures occur generally between the depth of 30-60 m in the crystalline rocks. The ground water is developed through dug and dug-cum-bore wells, in around Godavari river bank and valley portions. The depth to water level ranges from 4-10 m.

Ground water occurs under the confined conditions in Gondwana sandstones, between depth range of 40 to 60 m depth with water level ranging from 2 to 17 m. At deeper depths, the aquifers become unconfined due to aquicludes present in between 70-90 m depth and below this, coal seams exist between 158 and 230 m. The water level is observed to be deep in the order of 80-90 m in these aquifers.

In Manuguru, Pinapaka and Cherla areas, confined aquifers, which occur at a depth of 40 to 60 m becomes unconfined due to excessive drawl of ground water. The depth to water level is in the range of 17 to 21 m bgl. At deeper depths, the formations become clay with alternate beds of sandstones/shales. As such the formations do not form a good aquifer. Generally, the water levels are relatively very deep ranging from 70 to 90 m bgl.

In alluvium formations, the ground water occurs in unconfined condition in plain areas along the Godavari river. The depth to water levels is very shallow ranging from 0.5 to 5 m depth. Large scale of pumping is taking place for agricultural purposes with the help of filter point wells fitted with centrifugal pumping.

Micro level Studies:

Special studies were carried out in about 10 sq.km. radius in and around coal mine belt area, Manuguru and parts of Ashwapuram and Pinapaka mandals. In all, 43 wells were inventoried in the study area. The analysis of data of the wells inventoried in the study area reveals that the multi-aquifer system is present in the coal belt mine area. In general, the study area is delineated into 3-layered aquifer system between depth ranges of 0-15, 15-30 and 30-60 m. Beyond this depth, mainly the formations contain clay, siltstone and shale with coal seams.

In 0-15 m layered aquifer system, Upper Kamthi formations of Lower Gondwana Super Group are the main aquifers. The depth to water levels ranges from 4 to 10.76 m. In 15-30 m, the second aquifer exists in the Lower Kamthi formations with water levels ranging from 7.42 to 12.00 m. The third aquifer lies in the Lower Kamathi formations with the depth ranging from 30 to 60 m with water levels ranging from 7.86 to 17.92 m.

Though the mining is carried out at deeper depths ranging from 158 to 230 m, the shallow Phreatic aquifer is not affected i.e., there is no impact on ground water regime up to a depth of 20-60 m due to geological formation i.e., a thick 14 m clay bed acting as a barrier and the ground water dip is towards North East towards Godavari river.

In general, ground water quality is good for irrigation and domestic purposes both in hard rock and soft rock areas except in and around industrial areas like Bhadrachalam paper mill, where the EC is beyond 3000 micro

siemens/cm. In general, mine water pumped out is being used for both irrigation and after treatment, for drinking and domestic purposes.

The phreatic aquifer upto a depth of 20 to 60 m is not affected by the mining activity in Kamthi formation as the aquifer is separated by alternate clay, shale and silt stone layers. However, beyond 60 m, there is a marginal impact of mining on the ground water, which is inferred by the deep water level data as seen from piezometers data maintained by M/s. Singareni Collieries.

2.12.5 Mahabubnagar District:

To fine-tune the existing ground water resources estimation methodology, MBNR-D-44-Tarnikal watershed (Madharam basin) having an area of 95.30 $km^{2,}$ consisting of 9 villages in Midjil and Kalwakurthy mandals was selected for integrated studies. The normal annual rainfall in the basin ranges from 618 mm. The watershed is part of Dindi river sub-basin (Krishna River Basin) and underlain by pink and grey granites of Archaean age. The various activities are:-

- Weekly ground water levels were monitored from the established 11 key wells on weekly basis through outsourcing. The depth to water level (DTW) ranges between 9.20 meter below ground level (m bgl) to 20.88 mbgl during pre-monsoon season and between 9.20 mbgl to 21.89 mbgl during the year 2008. The seasonal fluctuations in water levels varies between –1.04 m to 3.0 m. The negative fluctuations in water levels are mainly due to less rainfall i.e.; 61.23% of normal rainfall (normal rainfall 618 mm, actual rainfall 378.4 mm).
- Rainguage station (manual) was established at center of the basin (at Urukonda village) and daily rainfall was monitored and during the year total 378.4 mm rainfall is recorded.
- Water levels were monitored at regular intervals in the irrigation tanks at Madharam village which is located at the discharge area of the water sheds.
- 8 EW, 7 OW and 1-piezometer wells tapping three different aquifer zones were constructed. 12 pumping tests (3 SDT and 9 APT) for determination of specific yield and Transmissivity (T) and Storativity (S) were conducted. The data is at various stages of compilation (analysis).
- Determined the reduced levels (RL) of 34 points including all key wells (11 nos) with the help of DGPS and normal surveys The RL values ranges between 447.465 meter above mean sea level (m amsl) to 550 m amsl with an elevation difference of 102.545 m. All exploratory, observation and piezometer wells are connected with mean sea levels.
- Geophysical Surveys for identifying the weathered thickness in the basin has been carried out. In all, 150 VES and 0.55 line km were carried out.
- Conducted soil infiltration tests at 7 sites in different types of soils by using double rig infiltrometer (Table-3). The infiltration rate varies between 0.1 cm/hour to 11.3 cm/hour.
- Injected Tritium traces (15 ml) of 30 micro curie at 5 points at each sites (3 ml each) and total 6 sites were selected covering paddy and non-paddy areas (groundnut, sunflower and vegetable crops). This work has been carried out in collaboration with NGRI scientists and final results are awaited.
- Procured digital remote sensing data for the rabi season crops (2008) (LISS-IV data). Efforts are being made to study the data in collaboration with NRSC, Hyderabad.
- Samples were collected from Urukonda, Madharam and Bommarajpally exploratory wells. It is found that samples collected from Urukonda village the fluoride concentration varies from 2.45 to 3.66 mg/L and nitrate concentration is beyond the permissible limits of 45 mg/L in two samples. In Madharam wells nitrate concentration is beyond the permissible limits of 45 mg/L in two samples. In Bommarajpally wells fluoride concentration varies between 1.3 to 2.9 mg/L.

2.12.6 Ravirala Watershed, Ranga Reddy District:

Ground water management studies were taken up for developing ground water management strategies in Rawiral Watershed, Maheshwaram mandal, Ranga Reddy district, covering an area of 110 sq km in the proposed industrial area to ground water baseline data. The area under study exhibits an undulating topography, pediment is the dominating geomotrphological unit with intervening vallies.The drainage in the area is dendritic to sub dendritic and all the streams joins the Rawiral tank.

The area is underlain by the crystalline rocks comprising granites gneisses of Archaen age. They are hard, compact and massive and grey to pink in colour. In order to study the area 20 observation wells were established and monitoried pre and post monsoon water levels and collected water samples for chemical analysis. Ground

water occurs mainly under water table conditions in the inter granular pore spaces of weathered mantle and inter connected fractures of compact rock. Groundwater also occurs under semi confined conditions in fractures that are hydraulically inter connected with top weathered mantle. The depth of weathering varies from 5 to 30mbgl, the fractures occur to the depth of 80 mbgl in the area. Ground water development in the area is mainly through bore wells and rarely by dug wells. In general depth to water levels monitored during premonsoon period varies from 9.84 to 34.35 mbgl, and during post monsoon period from 6.31 to 27.46 .mbgl. In general quality of the ground water is good.

2.13 SER, BHUBANESHWAR

The Ground Water Management Studies were carried out in Dhenkanal, Jajpur, Kendrapara, Jagatsinghpur, Cuttack,Bhadrak and Sambalpur districts and area covered 13825 sq.km.

2.13.1 Dhenkanal District (Ground Water Resource estimation):

During 2008-09, the ground water management study & resource estimation was carried out in parts of Dhenkanal district. An area of about 3500sq.km was covered in 7 blocks of three subdivisions viz. Dhenkanal, Kamakhyanagar and Hindol respectively. The agriculture is mainly rainfed as the irrigation facility in the district is limited and hence the food grains production suffers owing to erratic nature of rainfall. The areas irrigated through all sources are 30 % during Kharif & 8.5 % during Rabi seasons. The dug wells are the main source of irrigation from ground water in the district.

The river Brahmani and its tributaries controls overall drainage of the district which flows in East – West direction. It divides the district into two halves. The Brahmani is perennial in nature. The southwest monsoon is the principal source of rainfall in the district. The average annual rainfall (2008) was 1396 mm and the block wise average rainfall varies from 1171 mm to 1530 mm (2008). About 80% of the rainfall is received during the period from June to September. Water scarcity in summer season leads to mild drought in the area.

The district can broadly be divided into 4 natural physiographic units viz Southern Mountainous Region, The Eastern valley & plain, The Central undulating plain & the northern mountainous region. The soil type in the district depends upon its physiographic and lithologica variation and mode of original occurance. Soils of the district are classified into three types viz. Alfisols, Ultisols and Entisols.

The major part of the district is underlain by hard crystalline rocks (Granite gneiss, schists, khondalites, amphibolites etc.) of Pre-Cambrian age which is devoid of primary porosity and hence when weathered & fractured, secondary porosity is developed. The water bearing properties of the formations vary widely with lithological compositions & structures. The deep seated intersecting fractures developed from tectonic deformation plays an important role on occurance and distribution of ground water as well as water yielding properties. The thickness of the weathered zone varies from 5m to 20m which form the repository of ground water at shallow depth. The depth of dug wells varies from 4m to 12m and the water level varies from 1.60 m (Sadeibereni) to 12.12 metres below ground level during Pre-monsoon and 0.70 to 6.50 metres below ground level during post-monsoon period. The deep bore wells yield upto 10 lps depending upon the topography, thickness of weathered and saturated fractured zones. Khondalites are restricted to higher elevations forming steep linear ridges & hence ground water potential is limited. In pediment areas, the thickness of the weathering varies widely. The water level varies from 6.50 to 8 metres below ground level during Pre-monsoon and 3 to 5 metres below ground level during post monsoon period. The semi consolidated Gondwana Sandstones, Shale etc.

2.13.2 Jajpur District (Mining areas).

Jajpur district is one of the thickly populated districts of Coastal Orissa with an areal extent of around 2899 Km^2. Physiographically the district can be divided into three units. The hilly areas having high hills of Daitari, Tomka and Mahagiri occur in the north western part of the district. This is followed by lateritic plateau fringing the high hill region having a gentle to moderate slope. The gentle sloping to flat alluvial plain which covers 50% of the district is situated on the south-eastern part of the district. Brahmani, Kharasuan, Baitarani and Birupa are the major rivers draining the district. The rivers follow meandering drainage channels with numerous abandoned channels, ox-bow lakes and swamps and are characterized by anastomosing drainage pattern. The average annual rainfall is 1501.3 mm out of which 90% occurs during monsoon period.

Hydrogeologically the district can be sub-divided into 3 broad regions viz, unconsolidated formation, consolidated formation and the hilly areas. The unconsolidated formation comprising of sand, silt, clay & gravel deposited during Mahanadi Delta forms the major aquifer system in

the district. 50% of the district is underlain by this formation. The top phreatic aquifer and the confined aquifer extending upto 40 meters of depth are commonly exploited both for domestic and irrigational use. These aquifers are of moderate yield prospect with 20 to 40 lps discharge. In the extreme eastern part of Bari, Binjharpur & Mangalpur Blocks as saline formations are encountered on the top, deeper drilling beyond 120 meter of depth is resorted to tap the fresh water aquifer existing below the saline zone. However these deeper aquifers are having high yield prospect (> 40 lps) and are under artesian condition. Sandwiched in between, there is a zone where saline aquifers occurs at different depths under fresh water (48 m at Binjharpur & 28.5 m at Singhpur) and there necessary precaution to be taken during drilling and pumping for safe utilization of the fresh ground water resource.

The north-western part of the district is characterized by hard rock. Most of the isolated hills are also of the composition of Khondalite & Charnockite. The laterised capping on the weathered zone generally forms the main aquifer system in these terrain. The water table is generally deep except in valley areas which are ground water discharge zones and shows high water level fluctuation. The deeper fracture zones are limited and site specific and thus are only attempted for community water supply purpose by means of deep bore wells. The Sukinda valley forms a good synform and thus the fractured rock below the weathered talc and serpentine beds forms promising aquifer in the area. However Hexavalent Chromium released to surface water due to Mining activities is the major worry for the quality aspect of ground water. However the valley areas are more prone to quality hazards and since the settlements are situated on high and elevated lands, the impact will be less. To know the content of Cr^{6+}, 15 acidified water samples are collected from different villages in the valley. To know the ground water quantity & quality regime, 112 wells (including NHS) were monitored during Pre & Post monsoon season. This indicates that ground water level is shallow in the alluvial areas where as is moderate to deep in the hard rock terrain. Similarly water level fluctuation is also less in the alluvial areas as compared to the hard rock patches. The ground water quality is excellent to good in most part of the hard rock terrain and in the alluvial areas except the saline tract.

2.13.3 Parts of Kendrapara, Jagatsingpur and Cuttack(Conjunctive use of Surface water & ground water in parts of Delta Stage – I)

Mahanadi Delta Stage – I Project was taken up under the Command Area Development Programme by the Govt. of India in 1974 – 75 and was actually implemented by Govt. of Orissa in 1976 – 77. In this project, the water of the river Mahanadi and its Distributaries have been harnessed for Irrigation. The total area covered under the present study is approximately 3815 sq. The area receives almost the entire rainfall from the north east monsoon and is to the tune of 902 mm to 2337.8 mm.

The topography of the area is generally very flat. The higher land elevations are generally located along the river banks which dissects the delta and forms eight doabs (doab 1 – 4 falls within the delta stage 1 command area and doab 5 – 8 falls within delta stage 2 command area). The soil in the area is in general moderately sandy along the rivers to sandy clay loam in the low lying areas.

In Cuttack district, fresh water occurs down to bedrock or other hard formation except in Niali and in parts of Nischintakoili blocks. The southwestern part of the district bedrock or Gondwana shales and sandstones occur at shallow depth and unconsolidated formations are restricted down to a maximum of 50m depth. The cumulative thickness of aquifers vary from 25 to 30m and are mostly composed of older alluvium. The yield generally varies from 15 to 25 lps in major part and only in narrow elongated tract which occurs along the course of Mahanadi river where deposits of younger alluvium occurs, the yield goes upto 40 to 50 lps. In the eastern part of the district, fresh zone extends beyond 300m depth and the aquifer zones also occur beyond 300m depth. The cumulative thickness of aquifers is generally more than 60m and the yield is generally more than 50 lps. The draw down is generally restricted within 12 to 13m and static water levels are generally restricted within 3m bgl. Salinity problem occurs in the southern part of Niali block and Nischintakoili block. The fresh water bearing zone at Niali block extends down to 90 or 100m depth and below which saline water occurs and extend beyond 300m depth.

Jagatsinghpur district is underlain by alluvial deposits and major part of the district in the central and eastern sector (around 70% of total district area) suffers from salinity problem. Non-Saline area occupies the northwestern part covering entire block area of Biridi and Raghunathpur and adjoining major part of Jagatsinghpur and very small part of Tirtol blocks (north west). The fresh water bearing aquifers occur down to 300m depth and prominent aquifer zones are normally restricted within 200m depth and within this depth range the average cumulative thickness of aquifers is around 50 to 60m. The yield from these aquifers generally is more than 40 lps against the drawdown less than 12m. The static water levels vary from 2.56 to 4.60m bgl.

In Kendrapara district, the cumulative thickness of the aquifers which had been tapped by the tubewells varied from 20 to 69m with the average value ranging between 30 and 40m. The yield of these tubewells varied from 22 to 71 lps. The yield was normally found high (>50 lps) in the Pattamundai - Madanpur - Gopalpur - Sansarphal area while in other areas, on an average, the yield ranged between 30 and 40 lps. The boreholes data indicated that the entire district, except a very small portion in the southwest corner, reels under salinity hazard.

A perusal of April 2007 depth to water level data reveals that in general, the pre-monsoon depth to water level is in the range of 2-5 metres below ground level in the area. This covers more than 90 % of the area, spanning over all the four above-mentioned districts. However there are sporadic pockets having depth to water level in the range of 0-2 metres below ground level and 5-10 metres below ground level. These two combined contributes to less than 10 % of the study area.

A perusal of November 2007 depth to water level data reveals that in general, the post-monsoon depth to water level is in the range of 0-2 metres below ground level in the area. This covers more than 75 % of the area, spanning over all the four above mentioned districts. However there are sporadic patches having depth to water level in the range of 2-5 metres below ground level. This contributes to about 25 % of the study area.

Comparison between the pre and the post monsoon depth to water level revealed that the fluctuation of water level in the pre and post monsoon is not much pronounced in nature. A very small patch in the Cuttack district shows a fall in water level in the range of 0-2 metres. Major part of the area(more than 70%) shows a rise in the post monsoon, to the tune of 0-2 metres. Elongated patches have water level rise in the range of 2-4 metres and 4-6 metres and contributes to about 30 % of the area. Long term analysis of depth to water level data(10 years: 1998 – 2007) reveals that there have been no significant changes in the depth to water level in both pre and post monsoon. The rise and the fall are both in the tune of 0 - 2 metres in majority of the area.

The irrigation system of this project comprises of five canals off taking from the Mahanadi Barrage and Birupa Barrage in Orissa covering four districts(however only three out of four have been considered for our present study) at the primary level. At the secondary level, there are seven branch canals operating in the Delta Stage – 1 command area and at the Tertiary level both conveyance and distribution of water is manned through 431 numbers of distributaries and 531 numbers of minors and sub-minors spreading over the entire length of the command area.

Present Study

The Conjunctive use of surface water and ground water in part of the Mahanadi Delta Stage –1 was taken up and 167 No. of Key wells established & monitored – Phreatic Aquifer, 22 No. of Key wells established & monitored – Confined Aquifer, 20 No. of River / Canal Gauge Stations monitored ,41 no. of NHS Monitored and 9 no. of Piezometers Monitored Regular monthly monitoring have been carried out for ten months - May, June, July, August, October, November, December, January, February, March. The monthly monitoring for the month of September was not done due to occurrence of wide spread flood in the study area. In addition due to its remote location, the area has got accessibility problems for detailed study and data collection. Monthly monitoring of water level shows that most of the area remains affected by water logging.

In the Pre-monsoon around 22.5% of the total study area is water logged (depth to water level 0 – 2m) and around 44.8 % of the total study area is prone to water logging (depth to water level 2 – 3m). Maximum of this water logging condition is found in the area that lies between the rivers Mahanadi and Kathajodi and few patches near the coast. In the post monsoon however the extent of water logging increases to 2708 sq. km area i.e., around 70.9%(almost the entire Jagatsinghpur district) and area prone to water logging is about 683 sq. km i.e., roughly 17.9% of the study area.

Water samples have been collected from the study area and their pH and EC have been monitored for the pre-monsoon season. The pH ranges from 6.9 to upto 10 and electrical conductivity ranges from as low as 171 µS/cm to as high as 7940 µS/cm. The lower part of the command area, particularly in the Ersama block of Jagatsinghpur district and Mahakalpara Block of Kendrapara district have been affected by quality problem of higher EC. It is reported as the after effect of Super Cyclone of 1999, when sea water have entered into the phreatic aquifer system and in absence of proper natural flushing out mechanism is yet to be stabilized. More over, it has also rendered vast patch of agricultural land into a barren one.

The historical ground water exploration data carried out by CGWB in the study area have been collected for initial understanding of the aquifer disposition of the area, which shows the feasibility of conceptualizing a three layer model for the study area.

2.13.4 Parts of Jharsuguda and Sambalpur District :

Ground water management study was taken up in Jharsuguda and parts of Sambalpur districts to know the Hydrogeological condition in around 3500 sq.km. The Industrial areas of Jharsuguda and parts of Sambalpur districts has been chosen for the detailed study.

The study area is marked by high hills, isolated hillocks and undulating plains. About 80% of the area is characterized by undulating plains with isolated hillocks and mounds. A part of the Hirakud reservoir having 185 Sq.km is important land mark.
The drainage of the district is controlled by the Mahanadi in the western part and the IB River, a tributary of the Mahanadi in the central and eastern part. The IB River flows in a general Southerly direction. The drainage pattern of the area is dendritic and the drainage density is high in the western part of the district. The south western part of the study area is occupied by the Hirakud reservoir.

About 60% of the area is underlain by consolidated formations comprising Precambrian metasediments and Iron ore. The weathered residuum and fractured zones form the repository of ground water. The interconnected joints and fractures in the underlying hard rocks facilitates circulation of ground water and form the deeper aquifers.

Sandstones, Shales, Conglomerates, Grits etc. constitute the Semi consolidated formations. Shales and sandstones, due to the hard and compact nature and poorly developed joints does not form good aquifers. However the needle shales with high frequency of intersecting joints form good aquifers. Barakar sandstones, susceptible to weathering and characterized by well developed fissible bedding planes, open joints, fault planes form the potential aquifers.

Laterite and Alluvium constitute the unconsolidated formations. Laterite forms a very good shallow aquifer. Alluvium occurs as limited discontinuous patches forming the flood plain deposits and ranging in thickness from 10-15 m. The coarse grained sands with gravels and pebbles form repository of ground water under water table conditions. Alluvium forms potential shallow aquifer which are to be developed through dug wells.

2.14 SWR BANGALORE

The ground water management studies have been taken up in Chikamagalur, Kopal & Belgaum Chikmagalur, Shimoga & Davanagere Mangalore. Chitradurga

2.14.1 Ramdurg Taluka of Belgaum district (Farmers distress) and Yelbarga taluk (OE taluk) of Koppal district

Ground water management study area covering an area of 2706 sq. km falls in Malaprabha, Ghatprabha and Tungabhadra river sub-basins of Krishna river basin. The drainage pattern is dendritic and sub-parallel and drainage density varies from 0.80 to 2.50 km/km^2.

The normal annual rainfall ranges from 562.3 mm (Ramdurg taluk) to 593.2 mm (Yelbarga taluk). Groundwater accounts for 20.3% in Ramdurg taluk and 98 % in Yelbarga taluk of net irrigated area.

Ground water occurs under unconfined and semi-confined conditions in weathered, fractured, massive, vesicular and spheroidal basalts, sandstones, shales and quartzites and gneissic granites. The depth of the wells monitored varied from 5.00 meters to 18.00 meters bgl and the depth of bore wells varied from 45.00 meters to 170.00 m. The depth to water level during pre- moonsoon period varies from 2.0 to 37.00 meters bgl and during the post-monsoon period the depth to water levels vary from 1.5 to 30.50 mbgl. The depths to water levels vary depending upon topography and applied irrigation. The yield of the dug wells varied from 30 to 300 m^3 per day.

Basalts, limestones, sandstones, quartzites, shales and Granitic Gneisses constitute the major aquifer system in the area. Groundwater occurs under phreatic to semi-confined conditions in weathered, fractured, jointed and vesicular zones of these formations. The depth to groundwater level during pre-monsoon period varies from 3.75 to 15.00 mbgl in dug wells and 8.10 to 36.00 mbgl in bore wells and is in the range of 1.50 to 30.00 mbgl during the post-monsoon period. The fluctuation is in the range from 0.20 to 12.40 m. Long term water level data indicate that groundwater level raised from 0.20 to 2.50 m in 46% of wells and fall in water level ranging from 0.10 to 4.00 m was registered in 54% of the wells. The rising trend is more pronounced in canal command area.

The development of groundwater is through dug wells, dug-cum-bore wells and bore wells. There are 11412 and 20536 irrigation pump sets respectively in Ramdurg taluk of Begaum district and Yelbarga taluk of Koppal district. Dug wells in the command area sustain pumping for 6 to 8 hrs. at a discharge of 50 to 300 m^3\day. Irrigation bore wells sustain pumping for 2 to 12 hrs per day at a discharge of 0.5 to 7 lps. The unit area Specific Capacities of dug wells tested ranged from 0.35 to 10.0 lpm\m\m^2. The density of

dug wells varies from 8.3 (Ramdurg taluk) to 6.8 per sq.km (Yelbarga taluk) of net sown area.

In general the groundwater quality is good for domestic and irrigation purposes except at few villages where the EC exceeds 3000 micro-mhos\cm at 25°C. There is no remarkable change in groundwater quality since the last surveys.

Recommendations

- Based on available data on dug well performance and computed well parameters as well as nature and depth of weathering in phreatic zone, dug wells with depth of 10.0 to 15.00 m and dia of 3.0 to 8.0 m are recommended and DCB have bore of 20-35m deep below the well bottom, which may be vertical, inclined or horizontal.
- Our exploration data indicates that majority of EW and OW below the depth of 80 m and very few bore wells are drilled up to 120 m. The depth of penetration of these EW appears to be inadequate especially in limestones, Shales and basalts as exploration studies in adjoining districts have established continuation of fractures, fissures and aquifer contacts below 120 to 200 m. Then there is need for 2nd phase of exploration to a maximum depth of 300 m.
- There is need to educate the farmer community about planned utilization of ground water resources by arranging field demonstrations on surface water harvesting, dry land farming drip and sprinkler irrigation techniques with audio-visual aids. Ground water legislation and regulations are to be given wider publicity through audio- visual means.
- There is need to practice conjunctive use of surface and groundwater to avoid water logging and quality deterioration in command area.
- There is need to harvest rainwater and recharge groundwater through various recharge methods suggested especially in overexploited regions. This not only recharges ground water body but also dilute the inherent saline zones especially in western and southern parts of Yelbarga taluk.

2.14.2 Study on distressed condition of farmers in Ramdurg taluk of Belgaum district

During the study distress of farmers and their problems relating to ground water for irrigation were addressed to. From the discussions it was arrived that the distress among the farmers may be due to frequent crop failures due to irregular rainfall, lack of surface irrigation facilities, socio-economic conditions, and indebtedness. The list of distress farmers have been collected from the Deputy Commissioner and Agricultural Offices, Belgaum. The distress farmers spread across the taluk of Ramdurg at M.Chandargi, Bhatgurki, Chippalakati, Gudeguppa, Kallur, Chikka Tadasi, Hire Tadasi, Aneguddi, Nandihal, HaleToragal villages. These villages were visited to understand the specific problems, particularly the availability of ground water. Discussions were held with the 11 farmers in the areas in the light of existing hydrogeological conditions. The farmers were informed about the feasibility of ground water structures that can be constructed in their farmlands. The farmers were also enlightened on rain water harvesting & artificial recharge for augmenting dug and bore well yields. They were adviced to make use of the existing dug well recharge scheme.

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

An area of 1100 sq.kms was covered under conjunctive use of surface and ground water studies in command areas of Bhadra irrigation project. Bhadra dam is constructed across the river Bhadra. The command area covers parts of Shimoga, Chikmagalur and Davanagere districts.

The Bhadra reservoir has a capacity of 2023 MCM, which could irrigate an area of 1100sq.kms. through Bhadra Left and Right bank canals, with branch canals like Anveri, Davangere, Malebannur and Devarabilikere branch which branch from Bhadra right bank canal.
The main sources of ground water in the area are precipitation, seepage from canals, and return flow from applied irrigation water. Ground water occurs in weathered / semi weathered formations of granites/gneisses and fractured zones in deeper depths.

34 key observation wells indicates that pre-monsoon depth to water levels ranged from 0.68m to 10.60m and post monsoon depth to water level ranged from 0.88m to 5.76m. The analysis of monthly water levels from December-08 to March-09 indicates that the average depths to water level are 3.33m, 3.86m, 3.96m and 4.23m during December-08, January 09, February 09, and March 09 respectively and maximum fall in water levels is between Dec-Jan.

The analysis of long term water levels in 15 observation wells of CGWB indicates that the average pre monsoon water level ranged from 2.53m to 7.13m, and the average

post monsoon depth to water levels ranged from 1.68m to 5.59m.

Water logging conditions have been observed during the months of June to January and area in and around Kadaranayakanahalli, Kokkanur, Nanditavare, Kurki, Arasanaghatta and Lakkavalli villages show seasonal water logged conditions. It is reported that 30% of the total command area is being water logged.

The analysis results indicates that the pH, total Hardness and other parameters are well within the desirable/permissible limits indicating water is fresh and good for drinking purpose. Detailed survey with reference to farmers' distress areas in Bhadra command areas are as follows:

The depth to water levels ranged from 1.15m to 8.00m with an average of 3.35m. Sufficient surface water exists through Bhadra right bank canals and with branch canals.Ground water development is negligible and no irrigation dug wells or bore wells are in use.The main crops are paddy and arecanut, where areca nut garden facing water scarcity.Shortage of irrigation water observed in the areas of canal tail end and lands on elevated planes.Farmer's suicide cases are mostly related to financial crisis, long illness of farmers, and partly due to crop loss. Crop loss is due to lack of proper crop care/maintenance, no proper cropping pattern, and major problem is crop diseases, and rarely due to shortage of water.It is also observed Ground water management practices like drip/sprinkler irrigation are in use, especially in araca gardens.It is observed that the depth to water level in the Bhadra command areas is not alarming, except at few places wheret water logging conditions are observed. Farmers in command areas are getting water on rotation basis for their irrigation in their lands. So the conjunctive use of ground water and surface water will improve the situation. Farmers should be educated through agricultural scientists about how to protect crops from crop diseases.

Study on distressed condition of farmers in Shimoga District.

In the last four years there were about seventy suicide cases of farmers reported in the district. Out of these, there were about 16 suicide cases, which were reported to be related to crop failures. With about 89% of the cropped area in the district dependant on rains, failure of monsoon during the last four years has caused crop failure in a large scale. The small farmers usually take loan at each time of sowing and could not repay the loan for last three to four years, because of the crop failures. The list of farmers who are affected and resorted to suicide was collected from the district authorities & their family members were contacted during the survey to understand their problems related to water availability for irrigation. From the discussions, it was gathered that the distress among the farmers in this area is due to one or more of the following factors, i.e Indebtedness,Raising cost of cultivation,Absence of surface irrigation facilities andRepeated crop failure due to irregular rainfall. Discussions were held with the 14 farmers in the areas in the light of existing hydrogeological conditions & farmers' sucide. Major causes behind the suicides were burden of loan & frequent crop loss due to crop decease/inadequate water supply for irrigation during lean period. The farmers were informed about the feasibility of ground water structures that can be constructed in their farmlands. The farmers were also enlightened on rain water harvesting & artificial recharge for augmenting dug and bore well yields and to optimise irrigation through conjunctive use of both Surface & Groundwater.

2.14.4 Chikmaglur, Tarikere taluks of Chikmaglur district

The studies were carried out in area of 2836sqkm. On the basis of geomorphologic condition, the study area is divided into Southern malnad, Semimalnad, Southern maidan region.

The drainage network is generally sub dendritic in nature, Tunga and Bhadra are the principal streams of the district-forming the river Thungabadra, a tributary to Krishna River. Bhadra River has been harnessed for irrigation and power generation within the study area. The eastern portion of the area lies in Vedvathi sub basin, which is also a tributary to the Thungbadra River. Western part of the study area is drained by perennial rivers and a numerous hilly streams, which are mostly of seasonal characters.

The normal annual rainfall in the study area varies from 851mm to 1004.5mm. A number of MI tanks and lift irrigation schemes are augmenting the irrigation facility Weathered, fractured & jointed zones of gneiss and schist formations serve as potential aquifers in the study area. Ground water occurs under water table, semi confined & confined conditions. In Chikamaglur taluk, northern half is underlain by schistose rock formation and the southern half by gneissic rock formation. Depth of weathered zone ranges from 6.85 to 14.25mbgl. Nearly 50% of area in Tarikere taluk is underlain by schist which serves as potential aquifers and depth of weathered zones ranges from 6.85 to20.70mbgl.

To study the ground water regime of the area, 54 observation wells were inventoried with an average density of 52 sq.km which are evenly distributed through out the study area both in command and non command area. Depth to water level in dug wells varies from 2.60mbgl to 15.00mbgl during pre-monsson and during postmonsoon, depth to water levels varies from 1.71mbgl to 15.40mbgl with an annual fluctuation of 0.09m to 7.59m rise and fall of -0.90 to -1.12m. Ground water development in the area is through dug and dug cum bore wells, wherein dug-cum-borewells out number the dugwells for both irrigation and drinking. Most of the dug wells were found to be dry in Tarikere taluk and the depth to water level in bore well ranges from 8.0mbgl to 27.70mbgl and the discharge varies from 1.5lps to 4.lps. In general, the quality of water is found within desirable limits except few places where excess of nitrates are indicated. Special studies in an area of 1614 sqkm falling in Chikmaglur taluk was taken where excess of nitrates above the permissible limits was revaled. Totally 45 no of ground water samples were collected during post monsoon survey both in dug wells and irrigation bore wells and hand pumps used for drinking purposes were given for chemical analysis. And 2 sq km area is taken up for Ground water estimation in chikmaglur taluka.

Study on distressed condition of farmers in Chikamaglur District.

Farmers distress report was collected from 20 villages in Tarikere and Chikmaglur taluks. In last three years, there were about fifty suicide cases of farmers reported in the district. Out of these, there were about 23 suicide cases reported to be related to crop failures. With about 86% of the net sown areas in the district dependant on rains, failure of monsoon during the last three years has caused crop failure in big scale. The small farmers, who usually take loan at each time of sowing, were unable to repay the loan for last three to four years, because of the crop failures. Some farmers, because of this draught situation, have got into debt traps and forced to commit suicide in few extreme cases. In Chickmagalur taluk, seven cases and from Tarikere taluk, nine cases of suicide were reported. Ground water development is still a low-key affair in the district, with proper development of groundwater, distress situation of the farmers can be lessened to some extent during the drought period.

2.14.5 Hosadurga taluk, Chitradurga district (Remote sensing Studies)

Two drainage basins namely Kodi halla and Gundi Halla were selected for the detailed study in the Hosadurga taluk, Chitradurga district as series of artificial recharge structures constructed in the area. The Kodi halla drainage basin is consisting of gneiss and very small area is exposed with schist where as the Gundi Halla drainage basin is having multiple geology and structurally controlled.

To study the impact of the ARS constructed in the area, the information on Geology, Geomorphology, soil, landuse/landcover and slope are considered to be important. The Demarcation of area suitable for the artificial recharge structures were done based on the integration of multiple thematic maps prepared by using the remote sensing data.

The Kodihalla drainage basin is located in the northwestern part of the Hosadurga taluk, covering 274 sq.km. The Kodihalla drainage basin is tributary of Vedavathi catchments in Krishna River basin. The Gundi Halla drainage basin is located in the northeastern part of the Kodihalla drainage basin covering about 80 sq.km area.

In Kodi Halla drainage basin, Series of Check dams, Percolation Tanks and Bunds are the type of ARS constructed on the main stream of the basin. The check dams and Percolation Tanks were constructed in the lower part of the basin whereas the bunds were constructed in upper part of the basin on the first/second order stream of the basin. In Gundi Halla drainage basin, series of check dam only were constructed.

29 key wells were established to measure the ground water levels periodically in the area. The wells are equally distributed in the area to represent ground water levels in the area. Ground water levels were monitored in the months of May-08, September to November-2008 and the contours were generated for the all months. In Gundi Halla drainage basin, a total of 12 numbers of key wells were established and water level data had been collected. The depth to water level varies form 5.32 to 21.84 mbgl during the pre-monsoon. Water levels of the bore well located very close to the ARS are not showing any significant change in the water level. However, just downstream of the structure (Kenkere), flow of water is observed during the pre-monsoon. These base flow water was collected and pumped for the crops of plantain plant irrigation purposes.

The integrated maps results were compared with the water level data for the Kodi halla drainage basin. A shallow water level was observed in and around the percolation tank located in the Kengavalli village. It indicates that there is considerable improvement in the ground water conditions of the area.

2.14.6 Dakshina Kannada District, Karnataka (Impact Assessment and Ground Water Modeling Studies Of Vented Dam)

The Vented dam is a permanent Engineering structure constructed across a stream/river to impound the water flowing in the stream during non monsoon season. One Such large Vented dam is constructed across the River Nethravathi near Tumbe village in Dakshina Kannada District. Impact assessment and mathematical modeling of existing and proposed vented dam at Tumbe Mangalore, Dakshina Kannada district" was taken up. About 16 Key observations were established and monitored during the May, August, November-2007 and February,May-2008 in and around the existing vented dam of Tumbe. The entire area of the water shed was included for the study. Accordingly another 18 more Key observation wells over an area of 92 Sq.Kms covering the entire of the water shed (totally 34 key observation wells) were established and periodic monitoring of these Key wells was carried out during the months May, August, November-2008 and March-2009 .RL of all these Key wells (amsl) were also connected to know the impact of dam water on ground water system in the adjoining area of vented dam of Tumbe.

The following Maps are prepared : Location map of the study area,Drainage map of the area, Map showing the location of villages, Land use map, Geology map, Geomorphology map, Premonsoon DTW map (May-2008), Postmonsoon DTW map (November-2008),Water level fluctuation map(May-November-2008), Water table Contour map (November-2008). Water table contour map (May-2008).

2.15 SECR, CHENNAI

2.15.1 Parts of Thanjavur & Pudukkottai districts

The main Objective of the study was Delineation of Aquifer units- Sand / SST / Silt / Calc. SST / LST,Define Recharge Area- Local / distant / Vertical / Lateral,Groundwater Resource estimation in Orathanadu Block in Thanjavur dist-

The crystalline rocks of Archaean age occupy the small portion in the western part of study area where as in the porous sedimentary formation belongs to Cretaceous, Tertiary and Recent ages occupy in remaining part of the study area. Aquifer geometry has been delineated. The depth range of different aquifers are Cretaceous aquifers, also Known as Nakkudi Aquifer(upto 50m), Eocene Aquifer(Up to 80 (very limited use), Lower Miocene deep Aquifer System, Orathanadu Aquifer,also Known as Aquitainian Aquifer(upto 150m), Main flowing zone or Burdigalian Aquifer (Deeper aquifer 350 m), Pliocene – Miocene Shallow Aquifer, Pliocene Aquifer also Known as Podakkudi Aquifer(Shallow open wells up to 40 m), Quaternary aquifer(Shallow open wells 20 m)

The comparison of ground water during May –2008 and January –2009 indicates a rise in ground water levels in about 94.75 percent of wells analyzed. Rise in water levels is generally in the ranges of 0-5 m. Fluctuation of more than 5 m has been observed in the north western part of the study area.Ground water occurs under both phreatic and semi-confined conditions in the shallow aquifer, where as in the deeper aquifers it occurs under confined conditions. The yield of the bore wells constructed by State Govt. Agencies in crystalline rocks ranged from 20 to 300 lpm, where as in the Sedimentary terrain it varies from 40 to 500 lpm. The bedrock was encountered between 346 and 541m bgl. It has been observed that north of Vallam – Gandarvakottai, south of Kuppakudi areas are the recharge areas for Orathanadu Aquifer. The aquifers of these porous formations are broadly divided into two groups i.e. shallow aquifer group occurring down to 100 m depth and deeper aquifer group occurring below the depth of 100 to 450 m. In the 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 EC values ranges from 150 to 1931 µS /cm at 25^{o}C and the chloride values ranged from 19 to 539 ppm. The analysis of ground water samples does not indicate any major pollution in the study areas.
The estimation of groundwater resources of Orathanadu block using GEC-97 methodology indicates that the Stage of Development is 58 percent. It is proposed to estimate the groundwater reserve of Orathanadu aquifer using a new methodology as a case study to test the new methodology. The data collection has been made accordingly.

2.15.2 Peri-Urban Areas of Chennai City(Assessment of regulation of water market)

The main Objectives of the study is Impact of ground water marketing on ground water regime and To evaluate scientific ways of ground water management strategies Such as ownership of ground water, allocation and pricing of water resources, effective regulation of ground water withdrawal, and role of stakeholders in water use efficiency.

The Urban and Per-Urban area of Chennai City experiences multi facet threat viz., (i) erosion of sea coast (ii) indiscriminate dumping of municipal/industrial solid

waste (iii) water logging (iv) pollution due to industrial effluent (v) water table depletion (vi) sea water intrusion and (vii) depletion of natural recharge area. The demand is met from both surface water and groundwater sources. The near utilization of surface water sources and over dependence of groundwater sources has resulted in the declining of groundwater levels and become shortage. The Government has initiated many projects in the Peri Urban areas for supplementing the water supply to the city. The data supplied by CMWSSB, Chennai indicate that there was a deficit of 526, 597, 467 & 636 MLD during 2000 to 2003 and it has projected on the basis of current supply position that there would be a deficit of 685 MLD during 2008. The extraction of groundwater in Peri Urban areas may not be an optimal solution as it would deplete the aquifer over a period of time, it would be difficult to meet the domestic water supply in Peri Urban area itself.

In view of the large scale, indiscriminate withdrawal of ground water in Chennai city, Madras Metropolitan Development Authority (MMDA) introduced legislation for regulating ground water withdrawal by introducing a license system in 1988. The legislation is effective only in the urban area and as there is no control over the withdrawal of ground water, the trade of ground water marketing has flourished in Peri-urban area and hence the ground water situation in Peri-urban area also has deteriorated. The regulative measures have been suggested to safe guard the precious resource of the city.

- To ascertain the quantum of ground water withdrawal from each well, water metering should be installed.
- The user has to obtain "certificate of registration" from the authority for ground water use. Separate license must be obtained for non-domestic use.
- Slab pricing system based on consumption similar to power tariff may be introduced by the Govt. to regulate the use of water; in order to motivate people to use the precious scarce resource to meet their minimum requirement without any wastage. Higher price for urban areas with more consumption and comparatively less price for low users and free for poor through public posts.
- Ground Water clearance is required for projects with more than 1 MLD consumption and developmental projects in the coastal regulation zone up to 500 m from HTL should not take ground water by pumping but only with manual lift. All coastal aquifers should be notified and no marketing from the zone should be allowed.
- Rain Water Harvesting should be strictly adhered for all new and old establishments in the city and peri-urban area.
- Temple ponds in the urban area can be revitalized and supply channels to be desilted.
- Water supply can be made by desalination process from seawater as a long-term management strategy with cost recovery model.
- Royalty to be paid by the private water merchants of their pumping wells to the Govt. on monthly basis.
- There is a need to develop a universal bioethics regarding abstraction of Ground Water.
- Water should be treated as a common global heritage and should not be grouped with other natural resources.
- Water is the elixir of life hence it should be used to quench thirst and defuse passions and disputes.

2.15.3 Thiruvarur and parts of Thanjavur districts, Tamil Nadu(Conjunctive Use of surface and ground water resources in command area of Vennar, Vettar, Cauvery and Bamni rivers)

The main objectives of the study is Evaluation of hydrogeological situation,Quantification of different components of water balance in the canal command area,Identification of the critical areas in respect of water logging, water scarcity in the tail end areas and Preparation of suitable conjunctive use plan for development of ground water resources

The command area is about 1500 sq.km under Vennar, Vettar, Bamni and GA canal system out of total study area. The waterlogged area is in discontinuous patches and is localised. The depths of dug wells range from 5 m bgl to 15.0m bgl and yield 300 to 480 lpm and can sustain a pumping of 6 hrs in summer and more than 8 hrs in other season. The transmissivity varies from 200 – 250 m^2/day. The stage of ground water development in Thanjavur and Thiruvarur districts are 72% and 83% respectively. The stage of ground water development is very high in Valangaiman block (180%) and the lowest in Kottur block (42%). The lowest stage of development in the block due to bad quality water. Delineation of aquifer units – Occurrence of water bearing formations in different blocks in different depth all over the study area was identified and their chemical qualities were estimated and classified the water based on the EC values. Ground water resource estimation (as per GEC 1997 methodology) - Block wise ground water resources were calculated and allocation of ground water for different use has beencarriedout.
The conjunctive use of surface and ground water utilisation do exits in portions of the study area but not in entire command area. This study with full-fledged data analysis may bring out a conjunctive use plan for the command

area. River wise availability of surface water with space and time for the whole study area was calculated

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

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

The Pallikaranai dumpsite is located south of Chennai. Leachate is generated by different sources of moisture entering the waste like precipitation over uncovered waste, liquids present in the refuse, moisture resulting from decomposition and ground water flow across the landfill. High value of heavy metals like Cu, Zn, Pb and Fe are observed in the ground water. The high value of chemical oxygen demand indicates the presence of organic matter. The dominant cations and anions in the groundwater around the dumping site is found to be in the order of Na^{+}> Ca^{+}>Mg^{++}> $^{+}K^{+}$ and Cl^{-}>HCO_3^{-} >SO_4^{--} >NO_3^{-}.

Higher concentration of Mg, SO_4, NO_3, Cl have been noticed around the landfill site. The vertical extent of contamination of groundwater quality due to landfill waste depends on the factors mentioned above and in addition the level of connectivity over the depth within the same aquifer and in between aquifers in case of multiple aquifers. The quality of deeper aquifer tapping the fractures are poor in quality in comparison to the shallow aquifer and because of the interference of the landfill, at the places affected by the contamination, shallow aquifer will show higher concentration in comparison to deeper fractures.

Findings of the study

The high concentration of cations and anions in ground water near landfill sites indicate deterioration of the quality of ground water. The general quality of water in deeper aquifer is brackish in deeper aquifer and the impact of leachate need to be separated out. However, the shallow aquifer is of good quality water and any deterioration is only due to the impact landfill site. Thus the principal threat to groundwater comes from inadequately controlled landfills where leachate generated from the landfill is allowed to the surrounding and underlying ground. To minimize the impact of such landfills on ground water quality and the environment in general, it is necessary to properly design and build these facilities to prevent pollution

2.16 KERALA REGION, TRIVENDRUM

2.16.1 Wayanad District

Ground Water Management Studies (reappraisal survey in farmer's distress district) were carried out in Sultan Bathery and Mananthavady blocks of Wayanad district covering an area of 1350 sq.km.

The district of Wayanad can be divided into three physiographic zones-Wayanad Plateau, Central Sahayadri highland and mountainous region of Central Sahayadri. The western part of the district constituting the Ghat sections receives maximum rainfall of more than 3000 mm and the leeward side of the Ghat section on the eastern side of the area constituting Plateau region receives less rainfall (less than 1500 mm). The district but has two ongoing medium irrigation projects.

The change in cropping pattern. In the traditional paddy field of Wayanad district arecanut trees are planted in large scale which reduces the availability of water in the summer periods in the valley area.

During the premonsoon period about 100 key wells were established. The premonsoon and post monsoon water levels were monitored.Dug wells are the most common ground water abstraction structure in the area. Ground water occurs under unconfined condition in the weathered and fractured crystalline rocks and alluvial formations. Semi confined to confined condition exists in deep fractured system, which forms potential aquifers and is developed by bore wells. The DTW of dug wells ranges from 1.76 mbgl to 16.52 mbgl in the premonsoon period and 1.52 to 14.32 m in post monsoon period. The water level fluctuation ranges from 0.34 to 4.12 m. The depth of dug wells ranges from 2.12 m to 20.16 mbgl. The yield of dug wells ranges from less 1000 lpd to 30,000 lpd. In the bore wells the yield ranges from less 500 lph to about 10,000 lph.

Rain water Harvesting in Government UP School, Thalapuzha, Wayanad District. Rainwater collected in surface tank and flowers planted over the tank. The structure constructed with the financial support of MOWR

As the study is concentrated to farmers distress, discussions were held with District Collector, Wayanad district, Secretary of Block Panchayaths, District Officer, Ground Water Department, Planning Department, District Panchayath, Grama Panchayaths and individual farmers. From the discussions it is gathered that the distress among farmers may be due to Poor value of crops, Rising cost of cultivation,Crop failure, High cost of manures, pesticides and Poor credit availability. During the Survey, it is observed that change in cropping pattern and climatic changes made the reason for farmers distress. The reasons/changes noted during the survey are- Paddy cultivations, the main crops during earlier days are considerably reduced; The pepper plants being the main crop of north eastern part of the district mostly dried due to poor rainfall in the years 2002 to 2004, since most of these are not irrigated. The new pepper planted is not giving good yield as earlier. The farmers feel that the texture of soil is changed due to more use of chemical fertiliisers.

2.16.2 Palakkad District

Ground Water Management Studies in farmers distress districts of Palakkad district were carried out in an area of 2000 sq.km. The following 8 blocks in eastern part of the district viz. Mannarkkad, Malampuzha, Kuzhalmannom, Palakkad, Kollengode, Nemmara, Chittoor and Attappadi were taken up for study. During premonsoon reconnaitory survey 115 key wells were established to study the groundwater behaviour and water samples collected for chemical analysis. During post monsoon survey water levels had been monitored from the key wells in August – November and January months and additional ground water abstraction structures were monitored.

The entire study area falls in high land except a very minor part in the western study area, which is in mid land. The major physiographic feature in this area is the Palakkad gap. The elevation of the plain in the study area ranges from 60 meters in the west to 200 meters above msl in the east. The district experiences humid climate. The average rainfall of the district is 2348 mm. The major rainfall is from south west monsoon during June to September followed by north east monsoon. Further the rainfall decreases from west to east. The major part of the study area is drained by Bharathapuzha or Ponnani river. A small area in north eastern part i.e. Attappadi Plateau is drained by Bavani river tributary of Kaveri river.

The major rock types of the area mainly comprises of metamorphic crystalline rock complexes of Archaean age. They are charnockite, Hornblende biotite gneiss, biotite gneiss, migmatite, calc-granulites, schists, pegmatites and quartz veins and dolerite dykes are seen as intrusives in the crystalline formations. The sub recent age laterite with limited thickness occurs above the crystalline basement with thickness around 6.00 meters and its thickness increases towards west with around 12.00 mts. The recent alluvium occurs along the Bharathapuzha river.

The ground water occurs in all the geological formations. It is in phreatic condition in laterite, alluvium and weathered crystalline formations and in semi confined to confined condition in fractured crystalline formations.Potential phreatic aquifers are seen in alluvial area and also in western part of the study area where the weathered thickness is more. The DTW in pre monsoon period ranges from 1.60 m to 11.60 mbgl and in post monsoon period ranges from 0.60 to 8.60 mbgl. The water level fluctuation is 1.25 to 4.6m. Central Ground Water Board drilled several many bore wells in the area. The study reveals that potential fractures yielded 0.50 to 24 lps. The bore wells drilled in E-W lineaments yielded high discharge.

Farmers Distress Area:

The area falling in Eruthenpathy, Vadakarapathy and Muthalamada Panchayaths are the most critical area. Farmers in this area chasing potential fractured zones down to the depth of 200 meters. The immediate attention with remedial measures is very essential for this area. In the eastern side of the study area around Chittur, Kozhinjampara Fluoride contamination is reported in some pockets. Artificial recharge practices are very much

essential for this area. Rejuvenating the water bodies i.e. ponds/tanks by deepening and widening. Surface water utilization by inter linking Walayar, Varattar and Korayar.Micro irrigation system has to be practiced to conserve the resources. Short duration crops may be practiced. Proper System to be developed to give awareness to farmers regarding latest irrigation practices, crop patterns and financial assistance. Area falling in Eruthenpathy, Vadakarapathy and Muthalamada Panchayaths, the water levels in the phreatic aquifer are depleting. Further farmers are chasing for potential fracture zone by drilling bore wells to the depth range of 200 meters, which is not required since potential fractures are generally encountered between 50 to 120 mbgl. Thus the cost of drilling can be substantially reduced. The artificial recharge practices, rejuvenation of ponds/tanks, surface water diversion, making awareness to farmers regarding latest irrigation techniques, cropping pattern and financial assistance are essential to this area.

2.16.3 Kannur District

The studies were carried out in Kannur district covering an area of 3000 sq.km. During pre monsoon reconnaitory survey 105 key wells were established to study the groundwater behaviour and simultaneously 60 water samples were collected from both surface and ground water for chemical analysis. Kannur district receives a total annual rainfall of around 3453 mm. Valapattanam, Kuppam, Anjarakandy are the major drainages in the district.

Groundwater occurs under water table condition in the alluvium laterite and weathered crystalline formation and occurs under semi confined to semi-confined condition in the deeper fractured aquifer. The weathered, fissured and fractured crystalline formations, semi consolidated Tertiary formations occurring along the coastal plain, laterite formation and Recent alluvium are the important aquifer systems in the district. The coastal alluvium mostly comprising of sand form potential aquifers along the coast. The thickness of alluvium is generally shallow in that district and DTW of dug wells are generally less than 6.0 m. The yield of wells ranges from 5000 to 25000 lpd.

The Tertiary sediments along the coast and the crystalline formations in the midlands are widely lateritised at top. In the laterites the DTW ranges from 4.0 to 20.0 mbgl in premonsoon period and 1.5 to 19 mbgl in post monsoon period. The water table shows a fluctuation of 1.5 to 6.0 m. The yield of wells ranges from 5000 to 25000 lpd.

The water bearing properties of crystalline formations, which lack primary porosity depend on the extent of development of secondary intergranular porosity either through weathering, fissures and joints/ fractures. Fractured charnockites are more productive than fractured gneisses. The thickness of weathered zone in the district is in the range of 3 m to 20 m with a general thickness of 10 m to 20 m and in weathered zone groundwater is mostly developed by dug wells for domestic and irrigation purposes. In the crystalline formations of the district, depth to water level varies from 4 to 13 mbgl during premonsoon and from 3 to 11 mbgl during post monsoon period. The dug wells located in charnockites vary in depth from 6 to 13 mbgl.

Groundwater exploration carried out by CGWB indicates that the potential fracture zone encountered between 18 to 137 mbgl and the potential zone located along NE-SW; E-W lineaments. The yields of dug wells range from 0.5 to 24.5 lps.

The long term water level fluctuation for the premonsoon period (1996 – 2006) indicates that the water levels are showing a rising trend in about 66 % of the wells analysed and it ranges from 0.005 to 0.428 m/yr. Declining trend of water levels ranging from 0.002 to 0.648 m/yr have been observed in about 34 % of wells in the district. During post monsoon period, rising trend is observed in about 31% of the wells analysed in the district. The rise is in the range of 0.016 to 3.11 m/yr. Declining trend of water levels ranging from 00.052-1.933 m/yr have been observed in about 69 % of wells in the district.

The major ground water abstraction structures of the area are open dug wells, bore wells and shallow filter point wells along the coast. . The dug-cum bore wells are successful in eastern parts of the study area where crystalline rocks are dominant. The number of bore well construction has increased tremendously in the eastern parts of the district in recent years.

The total 35 water samples have been collected from different source of water to find out quality of surface and sub –surface water. The results of chemical analysis reveal that in general the quality of groundwater is good and can be used for drinking, domestic irrigation and industrial purposes. The water quality of water samples from the ground water monitoring stations also reveals that the different parameters are within the permissible limit and can be utilised for domestic and other purposes. There are 34 springs in the district the water is suitable for domestic, irrigation and industrial purposes.

Net Groundwater availability (as on 31.03.2004) in the district is 540.62 MCM. The stage of development in Kannur district is 48.31%.. Seven blocks in the district fall under safe category and two blocks namely Thalassery and Kuthuparambu blocks under critical category.
The groundwater development in Kannur district during 2004 is 48.31 % leaving wide scope for future development. It is recommended that all critical blocks may be given immediate attention for implementing artificial recharge schemes under state and central sectors. Suitable artificial recharge structures to be adopted in the area falling under safe category of groundwater development faces severe water scarcity during lean period of the water availability. Future ground water development may be restricted in Thalassery and Koothuparambu blocks. The census of abstraction structures is necessary for a realistic assessment of the resources.

The urban areas of Thalasserry, Payyannur, Irritty, Mattannur, Thaliparamba and Kuthuparamba are suitable for Roof top rainwater harvesting. The same can also be adopted along high land and rural areas where water scarcity is reported during peak summer. Percolation Tanks in areas with thick laterite patches and areas with highly fractured and weathered rocks.

2.17 UR, DEHRADUN

2.17.1 Pauri Garhwal district

9 blocks of Pauri Garhwal district. The area can be divided into three geological settings viz: 1) Lesser Himalaya, 2) Foot hill Himalaya and 3) Bhabar. The Lesser Himalaya consists of Garhwal Group of rocks having lithology mainly slate, phyllite, quartzite, dolomite and metavolcanics. The Foot Hill Hlimalaya consists of Siwalik Group having lithology mainly sandstone, siltstone etc and the Bhabar consists mainly of boulders, pebbles gravels, sand and silt.

During the course of Hydrogeological investigation a total of 100 hand pumps and 50 springs were identified and measured in pre-monsoon and the same structures were monitored in post-monsoon to know the change in water level and discharge.

The pre-monsoon water level of selected hand pumps ranges from 1.89 to 86.20 m bgl and during post-monsoon the depth to water level ranges from 1.72 to 81.17 m bgl. The present study reveals that only 10.29% of the total hand pumps shows decline in water level and rest of the hand pumps shows rise in water level. The decline in water level ranges from 0 .05 to 0.78 m, whereas rise in water level ranges from 0.10 to 15.48 m.

Springs are the main source of drinking/domestic water in hilly areas of Pauri Garhwal district. Most of the springs are situated at higher altitude, which have been tapped and supply to the villages situated at lower altitude through gravity. Springs discharge measured during pre-monsoon ranges from 0.50 to 126.67 LPM having temperature between 15° and 25°C. The same springs were monitored during post-monsoon and the discharge ranges from 1.25 to 120 LPM. Out of these 14 springs, 28.57% of total springs shows decrease in discharge, which ranges from 1.35 to 6.67 LPM. The increase in spring discharge ranges from 0.67 to 58.75 LPM. Some of the gadheras, which are caused by a group of springs flowing in the lower reaches, have discharge ranging from 60 to 100 LPM and water temperature from 22° to 24°C.

The pre and post-monsoon data of hand pumps and springs reveals that the district shows rise in water level and increase in spring discharge. The quality of water is good and potable, except in one location at Dugadda where the fluoride concentration in spring sample is 3.15 mg/l and at some localized places higher concentration of iron in hand pumps was observed. All the other parameters are well within permissible limit. Overall there is no ground water pollution reported in the district.

Ground Water Development: During the course of hydrogeological investigation, seven valleys have been delineated for future ground water development. These valleys are located near Yamkeshwar, Jogat, Dugadda, Rathwadhab and Dadamandi and at Srinagar and Satpuli.

2.17.2 Pithoragarh District (By Non-Conventional Method)

Hydrogeological studies have been carried out in upper reaches of Munsyari and Dharchula blocks, Pithoragarh district with remote sensing and GIS tools through non-conventional methods with proper ground truths. The area comprises metasedimentary rocks of Proterozoic Period. The main rock types are quartzite, dolomite, phyllite, slate, carbonaceous phyllite, granite gneiss and limestone. The regional trend of the strata is NW-SE with moderate dip towards NE. Several faults and three thrusts are exposed in the area. The main thrust, known as Main Central Thrust (MCT) separates Vaikritha Group of rock from Munsyari Formation. Almora Group is separated from Jaunsar Group by Munsyari Thrust while Berinag Thrust separates Jaunsar Group from Tejam Group.

Satellite data of IRS–1C, LISS–III Image, taken on 18th November 2005 was used. LISS–III sensor of multi spectral

data in 4 bands was used. Shuttle Radar Topographic Mission (SRTM) with Digital Elevation Model (DEM) elevation data of the path 145 and row 39 with 90.0 m resolution. Ancillary data of Survey of India toposheets are used. *ERDAS IMAGINE 9.1* with GIS Arc Map, Arc View, Arc Scene software were used along with portable advanced GPS along with ground truths/field checks. Based on these materials and methodology Structural map, Lineament and Lineament Density map, Slope and Slope Aspect map, Relief map, Geomorphological map, Specific Catchment Area map, Topographic Wetness Index map, Drainage map, Drainage Density map, Water Level map, Land Use/Land Cover map and Groundwater Prospects map have been prepared.

During the course of hydrogeological investigation 15 hand pumps and 16 springs were identified. Water level of hand pumps and discharge of springs were measured both during the pre-monsoon and post-monsoon periods in order to know the change in water level fluctuation and discharge of the springs. Water levels of selected hand pumps in pre-monsoon period range from 2.21 to 35.60 m bgl and that in post-monsoon period it ranges from 1.80 to 33.46 m bgl. The present study reveals that all hand pumps show rise in water level both in pre and post-monsoon periods.

Cold water springs are the main source of drinking/domestic water in hilly areas of Pithoragarh district. Most of the springs are situated at higher altitude, which have been tapped and supplied to the near by villages, situated at lower altitude through gravity system. Discharge of springs measured during pre-monsoon ranges from 2.0 to 20.0 lpm having temperature between 13° and 21°C. The springs were monitored during post-monsoon and the discharge ranges from 3.0 to 24.0 lpm. All these 16 springs show increase in discharge during post monsoon period. 17 representative water samples (6 from hand pumps and 11 from springs) were collected for complete chemical analysis.

Two thermal springs have been inventoried, located at Devibagar (Madkot) and Tapovan. Temperature of spring water ranges from 43ºC to 56ºC. The quality of water is good and potable and no ground water pollution is reported from the study area.

During the course of hydrogeological investigation two valleys have been identified for future ground water development. These valleys are located near Munsyari and Dharchula. There is limited scope for the large exploration activities but there is scope of deploying mini tube wells in the area.

2.18 NHR, DHARAMSHALA

The Ground Water Management studies were carried out in Chamba, Bilaspur districts and area was covered 4167 sqkm.

2.18.1 Chamba District

Ground Water Management studies was taken up in Chamba district comprises of 6528 km^2. The area form a part of lower & middle Himalayas with an average altitude of 600 to 6400m amsl. Topography of the area is rugged with High mountain ranges and deep dissected valleys. The area is mainly drained by the river Ravi & its tributaries which form a dendritic drainage pattern.
During the Ground Water Management studies sampling of 70 springs was carried out in the district and chemical analysis of the spring was also carried out . During the studies, it was found that all 1144 villages have been covered under potable drinking water supply scheme 622 water supply scheme are through springs & Nalas in the upper reaches and 168 lift water supply schemes. Total area under cultivation is 43000 ha. Out of which 5243 ha is under irrigation and remaining area depends on rainfall. Irrigation and Public Health department (I&PH) has drilled about 1000 handpumps in Chamba district with a depth ranging from 45 m to 75 m bgl and discharge varies from 0.01 to 1 lps. The low discharge is due to the formation encountered i.e mostly phyllites, slates. Few borewells are also energized along the tributaries of Ravi river. No deep borehole drilling has been done in the district. The area identified for exploration is Salooni area, Sihunta valley, Udaipur, Kriyan Hatli (Draman area), Banikhet, Chuari valley, Bathri and Sultanpur area.

Water supply scheme in the area depends on springs and springs are dried up due to tunneling below Churi, Basu, Gowad, Malah, Kohadi, Gothnu villages are situated on Chamera-III tunnel. Due to blasting and drilling process, all the perennial springs and Nallahs have dried up due to fractured developed in the formation. The main formation in the area is phyllites and slates. The I&PH were advised to follow rain water harvesting structures & artificial recharge in the area.

Most part of Chamba is underlain by Hard rock formations ranging in age from Paleozoic to Triassic. These older rocks are devoid of any primary porosity. Ground water movement in these rocks takes place through joints fractures and other structural features as a springs. In the younger rocks of Tertiary age & in terrace deposits along the major river & khad, the area can be explored by deploying DTH rigs attached with ODEX system. The I&PH

department has tapped almost all the major springs for water supply schemes and as per the data available 99% water supply schemes are based on springs and nallahs on the upper reaches.

During rainy season, the water supply scheme some times washed away by flash floods effect the water supply. The W.S.S based on lift irrigation defunct during monsoon as the turbidity in the water causes problem in pumping. To overcome the problems, the valley areas along the river nallahs and river terraces can be explored for ground water development in the district.

2.18.2 Bilaspur District

Ground Water Management Studies in district Bilaspur were carried out by covering 1167 sq km .

In all, 34 dug wells, 7 springs and 5 hand pumps were inventoried. 46 No. ground water samples were collected for chemical analysis. Key wells were established and monitoring was carried out during pre-monsoon and post monsoon period. Under exploratory drilling programme of CGWB 3 exploratory wells ranging in depth from 31 to 115 m bgl has been drilled.

Bilaspur district has a diverse landscape made of the hills, valleys with piedmont zone. There are seven main hill ranges i.e. *Naina Devi, Kot, jhanjiar, Tiun, Bandla, Bahaurpur and Ratanpur* constituting the hill system of District Bilaspur. The district is mostly hilly and has no mountains of higher altitude from the mean sea level.

The major river that passes through the middle of the district from east to west is Satluj. The Satluj is joined by several tributaries from both the sides, the main three tributaries are Ali Khad, Gamrola Khad and Seer Khad. The temerature varies from minimum of 5°C in winter to the maximum of 42°C in summer The area receives rainfall during monsoon period extending from June to September and also non-monsoon period (winter). The annual average rainfall in the area is about 720 mm with about 55 average rainy days.

The rock formations occupying the district range in age from pre-Cambrian to Quaternary period. Hydro-geologically, the unconsolidated valley fill or alluvial formation occurs in the valley area, the semi-consolidated sediments belonging to Siwalik & Subathu Group and consolidated Shali formation form the aquifer system in the district. Porous alluvial formation forms the most prolific aquifer systems in the valley area where as the sedimentary semi-consolidated formation form aquifer of low yield prospect. The consolidated formations form the poor aquifer systems. The ground water in the Siwalik & Subathu group rocks occur under the unconfined to semi confined conditions mainly in the arenaceous rocks viz., sandstone, siltstone, shales, gravel boulder beds etc. The occurrence and movement of ground water is controlled by inter granular pore spaces and also the fracture porosity. Siwalik sediments underlie Hilly/undulating areas where springs (mostly gravity/contact type) and *bowries* are the main ground water structures apart from the hand pumps. The discharges of the springs, varies from seepages to 0.50 lps. B*owries* are dug well type constructed on the hill slopes/ nalas for tapping the seepages. In the low lying areas underlain by Siwalik rocks, dug wells and hand pumps are the main ground water structures that range in depth from 3.00 to 25.00 m bgl where in depth to water level ranges from 2.50 to 15.00 m bgl.

In valley areas, the ground water occurs in porous unconsolidated / alluvial formation (valley fills) comprising sand, silt, gravel, cobbles / pebbles etc., & forms prolific aquifer. Ground water occurs both under phreatic & confined artesian conditions. Water logging areas are observed in northern part of Jukhola valley. Ground water is being developed in the area by medium tube wells & dug wells, and also by hand pumps.

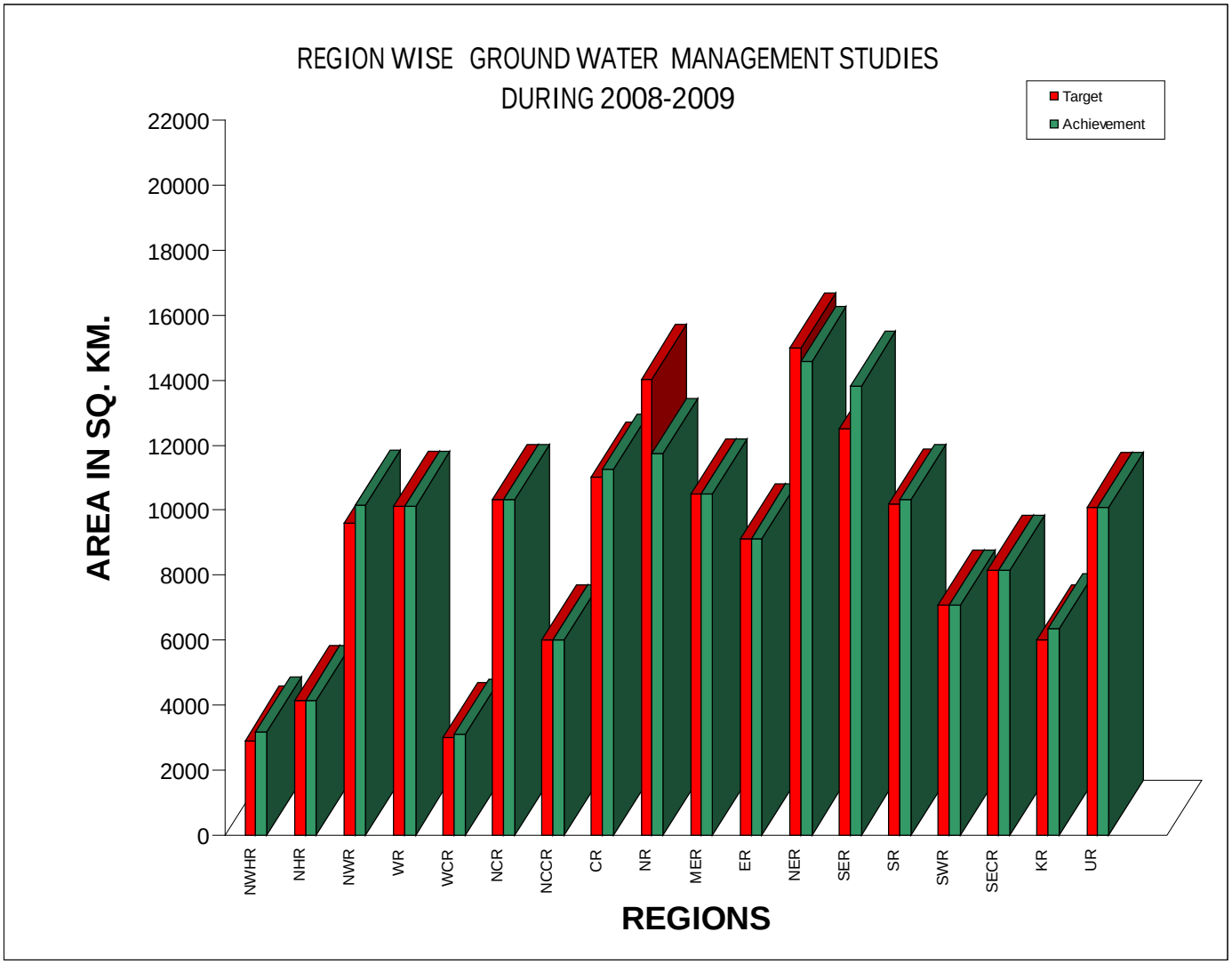
Depth of dugwells ranges from 4.00 to 15.00 m bgl. Yield of shallow aquifer is moderate with well discharges up to 10 lps. Where in depth to water level (DTW) ranges from 0.19 to 14.43 m bgl in pre monsoon period. DTW ranging from near surface to 12.03 m bgl is observed in post-monsoon period. The discharges of the springs range from seepages to 4.375 lps in pre monsoon and from seepages to 6.5 lps in post monsoon period and they are mostly gravity type of springs. Quality of ground water is good and potable with EC less than 965 µS/cm. Quality of ground water in shallow aquifer is good for domestic and irrigation purpose in the district

The district has a hilly terrain having very high slopes. The valley areas are narrow and isolated and therefore not considered for estimation of the ground water resources being discontinuous aquifers. The district being hilly & mountainous, traditional sources of ground water, mainly nallahs & springs have played a major role in providing assured irrigation and water supply. In some of the areas, these are the only sources for the water of the settlements. However modern means for tapping the ground water have been employed in recent years.

During the last 15-20 years, Irrigation and Public Health Department has constructed number of small depth bore

wells fitted with hand pumps in these areas. High hill ranges occupy the more than 95 % of the area of the district. Ground water development on small scale is seen in the valleys areas particularly in the Jukhala valley. Hand pumps have been installed in these areas and are energized for the water supply. There exists a scope to explore the potentialities of rest of the areas for ground water in low lying valley areas. The entire hilly area of the district is feasible for only drilling shallow to medium depth bore wells.

Graph 2.1 Showing Region wise Ground Water Management Studies during 2008-09



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 2008-09 up to 31st March, 2009, 761 wells (EW-404, OW-159, PZ-197, SH-01) have been constructed, against a target of 800 wells. It is heartening to report that out of 761 wells, 537 bore holes , 210 bore holes and 14 bore holes were constricted in hard rock, alluvium and bouldary formation respectively. 139 wells and 200 wells were constructed for exploration in tribal and drought prone areas respectively. The Board has so far drilled a total of 28328 bore holes to identify areas worthy ground water development in the country till March, 2009.

60 wells with discharge ranging from 90 LPM to 3000 LPM have been constructed in the states of Andhra Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh. 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 2008-2009 in the country is presented in Table 3.1 & Table-3.2. Region wise & Division wise status of bore holes drilled during 2008-2008 is shown as Graph 3.1, 3.2 & 3.3 .

Table 3.1 : STATE-WISE WELLS CONSTRUCTED BY CENTRAL GROUND WATER BOARD DURING THE YEAR 2008-2009

SNo	State/UTs	EW	OW	PZ	SH	DW	Total
STATES							
1.	Andhra Pradesh	31	14	32	0	0	77
2.	Arunachal Pradesh	1	0	0	0	0	1
3.	Assam	17	12	0	0	0	29
4.	Bihar	12	4	11	1	0	28
5.	Chhattishgarh	30	16	10	0	0	56
6.	Gujarat	15	10	21	0	0	46
7.	Haryana	0	0	5	0	0	5
8.	Himachal Pradesh	8	0	1	0	0	9
9.	Jammu & Kashmir	14	0	0	0	0	14
10.	Jharkhand	4	2	9	0	0	15
11.	Karnataka	39	16	0	0	0	55
12.	Kerala	11	6	19	0	0	36
13.	Madhya Pradesh	40	13	23	0	0	76
14.	Maharashtra	40	11	4	0	0	55
15.	Orissa	61	12	0	0	0	73
16.	Punjab	5	5	0	0	0	10
17.	Rajasthan	17	5	17	0	0	39
18.	Tamilnadu	10	8	23	0	0	41
19.	Uttar Pradesh	20	14	2	0	0	36
20.	Uttaranchal	1	0	0	0	0	1
21.	West Bengal	22	7	3	0	0	32

	TOTAL(A)	**398**	**155**	**180**	**1**	**0**	**734**
UNION TERRITORIES							
1	Delhi	6	4	14	0	0	24
2.	Daman&Diu	0	0	3	0	0	3
	TOTAL(B)	6	4	17	0	0	27
	GRAND TOTAL(A+B)	404	159	197	1	0	761

Table 3.2 DIVISION WISE WELLS CONSTRUCTED BY CENTRAL GROUND WATER BOARD DURING THE YEAR 2008-09

Sl No.	DIVISION	EW	OW	PZ	SH	DW	Total
1	I- AHMEDABAD	15	10	24	0	0	49
2	II- AMBALA	11	9	19			39
3	III- VARANASI	15	10	0	0	0	25
4	IV- CHENNAI	21	14	23	0	0	58
5	V- RANCHI	16	6	20	1	0	43
6.	VI-NAGPUR	40	11	4	0	0	55
7.	VII-GUWAHATI	18	12	0	0	0	30
8.	VIII- JAMMU	14	0	0	0	0	14
9.	IX-HYDERABAD	31	14	32	0	0	77
10.	X- BHUWANESWAR	61	12	0	0	0	73
11	XI- JODHPUR	17	5	17	0	0	39
12.	XII BHOPAL	40	13	23	0	0	76
13	XIII- RAIPUR	30	16	10	0	0	56
14.	XIV- BANGALORE	39	16	19	0	0	74
15.	XV- KOLKATA	22	7	3	0	0	32
16	XVI- BAREILLY	6	4	2	0	0	12
17	XVII- DHARAMSALA	8	0	1	0	0	9
TOTAL		**404**	**159**	**197**	**1**	**0**	**761**

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

SALIENT FINDINGS OF GROUND WATER EXPLORATION STUDIES

3.1 JAMMU & KASHMIR

Ground water exploration was carried in Jammu & Kashmir State both through deploying the departmental rigs and through outsourcing and 14 exploratory wells were drilled/constructed against the target of 23 EW. This includes four wells in Jammu province and ten wells in Kashmir province. Highlights of Ground Water Exploration in J&K are as follows:

Kathua District

Two exploratory wells were drilled at Nihalpur and Govindsar sites to explore alluvial formations of the outer plain. Drilling was carried down to 112.5 m in Nihalpur-EW and 102 m in Govindsar-EW and wells were constructed up to 103.00 m & 101 m respectively. The total aquifer thickness 36 m & 21 m of granular zones were tapped in Nihalpur and Govindsar exploratory site respectively.

Jammu district

Two exploratory wells were drilled at Upper Mashial and Sunail sites. Drilling was carried out up to 100 m at Upper Mashial and constructed upto 98.50 m, the static water level was 42 m bgl. At Sunail exploratory well site drilling was carried upto 56.40 m with open hole Shankyo drilling rig. The Bore Hole was abandoned due to strucking up of the tubular bit in the bore hole.

Srinagar District

Four exploratory wells were drilled and constructed in Srinagar district. Drilling of exploratory wells was carried up to 37.34 m bgl at Sofi Mohalla to 76.00 m bgl at Upper Athwajan. Static water level ranges from 3.5m at Upper Athwajan to 33.18 m bgl at Upper Ishber respectively. The

exploratory well constructed at Upper Athwajan have shown a very high yield of about 33 lps (high discharge).

Pulwama District

One exploratory well was drilled at Bathyan Zanatrag of depth 98.30 m bgl and the bore hole was abandoned due to non availability of water bearing zones in the sub-surface horizons in the bore well.

Anantnag District

Two exploratory wells were drilled both at Dardkote. The depth drilled ranges from 4.1 m and 19.6 m bgl respectively. The Dardkote-I was abandoned due to hard bouldary formation at shallow depth where as at Dardkote–II the well was constructed to a depth of 15 m bgl tapping the zone of 10.50 to 14.00 m and it recorded free flow discharge of 3 lps (free flowing).

Baramulla District

One exploratory wells was drilled at Sunburn. The drilling was carried out down to the depth of 134.5 m bgl and well was constructed down to 100 m bgl tapping granula horizon between 30 & 97 m depth. The static water level recorded was 1.46 m bgl and its discharge was 9 lps for 0.20m draw down.

Kulgam District

Two exploratory wells were drilled at Manchu and Hanjan with a depth range of 19.6 and 20.6 m bgl respectively. Both the exploratory wells were abandoned due to hard bouldary formations encountered at shallow depth during drilling.

3.2 HARYANA & PUNJAB

Ground water exploration was carried out in Gurdaspur and Jalandhar districts of Punjab and Yamuna Nagar, Panipat and Karnal districts of Haryana. The highlights are as follows:

Punjab:

A total of five exploratory wells and five observation wells were drilled in Punjab State. One exploratory well at village Phangtoli in Gurdaspur district, four exploratory wells and five observation wells at Goraya, Kharal Kalan & Bhatnaura Khurd in Jalandhar district were drilled. The exploratory wells were drilled in the depth range of 93.5 m bgl to 352 m bgl whereas observation wells were drilled in the depth range of 35.80m to 350 m bgl. The sub-surface Lithology comprise of sands, clays and kankar. Well assembly in depth range of 33 to 345 m were designed and lowered in the exploratory wells and observation wells. Aquifers in depth range of 46 – 341 m bgl were tapped in exploratory wells whereas in observation wells aquifer in the depth range of 25 – 340 m bgl were tapped to monitor ground water regime in the area. Depth to water level in the exploratory well Phangtoli (district Gurdaspur) recorded 18.14 m bgl and exploratory wells of Jalandhar district area ranges from 20.60 m to 20.90 m bgl.

Haryana

A total of five piezometers were drilled in the State. Three piezometers at village Babail in Panipat district and two piezometers at village Kairwali in Karnal district have been drilled. The piezometers were drilled down to depth of 209.20 m bgl and were constructed in the depth ranges from 18 m to 204 m bgl. Sub surface lithology consists of gravels, sands and clays. Coarse sand is forms a predominant aquifer material. Aquifers in depth range of 10 – 201 mbgl were tapped to monitor ground water regime in the area. Depth to water level in the area ranges from 10 to 14 m bgl.

3.2.1 Rehabilitation of old and sick Piezometers

Eight old and sick piezometers in Punjab were rehabilitated in AAP 2008-09. The location wise details are as follows:

Sl. No.	Location of PZ
	Punjab
1	Bholath (Deep)/ Kapurthala district, Punjab
2	Bholath (Medium)/ Kapurthala district, Punjab
3	Bholath (Shallow)/ Kapurthala district, Punjab
4	Kapurthala (Deep)/ Kapurthala district, Punjab
5	Kapurthala (Shallow)/ Kapurthala district, Punjab
6	Sulatanpur Lodhi-I/Kapurthala district, Punjab
7	Sulatanpur Lodhi-II/ Kapurthala district, Punjab
8	Nakodar /Jalandhar district, Punjab

3.3 RAJASTHAN

Ground water exploratory drilling operations were undertaken during the AAP 2008-09 and a total of 27 exploratory wells, 04 observation wells and 15 piezometers have been constructed in order to delineate various water bearing formations, their geometry, potentiality, quality aspects, etc. The highlights are as follows:

Bikaner district

1 exploratory well and 3 piezometers were constructed in Bikaner district in Tertiary sandstone and in alluvium and Nagaur sandstone. Depth of the bore holes drilled varies from minimum of 73.50 m to 202.70m having wells contructed depth between 61m and 189m. Static water level ranges from 5.94 to 135.00mbgl and discharge varies from 20 lpm. to 600 lpm. Chemical quality of groundwater is potable to saline having electrical conductivity from 1960 to 5560micromhos/cm at 25°C. Fluoride content has been noticed in range from 1.08 to 9.20mg/l. Iron concentration lies between 0.17 and 1.10 mg/l. Nitrate contents varies from 5 to 82 ppm.

Hanumangarh District

Two exploratory wells, one observation well and two piezometers have been constructed in alluvial formation. Depth of exploratory drilling ranges from 186m to 201m. bgl having depth of wells constructed from 60 to 152mbgl. Depth to water level in the exploration area varies from 6.00 to 21.28mbgl.. Discharge of the wells varies from 200 to 1500 lpm. Ground water is fresh to highly saline having electrical conductivity from 990 to 17540 micromhos/cm at 25°C. Fluoride content has been noticed in range from 0.42 to 1.80mg/l. Iron concentration lies between 0.13 and 1.80 mg/l. Nitrate content varies from 8 to 72 ppm.

Jaipur district

Two piezometers have been constructed in alluvial formation for ground water regime monitoring. Depth of exploratory drilling ranges from 78.40 to 87.60m bgl having depth of wells constructed from 75.50 to 87.60mbgl. Depth to bed rock in the exploration area has been countered between 77 and 87mbgl. Depth to water level varies from 39.85 to 60.19mbgl. Discharge of the wells varies from 30 to 135 lpm. Ground water is fresh electrical conductivity from 590 to 1080micromhos/cm at 25°C. Fluoride content has been noticed in range from 0.10 to 2.00mg/l. Iron concentration at Udaipur Mod has been found 0.11mg/l. Nitrate contents varies from 22 to 35 ppm.

Jaisalmer district

Two piezometers (one in alluvial formation and second in Lathi sandstone) have been constructed for long term ground water regime monitoring. Depth of drilling varies from 173.40 to 186.00mbgl having depth of piezometers constructed between 51.00 and 139.00mbgl. Static water level ranges from 16.17 to 47.57mbgl and discharge varies from 250 lpm to 400 lpm.

Rajsamand district

One exploratory borewells and 1 piezometer have been drilled in phyllite/schist formation. One exploratory borewell converted into piezometer owing to negligible discharge of well for ground water regime monitoring in the area. Depth of drilling/ depth of borewells ranges from 199.00 to 200.80mbgl. Static water level ranged from 9.15 to 43.90 mbgl. Discharge of one bore well at Rajnagar Police lines, Rajsamand is 120 lpm whereas at Nathdwara bore well has been found negligible.Chemical quality of ground water is generally fresh having electrical conductivity from 1610 to 2650 micromhos/cm at 25°c. Fluoride content is very well within permissible limit.

Sikar district

A total of 2 exploratory wells, 2 observation well and 3 piezometers were constructed in unconsolidated alluvial formation. Depth of drilling varies from 56.10 to 102.00mbgl. Depth to bed rock in exploration area has been found in the depth range from 55 to 93.80mbgl. Static water level ranges from 20.35 to 60.00mbgl and discharge varies from 20 lpm to 600 lpm. Chemical quality of ground water is fresh having electrical conductivity variation from 420 to 940 micromhos/cm at 25°c. Nitrate concentration ranges from 6 to 52 ppm. Fluoride content are within permissible limit of drinking water standards and lies between 0.19 and 0.87mg/l . Iron content ranges from 0.08 to 2.04mg/l.

Tonk district

A total of 5 exploratory borewells and 3 observation wells were constructed in consolidated formation i.e. phyllites and schists. Depth of drilling as well as depth of borewells vary from 62.90 to 201.50mbgl. Static water level in the explored area ranges from 2.32 mbgl at Chandali to 16.50 mbgl at Bagri and discharge varies from 120 lpm to 1300 lpm. Exoploratory well at Piplu Ki Dhani has yielded a very good discharge to the tune of 1300 lpm measured during air test. Chemical quality of ground water is fresh to brackish having electrical conductivity variation from 765 to 2850 micromhos/cm at 25°c. Nitrate concentration within permissible limit ranging from 5 to14 ppm. Fluoride content are mostly within permissible limit of drinking water standards and lies between 0.89 and 1.84mg/l . Iron content ranges from 0.61 to 2.46mg/l.

Udaipur district

A total of 4 exploratory borewell and 2 piezometer were constructed in consolidated formation i.e. phyllites, schists and gneiss. Depth of drilling as well as depth of borewells

vary from 193.00 to 200.80mbgl. Static water level in the explored area ranges from 4.20 mbgl at Brahmanao Ki Hundar (Bargaon block) to 34.35 mbgl at Sangath (Bargaon block) and discharge varies from negligible at Barori (Malvi block) to 310 lpm at Jawanji Ka Khera (Malvi block). Chemical quality of ground water is fresh in explored area having EC value ranging from 640 to 1395 micromhos/cm at 25°C except at Rundera (Bhinder block) where ground water has been found highly saline having EC value as 7830 micromhos/cm at 25°C. Nitrate concentration lies within permissible limit ranging from 1.60 to25 ppm. Fluoride content is within permissible limit of drinking water standards and lies between 0.26 and 1.15mg/l . Ground water has been found contaminated with Iron content more than permissible limit having range from 3.10 to 8.72mg/l.

3.4 GUJARAT

Ground water exploration was carried out in the districts of Vadodara, Bharuch, Panchmahals, Rajkot, and Mehsana. The exploration were undertaken in Hard rock formations of south Gujarat (Vadodara, Bharuch & Panchmahals districts) and Saurashtra (Rajkot districts) and also in soft rock formation of Mehsana districts. Piezometer Construction was taken up in North Gujarat Region manly in the districts of Ahmedabad and Mehsana In all 49 (15-EW, 10-OW & 24-PZ) wells have been constructed during the AAP 2008-09.

The district wise salient features of work carried out under ground water exploration programme through departmental rigs are given below:

3.4.1 Ground water exploration in Hard Rock Areas

Rajkot District

The area explored is occupied by the alluvium which is underlain by Deccan traps followed by Sandstone formation of Dhrangadhra & Wadhawan Formation. Deep Exploration was carried out with an aim to explore possibility of occurrence of deep seated aquifers/ Fractures having potable quality and sustainable yield of groundwater in Deccan Trap & Sandstone.

Four Exploratory wells and three Observation wells were constructed in Morbi Taluka of the district with depth range of 150 & 374 m bgl . The depth to water ranged from 5.13 m bgl(Moti Vavdi EW) to 66.18 m bgl (Jetpur OW). The compressor discharge of the wells varied between 90 (Dadashrinagar OW) to 840 LPM (Dadashrinagar EW). The EC values ranged from 530□S/cm (Moti Vavdi EW) to 11760 □S/Cm Brackish (Jetpur EW).

Panam basin covering parts of Panchmahal & Dohad District

Nine exploratory wells and three Observation wells were constructed in Panam basin covering parts of the district of Panchmahal & Dohad. The depth ranged from 135 & 200.7 m bgl. The depth to water level ranged from 2.79 m bgl (Orwad EW) to >150 m bgl (Kakachiya OW). The discharge of the wells varied between 15 (Sarori EW) to 480 LPM (Gothimba EW). The EC values ranged from 460 □S/cm (Boriya OW) to 1960 □S/Cm (Shehra EW).

3.4.2 Ground water exploration in Soft Rock Areas

Mehsana District

Over Exploited area of Mehsana district was explored. The area is characterized by multiple aquifer systems. Groundwater exploration was taken up in Gamanpura village, with the objective to identify mixing of water between aquifer. For this purpose one EW and 3 OW tapping different aquifers were constructed. The explored depth is 450.00 mbgl. The depth of the constructed tube wells varies from 241.00 m (Gamanpura OW-III) to 450.00 m (Gamanpura EW).

The depth to water level ranged from 15.41 mbgl (Gamanpura OW-I) to 125.66 m bgl (Gamanpura EW). The compressor discharge of these wells is ranged from 30 LPM (Gamanpura OW-III) to 120 LPM (Gamanpura OW-I). The quality of groundwater in the well □S/cm 2310 (Gamanpura EW) shallow depth. Deeper well is saline 24250 □S/cm (Gamanpura OW-I).

3.4.3 Piezometer Construction

24 Piezometer were constructed down to the dpth of 191mbgl for monitoring purpose mainly to improve the network in the districts of Mehsana, Gandhinagar, Ahmedabad and coastal district of Jamnagar, Porbandar, Junagadh & UT of Diu. A total of 24 piezometer were constructed. Ahmedabad, Gandhinagar & Mahesana districts form parts of the North Gujarat region and the ground water resources are highly developed. Most of talukas in these districts are OE/critical. Due to overdraft of groundwater the water level in deeper aquifer are declining at alarming rate.

The area is underlain by Alluvium. A multiaquifer system has been established during previous studies. Two major

aquifer units have been identified in the area. The upper unit is mostly unconfined and designated as aquifer 'A'. The lower unit, comprising a few hundred metres of alternating sandy and argillaceous beds, form confined aquifer system and the aquifers has been designated as 'B', 'C', 'D' and 'E' within post Miocene sediments, 'F' and 'G' in the Miocene sediments and aquifer 'H' in the Himmatnagar sandstone (Mesozoic). Aquifer 'A' shows the most favourable hydraulic parameters and contains the best quality of ground water in the vicinity of the recharge zone in the northeast. It deteriorates towards southwest. The same trends noticed in the confined aquifers also.

3.5 MADHYA PRADESH

Ground Water Exploration has been undertaken by constructing 40 EW, 13 OW & 23 PZ (Total-76 wells) in Betul, Mandla & Dindori & Sagar districts of Madhya Pradesh. District wise summarized details of Ground Water Exploration in the State are as follows:

Betul District:

During exploration in Betul district maximum drilling was done at 274.5 mbgl at Chandora and Masod site. Shallow drilling was done at 61.0 mbgl at Sawalmendha and Bheainsdehi (pz) for the construction of shallow piezometer. Water level ranges from 10 mbgl (Amla) to 112.80 mbgl (Bhainsdhi) . Yield of exploratory wells ranges from 0.75-24 lps.

Mandla district:

Mandla district is covered mostly by basaltic lava flows underlain by granite (basement rocks). Along the course of Narmada river near Khad Devra, it is covered by alluvium while in some isolated patches near Madhopur, Lametas are exposed followed by granitic basement. The lametas are highly potential and the exploratory drilling carried out at Madhopur yielded good discharge. At Bahchera Dona the lametas encountered at the depth of 110 m bgl is yielding good amount of water. Basalts and granites in the district form poor aquifers.

Dindori district:

During exploration work carried out in Dindori district maximum drilling was done at Dhanmasi & Vikrampur site upto 204 m bgl in basalt formation. Shallow drilling was done at Gadasarai upto 61 m bgl for the construction of shallow piezometer. Water level found ranges from 52.25 m bgl (Shahpur) to 5.00 m bgl (Amadongar). Yield of exploratory wells ranges from 3 m^3 /hr –24.66 m^3 /hr.

Sagar District:

During exploration work carried out in Sagar district maximum drilling was done at 185.10 mbgl at Banda site in Basalt/ Vindhyan sandstone. Shallower drilling was done at 48.0 mbgl at Surkhi (Pz) for the construction of piezometer. Water level drilled from 8.35 mbgl (Banda) to 53.20 mbgl (Surkhi). Yield of exploratory wells ranges from 13.2- 624 lpm.

3.6 CHHATTISGARH

Under exploratory drilling programme, 56 wells were drilled, out of which 28 were exploratory wells (EW), 18 were observation wells (OW) and 10 were piezometers (PZ). District wise Summarized details of ground water exploration are as follows:

Kanker district

In Kanker district, 16 wells were drilled in the depth range of 31-202 m. The District is covered with granite and gneiss of the Archaean age. The weathered mantle formed the potential aquifer in the area. Ground water occurs under unconfined conditions in weathered mantle and semi confined to confined condition in fractured zones, potential zone recorded at 22-23, 34-35, 43-45, 60-63, 125-130 m bgl and yield varies from 0.4 to 14 lps with a maximum draw down of 30 m. In four places (Pataud,Karap,Chhilati and Sirsida) observation wells are constructed for demarcation /extension of potential aquifer and assessment of aquifer parameter

Dhamtari District:

In Dhamtari district, 13 wells were drilled in hard rock area in the depth range of 27-200 m. Most of the part of Dhamtari district is covered by the rocks of Chhattisgarh Supergroup, which mainly consist of limestone, shale and sandstone. Weathered zone encountered down to 75 mbgl. Yield of the formation is moderately good, fractured zones observed at depth of 21-24, 35-40, 50-58, 78-80,145-155m bgl. Lower Charmuria formation formed potential aquifer in the area, for demarcation of cavernous zones observation wells are constructed at four sites.

Surguja District:

In Surguja district, 17 wells were drilled in hard rock area in the depth range of 47 – 202. The depth of aquifers in granite varies between 22 m to 119 mbgl.but generally the aquifers are within 50 m depth. At Dadgaon the weathered thickness was encountered down to 50 m. which was

followed by a fractured zone between 54 -58 m bgl and has yielded 3 lps discharge .A minor fracture between 115-119 has also contributed some yield. At kunni the weathered thickness is encountered down to 23.94 m but the aquifer is encountered within 43 and 52 meters in granite. This fractured granite has yielded 3.22 lps water. In granite the general discharge of phreatic aquifer (weathered granite) varies from 0.80 to 1.00 lps. Aquifer encountered in granites, just below the weathered mantle or within the massive granite down to 52 metres has comparatively yielded good water in the range of 1 - 5 lps for a draw down ranging between 22.76 and 33.74 m. Minor deep fractures encountered at 98 meter in kakna and between 115-119 in Dadgaon has yielded a little water. Static water level in granites varies between 3.00m bgl and 11.62 m bgl.The values of transmissivity ranges between 0.95 m2/day to 30 m2/day.

Korba District:

In Korba district, in the Barakar formation ten piezometers were drilled in the depth range of 50-150 m to study the behaviour of phreatic confined aquifers and effect of the coal mining. The formations encountered and tapped during drilling is sandstone of Barakar formation. In general three wells were constructed in each site ,tapping different aquifer of the Baraker Formation. Exploration data of existing bore wells drilled in the area marked presence of potential granular zones below 100 mbgl, yield varies from 0.5 to 4.55 lps with a draw down of 30m. Potential zones observed at depth of 30-40, 50-70, and 110-120.

3.7. MAHARASTHRA

Ground Water Exploration has been undertaken in Maharsthra and constructed 40 EW, 11 OW & 4 PZ, a total of 55 wells in the district of Amravati, Buldhana, Beed, Parbhani, Satara and Raigarh, Thane districts.

3.7.1 High Yielding wells

District-wise break up of High Yielding Bore wells in Hard Rocks

Out of 55 exploratory wells drilled, 13 EW's (about 23 %) have yielded more than 3 lps. The district-wise break up of high yielding bore wells is given in Table

DISTRICT-WISE SUMMARIZED DETAILS OF GROUND WATER EXPLORATION

Sl.No.	Salient Features	Amravati and Buldhana	Beed / Parbhani	Satara	Raigarh & Thane
1	No. of Exploratory Wells	8	11	12	9
2	Depth range (m.bgl)	300.00-300.30	122.10-200.00	160.00- 200.00	84.00 – 200.00
3	Depth of casing (m.bgl)	3.50-61.00	6.60-18.30	5.80-10.10	4.70 - 11.70
4	Number of zones encountered	1 to 4	2 to 3	1 to 4	1 to 2
5	Thickness of individual zone (m)	2 to 3	3 to 4	1 to 3.10	0.90 to 2
6	SWL range (m.bgl)	35.00 to 40.00	3.40 to more than 100m bgl	1.80 to 74.50	3.80 to more than 100
7	Yield range (lps)	0.01 to 2.15	Traces to 5.80	Traces to 4.77	Traces to 12.18
8	No. of EW's with yield > 3 lps	-	5	1	5
9	EC range (micromhos/cm)	1710-3700	500 to 1680	-	-
10	Formation	Alluvium	Basalt	Basalt	Basalt

DISTRICT-WISE BREAK UP OF HIGH YIELDING BORE WELLS IN HARD ROCKS

S.No	District	No. of EW Drilled	No. of EW with yield > 3 lps	% of High yielding EW	Depth Range (m. bgl)	Yield Range (lps)
1	Amravati and Buldhana	8	-	-	-	-
2	Beed / Parbhani	11	5	45 %	146.00-200.00	-
3	Satara	12	1	8 %	166.00	-
4	Raigarh & Thane	9	3	33 %	147.00-200.00	-

3.8 UTTAR PRADESH

Ground Water Exploration has been taken up in Lakhimpur Kheri, Ballia, Agra, Allahabad, Varanasi, Pratapgarh, Chitrakut, Mirzapur, Sonbhadra,Bagpat & Muzaffarnagar district of U.P and constructed 20 EW, 14 OW & 2 PZ(Total-36 wells). District wise Summarized details of Ground Water Exploration in the State are as follows:

Lakhimpur Kheri District

To mitigate the problems arising due to Arsenic contamination in ground water at sporadic spots in the villages of the district, 2 Exploratory wells namely Persia and Gadania have been drilled upto the depth of 357.00 to 361.00 m bgl for delineation of aquifers with arsenic free formation water for safe drinking water supply. Geologically the area is underlain by Quaternary alluvium consisting of clay, kankar, sands of various grades & gravels in different proportions. The results of exploratory drilling carried out down to the depth of about 450 mbgl indicate the existence of mainly three tier aquifer system in the district. The ground water occurs under water table condition in shallow aquifer and in deeper aquifer it occurs in confined condition.

Baghpat District

The district falling in part of Central Ganga plain, occupies part of interfluvial belt of Ganga-Yamuna doab in the extreme western part of the State. The district is underlain by a thick pile of alluvial sediments of Quaternary age. The unconsolidated sediments largely constitute sands of various grades, clays and kankar (calcareous nodules). The unconsolidated sediments have been deposited by the major drainage system of Yamuna and Hindon rivers.

For delineation of aquifer system, assessment of potentiality and sustainability of underutilized deeper Aquifer (Ganga-Yamuna doab the expl;oratory drilling has been undertaken at Baghpat down to the depth of 390 mbgl. It was observed that below 90 mbgl the quality of ground water is saline/brakish

Ghaziabad District:

For delineation of Aquifer system assessment of potentiality and sustainability of underutilized deeper aquifer (Ganga Yamuna doab) the exploration was taken up at Hapur disttt. Ghaziabad and tapped the middle aquifer between 208.00 mbgl to 344.00 mbgl. At Hapur a long term pump test conducted for 4000 minutes (steady state condition) at a constant discharge of 2200 lpm. The quality of water is good but the presence of arsenic in the deeper aquifer ranges 12 to 23 microgram/lit which is beyond permissible limit co per WHO & BIS.

Ballia District

To mitigate the problems arising due to Arsenic contamination in ground water at sporadic spots in the villages located mostly in Recent flood plain of Ganga and Ghaghra rivers, exploration in Balia district was undertaken for delineation of aquifers with arsenic free formation water for safe drinking water supply. During current AAP 2008-09, 2 Exploratory wells namely Adampur and Belthra Road and 4 observation wells have been drilled. The depth of well ranges from 350.00-359.50 m bgl.

Pratapgarh District

The area falling under central Ganga plain is underlain by thick piles of sediments belonging to Quaternary alluvium. The results of exploratory drilling taken up by CGWB reveal that broadly three tier aquifer system exist in the area to the maximum depth of drilling of 608 mbgl. The ground water occurs under unconfined to confined conditions. 1 Exploratory well & and 1 observation well at Kushphara have been drilled. The depth of well ranges from 201.0 0 m bgl and well constructed down to the depth of 198.00 mbgl.

Varanasi District

Exploratory wells namely Naria is constructed. The depth drilled is 199.70 and well constructed is 193.00mbgl .

Allhabad District

The area is characterized by the two distinct morphological units .The first Ganga alluvialplain unit occupying trans – Ganga area in the north of the Ganga –Yamuna doab area, and the second hard rock unit occur in trans Yamunaarea in the south. 2 Exploratory wells namely Chand Khamariar and Belthra Road and 4 observation wells have been drilled. The depth of well ranges from 350.00-359.50 m bgl.

Chitrakoot District

The geological setup of the area is mostly characterized by marginal alluvium of Quaternary age ,rewa sandstone and Trioham limestone. The basement pf the area is mostly madeup of Bundelkhad Granite gneiss. The overburden is maximum in Rajapur area where it is nearly 45 to 50 m thick whereas in Karvi area it is 37 to 40m thick. 4 Exploratory wells and 3 no. s of osbservation wells have been drilled. The depth of well ranges from 105.00 to 154.00 m bgl.

SUMMARISED DETAILS OF AQUIFER PARAMETER TEST RESULTS

S.No	District	Location / site	Discharge (LPM)	Draw down	Duration (Minutes)	Specific capacity (lpm/m)
1.	Chandauli	Chakia	908	2.20	300	412.72
2.	Chandauli	Helimpur	726	0.62	300	1170
3.	Chandauli	Amra	1198	1.74	300	594
4.	Mirzapur	Banki	506	2.06	300	217
5.	Sant Ravidas Nagar	Suriyawan	1200	2.56	300	469
6.	Lakhimpur	Trilokpur	1596	12.34	500	137
7.	Gaziabad	Hapur	2200	2.65	4000	154.93

Agra District

The area is mainly underlain by Quaternary Alluvium of Ganga –Yamuna rivers.The sand,gravel ,kankar of Quaternary Alluvium and the upper weathered portion of the basement provides the framework for the aquifer system. 3 Exploratory Aulendra & Akola wells and 2 no.sof observations, wells have been drilled. The depth of well ranges from 93.25 to120.00 m bgl.

Muzaffar Nagar District

In Muzaffar Nagar district the formation encountered is Quaternary alluvium comprising sand,clay & kankarin varying proportions. one piezometer was constructed namely khanjahanpur.

Mirzapur District

Geomorphologically the district can be divided into two Northeren flat ganga (marginal alluvial tract) and Southeren hilly region.4 exploratory and 2 observation wells were constructed.

Sonebhadra District (D)

In the district, the alluvial plains are underlain by thick pile of consolidated sediments down to the depth of basement which varies from 50 m to 204 mbgl (Drilled by CGWB). The rock types in hard rock terrain are sand stone & shales belonging to vindhyam formation. A multiple fracture encountered down to 150 m bgl in exploratory wells from promising ground water zones in hard rock terrain.

3.9 UTTARAKHAND

Ground Water Exploration has been undertaken by constructing 1 EW in Dehradun district of Uttarakhand. One well Hardwar district was under progress as on 31-03-2009. During 2008-2009, drilling of two exploratory wells was continued - one well at Bhagwanpur, Sahaspur block, Dehradun district and another well in Industrial Area, Hardwar district. In Bhagwanpur site, drilling was carried out down to a depth of 175.10 m bgl (as on 31st March 2009) .The discharge of the exploratory well was found to be 63 LPM or 3.78 m^3/hr. Geophysical logging of the borehole was conducted. A total of seven potential zones were deciphered at: 34.00 to 37.00, 44.00 to 53.00, 60.00 to 64.00, 76.00 to 80.00, 88.00 to 96.00, 109.00 to 113.00 and 130.00 to 138.00 m bgl having thickness varying between 3.0 to 9.0 m. Subsequently, the well assembly was recommended and the well has been constructed.

Besides this, the construction of Exploratory Well at Industrial Park, Haridwar district was continued. As on 31st March, 2009 the drilled depth was 125.0 m.

Sl No.	District	Depth Drilled (m)	Zones Tapped/Fractures Encountered(m)	SWL (mbgl)	Discharge (m^3/hr)	Formation
1.	Dehradun	175.10	89 – 95 109 – 113 130 – 136	80.80	3.78	Boulder Bed, Doon Gravels

3.10 BIHAR & JHARKHAND

Ground Water Exploration has been undertaken by constructing 16 EW, 6 OW & 20 PZ, total-42 wells in Bihar & Jharkhand state. District wise Summarized details of Ground Water Exploration in the State are as follows:

BIHAR

Ground water exploration in Bihar has been carried out to study the natural contamination of aquifer/fractures with arsenic in alluvial formation and fluoride in hard rock formation. In alluvial formations the exploratory drilling has been undertaken in one each in Samastipur/Begusarai and Saran districts, which drilled 4 Exploratory wells and 11 peizometers.

The peizometers have been drilled for assessing arsenic concentration in ground water of aquifers disposed at various depths. It has been observed that the aquifers are affected with arsenic down to a depth of 60 m (considering max. permissible limit as 50 ppb).

The exploratory wells have been drilled up to depth of 250m bgl with an objective to tap sufficient thickness of arsenic free aquifers for drinking water supply in the Arsenic affected localities. The aquifers are potential and very high yielding.

In fluoride affected areas of Jamui and Munger districts wells have been drilled in hard rock formations (mainly Pre-cambrian granite gneiss) up to a depth of 178 m. A total of 08 EW, 04 OW and 1 Slim hole have been drilled with an objective to tap fluoride free fractures so that the wells are used for drinking water supply to the affected localities. High discharge wells (>5 lps) have been drilled at villages Lilmi and Numer in Jamui district. The potential fractures have been encountered at 71-73 and 96-99 at Lilmi and at 39-42 m at Numer

JHARKHAND

Ground water exploration has been carried out in the unexplored tribal areas in parts of Simdega and Ranchi districts of Jharkhand. A total 04 Ews, 02 Ows and 9 PZ's have been drilled in tribal area Simdega and Ranchi districts of Jharkhand.

High discharge wells have been drilled at Joram (EW) in Simdega district (12 lps) and Deepatoli Cantonment (PZ) in Ranchi district (30 lps) in Ranchi district. The potential fractures have been encountered at 75-77 and 115-120 m at Joram and at 47-50 m at Deepatoli Cantonment.

In Ranchi urban area 09 piezometers have been drilled to study the temporal variation in piezometric level of fractures located at various depths. The objective of exploration is to study impact of urbanisation on existing ground water regime.

3.11 WEST BENGAL

Ground Water Exploration has been taken up in Darjeeling, Koch behar Dakhshin Dinajpur, Hugli, Haora North 24 Parganas, South 24, Malda, of West Bengal and constructed 22 EW , 7 OW & 3 PZ (Total-30 wells)

3.11.1 Highlights of Exploration in the State

Highlights of Exploration in the State of West Bengal are give n in table-

AQUIFER PARAMETERS OF EXPLORATORY WELLS IN BIHAR

Sl.No.	Locations	District	SWL (m bgl)	Discharge (m^3 /hr)	Draw down (m)	T (m^2/day)	S
1.	Madudabad	Samastipur	5.64	208	3.71	9002	$0.99x10^{-2}$
2.	Vidyapati Nagar	Samastipur	3.77	56.77	5.78	1247.51	$3.5x10^{-6}$
3.	Kancha	Samastipur	3.62	73.8	4.28	2702.94	$1.02*10^{-2}$
4.	Magahi	Jamui	4.00	5.4	18.20	9.98	
5.	Sandipi	Jamui	6.40	4.32	16.75	4.2	$7.8x10^{-3}$

HIGHLIGHTS OF EXPLORATION IN WEST BENGAL

Sl. No	District	Depth drilled (mbgl)	Zones tapped / fracture encountered (m bgl)	SWL (m bgl)	Discharge in m3/hr	Draw down (m)	Aquifer Parameters (T & S)	Formation
1.	Darjeeling & Jalpaiguri	Within 110 mbgl	i) Cumulative granular zones tapped in the depth span of 37-75 & 92-104 mbgl	1.39 – 1.65	25-90	Around 15 m (after 360 minutes of pumping)	T: 75 m^2/day	Bouldary Formation
		upto 161 mbgl	ii) Granular zones tapped in the depth span of 74-104 & 107-131 mbgl		45-65 (C)			Alluvium
2.	Kochbehar	Mekhliganj block: within 200 mbgl	98-104, 151-175	3.13	38	4.47	T: 666 m^2/day / S: $4.45x10^{-4}$	Alluvium
3.	Dakshin Dinajpur	Gangarampur block 221 mbgl	Cumulative granular zones tapped in the depth span of 176-203 mbgl	3.93	6.50 (C)			Alluvium
		Tapan block 200 mbgl	i) 52-60 ii) Cumulative granular zones tapped in the depth span of 122-161 mbgl	ii) 7.20-7.80	i) 11.70 (C) ii) 33.0 (C)			Alluvium
4.	Hugli	Jangipara block within 75 mbgl	28-58	6.25	50-86.40 (C)			Alluvium
		Pandua block Within 91 mbgl	35-52, 63-84	15.50-16.60	36-68 (C)			
5.	Haora	Bagnan-II blocks within 243 mbgl	182-188, 195-207, 226-232 Cement sealing done against clay layer in the depth span of 135-138 mbgl		11.0 (C)			
6.	North 24 Parganas	Amdanga block i) within 60 mbgl ii) upto 312 mbgl	i) 45-59 ii) 145-175 cement sealing done against clay layer in the depth	i) 6.89 ii) 11.50	i) 43.20 (C) ii) 65.40 (T)	i) Not yet tested ii) 2.07 m (after 400 min of pumping)	i) - ii) T = 6680.07 m^2/d S = 2.588 x 10^{-4}	Alluvium

Sl. No	District	Depth drilled (mbgl)	Zones tapped / fracture encountered (m bgl)	SWL (m bgl)	Discharge in m3/hr	Draw down (m)	Aquifer Parameters (T & S)	Formation
			span of 78-81 mbgl					
		Barasat-II i) within 60 mbgl ii) within 165 mbgl iii) within 304 mbgl	i) 46-58 ii) Cumulative granular zones tapped in the depth span of 130-163 mbgl with cement sealing between 79 & 82 mbgl iii) 194-212, 256-262 & 275-281 mbgl with cement sealing between 177-180 mbgl	i) 4.39 ii) 5.27 iii) 2.92	i) 57.60 (C) ii) 57.60 (C) iii) 75.60 (C)			Alluvium
7.	South 24 Parganas	Budge Budge – I & II blocks i) within 90 mbgl ii) within 327 mbgl	i) 53-65, 76-88 mbgl ii) 228-264 mbgl with cement sealing against the clay layer in the depth span of 184-193 mbgl.	i) 5.59 - 13.09 ii) 7.28 - 9.10	i) 18-29 (C) ii) 90-169 (C)			Alluvium

3.12 NORTH EASTERN STATES (ASSAM, ARUNACHAL PRADESH)

Ground Water Exploration has been undertaken by constructing 18 EW, 12 OW (Total-30 wells) in Barpeta, Lakhimpur, Dhubri & Kamrup in Assam and West Kameng district in Arunachal Prdaesh. District wise Summarized details of Ground Water Exploration in the State are as follows;

Barpeta District, Assam:

Ground water exploration was confined to southern part of the district with construction of 5 EW and 5 OW. Depth of drilling was within 41 –204m. Formation encountered belong to Alluvium of Recent toSub-Recent age and comprise clay, silt, sand gravel, pebble , cobble and associated boulder. Wells constructed record piezometric level within 5 mbgl, discharge 28-53 m^3/hr, drawdown < 2m , transmissivity – 4284 m^2/day, hydraulic conductivity 38 m/day, storage co-efficient 7.9X 10^{-3} and specific capacity 443 lpm/m.

The exploration has revealed that the area posses potential aquifer of homogeneous type sediments and Deposition of sediment is in normal sequence, the lithofacies variations are common.

Kamrup District, Assam:

Ground Water Exploration was confined to southern valley tract, north of Brahmaputra river. Drilling was confined within depth range of 189-200m in Recent to Sub Recent age Alluvium. Hydrogeological conditions and depositional environment posses similar conditions with Barpeta district. However, towards fringe area with inselburg / hill, predominance of clay is marked. In south of Brahmaputra in hard rock area of Archaean and Pre Cambrian age in Greater Guwahati in Eastern part 2 exploratory bore wells were constructed within range of 105-141.95m depth in valley fill shallow pediment of granite gneiss rock . Development of low to medium potential fractures were encountered within explored depth with discharge of 0.87-3.3 lps (5-20m^3/hr), piezometric levels rest within 6-7 mbgl, pumping test of one well at 1.6lps (100lpm) incurred draw down 1.9m and specific capacity 52.63 lpm/m

Lakhimpur District, Assam:

Exploration in vast flood plain of Lakhimpur district was carried out down to 135.5m depth comprising clay, sand, gravel of Recent to Sub Recent age. The depositional sequence implies environment for normal homogenous sedimentation. Hydrogeological parameters obtained are swl-2.34 mbgl, discharge 720 lpm (12 lps), draw down 4.41m, T 3607 m^2/day, k 150.3 m/ day, specific capacity 160 lpm/m. Discharge calculated at 6m draw down is 1210 lpm (20lps). Area proves to posses high ground water potential

Dhubri district, Assam:

Exploration in Alluvial formation of Recent to Sub Recent age in Dhubri district with construction of 6 EW , 3 OW by Rotary rig down to depth range 22 –102.37m . Drilling has proved deposition in shallow pediment surrounding scattered denuded inselberg / hill of Archaea and Pre Cambrian rocks. Occurrence of coarser sediments comprising gravel, pebble, cobble with sand and minor clay are believed to have derived from crystalline rock. Bed rock of granite gneiss was encountered at 51 m depth at one location NNE of Dhubri Town (about 35 Km distance). Wells constructed reveal water levels with in 3-5 m bgl, discharge 20-30 m^3/hr (Air Comressor), draw down within 2-3 m. The area is found to hold medium to high potential for ground water.

West Kameng District, Arunachal pradesh :

The foot hill area of West Kameng district of A.P adjoining to Assam comprises sediments of Recent to Sub Recent Alluvium and Upper Tertiary Semi-Consolidated formation. A well was drilled by deploying Percussion Rig down to 99.8 m depth. The lithology depicts alluvium upto 54 m followed by semi consolidated rocks of sandstone / shale. The well constructed shows swl 3 m bgl, discharge 197 lpm (Air Compressor)

3.13 Andhra Pradesh

Ground Water Exploration in Andhra Pradesh has been undertaken by constructing 31 EW, 14 OW & 32 PZ (Total-77 wells) in Karimanagar, Nizamabad, Mahabubnagar, Prakasam, Guntur & East Godavari district. District-wise Summarised details of Ground Water Exploration in the State are as follows:

Prakasam District

11 Exploratory Wells and 3 Observation Wells were drilled in Prakasam District during the AAP 2008-2009, covering the Mandals Korisapadu, Yeddanapudi, Santhamaguluru, Addanki, Ballikuruva, Mundlamuru, J. Panguluru and Martur. The area is underlain by granites and granite gneisses of Archaean age. The depth range of the wells varied from 62-200 m and the discharge ranges varied from 0.215 to 10.12 lps. The thickness of weathered mantle ranges from 6.0-15.0m. Most of the potential aquifer zones are found between 30 and 50 m depth. Static water level varies from 0.6 to 5.55 m and transmissivity values ranges from 5.99 to 219.68 sq.m/day. The results of the chemical analysis indicate that the water is suitable for drinking and domestic purposes.

In addition, 5 piezometers in Prakasam were constructed. About 3,000 sq.km area is proved to be potential and ground water worthy in the Mandals of Addanki, Sanathamagalur, Martur and J. Pongaluru of Prakasam district

East Godavari District

At Amalapuram in East Godavari district a well field was constructed down to 100 m bgl delineating three aquifers. The first aquifer extends upto 18 m, the second aquifer occurs in between 20 and 62 m and the third aquifer occurs in between 66 and 95 m. Three exploratory wells were constructed one in each of these aquifers. Piezometer nest is being constructed to use as observation well in the pumping tests to compute the aquifer parameters of each of the aquifers. As far as quality is concerned, only the top aquifer is fresh and the other two deeper aquifers are brackish.

Guntur District:

Exploratory Wells, 3 Observation Wells in Guntur District, covering Piduguralla, Dachepalli and Macherla mandals

covering an area of 1023.98 sq.km. The area explored is underlain by limestones, shales of Cuddapah Group of rocks. The total depth of Exploraotry Wells ranged upto 132.60 m. The discharges of the wells ranges from 0.45-7 lps. Very high yields are recorded in Piduguralla, Guttikonda Exploratory Wells with 17 lps and 9 lps, respectively. It is observed that high yields are associated with limestones/quartzite intercalations.

Six purpose built piezometers are constructed in three mandals for strengthening ground water monitoring data base.

Karimnagar District:

In all, 13 Piezometers were drilled to decipher the water levels of shallow aquifers where dug wells were dried up. The piezometers sites were selected in consultation with Ground Water Department. The site locations were mutually integrated with the GWD Pz network and are the representative of the area and hydrogeological horizon. The depth of piezometer wells ranged from 16 to 70 m. Fractures were encountered within the depth range of 11 to 30 m bgl. The discharges of the wells are ranged upto 2.11 lps.

Mahabubnagar District:

In order to estimate specific yield under Ground Water Resource Estimation Studies, During the Annual Action Plan 2008-2009, 8 Exploration Wells, 1 Observation Well and 1 Piezometer were drilled by tapping the different aquifer zones in three wel field sites. The area is underlain by Granite gneisses of Archaean age. The depth of the exploratory wells ranges from 26 to 100 m and the depth of peizometer is 100 m. Major potential zones were encountered from 30 to 50 m with varying discharges of 2.16 to 6.81 lps.

3.14. ORISSA

Ground water exploration was undertaken in in the hard rock areas of Deogarh, Nuapada, Boudh, Mayurbhanj and Sundargarh districts and in the alluvial tracts of Jajpur and Cuttack district by constructing 61 EW, 12 OW(Total-73 wells). The district wise highlights of exploration are as follows:

Angul/Deogarh District :

In the Angul district one exploratory well and one observation well at Khamar , Pallahara block was drilled. In the Deogarh district, 11 exploratory wells and 2 observation well was constructed during 2008 - 09. The major formation encountered are granite, granite gneiss and sandstones. The depth of drilling varies from 50.9 metres below ground level in Thianal, Barkote district to 177.2 metres below ground level at Khamar, Pallhara district of Angul with the overburden depth ranging from 6.3 metres below ground level at Pafand of Deogarh to 30.9 metres below ground level at Mandasila, Barkote. The water bearing farcture-zones have been encountered from 12.25 to 140 mbgl. The static water level varies from 2 metres below ground level at Phafand to 6.3 metres below ground level at Saida. The cumulative discharge varies from 0.5 lps at Saida(Badinali), Barkote to 8 lps at Badakudur. The net drawdown varies from 13.2 to 28.25 m.

Boudh District :

In Boudh district, 15 exploratory wells and 2 observation wells have been drilled during 2008 – 09. The depth of drilling varies from 69.10 metres below ground level at Kelakata,Harbhanga Block to 180.0 metres below ground level at Manmunda, Kantamal Block. Formation encountered are mainly granite, granite gneiss, granodiorite and basic rocks. The depth of overburden varies from 6 metres below ground level at Padmanpur ii to 18.2 metres below ground level at Erda. The yield of the wells varies from 0.5lps at Mundipadar to 3 lps at Bandhapadar & Maneswar. Two to three sets of saturated fractures zones exists within a depth of 120 metres below ground level. The static water level varies from 168 metres below ground level at Bandhapadar to 8.2 metres below ground level at Padmanpur ii. The transmissivity values varies from 0.95 m^2/ day at Padmanpur to 11.89 m^2/ day at Bandhapadar.

Jajpur/Cuttack District :

In the alluvial terrain of Cuttack district, only 61 exploratory well and 1 observation well have been drilled at Nischintakoili and Mahanga blocks. The depth of drilling is 83.23 metres below ground level at Koudakol to 219.17 at Taratsaason. Formation encountered are alternate layers of sands and clays with occasional presence of thin semi consolidated arenaceous and calcareous materials. Sand and gravels are very fine to coarse in texture, angular to sub-angular and sub-rounded in shape with moderate sorting. These are mostly quartzo-feldspathic in composition with ferruginous concretion at shallow depths. On an average three to four sets of granular zones are encountered .The water bearing zone encountered at 45 metres below ground level to 130 metres below ground level . The discharge measured there is 15 lps.

Nuapada District :

In Nuapada District,3 Exploratory wells have been drilled during 2008–09. The depth of drilling varies from 104.77 metres below ground level at Dumerpani to 190.35 metres below ground level at Nuapara Hospital & Nuapada College Station. Formations encountered are granite, granite gneiss and its variants. The depth of overburden varies from 5.10 metres below ground level at Khariar Road Police Station to 39.6 metres below ground level at Nuapara Hospital. The yield of wells varies from 0.5 lps at 0.35 at Nuapada Hospital to 1 lps at Nuapada Police Station. The static water level varies from 2.1 metres below ground level at Nuapada Police Station to 4.26 metres below ground level at Khariar Road Police Station.

Sundargarh District :

In Sundargarh District, 14 Exploratory wells and 3 observation wells have been drilled during the year 2008–09. The depth of drilling varies from 38.2 metres below ground level at Pithbhuin to 172.4 metres below ground level at 6 wells at different locations. Formation encountered are mica schist, granite and sandstone. The depth to overburden varies from 7.7 metres below ground level at Navodaya Vidyalaya to 24.75 at Remda. The yield of the well varies from 0.2 lps at Mundagaon to 7.5 lps at Pithbhuin and Pandherpally. Mica schists have poor yields. Granite and granite gneiss have poor to moderate yields and yield is higher where granites are intruded by pegmatite veins. In general two saturated fracture zones within 100 metres below ground level are of most common occurrence. At Kustuna SWL is 0.4 AGL ie Autoflow well. The maximum is 12. 5 metres below ground level at Govt. Womens College. The drawdown values varies from 0.35 metres at Pithabhuin to 36.23 metres at Karla.

Mayurbhanj District :

In Mayurbhanj district 11 Exploratory wells and 3 observation wells have been drilled during the year 2008-09. The depth of drilling varies from 55.9 metres below ground level at Jamdiha, Kaptipada to 196.2 metres below ground level at Nuagaon. Formation encountered is mostly granite gneiss. The depth of overburden varies from 17.3 m at Udala College to 45.13 m at Jamdiha. The yield of well varies from 0.5 lps Swapneswar Mandir (OW) to 8 lps at Mandakhai. Granite and granite gneiss have poor to moderate yields. In general two saturated fracture zones within 100 metres below ground level are of most common occurrence.

3.15 KARNATAKA

Ground water exploration was undertaken in 2 drought-prone districts and three Farmers distress districts for the construction of 39 EW, 17 OW, (Total-76 wells) in Karnataka.

Geomorphology, Lineament, Geology layers and Aeromagnetic layers prepared by using remote sensing data were used for pin pointing potential sites for ground water exploration in Hassan district especially in Arsikere taluk. Some of the sites were selected using baove data and the same have been recommended for geophysical survey. The recommended sites were drilled and intersected with high yield fractures. District wise summarised details of ground water exploration are as follows:

Chitradurga district:

Two exploratory wells at Hiriyur and Devarakota and 1 OW at Shivapuragate were drilled in Hiriyur taluk which falls in Vedavati river of Tungabhara sub-basin. Depth of the wells ranges from 185-200 mbgl with casing of 21.75 mbgl. Static water level is 10.17 mbgl and PYT discharge is negligible to 1.5 lps.

Chamarajanagar District:

6 EW & 1 OW were drilled in Chamarajanagar district is underlain by granite & Granite gneiss. Depths of the wells range from 110-201 mbgl with SWL in the range of 0.82-16mbgl. Discharge is in the range of 5.4 – 22.82 m^3/hour with drawdown in the range of 3.94 - 24.27m.

Hassan District:

8 Exploratory wells and 6 Observation wells were drilled in Hassan district. The explored area is underlain by Granitic Gniess and schist and quartz veins. The aquifer is weathered and highly fractured gniesses, schists and quartz veins and ground water occurs in unconfined and semi confined conditions to confined condition. The depth of Exploratory wells ranges 128.24 to 200 mts and that of Observation wells ranges 30-200 mts. Drilling has revelaed overburden thickness in the range of 12 to 32 mbgl. The water level ranges from 4.04 mbgl to 25.17 mbgl . The water bearing formations were encountered from depth range of 19.40 mts to 196 mts.The discharge of wells range from 12.6 m^3/hr to 43.7 m^3/hr for a drawdown of 8.49 - 14.57 mts. The specific capacity ranges 26lpm/m to 70 lpm/m and transmissivity ranges from 30 m^2/day to 81 m^2/day. The storativity ranges from $8.0X10^{-6}$ to $2.0X10^{-2.}$ All the four wells drilled are high yielding wells (4.26 to 24 lps) and if they put into use they will be highly beneficial in solving drinking water problem of explored area. The

quality Of water is Generally good, but the possibility of higher fluoride content is reported.

Belgaum district:

Ground Water Exploration was carried out in Khanapur taluk of Belgaum district. The explored area is underlain by Gneiss, schist and phyllites. 6 Exploratory wells and 1 Observation well were drilled. Depth of the bore wells ranged from 95.55 to 177.90 mbgl with casing lowered in the range of 8.00 to 36.00mbgl. Static Water Level ranged from 1.24 to 12.60 mbgl. Fractures were encountered in the area at the depth range of 20 to 142 m at diferrent depths with yield range of less than 1 lps to 4.5 lps. Trasnmiisivity of these aquifers varied from 0.715 to 70.32m^2/day. And specific capacity from 17.45 to 26.m^3/day/ The quality of ground water in the area is good in general.

Kolar district (Deep drilling Programme – 500 m depth)

A total number of 8 borewells were drilled under 'Deep Exploratory Drilling Programme' in Shrinivaspur (6 No) and Chintamani (2No) taluks, Kolar district, Karnataka. Of these, six are Exploratory wells and two are Observation wells. Kolar has witnessed a very high ground water development in the state (Av. 195%) and the area of GW exploration falls under over-exploited category. The explored area is underlain by granites gneiss of the Peninsular Gneissic Complex of pre-Cambrian age. Phreatic zone is practically dry except in the topographic lows and vicinity of existing surface water bodies like MI tanks. The depth explored ranged from 153 m (Muthukapalli, Shrinivaspur taluk) to 500 m (Bhairasandra & Akkimangala, Chintamani taluk). The depth of weathering (Overburden or depth of casing) ranged from 11.3 mbgl (Bhairasandra, Chintamani taluk) to 44 mbgl (Nambihalli, Shrinivaspur taluk). Yield ranged from negligibe quantity (Bhairasandra, Chintamani taluk) to 18 lps (Gaunipalli, Shrinivaspur taluk). Water yielding fractures are encountered at different depth between 14.3 and 388 mbgl. From the analysis of exploratory borewell data, it is found that fractures occurring at shallow depth (within 75 mbgl) are either dry or very poor yielding. Potential fractures are found at greater depths. In Gaunipalli potential fractures were encountered between 105 and 171m depth whereas in Akkimangala it is encountered between 61 and 389 m depth. The exploration has proved the existence of potential fractures below 61 m down to 389m.These aquifers are found in semi-confined to confined condition. A constant leakage from the upper zones through the borehole is evidenced in many of these exploratory borewells. The maintenance of the same head in the lower fracture zones in spite of recharge from top aquifer indicates a high transmissivity of the lower zones. The depth to water level ranges from 6.5 mbgl (Muthukapalli) to 87.58 mbgl (Huhalli). The 'T' values range from 18 to 426 m2/day as computed from short duration tests (100min PYT). However, Aquifer Parameter Tests can give a more accurate idea of potentials of these deep aquifers. Ground water quality is good, potable and the fluoride contents are within the specified limit of drinking water standard.

Bidar District

Ground water exploration studies in Basalt was carried out at 11 (EW) & 06(OW) sites in the Bhalki, Humnabad, and Basvakalyan taluks of Bidar district and depth of these wells ranged from 138.60 to 302.20 m. Promising aquifer zones were encountered in Basalt at Ballur (EW & OW), Gotala (EW & OW), Rajola (EW & OW), Khandala(EW & OW) and Methi Melkhunda (OW) and recorded discharge ranges from 19.48 to 49.72 m^3 /hour for drawdown ranges between 1.15 to 25.55 m. Preliminary Yield Test of the bore wells reveals that the basaltic aquifers have Transmissivity ranges from 5.61 to 228.0 m^2/day and Specific capacity ranges from 2.49 to 253.56 lpm/m.DD.

Gulbarga District

Ground water exploration studies at Madki in Aland taluk of Gulbarga district upto the depth 308.60m have revealed a thickness of Deccan traps 0 to 14.50m, Limestone from 114.50 to 256.80m and Pink granite from 257.80 to 308.60.

3.16 KERALA

Ground Water Exploration in Kerala has been undertaken by constructing 11 EW, 6 OW, 19 PZ(Total-26 wells) in Kollam & Malappuram district, Kerala. Summarised Details of Ground Water Exploration in Kerala are as follows:

Kollam district

The ground water exploration was carried out in Kollam district and observed the following salient features,

- Two auto flowing wells have been encountered during the exploration, which is very rare in Khondalitic terrain.
- The weathered zone varies from 4.90 to 30 mbgl .The depth of bore wells ranges from 68.70 to 200 mbgl.
- Most of the potential fracture zones are encountered between 40.80 to 187.20 mbgl and their discharge ranges between 1 to 10.12 lps.
- The water level of the bore wells drilled in Khondalite terrain ranges from 1.50 to 15.40 mbgl

- ❖ The preliminary yield test was conducted in all the bore wells with varying discharge rate and the draw down observed was from 9.25 to 28.45m mbgl.
- ❖ In general the quality of ground water is good and potable.
- ❖ It is observed that, the potential ground water zones were encountered wherever the dolerite dykes occur or the formation changes within in the country rock.

EW drilled at Chithara, Kollam district. The exploratory well is auto flowing (discharge 1 lpm), with a head of 0.95 magl, Depth drilled: 200m bgl and Formation: Leptinite, Khondalite and Dyke.

Piezometer construction in Malappuram district

Charnockite group is the major rock type Veins of pegmatite and quartz are common in the rock. The targeted depth of the Pz was 100 m. However Piezometers were drilled with varying depth, ranging from 80.0 to 116 mbgl.

One high yielding PZ constructed at Pangh, Malappuram district with discharge 10 lps, depth 184.50 mtrs and geology: Khondalite.

The DTW ranges from 3.03 m to more than 50 mbgl. The yield of the piezometers ranges from 0.25 to 10 lps. The fracture zones encountered are generally 13 to 74mbgl. The potential fractures are 40-60 mbgl. The quality of ground water is generally good.

3.17 TAMIL NADU

Ground Water Exploration in Tamil Nadu has been undertaken by constructing 10 EW, 8 OW, 23 PZ(Total-41 wells)

3.17.1 High lights of Ground water Exploration

- Kilkavarapalayam, Ariyalur district (11°21'10", 79°23'30"- 58 M/7) tube well constructed to a depth of 441 m bgl tapping the deeper zone yielded 21.75 lps of Cuddalore formation.
- Gangaikondacholapuram, Ariyalur district (11°12'28":79°27'00"- 58M/8) tube well constructed to a depth of 90 m bgl tapping the shallow zone of Cuddalore formation, yielded 9.9 lps.
- Melur, Ariyalur district long duration of 72 hours pumping test was conducted with a constant discharge of 502 imperial galance per minute, Drawdown of 6m. In the well field area shallow zones does not have any impact on the long duration pumping of deeper zone of Cuddalore formation
- Kilkavarapalayam,**Ariyalur District** (11°21'10", 79°23'30" – 58 M/7) tube well constructed to a depth of 441 m bgl tapping the deeper zone yielded 21.75 lps. Cuddalore formation.
- At Gangaikonda Cholapuram **Ariyalur District** (11°12'28", 79°27'00" – 58M/8) tube well constructed to a depth of 90 m bgl tapping the shallow zone yielded 9.9 lps. Cuddalore formation.
- Immitinayanapalli, Krishnagiri district (12°37'37": 78°04'33") bore well constructed to a depth of 138 m bgl tapping the shallow and deep fracture zone of granite gneiss , yielded 19 lps.
- Immitinayanapalli, Krishnagiri district (12°37'37", 78°04'33") bore well constructed to a depth of 138 m bgl tapping the shallow and deep fracture zone yielded 19 lps. In the Granite Gneiss formation.
- At Kilkavarapalayam **Ariyalur District** (11°21'10", 79°23'30" – 58 M/7) slug injection @ 6 lps for 72 hours in the shallow tube well . In the deeper tube well @ 6 lps for 2000 minutes slug is injected. Only the shallow had an impact during slug injection, a rise of 1.2 m. However, in the deeper zone with SWL 77.15 m bgl does not have any impact on the long duration slug injection.

DISTRICT WISE SUMMARIZED DETAILS OF GROUND WATER EXPLORATION

Location	Depth drilled	Zones tapped	SWL	Discharge m3/hr	Drawdown	Formation
Tiruvannamalai & Kancheepuram	28-200	Shallow and deep	1.37>50 m	10.8	>30 m	Archaeans, Charnockite & Granite Gneiss
Krishnagiri, Namakkal & Salem	80-138	Shallow and deep	0.7-2.7	<1 68.4	<30 m	Archaeans, Charnockite & Granite Gneiss
Ariyalur	100-114	Shallow 71-86 Deep 400-412	24.48-77.15	<1 78.3	1.4 to deep 2.4	Cuddalore formation Tertiary
Cuddalore	106	Shallow 72-87	24.4	--	--	Cuddalore formation Tertiary

3.18. HIMACHAL PRADESH

Ground Water Exploration in Himachal Prdesh has been undertaken by constructing 8 EW, 1 PZ, Total-9 wells. District wise summarized details of Ground Water Exploration in the State are as follows:

Kangra District

Kangra district comes under Beas drainage Basin. Geological successions encountered in the district are alluvium, glacial moraines, Siwalik and the basement comprising of older metamorphics. During the AAP 2008-2009, ground water exploration was carried out in glacial deposits in Massal and Tang Narwana area. The drilling depth ranges from 72.5 to 101.07 m bgl. The zones tapped pertains to shallow unconfined aquifer and ranges from 38-44, 54-60 and 62-71 m bgl. The pumping test of exploratory well at Tang Narwana is yet to be tested for its aquifer parameters and at Massal has a very low discharge.

Hamirpur District

During the AAP 2008-2009, ground water exploration was taken up in valley fill areas. One exploratory well was drilled at Chhinjiani. The area is drained by tributaries of river Beas. The valley fill deposits comprises of boulders, cobbles, pebbles mixed with sand and silt. The well was drilled up to a depth of 100.00 m bgl. The ground water potential zone encountered from 8-10, 13-16 and 47-51 m. The transmissivity of the well was 57.9 m^2/day.

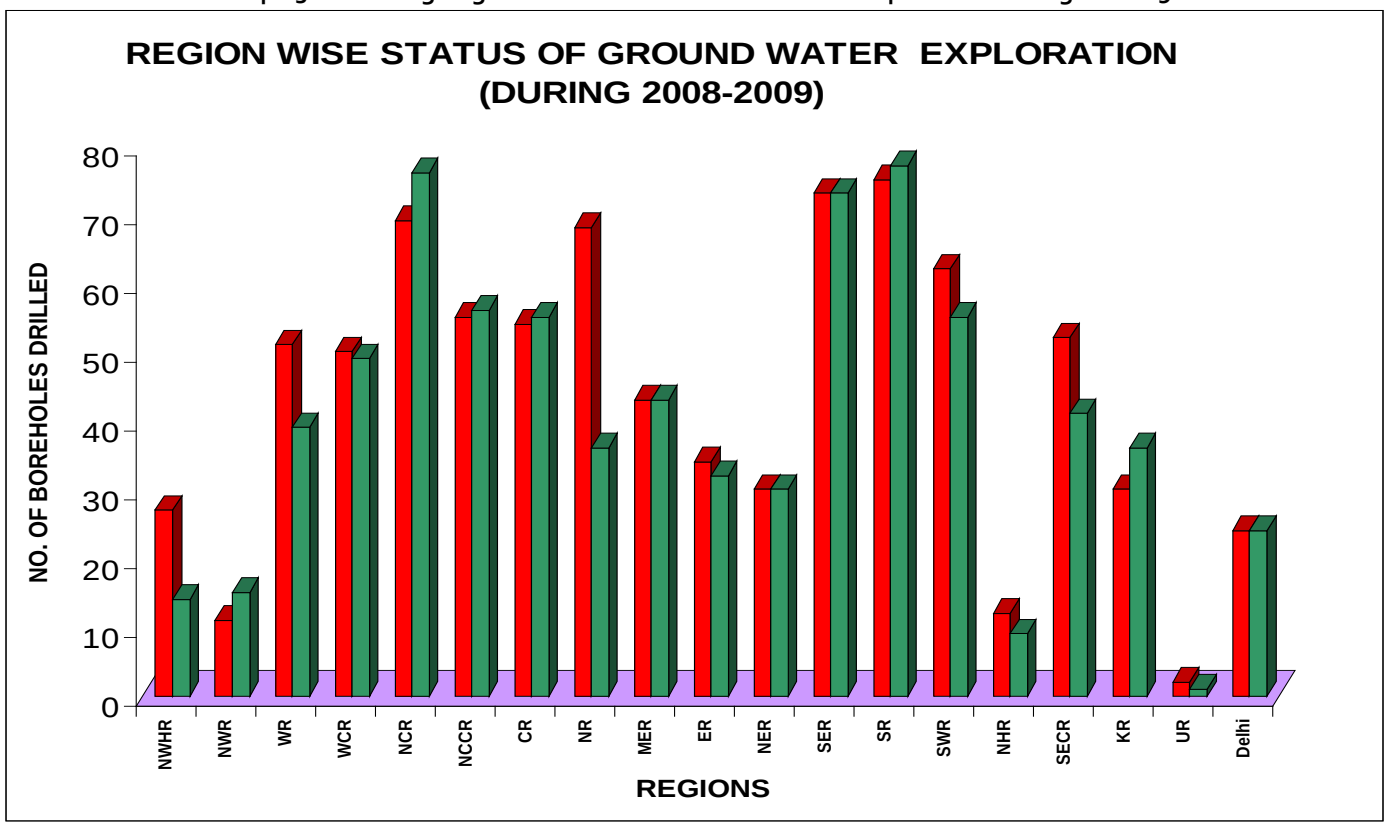
Una District

Una district comes under Soan drainage Basin. The area is occupied by alluvium and Siwalik. Three exploratory wells have been drilled in the depth range of 72.5-101.11 m bgl. The main water yielding aquifers comprises of sand, gravel, pebbles and boulders and were encountered at a depth range of 20-23, 44-57 and 60-70 m. The transmissivity values ranges from 284.95 to 467.02m^2 /day.

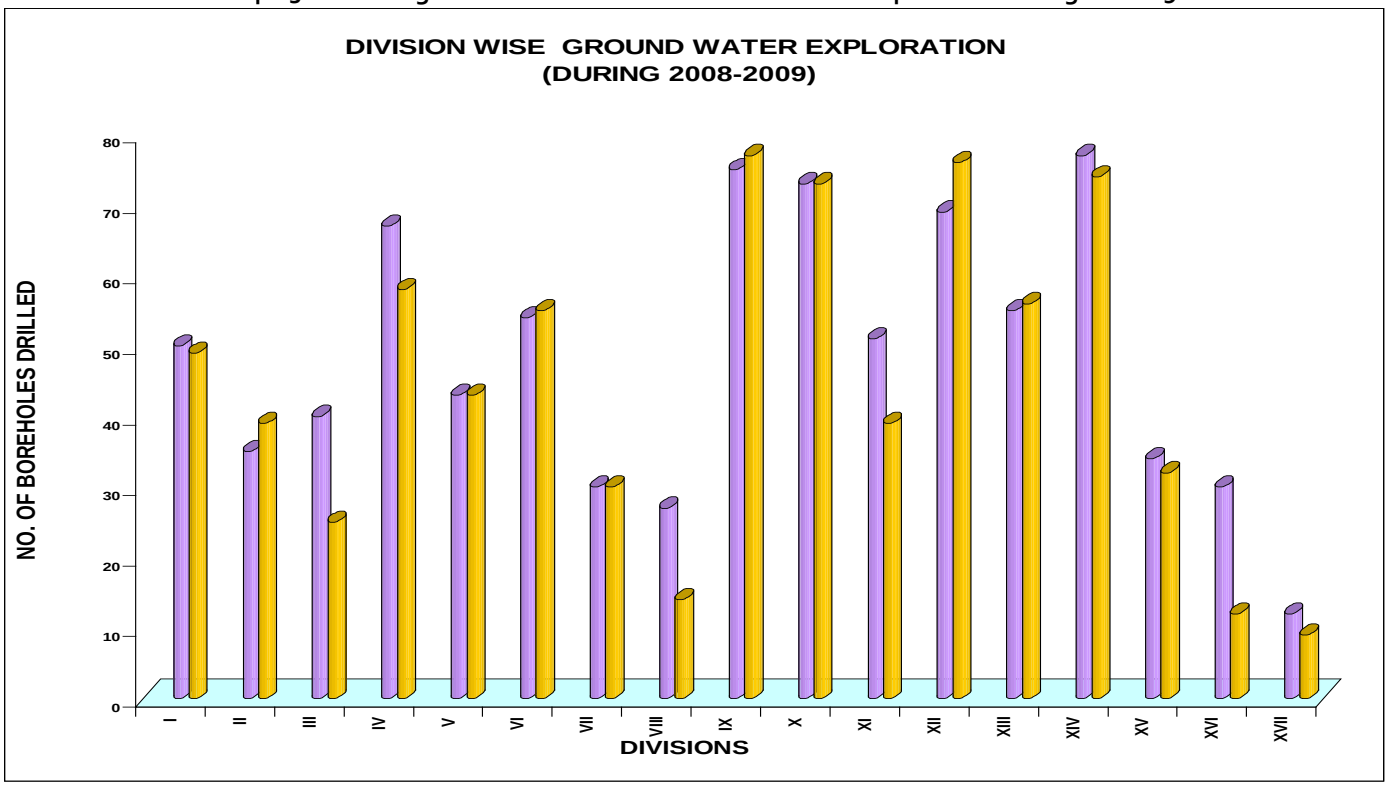
Bilaspur District

Two exploratory wells have been drilled in the district at Talli and Nella ranging in depth from 43.75 to 74.00 mbgl. The pumping test of Exploratory well at Nella is yet to be tested Talli have been abandoned due to well loss.

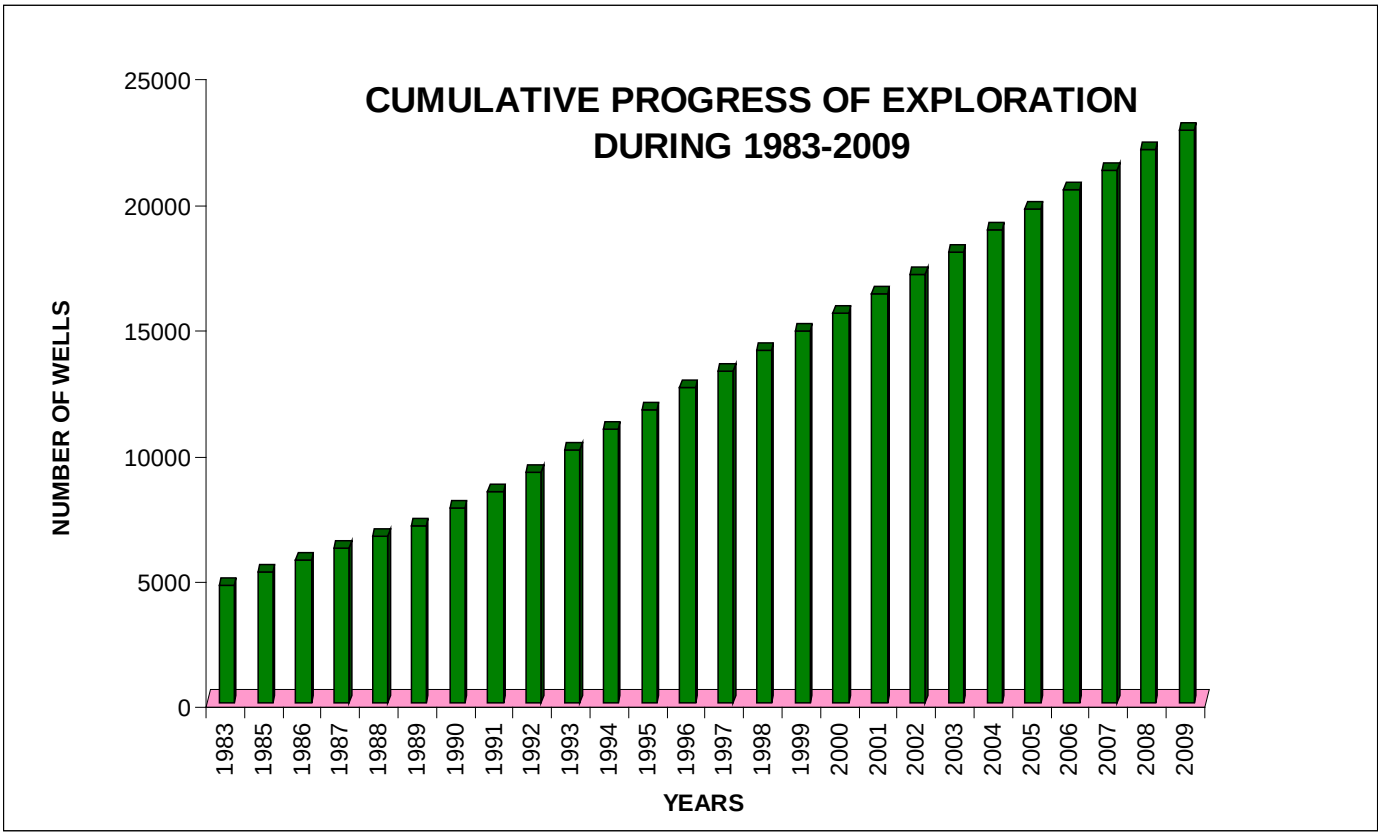
Graph 3.1 Showing Region wise status of Ground Water Exploration during 2008-09



Graph 3.2 Showing Division wise status of Ground Water Exploration during 2008-09



Graph 3.3 Showing Cummulative Progress of Ground Water Exploration during 1983-2009



4. DEVELOPMENTS AND TESTING OF WELLS

A tube well, is developed during its construction to increase its specific capacity to prevent sand rushing into the well and to obtain maximum well life. Thereafter, pumping tests are conducted for evaluating aquifer characteristics i.e. transmitivity, storage co-efficient and well characteristics viz. specific capacity and well efficiency, with a view to evolve efficient design for tube wells, assessment of yield capabilities and spacing criteria for tube wells. The Board has got the capacity of conducting 175 to 200 pumping tests per annum with the existing infrastructure facilities. With the increasing drilling activities, the Board is constructing, on an average, about 400 pumping wells every year, which have resulted in backlog of pumping tests. Procurement action has been initiated in the Board to equip each rig unit with adequate pumping test units. However, in spite of constraints faced by the Board in this aspect, a total of 191 wells were developed and tested during the year 2008-2009. Region wise achievement has been presented in Table 4.1

Table 4.1: REGIONWISE/STATEWISE PUMPING TESTS CONDUCTED IN THE YEAR 2008 – 2009

Sr. No.	Regions	State/ Union Territories	No of wells tested during 2008-09 Upto March,2009		
			No. of E. wells constructed during 2008-09 and tested	No. of E. wells constructed in earlier Year and tested	Total No. of wells tested
1	NWHR, Jammu	Jammu & Kashmir	1	7	8
2	NWR,Chandigarh	Haryana	-	1	1
		Punjab	1	2	3
		Delhi	2	5	7
3	WR, Jaipur	Rajasthan	-	12	12
4	WCR, Ahmedabad	Gujrat	2	8	10
5	NCR, Bhopal	Madhya Pradesh	6	3	9
6	NCCR, Raipur	Chhattisgarh	4	3	7
7	CR, Nagpur	Maharashtra	23	10	33
8	NR, Lucknow	Uttar Pradesh	1	11	12
9	MER, Patna	Bihar	-	5	5
		Jharkhand	-	-	-
10	ER,Kolkata	West Bengal	3	9	12
11	NER, Guwahati	Assam	3	10	13
		Arunachal Pradesh	-	-	-
		Meghalaya	-	1	1
		Tripura	-	-	-
12	SER ,Bhubneswar	Orissa	8	15	23
13	SR, Hyderabad	Andhra Pradesh	-	5	5
14	SWR, Bangalore	Karnataka	8	5	13
15	SECR, Chennai	Tamilnadu	4	1	5
16	KR, Kerala	Kerala	3	1	4
17	NHR, Dharamshala	Himachal Pradesh	2	6	8
18	UR, Dehradun	Uttarakhand	-	-	-
TOTAL			**71**	**120**	**191**

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 2008, a total of 12926 wells have been drilled, out of which 10074 successful exploratory wells have been constructed and only 5617 wells have so far been accepted /taken over by State Governments while 3482 successful wells are yet to be accepted/ taken over by them and only 975 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 31-03-2009 is presented in table 5.1

Table 5.1: HANDING OVER OF WELLS DRILLED BY CGWB (As on 31.03.2009)

Sl. No.	State/Union Territories	Total wells drilled	Total successful Wells	No. of wells accepted	No. of wells offered yet to be accepted	No. of wells to be offered
	States					
1	Andhra Pradesh	1211	868	728	71	69
2	Arunachal Pradesh	32	28	14	2	12
3	Assam	320	269	120	71	78
4	Bihar	271	219	61	131	27
5	Chhattishgarh	550	501	139	301	61
6	Goa	58	49	0	49	0
7	Gujarat	886	569	431	70	68
8	Haryana	363	194	145	48	1
9	Himachal Pradesh	170	156	77	53	26
10	Jammu& Kashmir	309	244	160	55	29
11	Jharkhand	279	230	75	132	23
12	Karnataka	1145	984	471	458	55
13	Kerala	378	273	229	38	6
14	Madhya Pradesh	844	540	447	17	76
15	Maharashtra	1072	895	793	59	43
16	Manipur	25	15	14	0	1
17	Meghalaya	80	69	14	8	47
18	Mizoram	3	3	3	0	0
19	Nagaland	11	7	5	1	1
20	Orissa	1223	1140	402	664	74
21	Panjab	164	140	78	54	8
22	Rajasthan	1065	768	249	485	34
23	Sikkim	31	10	6	0	4
24	Tamilnadu	907	658	496	147	15
25	Tripura	60	54	36	12	6
26	Uttaranchal	52	42	23	10	9
27	Uttar Pradesh	776	630	185	339	106
28	West Bangal	401	352	130	167	55
	TOTAL	**12686**	**9907**	**5531**	**3442**	**934**
Union Territories						
1	Andaman & Nicobar	46	12	-	10	2
2	Chandigarh	7	7	6	-	1
3	Dadara & Nagar Haveli	12	8	8	-	-
4	Delhi	145	127	59	30	38
5	Pondicherry	30	13	13	-	-
	TOTAL	**240**	**167**	**86**	**40**	**41**
	GRAND TOTAL	**12926**	**10074**	**5617**	**3482**	**975**

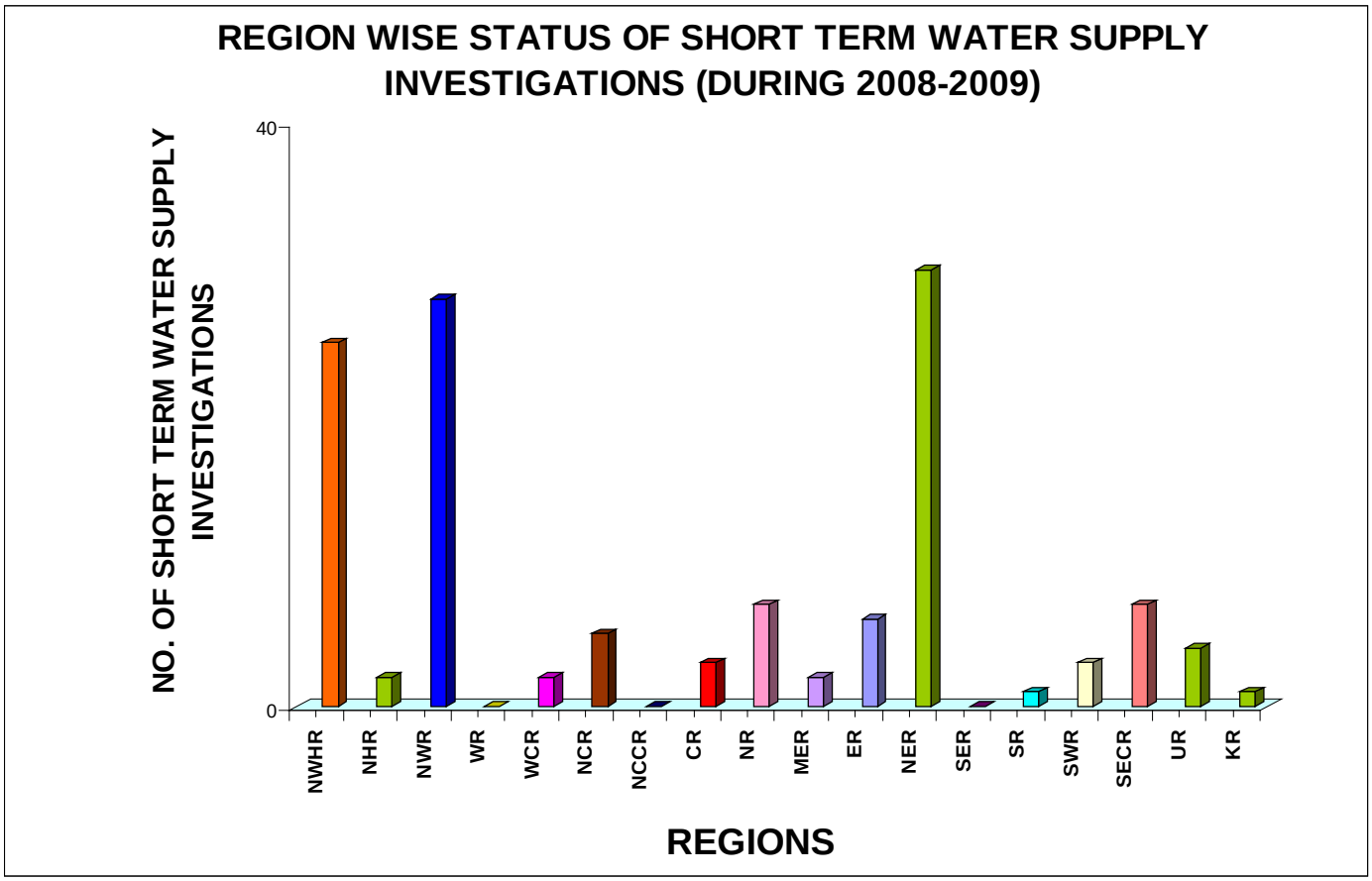
6. WATER SUPPLY INVESTIGATIONS

The Board provides assistance to various urban, defence and public sector establishments to solve their immediate water supply problems by selecting suitable sites for construction of ground water abstraction structures. During 2008-09, 126 Water Supply Investigations were carried out and region wise/state wise status is given in table 6.1 and **Graph** 6.1

Table 6.1 : REGION/STATEWISE WATER SUPPLY INVESTIGATIONS TAKEN UP DURING 2008-2009

Sl. No	Regions	States	Number of Water Supply Investigations
1	**NORTHERN WESTERN HIMALAYAN REGION**	Jammu & Kashmir	25
2	**NORTHERN HIMALAYAN REGION**	Himachal Pradesh	2
3	**NORTH WESTERN REGION**	Punjab	10
		Haryana	05
		Delhi	13
4	**WESTERN REGION**	Rajasthan	0
5	**WEST CENTRAL REGION**	Gujarat	2
6	**CENTRAL REGION**	Maharashtra	3
7	**NORTHERN REGION**	Uttar Pradesh	7
8	**UTTARANCHAL REGION**	Uttaranchal	4
9	**EASTERN REGION**	West Bengal	6
10	**NORTH CENTRAL REGION**	Madhya Pradesh	5
11	**NORTH CENTRAL CHATTISGARH REGION**	Chhattisgarh	-
12	**MID EASTERN REGION**	Bihar & Jharkhand	2
13	**NORTH EASTERN REGION**	Assam, Meghalaya, Arunachal Pradesh	30
14	**SOUTH EASTERN REGION**	Orissa	-
15	**SOUTERN REGION**	Andhra Pradesh	1
16	**SOUTH WESTERN REGION**	Karnataka	3
17	**SOUTH EASTERN COASTAL REGION**	Chennai	7
18	**KERALA REGION**	Kerala	1
		Total	**126**

Graph 6.1 Showing Short term Water Sypoply Investigations during 1983-2009



7. HYDROLOGICAL AND HYDROMETEROLOGICAL STUDIES

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

7.1 NORTH WESTERN REGION (Chandigarh)

Compilation of weekly rainfall data of North Western Region comprising 17 districts (old) of Punjab and 19 districts of Haryana (old) and Chandigarh (U.T.) for the year 2008-09 and utilizing the same to estimate district mean monthly, seasonal and annual rainfall. The data is being analyzed and used to compute the following after each NHS water level monitoring.

- May 2008: percent deviation of rainfall of June 2006 to May 2007 with rainfall of June 2007 to May 2008 and percent deviation of rainfall of Jan 2008 to May 2008 with normals of the same period.
- August 2008: percent deviation of rainfall of Sep 2006 to Aug 2007 with rainfall of Sep 2007 to Aug 2008 and percent deviation of rainfall of Jun 2008 to Aug 2008 with normals of the same period.
- November 2008: percent deviation of rainfall of Nov 2006 to Oct 2007 with rainfall of Nov 2007 to Oct 2008 and percent deviation of rainfall of Jun 2008 to Oct 2008 with normal of the same period.
- January 2009: percent deviation of rainfall of Jan 2007 to Dec 2007 with rainfall of Jan 2008 to Dec 2008 and percent deviation of rainfall of Jun 2008 to Dec 2008 with normals of the same period.
- Ground Water Year Book (2007-08): Analyzed rainfall data along with graphs and also prepared a write up on Hydrometeorology which is used in support of Ground Water Year Book report.

7.2 WESTERN REGION (Rajasthan)

- Compile hydrometeorological chapters for incorporation in reports pertaining to Pratapgarh district and ground water management studies in Nokha and Lunkaransar blocks of Bikaner district.
- Compile a note on the hydrometeorological aspects of Karauli district for incorporation in the district ground water brochure.
- Compile a note describing hydrometeorological conditions prevailing in Sawai Madhopur district for inclusion in the district ground water brochure.
- Compiled hydrometeorological chapter for inclusion in the ground water year book,2007-08, Rajasthan state.
- Updated monthly and annual rainfall data of all the raingauge stations of Rajasthan upto 2008.
- Compiled hydrometeorological chapter for incorporation in ground water management studies in part of Alwar district (AAP 2007-08).

7.3 NORTH CENTRAL REGION (Madhya Pradesh)

Normal hydrogeological data such as maximum & minimum temperature, wind velocity, relative humidity and rainfall data of Rewa, Morena and Indore stations was compiled. The seasonal rainfall distribution of these districts was also calculated. About 90% of the annual rainfall takes place during the monsoon season and only 10% of the rainfall takes place during summer and winter season i.e between October to May. Monthly rainfall and monsoon rainfall data of 2008, of 250 existing rain gauge stations of M.P. was collected. The isohyetal map of monsoon rainfall 2008 was prepared. From the map, it is evident that only northern parts of M.P. has received more than normal rainfall during year 2008 and rest of M.P. has received less than normal rainfall. Maximum rainfall was received at Bhind district and minimum at Burhanpur district.

7.4 CENTRAL REGION (Maharashtra)

7.4.1 Climatological input for District & RHS Reports:-

Climatological input for the following district reports were provided a) Raigarh b) Akola and also for Reappraisal reports of Wardha and Ratnagiri districts. These Climatological chapters include detailed analysis of rainfall of all raingauges in the district with isohytal maps, temperature, relative humidity and wind speed and direction and plates showing:

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

Apart from the above, analysed rainfall data for District Headquarters of Maharashtra. Prepared hydrometeorological write up of Amravati district for Mass Awareness programme and preparation of write up for Rainfall Analysis of Nagpur city.

7.4.2 Development Hydrometeorological Data Base: -

Updated and maintained hydrometeorological database of Maharashtra, which includes:

i. Compilation of rainfall data of 42 IMD observatories from daily weather reports of Nagpur.
ii. Data received from District Collectorate through field officers.
iii. Statistical data received from Socio-Economic Reviews of Maharashtra.

7.4.3 Hydrometeorological Data Analysis for Ground Water Year Book

The hydrometeorological data for Ground water Year Book for 2007-08 was analysed and were prepared for inclusion in the yearbook.

7.4.4 Hydrometeorological Data Analysis for GWRM Repors:

Hydrometeorological data are analysed and correlated with ground water levels after monsoon hydrograph monitoring for the preparation of status reports on ground Water levels during May 2008, August 2008, November-2008 and January-2009.

7.5 NORTHERN REGION (U.P.)

Hydrometerological studies with findings/conclusion :

1. Collected monthly rainfall data of Lucknow for the period 1999 to 2007, Extrapolated Interpolated rainfall data calculated values of standard deviation and coefficient of variation.
2. Prepared Isohyetal maps of Lucknow & Deoria districts.
3. Measurement of daily rainfall at raingauge station at Bhujal Bhawan continued.
4. Prepared write up of Hydrometeorology for ground water brochures pertaining to seventy districts of U.P.
5. Calculated & tabulated the values of annual rainfall for the year 2003, 2004, 2005, 2006, 2007 & normal rainfall for Lucknow, Lucknow (Obsty), Malihabad, Mohanlalganj, Bakshi-Ka-Tal, Unnao, Purva, Sefipur, Hasanganj, Bhigapur, Nawabganj, Nawabganj (Obsty), Ramsanehighat, Fatehpur, Haidergarh, Ramnagar, Barabanki, Sirauli, Kanpur, Kanpur (Obsty.),Bihaur, Ghatampur, Kannauj, Chibramau, Tirwa, Sahajahanpur, Sahajahanpur (Obsty.), Parayan, Tiehar, Zalalabad raingauge stations.
6. Tabulated max. min. temperature,relative humidity wind velocity,Potential Evapotranspitation (monthly & annual) pertaining to Lucknow, Kanpur and Hardoi districts.
7. Prepared Isohyetal map pertaining to area of flood plain & surrounding area of blocks Gomti River parts of Lucknow & Barabanki districts.
8. Prepared Isohyetal map pertaining to area of flood plain surrounding area of blocks along Ganga River parts of Kannauj, Kanpur Nagar, Unnao, Hardoi & Sahajahanpur districts.
9. Compiled monthly monsoon, non-monsoon & annual rainfall data of all district H.Q. of U.P. and prepared Isohyetal map of U.P. for the year 2007.
10. Prepared write ups of hydrometeorology pertaining to area of flood plain & surrounding area of Gomti River and Ganga River.
11. Prepared write up of climate and rainfall chapter for ground water year book for the year 2007-08.

7.6 SOUTH EASTERN REGION (Bhubaneswar)

Block wise monthly rainfall data for all the 30 districts were collected and compiled upto 2004. The exixting 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)

Planning and execution of hydrological and hydro meteorological work is basically undertaken. The work involved collection, compilation, analysis and interpretation of all relevant data. During this year rainfall, data pertaining to the year 2008 was collected from various central and state departments. The same is compiled and computerised with a view to efficient management and retrieval. Presently rainfall data is available from 1901 to 2008.

Data analysis and interpretation was carried out for periodic NHS reports, Hydrogeological survey reports and Groundwater resource estimation reports.

Rainfall Distribution During 2008:

a) South west Monsoon Season (June – September)

South-Interior Karnataka: The Cumulative rainfall was excess in Bangalore urban, Bangalore rural, Kolar, Chikkaballapura, Tumkur and Chitradurga districts and normal in Ramanagara, Davanagere, Chamarajanagara, Mysore and Mandya districts. Among the 63 taluks, rainfall was excess in 30 taluks, normal in 25 taluks and deficit in 8 taluks. Last year for the same period rainfall was excess in 30 taluks, normal in 30 taluks and deficit in 3 taluks.

North Interior Karnataka: The Cumulative rainfall was normal in Koppala, Bidar, Belgaum, Haveri and Dharwad districts and deficit in Bellary, Raichur, Gulbarga, Bagalkote, Bijapur and Gadag districts. Among the 69 taluks, rainfall was excess in 3 taluks, normal in 34 taluks and deficit in 32 taluks. Last year for the same period rainfall was excess in 39 taluks, normal in 26 taluks and deficit in 4 taluks.

Malnad Region; The Cumulative rainfall was excess in Hassan district and normal in Shimoga, Chikkamagalur and Kodagu districts. Among the 25 taluks, rainfall was excess in 6 taluks, normal in 18 taluks and deficit in one taluk. Last year for the same period rainfall was excess in 20 taluks and normal in 5 taluks.

Coastal Region: The Cumulative rainfall was normal in Uttara Kannada district, and deficit in Dakshina Kannada and Udupi districts. Among the 19 taluks, rainfall was normal in 13 taluks and deficit in 6 taluks. Last year for the same period rainfall was excess in 7 taluks and normal in 12 taluks.

b) Northeast Monsoon Season (October – December)

South Interior Karnataka: The Cumulative rainfall was excess in Chamarajanagara district, normal in Bangalore urban, Bangalore rural, Ramanagara, Kolar, Chikkaballapura, Tumkur and Davanagere districts and deficit in Chitradurga, Mysore and Mandya districts. Among the 63 taluks, rainfall was excess in 10 taluks, normal in 31 taluks, deficit in 21 taluks and scanty in one taluk. Last year for the same period rainfall was excess in 14 taluks, normal in 30 taluks, deficit in 17 taluks and scanty in 2 taluks.

North Interior Karnataka : The Cumulative rainfall was excess in Gadag district, normal in Bellary, Koppala, Haveri and Dharwad districts and deficit in Raichur, Gulbarga, Bidar, Belgaum, Bagalkote and Bijapur districts. Among the 69 taluks, rainfall was excess in 8 taluks, normal in 27 taluks, deficit in 25 taluks and scanty in 9 taluks. Last year for the same period rainfall was excess in 1 taluk, normal in 8 taluks, deficit in 25 taluks, scanty in 34 taluks and no rainfall in one taluk.

Malnad Region : The Cumulative rainfall was normal in Hassan and Kodagu districts and deficit in Shimoga and Chikkamagalur districts. Among the 25 taluks, rainfall was excess in 2 taluks, normal in 6 taluks, deficit in 11 taluks and scanty in 6 taluks. Last year for the same period rainfall was excess in 7 taluks, normal in 14 taluks and deficit in 4 taluks.

Coastal Region : The Cumulative rainfall was deficit in Dakshina Kannada and Udupi districts and scanty in Uttara Kannada district. Among the 19 taluks, rainfall was normal in 2 taluks, deficit in 9 taluks and scanty in 8 taluks. Last year for the same period rainfall was excess in 2 taluks, normal in 8 taluks, deficit in 8 taluks and scanty in one taluk.

7.8 SOUTH EAST COASTAL REGIOPN(Tamilnadu)

Updating and maintenance of

1. Rainfall data,
2. Studies on Hydrology & Hydrometeorologiy of Neyveli Hydrogeological basin
3. Preparation of Preliminary Report on Correlation of Hydrographs of River Water Volume and Ground Water Table Behaviour in Palar River Basin.

Achievements

1. Updating of hydrometeorological database
2. Completed Hydrological & Hydrometeorological studies in Neyveli hydrogeological basin

The Neyveli study area comprises of parts of 5 river sub-basins namely Varahanadhi, Ponnaiyar, Paravanar, Vellar and tail end of Cauvery sub basin.

Committed storage

The total committed storage in the study area for the tanks is about 5496 MCM and 5029 MCM for the reservoirs.

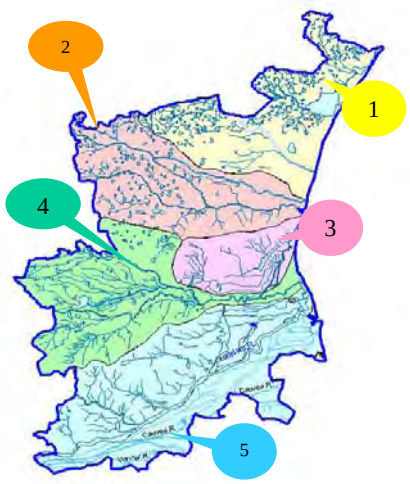
Surplus Flow to Sea

Based on the expert committee report, the quantity of out flow to sea from each sub-basin of study area for 25%, 50%, 75% dependability and average flow area given in the Table blow.

Surface water Potential of Neyveli Hydrogeological basin is as follows in the table.

	Varaha-nadhi	Ponnaiyar	Paravanar	Vellar	Tail end Cauvery
Total area of sub-basin (Sq.Kms)	4357	.		7659	
Area fall in study area (Sq.km)	2197	2181	760	2464	3545
Surface water potential (MCM)	412	1310		963	4655

Sl. no.	Name of Basin/ Period of Data considered	Average Surplus flow in TMC	At Dependability (in TMC)		
			25%	50%	75%
1.	Varhanadhi1991-2001	3.3	6.10	0.29	0.06
2.	Ponnaiyar1973-2000	9.09	13.99	1.73	0.06
3.	Vellar1968-2000	21.47	37.47	12.60	2.95
4.	Paravanar 1991-2001	8.27	12.60	4.90	4.90
5.	Tail end Regulators of CauveryDelta 1986-1996	29.71	39.60	20.58	15.52
	Total	71.84	110.01	40.60	24.24



Preliminary Report on Correlation of Hydrographs of River Water Volume and Ground Water Table Behavior in parts of Palar River Basin

The main objective of the study is to ascertain relationship between surface water flow and ground water levels in parts of Palar.

Correlation of hydrographs at Arcot - Devadanam site

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

Correlation of hydrographs at Magaral site -Walajabad Devadanam site

It is noticed from the hydrograph that peak flow in the river was recorded 5 times for the period between 1991 and 2006. Peak flow was recorded in the years of 1996-97, 1997-98 and 1998-99 and contributed hugely in raising the water level upto less than 2 m below ground level during jan-98. During the period between 1999 to 2005, there was nil flow in the river and the rise in water level of post monsoon is only due to the rainfall. Where as during the peak flow period, the rise in post monsoon water level was high, this may be due to combined effect of recharge from rainfall and contribution from river volume.

Correlation of hydrographs at Chengalpattu site:

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

7.9 KERALA REGION(Trivendrum)

During the AAP 2008-09, the weekly rainfall data of various rainguage stations established by the India Meteorological Department, Thiruvananthapuram has been received. The data has been analysed for the fourteen districts of Kerala. Monthly rainfall distribution, normal rainfall for various periods such as south-west monsoon, north east monsoon, winter and summer periods were determined, departure of the seasonal rainfall for preceding year, seasonal rainfall contributions to the total rainfall is also attempted. Various figures prepared for the different districts of Kerala by using Map Info 6.5 and Microsoft Excel.

The climatological and hydrological data collected during district ground water management studies in Wayanad, Palakkad and Kannur districts by the respective officers will be analysed for their reports.

7.10 SOUTHERN REGIO(Andhra Pradesh)

7.10.1 Hydrological studies with findings/Conclusions

Soil Infiltration Tests: Conducted soil infiltration tests at 7 sites in different types of soils by using double rig infiltrometer. The infiltration rate varies between 0.1 cm/hour to 11.3 cm/hour.

7.10.2 Hydrometeorological studies with findings/Conclusions

A) Collected and compiled rainfall data from State Agency, Department of Economics and Statistics, Govt. of Andhra Pradesh and Indian Meterological Department for the period 2007-2008 in respect of 1127 mandals, 32 IMD stations and updation of data into GEMS SOFTWARE is in progress. Compiled and analysed rainfall data in support of Ground Water Regime Studies during May, August, November, 2008 and January, 2009. The following 8 maps were prepared:

a) Rainfall departure map: June 2006-May 2007 w.r.t. June-May 2008:

More rainfall observed in almost entire State compared to last year except in parts of Adilabad, Nizamabad and Karinagar districts.

b) Rainfall departure map: Mean of June-May (1998-2007) wr.t.. June-May 2008

Deficient rainfall is observed in parts of Kadapa, Prakasam and Nizamabad only compared to decadal mean.

c) Rainfall departure map: June –Aug. 2007 w.r.t. June –August 2008

Most parts of the Telangana region, southern parts of Chittoor district have received more rainfall compared to lat year and rest of the state received less rainfall.

d) Rainfall departure map: mean of June-Aug (1998-2007) w.r.t June-Aug 08

Parts of East Godavari, Ranga Reddy, Nalgonda, Warangal, Khamam, West Godavari, Krishna, Guntur, Mahabubnagar, Adilabad and Anantapur received more rainfall an the rest of the State received less rainfall.

e) Rainfall and departure map: June 2007-Oct. 2008 w.r.t. June-Oct. 2008

Entire state received less rainfall compared to last year except in parts of Khammam, Guntur, Rangareddy and Adilabad districts.

f) Rainfall departure ma: mean of June-Oct (1998-2007) w.r.t June-Oct. 2008

Parts of Anantapur, Warangal, Nalgonda, Khammam, Krishna, West Godavari, Ranga Reddy, Medak and Karimnagar districts received more rainfall and the rest of the State received less rainfall.

g) Rainfall departure map: June-Dec. 2007 w.r.t. June-Dec. 2008

Central parts of central Telangana, parts of Guntur, Prakasam, Krishna, West Godavari, Kurnool and parts of Nizamabad received more rainfall and the entire State received less rainfall.

h) Rainfall departure map: mean of June-December (1998-2007)w.r.t Jun-Dec.08

Except central Telangana and parts of Anantapur district in Rayalseema Region, entire State receives less rainfall.

B) Monthly seasonal and annual rainfall of June 2007 to May 2008. Compiled from daily weather reports of India Meteorological Department and its analysis for the preparation of Ground Water Year Book 2007-2008.

The normal annual rainfall of the State is 923 mm and seasonal rainfall is 606 mm, 244 mm, 12 mm and 61 mm in southwest monsoon, southeast monsoon, winter and summer seasonas, respectively. Normal annual rainfall ranges from 570 mm in Anantapur to 1194 mm in Narsapur.

Actual rainfall during the period May 2007-June 2008 is 1140 mm, which is 24% more than the normal. Rainfall 748 mm, 218 mm, 58 mm and 115 mm in southwest monsoon, northeast monsoon, winter and summer seasons, respectively. About 66% of the annual rainfall is received during the southwest monsoon season. Actual rainfall ranges from 582 mm, about 26% less than normal, in Kadapa to 1624 mm, about 62% more than normal in Kavali. It has been normal to excess in the entire State and deficient in parts of Kadapa, Warangal, Karimnagar and Adilabad districts.

C) Analysis of rainfall data in support of district ground water management studies in Medak District was carried. The analysis involved a) Mandal-wise annual rainfall and its statistical analysis b) Monthly, seasonal actual rainfall of the district (2000-2006) c) Isohyetal map-normals and actual rainfall d) Drought analysis (1978-08) e) Bar diagram with mean monthly normal hydrometeorological parameters f) write-up.

The annual rainfall in the district is 873 mm in 52 rainy days. The rainfall increases from 635 mm in Kondapak to 1037 m in Medak mandal. The variation of annual rainfall is 28%, which indicates that the area is not drought prone.

The Potential Evapotranspiration is 1759 mm and ranges from 99 mm in December to 22mm in May. Whole year is facing moisture deficit except July and August months as P is greater than PET during these two months. The spatial variation of rainfall is 10%.

D) Analysis of Madharam watershed, Mahabubnagar district, rainfall data was carried out in support of ground water resource estimation studies. The annual normal rainfall in the area is 618 mm, of which 444 mm is contributed by the southwest monsoon and 142 mm is by northeast monsoon. The monthly rainfall recorded at Orukonda raingauge station of the department is 396.4 mm in 34 rainy days. 20th July alone received about 9cm of rainfall.

E) Established one hydrometeorological observatory consisting recording type of rainguage (LYNX) in the office complex and is being monitored and data collected on charts and is computerized into GEMS.

F) Established one ordinary non-recording type of raingauge station at Ururkonda village, Midjil mandal, Mahabubnagar district under ground water resource estimation studies and is being monitored.

8. GROUND WATER LEVEL SCENARIO

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

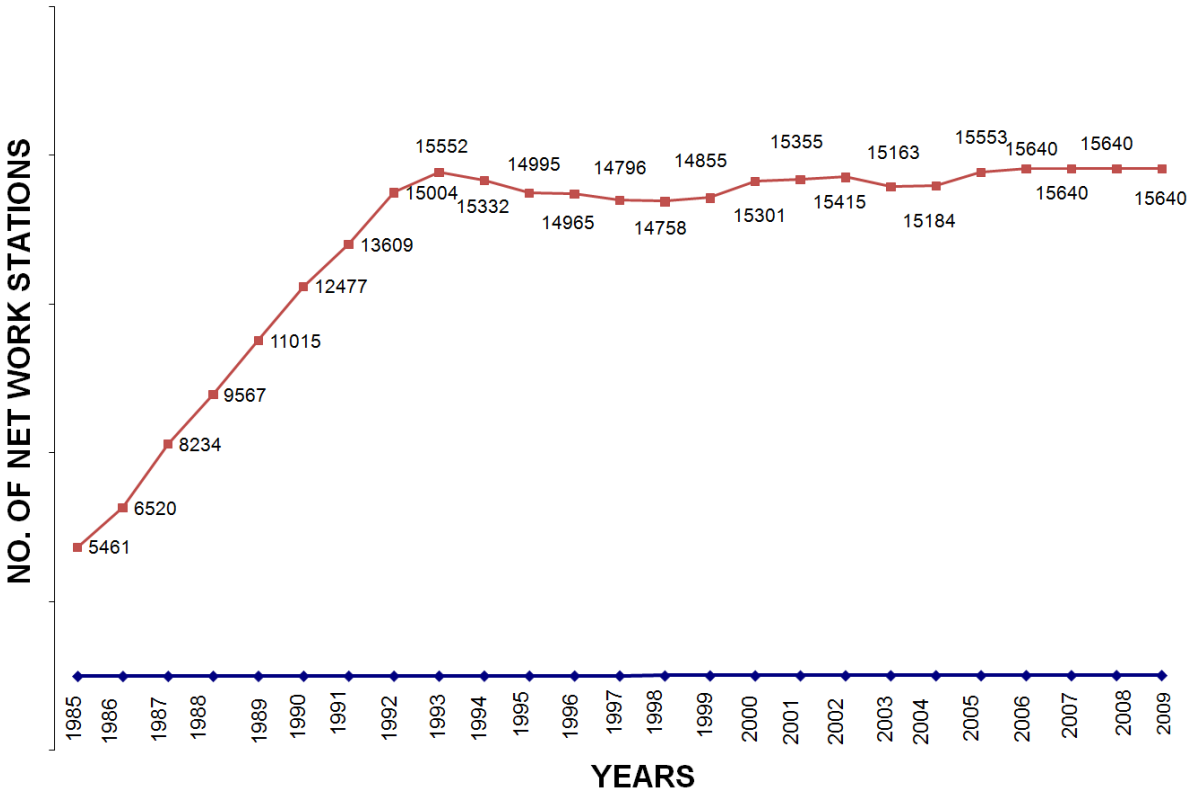
Ground water levels are being measured four times a year during January, April/ May, August and November. The regime monitoring started in the year 1969 by Central Ground Water Board . At present a network of 15640 observation wells located all over the country is being monitored. Ground water samples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

The State-wise distribution of the ground water observation wells is given in table 8.1 and in **Graph** 8.1 & 8.2.

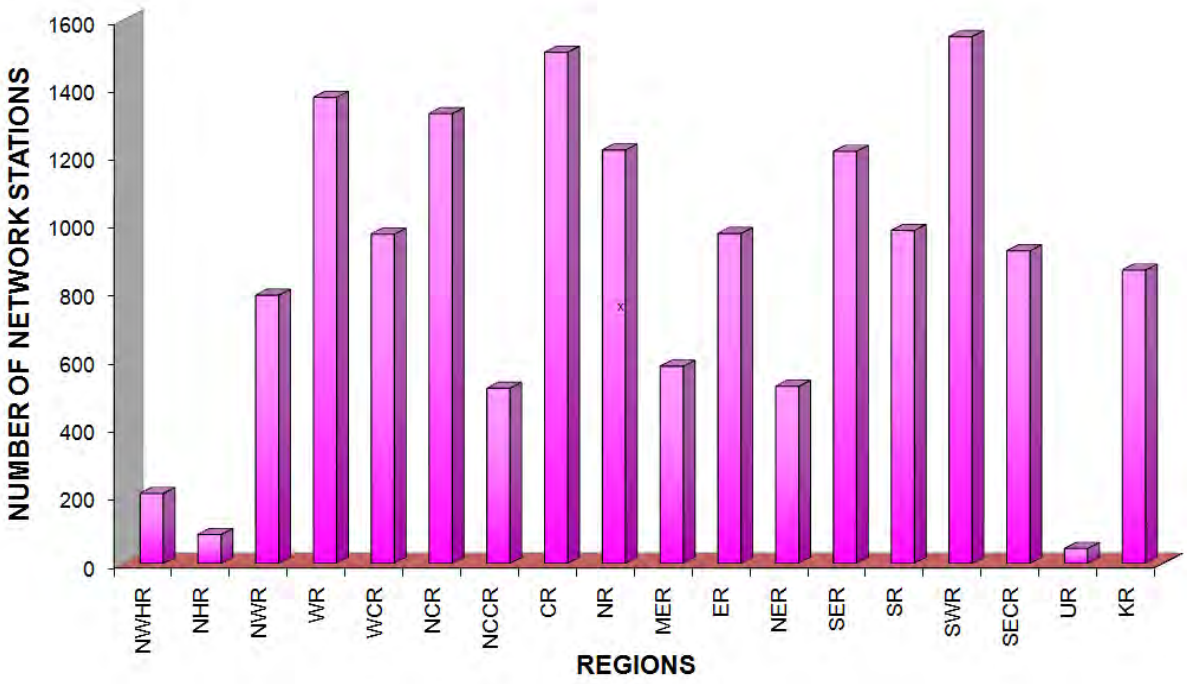
TABLE 8.1 : STATEWISE DISTRIBUTION OF OBSERVATION WELLS

Sl No.	Name of the State	Total No. of Observation Wells (as on 31.03.2009)
1	Andhra Pradesh	981
2	Arunachal Pradesh	19
3	Assam	381
4	Bihar	373
5	Chhatishgarh	516
6	Delhi	87
7	Goa	53
8	Gujarat	966
9	Haryana	426
10	Himachal Pradesh	85
11	Jammu & Kashmir	206
12	Jharkhand	208
13	Karnataka	1499
14	Kerala	864
15	Madhya Pradesh	1325
16	Maharashtra	1496
17	Manipur	25
18	Meghalaya	38
19	Nagaland	17
20	Orissa	1214
21	Punjab	261
22	Rajasthan	1373
23	Tamil Nadu	906
24	Tripura	42
25	Uttar Pradesh	1218
26	Uttaranchal	44
27	West Bengal	909
	UTs	
1	Andaman & Nicober	63
2	Chandigarh	16
3	Dadra & nagar Haveli	10
4	Daman & Diu	4
5	Pondicherry	15
	Total	**15,640**

Graph:8.1 National Hydrograph Network Stations of CGWB (1985-2009)



Graph:8.2 Regionwise National Hydrograph Network Stations of CGWB (1985-2009)



9.0 GEOPHYSICAL STUDIES

An integrated approach of Ground water sciences like remote sensing and geophysical studies basically seismic, electromagnetic, and electrical methods and borehole logging are used for pre estimation of aquifer geometry, water quality and quantity. Thus the effective cost of drilling is reduced and accurate well assembly is designed.

Application of geophysical techniques is essential for adequate understanding of the sub-surface hydrogeological characters. As such, the board undertakes geophysical investigations to support and supplement hydrogeological surveys, ground water exploration and short term water supply investigations as an integral part of its activities. Besides, geophysical surveys were also undertaken for demarcating saline - fresh water interface, Coastal aquifer management studies ,estimation of overburden thickness, and bedrock configuration, identifying favourable sites for artificial recharge structures,flood plain studies and in farmer distress villages etc.

9.1 CENTRAL GEOPHYSICAL CELL

The Central Geophysical Cell undertook the following works during year 2008-2009:

- 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 –
- Co ordination of Geophysical Surveys and related Activities. Preparation of inventory of equipments in different Regional Offces and Assessment of present capability of Board as regards instrumentation.
- Co-ordination of Training Activities for personnel in geophysical Survey and related items-

  One Training course On "Application of Geophysical Techniques in Ground Water Exploration and Management" was organized at Northern Region Lucknow.

9.2. GEOPHYSICAL SURVEYS AT A GLANCE

Central Ground Water Board was entrusted with a target of 2100 nos. of VES and need based Resistivity Profiling. Against this target a total no. of 1931 VES and 108.85 LKm of Resistivity profiling were carried out. Apart from this a total no. of 84 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.

Table 9.1: GEOPHYSICAL SURVEYS & BORE HOLE LOGGING DURING 2008-2009

Region	No. of VES	Resistivity Profiles (line km)	No. of boreholes logged	Total meterage Logged (m)
NWHR, Jammu	60	-	2	168
NWR, Chandigarh	178	-	18	2532
WR, Jaipur	102	-	7	1105
WCR, Ahmedabad	nil	-	9	1930
NCR, Bhopal	100	1.24	1	200
NCCR, Raipur	102	.2	nil	-
CR, Nagpur	102	-	3	272.8
NR, Lucknow	100	0.1	15	6616
MER, Patna	153	3	5	1010
ER, Kolkata	100	32.56	4	1060
NER, Guwahati	29	-	-	-
SER, Bhubneswar	62	-	6	946.8
SR, Hyderabad	365	.55	12	937
SWR, Bangalore	276	-	1	384
SECR, Chennai	102	61.2	5	1383
KR, Trivendrum	50	10	-	-
NHR, Dharamshala	-	-	-	-
UR, Utterakhand	50	-	1	170
TOTAL	**1931**	**108.85**	**89**	**18714.6**

* 0.8 line km of SP was carried out in Ranchi urban area,in MER patna

9.3 NWHR, J&K

Surface geophysical surveys were mostly carried out with an objective of selection & pinpointing the sites for ground water exploration and short term water supply investigations. The resistivity survey results were analyzed and interpreted for delineating the depth and thickness of ground water potential zones. The interpreted results of the VES conducted near the exploratory wells and litholog prepared were correlated to establish the resistivity ranges for different formations. The field VES data along with the interpreted results were also entered in GEMS.

Borehole geophysical loggings were also conducted by measuring the Spontaneous Potential (SP), Single Point Resistance (SPR), Short Normal Resistivity (N16") and Long Normal Resistivity (N64") parameters for deciphering the depth to water bearing granular zones, demarcating clay horizons etc. for recommending the well assembly design for the boreholes drilled in Kashmir Valley.

9.3.1 Surface Geophysical Studies:

A total of 60 Vertical Electrical Sounding (VES) have been carried out in the parts of J&K State.

9.3.2 Salient Findings of the Surveys :

1. The resistivity surveys at Shahnagri (Kupwara) was conducted with the maximum current electrode separation (AB) of 280 m only, due to the spread constraint. The interpretation revealed eight sub-surface geo-electrical layers upto the interpreted depth range of 82.41 m bgl. The sand, gravel mixed boulder formation is found in the depth range of 18 to 55.8 m bgl. Hard to semi-consolidated layers are found after this depth till 82.41 m bgl.

    - The resistivity of the 1st layer is 37 Ohm-m with thickness of 0.98 m, representing top surface layer.
    - Resistivity of the 2nd layer is 28.4 Ohm-m and thickness is 17.05 m indicating clay mixed with sand formation.
    - The 3rd layer is having resistivity of 105 Ohm-m and thickness of 3.2 m, which can be inferred as sand, gravel layer.
    - Interpreted 4th layer is having resistivity of 129.5 Ohm-m and thickness of 10.08 m representing sand, gravel and boulder.
    - The 5th layer can be inferred as fine to medium sand with gravel as it is having the resistivity of 82.5 Ohm-m with thickness of 24.5 m.
    - The 6th layer having resistivity value of 469 Ohm-m and thickness of 9.0 m represents hard formation.
    - 7th layer having resistivity 188 Ohm-m and thickness of 17.6 m represent semi-consolidated hard formation
    - And the interpreted last layer is having resistivity 234 Ohm-m representing hard semi-consolidated formation.

    The sand, gravel mixed boulder saturated formation is found in the depth range of 18 to 55.8 m bgl with resistivity values ranging from 82.5 to 129 Ohm-m. Hard to semi-consolidated layers are found after this depth of 55.8 m bgl till 82.41 m bgl having resistivity values in the range of 469 to 188 Ohm-m. The interpreted last layer is having resistivity of 234 Ohm-m, representing hard semi-consolidated formation.

2. The one VES was conducted at Dardkote (Anantnag) with the maximum current electrode separation (AB) of 90 m only, due to the field constraints. The interpretation revealed nine sub-surface geo-electrical layers upto the interpreted depth range of 25.66 m bgl. The sand, gravel mixed boulder formation is found in the depth range of 4.2 to 15.2 m bgl. Clay layer is found after this depth having thickness of 1.75 m bgl.

3. A total of five VES were conducted at Air Force Station, Natha Top (Udhampur) with the maximum current electrode separation (AB) of 150 m. The interpretation revealed six to nine sub-surface geo-electrical layers upto the interpreted depth range of 64.6 m bgl. In general, the sand, gravel mixed boulder formation in the area is found in the depth range of 12 to 44 m bgl. The clay layers are also found at different VES having the thickness of 3.4 to 5.4 m, in the depth range of 18-24 at VES 1, 44 m bgl onwards at VES 2, 38-41 m bgl and 66.4 m bgl onwards at VES 3, 16-31 m bgl at VES 4 and 27.11 m bgl at VES 5.

4. A total of eight VES were conducted near the exploratory well at Nihalpur, (Kathua) with the maximum current electrode separation (AB) of 200 m. The resistivity survey was conducted to assign the resistivity values for different litho-units and correlation of aquifer parameters (T & S values) with 'Dar Zurak' parameters (Transverse Resistance & Longitudinal Conductance).

5. A total of forty-five VES have been conducted along the Phinter-Billawar road (Kathua) for determining the

lateral variation in the resistivity and preparation of geo-electrical cross-section.

A total of eight VES were conducted near the exploratory well at Nihalpur, (Kathua) with the maximum current electrode separation (AB) of 200 m. The resistivity survey was conducted to assign the resistivity values for different litho-units and correlation of aquifer parameters (T & S values) with 'Dar Zurak' parameters (Transverse Resistance & Longitudinal Conductance). The resistivity values of the sub-surface geo-electrical layers ranges from 27 Ohm-m to 665 Ohm-m. The low resistivity value corresponds to clay formation whereas the high resistivity value represents hard compact dry boulder formation.

The resistivity values in the range of 20 + 15 Ohm-m, indicates the clayey or clay mixed formation.
The resistivity values in the range of 150 + 40 Ohm-m, indicates the gravel or sand mixed formation, partially / fully saturated with water.

The saturated sand gravel zone were in corroboration with the geophysical interpreted results

The transmissivity values were calculated by multiplying the thickness of the zones tapped with their respective true resistivity values. The transmissivity values for the deeper tapped zones (78 – 84, 86 – 92 & 94 – 100) could not be arrived at, as the true resistivity beyond the depth of 73 m bgl was not interpretated. The zone-wise calculated transmissivity values are tabulated as below:

Zones Tapped (depth range m bgl)	Thickness (m)	True Resistivity (Ohm-m)	Transmissivity
52 – 58	6	184	1104
60 - 66	6	665	3990
70 – 76	6	125	750

6. A total of 45 VES were conducted along the Phinter-Billawar road (Kathua) for determining the lateral variation in the resistivity and preparation of geo-electrical cross-section. Four to eight geoelectrical layers have been identified in the interpretation upto the depth range of 6 to 56 m bgl. The potential water bearing zones have been identified in the depth range of 42 to 50 m bgl and 24 to 32 m bgl in VES 31 & VES 35 respectively. The resistivity range of the saturated formation varies from 144 to 170 Ohm-m.

The cross-section reveals that clay layer starts from the shallow depths i.e. from the depth of 4 to 20 m bgl and is the last interpreted layer in most of the VESs. The resistivity ranges for different lithological units as assigned for this area is below:

Range of Resistivity (Ohm-m)	Lithological units
11 – 50	Clay
51 - 150	Clay mixed with sand.
151 - 250	Clay mixed with sand, boulder.
251 - 500	Sand, gravel and boulder.
> 500	Top surface layer or boulder bed.

9.3.3 Borehole Logging:

A total of 2 Borehole Electrical loggings were conducted in boreholes drilled in the Kashmir Valley, with total depth logged being 168 m. The district wise details of boreholes logged along with the depth drilled and depth logged is given in Table 9.3.3.

Table 9.3.3: District-wise Details of Boreholes Logged in Jammu & Kashmir State.

District	Village	Drilled Depth (m bgl)	Depth Logged (m bgl)
Bandipora	Sunbern	134.50	134.00
Srinagar	Sofi Mohalla, near Delhi Public School.	37.34	34.00

9.3.4 Salient Findings of the Logging:

The borehole geophysical logging at Sunburn (Bandipora) has revealed that the granular zones are in the depth range of 18 - 23, 24 - 33, 34 - 43, 48 – 51, 53 – 64, 66 – 78, 80 – 86 and 90 – 98 m bgl. The ground water below the depth of 100 m bgl may have quality problem. The logging at Soffia Mohala (Srinagar) revels a highly fractured zone in the depth range of 23 to 32 m bgl, with high potential of ground water.

9.4 NWR, CHANDIGARH

9.4.1 Surface geophysical studies with result

During 2008-2009, surface geophysical studies were conducted in Punjab and Haryana. In all a total of 178 VES (Vertical Electrical Soundings) were conducted in both the

states as part of electrical resistivity surveys. Out of 178 VES, 103 Vertical Electrical Soundings were conducted in Haryana and remaining 75 VES were conducted in Punjab. Three short-term surface geophysical investigations in Haryana were also carried out as part of assigned work.

Details of surface geophysical studies are described in the following sections:

(i) The Tohana block of Fatehabad Distt. in Haryana is partly affected with the problem of ground water salinity. The objective of the studies was to infer the extent of fresh and saline water interface and observe the lateral and vertical variation in quality of groundwater. A total of 26 Schlumberger vertical electrical soundings were conducted with current electrode separation varying between 200 and 1000 m in general covering approximately an area of 482 sq.Km. The instrument used was ABEM Terrameter. The study of the resistivity data indicates ground water is saline over a few pockets in Tohana block in south western parts.

(ii) The studies in Yamuna flood plains in Haryana were targeted to assess for delineation of shallow aquifers. A total of 63 Schlumberger shallow and deep vertical electrical soundings were conducted. The instrument used was CRM- 500 Aquameter. The study of the resistivity data indicates several geo-electrical layers being 7 to 10m thick suitable to re-tap the excess water of Yamuna river particularly during flood seasons.

9.4.2 Resistivity Surveys in Punjab

(i) Parts of Mohali district was assigned to study. A total of 25 Schlumberger shallow vertical electrical soundings were conducted covering approximately an area of 233 sq.Km. The instrument used was ABEM Terrameter.

(ii) The Tanda block in Hoshiarpur District was targeted to assess for thickness of aquifers. A total of 50 Schlumberger shallow and deep vertical electrical soundings were conducted. The instrument used was ABEM Terrameter. The preliminary study of data indicates comparatively slightly increased thickness of aquifer along Satluj river.

The details of Resistivity values pertaining to respective areas covered by geophysical work during AAP 2008-09 are as follows:

Area	No. Of VES	Area Covered (Sq.Km)	Interpreted Resistivity
Haryana State 1.Tohana Block Distt.Fatehabad	26	482	Fresh Water Sediments- More than 15 Ohm m. Saline Water Sediments – Less than 15 Ohm m
2.Yamuina Flood Plains of Haryana State	63	1000	Fresh Water Sediments- More than 15 Ohm m. Saline Water Sediments – Less than 15 Ohm m
Punjab State 1.Mohali District	25	233	Fresh Water Sediments- More than 15 Ohm m. Saline Water Sediments – Less than 15 Ohm m
2.Tanda Block Disstt.Hoshiarpur	50	233	Fresh Water sediments 25 to 75 Ohm m. .(No saline water sediments encountered.)

9.4.3 Short Term Geophysical Investigations

Short term surface geophysical investigations were carried out at 3 places located in the premises of ITBP (at Saboli in Sonepat distt.), Kund in Kaithal Distt. and Institute for Cabinet Secretariat in Sector 18, Gurgaon in Haryana state. In total 14 VES were conducted for the short term investigations. Suitable sites for construction of tubewells were recommended after each investigation in Gurgaon and ITBP, Sonepat Distt. The Kund area in Kaithal distt. was studied to assess the variation in water level. The details of the geophysical investigations districtwise are given in Table 9.4.1.

Table 9.4.1: DISTRICT WISE DETAILS OF RESISTIVITY SURVEYS

STATE/UT District	NO.OF VES	AREA COVERED
HARYANA 1.Tohana block, Distt, Fatehabad distt. 2. Yamuna Flood Plains of Haryana 3. Three no. of Short Term Geophysical Studies	 26 63 14	 482 Sq.Km.
PUNJAB 1.Parts of Mohali Distt. 2.Tanda block, Hoshiarpur Distt.	 25 50	 140 Sq.Km 233 Sq.Km
Total	**178**	

9.4.4 Borehole Logging

A total number of 18 boreholes were geophysically logged during AAP 2008-09, out of which two boreholes are located in Haryana, 3 boreholes in Punjab, one in Dehradun in Uttaranchal and remaining 12 boreholes in New Delhi. The total metrage of the entire borehole loggings conducted in entire North Western Region is 2532 m. The instrument used was Uptron EWL–600 logger. Spot recommendations in respect of granular zones and quality of groundwater were made after each logging for designing of well assemblies. The details of the geophysical investigations districtwise are given in Table 9.4.2.

Table 9.4.2: DISTRICT-WISE DETAILS OF BOREHOLE LOGGING

STATE/UT District	NO. OF BOREHOLES LOGGED	TOTAL DEPTH OF BOREHOLES LOGGED
PUNJAB Jallandhar Gurdaspur	2 1	701m
HARYANA Panipat Karnal	1 1	406m
DELHI Delhi	12	1255m
UTTARANCHAL Dehra Dun	1	170m
Total	**18**	**2532m**

9.4.5 Salient Features:-

1. A total of 178 VES(Vertical Electrical Soundings) were conducted in the states of Haryana and Punjab under AAP 2008 -09 as part of assigned duties against the set target of 150 VES, thus exceeded the target by 18 %

2. Preparation of Data sets for "Web Enabled Ground Water Information System". Digitization of geophysical logs.

Details of Resistivity values pertaining to respective areas covered by geophysical work during 2008-09 are as follows:

State	District	No. of borehole logged	Total Depth logged(M.bgl)	Recorded resistivity
Haryana	Panipat Karnal	1 1	 406	Fresh Water Sediments- 30 to 75 Ohm m. (No saline water sediments encountered.).
Punjab	Jallandhar Gurdaspur	2 1	 701	Fresh Water Sediments- 15 to 50 Ohmm. . (No saline water sediments encountered.) Fresh Water Sediments- 15 to 300 Ohm m. (No saline water sediments encountered.)
Delhi	--	12	1255	Fresh Water Sediments-15 to 75 Ohmm. Saline Water Sediments-Less than 15 Ohm
Uttaranchal	Dehradoon	1	170	Fresh Water Sediments – 50 to 300 Ohm m. (No saline water sediments encountered.)

9.5 WCR, AHMEDABAD

During the year 2008-09, geophysical borehole loggings were carried out in 9 boreholes drilled in alluvial area.

The data of 129 nos of VES conducted during 2005-06 & 2006-07, was plotted on double log graph sheets and geoelectric parameters were estimated using theoretical master curves. No VES survey was carried during the AAP 2008-09.

9.5.1 Borehole Logging

During the year 2008-09 a total of 9 wells were Electrical logged. Electrical Logging in 7 wells was done by the Departmental logger and two wells were logged through outsourcing from GWRDC Ltd, Govt. of Gujrat.Salient feature of logging are given below in Table 9.5.1.

Table: 9.5.1: District wise details of boreholes logged

Logging conducted	Aquifer	District	Bore holes logged	Total depth of bore holes logged(m)
Gujarat				
Conducte	**Alluviu**	**Ahmedabad**	**1**	**200**
	Alluviu	**Gandhinagar**	**2**	400
	Alluviu	**Jamnagar**	**1**	50.0
	Alluviu	**Mahesana**	**2**	650
	Alluviu m/ Basalt	**Rajkot**	**1**	230
		Sub Total	**07**	**1530**
Conducted by GWRDC Ltd. Govt. of Gujarat	**Alluviu m**	**Ahmedabad**	**2**	**400**
		Sub Total	**02**	**400**
		Grand Total	**09**	**1930**

9.6 WR, JAIPUR

Central Ground Water Board, western region is equipped one analog multi-channel of Uptron make and another OYO digital loggers for study of borehole geophysics and able to measure self potential, single point resistance, normal & 6' - lateral resistivity, natural gamma, caliper, temperature and fluid – conductivity parameters. Minitronics and DDR – IV resistivity meters are available for study of lateral and vertical variation of rocks properties. The following geophysical studies have been carried out by Geophysics of western region.

9.6.1 Surface geophysical studies.

In total 102 Vertical Electrical Sounding and one profiling under the resistivity survey was conducted during 2008 - 09, details of which are as follows;

(a) Electrical Resistivity surveys in Bharatpur district

Resistivity survey were under taken the around Nithar village in Bharatpur district of Rajasthan for identify the alluvium and base rocks interface and fracture being encountered at deeper depth in base rocks. On basis of this site selection for construction of tube well cum bore well have been done.

(b) Electrical Resistivity surveys in Bikaner district

Geo – electric sounding were carried out in Bikaner district at Meghora site for identify the salinity in the formation for site selection of exploratory boreholes.

(c) Electrical Resistivity surveys in Jaipur district

Electrical resistivity survey were carried out around the Governor House for feasibility of tube well for water supply to that house. Tube well site was pin – pointed in the campus of Governor house and report was submitted to the Secretary to the Governor.

42 VES were conducted around the area of Chaksu for delineating groundwater potentiality and inferring the bed rocks configuration which were controlled the groundwater. Report is under progress.

Electrical mapping were done of the Sahibi River near Kotputli for tracing the fractures and delineating the bed rocks topography of that area and total 50 VES have been carried out along the River. Report is under progress.

9.6.2 Borehole logging

The multi - channel electrical and gamma logger of Uptron Geo-logger (EL – 600) is available in region and is able to measure the Self potential, single point resistance, Resistivity (Short and long normal), 6"- Lateral resistivity and gamma logging parameters.

During 2008-09, seven pilot boreholes measuring cumulative depth of 1105 meters were logged at

different parts of Rajasthan. Logs parameters thus recorded and identify the granular zones and well assembly were recommended.

(a) Borehole logging in Bikaner district

One borehole was logged in this district. Formation dominated by the sandstone. The formation in between the 106 to 128 was identified hard sandstone / limestone inferred by gamma and resistivity logging. Formations above and below are friable / fractures and potential for groundwater. Ground water quality below hard formation is inferred to be potable for drinking water.

(b) Borehole logging in Hanumangarh district

Canal water are being seepage in under ground near around the area and resulted the groundwater up to the 40 to 60 m are inferred fresh and reflected in geophysical parameters. Gradually the quality is deteriorated to some extent of depth. Formation quality other than the effected by canal water varies from 1400 to 3500 ppm at 25^{o}. The formation are laminated with silt, sand and clay.

(c) Borehole logging in Jaipur district

The formation of boreholes of Jaipur district are dominated by sand silt and admixed of these sediments and also water is potable.

(d) Borehole logging in Tonk district

One bore well was logged in this district for being inferred the salinity in hard fractures.

9.7 NCR, BHOPAL

9.7.1 Surface Geophysical Surveys:

Surface resistivity surveys have been conducted to revealed the subsurface hydrogeological condition in parts of Ujjain, Burhanpur, Bhopal, Sagar and Gwalior district to support the groundwater exploration programme and augmentation of water supply to various government agencies. For conducting the resistivity investigation DDR-4 and SSR-MP1 resistivity meter have been used. To achieve the target 100 Vertical Electrical Sounding (VES) and 1.24 line-km Gradient Resistivity Profiling (GRP) have been conducted. Most of the VES curves have been interpreted through conventional curve matching techniques and modeled with computer software like SCHLUM and IPI2WIN. The GRP data have been interpreted qualitatively in terms of resistivity `low' with respect to the background resistivity. The Microsoft EXCEL software has also been used for plotting VES and GRP data.

Geophysical Investigation in Ujjain district:

Geophysical studies on "Characterization of alluvium/weathered rock thickness in Kshipra River basin through surface resistivity measurements" have been conducted in parts of Ujjain district. In this programme forty-one Vertical Electrical Sounding (VES) have been conducted in and around Ujjain city covering an area of about 250 km^2. The VES data have been processed and analyzed. The interpretation of VES data indicated that the flood plain area in Kshipra River basin is mainly limited along the bank of Kshipra River as well as some major tributaries of Kshipra River. It has been reveled that in the southern direction of Ujjain, the alluvium/weathered thickness varies from very shallow to 15 m bgl however in the northern side of Ujjain the alluvium/weathered formation attain its maximum thickness of about 30 to 40 m bgl. It is also indicated that the right bank of area of Kshipra River have more alluvium/weathered thickness in comparison to left bank area of Kshipra River. Based on interpretation of VES data a map of alluvium/weathered thickness have been generated for the study area.

Geophysical Investigation in Burhanpur district:

With objectives to rejuvenate the ancient water supply system (infiltration galleries) of Burhanpur town, Electrical Resistivity Survey comprised of Vertical Resistivity Sounding (VES), Wenner Resistivity Profiling (GRP) and Resistivity Imaging were carried out in Khuni- Bhandara area around Burhanpur town district Burhanpur, Madhya Pradesh to study the prevailing subsurface hydrogeological conditions beneath the area. In total 15 VES, 300-line m WRP and a resistivity imaging were conducted in the area. Geoelectrical cross-sections drawn for the area are able to reveal the qualitative knowledge of water bearing aquifers connected to the Khuni Bhandara system. Resistivity imaging has helped in delineating the hidden fault in the area.

Geophysical Investigation in Bhopal district:

For short Term Water supply investigations, Surface resistivity investigations have been conducted in sounding and traversing mode over different location in the premises of Neori (SI Lines) and 3 EME Center, Bairagarh,

Bhopal. In total, 10 VES and 0.64-line km GRP were conducted to pinpoint the suitable locations for augmentation of water supply to these establishments. The geophysical investigation successfully achieved the purpose.

Geophysical Investigation in Gwalior district:

On request of MES, Morar Cant Gwalior, 18 VES have been conducted in Morar Cant campus at Gwalior in Gwalior district to augment the water supply to the Defense establishment. The investigation clearly delineated the thickness of alluvium formation and identified suitable locations for drilling of new wells in their premises.

Geophysical Investigation in Sagar district:

To assist the groundwater exploration programme in Sagar district, surface resistivity investigations have been conducted by conducting VES in different villages. In total, 12 VES were conducted to pinpoint the suitable locations to support groundwater exploration in Sagar district.

9.7.2 Borehole Logging:

The geophysical logging of borehole has been conducted at Chhattarpur village exploratory/observation borehole sites in Betul district. The depth of boreholes logged in the district is 200.00 m bgl. The borehole is in Hard rock formation. The digital Geologger 3030 (Mark-II, OYO Japan) has been used for conducting the logging. As the electrical parameter of logger is not working, the only Natural gamma parameters of the boreholes could be recorded.

9.8 CR, NAGPUR

9.8.1 Surface Geophysical Surveys

Electrical resistivity surveys were carried out to delineate potential water bearing zones in the farmers distress areas of Wardha district, supporting studies for ground water modeling studies to determine the contact of different geological formations in Kanhan area of Nagpur district and short term water supply investigations of Air force station, Nagpur.

FINDING OF THE GEOPHYSICAL STUDIES

a. Electrical resistivity surveys (19 VES at 14 sites) were carried out to delineate potential water bearing zones in the farmers' distress areas of Wardha district. Submitted the report based on VES for 7 sites.

The resistivity of the top soil is ranging from 02 – 130 Ωm with thickness ranging from 0.9-3.3m, the resistivity of the highly weathered basalt is ranging from 02 – 130 Ωm with thickness ranging from 1-20 m, the resistivity of the weathered basalt is ranging from 10 – 25 Ωm with thickness ranging from 3.5-8 m, the resistivity of the fractured basalt ranging from 10-35 Ωm with thickness ranging from 8-18 m, the resistivity of the vesicular basalts ranging from 40-60 Ωm, with thickness 10-30 m and the resistivity of the massive basalts is > 60 Ωm.

b. Preliminary interpretation of VES in Nagpur district infers that the Gondwana formations are extending more than 100 m depth at and around Patansawangi, Saoner, Brahmanwada and Bopkhara. These are at shallow depths at and around Dahegaon (40m) and Kelod (15m).
c. Based on the VES for Air Force Station, Vayu Sena Nagar, Nagpur, Two sites were recommended for construction of bore wells at RR Station Amravati Road and one site was recommended for dug cum bore well at Vayu Sena Nagar.

9.8.2 Borehole Logging

Three geophysical loggings were carried out in Buldhana district at Madakhed, Tunki and Jalgaon Jamod. The quality of ground water at deeper levels between 119 and 115m at Jalgaon Jamod is lower than at shallower levels

9.8.3 Salient features:

The interpreted geoelectric parameters were standardized keeping in view of the local hydrogeology and hydrogeolology.

Resistivity Range (Ωm)	Probable lithology	Thickness(m)
4-130	Top soil	0.4-4
<5	Clay	1-10
5-50	Sand Stones	5-10
50-100	Moderately compact sand stones	10-25
100-500	Compact sand stones	10-25
100-500	Fractured Granite Gneiss	10-22
>500	Massive granite Gneiss	

The resistivity of the 1st geoelectric layer is in general is varying from 4 to 20 Ohm m represents top soil. The thickness of the 1st geoelectric layer in general is varying from 0.4 to 2m and occasionally exceeds 4m.

This 2nd geoelectric layer with < 5 Ohm m in the eastern, western, northern and southeastern parts of the area represents clay. In the southern and some central parts of the area with 5 to 40 Ohm m resistivity represents sandstone. The thickness of the 2nd geoelectric layer in general is varying from 1.0 to 10m and at few places in the central part of the area and at some localized patches in the southeastern part of the area exceeds 10m.

The 3rd geoelectric layer in the eastern, southeastern and northern parts, the resistivity with less than 4 Ohm m represents clay. In the central, south-central, western and southwestern parts, the resistivities from 4 to 50 Ohm m represent sandstone. In the western, central, southern and southeastern parts, the resistivities from 50 to 100 Ohm m represent moderately compact sandstone. In the western parts, the resistivities from 100 to 500 Ohm m represent compact sandstone. The same order of resistivities in the in the central part represent moderately weathered/fractured granite gneiss. In the northern, central, and southeastern parts, the resistivities more than 500 Ohm m represent massive granite gneiss. The thickness of the third geoelectric layer in general is varying from 10 to 25m and at few places in the northeastern part of the area exceeds 25m.

This 4th geoelectric layer layer with < 4 Ohm m resistivity in the southern part of the area represents clay. In the southern part, the resistivity order from 4 to 100 Ohm m represents sand stone. In the central part, the resistivity order from 100 to 500 Ohm m extending in E-W direction represents fractured granite gneiss. In the northern, central and eastern part, the resistivity order more than 500 Ohm m represents massive granite gneiss. The thickness of the fourth geoelectric layer in general is varying from 22 to 35m

The 5th geoelectric layer with <3 Ohm m in the southeastern and southern part represents clay and from 3 to 100 Ohm m represent sandstone. In the western, southern, southeastern and a small patch of central part with 100 to 500 Ohm m resistivity represent fractured granite gneiss with different grades of fracturing. The rest of the area with more than 500 Ohm m resistivity represents massive granite gneiss.

Based on the VES for Air Force Station, Vayu Sena Nagar, Nagpur, occupied by basaltic formations underlain by granite gneisses (15-50 Ohm m resistivity below 15m depth up to 70-140m depth), two sites were recommended for construction of bore wells at RR Station Amravati Road and one site was recommended for dug cum bore well at Vayu Sena Nagar.

Three geophysical loggings were carried out in Buldhana district at Madakhed, Tunki and Jalgaon Jamod. The quality of ground water at deeper levels between 119 and 115m at Jalgaon Jamod is lower than at shallower levels.

The granular zones inferred from Geophysical logging at Jalgaon Jamod are tabulated below.

Depth Range (m)	Thickness	SP (mv)	Resistivity (Ohm m)
6 - 26.5	20.5	-83 to -76	3.8 to 19
32.5 - 35	2.5	-74	2.8
40 - 44	4	-72	2.8
46 - 50	4	-71	2.6
53 - 56	3	-70	2.8
61 - 63	2	-66	3
73 - 75	2	-62	2.9
77 - 80	3	-69	3
85 – 86	1	-59	3
93 – 94	1	-59	2.8
99 – 100	1	-62 to -61	3
103 – 105	2	-63	20.7
109 - 115	4	-65	2.9

The granular zones inferred from Geophysical log at Madakhed are tabulated below.

Depth Range (m)	Thickness (m)	SP (mv)	Resistivity (Ohm m)
1.5-9	7.5	-107	10
9-10	1	-110	23
10-17	7	-115	16
17-22.5	5.5	-111	6
23-26	3	-117	3.1
26-27	1	-116	2.9
27-32	5	-115	2.8
32-36.5	4.5	-115	2.9
38.5-40	1.5	-115	2.6
54-59	5	-115	2.5

The granular zones inferred from Geophysical log at Tunki are tabulated below.

Depth Range (m)	Thickness	SP (mv)	Resistivity (Ohm m)
15.7-21.8	6.1	-95	17
24.9-40	15.1	-103	14

9.9 NR, LUCKNOW

9.9.1 Surface Geophysical Surveys

For the selection of exploratory drilling sites in and around Aulenda Geophysical surveys were carried out on the:

Gomti River Flood Plain, Chinhat block, Lucknow district: Surface geo-electrical surveys were conducted to delineate fresh water aquifers and define the top layer characteristics for the purpose of artificial recharge over an area measuring 80sq. kms– 78 VES. A close networking of VES is planned on the basis of this work for exploring flood plains to augment drinking water requirements. Akola villages for drinking purposes in saline environment 22 Vertical Electrical Soundings and 100 line – m Gradient Resistivity Profiling were conducted in Parts of Agra district Out of five sites pin - pointed, one site was drilled at Akola yielding fresh water up to 80m bgl.

9.9.2 Borehole loggings

Borehole geophysical logging of 15 boreholes with a cumulative depth of 6616 m, (as per regular exploration programme) was done for the delineation of fresh ground water zones and demarcation of thick clay zones for the purpose of cement sealing in the Arsenic affected area / districts (to prevent hydraulic continuity of overlying brackish / saline formation water), if any, for successful construction of tube wells.

STATE : - Uttar Pradesh

District	No. of wells Logged	Location	Depth Drilled (mbgl)	Depth Logged (mbgl)	Date of Logging	Logs Recorded	Total depth of logging (m)
B	C	D	E	F	G	H	I
Agra	*03*	*Aulenda Fatehpur Sikri*	*93.5*	*93.0 93.0*	*13.09.08*	*SP, N16", N64" Natural Gamma*	*186*
		Akola	*120.0*	*120 120*	*03.01.09*	*SP, N16", N64" Natural Gamma*	*426*
		Chhota Katchhpura	*120.0*	*118 120*	*06.03.09*	*SP, N16", N64" Natural Gamma*	*238*

District	No. of wells Logged	Location	Depth Drilled (mbgl)	Depth Logged (mbgl)	Date of Logging	Logs Recorded	Total depth of logging (m)
Bagpat	01	Community Centre Idgah Road	381.8	380 320	01.08.08	SP, N16", N64" Natural Gamma	700
Pratap garh	01	Shanideo Temple Kushphara	201.0	200.0 201.0	22.08.07	SP, N16", N64" Natural Gamma	401
Ballia	03	Belthara Road, Jila Panchayat Guest House	350.0	348 300	30.05.08	SP, N16", N64" Natural Gamma	648
		Adampur Nara Nagar Block	360.0	348 150	14.08.08	SP, N16", N64" Natural Gamma	498
Lakhi -pur Kheri	03	Gadania, Palia Block	361.0	360.0	19.04.08	SP, N16", N64"	360
		Parsia, Isha Nagar	151.0	150 148	16.12.08	SP, N16", N64" Natural Gamma	298
		Parsia, Isha Nagar	360.0	357 190	26.12.08	SP, N16", N64" Natural Gamma	547
	02	Behsuma Hastinapur Block	451.0	320 445 150	10.01.09 11.01.09	SP, N16", N64" SP, N16", N64 Natural Gamma	915
Muzaffar Nagar	01	Khan Jahanpur	150.5	150	08.07.08	SP, N16", N64"	150
Lucknow	01	Gomati Nagar	76	75 75	26.09.08	SP, N16", N64 Natural Gamma	150
Varanasi	01	BHU	200.5	200 190	04.12.08	SP, N16", N64 Natural Gamma	390

State :Bihar

Chhapra	01	Sitab Diara JP Nanar	250.0	80 130 235	22.01.09 29.01.09 29.01.09	Natural Gamma	445

9.9.3 Findings on the basis of Geophysical Studies

Surface Geophysical Surveys:

Electrical resistivity surveys were carried out at Aulendha, Kumharwara and Nagla Debia village, Fatehpur Sikri block Agra district for pinpointing water well site and to decipher fresh / saline interface. Five VES points are considered as containing fresh quality water column thickness varies between 45 to 65 m .

Seven electrical resistivity soundings were conducted at Akola village, Akola block, Agra district. Two VES points are recommended for well construction down to 90 mbgl. The saline quality water is found disposed immediately below this depth. On the basis of resistivity surveys, one borehole drilled at Akola, the fresh /saline interface was inferred at 90 m bgl and 35 m thick fresh water bearing formation were recommended for tube well construction.

Surface geo-electrical surveys were conducted on left bank of Gomti river, Chinhat block, Lucknow district over an area of 50 sq. kms to delineate fresh water aquifers and define the top layer characteristics for the purpose of artificial recharge. The aquifer zone starting from water table is characterized by resistivities in the range of 17 to 75 Ohm-m. It is present throughout the area but varies in thickness over a wide range of 50 to 150 m.

The maximum thickness of aquifer is 150 m. At most of the VES points in the surveyed area, comprising about an area of 45 sq. kms, a coarse grained sandy layer occurs upto 10 m depth above the aquifer. Such areas appear to be suitable for groundwater recharge.

Borehole Geophysical Logging: S.P., Short and Long Normal resistivity and Natural Gamma Ray logs were recorded in all the boreholes logged.

Agra: Three boreholes were logged in the district down to a maximum depth of 120.0m bgl. The sub-surface formation water in the district in general is brackish / saline at depths and also suffers with Nitrate and Fluoride problems at Places. In the boreholes drilled at Akola and Kachhpura, on the basis of resistivity survey, the fresh /saline interface was inferred at 90 and 99m bgl respectively and 35 to 40 m thick fresh water bearing formation were recommended for tube well construction. The third well drilled at Aulenda near Fatehpur Sikri was located in the proven saline environment encountering saline ground water from the surface with the resistivity in the zones ranging from 3 to 8 Ohm – m. Formation water quality is slightly better in the bottom / last zone i.e. in the depth range 86 – 92m bgl but still poor. So the well construction was recommended to be subjective of the zone test.

Bagpat: One borehole down to the depth of 380.0m bgl was logged. The quality of formation water is brackish below 62.0m bgl. and becomes saline below 100.0m bgl as the resistivity drops down to around 5.0 ohm - m. Good clays are inferred to exist in the depth range 43 – 52, 95 – 100m bgl for the purpose of cement sealing and further down to 357 – 362m bgl, as intercalations

Ballia: Geophysical logging of two boreholes were conducted down to a maximum depth of 355.0m bgl. Formation water quality is fresh down to 355 m depth and sediments are medium to coarse grained. Good clay zones having thickness of 2 – 12 m is found to exist as intercalations between the granular horizons through out the depth intervals logged for the purpose of cement sealing, if any, to prevent Arsenic contamination.

Lakhimpur Kheri: Geophysical logging of two boreholes were conducted down to a maximum depth of 360.0m bgl. The quality of formation water is good down to the depth of 360.0 m bgl depth and sediments are medium to coarse grained. Three aquifer groups were inferred in general in the depth ranges G.L. - 120 / 160, 120 / 160 – 264 / 300 and 264 / , 300 – 360m bgl, the depth of logging. Good clay zones having thickness of 2 – 9m are found to exist as intercalations between the granular horizons through out the depth intervals logged for the purpose of cement sealing, if any, to prevent Arsenic contamination.

Lucknow: One borehole (UP Jal Nigam, field demonstration to CGWB trainees) was logged down to the depth of 75.0m bgl. The formation water quality is fresh down to 75.0m bgl.

Meerut: Two boreholes were logged down to a maximum depth of 445.0m bgl. The sub-surface formations carry fresh quality water down to 445.0m depth. Three aquifer groups separated by 2 to 6m thick clays are identified. The aquifer contents are becoming finer with depth as the resistivity decreases with depth from around 100 Ohm-m to 30 Ohm-m.

Muzaffarpur(Bihar): One borehole was geophysically logged down to the depth of 150.0m bgl. The sub-surface formations carry fresh quality water down to the borehole

column logged. Good clays are inferred to exist in the depth range 49 – 53, 72 – 75 and 127 – 130m bgl.

Pratapgarh: One borehole at Kush Phara was logged in the district down to the depth of 201.0m bgl. The sediments are finer in nature and three aquifer groups separated by thick clays are identified down to 201.0m bgl. The formation water quality is fresh down to 201.0m. The sub-surface formation water in the district in general is brackish / saline at depths. Two - tier salinity was inferred from log correlation at places.

Varanasi: One borehole was logged in the district down to the depth of 200.0m bgl. The formation water quality is fresh down to the borehole column logged. Good clays are inferred to exist in the depth range 59 – 62 and 102 – 104m bgl.

Chhapra district,Bihar: One borehole was logged down to the depth of 250.0m bgl. The quality of formation water with is fresh down to the borehole column logged. Good clays are inferred to exist in the depth range 19 – 22 and 25 – 30, 69 – 73, 87 – 91, 148 – 153, 155 – 160, 167 – 173, 214 – 217 and 219 – 222 m bgl.

9.9.4. Salient features

- A 14 days Refresher Course was conducted on "Application of Geophysical Techniques for Ground Water Exploration and Management", for 24 Nos. of trainees from Central and different State Govt. departments of India at CGWB NR Lucknow.
- Field Demonstration of Surface Geophysical Surveys – Vertical Electrical Sounding, Gradient Resistivity Profiling and Magnetic Profiling and Borehole Logging – for Electrical Resistivity as well as Natural Gamma Ray Logs to all the trainees.
- Geophysical logs correlation along Flood Plain of Ganga river for evaluation of regional disposition of aquifers.
- Preparation and submission of Annual General Report of AAP 2007 – 08.
- Preparation of Refresher Course on "Application of Geophysical Techniques for Ground Water Exploration and Management.
- Interpretation of VES data of along Gomti River Flood plain, Chinhat Block, Lucknow district.
- Electric logs correlation of boreholes of Noida area, Gautam Budha Nagar district, U.P.
- Testing of Uptron Logger of CGWB, WCR Ahmedabad at Uptron factory borehole, Sarojini Nagar, Lucknow.
- Arrangements, Preparation and Preparation of Technical report on Electrical Resistivity Surveys in parts of Noida, Gautambuddha Nagar district, UP.
- Re-interpretation and Processing of Resistivity survey data of Jawahar Navodaya Vidyalaya, Gajokhar, Varanasi with reference to borehole logging results.

9.10 ER, KOLKATA

9.10.1 Surface Geophysical studies

Vertical Electrical Sounding have been carried out at 100 locations in parts of Hugli, Purulia districts of West Bengal and total 32.56 line Km of geophysical profiling has been conducted in the State.

9.10.2 Bore hole logging

A total of 4 nos. of borehole have been electrically logged in West Bengal. Electrical logging details and findings are as under:

Distric	Borehole electrically logged	Location	Depth drilled (mbgl)	Depth logged (mbgl)	Granular Zones identified (in mbgl)	Remarks
Haora	1	Hospital Ground, Mugkalyan	243	240	182-188, 195-207 & 226-232	Quality of water of the identified granular zones is fresh.
South 24 Parganas	1	Dongaria, BDO Office Compound, Budge	323.04	320	87-92, 109-115, 137-148, 156-160, 190-197, 219-280, 285-298 & 300-308	Quality of the granular zones beyond 160 mbgl is fresh, whereas granular zones above 160 mbgl are brackish.
Dakshin Dinajpur	1	Primary School Ground, Rampara Chenchra,	197	197	53-59, 120-163	fluoride concentration of granular zones in the depth span of 120-163 mbgl is above permissible limit (1.5 mg/L).
North 24 Parganas	1	Bokunda Free Primary School,	304.01	303	85-162, 194-232 & 243-282	-

9.10.3 Findings on the basis of Geophysical Studies

The geophysical investigation was carried out in Jangipara area of Hugli district under Ground Water Management Study, in order to delineate disposition of granular zones in the area. In general, two sets of granular zones are delineated, i.e. at the third/ fourth and the last layer. In the third layer, it is observed that towards northern and eastern part of the area (below the depth 10-12 m and thickness varying from 50-124 m) the grain size is medium to coarse, whereas at the southern and western part (below 12-22 mbgl and thickness varying from 38-140 m) the grain size is fine. The grain size of the last layer is of gravel and expected at the depth range of 100-200 mbgl. The thick clay layer which is the bed boundary between third and last layer pinches out at VES 5 creating a continuous sand bed.

The geophysical investigation was carried out in Purulia district under Ground Water Management Study to identify the depth of weathering and disposition of fractures. Geophysical survey reveals that, in general, four sub-surface layers have been identified, namely weathered, semi-weathered, partially weathered and fresh rock layer. Weathering is varying within the depth range of 5.70 to 46.80 mbgl, semi-weathered rock occurs within the depth range of 5.80 to 89.60 mbgl and partially fractured rock is lying within the depth range between 10.50 & 122.80 mbgl. The fractures are identified to be within the depth range of 40-50, 70-80 and 120-150 mbgl. The most dominating fractures are within 70-80 mbgl.

The geophysical survey was carried out in the blocks of Purulia district under Ground Water Management Study with the objective to measure the thickness of the alluvium in the Dwarakeswar and Futiary river bed and to know the nature of compactness of sub-surface formation.

The average thickness of alluvium in the Dwarakeswar river bed is 7.40 m in Hura block and 3.0 m near Sialbari area of Kashipur block, beyond which the fractures are identified in the depth span of 8-10, 12-15, 20-35 and 40-50 mbgl in Hura block, 12-15 and 20-40 mbgl in Kashipur block and 50-60 & 90-100 mbgl in Raghunathpur block. In the Futiary river bed, the average thickness of alluvium has been identified down to the depth of 9 m and the fractures in the depth span of 12-20 and 40-50 mbgl in Hura block.

9.11 MER, PATNA

9.11.1 Surface Geophysical studies

A total of 153 Vertical Electrical Soundings (VES) have been conducted in the districts of Patna, Jamui, Begusarai, Saran, Vaishali and Ara in Bihar and Ranchi and Simoga districts of Jharkhand State during 2008-09. Total 6 line Km magnetic profiling was carried out in Ranchi urban area as reconnaissance survey for ground water exploration using Proton Precession Magnetometer (PPM). 3000 line m gradient profiling was conducted in hard rock areas of Jharkhand covering Ranchi and Simdega districts and in Bihar covering Jamui and Munger districts using Syscal Resistivity meter. 800 line m self Potential Survey was done in Ranchi district.

9.11.2 Borehole logging

5 wells were logged for SP, N16 & N64 in the Gangetic alluvial areas covering Samastipur, Sahapur Patauri and Saran districts of Bihar State up to a depth interval between 100-235 m. The aquifer were precisely delineated in the arsenic affected areas of Gangetic Plain. With the help of arsenic concentration in different aquifers, arsenic free and arsenic contaminated aquifers were demarcated.

9.11.3 Salient findings based on geophysical survey

Flood Plain Study

A geophysical coverage of flood plain areas of Bihar was initiated by this Region during AAP 2007-08. Total 26 VES have been carried out during 2008-09. The VES were taken along the course of River Ganga. The study revealed following salient features.

Pre-monsoon and post monsoon VES were carried out at 3 places along the bank of river Ganga to estimate river bank aquifer storage. It was observed that geophysical survey is helpful for specific yield determination. The method is also very much cost effective. The specific yield value determined by applying this procedure is 15%. Another 6 VES were also carried out in pre-monsoon period in 2009 for further detail study.

The geo-electrical section along river Gandak prepared from the VES results was incorporated in hydrogeological map of Bihar.

Geophysical investigations in Hard Rock areas

A total of 127 VES and 3000 line m gradient profiling was conducted in the hard rock areas of Bihar (Jamui) and Jharkhand (Ranchi , Simdega). The main purpose was to have decisive idea about the ground water availability for exploration. The other objectives were to estimate weathered zone thickness and depth of the bedrock. Wherever enough space was available, Gradient profiling

was conducted to pinpoint drilling site. In most of the cases, drilling results were in well agreement with geophysical survey.

Self potential study was carried out for determination of ground water flow direction in Ranchi urban area. The study was very much fruitful in deciphering of ground water flow direction. Mise-a-la-masse survey was conducted in hard rock terrain of Munger for delineation of fracture geometry. The result clearly demarcated the geometry of two sets of fracture zone.

Artificial recharge studies:

Out of 127 VES carried out in hard rock areas 24 were carried out for feasibility study of artificial recharge structure in different blocks of Jamui districts. A special feasibility study for artificial recharge was conducted at Baroni OIL refinery, Begusarai.

9.11 NER, GUWAHATI

9.11.1 Surface Geophysical studies

Electrical Resistivity method has been employed for carrying out geophysical survey in various parts of Assam, Meghalaya and Arunachal Pradesh. A total of 29 Vertical Electrical Soundings (VES) have been conducted in Kamrup, Dhubri of Assam and East Khasi Hills, Ribhoi districts of Meghalaya and Kohima district of Nagaland adopting the Schlumberger/Half-Schlumberger electrode configurations to know the vertical extension of different litho-units and to delineate the existing potential fractures in hard rocks. All these 29 VES have been taken up under short-term water supply investigation and for pinpointing of exploration sites to facilitate the construction of tube wells for augmentation of drinking water.

In soft rock areas, a sequence of sand and clay with varied thickness has been identified where as in hard rock areas, weathered and fracture zones, semi-compact and compact formations have been identified. All the reports have been finalized and the findings/results are discussed in the next item.

9.12 SR, HYDERABAD

9.12.1 Surface Geophysical studies

During the year 2008-09, a total of 365 Vertical Electrical Soundings (VES) and 0.55 Line km of Resistivity profiling were conducted in parts of Kurnool, Prakasam, Mahaboob Nagar and East Godavari districts. The objectives of these surveys are to map the weathered zone thickness and to delineate the shallow/deep fracture zone in Mahaboob Nagar district and to support the coastal aquifer management studies in East Godavai district. Few more VES were taken in the farmers' distress Mandals of Prakasam district and for artificial recharge studies in Kurnool district.

In Kurnool district 34 VES were taken in and around Uppalapadu village (10 VES) of Oravakal Mandal and in and around Rmallakota village (24 VES) of Veldurti Mandal. These Vertical Electrical Soundings were taken as part of artificial recharge studies.

In Prakasam district 51 VES were conducted. Out of these, 29 VES were taken to benefit 18 farmers' distress villages of Addanki and Korsapadu Mandals. The remainng 22 VES were conducted to select the sites for exploration drilling in the district.

In Mahabubnagar district, a total of 150 Verticl Electrical Soundings were conducted in parts of Midjil and Madharam watershed to map the weathered zone thickness and to delineate the shallow/deep fracture zones.The analysis of data is in progress.

To support the coastal aquifer management studies that were taken up in East Godavari district, 130 VES were taken in parts of Amalapuram, Malkipuram Kothapet and Rajole Mandals.

9.12.2 Borehole logging

A total of 12 Boreholes were logged in Mahaboob Nagar and East Godavari districts. The SP, 16" & 64" Normal Resistivity logs were collected from all these wells. Out of these 12 loggings, 9 borehole loggings were conducted in boreholes drilled in Madharam watershed of Mahabubnagar district. The reports of all the 9 borehole loggings were prepared and submitted. Three Borehole loggings were conducted in East Godavari district where the drilling was done under exploration programme and the logging reports in terms of different litho units and depth wise quality of formation waters were submitted.

9.12.3 Findings of Geophysical Studies

Water resources estimation and modelling studies in Madharam Water Shed, Midjil mandal, Mahaboobnagar district:

From the interpreted results of the VES data from the Midjil Mandal of MahaboobnagarDistrict the following

layer parameters are assigned to different litho units. (Granites and Gneisses)

Litho unit	Resistivity range (in Ohm m)	Thickness range in m.
Weathered zone	15-106	0.6 – 30.0
Fractured zone	110 – 375	5.0 - 40.0

The depth to basement in the area is found to be in the range of 5.0 – 57.0 m. The Misa-la-Masse survey conducted near the Borehole No. 6 of the Urukonda well field indicated the presence of fracture in N60°E – S60°W direction.

Coastal aquifer management studies in East Godavari district:

Resistivity surveys are taken up in connection with the Coastal Aquifer Management studies in East Godavari district. The objective of the survey is to delineate clay layers, fresh water zones and demarcation of fresh/saline water interface. A total of 142 VES using Wenner electrode configuration are carried out in Razolu, Malikipuram, Mamidikuduru and Sakhinetipalli mandals, covering an area of about 400 sq.km

Resistivity soundings are also carried out along three traverses perpendicular to the coast. Based on the interpreted results of some of the data, it can be inferred that there exists 3-4 layer resistivity distribution of subsurface formations.

Clay/sands with saline water : less than 5 ohm-m
Sandy clay with brackish water : 5 – 10 ohm-m
Sand /sandy clay with fresh water : 10 – 15 ohm-m

Artificial recharge studies in Kurnool district

Resistivity surveys are carried out in Uppalapadu (Oravakul mandal) and Ramallakota (Veldurthi mandal) villages of Kurnool district in connection with artificial recharge of ground water (parts of toposheets 57 E/14 and 57 I/2). The objective of the survey is to establish the thickness of the weathered mantle, to identify fractures and to locate suitable sites for artificial recharge of ground water. A total of 34 VES with Schluberger electrode configuration are conducted at 5 sites in Uppalapadu and 6 sites in Ramallakota. VES curves show 3-4 layer geoelctric substratum. Based on the interpreted results, the thickness of the weathered zone is varying from 10 to 35 m with the resistivity varying from 13-57 ohm-m. The data is being processed further by other methods of interpretation.

Borehole logging

A total of 12 Boreholes were logged in Mahaboob Nagar and East Godavari districts. The SP, 16" & 64" Normal Resistivity logs were collected from all these wells. Out of these 12 loggings, 9 borehole loggings were conducted in boreholes drilled in Midjil and Madharam Mandals of Mahaboob Nagar district.

These boreholes were drilled in connection with the artificial recharge studies in selected watershed. The reports of all the 9 borehole loggings were prepared and submitted.

Three Borehole loggings were conducted in East Godavari district where the drilling was done under exploration programme and the logging reports in terms of different litho units and depth wise quality of formation waters were submitted. District-wise logging details be given hereunder.

District	No. of boreholes logged	Drilled depth (m)	Total depth of boreholes logged (m)
Mahaboob Nagar	9	695.5	677.0
East Godavari	3	285.0	260.0
TOTAL	**12**	**980.5**	**937.0**

Logging Parameters of granular zones of Amalapuram area, East Godavari District, Andhra Pradesh-

Sl. No.	Depth range (m)	SP in mV	Formation Resistivity (in Ohm m)	Natural Gamma radiation in cps	Salinity of the formation water
1.	8-18	-7	22	40-126	2360
2.	40-53	-35	4	40-126	5800
3.	64-75	-30	4	82-154	5200
4.	78-101	--25	4	82-154	4240

Logging Parameters of different litho units (Granitic) in Midjil area, Mahboobnagar District, Andhra Pradesh-

Formation	Formation Resistivity (in Ohm m)	Natural Gamma radiation in cps
Weathered granite	Less than 150	50-150
Fractured granite	150-1000	150-250
Massive granite	More than 2000	150-250

9.13 SER, BSSR

9.13.1 Surface geophysical studies with results/ findings /conclusion.

The Geophysical Investigations are taken up in two parts – Surface Resistivity Survey & Borehorle Geophysical Logging Resistivity Surveys comprising of 62 Vertical Electrical Soundings (VES) were conducted during 2008-09 in parts of Cuttack, Jajpur, Puri and Ganjam districts.

9.13.2 Borehole logging

Six nos of boreholes were geophysically logged in the districts of Cuttack, Kusupur, Jagannathpur, Mahanga Taratsasan, Koudakol, Kulia in the depth range of 84 to 219 m bgl. The logging results have deciphered the granular zones and suitable zones were recommended for well assembly on the basis of log interpretations.

9.13.3 Salient features :

Resistivity Surveys for Ground Water Exploration:

A total of 42 VES were conducted in parts of Cuttack-Jajpur districts to delineate the nature and depth of different subsurface formations, occurrence and direction of fractures in the hard formations and feasibility for drilling of production bore wells. Based on the VES results twenty sites were recommended for drilling under ground water exploration programme which yielded coupious water to meet the drinking water requirement of those areas.

Resistivity Surveys for Fresh / Saline Ground water interface studies:

The complex hydrogeological set up in the coastal tract of Orissa poses a serious problem for ground water management. 8 VES were conducted in Talasua creek of Puri district for monitoring saline water ingress study and 12 VES were conducted in and around Palur area, Ganjam district to delineate fresh/saline ground water interface and to demarcate areas with fresh water aquifers.

Borehole Geophysical Logging: -

The borehole geophysical loggings were conducted in six exploratory borehole of Cuttack district drilled with Direct Rotary Rig in coastal alluvial areas to demarcate the saline/fresh and pervious & non-pervious zones. SP, Short Normal (N16") and Long Normal (N64") resistivity logs were recorded using Uptron Multi-channel Logger. The productive zones and water quality estimations of the different zones with-in the bore hole are deciphered based on the logging results for the tube well assembly recommendations.

9.14 SWR, BANGALORE

9.14.1 Surface Geophysical Surveys

A total of 276 Vertical Electrical Soundings were conducted in parts of Karnataka for ground water exploration and one borehole was geophysically logged during 2008-09.

9.14.2 Findings of geophysical studies:

Exploration

Under GW exploration programme, geophysical surveys were carried out in Chamarajanagar, Belgaum, Bidar, Hassan, Chikkballapur. The geophysical surveys mainly comprised Vertical Electrical Soundings (VES) at the hydrogeologically selected sites in order to know the nature of sub-surface such as extent of weathering, fracturing, etc., to know the quality of ground water and to select comparatively better sites for taking up drilling. The details of surveys carried out district wise along with the results are presented below.

Chamarajanagar district:

As a part of the exploration programme based on the hydrogeological studies the geophysical surveys comprised 84 Vertical Electrical Soundings (VES) were conducted in parts of Kollegala taluk, Chamrajnagar district.

The VES curves obtained are 3-4 layered geoelectric section in which the last layer is basement. The first layer obtained

from the interpreted results was soil whose resistivity was varying in the range 52-90 Ohm.m. with thickness in the range of 1.5 - 5 mts. Depending on the resistrivity contrast the second and / or third layer resistivity was varying in the range of 25-500 Ohm.m. with thickness in the range of 27 – 35 mts and is considered as highly weathered to weathered formation. The partially weathered to hard formation resistivity was in the range of 30-300 Ohm.m. with thickness in the range of 50-95 mts. The fourth layer was recorded as massive formation with fractures. By considering the interpreted results and existing borewells data, 10 sites were recommended for drilling bore wells.

Belgaum district:

For ground water exploration in Belgaum district, 40 VES in 30 villages were covered by geophysical survey in Khanapur taluk.

From the VES results, it was concluded that the first layer was considered as a soil having resistivity range of 66-850 ohm m with the thickness in the range of 1-1.7 m. The second and third layer was characterised by the resistivity in the range of 18 – 900 ohm m which is considered as weathered / semifractured and massive formation in nature. The thickness of this formation is varying in the range of 3.5 to 87 m. The fourth and fifth layer resistivity is very high which is expected as massive formation with fractures. By considering qualitative and quantitative interpreted results, 10 sites were recommended for drilling borewells.

Bidar district:

In Basavakalyan taluk of Bidar district 12 VES in 6 villages were covered by geophysical survey. The VES curves obtained in the district have given to 5 layered geoelectric section in which the last layer was weathered / semi weathered and massive formation associated with fractures. From the VES results it was concluded that the first layer was considered as a soil having resistivity in the range of 23 -240 ohm m with the thickness in the range of 1 – 3.5 m. The second and third layer was characterised by the resistivity in the range of 7-300 ohm m which is considered as weathered / semi weathered formation in nature. The thickness in this formation is varying in the range of 3.5 to 66 m. The fourth and Fifth layer resistivity is very high which is expected as massive formation with fractures. By considering the interpreted results and the existing borewells data, 4 sites were recommended for drilling bore wells.

Hassan district:

As a part of the exploration programme in Arsikere taulk of Hassan district, a total 47 VES were done and selected in 18 villages to pinpoint sites for taking up drilling.

The VES curves obtained 3-4 layered geoelectric section in which the last layer is basement. The first layer obtained from the interpreted results was soil whose resistivity was varying in the range 3.6-1050 Ohm.m., with thickness in the range of 1.0-8.5 mts. Depending on the resistively contrast the second and / or third layer resistivity was varying in the range of 8.0-160 Ohm.m. with thickness in the range of 4.0-45.0.5mts and is considered as highly weathered to weathered formation. The partially weathered to hard formation resistivity was in the range of 92-415 Ohm.m.with thickness in the range of 20-45 mts. The fourth layer was recorded as massive formation with fractures. At 8 sites the drilling was carried out up to a depth of 200mts. All the sites were successful and the drilling discharge was in the range of 3 to 24 lps.

Chikkaballapur district:

A total 36 VES were conducted in Chintamani taluk, Chikkaballapur district. The VES curves obtained indicated a 3-4 layered geo electric section. The first layer obtained from the interpreted results was soil whose resistivity was varying in the range 22-140 Ohm.m. with thickness in the range of 0.5-3 mts.

Depending on the resistrivity contrast the second and / or third layer resistivity was varying in the range of 9-55 Ohm.m. with thickness in the range of 2 – 26.25mts and is considered as highly weathered to weathered formation. The partially weathered to hard formation resistivity was in the range of 97-335 Ohm.m. with thickness in the range of 29.75 - 110mts. The fourth layer was recorded as massive formation with fractures. By considering the interpreted results and the existing bore wells data 5 sites were recommended for drilling bore wells.

Special Studies: For Imapct assessment of ARS structures:

1. Iimpact assessment of Vented Dam at Tumbe, Bantwal:

The Geophysical survey was conducted near the Vented dam in Bantwal taluk South Canara district to delineate the thickness of weathered formation, fractured formation and depth to basement. A total of 22 VES were carried out in the study area. The interpreted results in the study area are showing 3 to 5 layered geoelectric section. It was observed that the soil formation is having thickness in the range of 0.5-9 mts. The weathered formation is having the thickness in the range of 4.5-36mts. The thickness of the fractured formation is in the range of 4-160mts. And thickness of the depth to basement is in the range of 20-75mts.which is very shallow at one site and extended with depth at one site.

2, Geophysical survey at Kanguvalli percolation tank area, Hosadurga taluk.

Geophysical survey comprising VES surveys was taken up to study impact of percolation tank at Kanguvalli, both on upstream and down stream portions in Kanguvalli village. Totally 11 profiles have been done with a distance of 100m between each profile. The profiles were carried out in grid pattern in three strips. The study could not be done in detailed manner on the down stream side due to space constraints.

VES curves indicated three to four layered geoelectric parameters. First layer is top soil with resistivity in the range of 18- 44 Ohm.m up to an average depth of 2m. Second layer is highly weathered layer with resistivity values of 2.0 to 9.0 Ohm.m in the depth range of 2-6m. Third layer is considered as weathered formation, with resistivity values of 12-24 ohm.m below 6 m to a depth range of 12 to 20m. Fourth layer is hard formation below the weathered zone in general, having resistivity values of 100-250 ohm with fractures. Good zones are expected in the depth range of 25-30m, even at lesser depth in the coconut grove in the northern portion of the tank bund. Shallow basement i.e., at 6 m depth is indicated in the VES conducted on the western portion on the upstream side.

Quality problem(Salinity) is indicated in the VES results of I, II and III profiles conducted on the southern and southwestern portion of the tank both on upstream and down stream side with resistivity values of of 2 to 6.5 ohm.m upto a depth of 5-6m in highly weathered zone & weathered zone in general. In the Northern portion also, quality problem is indicated as localized phenomena in the highly weathered zone. On the downstream, VES profiling indicated good quality of water on the eastern portion of the tank with good water bearing zones below the weathered zone of 12m.

9.15 SECR, CHENNAI

9.15.1 Surface Geophysical studies

102 (VES) Vertical Electrical Soundings and 61.2 Line Km profiling were conducted in parts of Cuddalore, Thiruvannamalai, Selam, Namakkal and Chennai in Tamil Nadu during 2008-09.

9.15.2 Borehole Logging

UPTRON logging unit was used for borehole logging of 5 wells in parts of Ariyalur district of Tamilnadu and Pudducherry for precise demarcation of clay zones and fresh and saline ground water zones.

9.15.3 Findings on the basis of Geophysical studies.

Conducted 60 Vertical Electrical soundings (VES) i.e., 3 VES at 2 sites in Salem, 9 VES at 5 sites in Namakkal and 48 VES at 22 sites in Tiruvannamalai district. Based on the VES results as well as local hydrogeology condition, the 20 sites were recommended for exploratory drilling in Tiruvannamalai district. Drilling results have confirmed the inferences from geophysical surveys.

Geophysical Studies comprising of 39 (VES) Vertical Electrical Soundings were conducted along the coastal tracts from Cuddalore to B. Mutlur of Cuddalore district. The data are under processing.
3 nos. of Vertical Electrical Soundings (VES) were carried out for Short-Term water supply investigations to identify feasible sites for production wells in Saint Thomas Mount and Coast Guard air station, Chennai.

9.16 KR, TRIVENDRUM

9.16.1 Surface Geophysical studies

A total of 50 Vertical Electrical Soundings and 10 Line Km profiling were conducted in parts of Trivendrum of Kerala State for ground water exploration during 2008-09.

9.16.2 Findings on the basis of Geophysical Studies:

In Kottukal microwater shed and in Neyyar basin of Trivandrum district Vertical Electrical Soundings(VES) were conducted in order to know the subsurface conditions such as variation of soil layer, extent of weathering and fracturing etc.

In this area the soil resistivity is varying in wide range of 75-3800 ohm.m with thickness in the range of 0.8- 6m. In the NW part of the study area soil layer was followed by lateritic formation with resistivity in the range of 340-3600 ohm.m and extends up to a depth range of 7 to 35 m and in turn followed by the formation with resistivity in the range of 60-100 ohm.m. The lower order of resistivities indicates clayey formation whereas higher order of resistivities indicates consolidated formation. In the remaining area the weathered formation recorded resistivity of 18-190 ohm.m and extends down to a depth range of 3-32 m. except at one VES where it was 50m.This was followed by the crystalline formation with resistivity in the range of 110-800 ohm.m with fractures at some of the VES.

The VES conducted in Neyyar basin indicated soil resistivity variation in the range of 50-2400 ohm.m with

thickness in the range of 1.3-3 m. The weathered Khondalite formation indicated resistivity in the range of 15-110 ohm. m and extends down to a depth range of 8-43 m. The fractured Khondalite formation resistivity was varying in the range of 175-320 ohm.m. The depth to massive formation was varying in the range of 18-105 m.

9.17 UR, DEHRADUN

9.17.1 Surface Geophysical studies

A total of 50 Vertical Electric Sounding (VES) were carried out in parts of Dehradun, Pithorgarh, Champawat and Haridwar districts of Uttarakhand. Out of this 43 VES were carried out for the areas recommended during Ground water Management Studies in parts of Pithoragarh and Champawat districts, 4 nos. VES were carried out for site selection for Artificial Recharge Studies at two sites one in each district in Haridwar and Dehradun and 03 nos. VES were carried out in Doon valley for filling the gaps for systematic coverage of Doon valley in grid pattern by resistivity survey.

9.17.2 Borehole logging

Geophysical logging of 1 no Exploratory well was conducted using Multichannel Uptron Logger down to depth of 170 m bgl against the depth drilled 175.10 m bgl for deciphering the granular zones. The data was processed and interpreted and recommendation report was submitted. The parameters SP, N64", N16", 6' Lateral and Natural Gamma Ray were recorded during the borehole logging.

9.17.3 Findings on the basis of Geophysical studies

Both the sites for which VES were conducted to know subsurface lithology were found to be feasible for artificial recharge studies. At site in the premise of the office of Water Shade Management Directorate at Indira Nagar, Dehradun, an injection well to depth of 50 m bgl was suggested for artificial recharge to ground water. At another site near the school at village Chudiala in Haridwar district artificial to ground water was suggested through the available pond by excavating it to depth of 2 m bgl for removing the surface silt deposited in the pond. The interpretation the VES for Ground Water Management studies is under progress. The geophysical Logging of the exploratory well reveals the following granular zones in the depth ranges of 34 – 37, 44 – 53, 60 – 64, 76 – 80, 88 – 96, and 109 – 113 and 130 – 138 m bgl. The value of apparent resistivity in the range of 90 – 270 Ohm-m was recorded against the granular zones indicating thereby the presence of subsurface formation comprising of coarse sand, gravels, pebbles, cobbles and boulders. Accordingly the well assembly was recommended by the combined analysis of Litholog and Geophysical Logs.

9.18 NCCR, RAIPUR

9.18.1 Surface Geophysical Studies

A total 102 nos. Vertical Electrical sounding (VES), and 2 nos. (0.20 line kms) Gradient Resistivity Profiling (GRP) are carried out during the year 2008-2009.

9.18.2 Findings on the geophysical studies

In Dhamtari district a total nos. of 24 VES have been carried out to delineate the subsurface formations. The alluvium thickness about 70m at Nawagaon and 58m at Danitola in Dhamtari Urban area are delineated based on VES data. In small water shade around Banroud the weathered thickness is observed around 4.5 to 34m followed by hard and massive Chandrapur Sandstone. In Kanker district 24 nos. VES and 2 nos. (0.20 line kms) GRP are carried out to delineate the subsurface formations.

The Interpretation of VES curves at village Telawat and Chilhati have shown the weathered thickness around 24 to 26m. On the basis of this the sites were recommended for ground water exploration. The exploratory wells at these two locations yield good discharge. In Durg district a total nos. of 36 VES have been carried out to delineate the subsurface formations in Tandula Command Area.

The thickness of weathered zone is varying from 10 to 30 m. This thickness is gradually increasing towards north end of the Command Area.

Five (5) VES were carried out in Central Excise Campus in Raipur district. The interpretation of VES curves are showing weathered thickness upto 45m (370hm-m) followed by a layer with resistivity value 300 ohm-m. A kink is observed at a depth of 80m also indicates the possibility of cavernous zone at this depth. .

9.19 GEOPHYSICAL REPORTS PUBLISHED: The following geophysical reports have been published by various Regions

9.19.1 NWR, Chandigarh:

Surface geophysical dat a pertaining to Jalandhar District (Punjab), Yamuna flood plains and areas covered under short term geo-physical studies during AAP 2008-09 were processed and detailed reports pertaining to Jalandhar Distt. and short term studies were submitted.

9.19.2 NCR, Bhopal:

1. Madhya Pradesh State Groundwater Geophysics Report .
2. Geophysical Investigation for Augmentation of Water Supply to MES Nowgong sCantt. District – Chhatarpur (M.P.) .
3. Geophysical Investigation for Augmentation of Water Supply to MES Morar, Gwalior (M.P.).
4. Geophysical Investigation for Augmentation of Water Supply to Neori (SI Lines), Bhopal (M.P.).
5. Geophysical and Hydrogeological Investigation for Augmentation of Water Supply to 3 EME Center, Bhopal (M.P.).

9. 19.3 CR, Nagpur:

1. Submitted the report based on VES for 7 sites in the farmers' distress areas of Wardha district.
2. Submitted the report based on VES for exploratory drilling sites in parts of Akola district.

9.19.4 NR, Lucknow:

Reports have been prepared/ submitted on the following:

1. Report on "Geophysical Surveys carried out in and around BHU, South Campus Barkachha, Mirzapur district".
2. Submission of report on "Electrical Resistivity Surveys for Identification of thick Shallow Aquifers and Artificial Recharge to Aquifers in parts of Bakshi ka Talab Block, Lucknow district".
3. Report in Hindi "On Land Subsidence and Development of Cracks in parts of Allahabad, Banda, Fatehpur, Hamirpur, and Kaushambi district".
4. Report on "Inland Ground Water Salinity in Central Ganga Plain".

9. 19.5 ER, Kolkata:

1. Report on status of geophysical investigation carried out in West Bengal and submitted.
2. Report on surface geophysical investigation carried out at Jangipara, Hugli district and submitted.
3. Report on surface geophysical investigation carried out in & around Baduria, North 24 Parganas district and submitted.

9. 19.6 SR, Hyderabad:

Details of various reports that were submitted during the year 2008-09 are listed below:

1. Report on Deep geoelectrical investigations for ground water exploration in south western part of Cuddapah basin, Kurnool district, Andhra Pradesh.
2. Report on Resistivity surveys in parts of West Godavari district (around Bhimavarm and up to the coast)
3. Report on the Geophysical logs (East Godavari District) collected from ONGC.
4. Logging Report of Piezometer wells in Medak district.
5. Report on geophysical surveys in parts of Nizamabad district for EW.
6. Report on deep resistivity surveys in parts of Kurnool District.

Compilation of data:

1. Entered resistivity data from Bhimavaram, West Godavari District and Nizamabad districts in GEMS soft ware.
2. Digitized logs of Urukonda of Mahaboobnagar district and Medikonda of Guntur district.

9. 19.7 SER, Bhubaneswar:

1. Six reports on the Geophysicalloggings of the exploratory bore holes in Cuttack district were prepared and submitted for construction of production wells.
2. Resistivity survey conducted in parts of Cuttack & Jajpur districts under exploratory drilling programme.

9. 19.8 SWR, Bangalore:

1. Report on geophysical survey carried out in North Canara district.
2. Two Interim reports on Geophysical survey carried out in Kollegal taluk of Chamarajnagar.
3. Geophysical study for Ground Water Management plan addressing farmer's distress in Shimoga district .

9. 19.9 SECR. Chennai:

Surface geophysical surveys conducted in parts of Villupuram district as well as surveys conducted in Chennai district for Short-Term Investigations.

9. 19.10 UR. Dehradun:

All the data of 50 VES conducted for the artificial recharge studies were submitted. Geophysical logging of exploratory well at Bhagwanpur, Dehradun was submitted.

9. 19.11 NER, Gauwahati:

Geophysical Report "Status report of Geophysical activities (both surface and sub-surface) in NER with special reference to Assam"- since 1974 to March,09 has been compiled.

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 elemts determinations using sophisticated instruments like Atomic Absorption Spectrophtometer (AAS), Digital PC based Spectrophotometer, Ion meter, Flame Photometer, ph meter, Conductivity meter, and Nephelometer. The laboratories are also provided with Electronic Monopan and Top loading Balances, Deionizer, Double Distillation Plant, Hot Air Oven, Water Bath, Magnetic Stirrer and Hot Plates. Four Regional Laboratories at Kolkata, Hyderabad, Lucknow and Raipur are also equipped with Gas Chromatograph (GC) to undertake the analysis of organic pollutants (Pesticides) at µg/l level. The Chemical Laboratory at Hyderabad is additionally equipped with Inductive Coupled Plasma Spectrometer (ICPS) for sequential analysis of multiple toxic elements with high accuracy. Total Organic Carbon (TOC) analyzer is installed in the Regional Chemical Laboratory at Kolkata. Some of these laboratories are also equipped with instruments and equipment to carry out biological and bacteriological analysis. The chemical data generated by these laboratories is utilized for monitoring and evaluating the groundwater quality in compliance with National Standards for its designated use, to study the impact of anthropogenic activities on ground water quality, to demarcate critical areas where there is water quality deterioration and to assess the point and non-point sources of ground water pollution so as to take necessary action for management of ground water resources.

During 2008-2009, 15671 No.water samples have been analyzed for determination of basic constituents. Analysis of 858 No. water samples for specific studies and analysis of 2625 No.water samples for Heavy metals involving the determination of elements like As, Cd, Co, Cr, Cu Fe, Mn, Ni, Pb and Zn has been carried out. Determination of organic constituents was carried out in 104 No. of water samples. Besides the analytical work, chemists from the various laboratories have participated in mass awareness programmes and trade fairs and have prepared exhibits, posters, handouts diagrams, etc. on water quality, for display. They have demonstrated the testing of various chemical parameters present in water and their impact on human body. The importance of water quality for artificial recharge to ground water through rain water harvesting and impact of chemical quality of the water being used for drinking, agricultural and industrial purposes has also been explained to farmers, visitors and students. The details of water samples analyzed by different Chemiacl Laboratories during 2008-2009 are tabulated (Table 10.1)

Table 10.1: Region-wise Water Samples Analysis

Region	Basic Analysis		Specific Analysis		Heavy Metals		Organic	
	Samples	Constituents	Samples	Constituents	Samples	Constituents	Samples	Constituents
NWHR	619	8050	7	35	46	322		
NWR	1322	17950			175	975		
WCR	894	14304	_	_	196	196	_	_
WR	1061	16253						
NCR	1656	21528			270	820		
NCCR	434	5286			178	178		
CR	1070	14062			257	1285		
NR	1371	17850	314	314	88	519	100	900
ER	1210	15169	2	2	255	255		
MER	781	6859						
NER	414	4679	18	18	374	399		
SER	735	4917						
SR	1260	16380			48	48	4	80
SWR	452	5877	519	2595	390	390		
SECR	1242	14842			229	2061		
KR	568	6199						
UR*	279	3348			119	846		
NHR*	199	2587						
SUO Delhi*	104	1352						
TOTAL	**15671**	**197492**	**858**	**2962**	**2625**	**8294**	**104**	**980**

*Regions don't have their own chemical laboratory, samples analyzed at other Regional chemical laboratories.

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

10.1 NORTH WESTERN HIMALAYAN REGION, JAMMU

On the basis of chemical data of ground water samples collected from National Hydrograph Stations, Reappraisal Hydrogeological Surveys, GW Exploration, and other Investigations carried out during the AAP 2008-2009, it is observed that the ground water of Jammu province, comprising of Jammu, Kathua, Udhampur and Rajouri districts, is generally fresh having low mineralization with value of Electrical conductivity varying from 215 micromhos / cm at 25°C (Batta Ballian) to 3220 micromhos / cm at 25°C (Suchetgarh). Ground water at Barni, Karol, Krishna and Suchetgarh is mostly of Calcium bicarbonate type but at few places it changes to Sodium bicarbonate type or mixed type. In Jammu provinces more than 50% of ground water samples are of very hard type. (Water having Hardness (as $CaCO_3$) more 180 mg/l is said to be very hard).

The concentration of Fluoride in ground water is generally below than 1.0 mg/l with only an exception in one water sample where fluoride concentration of 2.5 mg/l is observed that is higher than the permissible limit set by BIS-2007.

Nitrate concentration in ground water is generally low, with only a few exceptions where its value are more than the permissible limit (45 mg/l) BIS-2007.Its concentration ranges from traces to 274 mg/l (Gho Brahamna, Jammu district). In Kathua district 265 mg/l value of Nitrate is recorded at Jandi, while in Rajouri district 60 mg/l is observed at Seri. About 4.0%, 11.1% and 13.7% samples have recorded NO_3 more than 45 mg/l of Nitrate in Rajouri, Kathua and Jammu district respectively.

In Kashmir Valley only one place Kanshipora has 64 mg/l of Nitrate (more than permissible limit).In rest of the samples, Nitrate concentration is with in the permissible limits.

10.1.1 Kathua District

In ground water samples, the concentration of Copper, Lead, Zinc, Nickel, Cadmium is very low and are within the permissible limits (BIS-2007). At three locations, it is observed that Chromium concentration in water samples is slightly on higher side, (0.061 mg/l) with respect to its permissible limit (0.05 mg/l). High concentration of Chromium may cause lung tumors, nasal mucous membrane ulcers and dermatitis.

About 10.8% ground water samples of the area have concentration of Manganese more than the permissible limit (0.30 mg/l). Mn values vary from trace to 3.286 mg/l (Khagrod). High values of Mn are observed at Kandharnun (0.334 mg/l) Sherpur Bala (0.849 mg/l), Dewal (1.034 mg/l) and Basholi (2.294 mg/l). High concentration of Mn in ground water may cause changes in appetite and reduction in metabolism of Iron to form hemoglobin.

10.1.2 Kashmir valley

In Kashmir Valley, Iron (Fe) concentration in shallow ground water is generally less than water from deep aquifers. In shallow aquifer it varies from traces to 2.28 mg/l (Kungar H/P). Malingpora H/P (1.82 mg/l) & (Quazigund H/P (1.92 mg/l) are the places, where Iron value are beyond the permissible limit of 1.00 mg/l.

In deeper aquifer, maximum value of Iron is observed at Ghosebogh (8.80 mg/l). In Jammu province, about 15.7% (21 Nos.) samples have Fe more than permissible limit and concentration varies from traces to 12.2 mg/l (Nikowal Jammu District).

10.2 NORTH WESTERN REGION, CHANDIGARH

10.2.1 Hydrochemical Study for Determining Potability of Ground Water in Yamuna Flood Plain Area, Haryana

Samples were collected from the study area, comprising of 5 districts namely, Yamuna Nagar, Karnal, Panipat, Sonipat and Faridabad. These were analysed for basic chemical parameters. The sutability of ground water for drinking purposes is evaluated on the basis of Salinity (EC), SO_4, NO_3 & F.

District Yamuna Nagar

Perusal of the chemical data shows that ground water of the district is suitable for drinking purposes as the concentrations of all the chemical parameters is well within the permissible limits assigned by BIS (1991) for drinking waters.

District Karnal

Ground water collected from various locations is fresh and does not pose any problem for drinking purpose except at Pir Badauli where sulphate concentration (720 mg/l) is

found to be more than the permissible limit of 400 mg/l (BIS 1991).

District Panipat

The chemical analysis data shows that ground water is generally good and is suitable for human consumption except at Khotpura where it is unsuitable for drinking purposes due to high concentration of Fluoride (1.80 mg/l). BIS (1991) has recommended 1.5 mg/l F as the maximum permissible limit for drinking waters.

District Sonipat

31% of the collected ground water samples are found to be unsuitable for human consumption either due to high concentration of one constituent or more constituents when compared to concentration values for drinking waters prescribed for these parameters by BIS. These ground waters are from Kaimi (NO_3 63 mg/l), Akbarpur Barota (NO_3 52 mg/l), Janit Kalan (EC 2870µS/cm. at 25°C, SO_4 700mg/l) and Bahalpur (EC 3310µS/cm. at 25°C, SO_4 690mg/l). BIS(1991) has prescribed 45mg/l & 400 mg/l as maximum permissible limit for nitrate and sulphate respectively.

District Faridabad

Based on chemical analysis data, 53% of samples collected from the district are non-potable for human consumption due to high or very high value of EC/ SO_4/ NO_3/ For due to high concentration of more than one of these.

10.2.2 Conjunctive Use of Surface and Ground Water in Tohana Block, District Fatehabad, Haryana

Tohana block is one of the five blocks of Fatehabad district, which has an area of 476 sq.km. The block is drained by the Ghaggar river, which is also main source of recharge and its flood plain is soruce of the fresh water in the area. Tohana is having good canal network and main canal in the area are Bhakra Main Line, Fatehabad and Ratia Branch. Tohana and Ratia are two blocks of the district which has adequate amount of water either surface or ground water to support good agriculture activity. This is why these two blocks of the Fatehabad have witnessed highest level of agricultural development because of its water and soil resources.

Annual draft from the tubewell in the block has been calculated to be 2.14 ham, which is much higher in comparison to other blocks of the district. Lowest water level have been reported from Nanheri Kalan in Tohana block i.e. 37.00 mbgl where as minimum water level have been reported from Samain village around <3.00 m bgl. Maximum and minimum EC value has been reported from Indachoi and Chuharpur, with EC value of 4480 and 400 micro mho per cm respectively. In general a picture of EC can be painted as northern and north western part has fresh water and as we move towards the south eastern part of the block water becomes saline in shallow aquifers. Thickness of this fresh water reduces towards the south eastern part of the block.

In this study an attempt is being made so that maximum utilization of the ground water resources can be achieved by conjunctive use so that effective water resources are enhanced in comparison to actual water resources of the block.

10.2.3 Hydrochemical study of landfill area of Mohali, Punjab

The concerned area falls in Kharar block of Mohali District. It lies in north western part and outer periphery of Mohali town in sector 74. There is no salinity problem in the area. Nitrate concentration is higher than permissible limit in 3 numbers of water samples. Fluoride is more than the desirable limit in 2 water samples. Rest of the basic constituents is within the permissible limit for drinking as well as other domestic use. Trace elements could not be determined due to non-functioning of Atomic Absorption Spectrometer.

10.2.4 Micro Level Study in Tanda Block, District Hoshiarpur, Punjab

Tanda block is one of the eleven blocks of Hoshirpur district, which has an area of 28490 ha. Utilizable ground water resources for irrigation are 6484 ham and the annual net ground water draft is 8368 ham. Leaving ground water balance of 1884 ham.The block is already over developed.

Annual draft from the tubewell in the block has been calculated to be 2.54 ham, which is much higher in comparison to other blocks of the district. Tanda is drained by an ephemeral stream called Black Bein River, which is also main source of recharge during rainy season.

Deepest water level have been reported from Bhulwal in Tanda block i.e. 32.00 mbgl where as shallowest water level have been recorded at Jura village which is less than 8.00 mbgl. Maximum and minimum EC value has been reported from Tanda and Baich. In this study an attempt is being made so that maximum utilization of the ground

water resources can be achieved by effective water use efficiency.

10.3 WESTERN CENTRAL REGION, AHMEDABAD

Ground water samples from Ground Water Observation Wells were subjected to basic analysis. The pH values range from 7.20 to 8.86, which clearly indicate that the majority of the samples are basic in nature with fresh to saline in terms of conductivity.

The TDS values range from 200 to 21239 mg/l. The concentration of various anions varies from negligible to very high values, which mainly depends upon the country rock composition. The chloride value ranges from 14 to 10709 mg/l while sulphate ranges from Nil to 985 mg/l. The carbonate ions are absent in most of the ground water samples whereas bicarbonate ion ranges from 73 to 1659 mg/l. Majority of the cationic concentration is contributed by the Ca and Mg ions and the rest by Na and K ions. This phenomenon is supported by high hardness values ranging from 100 to 2550 mg/l.

In addition to the major cations and anions, samples were subjected to analysis of fluoride and nitrate, which range from nil to 7.5 mg/l and nil to 840 mg/l respectively. Sodium Adsorption Ratio, which is an important parameter in determining the suitability of ground water for irrigation purposes, was also calculated and the value ranges from 0.2 to 52.5.

Trace element analysis was carried out for some RHS samples of Banaskantha district. Trace metals such as Iron, Manganese, Copper, Lead, Zinc, Cadmium, Chromium and Nickel were identified.

10.4 WESTERN REGION, JAIPUR

Rajasthan suffers chemical quality problem in ground water due to arid climatic conditions. In order to ascertain the scenario of chemical quality of ground water in the State, water samples from National Hydrograph Network Stations, exploratory wells, Groundwater Management Study areas, polluted areas etc. were collected and analyzed.

10.5 NORTH CENTRAL REGION, BHOPAL

10.5.1 Impact of Idol Immersion on the Quality of Water bodies in Bhopal Town

A study on Idol Immersion in Bhopal and Shahpura lakes and its impact on groundwater was taken up in year 2008. Surface water and ground water samples were collected before and after the immersion of Idol during the September and October 2008 for basic chemical analysis including heavy metals.

Findings:

It was observed that dug well at Khatlapura Mandir recorded pH 8.73 exceeding BIS limit (6.5 to 8.5) it shows that water may be alkaline in nature. The concentration of major cations viz. calcium, magnesium, sodium and potassium was below the BIS maximum permissible limit for drinking water and concentration of major anions viz. carbonate, bicarbonate, chloride, nitrate, fluoride and sulphate was also below the BIS permissible limit for drinking water. Nitrate concentration more than 45 mg/l was recorded at lake view nursery, Prempuraghat and Bhabhada.

Regarding impact assessment of heavy metal it was observed that concentration of iron, manganese and lead in surface and groundwater were found above the permissible limit in the study area.

The concentration of iron recorded .53 mg/l at Shahpura Lake near Hanuman temple, 1.76 mg/l at Bhabhada Dam and 5.08 mg/l near Kalighat and Atuji Masjid exceeding BIS maximum permissible concentration of 1.0 mg/l. Concentration of manganese recorded at Prempuraghat, Bhadbhada 0.508 mg/l, Ginnori Mandir 1.406 mg/l, Kalighat 0.57 mg/l and Sehore Naka Bairagarh 0.51 mg/l were found exceeding BIS maximum permissible limit of 0.30 mg/l. Similarly lead concentration at Shahpura lake near EPCO, Parayaran Parisar 0.13 mg/l, Bhadbhada 0.091 mg/l, Lake view nursery, Prempuraghat and Kalighat 0.096 mg/l, Ginnori Mandir 0.0633 mg/l, Khatlapura Mandir 0.112 mg/l were found exceeding BIS maximum limit of 0.05 mg/l.

As the lead and manganese are used in paint for Idol making it is evident presence of concentration of these metals are directly linked to release of metal in the water body at Idol Immersion area causing surface water problem.

10.6 NORTH CENTRAL CHATTISGARH REGION, RAIPUR

As per the available facilities in the Regional Chemical Laboratory, 13 parameters like pH, EC, Carbonate, Bicarbonate, Chloride, Total Hardness, Calcium, Magnesium, Sodium and Potassium have been determined. The salient feature of the analysis results are given in the table 10.2

Table10.2: Concentration of the Major ions in ground water

Constituent	Range in mg/l	
	Min	Max
PH	7.2	8.6
EC µs/cm at 25° C	50	4350
Total hardness	10	1375
Calcium	2	328
Magnesium	1	135
Sodium	1	390
Potassium	0.1	120
Carbonate	0	12
Bi-Carbonate	12	488
Choride	4	724
Fluoride	0.1	2.8
Nitrate	0	2660
Sulphate	0	750
Iron	-	
Silica	3	11

The analysis results show that the chemical quality of ground water is good in Chhattisgarh. The pH value shows that the ground water is neutral to alkaline in nature. The electrical conductivity value in most of the samples are less than the 1000 µs/cm at 25° C which, indicate that the ground water is of low mineral content over Chhattisgarh. Exceptionally higher value of EC is recorded in samples of Chataud in Durg district (4350 µs/cm at 25° C) where as the lower value is recorded at Hatti (50 µs/cm at 25° C) in Raigarh district. Total hardness is observed within the permissible limit except in few locations of Bilaspur, Durg, Janjgir- Champa and Raigarh districts due to the presence of higher sulphate content. The concentration of nitrate is found to be less than 100 mg/l in majority of the samples. The Fluoride concentration in the ground water of Chhattisgarh State is generally below the recommended limits of BIS i.e. 1mg/liter. In few water samples of Bastar, Raipur, Kanker, Jashpur and Surguja districts it is found to be more than the 1.5 mg/ltr.

10.7 CENTRAL REGION, NAGPUR

Water Quality Maps

Water Quality Maps for TDS, TH, Cl, NO_3 & F of Maharashtra & U/T of DNH were prepared based on NHS-2007 data for inclusion in the yearbook.

Ground Water Quality Database Compilation, Validation & Computerization:

Compilation, Validation and Computerization of all ground water quality data generated after analysis in Chemical laboratory were carried out.

Inter-Laboratory AQC Exercise:

Participated in Inter-laboratory Analytical Quality Control (AQC) Exercise which was conducted by CGWB, Bhopal Laboratory under Hydrology Project-II (AQC-I Round).

10.8 NORTHERN REGION, LUCKNOW

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

Hydrogen Ion Concentration (pH):

The pH value of ground water in the state of U.P. varies from 7.75-8.25 which is within the permissible limits and water is found to be slightly alkaline in nature.

Electrical Conductivity (EC):

The Electrical Conductance of ground water is a measure of various chemical constituents present therein. It gives an overall quality of ground water for its use in various spheres of life like drinking, irrigation and other purposes.
Electrical conductance ranges from 190 to 7250 µs/cm at 25°C in the entire study area of Uttar Pradesh High EC (>3000 µs/cm at 25°C) 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°C) is observed at Malwa (5200 µs/cm at 25°C) in district Fatehpur; Fatehpur Sikri (4800 µs/cm at 25°C) in district Agra & Gujeni (4674 µs/cm at 25°C) in Kanpur Nagar. Highest value of EC is observed at Karahia (7250 µs/cm at 25°C) in district Hamirpur.

Such high values observed in the above mentioned districts indicate occurrence of saline water in the arreas.

Chloride (Cl):

It is one of the major ions present in water. Chloride ranges from 7.0 to 1917 mg/l in the state of Uttar Pradesh. Values of Chloride >250 mg/l (BIS-1991) are observed in the shallow ground water from Unnao, Fatehpur, Kanpur Nagar, Mau, Gautambudhnagar, Mahamayanagar, Mahoba, Hamirpur, Banda, Agra & Mathura districts. Extremely high values >1000 mg/l are observed at Fatehpur Sikri (1525 mg/l) district Agra & Shekhpur (1312 mg/l) district Kanpur Nagar. Highest value of Cl is observed

at Karahia (1917 mg/l) in district Hamirpur. Such high values of Cl contribute to the saline nature of ground water.

Nitrate (NO_3):

The concentration of nitrate has been found to vary widely in the state. It ranges from nd-775 mg/l. High values of No_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 (>300 mg/l) are observed at Malwa (302 mg/l) & Bilindi (775 mg/l) district Fatehpur & Khurhand (306 mg/l) district Banda. Moderately high values of No_3 are observed in the ground water from Hamirpur, Gautambudhnagar, Mau, Kannauj, Etah, Mahoba & Kanpur Nagar.

Fluoride (F):

Small quantities of Fluoride are beneficial in reducing dental caries whereas excess concentration (>1.5 mg/l, BIS 1991) is harmful and causes staining of tooth enamel and even fluorosis. Fluoride values range from nd-2.2 mg/l in the state of Uttar Pradesh. Values of Fluoride >1.5 mg/l are observed in the shallow ground water at Rupapur (1.78 mg/l) district Varanasi, Unnao City (2.2 mg/l) district Unnao & Salempur (1.6 mg/l) district Hamirpur.However Fluoride values >1.0 mg/l are observed in Hardoi, Shahjahanpur, Lucknow, Barabanki, Firozabad & Kanpur Nagar districts.

Total Hardness as $CaCO_3$:

The total hardness of ground water ranges from 110-2202 mg/l in the state of Uttar Pradesh. Higher permissible limit of 600 mg/l (BIS, 1991) has been set in the absence of alternate source. Values of total hardness >600 mg/l are observed in the shallow ground water from Agra,Mathura, Fatehpur, Mahoba, Hamirpur & Kanpur Nagar districts. A maximum value of 2202 mg/l total hardness is observed in the ground water from Fatehpur Sikri (Agar district).

10.9 EASTERN REGION, KOLKATA

Chemical analysis of ground water samples, collected during AAP 2008-09, revealed that fluoride content above permissible limit (1.5 mg/l) found in some isolated patches of Dakshin Dinajpur, Bankura, Purulia districts. Maximum value of 10.1 mg/l observed at Sarbamangala H.S. Compound, Gangarampur, Dakshin Dinakpur district. Similarly concentration of Iron above permissible limit (1 mg/l) found in isolated patches covering all districts of West Bengal. Maximum value of 12.62 mg/l observed at Durgapur, Basantpur of East Medinipur districts. Nitrate concentration above permissible limit (45 mg/l) found in some isolated patches of Malda, Murshidabad, Purulia, Hugli and East Medinipur districts. Maximum value of 80 mg/l observed in few locations of Purulia districts.

Arsenic concentration above permissible limit (0.05 mg/l) found in some solated patches of North 24 Parganas and Barddhaman districts. Maximum value of 0.146 mg/l observed in Kalna, Barddhaman district.

10.10 MID EASTERN REGION, PATNA

10.10.1 Bihar

Based on Ground Water Observation Wells samples analyzed, it is observed that Ground water 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 of Bihar. The maximum conductivity value (3720 microsiemens/cm) was found at Rupau of Nawada district whereas minimum conductivity value (185 microsiemens/cm) was reported at Gwalpara of Madhepura district.

In general, the quality of groundwater in terms of Total Hardness as $CaCO_3$ was found to be hard to very hard. The maximum concentration of Ca was found 142 mg/l at Nagra of Saran district whereas the minimum concentration of Mg was reported 1.2 mg/l at Begusarai of Begusarai district.

The concentration of chloride in majority of the ground water samples has been found to be within the desirable limit for drinking purpose (250 mg/l, IS:10500: 1991). The maximum concentration of chloride was found 540 mg/l at Tarwara of Siwan district.

The concentration of Na ranged from 11 mg/l at Gwalpara of Madhepura district to 345 mg/l at Brahampura of Bhojpur district and of K ranged from 0.5 mg/l at Jagdishpur (Bhojpur district) to 395 mg/l at Rupau (Nawada district).

Fluoride concentration was found to be more than 1.5 mg/l in about 17% of the groundwater samples analysed from Jamui and Munger district. The maximum concentration of F was found 8.04 mg/l at Khaira of Munger district.

By and large, ground water of shallow unconfined aquifer in Bihar was found suitable for irrigation, however, high values of EC > 2250 microsiemens/Cm, RSC > 2.5, and % Na (61-80%) makes the water injurious for irrigation.

10.10.2 Jharkhand

Based on ground water samples collected and analysed it is observed that 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 conductivity value, 3100 microsiemens/cm, was found at Chauparan of Hazaribagh district, whereas minimum value was found as 118 microsiemens/cm at Bhandra of Lohargada district. The value of electrical conductivity indicates wide variation in dissolved contents in groundwater of Jharkhand.

The concentration of chloride in majority of the groundwater samples has been found to be within the desirable limit for drinking purpose (250 mg/l, IS:10500: 1991). The maximum concentration of chloride was found 575 mg/l at Chauparan of Hazaribagh district.

The maximum concentration of Ca has been found 172 mg/l at Jasedih of Deoghar district whereas the minimum concentration of Mg was reported 1.2 mg/l at Burmu, Ranchi district.

The concentration of Na ranged from 8 mg/l at Berhait of Sahebganj district to 575 mg/l at Jasedih of Deoghar district. The concentration of K in groundwater samples was found 80 mg/l at Basia of Gumla district.

The maximum concentration of Fe was found 6.8 mg/l at Mandar of Ranchi district and the maximum concentration of F was found to be 4.2mg/l.

By and large, ground water of HNS in Jharkhand was found to be suitable for irrigation, however, high values of EC > 2250 microsiemens/cm, RSC > 2.5, and % Na (61-80%) makes the water injurious for irrigation.

10. 11 NORTH EASTERN REGION, GUWAHATI

10.11.1 Tripura

In general chemical quality of ground water in the state of Tripura is found good and portable. EC value range from 62 to 490 µmhos/cm at 25°C and states the freshness and potable nature of water. The pH value in the study area ranges from 5.28 to 8.42. Carbonate ranges from below detection limit to 15 ppm. The bicarbonate is important as it buffers both natural and human induced pH changes. In Tripura ground water HCO_3 ranges from 18 to 207 ppm. The chloride concentration of the ground water in the area ranges from 7 to 145 ppm which is well within the permissible limit. Analysis result of ground water sample reveals that SO_4 ranges from below detection limit to 29 ppm which is well within the permissible limit of 200 ppm. (BIS: 10500). The Fluoride concentration in the study area ranges from below detection limit to 0.61 ppm which is well within the permissible limit of 1.5 ppm. (BIS: 10500). Total Hardness in the study area ranges from 35 to 195 ppm.

The chemical quality of ground water in Tripura showed high concentration of Fe at some places. The Fe concentration in the study area ranges from 0.38 to 10.1 ppm. About 46 % ground water samples have Fe concentration more than the permissible limit of 1 ppm. (BIS: 10500). In general the ground water quality in the state of Tripura is found suitable for various purposes of drinking domestic and agricultural uses.

10.11.2 Arunachal Pradesh

In general chemical quality of ground water in the state of Arunachal Pradesh is found good and portable. EC value ranges from 82 to 261 µmhos/cm at 25°C, and states the freshness and potable nature of water. The pH range of 7.31 to 8.11 is quite safe and water is considered free from corrosive and scaling action. Carbonate concentration is below detection limit in ground water sample of the study area. The bicarbonate is important as it buffers both natural and human induced pH changes. HCO_3 ranges from 30.5 to 109 ppm.

The Cl concentration in the analysed water samples ranges between 3.54 to 18 ppm and is well within the permissible limit. Analysis result of ground water sample reveals that SO_4 ranges from below detection limit to 20 ppm which is well within the permissible limit of 200 ppm. (BIS: 10500).

The Fluoride concentration in the study area ranges from 0.08 to 1.17 ppm and does not exceed the permissible limit of 1.5 ppm for drinking water (BIS: 10500). The maximum concentration of Fluoride in Arunachal Pradesh is 1.17 ppm, found at Namphai of Changlang district. The Total Hardness of the analysed water samples in the study area varies from 30 to 90 ppm.

The chemical quality of ground water in Arunachal Pradesh shows that concentration of Fe ranges between 0.07 to 2.06 ppm. The maximum concentration of 2.06 ppm was found in Tirap Gate of Tirap District. The quality assessment of groundwater in the study area shows that all elements of water samples fall well within the desirable limits as given by norms of BIS.

10.11.3 Meghalaya

In general chemical quality of ground water in the state of Meghalaya is found good and potable. EC value ranges from 45 to 472 µmhos/cm at 25°C, and states the freshness and potable nature of water. The pH is an important factor in determining the chemical and biological properties of water. The pH value in the study area varies from 6.81 to 8.63. Carbonate concentration is below detection limit to 3 ppm. in ground water samples of Meghalaya. The Bicarbonate is important as it buffers both natural and human induced pH changes. In the study area Bicarbonate in ground water ranges between 18 to 232 ppm. The Cl concentration of the groundwater in the area ranges between 7 to 99 ppm which is well within the permissible limit (BIS: 10500). Analysis result of ground water sample reveals that SO_4 ranges from below detection limit to 27 ppm which is within the permissible limit of 200 ppm for drinking water (BIS: 10500). The Fluoride concentration in the study area ranges from below detection limit to 0.87 ppm which is well within the permissible limit of 1.5 ppm. (BIS: 10500). Ca ranges from 4 to 64 ppm. The Total Hardness of the analyzed water samples varies from 22 to 190 ppm as $CaCO_3$, which does not exceed the permissible limit of Bureau of Indian Standards for drinking water. In the state of Meghalaya, concentration of Fe ranges from below detection limit to 3.80 ppm. The maximum concentration of Fe was found 3.80 ppm at Bajendoba in the district of East Garo Hills. The quality assessment of groundwater in the study areas shows that all elements of water samples fall well within the desirable limits as given by norms of BIS.

10.11.4 Assam

In the state of Assam the quality of ground water is suitable for both domestic and irrigation purposes. Concentrations of different chemical constituents in most of the GWM stations are found within permissible limit. However concentration of some constituents exceeds permissible limit in pockets. EC value ranges from 77 to 2720 µmhos/cm at 25°C. In eleven ground water sample EC value were more than 1000 µmhos/cm at 25°C. The pH is an important factor in determining the chemical and biological properties of water. In the study area pH ranges between 5.27 and 9.89. In Bongaigaon, Darrang and Dhubri districts pH value is found beyond permissible limit in some wells. Fe concentration exceeds permissible limit in pockets in Dhemaji, Lakhimpur and Sonitpur districts. Fe concentration in the study area ranges from below detection limit to 10.5 ppm. It was found that 128 ground water samples in Assam have Fe concentration of more than 1 ppm., which is the permissible limit for Fe (BIS: 10500). SO_4 was found well below the permissible limit of 400 except at Darranggiri, Goalpara district where it was found 1040 ppm. The Cl concentration of the ground water sample in the study area ranges between 3 to 582 ppm. The maximum concentration of Cl was 582 ppm at Sualkuchi of Kamrup district. Carbonate concentration was found below detection limit to 10 ppm.

In several districts of Assam, high Fluoride content in ground water has been reported among those the worst affected areas are Karbi-Anglong and Nagaon district. It is observed that Fluoride content in the study area increases with depth. In Guwahati city of Kamrup district also high Fluoride content has been reported. High fluoride content (0.65 to 3.12 ppm.) has been reported from a few tube wells. The Fluoride concentration in the Assam state ranges from below detection limit to 7.2 ppm. In Majuli Island, Arsenic concentrations were found higher. Out of 24 samples it was found that 16 samples were having Arsenic concentration of more than 10 ppb., which is permissible limit for Arsenic. The Arsenic concentration in the Majuli Island ranges from below detection limit to 90 ppb. In general the ground water quality in the state of Assam is found suitable for various purposes of drinking domestic and agricultural uses.

10.12 SOUTHERN REGION, HYDERABAD

Water quality problems like Ground Water Exploration, Salinity, Total Hardness, Nitrates etc. were observed at Elchur, Prakasam district. Maximum concentration of Fluoride (3.9 mg/l) was observed at Urukonda of Mahabubnagar district. High Fluoride was observed at deeper bore wells. In all, 22 exploration samples were observed to contain Fluoride of more than 1.5 mg/l. Highest concentration of Nitrate was observed (1149 mg/l) at Elchur and 31 numbers of samples have Nitrate of more than 45 mg/l. High salinity of >3000 micro siemens/cm was observed at 6 sites. As a part of GWMS, major ground water quality problems observed were high salinity, nitrate and fluoride. Districts worst affected were Nalgonda, Prakasam and Anantapur.

Ground water samples collected from Kadapa, Anantapur, West Godavari and Prakasam district for reappraisal survey were analysed, High fluoride and Nitrate are the main water quality problem observed.

In West Godavari, maximum EC was found to be 11530 microsiemens/cm. Boron ranged from trace to 0.29 mg/l. Nitrate was in the range of 3 mg/l to 2294 mg/l.

In Prakasam district, EC range was observed to be between 380 and 2600 micro simenes/cm. Nitrate was in the range of 0 to 610 mg/l and Fluoride was in the range of 0.09 to 4.3 mg/l.

In Anantapur district, the range of EC was observed to be between 580 and 2600 micro simenes/cm. Nitrate was in the range of 15 to 296 mg/l and Fluoride was in the range of 08 to 3.23 mg/l.

In Kadapa district maximum EC found was 200 microsiemens/cm. About 25% of the samples have Nitrate and Fluoride of more than 45 mg/l and 1.5 mg/l respetively. Samples were also analysed for Aluminium. Concentrations found were trace to 0.5 mg/l.

10.13 SOUTH EASTERN REGION, BHUBNESHWAR

The Parameters determined in during the year were - pH, E.C., Carbonate, Bicarbonate, Chloride, Sulphate, Nitrate, Fluoride, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Phosphate and Iron. Samples from National Hydrograph Network Stations were analysed for pH, E.C., Fluoride, Chloride, and Nitrate contents apart from total Iron analysis in all the acidified samples from National Hydrograph Network Stations.

10.14 SOUTH WESTERN REGION, BANGALORE

In the South Western Regional Chemical Laboratory, a total of 971 ground water samples were analyzed for 8472 constituents during the AAP. In addition, 390 NHS samples were analysed for Iron. The samples were analyzed for major, minor and trace elements.

10.15 SOUTH EAST COASTAL REGION, CHENNAI

In general, the ground water quality in the state is fresh in about 15% of the NHMW as indicated by the EC value less than 750 µs/cm at 25°C. In about 52% of the NHMW, the EC varies between 751- 2250 and 12% of NHMW are between 2251-3000 indicating that the ground water is slightly mineralised and about 21% of NHMW, the EC is more than 3000 µs/cm at 25°C indicating that the ground water is highly mineralised.

The chloride content is less than 250 mg/l in about 52.5 percent of the sample analyzed and 37 percent of the samples are between 251-1000 mg/l and 10.5 % 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 91% of the sample analyzed and 9% of the sample shows more than 1.5 mg/l, which are from the districts Viz., Dharmapuri, Krisnagiri, Salem, Namakkal, Erode, Coimbatore, Pudukottai, Sivagangai, and Virudhunagar,

10.16 KERALA REGION, TRIVENDRUM

During the year 2008-09, a total of 568 water samples were analysed for basic parameters.Prepared Hydrochemistry Chapter based on April 2007 GWMW Data and submitted for Ground Water Year Book.

By observing the chemical analysis data of GWMW it can be concluded that over majority of the area, quality of ground water is suitable for domestic and irrigation purposes. The chemical contamination of groundwater in the state is in parts due to agricultural activities, industrialization, population growth and geological reasons in certain areas of Palakkad and Alappuzha districts registering relatively higher electrical conductivity and fluoride consistently for over a decade.

10.17 UTTARANCHAL REGION, DEHRADUN

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 78 samples were collected from Ground Water Observation Wells during May 2008 and analysed for determination of basic parameters. 121 number of

ground water samples collected for exploration reappraisal and other surveys were also analysed.

10.19 STATE UNIT OFFICE, DELHI

During May 2008, about 104 water samples from GWMS and exploration studies from Delhi were collected for detailed chemical analysis and no specific treatment such as acidification or filtration was given to them at site. Samples were analyzed for major anions (CO_3, HCO_3, Cl, SO_4, NO_3) and cations (Ca, Mg, Na, K) in addition to pH, EC, F, TH as $CaCO_3$, in the Regional Chemical Laboratory at Chandigarh.

11.0 HIGH YIELDING AQUIFERS EXPLORED

Board has explored high yielding aquifers during 2008-09 up to 31st March, 2009 in the various states of the Country under its scientific exploratory drilling programme, based on hydrogeological studies and utilizing remote sensing and geophysical techniques. High yielding wells with discharge ranging from 90 LPM to 3000 LPM have been constructed in the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Uttar Pradesh, 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 2008-09 up to 31st March, 2009 is given Table 11 .

Table 11: HIGH YIELDING WELLS CONSTRUCTED DURING 2008- 2009

Name of States	Description
Andhra Pradesh	i. An exploratory well drilled at Urukonda, Mahabubnagar district, Midjil basin has yielded a high discharge of 480 LPM, piercing through granitic formation of Archaean age. The well was drilled down to a depth of 200.00m bgl and the fractures were encountered at 35-36 m and 65-66 m respectively. 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. ii. An exploratory well drilled at Yelchur in Prakasam district down to a depth of 200.0 m bgl has yielded a high discharge of 270 LPM encountering the fracture at 42m, piercing granites of Archean age. 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. iii. An exploratory well drilled at Vemparala, Prakasam district has yielded a high discharge of 900 LPM. 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. iv. An exploratory well drilled at Piduguralla of Guntur district has yielded a high discharge of 960 LPM in Narji Limestones for a drawdown of 1.2m. This well can cater to drinking water requirements of a population of about 9500 (@ 60 lpcd for ten hours of pumping a day) in the area. v. An exploratory well drilled at Muppavaram Village, J. Ponguluru Mandal, Prakasam district down to a depth of 171.80 m bgl tapping of Archean age has yielded a high discharge of 195 LPM. This well can cater to drinking water requirements of a population of about 1950 (@ 60 lpcd for ten hours of pumping a day) in the area.
Assam	i. An exploratory well drilled at Daulasal, Barpeta district down to a depth of 204 m bgl has yielded high discharge of 883 LPM in alluvium consisting fine to medium sand formation. 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.
Bihar	i. A bore well drilled in granites at village Lilmi, Berhat block in the fluoride affected Jamui district to the depth of 73m. The high yielding fracture has been encountered in depth zone of 68-73 & 96-99m. The discharge (compressor) is about 64.8 m^3/hr (1080 LPM). This well can cater to drinking water requirements of a population of about 10000 (@ 60 lpcd for ten hours of pumping a day) in the area. ii. A bore well drilled down to a depth of 102m bgl. At Numer village of fluoride affected Jamui district has yielded a high discharge of 400 LPM in granite-Gneiss. 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.
Jammu & Kashmir	**i.** A bore well drilled down to a depth of 76.00 m. bgl. At upper Athwajan in Srinagar district drilled by DTH rig has yielded about 720 LPM. This well can cater to drinking water requirement of a population of about 7200 (@ 60 lpcd for ten hours of pumping a day) in the area. i. An exploratory well drilled at Sofi Mohalla (Srinagar) in Kashmir valley by down to a depth of 37.3 m bgl has yielded a high discharge of 1980 LPM in hard rock formation (Panjal Traps). The quality of groundwater is potable (EC- 210 µS/cm). This well can cater to drinking water requirements of a population of about 19800 (@ 60 lpcd for ten hours of pumping a day) in the area.

Name of States	Description
Chhattisgarh	i. A well drilled down to a depth of 122.7m bgl. at Pataud district Kanker has yielded a high discharge of 360 LPM in Granite 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. ii. . A well drilled down to a depth of 141m bgl. At Karap district Kanker has yielded a high discharge of 540 LPM in Granite Gneiss formation. 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. iii. A well drilled down to a depth of 159m bgl. At Chilhati district Kanker has yielded a high discharge of 840 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 8400 (@ 60 lpcd for ten hours of pumping a day) in the area. iv. A well drilled down to a depth of 101m bgl. At Sisida district Kanker has yielded a high discharge of 600 LPM in 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. v. A well drilled down to a depth of 200m bgl. At Lahsunwahi district Dhamtari has yielded a high discharge of 480 LPM in Limestone 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. vi. A well drilled down to a depth of 157m bgl. At Chhati district Dhamtari has yielded a high discharge of 345 LPM in Limestone formation. This well can cater to drinking water requirements of a population of about 3400 (@ 60 lpcd for ten hours of pumping a day) in the area. vii. A well drilled down to a depth of 63.7m bgl. At Charmuria district Dhamtari has yielded a high discharge of 300 LPM in Limestone formation. This well can cater to drinking water requirements of a population of about 3000 (@ 60 lpcd for ten hours of pumping a day) in the area. viii. A well drilled down to a depth of 200m bgl. At Khaira district Dhamtari has yielded a high discharge of 300 LPM in Limestone formation. This well can cater to drinking water requirements of a population of about 3000 (@ 60 lpcd for ten hours of pumping a day) in the area. ix. A well drilled down to a depth of 202m bgl. At Raipur Kala Surguja district has yielded a high discharge of 300 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 3000 (@ 60 lpcd for ten hours of pumping a day) in the area. x. A well drilled down to a depth of 198m bgl. At Dadgaon district Surguja has yielded a high discharge of 180 LPM in Granite Gneiss formation. 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. xi. A well drilled down to a depth of 196m bgl. At Kunni district Surguja has yielded a high discharge of 265 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 2650 (@ 60 lpcd for ten hours of pumping a day) in the area.
Gujarat	i. An Observation Well drilled down to a depth of 200 m.bgl at Ambhora village in Ashti taluka of Beed district has yielded a high discharge of 356.40 litre per minute in Deccan Trap formation. Three water-bearing zones were encountered at the depth of 7-10, 35-40 and 154-159 m bgl. The SWL was at 27.50 m.bgl. The formation is Jointed vesicular basalt. 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. ii. An Exploratory well drilled down to a depth of 185.90 m. bgl at Padwi village in Mahad tahsil of Raigarh district has yielded a high discharge of 730.80 litre per minute in Deccan trap formation. One water bearing zone was encountered at the depth of 185 – 185.90 m bgl. The SWL was more than 100 m and the formation is fractured vesicular basalt. This well can cater to drinking water requirements of a population of about 7300 (@ 60 lpcd for ten hours of pumping a day) in the area.
West Bengal	i. A well drilled down to a depth 327.27m bgl. at Kalipur of South 24 Parganas district has yielded a high discharge of 2820LPM in the recent alluvial formation. This well can cater to drinking water requirements of a population of about 28200 (@ 60 lpcd for ten hours of pumping a day) in the area.

Name of States	Description
Jharkhand	i. A Piezometer drilled at War Memorial, Dipatoli campus, Ranchi district down to a depth of 145.96 m bgl has yielded a high discharge of 1800 LPM encountered the fracture at 47m and 145m in granite gneiss. This well can cater to drinking water requirements of a population of about 18000 (@ 60 lpcd for ten hours of pumping a day) in the area. ii. An exploratory well drilled at Joram, Simdega district down to a depth of 123.72 m bgl has yielded a high discharge of 720 LPM in granite gneiss formation. 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.
Karnataka	i. An exploratory Well drilled down to a depth of 200.00 m. bgl at Hariharapura, Holenarsipura taluk, Hassan district has yielded 225 LPM. This well can cater to drinking water requirement of a population of about 2250 (@ 60 lpcd for ten hours of pumping a day) in the area. ii. An exploratory well drilled at Ghotala in Bidar district down to a depth of 245.10 m bgl has yielded a high discharge of 324 LPM. This well can cater to drinking water requirements of a population of about 3200 (@ 60 lpcd for ten hours of pumping a day) in the area. iii. An exploratory well drilled at Udiaganlu in Hassan district down to a depth of 128.0 m bgl has yielded a high discharge of 780 LPM. This well can cater to drinking water requirements of a population of about 7800 (@ 60 lpcd for ten hours of pumping a day) in the area. iv. An observation well drilled at Ghotala in Bidar district down to a depth of 241.0 m bgl has yielded a high discharge of 494 LPM. This well can cater to drinking water requirements of a population of about 4900 (@ 60 lpcd for ten hours of pumping a day) in the area. v. An exploratory well drilled at Srinivasapura taluk, Kolar district down to a depth of 201.90 m bgl has yielded a high discharge of 1060 LPM. This well can cater to drinking water requirements of a population of about 10000 (@ 60 lpcd for ten hours of pumping a day) in the area. vi. An observation well drilled at Arsikere taluk, Hassan District down to a depth of 143.52 m bgl has yielded a high discharge of 894 LPM. This well can cater to drinking water requirements of a population of about 8900 (@ 60 lpcd for ten hours of pumping a day) in the area. vii. An exploratory well drilled at Arsikere Jajuru, Arsikere taluk, Kolar district down to a depth of 200.00 m bgl has yielded a high discharge of 252 LPM. This well can cater to drinking water requirements of a population of about 2500 (@ 60 lpcd for ten hours of pumping a day) in the area. viii. An observation well drilled at Gaunipalli, Srinivasapura taluk, Kolar district down to a depth of 200.00 m bgl has yielded a high discharge of 225 LPM. This well can cater to drinking water requirements of a population of about 2250 (@ 60 lpcd for ten hours of pumping a day) in the area. ix. An observation well drilled at Rajola, Basaava Kalyani, Bidar district down to a depth of 275.00 m bgl has yielded a high discharge of 247.80 LPM. This well can cater to drinking water requirements of a population of about 2500 (@ 60 lpcd for ten hours of pumping a day) in the area. x. An observation well drilled at Gandigawada, Bidar district down to a depth of 95.50 m 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. xi. An exploratory well drilled at Halagapura, Kollegal taluk, Chamarajanagar district down to a depth of 121.96 m bgl has yielded a high discharge of 607.20 LPM. 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. xii. An exploratory well drilled at Madalu, Arsikere tauk, Hassan district down to a depth of 192.00 m bgl has yielded a high discharge of 541.80 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. xiii. An Exploratory Well drilled down to a depth of 138.52 m.bgl at Marakattur, Hassan district has yielded a high discharge of 706 litre per minute. This well can cater to drinking water requirements of a population of about 7000 (@ 60 lpcd for ten hours of pumping a day) in the area.

Name of States	Description
	xiv. An Exploratory Well drilled down to a depth of 162.44 m.bgl at Marakattur, Hassan district has yielded a high discharge of 1440 litre per minute. This well can cater to drinking water requirements of a population of about 14000 (@ 60 lpcd for ten hours of pumping a day) in the area. xv. An Exploratory Well drilled down to a depth of 501 m.bgl at Akkimala, Kolar District has yielded a high discharge of 255 litre per minute. This well can cater to drinking water requirements of a population of about 2550 (@ 60 lpcd for ten hours of pumping a day) in the area. xvi. An Exploratory Well drilled down to a depth of 137.60 m.bgl at Hippargh bagh, Bidar District has yielded a high discharge of 706 litre per minute. This well can cater to drinking water requirements of a population of about 7000 (@ 60 lpcd for ten hours of pumping a day) in the area. xvii. An observation Well drilled down to a depth of 168.60 m.bgl at Hippargh bagh, Bidar District has yielded a high discharge of 660 litre per minute. This well can cater to drinking water requirements of a population of about 6600 (@ 60 lpcd for ten hours of pumping a day) in the area.
Kerala	i. An exploratory well drilled at Anchal East in Kollam district down to a depth of 147.6 m bgl has yielded a high discharge of 420 LPM in Khondalite 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. ii. One Observation Well drilled at Anchal East in Kollam district down to a depth of 182.0 m bgl has yielded a high discharge of 330 LPM in Khondalite 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. iii. An exploratory well drilled at Ayiranallur in Kollam district down to a depth of 184.50 m bgl has yielded a high discharge of 607 LPM in Khondalite 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. iv. An exploratory well drilled at Bharatipuram in Kollam district down to a depth of 185.50 m bgl has yielded a high discharge of 258 LPM in Khondalite formation. 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. v. A Piezometer drilled at Kulathur, Malappuram district down to a depth of 100.00 m bgl has yielded a high discharge of 420 LPM in Charnockite 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. vi. An observation well drilled (auto flowing) at Chithara , Kollam district down to a depth of 200 m bgl has yielded a high discharge of 90 litre per minute in khondalite & Leptinite formation. This well can cater to drinking water requirements of a population of about 900 (@ 60 lpcd for ten hours of pumping a day) in the area. vii. An exploratory well drilled (auto flowing) at Chithara , Kollam district down to a depth of 200 m bgl has yielded a high discharge of 95 litre per minute in khondalite & Leptinite formation. This well can cater to drinking water requirements of a population of about 950 (@ 60 lpcd for ten hours of pumping a day) in the area.
Madhya Pradesh	i. An exploratory well drilled down to a depth of 122.67 m.bgl in Mandla district near Suraj Kund at the bank of Narmada river yielded a discharge of 285 LPM. The aquifer zones encountered are 114-117 mbgl. SWL was 40.60 mbgl. This tube well can cater to drinking water requirements of a population of about 2850 (@ 60 lpcd for ten hours of pumping a day) in the area. ii. An exploratory well drilled down to a depth of 112.0 m.bgl in Decaan Traps at Prabhat Pattan, Betul district yielded a high discharge of 1500 LPM. The aquifer zones encountered were between 100-112 mbgl. SWL was 40.60 mbgl. This tube 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.

Name of States	Description
Maharashtra	i. An exploratory Well drilled down to a depth of 146.00 m. bgl. At Pali village in Beed taluka of Beed district has yielded 356 LPM in deccan trap formation. Two water bearing zones were encountered at 17.00-19.00 and 91.00-93.00 m. bgl. The SWL was at 9.00 m.bgl. The formation is fractured vesicular basalt. This tube well can cater to drinking water requirement of a population of about 3500 (@ 60 lpcd for ten hours of pumping a day) in the area. ii. An exploratory Well drilled down to a depth of 200 m. bgl. At Pimpalwandi village in Patoda taluka of Beed district has yielded 190 LPM in Jointed Vesicular Basalt. This tube well can cater to drinking water requirement of a population of about 1900 (@ 60 lpcd for ten hours of pumping a day) in the area. iii. An exploratory Well drilled down to a depth of 200 m. bgl. At Kada village in Ashti taluka of Beed district has yielded 265 LPM in Jointed Vesicular Basalt. This tube well can cater to drinking water requirement of a population of about 2650 (@ 60 lpcd for ten hours of pumping a day) in the area. iv. An exploratory Well drilled down to a depth of 200 m. bgl. At Ambhora village in Ashti taluka of Beed district has yielded 224LPM in Jointed Vesicular Basalt. This tube well can cater to drinking water requirement of a population of about 2200 (@ 60 lpcd for ten hours of pumping a day) in the area. v. A Piezometer drilled down to a depth of 70 m. bgl. At Tunki village in Jalgaon Jamod taluka of Buldhana district has yielded 728LPM in Alluvial. vi. An exploratory Well drilled down to a depth of 166m. bgl. At Karawadi village in Karad taluka of Satara district has yielded 286LPM in weatherd Vesicular, Basalt. This tube well can cater to drinking water requirement of a population of about 2800 (@ 60 lpcd for ten hours of pumping a day) in the area. vii. An exploratory Well drilled down to a depth of 187 m. bgl. At Veshwi village in Alibag taluka of Raigarh district has yielded 466LPM in Fractured Vesicular, Basalt. This tube well can cater to drinking water requirement of a population of about 4600 (@ 60 lpcd for ten hours of pumping a day) in the area. viii. An exploratory Well drilled down to a depth of 93 m. bgl. At Pen village in Pen taluka of Raigarh district has yielded 356LPM in Fractured Vesicular Basalt. This tube well can cater to drinking water requirement of a population of about 3500 (@ 60 lpcd for ten hours of pumping a day) in the area. ix. An exploratory Well drilled down to a depth of 200 m. bgl. At Chainchvali village in Khalapur taluka of Raigarh district has yielded 190LPM in Fractured Vesicular, Basalt. This tube well can cater to drinking water requirement of a population of about 1900 (@ 60 lpcd for ten hours of pumping a day) in the area. x. An exploratory Well drilled down to a depth of 147 m. bgl. At Kalhe village in Panvel taluka of Raigarh district has yielded 190LPM in Fractured Vesicular Basalt. This tube well can cater to drinking water requirement of a population of about 1900 (@ 60 lpcd for ten hours of pumping a day) in the area. xi. An exploratory Well drilled down to a depth of 185.90 m. bgl. At Padvi village in Mahad taluka of Raigarh district has yielded 731LPM in Highly Fractured Basalt. This tube well can cater to drinking water requirement of a population of about 7300 (@ 60 lpcd for ten hours of pumping a day) in the area.
Orissa	i. An exploratory Well drilled down to a depth of 219.00 m. bgl. At Nischintakoili block, Cuttack district has yielded more than 1200 LPM in alluvium area. This well can cater to drinking water requirement of a population of about 12000 (@ 60 lpcd for ten hours of pumping a day) in the area. ii. An exploratory well drilled at Bargaon block, Sundergarh district down to a depth of 118.00m bgl has yielded a high discharge of 420 LPM in Mica Schist formation. The casing of this well is 19.80 m bgl. 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. iii. An exploratory well drilled at Udala block, Mayurbhanj district down to a depth of 56.40 m bgl has yielded a high discharge of 300 LPM in Granite Gneiss formation. The casing of this well is 22.00 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.

Name of States	Description
	iv. An observation well drilled at Bargaon in Sundargarh district down to a depth of 99.20 m bgl has yielded a high discharge of 330 LPM in Schist 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. v. An observation well drilled at Barkote block in Deogarh district down to a depth of 104.20 m bgl has yielded a high discharge of 408 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 4000 (@ 60 lpcd for ten hours of pumping a day) in the area. vi. An exploratory well drilled at Barkote block in Deogarh district down to a depth of 141.40 m bgl has yielded a high discharge of 420 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 4200 (@ 60 lpcd for ten hours of pumping a day) in the area. vii. An exploratory well drilled at Maneswar Boudh block, Boudh district down to a depth of 180.00 m bgl has yielded a high discharge of 180 LPM in granite. 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. viii. An exploratory well drilled at Thianal , Bankota block, Deogarh district down to a depth of 50.90 m bgl has yielded a high discharge of 330 LPM in Amphiobolite . 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. ix. An exploratory well drilled at Jamdiha , Kaptipada block, Mayurbhanj district down to a depth of 56.40 m bgl has yielded a high discharge of 240 LPM in Granite Gneiss 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. x. An exploratory well drilled at Udala College , Udala block, Mayurbhanj district down to a depth of 86.40 m bgl has yielded a high discharge of 390 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 3900 (@ 60 lpcd for ten hours of pumping a day) in the area. xi. An exploratory well drilled at Koudakol, Mahanga block, Cuttack district down to a depth of 86.00 m bgl has yielded a high discharge of 1080 LPM in Alluvium formation. This well can cater to drinking water requirements of a population of about 10800 (@ 60 lpcd for ten hours of pumping a day) in the area. xii. An exploratory well drilled at Barkote block, Deogarh district down to a depth of 123.10 m bgl has yielded a high discharge of 300 LPM in qtz-cht-bt-schist formation. This well can cater to drinking water requirements of a population of about 3000 (@ 60 lpcd for ten hours of pumping a day) in the area. xiii. An observation well drilled at Barkote block, Deogarh district down to a depth of 110.90 m bgl has yielded a high discharge of 420 LPM in qtz-cht-bt-schist 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. xiv. An exploratory well drilled at Barkote block, Deogarh district down to a depth of 165.80 m bgl has yielded a high discharge of 210 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 2100 (@ 60 lpcd for ten hours of pumping a day) in the area. xv. An exploratory well drilled at Tangerpalli block, Sundargarh district down to a depth of 105.30 m bgl has yielded a high discharge of 240 LPM in Granite Gneiss 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. xvi. An observation well drilled at Tangerpalli block, Sundargarh district down to a depth of 38.20 m 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.

Name of States	Description
	xvii. An exploratory well drilled at Udala block, Mayurbhanj district down to a depth of 150.00 m bgl has yielded a high discharge of 210 LPM in Granite Gneiss formation. This well can cater to drinking water requirements of a population of about 2100 (@ 60 lpcd for ten hours of pumping a day) in the area. xviii. An exploratory well drilled at Barkote block, Deogarh district down to a depth of 141.40 m bgl has yielded a high discharge of 180 litre per minute in Granite gneiss formation. 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. xix. An exploratory well drilled at Barkote block, Deogarh district down to a depth of 62.10 m bgl has yielded a high discharge of 240 litre per minute in basic rock 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.
Rajsthan	i. An exploratory drilling in hard rock area at Shhesha of Sawai Madhopur district has yielded a high discharge of 3000 LPM . The well was drilled down to a depth of 119.0 mbgl. This tube well can cater to drinking water requirements of a population of about 30000 (@ 60 lpcd for ten hours of pumping a day) in the area.
Uttar Pradesh	i. An exploratory well drilled at Patchra block, Mirzapur district has yielded a high discharge of 896 LPM in Vindhyan Sand Stone formation. The fractures were encountered at 17- 20 m, 60-63m, 72-75m and 78-81m respectively. This well can cater to drinking water requirements of a population of about 8960 (@ 60 lpcd for ten hours of pumping a day) in the area.
Tamilnadu	i. An exploratory well drilled down to a depth of 441m bgl. at Kil Kavarapalayam, Ariyalur district has yielded a high discharge of 1305 LPM in cuddalore sand stone formation. This well can cater to drinking water requirements of a population of about 13000 (@ 60 lpcd for ten hours of pumping a day) in the area. ii. An observation well drilled down to a depth of 385m bgl. at Kil Kavarapalayam, Ariyalur district has yielded a high discharge of 295 LPM in cuddalore sand stone formation. This well can cater to drinking water requirements of a population of about 2950 (@ 60 lpcd for ten hours of pumping a day) in the area. iii. An observation well drilled down to a depth of 100m bgl. at Gangaikondacholapuram, Ariyalur district has yielded a high discharge of 594 LPM in cuddalore sand stone formation. This well can cater to drinking water requirements of a population of about 5900 (@ 60 lpcd for ten hours of pumping a day) in the area. iv. A well drilled down to a depth of 227m bgl. at Olaiy'lr, Ariyalur district has yielded a high discharge of 2580 LPM in cuddalore sand stone formation. This well can cater to drinking water requirements of a population of about 25800 (@ 60 lpcd for ten hours of pumping a day) in the area. v. A well drilled down to a depth of 200m bgl. at Dhanakottaipuram, TV Malai district has yielded a high discharge of 180 LPM in Charnokite Gneisses formation. 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. vi. A well drilled down to a depth of 200m bgl. at Chengam, TV Malai district has yielded a high discharge of 180 LPM in Charnokite Gneisses formation. 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.

12.0 HYDROLOGY PROJECT II

The Hydrology Project - Phase –II (HP-II) is a follow up project of HP-I. Its major thrust is to use Hydrological Information System (HIS) data effectively and efficiently for water resources planning and management. A longer-term aim of the project is to assist the Governments at both Central and State levels to address the issues of intra-sectoral demands and overall resource planning and management through the establishment of core hydrological organizations serving all specialized water agencies.

The Project will further extend and promote the sustained and effective use of the HIS by all potential users concerned with water resources planning and management, including both public and private, thereby contributing to improved productivity and cost-effectiveness of water-related investments in the 13 states and eight Central agencies. The coverage of existing states under the project is to help these agencies from moving over from development of HIS (as in HP-I) towards use of HIS in water resources planning and management. The project objectives will be achieved by:

(a) Strengthening the capacity of hydrology departments to develop and sustain the use of the HIS for hydrological designs and decision tools thus creating enabling environment for improved integrated water resources planning and management;

(b) Improving the capabilities of implementing agencies at state/central level in using HIS for efficient water resource planning and management in reducing vulnerability to droughts and thereby meeting the country's poverty reduction objectives;

(d) Establishing and enhancing user-friendly, demand responsive and easily accessible HIS to improve shared vision and transparency of HIS between all users; and

(e) 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 27.8 Crores and project has duration of 6 years staring from May 2006 to 2012. The revised provision for the year 2008-09 is Rs 7.12 Crore. H-P-II has two major components i.e Horizontal Expansion in three new States covering Goa, Himachal Pradesh and Punjab and Vertical Extension in the 9HP-I peninsular States. Under Horizontal Expansion, HP-I type of activities and facilities will be extended to new states, however, under Vertical Extension special knowledge enhancement type of activities such as Hydrological Design Aid, Decision Support System and Purpose Driven Studies would be taken up. In this year of the project domain specific training would be imparted, Awareness raising program are being held, tender documents for procurement/upgrading of the equipments have been prepared and construction of the piezometers is being taken up. The expenditure incurred on the project till March, 2009 is Rs 211.65 lakhs. Achievements against the target of Hydrology project II during 2008-09 up to March,2009 is given in table 12.1.

Table 12.1: ACHIEVEMENTS AGAINST THE TARGET OF HYDROLOGY PROJECT II DURING 2008-09

Activities & target	Achievements
Awareness raising training	Seven programme organized
Preparation and Implementation of Purpose Driven Study = 1	One study of CGWB, SECR, Chennai has been approved. MoU between CGWB, SER and Collaborative agency signed. Tender document for construction of observation wells published. Technical & financial Bid opened & evaluation process completed and the case is under approval. Sanctioned amount under the scheme is Rs.32.38 lakhs.
Construction of Piezometers/ Protection box = 97	Bid for Goa State and Re-tendering for Punjab State for Piezometers construction published. Technical and financial Bid opened. Tender for Himachal Pradesh State for Piezometers construction is under preparation.
Analytical Quality Control Exercise = 1	Analytical Quality Control was taken up by Bhopal lab and consolidate report on findings submitted.

Activities & target	Achievements
Water Quality and Exploration Data Entry and validation = All times	Completed
Hydrological Design Aid activities – selection & collection of data for piloting of Design aid	Proposed to be dropped & additional PDS to be taken.
Decision support system – collection of data for piloting of DSS = 1	Awaiting advice from DSS NIH consultant.
Upgrading of Hardware and software & Procurement of data = 12	Procured 12 Servers
Procurement of equipment for 3 offices	3 sets procured
Vehicles for 3 offices	Awaiting sanction of MOWR
Procurement of DWLR's = 40	To be procured after construction of Piezometer.
Training, International study tours = 7	Case for International training with MOWR for sanction. Three Training organized

13. STUDIES ON ARTIFICIAL RECHARGE OF GROUND WATER

13.1 DEMONSTRATIVE PROJECTS ON "ARTIFICIAL RECHARGE TO GROUND WATER & RAIN WATER HARVESTING"

A demonstrative scheme on "Rain Water Harvesting and Artificial Recharge to Ground Water" for 2006-08 has been taken up. These schemes are being implemented in the following areas.

i. **Lingala, Pulivendula Vemula and Vemalli blocks** in Kadapa district, Andhra Pradesh
ii. **Gangavalli block** in Salem district, Tamil Nadu
iii. **Mallur block** in Kolar district, Karnataka
iv. **Bel watershed,** Amla & Multai blocks in Betul District, Madhya Pradesh.
v. **Upper reaches of Chhoti Kali Sindh river** in parts of Sonkatch & Bagli blocks in Dewas district, Madhya Pradesh.

Under the scheme, recharge structures in over-exploited area were approved for implementation by the respective state departments under the overall technical guidance of CGWB with 100% funding by the Central Government under Central Sector Scheme. The approved cost of construction of recharge structures in cluster mode is Rs. 5.95 Crores. The norms adopted in implementation of National Rural Employment Guarantee Scheme (NREGS) by the Ministry of Rural Development are being followed. The details of demonstrative recharge projects on Artificial Recharge to Ground Water and Rain Water Harvesting being implemented in the states of Karnataka, Tamil Nadu, Andhra Pradesh and Madhya Pradesh are given in **table13.1 .** Impact assessment studies are also incorporated to assess the efficacy of artificial recharge and rain water harvesting structures taken as in cluster mode in the above mentioned sites. Success of demonstrative recharge projects constructed in different hydrogeological conditions would be encourage the states to replicate the same in the similar set ups.

13.2 SCHEME ON "ARTIFICIAL RECHARGE TO GROUND WATER & RAIN WATER HARVESTING" UNDER SURVEYS, EXPLORATION & INVESTIGATION SCHEME OF CGWB

Demonstrative projects on Artificial Recharge to Ground Water and Rain Water Harvesting are proposed to be taken up during XI Plan under central sector scheme of " Ground water Management Regulation "by CGWB, at an estimated cost of Rs.100 Crores with 100% funding by the Central Government. Under the scheme, it is proposed to construct structures for artificial recharge and rainwater harvesting through implementing agencies / beneficiaries and Panchayats. The scheme will demonstrate the efficacy of artificial recharge and rain water harvesting techniques in identified areas selected on scientific basis in different hydrogeological situations and encourage implementing agencies to replicate successful models in similar set ups. It will result in capacity building of the various agencies involved in construction of such recharge structures for optimum benefits.

Central Ground Water Board, in coordination with concerned State Government departments will take up recharge and rain water-harvesting projects in following areas on priority:

i. **Over-exploited / Critical Blocks**
ii. **Urban areas showing steep decline in ground water levels**
iii. **Drought prone & water scarcity area**
iv. **Coastal areas**
v. **Sub-mountainous / hilly areas**
vi. **Area with geo-genic contamination of ground water.**

Sites for construction of feasible artificial recharge structures would be identified by taking into consideration Watersheds / Talukas / Block / Mandal on compact area basis. Computation of surplus runoff and hydrogeological conditions need to satisfy the pre-requisites for recharge projects. The implementing agency would be responsible for preparation of Detailed Project Report for the recharge projects and may take technical guidance from regional office of CGWB. Schemes would be implemented in coordination with the State Government by implementing agency under technical supervision of Regional office of the Central Ground Water Board.

Three project proposals costing Rs.5.66 Crores (2 from Tamilnadu and one from Punjab) and only lumpsum estimates for Rs.18 Crores are received from Karnataka & Orissa states. The three DPRS were considered by the TCC (CHQ) and suggested modification of DPR and advised to submit the modified DPR for consideration in next meeting.

Regional Director in remaining states are further advised to expedite submission of projects from implementing agencies and forwarding to CHQ at the earliest in this quarter so that proposals can be considered in the next TCC(CHQ) meeting.

Table 13.1:Details of Demonstrative Projects on Artificial Recharge to Ground Water and Rain Water Harvesting in Karnataka, Tamil Nadu, Andhra Pradesh and Madhya Pradesh

State (Number of structures)	District	Blocks (Number of structures)	Project proposals approved (Number of structures)	Amount Sanctioned (Rs. in lakhs)		Amount Released (Rs. in lakhs)	Rrecharge structures completed	Cumulative Physical progress	Financial status (Rs. in Lakhs)
1	2	3	4	5		6	7	8	9
Karnataka	Kolar	Malur	Check dam -23	92.19		64.53	21	23	61.44
		(28 Structures)	Percolation tank-3				2		
			Sub Surface Dyke-2				0		
Tamil Nadu	Salem	Gangavalli	Check dam-23	223.15		223.15	23	41 (Scheme completed)	221.87
		(41 Structures)	Desiltation of tanks-2				2		
			Percolation tank -16				16		
Andhra Pradesh	Kadapa	Lingala -(9 Structures)	Check dam -5	59.71	130.46	130.46	5	21	117.45
			Mini Percolation Tank -1				1		
			Percolation Tank -3				3		
	Kadapa	Pulivendla -(3 Structures)	Check Dam -2	11.82			2		
			Mini Percolation Tank -1				0		
	Kadapa	Vemula -(6 Structures)	Check Dam -5	38.79			5		
			Percolation Tank -1				1		
	Kadapa	Vempalli -(5 Structures)	Check dam -3	20.14			3		
			Mini Percolation Tank -1				0		
			Percolation Tank -1				1		
Madhya Pradesh	Betul	Bel Watershed of Amla and Multai blocks (67 Structures)	RCC check Dam -18	99.81	99.81	73.517	18	65	80.485
			Masonry Check Dam -5				5		
			Recharge Shaft-3				2		
			Percolation Tank -1				0		
			Piezometers-40.				40		
	Dewas	Sonkatch and Bagli blocks - (41 Structures)	Stop dam-11	49.06	49.06	46.96	11	41	31.55
			Gabion structures-10				10		
			Piezometers-15				15		
			Sub surface Dyke -1				1		
			Roof top rain water harvesting - 2				2		
			Percolation Tank -1				1		
			Recharge shaft-1				1		
GRAND TOTAL			**200**	**594.67**	**594.67**	**538.617**	**191**	**191**	**512.80**

Artificial Recharge Field Photographs of Farmers Distress Area Wardha district

Water level at Kharangna (Gode)

Well in alluvium and weathered massive basalt-Kharangna (Gode)

Water level at Agargaon

Percolation Tank at Chikmoh

Collapsed well in farmers field at Chikmoh

Dug Well Recharge Model

13.3 ARTIFICIAL RECHARGE TO GROUND WATER THROUGH DUG WELLS.

The Scheme of the Ministry of Water Resources on "Artificial Recharge to Ground Water through Dug Wells" in 7 states namely Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Tamilnadu, Gujarat and Madhya Pradesh has been launched. The scheme has been approved for a cost of Rs. 1798.71 Crores with net cost of subsidy to Government in terms of civil works of Rs. 1499.27 Crores.

The salient Features of the scheme are as follows:-

The main objective of the scheme is to adopt suitable measures for augmenting the ground water resources in over-exploited/Critical/Semi-critical areas in 7 states to provide sustainability to the dug wells. The beneficiaries would be the farmers having own well in their agricultural land. Average cost of dug well recharge is Rs.4000/- which varies from Rs.3600/- as in Maharashtra to Rs.5700/- as in Andhra Pradesh. 100 % subsidy to marginal and small farmers and 50% subsidy to other farmers.

Recharge of rainfall runoff from the agricultural fields through existing dug wells will facilitate augmentation of ground water resources which will help to arrest depletion of ground water levels and will increase the sustainability of wells during lean period. In all participating states (i.e. 7 states) State Level Steering Committee (SLSC) and District Level Implementation and Monitoring Committee (DLIMCS) are constituted by the state to ensure effective implementation of the scheme. A Nodal Department are identified by the state government and charged with overall responsibility for planning, execution and monitoring of the scheme. Design for Recharge structures have been finalized in respect of all states. The statement showing the status of release of funds under IEC and Subsidy by NABARD as on 31st March, 2009 given in table 13.3.

Table 13.3: STATUS OF RELEASE OF FUNDS UNDER IEC AND SUBSIDY BY NABARD AS ON 31ST MARCH, 2009

Sl. No.	States	Release of funds under IEC activities (in Rs. Crores)		Release of funds under Subsidy Head (in Rs.Crores)	No. of Beneficiaries to whom subsidy released by NABARD
		Amount released	Expenditure made as 31.03.2009	as 31.03.2009	as 31.03.2009
1.	Andhra Pradesh	0.00	0	0.000	0
2.	Gujarat	3.25	0.52	35.334	120949
3.	Karnataka	2.00	0	0.194	494
4.	Madhya Pradesh	2.00	0.358	0.000	0
5.	Maharashtra	2.00	0	9.324	29632
6.	Rajasthan	2.00	0.106	0.156	453
7.	Tamil Nadu	5.75	1.187	85.577	229769
	Total (in Rs. Crores)	**17.00**	**2.171**	**130.585**	**381297**

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.

14.1 Kottukal Thodu water shed of Neyyar basin, Kerala

The Kottukal thodu watershed of Neyyar basin is being modelled for groundwater flow and the impact of various stresses on the flow regime. It is a small watershed of about 35 sq.km. comprising Precambrian crystallines, Tertiary sediments and coastal alluvium. The phreatic aquifer system in the area is being modelled in the present study.

As part of the study, established key wells for water level monitoring, collected data on lithology of well sections, rainfall, groundwater structures, groundwater draft, soil etc. The infiltration characteristics and aquifer characteristics are to be identified in the ensuing studies. The study is being continued in the ensuing field season.

14.2 Ranchi Urban Area, Jharkhand

Monthly monitoring of the water level of 37 key wells (open dug wells) and 10 (piezometers constructed by CGWB) were carried out. The depth to water level of dug wells ranges from 2.81 to 13.33 m bgl, 0.65 to 3.28 mbgl and 1.15 to 5.79 m bgl during the period of pre – monsoon, monsoon and post monsoon respectively. The depth to water level of the piezometers ranges from 3.97 to 21.29 m bgl in pre – monsoon period, 2.67 to 18.06 m bgl in monsoon period and 2.77 to 16.81 m bgl during the post monsoon period.

During the year base map, drainage map, geological map, pre monsoon DTW map (May 2007), post monsoon DTW map (October 2007), DTW map of October 2008 and December 2008 and depth to weathering map of Ranchi urban area were prepared. Monthly rainfall data (2004 – 08) and ward wise population data were collected.

14.3 Patna Urban area, Bihar

Monitoring of the water level of 37 key monitoring wells (open dug wells) and 8 piezometers were carried out. The dug wells were monitored for pre- and post monsoon period while the piezometers were monitored monthly. The depth to water level of key well ranges from 1 to 8.9 m bgl, and 0.95 to 5.2 m bgl during the period of pre – monsoon and post monsoon respectively. The depth to water level of the piezometers ranges from 4.19 to 12.95 m bgl during pre – monsoon period and 2.90 to 11.35 m bgl during post-monsoon period.

During the year base map, drainage map, geological map, pre monsoon and post monsoon DTW map has been prepared. Daily rainfall data (April 2007 – February 09) have been procured. Ward wise population data has been collected from concerned agencies.

14.4 Lucknow urban area, Uttar Pradesh

Justification For Selecting the Area For Modeling Studies:

1. Rising population, urbanisation and associated anthropogenic activities have left a debilitating effect on the qualitative and quantitative aspects of the ground water resources in the city area. Lucknow being the capital and an important city naturally calls for such types of studies to be undertaken to understand and address the problem realistically.
2. A lot of exploratory and related hydrogeological data is already available for the city. CGWB has already constructed a number of Piezometers in the city to facilitate ground water level monitoring. The water level data of more than 5- years is available with the office.

The study in and around Lucknow city is to be carried out with a view to :

(i) Studying the ground water regime in the area with a view to make predictions in response to ground water withdrawals, rainfall and ever increasing urbanization.

(ii) Quantitative estimation of the ground water resource potential of shallow as well as deeper aquifers in the urban area of Lucknow.

Details of the model area

Lucknow city covering an area of approximately 340 Sq. Km. and is parts of three blocks – Chinhat, Sarojini Nagar and Kakori .

Physiography:

Lucknow City falls in the central gangetic plain and is part of Sai-Gomti Sub-basin. It is almost a flat country with

conspicuous natural depressions around Bakshi Ka Talab, Janaki Puram, Saleh Nagar etc. The general slope of the area is from NNW to SSE. The highest elevation is 123.5 mamsl around Bara Birwa in Alambagh area & lowest being 108.5 mamsl in the flood plain at Pragya Dham near Patang Park.

Drainage :

Older alluvial fill in the area probably belongs to the older Ganga river system in which subsequently Gomati has carved out its own valley forming the lower terrace (T_1) and the active flood plain in the area. The Gomati flows from NW to SE direction and forms a prominent meander between Lamartiniere School and Shahid Smarak. The river is characterised by sluggish flow throughout the year, except during monsoon season when heavy rainfall causes a manifold increase in the runoff. There are 23 nalas which drain into Gomti between Gaughat and Gomti barrage out of which 11 nalas viz. Gaughat nala, Patanala, Sarkata nala, Gazi Haider canal etc are located on the right bank and 12 nalas viz. Nadwa nala, Khadra nala, Mahanagar nala, Kukrail nala etc are located on the left bank of Gomati.

Sub-Surface Geology

The available lithological and electrical log data of CGWB exploratory tubewells reveal five aquifer groups, broadly in the following depth range, occuring in the city area.

(1) 8-112 m
(2) 120-254 m
(3) 268-379 m.
(4) 371-483 m
(5) 483-620 m

Ist Group of Aquifer (8 m to 96/112 m):

It has a sandy layer occuring between 8-35 mbgl depth, ranging in thickness from about 15 to 25 m. This zone is the unconfined aquifer which supports handpumps and dugwells. In the central part sands are coarser but become finer away in all directions.

The unconfined zone is underlain by a thick clay layer occuring in the depth range of 25-60 mbgl with an average thickness of 20-25 m. In the north and south, this clay layer is intercalated with sand, 15-20 in thickness which pinches out towards the central part of the city.

The clay layer is underlain by a granular zone almost continuous between 51 and 112 mbgl depth range. This is intercalated by clay layer of 20-25 m. thickness at variable depth broadly between 65 and 100 mbgl restricting the granular zone to an average thickness of 25-30 m.

The sands of the first aquifer group are coarser towards the top but become successively finer with depth. The cumulative thickness of the granular zone in the first aquifer ranges from 32-66 m. averaging about 51 m. within the depth of 112 mbgl. The sand content on an average is about 48 percent but the average sand content at Patang Park and Lalbagh is about 36 percent.

IInd group of aquifer (120/138 m to 226/254):

The second aquifer group is highly silty in nature below 150 m depth. It has several discontinuous bands of silty layers. The reasonably continuous granular zone occurs between 120 and 148 m and between 220 and 254 mbgl with their thickness ranging from 6-20 m. The other two conspicuous granular zones occur between 144 and 158 mbgl and 175 and 194 mbgl, they appear to be discontinuous.

The average sand content within the depth upto 254 mbgl is 29 percent and cumulative thickness of the granular zone within this aquifer, on an average is about 38 m. but in the flood plain of the city area, average sand content is about 34 percent and cumulative average granular zone thickness is a little higher.

IIIrd Group of Aquifer (254/283 m to 353/379 m):

This group of aquifer is constituted by three reasonably continuous thin layers of fine sand 6 to 20 m. in thickness occuring between 254 and 294 mbgl, 307 and 321 mbgl and 339 and 368 mbgl. The aquifer is highly interlayered sequence of sands and clays.

The sand content in this aquifer ranges between 23 and 42 percent averaging about 33 percent. The cumulative granular zone thickness is about 28 m. The flood plain area is in conformity with the rest of city with respect to the sand content.

IVth Group of Aquifer (371/379 m to 483 m):

The fourth group of aquifer comprises of broadly three relatively thicker granular zones occuring between 380 and 404 mbgl, 421 and 443 mbgl and 463 and 483 mbgl depth range. This aquifer is also highly interlayered sequence of sands and good clays.

The sandy zones between 421 and 443 mbgl and 463 and 483 mbgl are admixed with 1-3 mm chips of sub-angular to sub-rounded not too compact or friable sandstone, bluish

grey sand different from above and highly interlayered nature of the aquifer indicates that the sediments of this aquifer may be related to the middle Siwalik super group.

The sand content in this aquifer ranges from 35 to 52 percent averaging about 42 percent. The cumulative granular zone thickness ranges from 36 to 59 m. averaging about 46 m.

Vth Group of Aquifer (483 m to 620 m):

This aquifer group is highly interlayered or intercalated with very fine sand, silt and clay sequence, sandy layers are thin and predominantly silty in nature, clays are variegated in colour towards the bottom.

14.5 The model area includes 31 blocks of 5 districts namely Hoshiarpur, Jalandhar, Kapurthala, Nawanshahar and Ropar, Punjab

The total geographical area of Bist Doab Tract which has been identified for modeling is 8926 sq km,. The model area includes 31 blocks of 5 districts namely Hoshiarpur, Jalandhar, Kapurthala, Nawanshahar and Ropar.

The area is by and large underlain by Quaternary Alluvial Deposits except in the northeastern parts that is underlain by the Tertiary formations belonging to the Siwalik system. The Siwaliks are poor ground water repositories and do not yield groundwater in economic quantities. The alluvial deposits can be broadly divided into two types in the area – Piedmont (also known as Kandi) in the foothills of Siwalik and Fluvial plains. Kandi formations occupy roughly 900 sq. km of the Bist Doab tract. The aquifers in this belt are unconfined in nature and yield prolific quantities of ground water for reasonable drawdowns.

Based on the exploration carried out by CGWB in this area, 3 aquifers are deciphered down to depth of 450 mbgl. The first aquifer is under unconfined conditions, while the 2nd and the 3rd aquifers are under semi-confined to confined conditions. The unconfined aquifer in the Bist-Doab tract is under very high stress due to very high withdrawal of ground water. As per the Groundwater Resource estimation carried out in 2004 jointly by CGWB and Govt of Punjab, the stage of ground water development of the districts falling in the Bist-Doab tract is:

Jalandhar-254%, Hoshiarpur-85%, Kapurthala-204% and Nawanshehr-175%

The stage of development of Hoshiarpur as 85% is only due to the fact that groundwater development in the Kandi area is very low due to deep water levels and difficult drilling conditions due to boulder formations. Otherwise, the groundwater development in whole of Bist Doab is going on at a very high pace.

Moreover, the Bist Doab Area of Punjab State is a typical Ground Water Basin in triangular shaped with well defined hydraulic boundaries. On two sides, it is bounded by Beas and Satluj River and on third side it is bounded by Katar Dhar Range of Siwalik Hills. In the area the irrigation supplies are mainly dependent on ground water, which is considered as assured source of supply. Out of total irrigation, around 80% is met through Ground water.

The Bist Doab Area is rich from point of view of availability of ground water. It has witnessed phenomenal increase in the ground water development over the years. As a consequence, the area experiences the problem of declining water table in large part of this tract. The rate of decline in ground water ranges from 4.4 cm to 116.7 cm per year. Out of 31 blocks of modeled area, 20 blocks have already been categorized as over exploited. So, the reasons for being chosen this area for modeling studies is to develop a mathematical model to simulate the hydrogeological conditions and ground water flow systems to find a solution to alleviate the problem of declining ground water levels and to come out with optimal ground water management plan as per available resources.

Bist Doab mainly consists of two types of alluvium. In the northeastern part sediments of recent origin are deposited in an area running parallel to the Himalayan range. The underlying beds are mainly Siwaliks. This area is locally called Kandi and forms major recharge zone to the underlying aquifers in the lower reaches of the Bist-Doab. In this belt, ground water occurs mainly under unconfined conditions. Sand lenses interspersed with clay beds are predominant lithology in the area. Other type of alluvium consists of sediments mainly of fluvial origin. Main lithological units are sand and gravel horizons coupled with intercalating clay beds.

Objectives of the study:

It is proposed to develop a mathematical model to simulate hydrogeological conditions and ground water flow systems in the area and generate alternate management scenarios and develop optimal allocation plan for water resources. The main objectives of this study are:

i. Quantitative assessment of ground water in space and time.

ii. To recommend the suitable areas for ground water irrigation development.
iii. To gain insight into the surface water-ground water interactions in the area and to develop optimal allocation plan for surface and ground water use.
iv. To advise on solutions for areas with declining ground water levels.

Hydrogeological Framework:

Bist Doab is a triangular region lying between the Sutlej and Beas river on two sides and Siwalik ranges running in north western- south eastern direction on the third side. It comprises of Kapurthala, Jalandhar, Nawan shahar and Hoshiarpur districts and covers a total area of 8872 sq. km.

The depth to water level of unconfined aquifer in the area ranges between 3.0 to 28.0 m bgl. The ground water table elevation in the area ranges between 200 m and 471m amsl. The ground water flow in northern and central part of the area is from North east to South west in direction whereas in southern and south eastern part it is almost from eastern to western and south western direction. However the master slope of the ground water is from north east to south west direction. The gradient of ground water flow in north and north eastern part of the area is quite steeper in the order of 2.4 m/km. In central and south eastern part ground water flow is gentle and is of the order of 0.44 m to 0.69 m per km. The average gradient of ground water flow across the area has been worked out to be 1.17 m per km.

The long-term water level fluctuation for past 10 years (Decadal Mean- May 2007) reveals that there is decline in water level through out the Bist Doab Area except in a small patch in the northern part where rise in water level is in the range of 0 to 2 m. It is further observed that water level has declined more than 4 m in southern and central parts of the area. However, in major part of the southern area decline of 2 to 4 m has been observed. In northern part, the decline is in the range of 0 to 2 m.

The study of water level trend indicates that the rate of decline in Hoshiarpur district varies from 4.4 cm to 17.7 cm per year, in Jalandhar district 4.7 cm to 116.7 cm, in Kapurthala district 1.3 cm to 47.6 cm and in Nawanshahr district the decline is 16 cm to 24.7 cm per year. This indicates the high dependency and stress on ground water.

Aquifer geometry of the area has been worked out on the basis of available lithological and geophysical data of exploratory wells/piezometers drilled. The data of only those wells have been considered which are found to be representative of the area. It has been observed that multi layered aquifer system exists in the area which is described as follows

Aquifer group I

The top layer of this aquifer group comprises of coarse sand beds, which are at places gravelly in nature. The sand beds are generally thick separated by small, thin clay beds that are not regionally extensive. In the northern part of the area thickness of clay beds and their occurrence increase substantially. This layer has varying thickness that ranges from 72m to 94m. The average thickness of this top layer is 72m in Hoshiarpur district, 76m in Nawanshahr district, 81m in Jalandhar district and 94m in Kapurthala district. A regionally extensive clay layer with varying thickness from 16 to 32m separates this aquifer from underlying aquifer group II. This clay layer is only 16m in Kapurthala district, 21m in Nawanshahr and around 24m in Jalandhar district. The thickness of this layer is maximum in Hoshiarpur district towards north where it is 32m thick. This layer generally acts as a confining layer though confining properties are not very much clear.

Aquifer Group II

This group comprises of alternating sequences of thin layers of sand and clay beds. Sediments of this aquifer group are chiefly sand, clay, gravel and occasional kankar. The sand beds are generally thick and are separated by thin clay beds. Clay beds are not regionally extensive and they normally pinch out. The aquifer thickness of this group below the confining layer upto 250m has also been worked out. It has been estimated that a thick aquifer having a thickness ranging between 81 m to 105m occur in the area. The thickness of aquifer material bearing fresh water sediments is 81m in Hoshiarpur district, 85m in Kapurthala district, 87m in Jalandhar district and 105m in Nawanshahr district.

Water level monitoring is being done from 27 piezometers drilled in shallow and deep aquifers since 1986. Transmissivity value for aquifer groups is computed to be in the range of 103 to 4120 whereas Storage Coefficient worked out to be in the range of $6.0 *10^{-3}$ to $6.8*10^{-4}$.

In order to calculate the actual withdrawal of ground water for irrigation, field studies were conducted to establish unit well draft. Unit well draft was calculated from Horizontal pipe flowing full (Lawrence and Braunworth) method. In this method approximate value of discharge from a

horizontal pipe flowing full and with free fall from the end of pipe can be obtained by measuring horizontal (feet) and vertical distances (12 inch) from the end of the pipe to a point in the flowing stream of water. Flow is obtained by multiplying the horizontal distance and rate of flow.

The depth of the tubewells in the area ranges from 20 to 130m. The depth ranges of aquifer tapped is 22 to 130. The unit well draft calculated for the monsoon period is 3.8 ham and for the Non-monsoon period is 0.73 ham. The annual unit draft of the area worked out to be around 4.53 ham.

Model conceptualization and description:

Details of Base map:

The base map of Bist Doab Area has been prepared containing following information:

- Boundaries of Area:
  The area is a triangular region bounded by river Satluj and Beas on two sides and Katar Dhar ranges of Shiwaliks on third side, which runs in north western and south-eastern direction.
- Districts boundary, blocks boundary, state boundary and district and blocks head quarters have been digitized and imported into Visual Modflow software.
- The existing canal network (Shah Nahar Canal and Bist Doab Canal), drainage (Black Bein and White Bein) and small choes have been digitized and imported into Visual Modflow software.
- Location of Exploratory wells and Piezometers have been digitized and imported into Visual Modflow software.

Details of cross sections

Based on lithological log and Geophysical log a fence diagram has been prepared, which indicate that there exist a multi layer aquifer system which have been categorized into two separate groups. The top layer of group I comprise of coarse sand beds. The thickness of this layer ranges from 72 to 94 m. A regionally extensive clay layer with varying thickness from 16 to 32 m separate this aquifer from underlying Aquifer group. This group comprises of thin layer of sand and clay layers. The thickness of this group ranges from 81 to 105 m.

Details of table/data prepared for Data Entry into software:

The following tables have been prepared for data entry into the software:

- Ground water exploration data pertaining to aquifer groups containing information regarding Transmissivity (T), Storativity (S), aquifer zones etc.
- Water level data of shallow and deep piezometers.
- Ground water draft data for kharif and Rabi period.
- Districts, blocks and State boundaries
- Natural Drainage
- Canal Network
- Exploratory wells and piezometers

Discritization of space in terms of Grid size and layer to be modeled:

A model was conceptualized on the basis of existing hydrogeological data and it is decided to develop a three-layer ground water flow model for the area. The details of these layers are as follows:

Layer I: Unconfined Aquifer: Thickness varies from 72 – 94 m
Layer II: Confining Layer: Thickness varies from 16 – 32 m
Layer III: Semi-Confined/confined Layer: Thickness varies from 81 – 105 m

Accordingly, modeled area of 8926 sq km has been initially discretized with 10 km * 10 km grid size with a total of 90 cells with 10 number of columns and 9 number of rows. The cell size can be reduced depending upon the data availability.

14.5 Gangavalli block, Salem district, Tamil Nadu

Justification for selecting the area for modeling study

It was proposed to carry out modelling studies to study the impact of Demonstrative Project on Artificial Recharge to groundwater, executed in Gangavalli block, Salem district, Tamil Nadu by simulating the ground water flow in the system.

Details of model area

Location: The total geographical area of the Block is 410.18 Sq.km. between North Latitudes 11° 00' 30" and 11° 58'30" and East Longitudes 77° 39'0" and 78° 50'30".

Rainfall: The normal annual rainfall over the block varies from about 800 mm to about 1600 mm

Soil: The major part of the block is characterized by red in-situ soil and forest soil in reserved forest area and Black soil

as a small patch on the northeastern part and mixed soil as a small patch on the southwestern part of the block.

Geomorphology: The geomorphic units encountered in the block are Structural hills, Valley fill, Pediments and Buried Pediments.

Drainage: Swetha Nadhi draining the central part of the block is the major watercourse controlling the drainage in the block. The area is characterised by dentritic drainage.

Geology: Gangavalli Block is underlain entirely by Achaean Crystalline formations with recent alluvial deposits of limited areal and vertical extents along the courses of major rivers.

Hydrogeology: Ground water occurs under phreatic conditions in the weathered zone and under unconfined to confined conditions in the deeper fracture zones. The thickness of weathered zone in the block ranges less than 2 to 28 m and fractures are encountered down to a depth of 300m. The dug wells are used to extract groundwater from weathered residuum while bore wells are used to develop groundwater from the deeper fractures. Dug wells are the most common ground water abstraction structures used for irrigation in the block, with yields ranging from 35 to 140 lpm in weathered crystalline rocks and can sustain up to 2-4 hours of pumping. The yield of bore wells ranged from 20 to 500 lpm and can sustain a pumping for 6-8 hours of pumping.

Hydrochemistry: Groundwater quality in phreatic aquifers in Gangavalli block is colorless, odorless, and alkaline in nature. The electrical conductivity of ground water in phreatic zone during May 2006 was in the range of 256 to 2870 µS/cm.

Objectives

The objectives of the present work are listed below.

1. Simulate hydrodynamics of the ground water system in the study area.
2. Impact assessment of artificial recharge structures
3. Quantification and evaluation of efficacy of artificial recharge structures based on stimulated stress conditions.
4. Study the aquifer response for different ground water development plans to evolve a sustainable ground water development strategy.

Model conceptualization & description

Details of base map/ cross section/table prepared for data entry into software

A) Base map

1. Georeferenced base map of the study area with all details of structures
2. Geological/geomorphological/watershed maps
3. Depth to weathered thickness map.

B) Tables prepared.

1. Details of key wells and structures.
2. Details of monthly water level
3. Details of Reduced Level data
4. Spatial variation of weathered thickness

C) Discretization of space in terms of Grid size and layer to be modeled

Total area considered for the study is 410 sq.km. The area has been represented by a grid of 19*29 with a grid size of 1 sq.km.

- Status of data entry into software: Data entry is in progress.
- Tentative programme and activity chart for remaining work to be carried out

Progress of modeling studies- Lumped Model

Ground water balance for lumped model has been carried out considering the whole area as a single cell, water balance for the study area has been computed to ascertain the different recharge and discharge components. After the validation of lumped model, the average aquifer parameter values used in the computation will be used initially in the distributed model and will be calibrated during different runs.

A perusal of the results show that there is an annual recharge of 97.238 M Cu.m while the annual discharge works out to be of the order of 107.07 M.Cu.m. The stage of development (Annual Discharge/Annual Recharge) works out to be 110%.

Further Work

It is proposed to carryout distributed modelling in the study area to achieve the objective of simulating the ground water flow condition and study the impact of artificial recharge structures on the ground water system. Further the model will be utilised for predictive simulation to test various strategies to formulate optimum ground water development plan.

14.6 Modeling studies in Madaram watershed Mahabubnagar district, A.P.

For modeling studies in Madaram watershed Mahabubnagar district has been taken up for creating the database. Under the study, key wells monitoring on monthly basis was taken up and accordingly water levels are being monitored. Geophysical surveys and ground water exploration completed for knowing the thickness of weathering and was assessing various hydraulic parameters.

14.7 Impact Assessment and Ground Water Modeling Studies Of Vented Dam At Tumbe, Dakshina Kannada District, Karnataka.

The Vented dam is a permanent Engineering structure constructed across a stream/river to impound the water flowing in the stream during non monsoon season. The Sub-surface run off (base flow) available in streams/rivers in coastal districts of Karnataka (Dakshina Kannada and Uttara Kannada districts) is traditionally harvested by farming community by constructing barriers across streams after monsoon season. These barriers locally called by the name MaduKattas and are in practice over the years. The water retained in these structures was utilised for lift irrigation, for domestic water supply and for recharging ground water. As these coastal districts receives very heavy annual rain fall (2500mm to 4000 mm) these barriers will be washed away during monsoon rains. And the farmers have to construct these barriers after each monsoon rains. To overcome this draw back, vented dams are built with modern techniques in such a way that the vents will be opened during monsoon season so that the water flows freely along with silt in the streams/rivers. These vents will be closed after monsoon rains and the water is impounded in the Vented dam. The opening and closing of these vents is repeated during and after monsoon rains. These vented dams are popularly called by the name Kolhapur type weirs (K.T. Weirs) in Coastal districts of Maharashtra. These are ideal structures for the hilly areas receiving heavy rainfall (2500 to 4000 mm) where permanent surface water structures (Major Dams) are not feasible.

One Such large Vented dam is constructed across the River Nethravathi near Tumbe village in Dakshina Kannada District. Impact assessment and mathematical modeling of existing and proposed vented dam at Tumbe Mangalore, Dakshina Kannada district" was taken up during 2007-08. About 16 Key observations were established and monitored during the May, August, November-2007 and February,May-2008 in and around the existing vented dam of Tumbe. The study was continued to AAP 2008-09. As per the instructions from the head quarters the entire area of the water shed was included for the study. Accordingly another 18 more Key observation wells over an area of 92 Sq.Kms covering the entire of the water shed (totally 34 key observation wells) were established and periodic monitoring of these Key wells was carried out during the months May, August, November-2008 and March-2009 (Table-14.8).RL of all these Key wells (amsl) were also connected to know the impact of dam water on ground water system in the adjoining area of vented dam of Tumbe.The following Maps are prepared & Compilation of the report is in Progress.

- Location map of the study area.
- Map showing the location of villages.
- Geology map.
- Premonsoon DTW map (May-2008).
- Water level fluctuation map (May-November-2008).
- Water table Contour map (November-2008).
- Drainage map of the area.
- Land use map.
- Geomorphology map
- Postmonsoon DTW map (Nov.-2008).
- Water table contour map (May-2008).

14.9 Modelling studies in parts of Ruparel basin, Alwar district, Rajasthan

Ground water modelling studies in parts of Ruparel basin, Alwar district are in progress and following work has been done in this regard.

- Base map of area has been prepared on 1:50,000 scale.
- Made entries of water level date of CGWB & GWD in to the software.
- Calibration of steady state model under progress.

Table14.8:Water level data of Key wells of Vented dam at Tumbe, Dakshina Kannada

Location	RL at GL m amsl	SWL (m bgl)							
		May '07	*Aug 07*	*Nov 07*	*Feb 08*	*May 08*	*Aug 08*	*Nov 08*	*March 09*
Tumbe 1	10.420	7.73	4.20	6.85	7.35	8.35	4.5	6.20	6.9
Kallige	8.885	5.03	1.25	2.42	3.61	4.28	1.21	2.51	4.13
Bramhara Kotlu	9.350	8.75	2.58	5.96	7.32	8.55	1.70	6.85	8.05
Valavur	10.035	6.82	3.86	7.27	7.13	7.82	2.37	7.11	5.87
Tumbe 2	8.695	6.90	0.95	5.05	6.11	6.45	0.15	5.12	6.25
B.C.Road (Talapadi 1)	12.750	9.60	2.24	7.20	8.90	9.05	1.71	7.15	9.00
B.C.Road (Talapadi 2)	9.535	5.20	1.11	4.40	4.65	5.45	1.43	4.85	5.51
B.C.Road (Sabhagruha)	10.945	7.40	4.58	6.80	6.62	7.55	3.20	7.2	7.40
B.C.Road (Kaykunja)	7.720	9.76	5.30	8.60	9.45	9.85	4.05	9.6	9.80
Bantwal 1	10.730	7.05	3.02	6.35	6.89	6.85	1.48	6.73	7.03
Pane Mangalore	5.785	7.52	1.63	5.70	7.00	7.33	1.50	6.90	7.50
Nandavara	5.235	7.05	2.05	3.35	4.37	4.70	1.73	4.45	3.65
Mannaur	9.506	3.96	1.64	3.85	4.00	3.22	1.15	2.85	4.75
Aladi	7.350	4.85	3.50	3.70	3.40	4.15	1.05	3.10	3.92
Bantwal 2	10.980	5.37	2.82	5.30	6.64	5.85	2.30	6.32	7.70
Bantwal (NHS)	10.115	5.37	1.62	4.62	4.77	5.62	0.75	5.17	4.37
Tumbe 3	15.045	-	-	-	-	4.35	2.45	4.12	4.92
Kaikamba	19.040	-	-	-	-	2.55	1.25	2.15	3.20
Modakapu	18.515	-	-	-	-	6.45	0.70	5.35	6.45
Amtady	29.860	-	-	-	-	7.35	4.60	6.95	7.15
Goremaru	42.475	-	-	-	-	6.00	0.88	5.10	5.35
Bantwal 3	13.365	-	-	-	-	5.20	0.75	5.26	4.90
Narikombu	12.990	-	-	-	-	6.85	3.25	6.44	7.27
Shamburu	37.270	-	-	-	-	9.55	3.90	5.10	8.35
Nirpade	51.785	-	-	-	-	4.52	0.20	3.70	4.10
Dasakodi	61.575	-	-	-	-	6.60	1.62	4.58	6.10
Kalladka	33.115	-	-	-	-	3.00	1.20	1.88	2.85
Virakamba	56.010	-	-	-	-	3.35	1.28	3.15	3.25
Amturu	22.970	-	-	-	-	7.50	0.93	3.00	8.20
Bolangady	22.580	-	-	-	-	5.95	2.01	3.93	6.17
Maranabailu	20.000	-	-	-	-	9.95	0.89	5.51	9.45
Bollai	31.995	-	-	-	-	8.25	0.90	5.42	8.05
Subhash Nagara	19.280	-	-	-	-	4.22	2.07	3.36	4.67
Beraje	23.380	-	-	-	-	5.65	2.10	4.73	5.90

FRL of Vented dam: 3.775 m amsl

Hydrogeological data of Key wells established during 2008-09 at Vented dam at Tumbe Village, Dakshina Kannada district, Karnataka

Location	Dia (m)	M.P	SWL (m)	Lifting Divice	Aquifer
Tumbe-3: About 800m East of Tumbe in the house premises Sri Sunkappa Kulal	2.10	GL	4.35	R&B	Laterite
Kaikamba: 1 Km N of B.C. road in the house premises of Sreenivasa shenai.	1.40	0.80 m agl	3.35	R&B	Gneiss
Modakapu: About 1 Km N of B.C.road cross in the house premises of Sanjeev Shetty.	1.85	0.80 m agl	7.25	1H.P. E pump	Laterite
Amtady: About 2 Kms N of B.C road cross in the house premises of Valerian Pinto.	2.60	0.90 m agl	8.25	1 H.P E pump	Leterite
Goremaru: About 4 Kms NW of B.C. road Cross on polali road in the house premises of Chandran Nair	1.70	0.75 m agl	6.75	1 H.P.E pump	Gneiss
Bantwal: North of Bantwal town in the house premises of Sri M.Varadacharya.	1.35	1.00 m agl	6.20	1 H.P. E pump	Gneiss
Narikombu: About 2 Kms North of Panemangalore in the house premises of Sri Sanjeeva by the side of hotel mogarnadu	3.00	0.65 m agl	7.50	3 H.P.E pump	Laterite
Shamburu: About 4 Kms NE of Panemangalore in the house premises of Sri Seetharama poojari.	2.50	0.65 m agl	10.20	1 H.P. E pump	Gneiss
Nirpade: In the premises of Govt. Higher Primary School of Nirpade.	2.50	0.80 m agl	5.32	R&B	Gneiss
Dasakodi: In the house premises of Sri Ananda Poojari.	3.50	0.80 m agl	7.40	I H .P.E.P	Gneiss
Kalladaka: In the house premises of Sri Sanjeeva .M	1.65	0.55 m agl	3.55	R&B	Laterite
Virakamba: In the house premises of Sri Abdul Khadar	2.10	0.70 m agl	4.05	R&B	Gneiss
Amturu: In the house premises of Sri Riyaz	3.75	0.75 m agl	8.25	1 H. P. E.P	Gnieiss
Bolangady: In front of the house of Sri Humarabba by the side of Havva Jumma Masjid.	1.25	0.75 m agl	6.70	R&B	Gniess
Maranbailu: By the side Junction of the roads	2.50	0.65 m agl	10.60	R&B	Gneiss
Bollai: In the house premises of Sri Mohamad Ranger	2.50	0.75 magl	9.00	1H.P.Epump	Gneiss
Subashnagara: In the premises of Zillapanchayat High School	2.35	0.83 m agl	5.05	R&B	Gneiss
Beraje: In the house premises of Sri Janardhana Poojari	1.40	0.50 m agl	6.15	I H.P.E.P	Gneiss

15. CENTRAL GROUND WATER AUTHORITY (CGWA)

Central Ground Water Authority was Constituted vide notification no. S.O. 38(E) dated 14.01.97 with the mandate to regulate and control ground water development and management in the country under Environment (Protection) Act. 1986. Activity wise achievements during the period of 1st April 2008 to 31st March, 2009 are summarized below.

a. Regulation of Ground Water Development:

Till 31st March, 2009, 43 Blocks/Mandals/ Talukas etc. in the country remains notified for regulation of groundwater development in the states of Haryana, Punjab, Uttar Pradesh, Rajasthan, West Bengal. Gujarat, Andhra Pradesh, Madhya Pradesh, NCT Delhi and Union Territory of Diu. This is in exercise of powers under Section 5 of Environment Protection Act, 1986.

b. Registration of Ground Water Structures:

Another 65 Blocks/Mandals/Talukas in the country was notified for registration of groundwater structures in the states of Haryana, Punjab, Uttar Pradesh, Gujarat, Andhra Pradesh, Karnataka, Kerala, Tamilnadu, Madhya Pradesh. Maharashtra, NCT Delhi and Union Territory of Pondicherry. The process of registration was discontinued as per the decision taken in the 25th meeting of CGWA held on 7th August, 2008.

c. Regulation of Ground Water Withdrawal by Industries

As per the list of over exploited/critical/semi critical areas have been circulated to statutory organizations like State Pollution Control Boards, Ministry of Environment and Forest etc., the organizations refer applications of new industries/infrastructure projects to CGWA for NOC to withdraw ground water. The proposals received are evaluated on case to case basis, based on site specific recommendations of Central Ground Water Board. During the period (April 2008 to 31st March, 2009), 369 industries have been accorded NOCs.

d. Registration of Drilling Agencies

Registration of water well drilling agencies was being undertaken by CGWA to develop micro level data base on ground water development and to control indiscriminate drilling activity in the country. The process of registration was discontinued as per the decision taken in the 25th meeting of CGWA held on 7th August, 2008.

e. Appointment of authorized Officers by CGWA

CGWA in exercise of powers under section 4 of Environment Protection Act, 1986 appointed district level Authorized Officers for the purpose of regulation and control of ground water development and management in areas where regulatory directions are in force. So far, 36 District Collectors / Deputy Commissioners have been appointed as authorized officers in notified areas during 2008-09 upto 31st March, 2009.

f. Updating of web site of CGWB

The details of the activities of Central Ground Water Authority and various proforma to CGWA and other related information on CGWA have been posted in the web site for use by the general public and can be downloaded from the site www.cgwb.gov.in. The progress of work done in granting clearances to industries/ infrastructure projects an status of project proposals submitted are also placed on the web-site on monthly basis.

g. Media Activitiess

During the year, various activities under the IEC programme of Ministry of Water Resources were taken up by Central Ground Water Board through its Regional Office. The following activities were carried out :

a. 19 Mass Awareness Programmes
b. 19 Water Management Training Programme
c. 19 Workshops

Apart from the above awareness programmes such as Jalyatra anisplaying messages through Posters, Banners etc. were done.

16. GROUND WATER MANAGEMENT STUDIES IN DROUGHT PRONE AREA

The Central Ground Water Board covered an area of 40809sq. km. categorized as drought prone in Gujarat, Rajasthan, Maharashtra, West Bengal, Orissa, Andhra Pradesh and Karnataka States of the country under ground water management studies.

In addition to this, 200 bore holes (125 EW, 37 OW & 38 PZ) by departmental rigs were drilled in drought prone areas of Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh.

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 & Graph 17.1 & 17.2 respectively.

Table 16.1 : AREA COVERED UNDER GROUND WATER MANAGEMENT STUDIES IN DROUGHT PRONE AREAS DURING 2008-2009

Sl. No.	Regions/ State	Districts	Achievement Sq.Km.
1.	**WEST CENTRAL REGION**	Mehsana	3000
	Gujarat	**Total**	**3000**
2.	**WESTERN REGION**	Bikaner	10128
	Rajasthan	**Total**	**10128**
3.	**CENTRAL REGION**	Ahmednagar	3590
	Maharashtra	**Total**	**3590**
4.	**EASTERN REGION**	Purulia	4500
	West Bengal	**Total**	**4500**
6.	**SOUTH EASTERN REGION**	Dhenkanal	3500
	Orissa	Jajpur	3000
		Jharsuguda & Sambalpur	3000
		Total	**9500**
7.	**SOUTHERN REGION**	Prakasam	3000
	Andhra Pradesh	Mahabubnagar	95
		Total	**3095**
8.	**SOUTH WESTERN REGION**	Chikmagalur district /Farmers distress	2836
	Karnataka	**Belgaum/** Farmers distress	1216
		Koppal/OE area	1490
		Shimoga & Davanagere districts/ Farmers distress	1100
		Chitradurga district/ Farmers distress	354
		Total	**6996**
		GRAND TOTAL	**40809**

Table 16.2 : EXPLORATORY WELLS DRILLED IN "DROUGHT PRONE" AREA DURING 2008-2009 (By Departmental Rigs)

Sl. No	States	Districts	EW	OW	PZ	SH	DW	Total
1	Karnataka	Kolar	6	2	-	-	-	08
		Bidar	11	5	-	-	-	16
		Belgaum	6	1	-	-	-	7
		Chitraddurga	2	1	-	-	-	3
		Total	**25**	**9**	**-**	**-**	**-**	**34**
2	Kerala	Kollam	11	6	-	-	-	17
		Mallapuram	-	-	19	-	-	19
		Total	**11**	**6**	**19**	**-**	**-**	**36**
3	Madhya Pradesh	Sagar	8	1	4	-	-	13
		Total	**8**	**1**	**4**	**-**	**-**	**13**
4	Maharashtra	Satara	12	3	-	-	-	15
		Total	**12**	**3**	**-**	**-**	**-**	**15**
5	Orissa	Angul	01	-	-	-	-	01
		Deogarh	11	3	-	-	-	14
		Boudh	15	2	-	-	-	17
		Mayurbhanj	10	3	-	-	-	13
		Nuapada	3	-	-	-	-	3
		Sundergarh	15	3	-	-	-	18
		Total	**55**	**11**	**-**	**-**	**-**	**66**
6	Rajasthan	Bikaner	1	-	3	-	-	04
		Hanumangarh	2	1	3	-	-	06
		Jaipur	-	-	3	-	-	03
		Jaisalmer	-	-	2	-	-	02
		Sikar	2	1	4	-	-	07
		Total	**5**	**2**	**15**	**-**	**-**	**22**
7	Uttar Pradesh	Chandauli	4	3	-	-	-	07
		Mirzapur	4	2	-	-	-	06
		Sonebhadra	1	-	-	-	-	01
		Total	**9**	**5**	**-**	**-**	**-**	**14**
GRAND TOTAL			**125**	**37**	**38**	**-**	**-**	**200**

17. GROUND WATER MANAGEMENT STUDIES IN TRIBAL AREAS

The Central Ground Water Board, in its 2008-2009 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 26014 sq. km. was covered in Tribal areas of the country and 139 bore holes (EW- 72, OW-28, PZ-38 & SH-1) were drilled in Tribal areas to explore the possibility of tapping potential aquifers.

The status of coverage under Ground Water Management Studies and exploratory drilling in tribal areas are shown in Tables 17.1 & 17.2. and **Graph** 17.1 & 17.2 respectively.

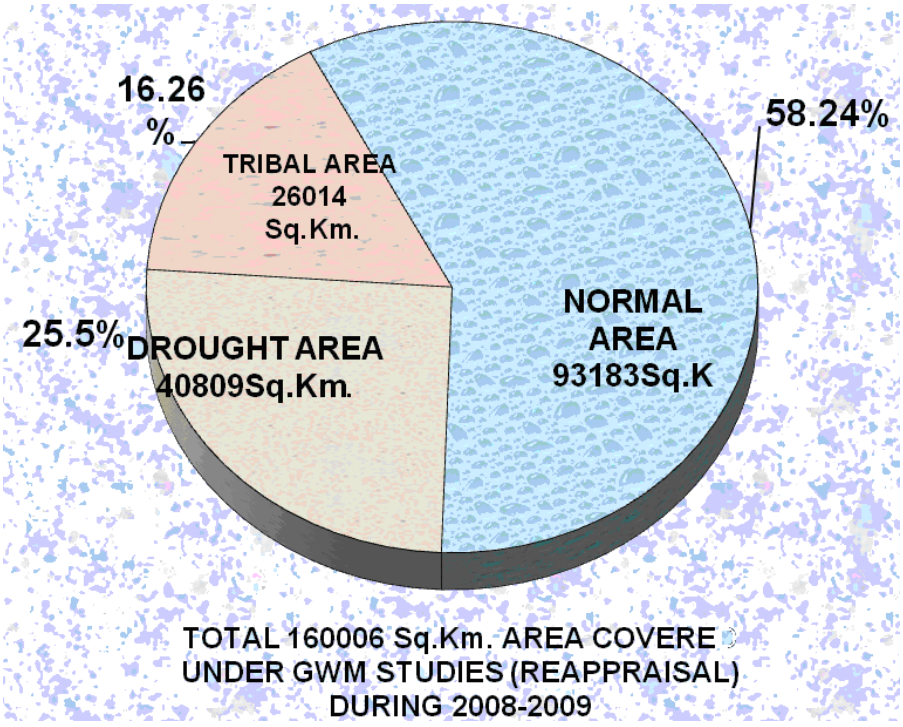
Table 17.1 :AREAS COVERED UNDER GROUND WATER MANAGEMENT STUDIES IN TRIBAL AREAS DURING 2008-2009

Regions/state	District	Achievement (Sq.Km.)
NORTH CENTRAL REGION	Shahdol & Anuppur	6404
Madhya Pradesh	**Total**	**6404**
NORTH CENTRAL CHHATTISGARH REGION	Durg	3000
Chhattisgarh	Korba	3000
	Total	**6000**
EASTERN REGION	Puruliya	4500
West Bengal	Murshidabad	104
	Hugli	500
	North 24 Parganas	531
	Total	**5635**
SOUTH ERN REGION	Khammam	2400
Andhra Pradesh	**Total**	**2400**
MID EASTERN REGION	Palamu	2700
Jharkhand	**Total**	**2700**
NORTH EASTERN REGION	Papumpare	2875
Arunachal Pradesh	**Total**	**2875**
		26014

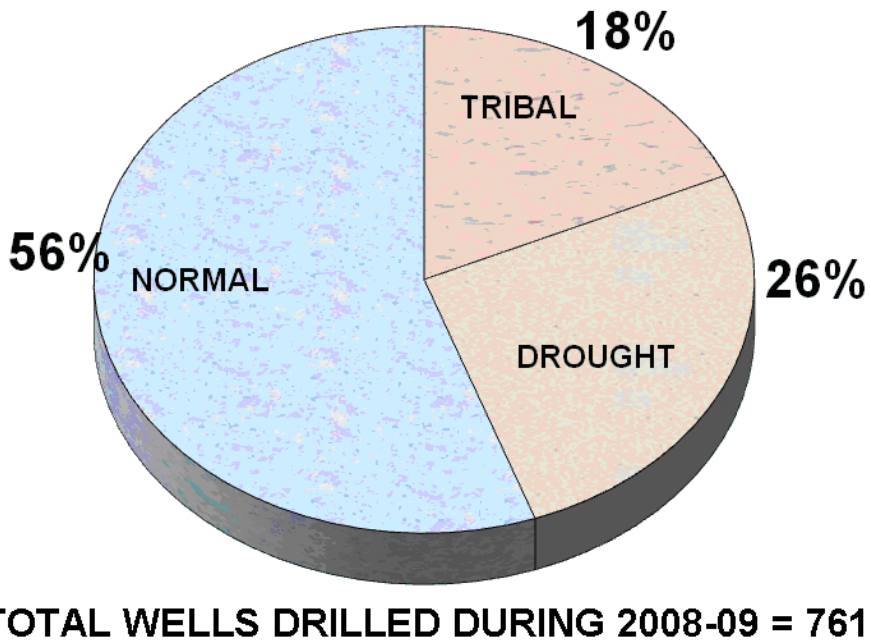
Table 17.2 : EXPLORATORY WELLS DRILLED IN "TRIBAL" AREA DURING 2008-2009 (by Departmental Rigs)

States	Districts	EW	OW	PZ	SH	DW	Total
Arunachal Pradesh	West Kameng	1	-	-	-	-	01
	Total	**01**	**-**	**-**	**-**	**-**	**01**
Bihar	Jamui	8	4	-	1	-	13
	Total	**8**	**4**	**-**	**1**	**-**	**13**
Chattisgarh	Kanker	11	5		-	--	16
	Korba	-	-	10	-		10
	Total	**11**	**05**	**10**	**-**	**-**	**26**
Jharkhand	Ranchi	1	-	-	-	-	01
	Simdega	3	2	9	-	-	14
	Total	**04**	**02**	**09**	**-**	**-**	**15**
Madhya Pradesh	Betul	11	7	2	-	-	20
	Dindori	12	3	11	-	-	26
	Mandla	9	2	6	-	-	17
	Total	**32**	**12**	**19**	**-**	**-**	**63**
Maharashtra	Raigarh	9	3	-	-	-	12
	Total	**9**	**3**	**-**	**-**	**-**	**12**
West Bengal	Darjeeling	2	-	-	-	-	02
	Jalpaiguri	2	-	-	-	-	02
	South Dinajpur	3	2	-	-	-	05
	Total	**07**	**02**	**-**	**-**	**-**	**09**
		72	**28**	**38**	**1**	**--**	**139**

Graph 17.1: Ground Water Management Studies in Tribal, Drought and Normal Area



Graph 17.2: Ground Water Exploration in Tribal, Drought and Normal Area



18. ESTIMATION OF GROUND WATER RESOURCE BASED ON GEC - 1997 METHODOLOGY

As per the National Water Policy 2002, the ground water resource potential need to be re-assessed periodically on scientific basis. Accordingly, the ground water resource of the entire country is being re-assessed jointly by the Central Ground Water Board and the States based on the Ground water resources estimation methodology, (GEC – 97) .

The Total Annual Replenishable Ground Water Resources of the Country have been reassessed as 433 Billion Cubic Metres (bcm) and the Net Annual Ground Water Availability is estimated as 399 bcm. Annual Ground Water Draft as on March, 2004 for all uses is 231 bcm. The Stage of Ground Water Development is 58%. The state – wise availability of ground water resources is given in Table 18.1.

The development of ground water in different areas of the Country has not been uniform. Highly intensive development of ground water in certain areas in the country has resulted in over – exploitation. As per the latest assessment of ground water resources out of 5723 assessment units (Block/Mandals/Talukas) in the country, 839 units in various States have been categorized as ' over-exploited' i.e. the annual ground water draft exceeds the annual Replenishable ground water resources and significant decline in long term ground water level trend has been observed either in pre-monsoon or post-monsoon or both. In addition 226 units are 'Critical' where the stage of ground water development is 100% of annual replenishable ground water resource and significant decline is observed in the long term water level trend in both pre-monsoon and post-monsoon periods. There are 550 semi-critical units, where the stage of ground water development is between 70 - 90% and significant decline in long term water level trend has been recorded in either Pre-monsoon or Post-monsoon. The state – wise status of over – exploited and critical and semi-critical areas is given in Table 18.2.

Table 18.1: STATE-WISE GOUND WATER RESOURCES AVAILABILITY,UTILIZATION AND STAGE OF DEVELOPMENT

States/ UTs	Annual Replenis-hable Ground Water Resource	Natural Discharge during non-Monsoon season	Net Annual Ground Water Availability	Annual Ground Water Draft			Stage of Ground Water Development (%)
				Irrigation	Domestic and Industrial uses	Total	
States							
Andhra Pradesh	36.50	3.55	32.95	13.88	1.02	14.90	45
Arunachal Pradesh	2.56	0.26	2.30	0.0008	0	0.0008	0.04
Assam	27.23	2.34	24.89	4.85	0.59	5.44	22
Bihar	29.19	1.77	27.42	9.39	1.37	10.77	39
Chattisgarh	14.93	1.25	13.68	2.31	0.48	2.80	20
Delhi	0.30	0.02	0.28	0.20	0.28	0.48	170
Goa	0.28	0.02	0.27	0.04	0.03	0.07	27
Gujarat	15.81	0.79	15.02	10.49	0.99	11.49	76
Haryana	9.31	0.68	8.63	9.10	0.35	9.45	109
Himachal Pradesh	0.43	0.04	0.39	0.09	0.02	0.12	30
Jammu & Kashmir	2.70	0.27	2.43	0.10	0.24	0.33	14
Jharkhand	5.58	0.33	5.25	0.70	0.38	1.09	21
Karnataka	15.93	0.63	15.30	9.75	0.97	10.71	70
Kerala	6.84	0.61	6.23	1.82	1.10	2.92	47
Madhya Pradesh	37.19	1.86	35.33	16.08	1.04	17.12	48
Maharashtra	32.96	1.75	31.21	14.24	0.85	15.09	48
Manipur	0.38	0.04	0.34	0.002	0.0005	0.002	0.65

States/ UTs	Annual Replenis-hable Ground Water Resource	Natural Discharge during non-Monsoon season	Net Annual Ground Water Availability	Annual Ground Water Draft			Stage of Ground Water Development (%)
				Irrigation	Domestic and Industrial uses	Total	
Meghalaya	1.15	0.12	1.04	0.00	0.002	0.002	0.18
Mizoram	0.04	0.004	0.04	0.00	0.0004	0.0004	0.90
Nagaland	0.36	0.04	0.32	0.00	0.009	0.009	3
Orissa	23.09	2.08	21.01	3.01	0.84	3.85	18
Punjab	23.78	2.33	21.44	30.34	0.83	31.16	145
Rajasthan	11.56	1.18	10.38	11.60	1.39	12.99	125
Sikkim	0.08	-	0.08	0.00	0.01	0.01	16
Tamil Nadu	23.07	2.31	20.76	16.77	0.88	17.65	85
Tripura	2.19	0.22	1.97	0.08	0.09	0.17	9
Uttar Pradesh	76.35	6.17	70.18	45.36	3.42	48.78	70
Uttaranchal	2.27	0.17	2.10	1.34	0.05	1.39	66
West Bengal	30.36	2.90	27.46	10.84	081	11.65	42
Total States	**432.43**	**33.73**	**398.70**	**212.38**	**18.04**	**230.44**	**58**
Union Territories							
Andaman & Nicobar	0.330	0.005	0.320	0.000	0.010	0.010	4
Chandigarh	0.023	0.002	0.020	0.000	0.000	0.000	0
Dadra & Nagar Haveli	0.063	0.003	0.060	0.001	0.007	0.009	14
Daman & Diu	0.009	0.0004	0.008	0.007	0.002	0.009	107
Lakshdweep	0.012	0.009	0.004	0.000	0.002	0.002	63
Pondicherry	0.160	0.016	0.144	0.121	0.030	0.151	105
Total Uts	**0.597**	**0.036**	**0.556**	**0.129**	**0.051**	**0.181**	**33**
Grand Total	**433.02**	**33.77**	**399.25**	**212.51**	**18.09**	**230.62**	**58**

Table 18.2: CATEGORIZATION OF BLOCKS/ MANDALS/ TALUKAS IN INDIA AS ON 31st MARCH, 2004

States /Union Territories	Total No. of Assessed Units	Semi-Critical		Critical		Over-exploited		Remarks
		Nos.	%	Nos.	%	Nos.	%	Nos.
States								
Andhra Pradesh	1231	175	14	77	6	219	18	-
Arunachal Pradesh	13	0	0	0	0	0	0	-
Assam	23	0	0	0	0	0	0	-
Bihar	515	0	0	0	0	0	0	-
Chattisgarh	146	8	5	0	0	0	0	-
Delhi	9	0	0	0	0	7	78	-
Goa	11	0	0	0	0	0	0	-
Gujarat	223	69	31	12	5	31	14	Rest 14 talukas Saline
Haryana	113	5	4	11	10	55	49	-
Himachal Pradesh	5	0	0	0	0	0	0	-

States /Union Territories	Total No. of Assessed Units	Semi-Critical		Critical		Over-exploited		Remarks
		Nos.	%	Nos.	%	Nos.	%	Nos.
Jammu & Kashmir	8	0	0	0	0	0	0	-
Jharkhand	208	0	0	0	0	0	0	-
Karnataka	175	14	8	3	2	65	37	-
Kerala	151	30	20	15	10	5	3	-
Madhya Pradesh	312	19	6	5	2	24	8	-
Maharashtra	318	23	7	1	0	7	2	-
Manipur	7	0	0	0	0	0	0	-
Meghalaya	7	0	0	0	0	0	0	-
Mizoram	22	0	0	0	0	0	0	-
Nagaland	7	0	0	0	0	0	0	-
Orissa	314	0	0	0	0	0	0	Rest 6 blocks Saline
Punjab	137	4	3	5	4	103	75	-
Rajasthan	237	14	6	50	21	140	59	Rest 1 block Saline
Sikkim	1	0	0	0	0	0	0	-
Tamil Nadu	385	57	15	33	9	142	37	Rest 8 blocks Saline
Tripura	38	0	0	0	0	0	0	-
Uttar Pradesh	803	88	11	13	2	37	5	-
Uttaranchal	17	3	18	0	0	2	12	-
West Bengal	269	37	14	1	0	0	0	-
Total States	5705	546	10	226	4	837	15	-
Union Territories								
Andaman & Nicobar	1	**0**	**0**	**0**	**0**	**0**	**0**	**-**
Chandigarh	1	**0**	**0**	**0**	**0**	**0**	**0**	**-**
Dadra & Nagar Haveli	1	**0**	**0**	**0**	**0**	**0**	**0**	**-**
Daman & Diu	2	**1**	**50**	**0**	**0**	**1**	**50**	**-**
Lakshdweep	9	**3**	**33**	**0**	**0**	**0**	**0**	**-**
Pondicherry	4	**0**	**0**	**0**	**0**	**1**	**25**	**Rest 1 Region Saline**
Total UTs	**18**	**4**	**22**	**0**	**0**	**2**	**11**	**1**
Grand Total	**5723**	**550**	**10**	**226**	**4**	**839**	**15**	**30**

Blocks- Bihar, Chhattisgarh, Haryana, Jharkhand, Kerala, Madhya Pradesh, Manipur, Mizoram, Orissa, Punjab, Rajasthan, Tamilnadu, Tripura, Uttar Pradesh, Uttaranchal , West Bengal

Mandals (command/ non-command) - Andhra Pradesh

Talukas - Goa, Gujarat, Karnataka, Maharashtra

Districts - Arunachal Pradesh, Assam, Delhi, Meghalaya, Nagaland

Districts (Valley) - Himachal Pradesh, Jammu & Kashmir

State – Sikkim

Islands – Lakshdweep

UT - Andaman & Nicobar, Chandigarh, Dadra & Nagar Haveli,Daman & Diu, Pondicherry.

19.0 TECHNICAL SCRUTINY / EXAMINATION OF SCHEME / PROPOSALS

19.1 MAJOR AND MEDIUM IRRIGATION SCHEME / PROPOSALS

As per the directives of the Planning Commission, the Board is scrutinizing the major and medium irrigation project reports/proposals from the point of view of their impact on ground water regime and specific recommendations are being made to protect quality and quantity of ground water. During the year 2008-09 up to 31st March, 2009, Sixteen major irrigation project proposals of Central Water Commission listed below were examined and area specific recommendations were made.

i. Sharda Sahayak System, U.P.
ii. Indira Sagar Lift Irrigation
iii. Sripada Sagar Project, Andhra Pradesh
iv. ERM of Canals fed from Sutlej.
v. Umarhut Pump Canal Phase II Project, U.P.
vi. Kanahar Irrigation Project, U.P.
vii. Revised Estimate of Sub stage I of Teesta Barrage.
viii. Rajiv Sagar (Dammugudum) Lift Irigation Project, Andhra Pradesh
ix. Flood Carrier Canal from Kannadia Channel, Tami Nadu.
x. Sripada Sagar Project, A.P.
xi. Relining of Sirhind Feeder and Rajasthan Feeder.
xii. Warna Irrigation Project, Maharashtra.
xiii. Flood Carrier Canal from Kannadian Channel to drought prone areas of Sathankulam and Thaisaiyanvilai, Tamilnadu.
xiv. Halon Irrigation Project, Madhya Pradesh.
xv. Malampuzha Irrigation Project, Kerala.
xvi. Interstate Linking of Rivers, Tamilnadu

19.2 R&D PROJECTS FROM MINISTRY OF ENVIRONMENT AND FOREST

The Central Ground Water Authority being a member of Ministry Of Environment and Forest receives projects involving R&D activity in field of ground water for comments and observation of the Board. During the year following projects were received and scrutinized –

a. Geospatial Modeling of Geo- Environmental Parameters Using Geo-statistics and GIS for Mapping of Environmentally Stressed Area in Jharia Coal – Field, Jharkhand.
b. Identification of Ground Water Pollution Zones Due to Industrial and Agricultural Practices in Gorakpur and Maharajganj districts in Eastern Uttar 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 S&T 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 2008-09.

The following studies were initiated during 2008-09

20.1 ER, KOLKATA

❖ **Ground Water Management Studies in drought prone water scarce area of Purulia district by using remote sensing techniques with the objective**

- To assess the scope for GW development vis-à-vis possibility of rain water harvesting in water scarce hard rock terrain,
- To study the impact of already constructed RWH structures under CSS
- To ascertain the magnitude & extent of ground water contamination with fluoride.

Hydrogeological survey was carried out over an area of 4500 sq km with the help of surface geophysical surveys.

- **Salient Problems in the area under study:**
  - Meagre scope of ground water development in the prevailing geological set up
  - At places high fluoride in ground water has been reported.

- **Findings of the work done:** The area under study belongs to the peripheral part of Chhotanagpur Plateau predominantly composed of granite gneiss (Precambrian) with small patches of Gondwana formation in Neturia area. Here, ground water, in general, occurs in the weathered zone within 10 m bgl and/ or shallow fracture zones forming unconfined to semi-confined aquifers. A total of 120 key dug wells were monitored and it has been observed that depth to water level varies from 3.67-9.76 m bgl in pre-monsoon and 1.32-7.31 m bgl in post monsoon period. A comparative study on water level shows that there has been no significant change in water level over last 25 years. During lean period most of the dug wells and the surface water bodies become dry.

Ground water is being extracted through a no. of dug wells and shallow hand pump fitted tube wells of 10 m depth. The deep tube wells for irrigation and under PHED Water Supply Scheme are, in general, not available. River bed tube wells and collector wells, installed by PHED, down to the depth of about 3 m in the beds of Kangsabati and Dwarakeswar at few places are in use for meeting the domestic water requirement through a supply network. PHED data shows that about 10% of the total population of the study has been covered under PHED Water Supply Scheme.

The geophysical investigation was carried out in the area of Hura block to identify the depth of weathering and disposition of fractures. Geophysical survey reveals that, in general, four sub-surface layers have been identified, namely weathered, semi-weathered, partially weathered and fresh rock layer. Weathering is varying within the depth range of 5.70 to 46.80 mbgl, semi-weathered rock occurs within the depth range of 5.80 to 89.60 mbgl and partially fractured rock is lying within the depth range between 10.50 & 122.80 mbgl. The fractures are identified to be within the depth range of 40-50, 70-80 and 120-150 mbgl. The most dominating fractures are within 70-80 mbgl.

The geophysical survey was also carried out with the objective to measure the thickness of the alluvium in the Dwarakeswar and Futiary river bed and to know the nature of compactness of sub-surface formation.
The average thickness of alluvium in the Dwarakeswar river bed is 7.40 m in Hura block and 3.0 m near Sialbari area of Kashipur block, beyond which the fractures are identified in the depth span of 8-10, 12-15, 20-35 and 40-50 mbgl in Hura block, 12-15 and 20-40 mbgl in Kashipur block and 50-60 & 90-100 mbgl in Raghunathpur block.

In the Futiary river bed, the average thickness of alluvium has been identified down to the depth of 9 m and the fractures in the depth span of 12-20 and 40-50 mbgl in Hura block.

The geophysical studies reveals the presence of promising ground water bearing zones which may be harnessed through dug wells and shallow hand pump fitted tube wells for domestic water supply.

Ground water sampling has been done to determine the concentration of fluoride and other parameters in ground water with respect to the Purulia South and Purulia North Shear Zones. From the available data, it has been observed that a maximum of 3.7 mg/l of fluoride is present in ground

water. The results of chemical analysis of the samples, collected during the survey, are awaited.

- **Recommendation to be provided to the State Govt./ User agencies:**

➢ Based on the findings of hydrogeological and geophysical surveys, sites for ground water abstraction structures, e.g. tube wells and intake wells have been selected to cater to the need in future due to ever increasing population growth and urbanization.

➢ Since the average annual rainfall in the area is around 1400 mm (1369.80 mm annual rainfall in the last 20 years & 1245.30 mm during 2007), rain water harvesting for conservation and through artificial recharge to ground water may be attempted for augmentation of ground water. Sites for artificial recharge structures through nullah bunding, gully plugging, renovation of tanks/ ponds, abandoned dug wells etc., have been selected. Roof top rain water harvesting technique may also be adopted in some schools on experimental basis. On successful compilation and analysis of all the field data, suitable recommendation will be forwarded to the State Govt. and other beneficiaries with an aim that the most suitable sites for artificial recharge may be taken up as a pilot scheme by the State Govt itself or under the Centrally Sponsored Scheme (funded by Govt. of India), subject to the technical and financial approval of Central Level Technical Co-ordination Committee headed by CGWB at National level.

20.2 NER, GUWAHATI

Under remote sensing studies in Lakhimpur district of Assam, the following works have been completed:

1) Base map layer has been prepared
2) Prepared drainage, geology and soil thematic layers of Lakhimpur district, Assam
3) Further compilation of data for the same is under progress.

20.3 NR, LUCKNOW

Feasibility study of demarcating ravine area in parts of Sengar river watershed, Kanpur Dehat district and suggesting measures for ravine reclamation by measure of runoff control and artificial recharge.

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

The study was planned on the line of previous studies, carried out by Special Studies Directorate, Faridabad and North Central region of CGWB, Bhopal in Chambal river basin, Neemuch district, Madhya Pradesh during 2005-06 which was based on remote sensing digital data interpretation for the mapping of ravine land and geo-morphological features supported by field checks.

On the guidelines of Central Headquarters the procurement of latest satellite digital data and paper prints was initiated with NDC, NRSA, Hyderabad and CHQ, Faridabad. Procurement of a new computer and support system with advance configuration that compatible to handle satellite digital data processing and the GIS software (Geomatica) was also initiated with the office.

The study was however, initiated with the available remote sensing data i.e. old Black & White MSS images and FCC's The preliminary field surveys were carried out to gather the ground information to facilitate satellite data interpretation for the mapping of ravine land. The work done previously by different organizations has been reviewed.

In the want of latest remote sensing satellite data and necessary hardware support system the study has not been completed.

Remote Sensing Studies in support of Reappraisal surveys and ground water exploration by aerial photo & satellite imagaery interpretation.

1) Remote sensing data interpretation has been done for hydromorphological mapping in aid to Ground water Management studies in Gautam Budh Nagar district, U.P., using morphological signatures on Land Sat MSS images (Black & white and FCC's).
2) Interpreted the FCC data for parts of Pithoragarh & Champawat Districts, Uttrakhand, for non-conventional hydrogeological studies being carried out by U.R.
3) Mapping of Flood Plain Aquifers of major rivers in Ganga Basin.
4) Gomati River : Flood Plain map of Gomati river has been prepared with necessary data input.
5) Ganga River : River Morphology & Flood plain Map of Ganga river has been compiled. Different thematic layouts of Ganga flood plain has been prepared. Compiled data for aquifer geometry and potential assessment of Ganga flood plain. Submitted a detailed note on Hydrogeological Conditions in Ganga River Flood Plain to technical cell so as to send the same to Member (SAM) as desired.

Transfer of Aerial Photographs & Satellite data to Uttrakhand Region, Dehradun. Aerial photographs these pertaining to Uttrakhand region were sorted out on the basis of available flight charts. Mandatory permission for transfer of Aerial Photographs & Satellite data to Uttarakhand Region, Dehradun was seeked .from CHQ, CGWB / Survey of India which has been later received. Transfer of the data is pending for arrival of an officer from CGWB, U.R., Dehradun.

20.4 NWR, CHANDIGARH

The remote sensing studies were proposed to take up in Yamuna flood plain area, Haryana. The following work has been done during the AAP.

- Request made to NRSA for procurement of Remote Sensing Data.
- Discussions were carried out with NRSA scientist to procure precision-Geo-coded LISS-III data.
- Reminder sent to NRSA for procurement of digital data.
- Central Headquarter requested to accord administrative and financial sanction for procuring the Remote Sensing Data.
- Procurement of Satellite Data from NRSA is under progress.

20.5 SECR, CHENNAI

Remote sensing studies in Gangavalli and Thalaivasal blocks, Salem district

20.5.1 Objective

1. Mapping of lithology, geomorphology, structure/lineaments, Drainage morphology, Land use/landcover.
2. Integration of different thematic layers using GIS.
3. Delineation of ground water potential zones.
4. Selection of sites for artificial recharge.
5. Impact assessment of artificial recharge structure by mapping of change in cropping area/waste land area.

20.5.2 Status of procurement /Utilization of softwares & digital data

Data for 3 sheets was received from NRSA during December 2008 and remaining during February 2009.

20.5.3 Study area

"Demonstrative Project on Artificial Recharge to groundwater" had been taken up in Gangavalli block to improve the over all groundwater situation and to demonstrate the efficacy of the artificial recharge techniques for the State agencies to replicate in other areas. A total of 41 artificial recharge structures had been executed during 2006-08. Check Dam, Check Dam with recharge well, Percolation pond and percolation pond with recharge wells were constructed under this scheme. In addition, desilting of existing tanks was also taken. In Thalaivasal block Artificial recharge structures has been proposed.

20.5.4 Work done

Collected the field data from secondary sources. The terrain is having varied geomorphic features with number of lineaments and structural features having impact on ground water resources.

20.6 SER, BHUBANESWAR

In pursuance to the field season programme 2008-09, the present study was taken up to delineate the different geomorphic units using Remote Sensing techniques. The study was corroborated with co-lateral data for GIS data analysis. An attempt has been made to delineate the ground water potential areas using both spatial and non spatial data in a GIS domain.

Basudevpur block with an area of 511 sq km is bounded between latitudes 20° 56 '05" N and 21 ° 13' 55" N and Longitude 86° 38' 51" E and 86° 53' 43" E. It is one of the CD blocks out of the 7 blocks in the district Bhadrakh, Orissa. It is bounded in the north by balasore district, west by Bhadrakh and Tihidi block, south by Chandbali block and Bay of Bengal in the eastern part. The coastal block basudevpur is endowded with abundance of water resources and vast stretch of fertile land. The economy is agriculture based. Because of its characteristic geological, hydrological, hydrogeological setting, the tract presents typical problems in ground water development and management. This is the area where the population density is high and agriculture activities intense with ever increase demands for freshwater. This terrain is endowed with large freshwater reserve in the subsurface geological formations. But its development is constrained due to proximity of the sea and salinity hazards. Its unplanned development may upset hydro-chemical balance leading to seawater ingress. Thus the development of ground water in the terrain requires a proper understanding of hydro-geological and hydro-chemical setup and management scenarios.

In preparation of this report, an attempt has been made to study the different geomorphic and hydrogeomorphic

parameters such as geology, geomorphology, land use & land cover, slope, DEM (Digital Elevation Model) using Remote Sensing and Geographical Information System (GIS). To map the saline affected areas different hydrogeologic parameters like hydraulic conductivity, aquifer types, distance to coast, water table above mean sea level, are analysed in a very popular GALDIT model. Thematic maps are prepared and analyzed in a GIS environment. Relationship of each layer to the ground water regime has been evaluated through detailed analysis of the individual parameters. These relationships are used for the development of an algorithm to be used in spatial multi-criteria evaluation (SMCE) decision model (*ILWIS, User Manual, 2008*). Ground water potential zones have been identified based on integration of data and various themes.

Discussion:

The GALDIT parameters are the ranked, weighed and normalised to generate the salinity ingress vulnerable map. The ranking order is knowledge based, purely on scientific data base generated from field investigation, existing maps and the data generated through years of exploration done by CGWB on Basudevpur area. The data generated during the course of creek project work has also been utilised to integrate the information in a spatial domain. The map thus generated is shown in Figure-1. It is observed that the map generated through GIS data interpretation is almost compatible with the earlier published hydrogeological map demarcating the saline and non saline areas (Figure-1 (a)). From the chemical data analysis, high values of EC, Cl, Sodium Absorption Ration(SAR) and TDS are recorded from the areas in Chandanpur, Bacchada, Untira in the northern part and in Naikandiha, Irum, Chudamani, Ramchandrapur in south eastern part of the area.

From integration of different thematic layers like Geomorphology, Landuse, Depth to Water Level, Slope and soil map in the SMCE method the final out put map shows that nearly 85% of the area is falling in very good to excellent categories from ground water potential point of view (Figure-2).

On combining both the maps, the area demarcating the non saline areas with high ground water potentiality has been demarcated and shown in Figure-3. It is inferred from the map that the area in the north eastern part in Ratang, Narsinghpur, Bhairabpur, Deuli, Binayakpur, Guagadia, Basudevpur, Edtal, albaga, Kapagadia sector are free from salinity ingress. The areas near the coast and the south eastern part covering Naikandiha, Chudamani, Bideipur, Habelisahi, Balimunda, Balimedh, Rajpokhari, Khedarpur are saline affected areas.

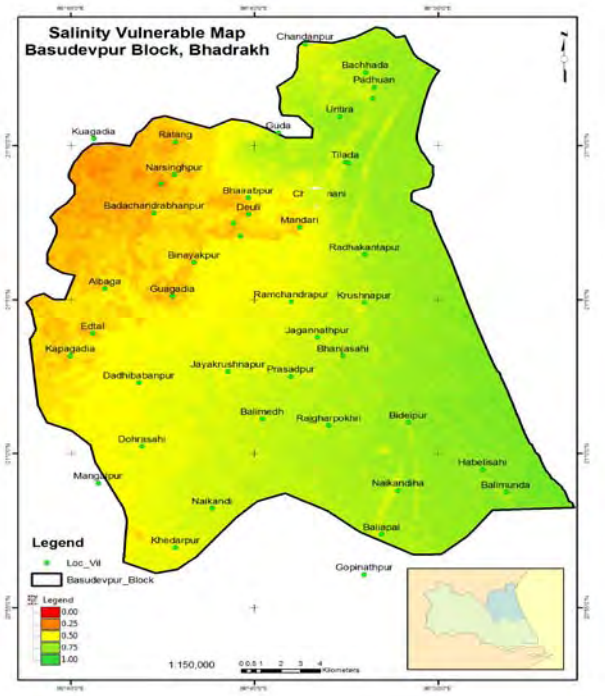


Figure-1: Salinity vulnearable Map of Basudevpur Block, Bhadrakh District, Orissa, Generated through spatial data analysis.

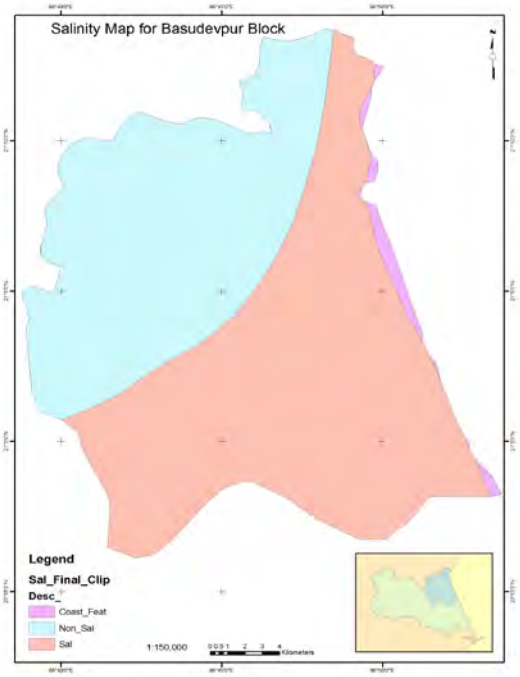


Figure-1(a) Existing Hydrogeological Map showing saline-non saline areas based on ground water exploration, Basudevpur Block, bhadrakh District

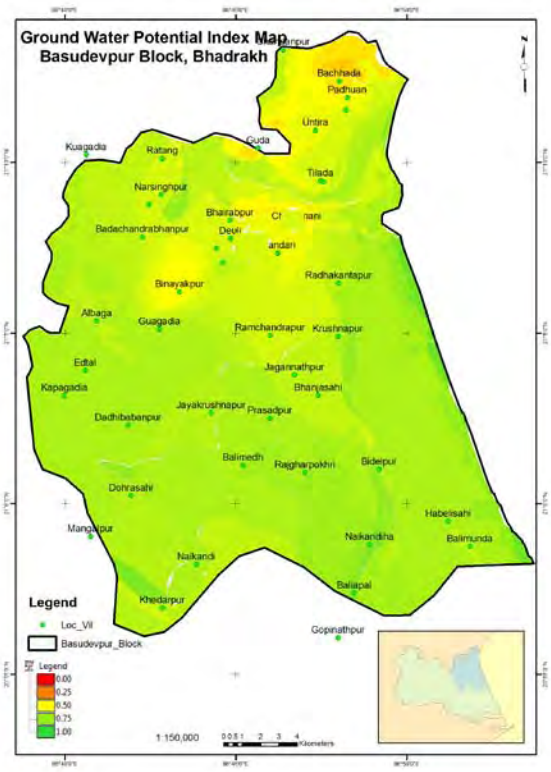


Figure-2: Ground Water Potential Map of Basudevpur Block, bhadrakh District, Orissa

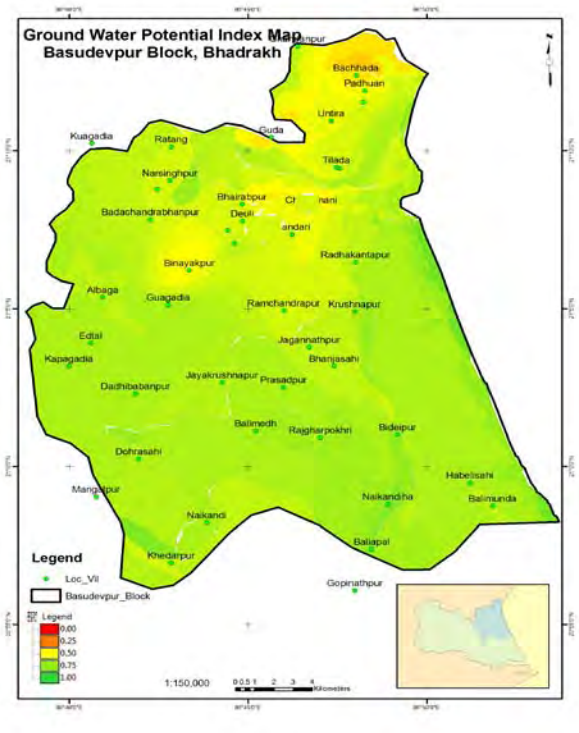


Figure-3: Map Showing the Non Saline area with High Ground Water Potential in Basudevpur Block, Bhadrakh District, Orissa

20.7 SWR, BANGLORE

20.7.1 Special studies: Impact assessment of artificial recharge structures in Kodi halla and Gundi halla drainage basin, Hosadurga taluk, Chitradurga district using remote sensing and conventional studies.

Two drainage basins namely Kodi halla and Gundi Halla were selected for the detailed study in the Hosadurga taluk, Chitradurga district as series of artificial recharge structures constructed in the area. The Kodi halla drainage basin is consisting of gneiss and very small area is exposed with schist where as the Gundi Halla drainage basin is having multiple geology and structurally controlled.

To study the impact of the ARS constructed in the area, the information on Geology, Geomorphology, soil, landuse/landcover and slope are considered to be important. The Demarcation of area suitable for the artificial recharge structures were done based on the integration of multiple thematic maps prepared by using the remote sensing data.

The Kodihalla drainage basin is located in the northwestern part of the Hosadurga taluk, covering 274 sq.km. It lies between longitudes of 76° 06′ E- 76° 16′E and latitude of 13° 42′ N – 13° 55′ N. The Kodihalla drainage basin is tributary of Vedavathi catchments in Krishna River basin. The Gundi Halla drainage basin is located in the northeastern part of the Kodihalla drainage basin covering about 80 sq.km area.

In Kodi Halla drainage basin, Series of Check dams, Percolation Tanks and Bunds are the type of ARS constructed on the main stream of the basin. The check dams and Percolation Tanks were constructed in the lower part of the basin whereas the bunds were constructed in upper part of the basin on the first/second order stream of the basin. In Gundi Halla drainage basin, series of check dam only were constructed.

During the intensive fieldwork, 29 nos of key wells were established to measure the ground water levels periodically in the area. The wells are equally distributed in the area to represent ground water levels in the area. Ground water levels were monitored in the months of May-08, September to November-2008 and the contours were generated for the all months.

In Gundi Halla drainage basin, a total of 12 numbers of key wells were established and water level data had been

collected. The depth to water level varies form 5.32 to 21.84 mbgl during the pre-monsoon. Water levels of the bore well located very close to the ARS are not showing any significant change in the water level. However, just downstream of the structure (Kenkere), flow of water is observed during the pre-monsoon. These base flow water was collected and pumped for the crops of plantain plant irrigation purposes.

The integrated maps results were compared with the water level data for the Kodi halla drainage basin. A shallow water level was observed in and around the percolation tank located in the Kengavalli village. It indicates that there is considerable improvement in the ground water conditions of the area.

20.8 UR, DEHRADUN

During AAP 2008 – 09, Remote Sensing and GIS studies have been taken up under the head of District Ground Water Management Studies (DGWMS) in collaboration with Indian Institute of Remote Sensing (IIRS), Department of Space, Dehradun in Pithoragarh District.

20.8.1 Title of the study:

1) Terrain Characterization and Groundwater Potential Zone in Ramganga Watershed, Pithoragarh District, Uttarakhand, India.
2) Groundwater Potential Zoning and Hydrochemistry of Ramganga watershed, Pithoragarh District, Uttarakhand.
3) Groundwater prospects mapping and Hydrochemistry of Thuli Gad Watershed, District Pithoragarh, Uttarakhand.

20.8.2 Objective of the Study:

The objective of the study is to characterize the terrain with respect to parameters controlling groundwater occurrence and movement by using satellite imagery and ancillary data and to prepare maps of the Groundwater Potential Zones by integrating different controlling parameter maps using GIS techniques. It was also postulated to integrate various hydrochemical parameters in GIS environment of Ramganga Watershed, Pithoragarh District, Uttarakhand, India. To prepare thematic maps of geomorphology, geology, lineament, land use / land cover, drainage and slope maps and hydrochemical parameters of Thuli Gad watershed of Pithoragarh district.

Scientists of CGWB, UR, Dehradun and Dr. Sk. K. Srivastava, Scientist–SF, Geosciences Division, IIRS, Dehradun are associated with these studies. CGWB, UR, Dehradun neither procured any kind of digital data nor softwares for the proposed studies. These collaborative studies were undertaken by the CGWB and IIRS, Dehradun based on the mutual understandings and to work in the hilly terrain of Uttarakhand State.

20.8.3 Study Area:

Ramganga Watershed lies between the latitudes 29°31'28.92"N to 30°13'57.26"N and longitudes 80°00'02.41"E to 80°17'19.64"E, covering an area of about 1365 Sq. km. The study area falls under the Survey of India (SOI) toposheet nos. 62 B/4, 62 C/1, 62 C/2, 62 C/5 and 62 C/6. Ramganga River roughly forms the boundary between Almora and Pithoragarh Districts. It originates from Namik glaciers and is fed by numerous big and small rivers and finally joins Sarju at Rameshwar. The northern most part of the watershed is covered by snow capped peaks throughout the year. Ramganga Watershed has an elongated shape in North-South direction with length of 78.97 km and width 26.72 km. it falls in the zone of Inner Lesser Himalayas with elevation ranging from 3000 to 4750 m above mean sea level. There are four main seasons in the study area, winter or cold weather (December to March), summer or hot season (March to June), rainy season (mid June to mid September) northwest monsoon, retreating of monsoon (September to November). The annual average rainfall of the study area is 1223 mm.

Materials and methodology: Satellite data of IRS–1C, LISS–III Image, taken on 18th November 2005 used. LISS–III sensor of multi spectral data in 4 bands was used. Shuttle Radar Topographic Mission (SRTM) with Digital Elevation Model (DEM) elevation data of the path 145 and row 39 with 90.0 m resolution. Ancillary data of Survey of India toposheets as mentioned. ERDAS IMAGINE 9.1 with GIS Arc Map, Arc View, Arc Scene softwares were used along with portable advanced GPS.

Geology of the area: geologically, the rocks of the study area metasedimentary of Proterozoic. Ramganga watershed belongs to Damta, Jaunsar, Tejam and Vaikrita group of the Precambrian-Paleozoic rocks. The main litho units are quartzite, dolomite, phyllite, slate, carbonaceous phyllite, granite gneiss and limestones. The regional trend of the strata is NW-SE with moderately dipping towards NE direction. Structurally, the study area is disturbed by numerous faults and three thrusts. The main thrust zone, known as Main Central Thrust (MCT) separates Vaikritha Group of rock from Munsyari Formation. Munsyari Thrust separates Almora Group from Jaunsar Group while Berinag Thrust detaches Jaunsar Group from Tejam Group.

Hydrogeology of the area: Water levels were obtained from hand pumps, and measured discharge of springs. Total of 50 groundwater abstraction locations were established during the post monsoon (November, 2008). The water level in 35 hand pumps varies from 0.83 (Jarmalgaon) to 47.12 (Naulara) m bgl. The average water level in the watershed is 18.6 m bgl. On the bassis of lithological map, in dolomites ranges from 3.0 to 10.0 m bgl and Mandhali and Rautagara formation water level varies from 15.0 to 30.0 m bgl. In quartzite, discharge of springs ranges from 2 to 5 lpm. Discharge of the springs in Munsyari and Vaikrita formations showing higher discharge through seepage due to presence of secondary porosity and permeability.

Hydrochemistry: During the course of investigation, 40 representative groundwater samples collected and were analyzed at chemical laboratory of Indian Institute of Remote Sensing, Dehradun. pH, EC and TDS were measured right after collection of samples in the field. pH is ranging from 7.2 to 8.5 in ground water and 5.9 to 8.3 in surface water. Electrical Conductivity (EC) in groundwater and surface water range from 29. 5 to 799 µS/cm and 120 to 276µS/cm, respectively. TDS varies from 19.7 to 664 mg/l in the study area. Sodium concentration in groundwater varies from 10.5 to 24.17, which is within the permissible limit. Concentration of potassium varies from 0.65 to 13.02 mg/l, that of calcium varies from 2.7 to 102.1 mg/l, magnesium concentration ranges from 1.2 to 51.8 mg/l, fluoride ranges from 0.02 to 0.33 mg/l, which is well within the prescribed limit. Chloride concentration in the study area ranging from 0.06 to 56.1 mg/l, nitrate concentration varies from 0.07 to 259 mg/l. Concentration of sulphate varies from 0.04 to 32.12 mg/l and bicarbonate concentration ranges from 18 to 369 mg/l.

The following maps were generated:

1. Structural map of the study area, 2. Lineament and Lineament density map, 3. Slope and slope aspect map, 4. Relief map, 5. Geomorphological map, 6. Specific catchment area map, 7. Topographic wetness index map, 8. Drainage map, 9. Drainage density map, 10. Water level map, 11. Land use / land cover map, 12. Groundwater prospects map, 13. EC, pH and TDS maps, 14. Na, K, Ca, Mg maps and 15. F, Cl, Br, Nitrate Sulphate and Bicarbonate maps.

Output of the study: Groundwater is a dynamic natural resource, but in hilly terrain availability of groundwater is limited extent and its occurrence confined to fractured and weathered zones. For solving this problems, large amount of data from various sources are integrated for groundwater exploration. Integration of remote sensing and GIS techniques with ground truth checks in the field have boosted to analysis and identifying the groundwater potential zones in the hilly terrain. Drainage analysis suggests that high drainage density shown high to moderate prospects, slope of the study area is ranging from 0 to >70 degrees. Geomorphological features like active flood plains, river terraces, agricultural land have good groundwater prospects. High altitude mountain snow peaks have low prospects. Land use/land cover delineated agricultural pattern. The outcome of the study is to demarcate the groundwater potential zones and the quality of water of Ramganga Watershed.

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 PROGRAMME ON "ARTIFICIAL RECHARGE TO GROUND WATER AND RAIN WATER HARVESTING

- North Western Himalayan Region, Central Ground Water Board, Jammu organized a training programme on Roof Top Rainwater Harvesting & Artificial Recharge to Ground Water on 3rd & 4th February 2009 at University of Jammu. Dr. B.P.Singh Sehgal, Dean (Academic Affairs) & Professor of Law, University of Jammu was the Chief Guest and Maj. General (Retd.) Goverdhan Singh Jamwal, AVSM was the guest of honour. Regional Director, North Western Himalayan Region, Central Ground Water Board , Jammu presided over the function.
- Northern Himalayan Region, Central Ground Water Board, Dharamshala organized a training programme on Roof Top Rainwater Harvesting & Artificial Recharge to Ground Water on 6th February 2009 at Conference Hall, Una. Shri Parvez Akhter, Superintending Engineer, Irrigation & Public Health Department was the Chief Guest and Shri Y.K. Sharma,Senior Hydrogeologist, Ground Water Organization (I&PH), Una was the guest of honour. Shri J.S. Sharma, Regional Director(I/C), Northern Himalayan Region, Central Ground Water Board , Dharamshala presided over the function.
- South Eastern Region, Central Ground Water Board, Bhubaneswar organized a two days Water Management Training programme on Roof Top Rainwater Harvesting & Artificial Recharge to Ground Water on 12th and 13th February 2009 at DRDA Conference Hall, Jajpur. It was attended by 40 participants.
- Central Ground Water Authority & Central Ground Water Board, Eastern Region, Kolkata organized a two day Water Management Training Programme on 24.02.2009 & 25.02.2009 on " Ground Water Management with Special Reference to Rain Water Harvesting and Artificial Recharge to Ground Water" at Conference Hall, Maa Santoshi Lodge, 3 No Talikhola, Bagdah road, Bongaon, North 24 Parganas District, West Bengal. In total 23 trainees were selected and attended the training programme. At the end of technical lecture session the respective queries of the trainees were elaborately explained up to their satisfaction ,followed by a test awarda nd certificates.
- Central Ground Water Board, Central Region, Nagpur organised Water Management Training Programme (WMTP) at Hotel Shripad Continental, Amravati district on 25th and 26th February 2009 with Ground Water Surveys and Development Agency (GSDA) as the local co-organizer.

The training programme was inaugurated on 25th February 2009 by Shri B. Jaya Kumar, Regional Director CGWB, CR, Nagpur. The welcome address was given by Shri P.K. Parchure, Supdt. Hydrogeologist, CGWB, Nagpur. He also explained the concept of rainwater harvesting and the various techniques involved in rainwater harvesting particularly in Amravati District.

Regional Director CGWB, CR, Nagpur expressed his keen interest to implement rainwater harvesting schemes in hilly and remote areas of the district with the active support and technical guidance of CGWB. He also spoke on the need to effectively manage the ground water resources of the country and explained the overall rain water harvesting scenario.

During the two days of the training programme the multidisciplinary faculty of CGWB, Nagpur and GSDA, Amravati delivered various lectures keeping in view the problems of Amravati district. The programme also included a field visit to nearby village Warha khurha where RWH structures were shown to the participants.

The lectures were followed by evaluation test on roof top rain water harvesting, so as to guide the trainees on formulation of rain water harvesting schemes.

A total of 37 trainees attended the training programme, the participants were officers and representatives of Agriculture Department, Irrigation Department, Forest Department, Department of Geology, Amravati University and Shri Shivaji College, NGO's and Private professionals. The trainees took active participation and appreciated the contents and presentation of WMTP.

Various technical publications of CGWB along with posters were displayed at the venue. Various reports generated by CGWB, CR were also displayed along with charts, atlas, water user maps, etc. The exhibition has keenly observed by all the trainees. The training programme concluded with the distribution of certificates.

- Central Ground Water Board, North Eastern Region, Guwahati Organized two days training programme on Roof Top Rain Water Harvesting & Ground water Management on 11th & 12th February, 2009 at Conference Hall, Brahmaputra Board, Guwahati, Kamrup district, Assam. 24 persons from different organizations, i.e Directorate of Geology & Mining, Govt of Assam, Irrigation Department, Govt of Assam, Public Health Engineering Department, Govt of Assam, Agriculture Department, Govt of Assam, Central Water Commission, Brahmaputra Board, Central Public Works Department, National Institute of Hydrology, were imparted training. Shri Rajan Nair, Chairman, Brahmaputra Board inaugurated the Training programme. Shri B.C.Patowary, Scientist F & Head, National Institute of Hydrology attended valedictory function as Chief Guest. Both the sessions were presided over by Regional Director, Central Ground Water Board, North Eastern Region.
- West Central Region, Central Ground Water Board, Ahmedabad organized a training programme on Ground Water Augmentation and Management – withSpecial Reference to Scheme on Artificial Recharge to Ground Water through Dug Wells" at Gandhinagar on 26th March, 2009. Smt. Rita Teotia, IAS, Commissioner & Principal Secretary, Rural Development was the Chief Guest, Shri S.G. Siddesh, Chief General Manager, NABARD and Shri Ram Kumar, Chief Conservator of Forest, Govt. of Gujrat were the Guest of Honour on the occasion. Regional Director presided over the Inaugural Function. 40 trainee officers from Gujarat State Watershed Management Agency (GSWMA), Govt. of Gujarat participated in the training programme.
- Training programme on "Ground water recharge through Dugwells" have been conducted on all 4 taluks of Bangalore rural district during 17-20th March 2009.

21.2 TRAINING UNDER HYDROLOGY PROJECT

- Central Ground Water Board, Central Region, Nagpur organised a one day Awareness Raising Training Programme under Hydrology project –II on 20th March 2009 at Nagpur.

21.3 INTERNATIONAL TRAININGS

Dr. N.Majumdar, Asstt. Hydrogeologist in Eastern Region Kolkata has completed nearly five months International Training on " Groundwater Governance in Asia. Theory and Practices organized by International Water Management Institute (IWMI) in New Delhi and Kathmandu from November 2007 to March 2008. Dr. Majumdar was nominated by the department for deputation to IWMI for the said training programme and participate as the Junior Professional Research Fellow during entire course of training and research. Several trainees from India, China, Pakistan, Nepal and Bannglaesh took part in the program. Dr. Majumdar along with other three Indian trainees represented the West Bengal group and took up a short term socioeconomic research in West Bengal which was an essential component of the said training and research course. The group has shown excellent performance in respect of quality research and hence, awarded by IWMI in recognition of the best comprehensive research paper on "Transition from flat to metered electricity tariff in agriculture: Who wins and who loses? Evidence from West Bengal, India" presented at the final session of the program held at Kathmandu in the second half of March, 2008. Adding much to glory, this is for the first time any Indian group has ranked 1st in the five participating countries in the context of quality research output.

21.4 RAJIV GANDHI NATIONAL GROUND WATER TRAINING AND RESEARCH INSTITUTE

Fifteen training courses were conducted during 2008 – 09 up to 31st March 2009 under Rajiv Gandhi National Ground Water Training and Research Institute. The details of training courses are given below -

i. A one week refresher course for Chemist on Analysis of Basic Water Quality Parameter was successfully organized during 16th June 2008 to 20th June 2008 at Central Ground Water Board, Southern Region, Hyderabad. 20 participants were attended the course.

ii. Four weeks training course on "Hydrogeological Investigation, Development and Management of Ground Water in Hard Rock Terrain – Technique, Equipment and Practices" was successfully conducted at Southern Region, Hyderabad during 18.08.2008 to 12.09.2008. 18 participants attended the course from CGWB and other State Govt. Department & Institutes etc.

iii. Two weeks training course on "Application of Geophysical Techniques for Ground Water Exploration and Management" was successfully conducted during 15-27th September 2008 at Northern Region, Lucknow. The training course was inaugurated by Chairman, CGWB . Dr. P.N. Rajdan,

Senior Dy. Director General of GSI, Lucknow was the Chief Guest on the occasion. 23 trainees attended the training course.

iv. A one week Refresher course on "Material Management" was successfully conducted during 8-12th September 2008 at Central Ground Water Board, Division XII office, Bhopal. 18 participants attended the training course.

v. A one week Administrative training course for staff of Central Ground Water Board was successfully conducted during 8 - 12th September 2008 at ISTM, New Delhi. 25 participants have attended the training course.

vi. A one week Refresher course on "Ground Water Resource Estimation" was successfully conducted during 13 - 17th October 2008 at RGI, Central Ground Water Board, Bhujal Bhawan, Faridabad. 22 participants attended the training course out of which 9 officers were from State Ground Water Departments.

vii. A one week training course on "Artificial Recharge in different hydrogeological conditions" was successfully completed on 21st November 2008 at RGI, Central Ground Water Board, Bhujal Bhawan, Faridabad. 23 participants attended the training course out of which 22 officers were from State Departments and NGO's.

viii. A training course on "Hydrogeological Investigation, Development, Management of Ground Water in Alluvial Terrain-Techniques, Equipments and Practices" was successfully conducted during November 11th to 5th December 2008 at North Western Region, Chandigarh. 17 trainees from CGWB, States Government and other Central Government departments were attended the course.

ix. Training course on "Administrative matters for Senior officers of CGWB" was successfully conducted at Indian Institute of Public Administration (IIPA), New Delhi during 3rd – 7th November 2008. 20 officers of CGWB attended the course.

x. Training Programme on Geographical Information System (GIS) and Mapping Tools was conducted at NITTT&R, Chennai during November 24th – December 5th , 2008. 20 trainees attended the course.

xi. A one week Refresher course on "Analysis of Pumping Test Data" was successfully completed on 20th December 2008 (December 15-20 2008), at Central Ground Water Board, Central Region, Nagpur. 7 officers from CGWB and 14 officers from State Ground Water Organization/Institutes attended the training course.

xii. A two weeks training course on "Application of Remote Sensing & GIS in Ground Water System" was successfully completed on 30th January 2009 (19th January – 30th January 2009) at IIRS, Dehradun. 18 participants from CGWB and State Ground Water Organizations attended the training course.

xiii. An Eight weeks training course on "Water Well Construction – Techniques, Equipment and Management" was successfully completed on 27th February 2009 (January 05 to February 27, 2009) at Central Ground Water Board, Division XII, Bhopal. 18 officers from CGWB and State Ground Water Organization/Institutes attended the training course.

xiv. A two weeks training course on Mathematical Modelling of Ground Water System " was successfully completed on 28th March 2009 (March, 16-28, 2009) at IIT , Roorkee. 15 officers from CGWB and State Ground Water Organisations attended the training course.

xv. A three days training course on "Appreciation Course on Ground Water Estimation and Management Software (GEMS) for Senior Officers" was successfully completed on 1st April 2009 (30th, 31.03.09 to 1.03.2009) at State Ground Water Department, Shimla. 30 officers from State Ground Water Organisation attended the training course.

Total 308 trainees from various disciplines have been trained in the above training courses conducted at various places during the year up to 31st March 2009.

21.5 TRAINING UNDER OTHER AGENCY

- Scientists from Central Region, Central Ground Water Board, Nagpur and SUO, Pune attended two weeks training programme on "Application of Geoinformatics (Remote Sensing/GIS/GPS) in Water

Sector conducted by National Water Academy, Khadakwasla, Pune from 8th to 18th July, 2008.

- Scientist from Southern Region, Central Ground Water Board, Hyderabad attended a training programme on "Water Harvesting for Drought Management" from 1st to 5th July, 2008 at Engineering Staff College of India, Hyderabad.
- Four persons of Central Ground Water Board, Faridabad attended training course on Capacity building for officers of Ministry of Water Resources, Central Water Commission, Central Ground Water Board and other department organized by CWC at New Delhi from 22nd – 24th July, 2008.

PHOTOGRAPHS OF INDUCTION LEVEL TRAINING PROGRAMME AT HYDERABAD

Lecture given by Faculty to trainees

Trainees at Drilling Site

Field visit of Trainees

Pump test training at Drilling Site

22.0 SPECIAL STUDIES

22.1 UR, DEHRADUN

Special Studies were taken up in an area of 600 km^2 in parts of **Udham Singh Nagar district**. Udham Singh Nagar District is the 'food bowl' of Uttarakhand State. Prior to its formation, it was part of District Nainital. It was separated out on the basis of physiographical conditions i.e. Tarai and Bhabar. It is also well known for the industries, as the geographical location is conducive. District is famous for its agriculture and irrigation on synchronized patterns from the past as garner of popularity for its productivity in paddy crops in the whole Uttarakhand state, and it is rightly called "Chawal ki Nagari".

Udham Singh Nagar district falls in the Tarai region of Kumaon Divison. The geographical area of the district is 3055 Km^2. It is located between latitude 28° 53' N and 29° 23' N and laterally extends between longitudes 78° 45' E and 80° 08' E. The district is bounded by Nainital and Champawat districts of Uttarakhand on the north, Moradabad, Rampur, Bareilly and Philibhit districts of Uttar Pradesh on the south, Bijnor district of Uttar Pradesh on west and Nepal on the east. The Sarada River forms the international boundary between India and Nepal. The study area falls in Survey of India Toposheet (Quadrangle Maps) Nos. 53K, O, P and 62D.

For the Administrative convenience, the district has been divided into 7 developmental blocks and 7 tehsils, viz. Japsur, Kashipur, Bazpur, Gadarpur, Rudrapur, Sitargunj and Khatima with the district's headquarters at Rudrapur. District Udham Singh Nagar is reported with 669 inhabited villages. Forest covers 5.0% area of the district. The total population of the district is 12,35,614 (Census: 2001), out of which male, female population is 6,49,484 and 5,86,130 respectively. It ranks third in the state in respect of the population. The population density is 404.45 person/km^2. The overall literacy rate is 64.86%.

District Udham Singh Nagar 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 unique feature of the area is debouching of major rivers into the plains from Lower Himalayas. The overall flow direction of these rivers is generally north – south trending or northeast – southwest trending and flows to south till its confluences with the Ganga River. The major rivers are perennial, whereas their tributaries originating from sub-Himalayan zone are ephemeral and remain dry during the non-monsoon seasons. The overall drainage pattern in the study area is sub dendritic to sub parallel.

Agriculture is the primary occupation of the people as it justifies the title of "Chawal ki Nagari". It is just because of the ample water facilities by artesian wells. About 64% of the total work force is engaged in farming the very fertile land. Khariff and Rabi are two major cropping seasons. The main Khariff crops are rice, soyabean, Urd, Moong and till, and the Rabi crops are wheat, barley, Gram, Masoor, Mustard, Sunflower. It is observed in the study area that the rice crop is grown twice in a year. The total reported area in district is 279455 ha, out of which 84717 ha are occupied by the forests. Net sown area in the district is 149523 ha and gross sown area is 246481 ha. Area had sown more than once in the district is 96561 ha. Area under Rabi and Khariff crops are 97973 ha and 139928 ha respectively. 8580 ha is reported under the Zaid crop. The sugarcane crop is also grown in very intensively as it is a cash crop.

The major rivers Kosi, Gola, and Sarada provide ample water to meet the irrigation demand, besides major reservoirs like Tumaria (Jaspur), Gularboj and Haripura (Gadarpur), Dron, Baghul and Nanak Sagar (Sitargunj) and Sarada Sagar (Khatima) in the study area. The prominent canals like Kosi, Gola and Sarada irrigate a large area of the Tarai belt and the other canals are Tumaria, Nathanpir. The branches of the major canals are the Gandli, Sukhi, Katna, Kailash, Kaman, Sanedi. The length of the canals in the study area is 924.3 km, which caters the needs of irrigation. Gadarpur block owns the maximum length of canals in the district, is of 205.65 km. The total irrigation potential created/utilized through minor irrigation schemes, through groundwater and surface water scheme is 144.140 and 72.851 mha, respectively. There are 24703 shallow tubewells and 400 deep tube wells tapping multiple aquifers in the study area.

Rainfall, spatially, is highly variable depending upon the altitude. The intensity of the rainfall increases from south to north and the amount of rainfall decreases in generally from west to east. About 90% of the rainfall received during the monsoon period, and the remaining 10% of the rainfall in non-monsoon period. The average annual rainfall in the district is 1296.85 mm (Year, 2004).

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) The piedmont fan deposits known as Bhabar

(B) The Tarai Alluvium

Piedmont alluvial deposits represent the geology of the study area. Broadly, it can be divided into two formations viz. Bhabar and Tarai. These are characterized by distinct lithology, grain size distribution, variation of degree of sorting etc.

Bhabar formation is essentially constituted of alluvial deposits lying on the sloping plains in the Himalayan foothills. It is primarily consists of unconsolidated sediments like sand, gravel, boulder and clays. It is observed at northern parts of the Bazpur, Siatargunj and Khatima blocks. The exact trend and disposition of Bhabar formation depends largely upon the disposition of the Siwaliks. 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 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. The groundwater body appears to be sustained and recharged by (1) direct infiltration from precipitation on the land surface, and (2) infiltration from turbulent streams flowing across the belt. 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. The pre monsoon and post monsoon depth to water level ranges from 2.01(Barhini) to 5.58 (Chakarpur) m bgl, and 1.73 (Barhini) to 5.20 (Chakarpur) m bgl, respectively. Seasonal fluctuation varies from 0.28 to 0.38 m.

Tarai formation is exposed immediately south of the Bhabar formation, and the name itself being derived from marshy conditions. Tarai formation consists of clays, sandy clays, fine to medium sand and occasional gravels. The boundary between the Bhabar and the Tarai is defined by a spring line, which is characterized by auto-flow (free-flowing) conditions. There are plenty of moist and waterlogged areas around the spring line particularly during monsoon season. The sand and gravel associated with the finer fractions are the major aquifers in this zone.

Groundwater in shallow aquifer is tapped through dug-wells; the groundwater occurs under unconfined/phreatic conditions. The groundwater in deep aquifers is, under confined and artesian conditions. The deeper aquifers (>50 m) being generally confined conditions with higher artesian heads, and the tightly cased tube wells constructed in them result in flowing wells. The unconfined shallow groundwater of the Tarai may be recharged by (1) the direct infiltration from rainfall on the land surface, (2) the infiltration from the streams when flooded, (3) return seepage from irrigation (4) lateral percolation from adjacent Bhabar zone. On the contrary, the confined groundwater is probable recharged by downward percolation and lateral flow from Bhabar belt. Bhabar is, therefore, the intake area for Tarai as well.

The groundwater in Tarai zone occurs both in unconfined and confined conditions. In the unconfined aquifer, the depth to water level in pre monsoon and post monsoon varies from 2.09 to 7.08 m bgl and from 1.99 to 6.89 m bgl, respectively. The seasonal fluctuation varies from 0.09 to 3.56 m. The tube wells tapping deeper confined aquifers with auto-flow conditions yield 25.0 to 55.0 lps of freshwater for a draw down of 2.0 to 8.0 m. In case of tube wells tapping confined aquifers with non flowing conditions the yield varies between 10 and 40 lps for a draw down of 4.0 to 9.0 m. The exploratory wells of CGWB tapping confined aquifer, drilled depth ranges from 74.98 to 433.0 m, yield ranges from 2683 to 3100 lpm, transmissivity values range from 1180 to 2500 m^2/day, and the hydraulic conductivity ranges from 25 to 243 m/day. The hydraulic gradient ranges between 1.35 to 4.0 m/km. The coefficient of permeability ranges between 17 and 108 m/day.

Groundwater conditions in Artesian wells: Artesian conditions are restricted to the Tarai zone. In a well, penetrating through an aquifer, the water level will rise above the bottom of the confining bed. If the water level rises above the top of the upper confining layer, above the ground surface, free flowing /auto flow conditions result. In this zone confining conditions result due to intercalation of permeable materials like sand and gravel with impervious clay horizons. The difference in elevation of Bhabar and Tarai, together with the regional slope of the strata, appears to build the artesian head in the aquifers. Permeability of the Tarai aquifers is less than that of Bhabar, thereby playing a vital role in developing the pressure, as it impedes ground water flow. The discharge of the tube wells is dependent of aquifer properties, and local ground conditions. There are more than 2000 artesian wells existing in Kashipur, Bazpur, Gadarpur, Rudrapur, Sitargunj and partly in Khatima blocks. Central Ground

Water Board has constructed artesian wells at Basai, Kashipur, Bazpur, Nagla and Rudrapur. The drilled depth ranging from 84.4 to 433.0 m bgl, with free flowing head up to 8.69 m above ground level. The yield of these wells is up to 3400 lpm, with the drawdown varying from 5.39 to 10.69 m. The Transmissivity values range from 825 to 12274 m^2/day, and the hydraulic conductivity ranges from 16.17 to 106.6 m/day.

Based on the inventoried data, in the Tarai zone auto-flowing conditions, due to confinement of aquifer, are abundant.

- The past extent of the autoflow zones i.e up to 1995 have been established that in the west boundary was marked by he Dhela River, in the east the boundary was marked by the Nanak Sagar and Deoha River, in the south it extended up to 800 m south of Kichha, and in the north it was limited by the spring line.
- In Khatima block, the piezometric head during pre monsoon and post monsoon ranges from 0.20 to 0.30 m agl and from 1.20 to 1.50 m agl, and discharge ranges from 15 to 24 lpm and from 33 to 48 lpm, respectively.
- In the Sitargunj block, the piezometric head during pre monsoon and post monsoon ranges from 0.10 to 5.0 m agl and from 2.40 to 7.0 m agl, and discharge ranges from 23 to 360 lpm and from 42 to 840 lpm, respectively. The artesian granular aquifers are 10.0 and 36.0 m bgl, 46.0 and 58.0 m bgl and 70.0 to 100.0 m bgl.
- In the Rudrapur block, the piezometric head during pre monsoon and post monsoon ranges from 0.16 to 6.0 m agl and from 0.50 to 8.0 m agl, and discharge ranges from 12 to 1575 lpm and from 90 to 1575 lpm, respectively. The artesian granular aquifers are a) 35.0 and 50.0 m bgl, b) 70.0 and 100.0 m bgl c) 205.0 to 258.0 m bgl and d) 280.0 to 317.0 m bgl.
- In the Gadarpur block, the piezometric head during pre monsoon and post monsoon ranges from 3.0 to 8.0 m agl and from 5.0 to 8.0 m agl, and discharge ranges from 89 to 1665 lpm and from 765 to 1665 lpm, respectively. The artesian granular aquifers are a) 62.0 and 72.0 m bgl, b) 82.0 and 92.0 m bgl.
- In the Bazpur block, the piezometric head during pre monsoon and post monsoon ranges from 1.75 to 5.3 m agl and from 2.50 to 6.50 m agl, and discharge ranges from 600 to 3000 lpm and from 765 to 1665 lpm, respectively. The potential artesian granular aquifers are a) 76.0 and 85.0 m bgl, b) 199.0 and 214.0 m bgl.
- In the Kashipur block, the piezometric head during pre monsoon and post monsoon ranges from 3.0 to 6.0 m agl and from 6.0 to 8.0 m agl, and discharge ranges from 1575 to 2729 lpm and from 2729 to 2900 lpm, respectively. The artesian granular aquifers are a) 49.0 and 63.0 m bgl, b) 70.0 and 107.0 m bgl and c) 172.0 and 222.0 m bgl.

The artesian head appears to have no relationship with depth as well as discharge in the Tarai zone.

Present studies: during the current AAP 2008 – 09, an area of 600 km^2 was demarcated to identify and study the characteristics of artesian wells in Udham Singh Nagar district. During the course of investigation, 129 artesian wells were monitored/observed, out of which 59 representative samples were collected for complete chemical analysis to know the quality of deeper aquifers. Pre and post monsoon studies were carried out. The overall pressure head in the district ranges from 0.08 to 2.30 m agl, the discharge of the wells ranging in pre and post monsoon from 30 to 1920 lpm and 40 to 2200 lpm, respectively. Based on the present pre and post monsoon studies the tentative artesian area has been demarcated.

Objective: 1. Demarcation and assessment of the artesian area, 2. To study the change in behavior of piezometric head and discharges of artesian wells in the district and 3. To assess the groundwater quality of the area.

Procurement of Data: The Irrigation departments, Tube well departments of Uttarakhand were requested to provide the data of the artesian wells along with the strata charts. Aquifer geometry (Fence diagrams) can be prepared based on the lithological information.

Observations: It is observed that the pressure head of the artesian wells drastically reduced over the two decades and some of the shallower depth wells lost its artesian conditions. If the same conditions prevail, some of the wells may loose artesian nature forever. The potential artesian area exists in Kashipur, Bazpur, Gadarpur and Rudrapur blocks.

Discharge Reduction Causes: based on the field observation during the present studies, it is observed that the discharge of the wells reduced along with the artesian pressure heads. The causes of reduction in discharge of artesian aquifer and its head probably;

i. Exploitation of more groundwater (industries) in the Bhabar zone as there is no measure
ii. Reduction in recharge area of confined aquifer
iii. Over exploitation of confined aquifer
iv. Interlinking of confined and unconfined aquifers

v. Choking of wells
vi. Continuous free flow of artesian water as there is no device to arrest the flow
vii. Massive deforestation in the Tarai zone as 20 to 30 years back the area was covered by dense forest, which has caused more run off resulting declining recharge.
viii. Tremendous increase in the population, resulting more consumption of groundwater
ix. Increase in agricultural land consequent upon deforestation where intensive agricultural practices are vigorous.
x. More developmental activities in the Bhabar areas, which is the recharge area

Recommendations: based on the present and past studies certain recommendations are made to augment the artesian wells for further future needs and development.

1. Artesian wells should be provided a mechanism to control and regulate the flow so that the unnecessary wastage can be controlled/avoided, thus pressure heads can be preserved for more sometime.
2. Faulty construction and design of the shallow private tube wells be avoided ranging in depth 50.0 to 100.0 m bgl, is almost got exhausted during the pre monsoon period.
3. Artificial recharge structures are implemented in Bhabar areas by adopting suitable structures according to the feasibility.
4. Deforestation is avoided in Bhabar as well as in Tarai areas, which has greater impact on climatological order.
5. Change of cropping pattern also to be adopted, which helps to augment the groundwater.
6. Battery of tube wells can be constructed at the flood plains of the river, instead of drilling cluster of tube wells in the different areas.

22.2 KR, TRIVENDRUM

- Sea water ingress studies along the coastal tract Trivandrum district-500 sq.km.
- Hydrogeological studies in urban area, Trivandrum district- 200 sq.km.

22.3 MER, PATNA

22.3.1 Mining hydrogeology (Parts of Ramgarh district 250 Sq Km)

During AAP 08-09 detailed study was conducted under mining hydrogeology in parts of Ramgarh district. A number of open cast coal mines are located in the area.During pre-monsoon 16 wells were monitored. Water level was found varying from 6,69 to 14.21 m bgl. During post- monsoon period considerable rise in water level were observed and depth to water level was found varying from 3.27 to 11.70 m bgl. Eighteen water samples were collected for complete chemical analysis.

22.3.2 Demarcation of Younger Alluvium (Vulnerable to arsenic contamination) along River Ganga

Detailed investigations by CGWB & GSI have indicated arsenic ground water contamination is confined in the newer (Younger) alluvial deposits of Holocene age along along the Ganga River. The Older Alluvial deposits of Pleistocene age, forming the upper terrace of the Flood Plain The objective of the study was to demarcate the newer alluvial belt along the River Ganga for the entire length of the state extending from Buxar in the west to Bhagalpur in the east. To execute the work a Joint study is being undertaken with BIT Mesra, Digital data of LISS III, Band 2, 3 and 4 are being interpreted for different seasons. High arsenic wells are being plotted. Quarternary geomorphic features are being studied.

22.4 NR, LUCKNOW

22.4.1 Special Study of Organic Pollution in Ground Water in parts of Faizabad District , particularly in Masodha block, U.P.

Contamination of ground water due to extensive agriculture practices has increased many folds. Agriculture in water supply areas poses considerable threat to vulnerable shallow aquifers. Majority of population is dependent on agriculture which in turn depends upon water availability and use of fertilizers and pesticides. The use of pesticides have posed a question mark on resultant quality of ground water. As the chemical, pesticides percolate through the soil zones and reaches the ground water body, the degradation of ground water quality starts and some times attains to such a level which is considerable to be objectionable with regards to drinking water standards. The extensive use of pesticides in the agriculture fields due to ever increasing demand for food production, and the high leaching potential of many of them, is among the most prominent sources of ground water contamination. In India organochlorine pesticides (OCPs) are extensively used due to their low cost and broad-spectrum toxicity. As the OCPs are lipid soluble in nature, cumulative bioaccumulation of low concentrations of these in the body fat of mammals might pose potential hazards in the long run. The organochlorine pesticides like dichlorodipheny ltrichloroethane (DDT) and

hexachlorocyclohexane (HCH) are well known for their persistence in the environment.

22.4.2 The special study entitled," Organic Pollution in Ground Water in parts of Faizabad District , particularly in Masodha block, U.P."

The samples were analysed for pesticides residues in the Chemical Laboratory of C.G.W.B. at N.R., Lucknow on Gas chromatograph (SHIMADZU GC –17A) using Electron Capture Detector (ECD) and Flame Thermoionic Detector (FTD) observing manufacturer guidelines and following methodology laid down in APHA (19th edition, 1996). The pesticide residues from water samples was separated by using organic solvents. Identification and quantification were accomplished using a known amount of external standards.

For evaluating the water quality for domestic or municipal uses, the limits laid down by Prevention of Food Adulteration Act (25th edition 2004) and EEC (1988) are taken into account. These agencies permit the individual pesticide residue to be not more than 0.1 µg/l and Total pesticide residue as 0.5 µg/l in drinking water.

The study reveals that in parts of Faizabad district the Hexachlorocyclohexane (HCH) isomers (α, β, γ and δ) are localized with the highest value of Total HCH is 0.00014µg/l in Kurawa II. The only DDT metabolite i.e. 4,4'-DDT is also localized with the highest value being 0.0003µg/l in Madhavpur. Aldrin could be detected in 24% samples with the highest value being 0.0001µg/l in Manshi Wala. The other pesticide residue Chlorpyriphos is also present in few samples with the highest value being 0.00008µg/l in Pamparpur whereas Under this programme 100 no. of water samples of Faizabad district particularly Masodha block were collected & extracted. Atrazine, Aldicarb and Carbofuran could not get their way.. The report is under process.

22.4.3 Special Study of Arsenic in Phreatic aquifer System in parts of Balrampur District.

Arsenic in the natural environment occurs in soils at an average concentration of about 5 to 6mg/kg. The high concentration of arsenic in rocks results from the case with which arsenic substitutes for Si, Al or Fe in crystal lattices of silicate minerals Sedimentary rocks contain higher concentrations of arsenic compared to igneous or metamorphic rocks. The special study entitled "Occurrence And Distribution Of Arsenic In Aquifer System in Parts of Balrampur District, Uttar Pradesh" under the special studies item for AAP 2008-2009 is based on the chemical analysis of 154 nos.of water sample collected from dug well, IM II, private hand pump within Balrampur district. These samples were analyzed in the CGWB, Northern Region, Chemical Laboratory, Lucknow on Atomic Absorption Spectrophotometer (SHIMADZU – AA 6701 F) using HVG attachment and following the methodology given in Standard methods for the examination of water and waste water (APHA 19th edition) & Arsenic Field Test Kit [Merck].

22.5 SWR, BANGALORE

22.5.1 Water Mangement Practices Adopted By Urban Municipal Bodies in Karnataka State:

There are 7 municipal corporations, 43 city municipal councils, 79 town municipal councils and 93 town panchayats located in Karnataka state. Even though they cover about 2.3% (4404 sq.kms) of the total area of the state about 32% of the state population living in these urban pockets. The demand of drinking, domestic and industrial requirement of water in these areas is around 3864 MLD. This brings a very heavy load not only on water supply for these municipal areas but also on wastewater disposal from these areas, which is also of the same magnitude. So, proper water management practices are very much essential to tackle both water supply and waste water disposal problems.

Almost all municipal areas in the state have surface water source as the main source of water supply and this is supplemented by ground water source. The public water supplies in these municipal areas vary from once during every alternate day to once in a week. Per capita public water supply in these urban areas varies from 0.74 litres per day (Kolar) to 147 litres perday (BBMP area).

For the cities Belgaum, Gulbarga, Hubli-Dharwad, a Momorandum of Understanding (MOU) has been signed to implement 235 crores World Bank Project to supply 24/7 days (during all 24 hours during all 7 days of the week) by plugging all the leakages during distribution.

In Greater Bangalore Municipal Corporation areas in addition to making rainwater-harvesting schemes as mandatory, water recycling practices are under consideration to enhance the quantum of water supply to 2335 MLD by the year 2015.

In Mysore Municipal Corporation, for better handling of the City water supply it has been handed over to a private

company M/S Jamshedpur Utilities and Supply Company Limited.

So, plugging all the leakages during water distribution, water recycling, allowing private company participation, creating awareness among public about water conservation and rooftop rainwater harvesting are the part of future strategies in water management field in the municipal areas of Karnataka.

22.6 WR, JAIPUR

22.6.3 Impact of marble slurry on ground water at udaipur city industrial area, udaipur district, Rajasthan

Marble industry is located at Sukher industrial area at Udaipur city and is one among the important marble industries in the State where processing and trading of marble as building stone takes place. The major works which are carried out in the Sukher industrial area are Processing, Art and craft, Trading, Tranportation and disposal of slurry of marble and these are the major activities by which there is a threat to ground water and environment in the area.

Mount of marble slurry along the road

Marble slurry is produced as a by product during cutting and polishing of marble at the marble industries units. The waste material is generally in the range of 20% of the total marble handled. The marble cutting units are dumping the marble slurry in open land near their units in much unplanned way, although notified areas have been marked for dumping. This may lead to contamination of ground water resources. During summer season, the dust generated during marble cutting and polishing gets dried up and poses serious environmental hazards/pollution. It is also the source of occupational disease like silicosis among the workers deployed in this industry and to habitants in the close vicinity.

Visible impacts of marble slurry on the vegetation and crops

The principal water bearing formation in the area is Phyllite and Schist which covers the major part of the area and is fairly hard and compact. Therefore the ground water development in Phyllite and Schist is very limited. Ground water occurs in hard rocks i.e. in the zones of weakness such as joints, shear foliation planes, fractures and weathered mantle. Ground water generally occurs under water table condition; however it may occur under semi-confined condition in deep seated fractures. Depth to water and yield of wells is generally controlled by physiographic location of wells and intensity of secondary openings encountered in well sections. The depth to water level in the study area varies from 5.78 to 26.68 mbgl (Pre-monsoon, 2008). The ground water table in the area slopes with local undulations and generally conforms to the configuration to topography. The ground water flow has a dominant south easterly movement and to some extent it is in south direction. The yield of wells fitted with pump sets ranges from 30,000 to 65,000 litres per day. In general the quality of ground water is suitable for irrigation and drinking purpose except in few localized patches of limited extent. The water samples were subjected to complete chemical analysis and heavy metals analysis to reveal the presence of ground water pollution if any in the area under study.

Marble cutting units at present in the area is generating marble slurry, which is being dumped at dumping yard constructed near sports complex locted north of Udaipur city and it is also being dumped in nearby nallah/ streamlet originating from hills. There are mainly two ill effects noticed, which may cause water and air pollution in the area under study.

Environmental hazard due to marble slurry

The marble slurry poses serious threat to ecosystem including physical, chemical and biological component of environment. The slurry produced from the marble industry is spread over the land surface and it tends to

decrease the porosity and permeability of the soil and in turn prevents water absorption and percolation thereby eventually reducing the recharge to group water body. Areas where, slurry is being dumped can not support any vegetation and leads to degradation. When slurry gets dried up, the fine particles become air borne and cause severe air pollution. It may lead to the occupational hazard and silicosis disease to the inhabitants of the area. Long term deposition of marble slurry on land surface will reduce the surface storage and ultimately affecting the ground water availability in the area. The heaps of slurry which are dumped all around the area spoil the aesthetic value of the entire region subsequently adversely affecting the industrial and tourism potentiality of the town.

Based on the above discussion and results of chemical analysis of ground water samples collected during the field investigation from the upstream and downstream of dumping yard and along Ahar River, it has been observed that as such no major contamination has been found in ground water. However, it may contribute to ground water hard to very hard and may cause salinity hazard.

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 2008-2009, Bihar, Kerala state reports completed where as Gujarat, Nagaland, and Delhi state reports were under preparation.

23.1.2 District Reports

The Central Ground Water Board is compiling and issuing district reports of each district from time to time containing all the results of ground water surveys, exploration and other related studies.

Further, groundwater development perspectives are also worked out for the benefit of State and other users agencies. The reports have been found very useful for their strategies for future. During 2008-09, 18 district reports were prepared and submitted. Region wise status of preparation of District Reports are presented in Table 23.1

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 2008-09, 23 reports were prepared . Region wise status of preparation of ground water year book are presented in Table 23.2

23.3 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 2008-09 up to 31st March 2009, the Vol. No 22, 2007 issue has been finalized and under printing.

23.4 GROUND WATER EXPLORATION REPORTS

During 2008-09, 7 Ground Water Exploration Reports have been completed / submitted in the states of Chhattisgarh, Karnataka, Maharashtra & UT of Dadra & Nagar Haveli, Meghalaya, Uttar Pradesh, UT of A&N Islands and West Bengal. The details are given in Table 23.4.

23.5 GROUND WATER INFORMATION BOOKLETS

During 2008-09, 213 Ground Water information Booklets have been completed/released in the states of Andhra Pradesh, North Eastern States, Chhattisgarh, Goa, Himachal Pradesh,Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajsthan, Sikkim, Uttarakhand, Uttar Pradesh, Tamil Nadu and West Bengal. The details are given in Table 23.5.

Table 23.1: STATUS OF DISTRICT REPORTS COMPLETED DURING 2008-2009

Regions	Nos.	Name of District Report
North Western Himalayan Region	1	Srinagar District
North Western region	1	Mewat
West Central Region	1	Porbandar
North Central Chhatisgarh Region	1	Sarguja
Central Region	1	Raigad
Northern Region	1	Kannuaj
Mid Eastern Region	3	Katihar, East Champaran, Khunti
Eastern Region	1	South 24 Parganas

Regions	Nos.	Name of District Report
North Eastern Region	2	Karimganj & Hailakandi
South Eastern Region	1	Keonjhar
Southern Region	2	Medak, Krishna
South Western Region	1	Gulbarga
Kerala Region	1	Alappuzha
North Himalayan Region	1	Shimla
Total	**18**	

Table 23.2: STATUS OF GROUND WATER YEAR BOOKS COMPLETED DURING 2008-09

Region	Ground Water Year book prepared	
	Nos.	State
North West Himalayan Region	1	Jammu & Kashmir
North Himalayan Region	1	Himachal Pradesh
North Western region	3	Punjab, Haryana & Chandigarh
Western Region	1	Rajasthan
West Central Region	1	Gujarat
North Central region	1	Madhya Pradesh
North Central Chhatisgarh Region	1	Chhattisgarh
Central Region	1	Maharashtra
Northern Region	1	Uttar Pradesh
Mid Eastern Region	2	Bihar, Jharkhand
Eastern Region	1	West Bengal
North Eastern region	1	North Eastern States
South Eastern region	1	Orissa
Southern Region	1	Andhra Pradesh
South Western Region	2	Karnataka, Goa
South Eastern Coastal Region	1	Tamilnadu
Kerala Region	1	Kerala
Uttaranchal Region	1	Uttarakhand
SUO, Delhi	1	Delhi
Total	23	

Table 23.4 :GROUND WATER EXPLORATION REPORT DURING 2008-09

Name of States	Nos.	Name of Districts
Chhattisgarh	1	Submitted
Karnataka	1	Submitted
Maharashtra & UT of Dadra & Nagar Haveli	1	Submitted
Meghalaya	1	Submitted
Uttar Pradesh	1	Completed
West Bengal	1	Submitted
UT of A & N Islands	1	Submitted
Total	**7**	

Table 23.5 :GROUND WATER INFORMATION BOOKLETS COMPLETED DURING 2008-09

Name of States	Nos.	Name of Districts
Andhra Pradesh	7	Anantapur, Prakasam, Mahabubnagar, Medak, Guntur, Krishna, Nellore
North Eastern States	20	Submitted
Chhattisgarh	12	Jashpur, Kawardha, Bilaspur, Korba, Koriya, Rajnandgaon, Dhamtari, Raipur, Durg, Mahasmund, Dantewada, Sarguja
Goa	2	Submitted
Himachal Pradesh	4	Bilaspur , Hamirpur , Kulu, Lahul and Spiti
Jammu & Kashmir	14	Srinagar, Jammu, Punch, Kupwara, Badgam, Baramula, Pulwama, Anantnag, Kathua, Udhampur, Doda, Rajauri, Leh, Kargil
Karnataka	8	Submitted
Kerala	11	Kannur, Kozhikode, Thrissur, Earnakulam, Idukki, Alapuzha, Kottayam, Pathanamthitta, Kollam, Thiruvananthapuram, Malappuram
Madhya Pradesh	15	Guna, Rajgarh, Jhabua, Panna, Burhanpur, Dhar, Ratlam, Ujjain, Satna, Raisen, Neemuch, Indore, Sidhi,Barwani, Sehore.
Maharashtra	29	Pune, Satara , Mumbai City, Mumbai Suburban, Raigad, Jalgaon, Osmanabad, Nagpur, Ratnagiri, Ahmadnagar, Sangli, Hingoli, Parbhani, Nanded, Thane, Bhandara, Gondia, Gadchiroli, Latur, Chandrapur, Solapur, Aurangabad, Jalna, Kolhapur, Sindhudurg, Beed, Nashik, Dhule, Nandurbar
Rajasthan	19	Completed
Tamil Nadu	23	
Uttar Pradesh	37	Under Preparation
Uttarakhand	8	Submitted
West Bengal	3	Birbhum, Murshidabad, Darjeeling,
Sikkim	1	West Sikkim
Total	**213**	

24. VISITS BY MINISTERS, SECRETARY AND INTERNATIONAL DELEGATIONS

- The Secretary, Ministry of Water Resources, Govt. of India visited Bangalore on 2.05.2008 and attended meeting with Chief Secretary, Govt. of Karnataka, Bangalore to discuss the modalities of the Dugwell Recharge Scheme. The Meeting was also attended by Regional Director, South Western Region, Bangalore. It was decided that Kannada version of the brochure will be made available in a week's time. District specific designs will be made available in a week's time. District specific designs will be provided. NABARD will organize another State Level Seminar and Central Ground Water Board will give the salient points of the scheme.

- Hon'ble Minister of Water Resources, Govt. of India visited at Dinhara, Jamui disttrict, Bihar on 13th May, 2008 and meeting attended by Dr. K.K. Singh, Scientist from Central Ground Water Board, Mid Eastern Region, Patna regarding problems related to ground water in Jamui district.

- The Secretary, Ministry of Water Resources, Govt. of India along with Senior officers of the Ministry visited Central Ground Water Board, CHQ, Faridabad on 14.05.2008 to review the functioning of CGWB. The meeting was attended by Chairman, Member (SML), Regional Director (HP), Director (Admn.) and other Senior officers of the Board.

- The Hon'ble Minister for State, Ministry of Water Resources Shri Jai Prakash Narayan Yadav visited Nainital during 16th and 17th May, 2008. The technical materials of Uttarakhand State and Nainital District were given to the Hon'ble Minister both in Hindi and in English. A Press Conference was called by the Hon'ble Minister for which the relevant material was prepared in Hindi by the officers of CGWB, Uttaranchal Region, Dehradun.

- Scientists of CGWB, Southern Region, Hyderabad visited M/s. Singareni Collieries Company Ltd. Kothagudem on 16th and 17th May, 2008 to discuss regarding the selection to study the impact of coal mining in Khammam district under Ground Water Management Studies during the current Annual Action Plan.

- Scientists of CGWB, North Western Himalayan Region, Jammu accompanied the Hon'ble Minister of Water Resources to exploratory sites in Kashmir Valley. It has been decided to take up an exploratory site near Ankula village in Baramulla district. Accordingly, a site at Sunburn village, district Baramulla was selected.

- Prof. Saifuddin Soz, Hon'ble Union Minister of Water Resources, Government of India and Shri Umesh Chandra Panjiar, Secretary, Ministry of Water Resources visited Pune on 9th and 10th June 2008. Regional Director, Central Ground Water Board, Central Region, Nagpur along with Scientists from the Region and SUO, Pune also called on them. The Hon'ble Minister and Secretary visited NWA and CWPRS on 9th June 2008 and also held brief discussions with CGWB officers. The Hon'ble Minister and Secretary visited the sites developed under the mini-watershed development at Hiware Bazar on 10th June 2008.

- Prof. Saifuddin Soz, Hon'ble Union Minister of Water Resources, Government of India and inaugurated newly built office building of CGWB, SWR, "Bhujal Bhawan" at HSR Lay out Bangalore on 11.06.2008. He was the Chief Guest and addressed the gathering. Shri B.M. Jha, Chairman, CGWB gave the welcome address. Other dignitaries who addressed the gathering were Shri Satish Reddy, MLA and Addl. Secretary Shri S. Manoharam, MoWR, Govt. of India. Regional Director, Southern Region gave the vote of thanks. Minister visited the different sections of the office and appreciated the Rainwater Harvesting structure installed in the office building. Scientists and technical experts from State Departments also attended the function.

- The Hon'ble Minister visited Hardwar, Rishikesh and Rudraprayag on 30th and 31st May 2008. The Hon'ble Minister held meeting with CGWB officers at Hardwar (30.05.2008) and Rishikesh (31.05.2008). He discussed the work done by Central Ground Water Board in these areas and the hydrogeological conditions of district Hardwar, Dehradun and Rudraprayag. Brochures of the respective areas were given to the Hon'ble Minister.

- Shri U.N. Panijiar, IAS, Secretary, Ministry of Water Resources, Govt. of India visited Hyderabad and reviewed the activities along with Chief Secretary, Govt. of Andhra Pradesh pertaining to Artificial Recharge through Dug Wells on 9.06.2008. Regional Direcor, SR, Hyderabad accompanied the Secretary during the tour programme. He inaugurated the "National Colloquium on Water Land Management

Institutes (WALMIs) at NIRD, Hyderabad on 23rd June 2008.

- Hon'ble Minister of Water Resources, Govt. of India visited at South Western Region, Bangalore. Hon'ble Minister of Water Resources inaugurated the Office Building of Central Ground Water Board on 11th June 2008 at Bangalore. The function was attended by the AS(WR), Chairman, CGWB, Director (Admn.) and OIC, SUO, New Delhi besides Regional Director and officers of South Western Region, Bangalore.

- Hon'ble Minister of State , Ministry of Water Resources, Govt. of India visited at Mid Eastern Region, Patna and meeting were held with senior Scientific officers of Central Ground Water Board called by him and apprised the Hon'ble Minister of the works being carried out by CGWB in the State of Jharkhand.

- Hon'ble Minister of State , Ministry of Water Resources, Govt. of India visited at Western Region, Jaipur and Ajmer from 25.06.2008 to 26.06.2008. Hon'ble Minister of State discussed with senior Scientific officers of Central Ground Water Board on various technical activities of the Region.

- Regional Director, Central Ground Water Board, NER, Guwahati accompanied Shri M.L.Goyal, Consultant, Ministry of Water Resources for inspecting 8 demonstration sites of Golaghat and Barpeta districts of Assam from 18th to 21st June, 2008 under Farmers Participatory Action Research Programme (FPARP) along with the Scientist of the implementing agency AIRCP (Water Management), Assam Agriculture University, Jorhat, Assam. In addition to field visit different Krishi Vigyan Kendras of Assam Agriculture University, Jorhat, Assam made Power point Presentation regarding the physical and financial progress of Farmers Participatory Action Research Programme at Jorhat in presence of the Regional Director, Central Ground Water Board, NER, Guwahati, Consultant, Ministry of Water Resources , Director (Research) , Dean and other Agricultural Scientists of Assam Agriculture University, Jorhat, Assam.

- Scientists from Central Ground Water Board, West Central Region, Ahmedabad visited districts of Amreli, Bhawnagar, Jamnagar, Junagadh, Porbandar, Rajkot and Surendernagar and contacted District Collectors regarding the District wise Ground Water Details in connection with "Review Activities of CGWB by Ministry of Water Resources".

- Chief of Staff (HQWC), General Amar Aul accompanied by Major General Anil Manan, Chief Engineer (HQWC) and Col. Rehsi (AF), Chandigarh Zone visited Nortth Western Region, Central Ground Water Board office on 4th June 2008 for discussing the rainwater harvesting measures which can be adopted in the States of Punjab, Haryana and Himachal Pradesh. General Amar Aul was briefed by Scientists regarding various techniques of rainwater harvesting and artificial recharge. The guest was presented a set of publications on Rainwater Harvesting published by Central Ground Water Board. Concept of rainwater harvesting was explained to General Amar Aul with the help of model project implemented at Bhujal Bhawan. He showed keen interest in the project and expressed happiness over the lead taken by Central Ground Water Board in this regard.

- The Chairman, CGWB visited the SUO, Srinagar. Regional Director & OIC, SUO, Srinagar were accompanied along with Chairman during his visit to exploratory well sites.

- The Joint Secretary (Admn.), Ministry of Water Resources, Govt. of India visited the field at Wardha district along with Chairman CGWB, Regional Director, Central Region, Nagpur and other Senior officers of the Region to have interaction with the farmers about the problems related to ground water availability, utilization and management.

- The Joint Secretary (Admn.), Ministry of Water Resources, Govt. of India visited Guwahati and meeting on "Water Quality Issues in North East States" on 29th August 2008 with the State Departments dealing with Ground Water problems.

- Chairman, CGWB visited Bhopal on 8.09.2008 for inaugurating the Training Course on "Material Management" organised by Central Ground Water Board, Division XII, Bhopal. During his visit, the Chairman took meeting regarding Dug Well Recharge and Replication of Hiware Bazar Experience in Bundelkhand Region of Madhya Pradesh.

- Vice Chancellor of MGR University, Chennai has visited this office and interacted with the Senior officers for taking up the rain water harvesting and associated groundwater related subject as academic courses. This is in response to the letters written by Chairman, CGWB to UGC Chairman and directives from UGC to all Universities in the country. Similar enquiries have also been received over phone from other Universities in Tamil Nadu and needful technical support has been assured.

- Additional Secretary , Ministry of Water Resources, Govt. of India visited Chennai to review the progress in the Implementation of Dug Well Recharge in the State of Tamilnadu. The meeting was convened at PWD Secretariat on 26.09.2008 and Regional Director and other Senior officers attended the meeting. In addition, Additional Secretary, Ministry of Water Resources and Regional Director attended the meeting with Chief Secretary to Govt. of Tamilnadu to review the progress in the implementation of Dug Well Recharge in the State of Tamilnadu. Additional Secretary also made inspection of workshop of Division IV, CGWB.

- Shri Vikas Kharge, IAS and Director, GSDA, Govt. of Maharashtra visited Central Ground Water Board, Central Region, Nagpur on 22.12.2008 and had a meeting with the Regional Director, CGWB, Central Regiion. The issues related Dugwell Recharge, Ground Water Resource Estimation for the base year 2007, Model Bill, Data Exchange, Artificial Recharge Project etc. were discussed in length.

- Smt Ananya Roy, JS (Finance), Ministry of Water Resources, Govt. of India visited Central Ground Water Board, South Eastern Region, Bhubaneswar on 2nd January 2009 for inspection of land acquired for the staff quarter at Dumduma, Bhubaneswar and had a meeting with the Regional Director, CGWB.

- Shri Rajan Nair, Chairman, Brahmaputra Board inspected North Eastern Region at Guwahati on 20.03.2009 and discussed about the activities of Central Ground Water Board. He was given the latest reports of NER, CGWB. He desired to work with CGWB specially in Chemical quality determination aspects.

- Shri K.C. Wankhede, Dy. Director, GSDA, Amravati Division visited Central Region, Nagpur on 9th January 2009 and had a meeting with the Regional Director, CGWB, Central Region. The issue regarding formation of a common team for taking up studies for estimating rainfall recharge factor under different hydrogeological and crop conditions and also about the organizing Mass Awareness Programme in their jurisdiction of Amravati Division was discussed. The issue regarding taking up Hydrogeological and Geophysical surveys in the field lands of farmers who are under distress at 50 sites which have identified by the District Administration was discussed.

25. CONSTRUCTION / ACQUISITION OF OFFICE BUILDINGS

The details of following construction work for own office building of Central Ground Water Board have been carried out during 2008 – 09 up to 31st March 2009 is given in table 25,

Table 25:CONSTRUCTION WORK FOR OWN OFFICE BUILDING DURING 2008-09

Region	Status
Hyderabad	The construction work of office building at Hyderabad has been completed. The Regional & Divisional Offices are functioning in our own building.
Guwahati	The construction work for 2 RCC Culverts and Store building has been started . Construction for Regional and Divisional office, the estimated submitted by CPWD is on very higher side. However, for the comparability, the estimate from NPCC has also been called for. Further course of action shall be taken after receipt of P.E. from NPCC.
Bhubaneswar	The construction work of boundary wall likely to be completed by the end of March, 2009. Funds for an amount of Rs.27.29 Lac have been released by the Ministry on 30.12.08. The work is under progress and likely to be completed by the end of March,2009.
Bangalore	Boundary wall has already been constructed and Divisional workshop is functioning on our own land. The construction work is likely to be started in the first quarter of 2009-10. The revised estimate for an amount ofRs.4,04,60,000/- received from CPWD Bangalore has been sent to the Ministry for AA&ES.
Ambala	The land for construction of building of CGWB, Division – II at Ambala has been purchased.
RGI Raipur	Land for construction of RGI Building at Raipur has already been acquired.
RGI at Faridabad	The building proposed to be constructed on the space available in the campus of "Bhujal Bhawan" at Faridabad. The Senior Architect CPWD prepared drawings which have been returned duly approved by the Chairman, CGWB.
Jammu	The possession process of land from JDA is at final stage.
Bhopal	The construction work of the Division building at Bhopal is likely to be started during 2009-10. The CPWD has submitted revise P.E. which has been submitted to the Ministry for AA&ES. Ministry's decision is awaited

26. DISSEMINATION AND SHARING OF TECHNICAL KNOW-HOW

26.1 Workshop on Sinking of Wells In Farmers Distress Districts of Vidarbha Region, Maharashtra

Farmers in Vidarbha region of Maharashtra are facing various problems due to irregular rainfall pattern, decline in water level in some part of Vidarbha, debt taken from various financial institutions for agricultural activity, irregular power supply etc. which causes them under distress conditions. To overcome these problems, Central Ground Water Board (CGWB), Central Region, Ministry of Water Resources, Govt. of India, Nagpur in collaboration with Groundwater Surveys and Development Agency (GSDA), Govt. of Maharashtra organised one-day "Workshop on Sinking of Wells in Farmers Distress districts of Vidarbha Region, Maharashtra" at two places as detailed below:-

1) At Bachat Bhavan, District Collectorate, Yavatmal District on 19-9-2008 with 115 participants.
2) At Hotel Central Plaza, Kedia Plots, Akola District on 21-10-2008 with 102 participants.

The participants were mainly from various State Govt. departments like Soil Conservation, Minor Irrigation, ZP, BDO's, Tahsildar, Animal Husbandry, NABARD, NGO's and Farmers attended the workshop. The workshop was aimed to provide technical guidance on various aspects of Ground Water Management with special reference to sinking of wells. The multidisciplinary faculty of CGWB and GSDA, delivered the lectures. In the end, technical discussion session was held between the faculty members and the participants where the faculty members answered on scientific aspects to all the queries raised by the various field officers/officials from the State Govt.

26.2 WATERTECH 2009 Conference held at NSE Complex, Goregaon Mumbai.

The conference was organized by Society of Chemical Industry and Chemical Foundation. The chief guest was Mr Suresh Prabhu, Hon'ble Member of Parliament. In the keynote address the chief guest Mr Suresh Prabhu, stressed on the management of water resources with emphasis on ground water management. He mentioned that the ground water quality aspect and referred to the arsenic contamination of ground water in West Bengal.

In second session of the conference the speakers made presentation on desalinization of sea water to have sustainable supply of water to the industrial need.

In the third session the recycling and reuse of water to reduce the industrial water supply from various sources. The emphasis was given to zero discharge of industrial effluents system so that the substantial demand can be reduced.

The conference was concluded with remarks that to have sustainable supply of water to the industrial effluents are recycled and reused to decrease the dependence on water supply. However in the industries located in the coastal area should resort to desalinization of sea water to meet their various needs.

26.3 Presentation of Technical Papers and Lectures

- Suptdg. Hydrogeologist, South Eastern Region, Bhubaneswar presented a paper entitled "Ground Water Resource of Orissa, a boon for agrarian & industrial development of the State" in the Workshop on Requirement of Water for Mining and Mineral based industries in Orissa organized by SGAT on 19th July, 2008 at Bhubaneshwar.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai delivered presentation on "Ground Water Scenario of Tamil Nadu" in the Expert Committee Meeting of State Planning Commission on 4.07.2008 at Chennai. Scientists from South East Coastal Region, Chennai also attended the meeting.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai delivered presentation on "Ground Water Scenario of Tamil Nadu and Implementation of various Artificial Recharge methods to Ground Water with some of the Impact assessment" in the Expert Committee Meeting of State Planning Commission on 9.07.2008 at Chennai. Scientists from South East Coastal Region, Chennai also attended the meeting.
- Scientist – B presented a technical paper entitled "Impact of Rock Excavation on Ground Water and its Assessment and Utilization in a mining complex – A case study in an "International Symposium on Rock Mechanics and Geo – Environment in Mining and Allied Industries" (RGMA-09) held during 12 – 14th February 2009 at BHU Varanasi.

- Scientist – B presented a technical paper entitled "Role of Sand Dunes in Coastal Saline Environment" in the National Seminar on Emerging Research and Development Trends in Earth System Science organized by P.G. Department of Geology, Utkal University, Bhubaneswar on 2nd February 2009.
- Regional Director, North Western Region, Chandigarh attended Chandigarh Science Congress on 26.02.2009 and presented a paper on "Arsenic Contamination in Ground Water of Balia District U.P.
- Regional Director, North Western Region, Chandigarh attended and presented a paper on "Need of the Hour- Thirsty Aquifers of Punjab through Artificial Recharge" in the seminar on Future Strategies for Conservationand Management of Natural Resources on 27th February 2009 at Mohali (Punjab).
- Regional Director, West Central Region, Ahmedabad delivered lectures on "Ground Water Potential and Development Prospect in Tribal Areas of Gujarat" at Dohad on 28.04.2008.
- Scientist – B were delivered lecture on "Hydrogeological Investigations for Recharge Site Selection" dduring Training Course on "Site Selection for Recharge Structures" held at Gandhinagar on 24.04.2008.
- Scientist – B delivered lecture on "Jal Mein Rasayan Tatvon Ka Badhta Prakop " at Awareness Programme in Betul district on 13.05.2008 (for school children) and on 14.05.2008 (for NGO's, VOs, Corporators etc.).
- Member (SML) of Central Ground Water Board delivered presentation in the National Seminar on "Land and Water Management in Cold Desert" at India Habitat Centre, Lodhi Road, New Delhi on 20th June 2008.
- Regional Director, Central Ground Water Board, West Central Region, Ahmedabad delivered lecture on "Ground Water Estimation Methods" during Training Programme organized by NIH at Junagadh Agricultural University, Junagadh on 20th June 2008.
- Scientist of Central Ground Water Board, North Western Region, Chandigarh delivered lectures on "Mapping of Groundwater" & "Water Conservation Techniques" on 25th June 2008 during DRUM Training Program at Bhakra Beas Training Centre, BBMB, Nangal Township.
- Scientists from Central Ground Water Board, North Central Region, Bhopal gave a lecture on the technical modalities of Artificial Recharge to Ground Water through Dug wells at " Training to State Level Master Trainers" at State Level Workshop organised on 14.8.2008 at WALMI, Bhopal.
- Scientist delivered a lecture on 'Bhujal Sarankashan-Aavyashakta evam taknik' on 12.8.2008. The target audience were members of NGC eco cliubs formed in schools at district level. The training programme was organized under the aegis of EPCO under the programme of 'Paryavaran Shiksha' and Eco-tourism.
- Scientist - D. from Central Ground Water Board, North Western Region, Chandigarh delivered presentation about "Proposal on Management of Decline of Ground Water Table and its impact on food production for farming of Punjab, Haryana and Western Uttar Pradesh on 19.09.2008 at the office of Secretary Ministry of Water Resources New Delhi. The presentation was chaired by the Secretary Ministry of Water Resources, Govt. of India and attended by Senior officers from the State Govt. of Punjab, Haryana and western Uttar Pradesh, Rainfed Area Authority and Ministry of Agriculture etc.
- Scientist, North Central Region, Bhopal delivered a lecture on "Computer Interpretation of Surface Resistivity Data" in training programme on "Application of Geophysical Techniques in Ground Water Exploration and Management" organized by Central Ground Water Board, Northen Region, Lucknow.
- Supdt. Hydrogeologist delivered a lectured on "Ground Water Regime Monitoring – Methods of Monitoring, Optimization, Data Retrieval, Analysis and Presentation" on 10.09.2008 at the Induction Level Training Programme on Hydrogeological Investigations, Development and Management of Ground Water Resources in Hard Rocks – Techniques, Equipment and Practices held at Central Ground Water Board, Southern Region Hyderabad during 18.09.08 to 12.09.2008.
- Scientist – D delivered a lecture on " Surface Geophysical Surveys in a Coastal Tract : Success & Failures" on 19.09.2008 at the Training Course on "Application of Geophysical Techniques for Ground Water Exploration and Management held at Central Ground Water Board, Northen Region, Lucknow during 15.09.2008 to 27.09.2008.
- Scientist – B delivered a lecture on "Interpretation of temperature – fluid conductivity, flow meter and caliper logs with case studies" on 20.09.2008 at the Training Course on "Application of Geophysical Techniques for Ground Water Exploration and Management" held at Central Ground Water Board, Northen Region, Lucknow during 15.09.2008 to 27.09.2008.
- Scientists delivered lectures on "Artificial Recharge Structures used in Rain Water Harvesting" by Institute

of Environmental Studies and Wetland Management at Institute of Co-operative Management for Agriculture and Rural Development, Kolkata during this month.

- Scientists delivered lectures on "Waste Water Management and Rain Water Harvesting" organized in the office of HQ Chief Engineer Siliguri Zone on 23.9.2008.
- Scientist – B, Central Ground Water Board, Central Region, Nagpur have delivered lecture on GEC methodology at Groundwater Surveys and Development Agency, Nagpur for the technical training under Jalswarajya Project on 24th November 2008.
- A paper entitled on "Assessment of Water Quality for Hexavalent Chromium Mining Area" by Shri Gulab Prasad Scientist – B, South Eastern Region, Bhubaneswar and others had been presented at National Seminar on Environmental Management in Mining & Allied Industries (EMMA-2008) held on 7th & 8th November 2008 at IT, BHU, Varanasi.
- Scientist C delivered a lecture on Rainwater Harvesting and Artificial Recharge to Ground Water during Awareness Programme at Dhamadka, Surat district on 18th November 2008.
- Regional Director, Central Ground Water Board, North Western Region, Chandigarh has delivered lecture on Water Conservation, Rainwater Harvesting etc. including involvement of Industries and Institution" on 16th December 2008 during DRUM Training Program at Bhakra Beas Training Centre, BBMB, Nangal Township.
- Scientist – D, North Western Region, Chandigarh have delivered lecture on "Mapping of Ground Water" and "Water Conservation Techniques" on 16th December 2008 during DRUM Training Program at Bhakra Beas Training Centre, BBMB, Nangal Township.
- Scientist – B, North Western Region, Chandigarh delivered lectures on "Artificial Recharge Techniques" and "Construction of structures for Rainwater Harvesting" on 18th December 2008 during training of Sustainable Ground Water Management organized by Haryana Irrigation Research and Management Institute (HIIRMI), Kurukshetra(Haryana).
- Regional Director along with Scientists, Central Ground Water Board, South East Coastal Region, Chennai have delivered lecture in the training programme on "Ground Water Hydrometry" under HP-II during 19.01.2009 to 23.01.2009 organized by State Ground & Surface Water Resources Data Centre, Chennai at NITTTR, Chennai.
- Asstt. Hydrogeologist delivered lecture on Artificial Recharge to Environment Society of India at Chandigarh on 17.01.2009.
- Supdtg. Hydrogeologist, South Eastern Region, Bhubaneswar presented a lecture on "Ground Water Resource in sustainable development of Orissa" in the seminar on "Sustainable Development and Management of Ground Water Resources in Orissa" organized by GWS&I, Govt. of Orissa on 18th March, 2009 at Bhubaneswar. This seminar was also attended by six officers from CGWB.
- Suptdg. Hydrogeologist presented a lecture on "Development and Management of Ground Water Resources in Orissa" in the workshop conducted by Department of Water Resources, Govt. of Orissa under the Chairmanship of Commissioner cum Secretary, Department of Water Resources, Govt. of Orissa at Rajiv Bhawan on 21st March, 2009. This seminar was also attended by two officers from CGWB.
- Scientist – D, NWR, Chandigarh delivered lecture on 19th March, 2009 on Artificial Recharge Techniques adopted by Central Ground Water at NITTTR Chandigarh for the lectures of Polytechnic College of Jalandhar.
- Regional Director, CGWB, CR, Nagpur delivered a lecture on "Concepts of Remote Sensing and its application to Ground Water" at CGWB, SR, Hyderabad in the Induction Level Training Course on Hydrogeological Investigations, Development & Management of groundwater in Hard Rock Terrain-Techniques, Equipments and Practices on 20th August 2008.
- Scientist-D, CGWB, Nagpur delivered a lecture on 'Ground Water Hydraulics' at CGWB, SR, Hyderabad in the Induction Level Training Course on Hydrogeological Investigations, Development & Management of groundwater in Hard Rock Terrain-Techniques, Equipments and Practices on 25th August 2008.
- Scientist-B CGWB, CR, Nagpur has delivered lectures at Groundwater Surveys & Development Agency, Nagpur Region, Nagpur for the technical training under Jalswarajya Project on 24th November 2008 on following topics.

i. Introduction to GEC –1997 Methodology, GW assessment Software, Data entry, Analysis and reports.
ii. Validation of various components, interpretation and final output

26.4 Participation in Workshop, Seminars and Conference

- Member (SML), OIC SUO, New Delhi and other Senior officers of the Board attended a National Workshop on "Providing Safe Drinking Water Protecting Drinking Water Sources and Catchments. Exhibits were displayed by Central Ground Water Board at Scope Complex, New Delhi on 10.05.2008.
- Scientist from Central Ground Water Board, Central Region, Nagpur attended a Workshop on 15.05.2008 on Artificial Recharge through Dug Wells at 11.00 AM at Hotel Hardeo, Nagpur. The Workshop was organized by NABARD, Nagpur.
- A Sensitization Workshop at the State Level on Scheme on Artificial Recharge of Ground Water through Dug Wells was held on 2.05.2008 at Bhopal. Regional Director, Senior officers and all Nodal Officers from Central Ground Water Board attended the Workshop. Technical aspects of recharge structures and Fund Flow Mechanism were elaborated in the workshop from CGWB & NABARD officers.
- In connection with Scheme on Artificial Recharge through Dug Wells, 8 district level workshop have been held at Dewas on 15.05.2008, at Ujjain on 16.05.2008, at Dhar on 19.05.2008, at Ratlam on 19.05.2008, at Barwani on 21.05.2008, at Khandwa on 22.05.2008, at Burhanpur on 23.05.2008 and at Satna on 23.05.2008. Nodal Officer for each district attended the workshop and gave a presentation on the design aspect of the recharge structures.
- Member (SML) attended workshop of State Secretaries organized by Ministry of Rural Development. Slot of 15 Minutes Convergence of Dug well Recharge & Flood Plain Programming at Hotel Raj Hans, Suraj Kund on 13.05.2008.
- Scientists from Central Ground Water Board, South East Coastal Region, Chennai attended Workshop organizedd by NABARD and power point presentation were made on the design aspect of Artificial Recharge to Ground Water through Dug Wells.
- Scientists from Central Ground Water Board, Southern Region, Hyderabad attended the Workshop on "District Level Implementation of Subsidy Scheme Committee (DLIMC)" regarding Artificial Recharge of Ground Water through Dug Wells in Hard rock areas on 13.05.2008 at Ongole, Prakasam district and Kadapa on 17.05.2008 organized by NABARD, interacted with State Officials and presented the Applicability, Usefulness and Design aspects as per guidelines for implementation of the Scheme.
- Scientists from Central Ground Water Board, Western Region, Jaipur attended and participated in the district level workshop on artificial recharge to ground water through Dug Wells organized by NABARD at 27 districts in Rajasthan during this month.
- Scientists from Central Ground Water Board attended a Workshop on 10.04.2008 on **India Environment Portal** jointly organized by the **National Knowledge Commission and Centre for Science and Environment** at CSE Office at Indian Habitat Centre, Lodhi Road, New Delhi .
- Abstract paper title "Impact of Mining Activities on Ground Water Regime in and Around Jharkhand State, India" sent for National Seminar (EMMA 2008) on Environmental management in mining and allied industries to be organized by IT BHU, Varanasi.
- Chairman and Member (SML) and Senior Scientists attended the one day conference of Principal Secretaries/Secretaries of Irrigation, Water Resources & Command Area Development of States & Uts at ICAR, New Delhi on 16.06.2008.
- Member (SML) attended National Seminar on "Land and Water Management in Cold Desert" at India Habitat Centre, Lodhi Road, New Delhi on 19th June, 2008.
- Superintending Hydrogeologist of Central Ground Water Board, Eastern Region, Kolkata attended Training Workshop on the International Guidelines for National Sustainable Consumption and Production Programme during 18-21 June, 2008 in Kathmandu, Nepal under United Nation Environment Programme.
- Regional Director Central Ground Water Board, Central Region, Nagpur along with Scientists from the Central Region attended a Workshop on "Use of Microwave Data for Geology, Forestry and Soil Moisture Studies" in view of launching of RISAT in 2009 at Regional Remote Sensing Service Centre (RRSSC) at Nagpur on 25th June 2008 between 9.30 and 13.30 hrs.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai participated for the invited speaker on the topic of "Water Harvesting & Ground Water Recharge" for International Symposium on "Water Harvesting" held at Tamil Nadu Agriculture University, Coimbatore on 23rd June 2008 and Scientists from the Region have also participated and presented papers.
- Regional Director, Central Ground Water Board, Mid Eastern Region, Patna attended seminar on "Significant Milestone in the Growth of geophysics during 50 years period (1958-2008)" at NGRI, Hyderabad. He was presented a paper on "Future

challenges and growth of ground water geophysics in India" during seminar.

- Senior Scientists of Central Ground Water Board, Mid Eastern Region, Patna and SUO Ranchi participated in seminar organized by Department of Geology, Patna University on the occasion of "World Environment Day" on 5th June 2008. Regional Director graced the occasion as Chief Guest. Scientists of Central Ground Water Board, Mid Eastern Region, Patna delivered technical lectures related to ground water.
- Scientist of Central Ground Water Board, Western Region, Jaipur participated and presented paper in the International Symposium on Water Harvesting organized by Tamil Nadu Agriculture University, Coimbatore during 23.06.2008 to 25.06.2008.
- Scientist from Southern Region ,Hyderabad participated in the National Seminar on "Significant Milestones in the Growth of Geophysics during the 50 years period 1958-2008" organized on the eve of Golden Jubilee Celebrations of Geological Society of India on 25th June, 2008 at NGRI, Hyderabad.
- Chairman, Member (SML), Member (SAM) and other Senior officers of the Central Ground Water Board and Central Ground Water Authority attended a Workshop on Web-enabled Ground Water Information System Chaired by Ms. Sunita Narain, Director, CSE on 4.07.2008.
- Scientists from Central Ground Water Board, South Western Region, Bangalore attended district level workshop on "Artificial Recharge through Dug Wells" organized by district level implementing agency, Zilla Panchayat rendered technical expertise on 4.07.2008, 9.07.2008 and 22.07.2008.
- Regional Director, South Western Region, Central Ground Water Board, Bangalore attended the seminar on "Rajiv Gandhi Accelerated Rural drinking Water Project" which was organized by the convener of exhibition organized by Press Information Bureau at Mulabagal, Kolar district from 19.07.2008 to 22.07.2008 and gave presentation on Rain Water Harvesting and Sustainability of ground water.
- Member (SML), Central Ground Water Board attended Seminar on "Water and Sanitation" at Scope Convention Centre, Lodhi Road, New Delhi on 25.07.2008.
- Regional Director, South East Coastal Region, Central Ground Water Board, Chennai attended the Workshop on "Water Management" in Tamil Nadu on 19.08.08 at Sathabhama University.
- Member (SML) and Scientist – D attended 13th National Symposium on Hydrology organized by National Institute of Hydrology and IIT Delhi on 28.08.2008
- Regional Director, South East Coastal Region, Central Ground Water Board, Chennai attended the Workshop on "Decision Support System" under Hydrology Project –II which was organized by State Ground & Surface Water Resources Data Centre on 28.07.2008 at Chennai.
- OIC, SUO, New Delhi attended Workshop on "Clean Yamuna" organized by ACCORD, an NGO at Sri Satya Sai International Centre, Prragati Vihar, Lodhi Road, New Delhi on 28.08.2008.
- Scientist of Central Ground Water Board attended one day workshop of senior officers on "Common Guidelines for Watershed Development Projects" organized by National Rainfed Area Authority at NASC Complex, PUSA, New Delhi on 5th August 2008.
- Scientists and nodal officers from Central Ground Water Board, South Western Region, Bangalore attended District Level Workshop on Artificial Recharge through Dug Wells at Mandya on 5.08.2008, at Chamrajnagar on 8.08.2008, at Koppal on 19.08.2008 and at Chitradurga on 20.08.2008 organized by District Level Implementing Agency, Zilla Panchayat and rendered technical expertise.
- Chairman, CGWB attended Seminar on Water Resources in the North East Harnessing of the Potential held at Guwahati on 26th September 2008.
- Regional Director, Eastern Region, Central Ground Water Board, Kolkata attended one day seminar on the occasion of Golden Jubilee Celebration on 16th September 2008 at K.P. Basu Memorial Hall, Jadavpur University, Kolkata. The theme of the seminar was "Socio Economic Development of Workers in Informal Sector and Role of Workers Education".
- As a following the recommendation of the Advisory Council on Artificial , Central Ground Water Board, Central Region organized a one day Workshop on **Sinking of Wells in Farmers Distress districts of Vidarbha** on 19th September 2008 at Bachat Bhawan, District Collectorate, Yavatmal district in collaboration with Ground Water Surveys and Development Agency (GSDA), Govt. of Maharashtra. The workshop was aimed to provide technical guidance on various aspects of Ground Water Management with special reference to sinking of wells. The workshop was inaugurated by Shri Sanjay Deshmukh, IAS, District Collector, Yavatmal district as a Chief Guest in presence of Shri Dheeraj Kumar, IAS, CEO, ZP Yavatmal as special invitee. Shri B. Jayakumar, Regional Director, Central Region, Nagpur presided over the function. Shri K.C. Wankhede, Dy.

Director,GSDA, Amravati Region was the guest of honour. The welcome address was given by Shri P.K. Parchure, Scientist – D, CGWB, Nagpur. On this event, dignitaries released a booklet entitled "Hydrogeology and Ground Water Resources of Yavatmal District" prepared by CGWB, Nagpur. A total of 115 participants from various State Govt. like Soil Conservation, Minor Irrigation, ZP, BDO's, Tahsildars, Animal Husbandry, NABARD, NGO's and Farmers attended the Workshop and actively participated in technical session as well as in technical discussion.

- Scientists of Central Ground Water Board, Southern Region, Hyderabad attended a Workshop on Dug Well Recharge at Andhra Pradesh Academy of Rural Development, Hyderabad on 9.09.2008 & 10.09.2008 and made power point presentation on design and implementation of the Scheme.
- Regional Director, Central Ground Water Board, South East Coastal Region, Chennai participated the Workshop on "Renovation of Traditional Ooranies " at Ramanathapuram on 6.09.2008 organized by TWAD Board, Ramanathapuram.
- Regional Director, Supdtg. Chemist , Central Ground Water Board, North Central Region, Bhopal attended a workshop on "Drinking Water Security during Drought" organized by Water Aid India at Bhopal on 4th September 2008.
- Scientist – D attended Workshop on Water Contamination Source and Solution at India Habitate Centre organized by Japanese Company on 23rd September 2008.
- Scientist – D, West Central Region Ahmedabad attended One day District Level Education Workshop on Artificial Recharge to Ground Water through Dug Wells was organized by DRDA, Banaskantha at Palanpur on 25th September 2008. He made a presentation on Hydrogeology, Ground Water Scenario and Dug Well Recharge in Banaskantha.
- Member (SML) attended Conference regarding Water Conservation and Management on 23.10.2008 .
- Shri M.Muthukannan, Sci 'D attended the workshop of Tungabhadara stake holders, organized by Society for Promoting Participative Ecosystem Management (SOPPECOM), ISEC & ZEF on 1.10.2008 at Bangalore.
- Regional Director, Supdtg. Hydrogeologist and Senior officers of South Western Region office attended Golden jubilee celebration of Geological Society of India which was organized at Bangalore on 12th & 13th October 2008.
- Central Ground Water Board , Central Region, Nagpur organized one day Workshop on "Sinking of Wells in farmers distress districts of Vidarbha" on 21.10.2008 at Hotel Central Plaza, Akola district in collaboration with Groundwater Surveys and Development Agency(GSDA), Govt. of Maharashtra. The Workshop was aimed to provide technical guidance on various aspects of Ground Water Management with special reference to sinking of wells. The workshop was attended by Officers/Officials of various organizations like Soil Conservation, Minor Irrigation, ZP, BDO's, Tehsildars, Animal Husbandry, NABARD, NGO's and Farmers. The Workshop was inaugurated on 21.10.2008 with lighting of traditional lamp by Shri H.P. Tummod, Additional District Collector, Akola district. Shri B. Jayakumar, Regional Director presided over the function. Shri K.C. Wankhede, Deputy Director, GSDA, Amravati Region, was the guest of honour. The welcome address was given by Shri P.K. Parchure, Scientist – D, CGWB, Nagpur. A total of 102 participants from various State Govt. like Soil Conservation, Minor Irrigation, ZP, BDO's, Tahsildars, Animal Husbandry, NABARD, NGO's and Farmers attended the Workshop and actively participated in technical session as well as in technical discussion.
- Regional Director Chennai attended the veledictory function of the workshop on "Environment and People" organized by Madras University on 30.09.2008 and delivered valedictory address.
- Regional Director & Dr.K.Md. Najeeb, Supdtg. Hydrogeologist attended Workshop on water resources management & pollution control organized by Eco-Watch at Belgaum on 14.11.2008.Regional Director was the Chief Guest for the function.
- Supdtg. Hydrogeologist, Central Ground Water Board, South Eastern Region, Bhubaneswar attended the interactive workshop and seminar for obtaining feedback to draft report of the Comprehensive Development Plan for Bhubaneswar Development Area including Khurda and Jatni on 21.11.2008 at IDCOL House, Bhubaneswar.
- Supdtg. Hydrogeologist, Central Ground Water Board, South East Coastal Region, Chennai attended the Workshop for project on "Developing a Model for sustainable Development of Towns with Small Manufacturing Units in South Asia" on 19.11.2008 at Karunya University, Coimbatore and gave presentation on "Ground Water Pollution in Tiruppur and its Environs, Coimbatore district, Tamil Nadu.
- Chairman, CGWB inaugurated the Seminar on Water Asia – 2008 at Pragati Maidan, New Delhi on 10.12.2008. The Seminar was attended by Officers Incharge, State Unit Office and Senior Scientists of

Central Ground Water Board participated in the Exhibition.

- Participated in the Workshop Cum Exhibition of Water Asia – 2008 at Pragati Maidan, New Delhi which was inaugurated by Hon'ble Ambassador of Israel. The Central Ground Water Board has also displayed Water Conservation Models and Posters on the same.
- Regional Director participated in State Level Workshop for common guidelines on watershed development projects organized by GEER Foundation held on 9.01.2009 at Gandhinagar.
- Scientist of Southern Region, Central Ground Water Board, Hyderabad attended International Conference on "Water, Environment, Energy and Society (WEES – 2009)" during 12-16th January, 2009 at New Delhi.
- Regional Director (HP) & two Senior Scientists attended Inception Workshop on DSS (Planning) for Integrated Water Resources Development and Management under HP-II organized by National Institute of Hydrology at Sewa Bhawan, New Delhi on 9.02.2009 & 10.02.2009.
- Member (SML) attended Conference of National Stakeholders Consultation on the draft white paper for the preparation of National Medium Term Priority Frame Work - FAO Conference at ICAR Conference Facility – NASC Complex, New Delhion 12.02.2009.
- Scientist of Southern Region, Central Ground Water Board, Hyderabad attended Map World Forum, the second Global Conference on Geo-spatial Technologies and Application organized by GIS DEVELOPMENT, Sector – 63, Hyderabad from 10 – 13th February 2009.
- Superintending Hydrogeologist, Central Ground Water Board, South Eastern Region, Bhubaneswar attended the 7th International R&D Conference organized by CBIP held at Bhubaneswar on 4th – 6th February 2009 and delivered a lecture on Ground Water Resources and their Management on the behalf of CGWB.
- Regional Workshop on Ground Water Related Issues - West Bengal, Andaman & Nicobar Islands and Sikkim held on 13th and 14th Februrary 2009. Smt. Mira Pande. IAS and Additional Chief Secretary, Water Resources Investigation and Development Department, Govt. of West Bengal graced the function as Chief Guest. About 150 participants from different Central, State Govt. organizations, Educational Institutions, NGOs, and Water User Agencies in the block level associated with Farmers Participatory Action Research Programme and Renovation of Water Bodies, Industrial organizations and freelance writers participated in the programme. A bound volume of proceedings on the Technical papers was circulated during the Workshop. Different ground water related issues were identified by the participants through their deliberations for 2 days and based on the deliberations the recommendations have been compiled and will be circulated.
- Central Ground water Board, North Eastern Region organized Regional workshop on "Hydrogeology and Hydrochemistry and Related issues in North Eastern States" at Conference Hall, National Institute of Rural Development, Guwahati on 25th and 26th February, 2009. Delegates & officials from different organizations / Institutions, NGOs, VOs such as Directorate of Geology & Mining, Govt of Assam & Mizoram, Public Health Engineering Department, Govt of Assam, Central Water Commission, Brahmaputra Board, National Institute of Hydrology, Tripura University, Gauhati University, Faculty and Students of Cotton College, B.Barua College, R.G.Barua College etc participated. 22 papers were presented in different focal themes. In the inaugural Session Dr.S.B.Medhi, IAS (Retd) was chief Guest, Dr.A.D Patgiri, Professor, Gauhati University and Shri N.K.Kakati, Secretary, Public Health Engineering Depatment, Govt of Assam were Guests of Honour. In the Valedictory function, Shri Rajan Nair, Chairman, Brahmaputra Board was chief Guest. Dr. S. K. Dutta, Deputy Director, N.I.R.D and Dr.A.D Patgiri, Professor, Gauhati University were Guests of Honour. Recommendations were accepted after fruitful discussions. Shri G.C.Saha, Regional Director, CGWB,NER Presided over both the sessions.
- Regional Director and Shri S. Marwah, Scientist – D, North Western Region, Chandigarh attended State Level Credit Seminar of Haryana State organized by NABARD on 26th February, 2009.
- Chairman, CGWB attended Workshop organized by Ministry of Water Resources regarding study related to the gap between irrigation potential created and utilized and draft Mission Document on National Water Mission by Secretary (DST) on 17.03.2009.
- Member (SML) and Scientist – D attended a Workshop of CII on 17.03.2009 at India Habitate Centre regarding Corporate Social Responsibility and Sustainable Water Management and Rain Water Harvesting.
- Chairman and Member (SML) CGWB attended Seminar on Business Response to Climate Change at India Habitate Centre, New Delhi on 16.03.2009.
- Chairman, Member (SML) and Senior officers of the Board attended Workshop organized by Ministry of Water Resources regarding Trans-boundary Aquifer

System held at CSMRS, New Delhi on 23rd March, 2009. Regional Directors of West Central Region, Western Region, North Western Region and Eastern Region made presentation.

- Chairman, CGWB and Senior officers of the Board attended lWorkshop organized by Ministry of Water Resources regarding Data Base Management held at CSMRS, New Delhi on 24th March, 2009.
- Chairman, Member (SML) and Senior officers ofthe Board attended Workshop organized by Ministry of Water Resources regarding Conjunctive Use of Surface and Ground Water held at CSMRS, New Delhi on 26.03.2009.
- Organized the Regional Workshop on "Water Quality and Water Efficiency issues in Tamil Nadu" during 19th – 20th March, 2009 at Hotel Vijay Park, Chennai. Shri Swaran Singh IAS, CMD, TWAD Board , Tamil Nadu presided the meeting and more than 125 delegates attended. There was goo coverage in Press and TV.
- Central Ground water Board, South Eastern Region organized Two days workshop on "Ground Water Scenario and Quality of Orissa" at Bhubaneswar on 6th and 7th March, 2009. Itwas attendedby around 200 participants.
- Scientists from South East Coastal Region, Chennai attended the Seminar on "Rejuverattion of Water Bodies and Water Causes in Chennai Metropolitan Area, Tamil Nadu" organizedd by Department of Environment, Chennai on 23.03.09.
- Organized the two days Workshop during 18- 19th March, 2009 on Ground Water Resource and Management in Kerala and Lakshadweep – Retrospect, Perspect and Prospect . and Water Efficiency issues in Tamil Nadu" during 19th – 20th March, 2009 . Shri K. Jayakumar, IAS, Additional Chief Secretary, Water Resources inaugurate the function and Shri D.S.C. Thambi, Regional Director presided over the function. The workshop was a grandeur and was well participated by eminents and professionals from the Water Sector fraternity. A total of 17 papers were presented during the technical sessions. The workshop volume threading the papers was released during the inaugural function which was well appreciated by one and all.
- Central Ground Water Board, Southern Region organized a workshop on "Water Use Efficiency and Water Quality Issues in Andhra Pradesh" on 13th – 14th March, 2009 at Platinum Jubilee Auditorium , Qsmaania University, Hyderabad. Experts from State/ Central/ Institutional organisations presented 24 key papers in the Workshop. Shri A.D. Rao, Scientist of CGWB presented key paper on "Water Use Efficiency Concerns in Andhra Pradesh".
- Scientists from Central Ground Water Board, Southern Region, Hyderabad attended one day Workshop on "Water and Environment" organized by JNTU, Hyderabad on 20.03.2009. Shri A.D. Rao, Scientist of CGWB delivered a keynote paper on "Hydrogeological Scenario of India".
- The Regional Director, Central Ground Water Board, West Central Region, Ahmedabad participated in Seminar on "Water for Future – Issues and Option" (Gujarat) organized by CWC during 4th – 5th March, 2009 at Gandhinagar and presented paper in the Seminar.
- The Regional Director, Central Ground Water Board, West Central Region, Ahmedabad participated in Workshop organized by Everything About Water, New Delhi at Ahmedabad on 4th March, 2009 and presented paper in the Workshop.
- The Regional Director, Central Ground Water Board, West Central Region, Ahmedabad participated in Workshop on Trans boundary Aquifers at New Delhi on 23rd March, 2009 and presented a paper entitled "Trans Boundary Aquifer – Social & Economic Perspective".
- A Regional Workshop on "Issues Related to Ground Water Management and Water Use Efficiency in the State of Gujarat and U.T. of Daman & Diu" was organized on 2nd & 3rd March, 2009 at Ahmedabad. Dr. Y.K. Alagh, Chairman, Indian Institute of Rural Management, Anand & Vice-Chairman, Sardar Patel Institute of Social & Economic Research, Ahmedabad was the Chief Guest on the occasion. Shri B.N.Navalawala, Advisor to the Hon'ble Chief Minister, Govt. of Gujrat was the Guest of Honour. Shri V.S. Gadhavi, Secretary (Water Supply) and Shri S.J. Desai, Secretary (Water Resources), Narmada, Water Supply & Kalpsar Department, Govt. of Gujrat. graced the occasion. Recommendations of the Workshop were discussed and finalized by a panel of experts under the Chairmanship of Dr. B.N. Navalawala.
- Central Ground Water Board, Central Region, Nagpur organised a workshop on " Ground Water Resource Management in Maharashtra" at VANAMATI Nagpur on March 3- 4, 2009. Dr. S.C. Dhiman, Member of CGWB was the Chief Guest to inaugurate the programme. Regional Director, Central Region presided over the function.
- Two-day Workshop on "Ground Water Scenario and Water Quality of Uttarakhand" was held at Dehradun on 19th and 20th March 2009.

- Central Ground Water Board, North Western Himalayan Region, Jammu organized a workshop on "Ground Water Scenario& Quality Issues in Jammu & Kashmir" on 2nd – 3rd March, 2009 at Jammu. Shri Ashok Angurana, IAS & Principal Secretary, PHE, I&FC Department Govt. of J&K was the Chief Guest of the function.
- Two-day Regional Workshop on "Geoganic Contamination of Ground Water" was held on 21st and 22nd March 2009 at Patna. Chief Guest of the function was Shri U.N.Panjiar, Secretary of Ministry of Water Resources, Govt. of India.
- A Regional Workshop on 'Ground Water Scenario, Water Quality, Information Dissemination and Capacity Building in NCT Delhi' was organized by Central Ground Water Board, State Unit Office, Delhi on 4th and 5th March, 2009 at the auditorium of Nuclear Research Laboratory, Pusa. Delegates & invitees from various walks of life including professionals from Central and State Agencies like Delhi Jal Board, academicians from various institutes like Delhi University, Jawahar Lal Nehru University, IIT, Delhi etc, scientists from Nuclear Research Laboratory etc., planners and administrators and representatives from non-Government Organizations attended the two days workshop. The lively interactions during the two days workshop brought out several key issues in the field of ground water management in NCT Delhi and drawn the road map for future planning regarding optimal and judicious utilization, conservation and management of this pristine natural resource.

Abstract volume of the workshop on Geogenic contamination of Ground Water being released by Sh U.N.Panjiar,Secretary (MOWR) Govt of India

Shri. A.K.Angurana, IAS, Principal Secretary, PHE&IFC Department, Govt of J&K addresses the gathering on the occasion of Regional workshop on 2nd March 2009

***Dr. Y.K.Alagh, inaugurating the Regional Workshop** on "Issues Related to Ground Water Management and Water Use Efficiencyin Gujarat and U.T. of Daman & Diu" was organized on 2nd & 3rd March 2009 at Ahmedabad.*

Release of workshop volume at SECR, Chennai

Chief guest inaugarating the workshop at shimla

27. RESEARCH AND DEVELOPMENT STUDIES

An Indian National Committee on Ground Water (INCGW) is constituted by the Ministry of Water Resources, Govt. of India by order No. 38/1/2008-R&D/5709-II dated September 2008. Chairman Central Ground Water Board is Chairman of INCGW, a sub committee of Indian National Committee on Hydrology (INCOH) on R&D in Ground Water constituted with a view to accelerate the development programmes in ground water sector and giving due consideration to increased need of taking up research in the field of Ground Water. This committee has 15 members and examines the project proposals received on ground water issues for their suitability for funding and recommends for sanctioning by the Ministry of Water Resources. The committee has been entrusted with the following functions-

- To give advice to Central and State Governments and their agencies on matters related to ground water; to appoint expert panels to consider special problems to advice the committee.
- To prepare and periodically update the state of art in the country in different , branches of Ground Water; to disseminate information related to ground water by way of publishing journals, research news/digests; to support and conduct mass awareness programme like seminars/ conferences/ workshops; and to arrange R&D review sessions for ground water.
- To undertake studies on historical appreciation of development of ground water and introduce perspective planning for research in Ground Water.
- To recommend funding' for the infrastructure development of ground water research institutions; to recommend recognition of Centers of Excellence in ground water; to maintain effective cooperation with other National Committees /Boards, related Gal/State Ministries, CSIR Labs, IITs, Engineering Colleges and Polytechnics. Universities and other academic institution.
- To coordinate the R&D activities in ground water in general and to coordinate R&D programme of the MoWR in particular; to monitor the progress made by the executing institutions on research schemes; to identify areas which need immediate attention; to avoid overlaps in the research programmes of the different institutions, to invite and encourage R&D proposals in areas where work being done is inadequate; to encourage the national institutions, voluntary. professional bodies and non commercial NGO'S to take up R&D in Ground Water.
- To promote HRD programmes leading to specialization of research staff and recommend encouragement for the outstanding research personnel
- To promote and coordinate effective participation of India in the international programmes related to Ground Water and to act as national committee for such international bodies.
- To encourage indigenous industry through loans to take up technological development of Ground Water where required.

During the year total 19 projects were received. Out of 19 projects, 2 proposals were approved and recommended by R&D(GW) sub committee, 2 proposal approved in principle and sent to PI for revision and remaining 15 proposals are under scrutiny. The details of the proposals are given in Table 27a, Table 27b and Table 27c:

Table 27a: List of approved & recommended proposals by R&D (GW)Sub Committee:

Project Title	Project Cost (Rs. In Lakhs)
Spatio-temporal Modelling of Ground Water Quality using Artificial Neural Network	13.40
Developing a Methodology for Evaluating the Impact of Rain Water Harvesting in Urban Areas	15.25

Table 27b: List of Proposals approved in principle by R&D (GW) Sub Committee and sent to PI for revision based on observation of the committee:

Project Title	Project Cost (Rs. In Lakhs)
Arsenic Problem in Jharkhand & Bihar and some remedial measure	14.03
Evaluation and Modelling of Rain Water Harvesting Filter Systems	8.00

Table 27c: List of New R&D Proposals received on ground water and under process:

Project Title	Project Cost (Rs. In Lakhs)
Bacterial Degradation of Lignin and Pentachlorophenol from Pulp Paper Effluent and its Applications for Aquaculture & Ferti-Irrigation.	26.22
Fluoride Contamination of Ground Water in Nayagarh District, Orissa	25.36
Morpho-tectonic Study of Jhalawar Urban area & its Hinterland towards Groundwater Recharge Enhancement: A Remote Sensing and GIS based approach, Jhalawar districts, Rajasthan"	21.34
Evaluation of Heavy Metal Pollution index for groundwater of townships located near different mining areas	29.68
Groundwater potential assessment and management in the Rangamalai watershed, a hard rock region in Dindigul district, Tamil Nadu	43.65
Assessment, Augmentation and Regulation of Water Resources at Banaras Hindu University Main Campus Varanasi and its Rajeev Gandhi South Campus, Barkachha, Mirzapur	173.12
Vulnerability assessment and groundwater management studies in aquifers of Pondicherry and Karaikal regions	20.86
Management of Aquifer Recharge for Augmentation of Groundwater Resources (MAR for AGWR	175.00
Development of Nanofiltration Membrane Technology for Drinking Water Purification and Water Reclamation for Industrial Use	11.592
Hydro-Geochemical Investigations of high fluoride groundwater terrain in part of Morel Basin, Jaipur District, Rajasthan	11.80
Estimation of aquifer potential in coal mining region with suitable techniques to improve the recharge	16.39
Integrated groundwater management in Chubaka Basin, West Bengal	37.97
Assessment of hydro-geochemical impacts of shrimp farming on coastal watershed	25.00
Fluoride removal from contaminated groundwater using developed media packed filtration bed in the lab and field	14.30
Assessment of groundwater potential in velar river basin based on GWREC Norms of 1997	31.20

28. PUBLICITY AND PUBLIC AWARENESS

Central Ground Water Board/ Ministry of Water Resources participated in following Exhibition/Trade Fair till 31st March, 2009.

i. India International Trade Fair-2008:

Central Ground Water Board participated in the MOWR pavilion of **IITF-2008** at Pragati Maidan, New Delhi during 14-27th November 2008. 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. Participated in the Exhibition organized by PIB

Central Ground Water Board, South Western Region, Bangalore participated and displayed working models of Rain Water Harvesting and other displays on water conservation at the exhibition organized by Press Information Bureau at Mulabagal, Kolar district from 19.07.2008 to 22.07.2008. Regional Director, SWR attended the seminar on "Rajiv Gandhi Accelerated Rural Drinking Water Project" which was organized by the convener of exhibition and gave presentation on Rain Water Harvesting and Sustainability of ground water. There was wide response from students and general public for the exhibits on water conservation during the exhibition.

iii. Celebration of Water Resource Day

Regional Director, Central Ground Water Board, South East Coastal Region, Chennai participated and delivered special lecture on "Integrated Water Resources Development and Management" on Water Resources Day held at Neyveli Lignite Corporation (NLC), Neyveli on 13th June 2008 organized by Institution of Engineers (India), Neyveli.

iv. Rain Water Harvesting Model displayed

Central Ground Water Board displayed a model on Rain Water Harvesting during the ROSHNI programme held at Rashtrapati Bhawan on 25th and 26th July 2008, in which Hon'ble President has appreciated model structures after having a close view. Hon'ble President has also interacted on the technicality of Rain Water Harvesting.

v. Tele – talk to Akashwani Jalandhar Kendra

Shri C.P. Srivastava, Superintending Hydrogeologist gave a tele – talk to Akashwani Jalandhar Kendra for FM Channel during which general questions on rainwater harvesting in Punjab State were answered for the benefit of listeners.

vi. Broadcast on All India Radio, Ahmedabad

A message by Regional Director, CGWB, West Central Region, Ahmedabad was broadcasted on All India Radio Gujrat in "Ghatna Chakra" programme on 27th February 2009 regarding objectives of the Regional Workshop on "Issues related to Ground Water Management and Water Use Efficiency in the State of Gujarat and U.T. of Daman and Diu" to be organized on 2nd and 3rd March, 2009 at Ahmedabad.

vii. Celebration of Hindi Pakhwara

Central Ground Water Board organized Hindi Pakhwara from 14.09.2008 to 28.09.2008 at Bhujal Bhawan, Faridabad. Officers & staff of CGWB and Pay Accounts Office attended the function and participated various competitions of Poim writing, Hindi Quiz, Tankad lakhon etc. Hindi Pakhwara/Week/Saptaha was also celebrated in Regional Offices, Divisional Offices and State Unit Offices of Central Ground Water Board.

Viii Participation in Sonepur Mela

As per the advice of the Ministry of Water Resources, Central Ground Water Board, Mid Eastern Region, Patna has actively participated in the World famous Sonepur Mela of Bihar state and arranged the Ground Water exhibition and Awareness Campaign on 6th December 2008, which received overwhelming public response. On this occasion, the officers of the Mid Eastern Region fully involved in the following works

a. Distributed 3500 banners on different activities of CGWB to the visitors.
b. Demonstration on Investigation of Ground Water through Satellite. This technique was appreciated by the visitors.
c. The area of Sonepur Mela is already effected by arsenic in Ground Water. In this regard pamphlets have been distributed regarding what is effect of arsenic on health of persons.
d. Various ground water related features and issues requiring awareness and public attention were displayed and literature was distributed to the visitors.

ix. Participation in the 2ND ASOM INTERNATIONAL TRADE FAIR, 2009

Central Ground water Board, North Eastern Region participated in the **2nd Asom International Trade Fair, 2009** at Guwahati from 4th February, 2009 to 16th February, 2009. Models, Maps were displayed and literature related to Roof top Rainwater harvesting, water related issues were distributed for awareness of public. The CGWB pavilion was awarded 1st Prize in the fare for its attracting display of working models and demonstrations.

x. Organization of "Jal Yatra" 2009

- Regional Director, South Eastern Region, Central Ground Water Board, Bhubaneswar organized a one day programme on Jalyatra at Bhramarabara Vidyapitha, Tomando on 24th February 2009. It was attended by more than 300 students and villagers.
- Central Ground Water Board, Central Region, Nagpur organised "Jal Yatra" 2009 at Dindori taluka of Nashik district on 5th February 2009. School children took active participation in the "Jal Yatra" by displaying placards with messages on water conservation. Drawing and song competitions for the school children were also arranged. The Jal Yatra concluded with the address by the senior scientists of CGWB & GSDA about the water conservation and other related issues and distribution of certificates to the participants and awards to the winners.
- Regional Director, South East Coastal Region, Central Ground Water Board, Chennai presided over the Jal Yatra organized by CGWB in coordination with PALMYRA , Auroville at Kaniyur, Villupuram district on 12th March 2009 and delivered talk in local language to the self help group (SHG),farmers and public on water conservation.
- A Jal Yatra was organized on the eve of World Water Day on 22ND March, 2009 in collaboration with the teachers and students of Kendriya Vidyalaya, Pattom. The same was flaged off by Smt. Cicily Roy, Principal, Kendriya Vidyalaya, Pattom. The procession led by Shri D.S.C. Thambi, Regional Director spread the massage on the importance of water.
- Southern Region, Central Ground Water Board, Hyderabadd has celebrated " World Water Day". On the eve of this occasion, Jal Yatra depicting placard and slogans with the theme of water conservation and related aspects was taken up with school childeren of St. Mary Pias Good Shephered School, Nagole.
- Organized one day Jalyatra under I.E.C programme on Conservation and use of Ground Water on 20th March, 2009 at Lakhiram Barua Sadan, Guwahati, Kamrup district, Assam in collaboration with Shri Lakhi Borthakur & group – the well known drama group of Assam. 150 persons from different organizations and public were present in the programme. To start with Regional Director, CGWB, NER explained the background of the short drama and emphasized on the importance of Jalyatra , Puppetshow and pentomime to educate the mass specially in the rural area. Shri Lakhmi Barthakur and his team staged a short drama "Upanayan". The drama emphasized on the use of safe water, avoid wastage, practice conservation of water and adopting rainwater harvesting.

xi. World Water Day 2009

- World Water Day was celebrated on 22nd March, 2009 by participation in the programme organized by State PWD, Trichy and Central Water Commission, Chennai. Regional Director, Central Ground Water Board, South East Coastal Region, Chennai participated in the programme at Trichy as Special Invitee and delivered a talk on the theme of the World Water Day.
- Regional Director and Scientists of North Western Region, Central Ground Water Board attended World Water Day on 22nd March 2009 organized by Central Water Commission, Chandigarh and Shri Sushil Gupta Regional director presented a paper on "Trans Boundary Aquifer of Punjab".
- Smt. Anita Gupta, Regional Director, Central Ground Water Board, Uttarakhand Region, Dehradun attended Water Resources Day/World Water Day on the theme "Trans-boundary Water" on 24th March 2009.
- Programme of Valedictory Function of World Water Day 2009 celebrated on 30th March, 2009 at Vigyan Bhawan, New Delhi. On this occasion, Welcome address given by Shri A.K. Bajaj, Chairman CWC and Inaugural address by Shri U.N. Panjiar, Secretary (WR). Brief presentation given by Shri R.M. Mishra, Joint Secretary(Admn.) on findings of Workshops held on the occasion of World Water Day. Vote of thanks was proposed by Shri B.M. Jha, Chairman, CGWB. Officers and representatives from different organizations of also attended the programme of valedictory function.

xii. Regional Ground Water Summit 2009

The Regional Ground Water Summit 2009 was organized by Central Ground Water Board, North Western Region,

Chandigarh. The event was inaugurated by **His Excellency ,** the Governor of Punjab, General (Retd.) S.F. Rodrigues PVSM, VSM on 5th March, 2009 while Shri B.M. Jha, Chairman, CGWB and Shri Pratap Aggarwal, Vice Chairman, CII (Punjab State Council) was the Guests of Honour, Shri Sushil Gupta, Regional Director, NWR presided over the function. The following reports were released by His Excellency, the Governor of Punjab & Administrator of UT Chandigarh:

a. Hydrogeology of Punjab State.
b. Ground Water Information Booklets of Punjab & Haryana States and UT of Chandigarh.
c. A workshop volume on Scientific Papers presented in the summit.

xiii. National Productivity Week Celebrations

- Central Ground Water Board, Southern Region, Hyderabad observed "**National Productivity Week"** and an Essay Competition on "**National Productivity – Role of CGWB**" was conducted. Officers / staff participated in the programme with great enthusiasm. Prizes were distributed to the wining participants on the occasion.
- National Productivity Week from 12 to 18th February 2009 was observed successfully Uttaranchal Region, Dehradun. The closing ceremony was held in the office premises of CGWB, Uttaranchal Region, Dehradun which was attended by Director, Geological Surveyof India and Superintending Engineer, Central Water Commission, along with officers of these departments. The closing ceremony was given coverage in Rashtriya Sahara, a daily Hindi News paper published from Dehradun.
- Central Ground Water Board, North Western Region, Chandigarh was celebrated "**National Productivity Week"** from 12th – 18th February 2009.
- Central Ground Water Board, West Central Region, Ahmedabad organized a workshop on "**National Productivity Week"** from 12th – 18th February 2009. Theme paper on "Prosperity through Productivity" was read out and group discussion washeld on the theme. A quiz contest was also conducted on the theme and prizeswere distributed to the contestants and participants.

Scientists ER answering the questions in MAP in North 24 Parganas, West Bengal

RD, CGWB, KR delivering Presidential address at the WMTP at Thrissur

Trainee present in WMTP, Bongaon, North 24 Parganas ,West Bengal

Students participating in drawing competition, MAP in Bongaon, North 24 Parganas, West Bengal

WMTP on Ground Water Management was organised during 04 & 05.03.2009 at Zilla Panchayath Meeting Hall Hassan.

R D & senior officers during WMTP on Rain Water Harvesting and Artificial Recharge to GWr at Deptt. of Environmental Sciences, University of Jammu, Jammu on 3rd February 2009.

Jalyatra under Media Activities under IEC Scheme

Jalyatra was organised at Jajur on 7.3.2009. Jajur in Arasikere taluk in Hassan district

Jalyatra programme organised by CGWB At Sagar Block, South 24 Parganas, West Bengal

School students Participating in the Jal Yatra at Madhupur, Bihar

Jalayatra held at Venkatagiri, Nellore District, Andhra Pradesh

World Water Day Celebrations at Good Shepherd School, Nagole, Rangareddy District, Andhra Pradesh

29. 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 2008-09 up to 31st March 2009 are given below in Table 29:

Table 29- MAJOR ACHIEVEMENTS OF THE NORTH EASTERN REGION

Activities	Achievements
Ground Water Management studies	14500 Sq. km (Pre-monsoon) 10374 Sq.Km. (Post-monsoon)
Ground Water Exploration	30 wells drilled in North Eastern Region
Monitoring of Ground Water Wells	Monitored during April, August, November 2008 and January, 2009 through a network of 620 Ground Water Monitoring Wells. The water samples were collected during the pre-monsoon monitoring.
Water Quality Analysis	463 samples analyzed for basic constituents and 428 samples have been analyzed for heavy metals such as Cu, Zn, Fe, Mn, CO, Cd, Cr, Ni, Pb etc. ad 18 samples analyzed for specific purpose.
Short Term Water Supply Investigations	31 investigations
Geophysical Studies	VES (Vertical Electrical Sounding) – 29
Reports	20 District ground water brochures, 1 Ground Water Year Book of N E States were issued. 1 Ground Water Exploration Report submitted whereas 1 District Report under issuance & 1 State Report is under compilation.
Estimation of Ground Water Resource of the entire Region based on GEC - 1997 Methodology	Completed
Organized Mass Awareness Programme	1 Mass Awareness Programme completed
Organized Training Programme on Rain Water Harvesting	1 Water Management Training Programme completed
Miscellaneous	Central Ground Water Board, NER participated in the 2nd Asom International Trade Fair 2009 at Guwahati from 4th February 2009 to 16th February 2009. Models, Maps were displayed and distribute literatures relate to Roof Top Rainwater Harvesting, Water related issues for awareness of public. The Central Ground Water Board pavilion was awarded 1st Prizewinner in the fare for its attracting display of working models and demonstrations.

30. PROGRESSIVE USE OF HINDI

- The provision relating to Section 3(3) of the Official Language Act, 1963 is complied.
- Letters received in Hindi are invariably replied in Hindi.
- Hindi Quartely Progress report is 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. Rule 1976 & O.L. Act 1963.
- During 2008-09 a Hindi workshop for two days was organized from 12-13th May,2008 and 19 – 20th March, 2009. 20 Officers/ officials were trained in the workshop.
- 'Hindi Pakhwara' was celebrated from 14 – 28th September 2008. Various competitions and other programmes were organized during the Pakhwara. The participation of officers/ officials in these competitions was encouraging.
- 12 officials were awarded cash prize for original Noting and drafting in Hindi.
- 'Bhumijal News Letter' the quarterley magazine highlighting on the activities of Central Ground Water Board is being published.
- CGWB has been awarded with first prize by TOLIC Faridabad for doing maximum work in Hindi during the year 2007-08.
- Ministry of Water Resources has awarded first prize to Central Ground Water Board for remarkable achievement in the field of Hindi for the year 2007-08.
- Ten sections of the office have been specified to work cent-percent in Hindi.
- The Board is committed towards the progress and implementation of Hindi and is determined for progressive use of Hindi as per the Annual Programme issued by Official Language Department.

31. VIGILANCE ACTIVITIES

i. Vigilance Activities

During the year 2008-2009, 21 complaints cases were brought forward from the last year and 7 complaints were received during 2008-2009 up to 31st March, 2009. Thus total 28 complaint cases were on the record. Out of these 5 complaints have been closed and 1 complaint case has been taken up as disciplinary proceedings. Therefore, 22 complaint cases have been carried forward w.e.f. 1.04.2009.

ii. Disciplinary Proceedings

10 cases of disciplinary proceedings were brought forward w.e.f. 1.04.2008 and 1 case of disciplinary proceeding has been received during the year. Thus a total 11 cases of disciplinary proceedings were on the record. Out of these 3 cases of disciplinary proceedings have been finalized and 8 cases have been carried forward.

32. PERSONNEL MANAGEMENT

The total sanctioned strength of the Central Ground Board as on 31st March 2009 is 4251 out of which the filled up posts are 3640 and vacant posts are 611.

The vacancy position and category-wise personnel deployed in the Central Ground Water Board are presented in table 32.

Table 32- PERSONNEL DEPLOYMENT IN CENTRAL GROUND WATER BOARD DURING 2008-2009 (Up to 31st March, 2009)

GROUP "A"						
Sanctioned	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
442	385	57	26	-	53	16
GROUP "B"(Gazetted)						
Sanctioned	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
364	305	59	2126	-	46	19
GROUP "B"(Non-Gazetted)						
Sanctioned	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
198	170	28	13	2	30	11
GROUP "C"						
Sanctioned	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
2000	1707	293	111	11	344	127
GROUP "D"						
Sanctioned	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
1247	1073	174	96	6	273	68
GRAND TOTAL						
Sanctioned	**Filled**	**Vacant**	**OBC**	**Handicapped**	**SC**	**ST**
4251	**3640**	**611**	**267**	**19**	**746**	**241**

33. PERSONS WITH DISABILITIES

The position of persons with disabilities for the Year 2008 - 2009 up to 31st March 2009 under Group A, B, C & D of the Central Ground Water Board are given in table 33.

Table 33 : PERSONS WITH DISABILITIES FOR THE YEAR 2008-2009

Schemes/Policies run by the respective Ministry/Department for the benefit of Persons with Disabilities.					Nil
Budget allocated and expenditure incurred under each scheme during the financial year.					Nil
No. of persons benefited					Nil
Per capita expenditure					Nil
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	442	81	-	Requisition for filling up 2 posts of physical handicapped (1-HH & 1-OH) has been sent to the UPSC.
	B	562	121	-	Requisition for filling up 1 post of VH has been sent to the UPSC.
	C	2000	167	-	Requisition for filling up of 3 PH posts has been sent to the UPSC.
	D	1247	232	3	-

34. BUDGET AND ACCOUNTING

Statement showing actual expenditure incurred by the Board during 2008 - 2009 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 2008-2009 (Up to February 2009)

Sub-Head	Plan (Rs. In Lakhs)		Non-Plan (Rs. In Lakhs)	
	Funds	Expenditure	Funds	Expenditure
Salary	1885.45	1777.94	8600.00	8132.31
Wages	12.00	9.47	0.95	0.34
O.T.A	2.00	1.45	14.40	11.10
T. E	349.00	242.51	250.00	211.08
F.T.E	3.00	0.00	1.80	0.75
O.E	524.50	454.70	6.30	4.32
P.S	15.00	3.13	0.00	0.05
R.R.T	225.00	161.40	4.75	1.98
Publications	70.00	32.36	1.80	0.00
Subsidies	0.50	0.05	0.00	0.00
Susp. Stock	1098.50	725.28	0.00	0.00
W.O.L	10.00	0.00	0.00	0.00
M.V.	99.00	30.64	0.95	0.78
M & E	85.00	3.52	0.00	0.00
Works	1611.00	1128.52	0.00	0.00
Medical	65.00	46.73	124.70	106.58
Other Charges	4.00	0.00	0.21	0.00
B.C.T.T.	0.05	0.02	0.00	0.00
POL	1249.00	905.23	2.00	0.86
O.A.E.	70.00	6.30	0.09	0.05
Adv./Publicity	0.00	0.00	4.05	0.00
Minor Works	100.00	95.32	0.00	0.00
Total	**7478.00**	**5624.57**	**9012.00**	**8470.20**

Table 34b: Rajiv Gandhi National Training & Research Institute for Ground Water

Sub-Head	Fund Allotment	Expenditures
Salaries	13.30	11.79
Wages	1.00	0.00
O.T.A	0.00	0.00
D.T.E	16.00	8.76
O.E	4.00	0.83
R.R.T	0.00	0.00
Publication	0.20	0.00
P.S	26.00	16.25
M.V	0.50	0.23
M & E	1.00	0.00
Medical treatment	4.00	0.02
P.O.L	4.00	2.69
Total (RGNTR&I)	**70.00**	**40.57**

Table 34c: Hydrology Project Ext. Support 8.01 & Domestic Support 8.02

Sub-Head	Fund Allotment	Expenditures
Salaries	219.97	135.63
M/Treatment	4.50	1.00
D.T.E	6.65	4.28
F.T.E.	12.00	0.00
O.E	37.53	17.32
B.C.T.T.	0.00	0.00
O.A.E.	3.00	0.00
P.S.	31.50	6.01
M. V.	48.00	1.14
M&E	103.08	0.00
M/Works	0.00	2.83
Salaries	73.32	20.04
M/Treatment	1.50	0.23
D.T.E	2.22	0.57
F.T.E.	12.51	0.00
O.E	0.00	3.32
B.C.T.T.	0.00	0.00
O.A.E.	1.00	0.05
P.S.	3.50	0.00
M.V.	12.00	0.02
M&E	25.77	0.00
M/Works	0.00	0.04
Total (Hydrology Project)	**598.05**	**192.48**

Table 34d : Central Ground Water Board building for offices

Sub-Head	Fund Allotment	Expenditures
Major Works	320.00	268.16
Total	**320.00**	**268.16**
Total CGWB	**8466.05**	**6125.76**

Table 34e : DEDUCT RECOVERIES

Sub-Head	Fund Allotment	Expenditures
Central Ground Water Board		
Issue to works and other credits		
Deduct Recoveries 17.01.70 issue to work	1100.00	1011.43
Other Suspense Stock 17.02.70	100.00	0.00
Deduct Recoveries 01.03.70	0.00	0.00
Total Recoveries	**1200.00**	**1011.43**
NET CGWB	**7266.05**	**5114.33**

Annexure -1

LOCATION AND JURISDICTION OF REGIONAL AND OTHER OFFICES OF CENTRAL GROUND WATER BOARD

REGIONS	HEADQUARTERS	JURISDICTION
i)NORTH WESTERN HIMALAYAN REGION		
Regional Office	Jammu	J&K
Division Office	Div. VIII, Jammu	J&K
ii) NORTH HIMALAYAN REGION		
Regional Office	Dharamshala	Himachal Pradesh
Division Office	Div. XVII, Dharamshala	Himachal Pradesh
iii)NORTH WESTERN REGION		
Regional Office	Chandigarh	Punjab, Haryana, NCT of Delhi & UT of Chandigarh
State Unit Office	Delhi	NCT of Delhi
Division Office	Div. II, Ambala	Punjab, Haryana, NCT of Delhi & UT of Chandigarh
iv)WESTERN REGION		
Regional Office	Jaipur	Rajasthan
State Unit Office	Jodhpur	Western Rajasthan
Division Office	Div. XI, Jodhpur	Rajasthan
v)WEST CENTRAL REGION		
Regional Office	Ahmedabad	Gujarat, UT of Daman & Diu
Division Office	Div.I, Ahmedabad	Gujarat, UT of Daman & Diu
vi)NORTH CENTRAL REGION		
Regional Office	Bhopal	Madhya Pradesh
Division Office	Div.XII, Bhopal	Madhya Pradesh
vii)NORTH CENTRAL CHATTISGARH		
Regional Office	Raipur	Chattisgarh
Division Office	Div.XIII, Raipur	Chattisgarh
viii)CENTRAL REGION		
Regional Office	Nagpur	Maharashtra, UT of D & N. Haveli
State Unit Office	Pune	West Maharashtra
Division Office	Div. VI, Nagpur	Maharashtra, UT of D & N. Haveli
ix)NOTHERN REGION		
Regional Office	Lucknow	Uttar Pradesh
State Unit Office	Allahabad	Uttar Pradesh
Division Office	Div.III, Varanasi	Uttar Pradesh
x)UTTARANCHAL REGION		
Regional Office	Dehradun	Uttaranchal
State Unit Office	Bareilly	Uttaranchal
Division Office	Div.XVI, Bareilly	Uttaranchal
xi)MID EASTERN REGION		
Regional Office	Patna	Bihar, Jharkhand
Division Office	Div. V, Ranchi	Bihar, Jharkhand
xii)EASTERN REGION		
Regional Office	Kolkata	West Bengal, Sikkim, UT of A & Nicobar Islands
Division Office	Div. XV, Kolkata	West Bengal, Sikkim, UT of A & Nicobar Islands
xiii)NORTH EASTERN REGION		
Regional Office	Guwahati	Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura
State Unit Office	Itanagar	Arunachal Pradesh
	Shillong	Meghalaya
	Agartalla	Mizoram, Tripura
Division Office	Div.VII, Guwahati	Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura

REGIONS	HEADQUARTERS	JURISDICTION
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