JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF WATER RESOURCES
INDIA

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE IMPROVEMENT OF EQUIPMENT FOR WATER QUALITY MONITORING IN INDIA

MARCH, 1994

JAPAN TECHNO CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY

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BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE IMPROVEMENT OF THE GROUNDWATER MANAGEMENT EQUIPMENT IN INDIA

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PREFACE

In response to a request from the Government of India, the Government of Japan decided to conduct a basic design study on THE PROJECT FOR THE IMPROVEMENT OF THE GROUNDWATER MANAGEMENT EQUIPMENT IN INDIA and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to India a study team headed by Mr. Yuji Maruo, Senior Development Specialist, JICA and constituted by member of Japan Techno Co., Ltd., from December 1 to December 21, 1993.

The team held discussions with the officials concerned of the Government of India, and conducted a field study at the study area. After the team returned to Japan, further studies were made, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relation between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of India for their close cooperation extended to the team.

March, 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

March, 1994

Mr. Kensuke Yanagiya,
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on THE PROJECT FOR THE IMPROVEMENT OF THE GROUNDWATER MANAGEMENT EQUIPMENT IN INDIA.

This study was conducted by Japan Techno Co., Ltd., under a contract to JICA, during the period November 25, 1993 to March 18, 1994. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of India and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Health and Welfare. We would also like to express our gratitude to the officials concerned of the Ministry of Water Resources, the JICA India office, the Embassy of Japan in India for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

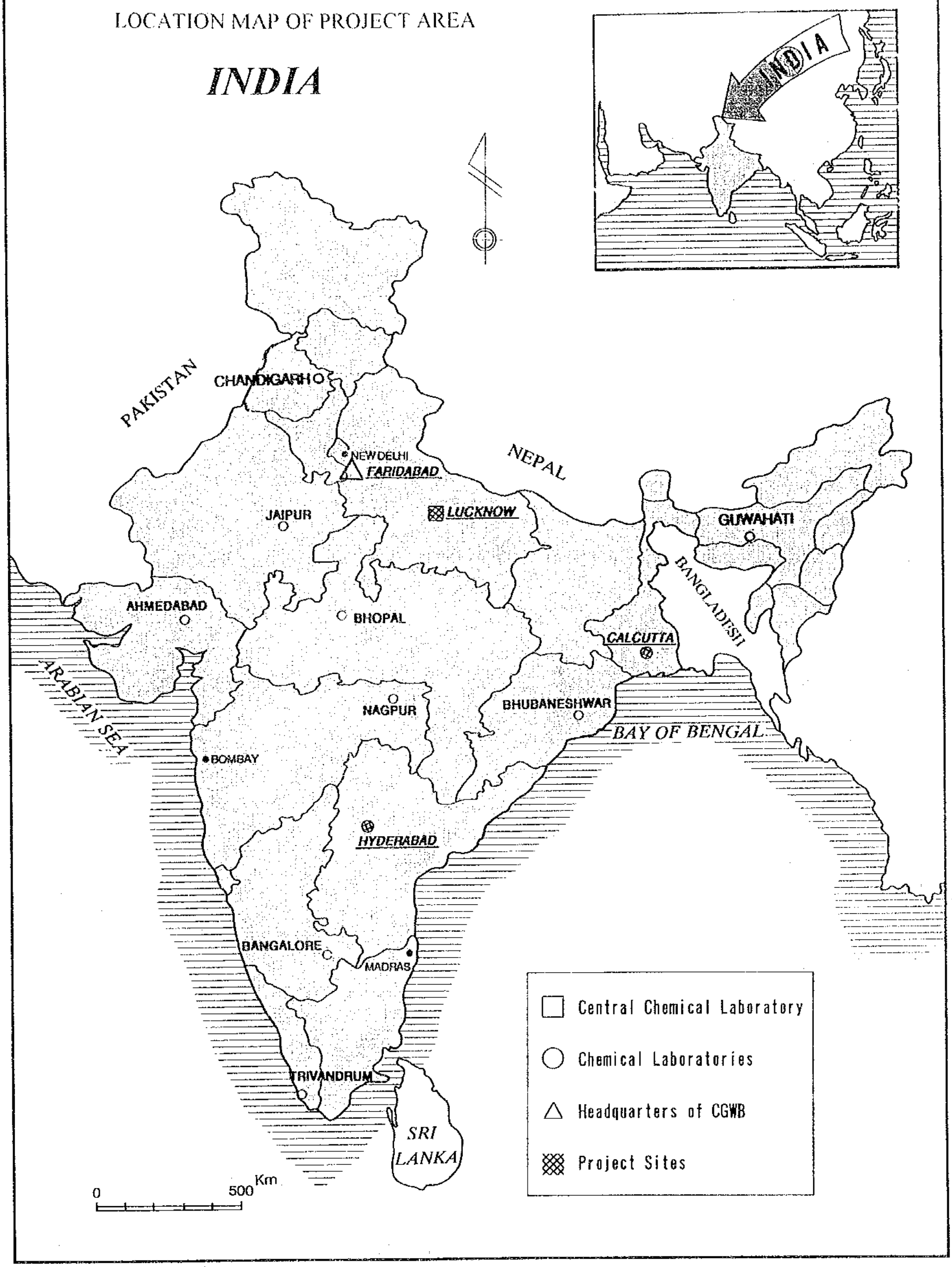
Yours faithfully,

Masaru Nakayama

Masaru Nakayama
Project manager,
Basic design study team on The Project for The Improvement of The Groundwater Management Equipment in India
Japan Techno Co., Ltd.

LOCATION MAP OF PROJECT AREA

INDIA



SUMMARY

SUMMARY

India is located in the southern part of the Asian continent, and occupies an area of approximately 3,280,000 km^2. India's population is approximately 870 million (1992). The GNP per capita is approximately US$330 (1991). India is an agricultural country: agricultural production represents approximately 32% (1991) of the GDP, with 65% of the working population engaging in agriculture.

India began the First Five Year Plan (1951-1956) shortly after independence in 1947 in order to facilitate economic and social development. India is currently into its Eighth Five Year Plan (1992-1996). In the Eighth Five Year Plan, "the provision of safe drinking water" is listed among the top priorities which include adequate employment generation, the containment of population growth, the eradication of illiteracy, the provision of primary health facilities, self-sufficiency in food, the generation of agricultural surpluses for export, and the strengthening of the infrastructure. As approximately 80% of the rural water supply and 50% of the agricultural irrigation depend on groundwater resources, the groundwater development in the rural area is essential for water supply and for the development of agriculture. Nonetheless, a balance between industrialisation and the natural environment and the ecology is strongly desired.

The Central Ground Water Board (CGWB) of the Ministry of Water Resources is the executing agency responsible for the scientific exploitation of groundwater resources and groundwater management throughout India. CGWB is drilling about 800 tubewells every year across the country as a part of the programme for the hydrogeological exploration of groundwater for the broad regions and also is conducting a ground water management through a nationwide monitoring for the water level and the water quality of groundwater.

Countermeasures are urgently required for the environmental pollution which has accompanied the progress of India's industrialisation and urbanisation. Recognising that water pollution has a potential impact, especially on the ecology, priority has been given to water pollution control measures, and ongoing efforts are being made to eliminate or at least arrest

water pollution hazards. The "Act of Prevention and Control of Pollution of Water" enforced in 1974 and "The Environmental (Protection) Act" enforced in 1986 are both related to water quality. Environmental pollution countermeasures are listed as an important issue in the current Eighth Five Year Plan. Through a request by the Central Pollution Control Board (CPCB) of the Ministry of Environment and Forests, which is responsible for environmental problems in India, CGWB monitors groundwater levels and analyse the water quality at the approximately 16,000 hydrography net-work stations throughout the nation. Water quality analysis is conducted at 12 Chemical Laboratories, and 17 identified industrial estates where disposal of waters has led to a change in quality regime are being monitored. And CGWB is yet to be equipped with sufficient analysis equipment necessary to perform water quality analysis related to environmental pollution prevention.

In this background, the Government of India requested a grant aid to supply equipment for groundwater development in 1988, and the Japanese Government provided four Cable Percussion Rigs for the drilling in Bhabar area and others as "the Project for Exploitation of Groundwater in India (Phase-1)" (hereafter, "Phase-1 Project"), implemented in 1989 and 1990 through the grant aid followed by another Japanese grant aid for "The Project for Exploitation of Groundwater in India (Phase-2)" (hereafter, "Phase-2 Project") in 1992 to procure another three Cable Percussion Rigs and others.

The Indian Government requested a grant aid from Japan in January 1993 for the supply of equipment for water quality monitoring and for equipment for tubewell construction. The supply of the equipment for water quality monitoring was aimed at improving the capability of the prevention and control of water pollution taking the lack of such equipment into consideration; and the supply of the equipment for tubewell construction was aimed at promoting further groundwater development in the Bhabar area; and at promoting development of possible deep-seated groundwater aquifers located in the alluvial plain.

In response to this request, the Japanese Government decided to carry out a basic design study, and the Japan International Cooperation Agency (JICA) dispatched a Basic Design Study Team to India from December 1 to December 21, 1993, to examine its feasibility as a grant-aid project, along with the effects of the grant aid and the details of cooperation required from Japan. In order to determine the appropriate design and the scope of the Project, the Study Team conducted discussions with the Indian government officers concerned as well as the site survey.

Upon its return to Japan, the Study Team analysed the results of the site survey and recognised that the need of the effective equipment for the prevention of water pollution is a common importance not only for CGWB but also for the entire India and that the implementation of the Project will not only improve the equipment for water quality monitoring of CGWB but also construct the base of overall effective water quality conservation system for the groundwater management for all the country. Based on the recognition, the Team formulated the Basic Design appropriate to CGWB by selecting equipment which is practically operationable in CGWB and orients the future requirements examining such important factors as the operation plans of CGWB, the technical levels and maintenance capability of CGWB, and the foresight of the future trend of water quality monitoring in CGWB and in India. However, the equipment for tubewell construction is not included in the Project because it is concluded no further supply of the equipment is necessary at the present time. As a result, the Basic Design of the Project was decided to be limited to the equipment for water quality monitoring. The following is a summary of the Project outline.

Although major Project sites, where will be installed with the equipment for water quality monitoring through the implementation of the Project, are the Central Chemical Laboratory in Lucknow and the Chemical Laboratories in Calcutta and Hyderabad, other 9 Chemical Laboratories will be installed with some pieces of equipment. The number of water samples to be analysed is estimated to be about 29,000 in 1997. It is decided that one unit of the Inductively-Coupled Plasma Spectrometer (ICP) is to be installed in Hyderabad where CGWB is planning to install it at the existing Chemical Laboratory. Regarding ICP, two units are requested by CGWB for Lucknow and Hyderabad. Out of two, one unit of ICP is no problem because its project site is Hyderabad and its installation is specified to the existing Chemical Laboratory. On the other hand, another unit of ICP can not be justified because its installation is not be specified within the implementation schedule although the its project site is specified to be Lucknow. Thus, it is judged appropriate to install one unit of ICP at Hyerabad.

The Project is outlined in Table S.1 which specify the Project equipment grouped by the objectives of analysis and use in (1) heavy metals, (2) organic compounds, (3) elements and inorganic compounds, and (4) peripheral equipment.

Table-S.1 The List of the Equipment for the Project

	Name of Equipment	No. of Equipment	Locations
Heavy Metals	Inductively-Coupled Plasma Spectrometer (ICP)	1	Hyderabad
	Atomic Absorption Spectrophotometer (AA)	3	Lucknow, Calcutta, Hyderabad
Organic Compounds	Gas Chromatograph (GC)	2	Lucknow
	Total Organic Carbon Meter (TOC)	1	Calcutta
Elements and Inorganic Compounds	Semi-Automatic Analysis System (SAA)	13	12 Chemical Laboratories
	Ion Meter (IM)	13	12 Chemical Laboratories
Peripheral Equipment	Vadose Zone Sampler (VZS)	24	12 Chemical Laboratories
	Table-Type Water Treatment Equipment (TWT)	3	Lucknow, Calcutta, Hyderabad

CGWB is requested to provide the budget for the implementation of the Project as follows:

The costs for anti-dust measures is calculated at 299,000 Rupees (approx. 865 thousand Yen).

The operation and maintenance costs for the equipment is estimated at 1,261,000 Rupees/year (approx. 4,325 thousand Yen/year).

As mentioned earlier, the Project will be implemented by CGWB. In regard to the operation and maintenance capabilities of CGWB, the Team could evaluate that CGWB has the sufficient technical level to perform the operation and maintenance of water quality analysis works. As regards their budget, the Team also could evaluate that CGWB is capable of paying the operation and maintenance costs for the equipment to be procured.

Through the implementation of the Project, it is expected that the analysis capacity of equipment for water quality monitoring possessed by CGWB, will be remarkably improved. Such effects are expected with the implementation of the Project as follows. The Project is also expected to widely contribute to the improvement in the sanitary environment for the country. Therefore, implementation of the Project under grant aid scheme is considered feasible.

1. The implementation of the Project will enable CGWB to analyse a substantially increased quantity of water samples with necessary accuracy for analysis for heavy metals, organic compounds, elements and inorganic compounds.

2. The results explained above will enable CGWB to publish the annual report and maps on nation wide changes in water quality from year to year and years which are suggested by the Ministry of Environment and Forests.

3. The effects of the accurate reports and maps obtained enable administrators to envisage the situations, to establish policies and to enforce the remedy measures legislation, scientists to establish definite and effective remedial measures by clarifying the scientific ground for the remedy of the change or deterioration in water quality and inhabitants to recognise the pollution problems objectively.

4. Thus, the Indian Government will be able to save or minimise the hazards and also able to establish early remedial programmes.

5. In the 17 specified industrial estates, the effects of the implementation of the Project will enable CGWB to assess the extension of damaged area to the groundwater regime due to

unscientific disposal of wastes, suggest alternatives, and prepare remedy and implement programmes.

6. The compiling data and experiences will enable CGWB to safeguard such situations in the future in the major urban complexes and agricultural belts as well as industrial estates.

7. There have already been problems of water pollution in areas at the initial stage of industrialisation in India. The implementation of the Project enables the Indian Government to clarify the water pollution mechanism through scientific investigation on the present situation and to establish early prevention policies for water quality in further development.

Through the implementation of the Project, the analysis capability is expected to be improved in all 12 Chemical Laboratories. It may cause the problems of the lack of the consistency of data and of the loss in personnel, equipment and materials if each Chemical Laboratories is operated separately. A well organised structure will be needed for the all 12 Chemical Laboratories to prevent these problems. Therefore, it is recommended to form a committee and sub-committee organisation which is composed of all Chemical Laboratories of CGWB for the standardised activities. The organisation will establish the goals and the long term programme and will conduct an efficient and effective operation, control and maintenance for the Project equipment through the formulation and implementation of various standards under the goals and the programme.

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LIST OF ABBREVIATIONS

AA	Atomic Absorption Spectrophotometer
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
CPU	Central Processing Unit
ECD	Electron Capture Detector
E/N	Excange of Notes
ETO	Exploratory Tubewells Organisation
FID	Flame Ionization Detector
FPD	Flame Photometric Detector
FTD	Flame Thermionic Detector
GC	Gas Chromatograph
GC-MS	Gas Chromatograph/Mass Spectrometer
GDP	Gross Domestic Product
GNP	Gross National Product
ICP	Inductively-Coupled Plasma Spectrometer
IM	Ion Meter
JICA	Japan International Cooperation Agency
NDIR	Nondispersible Infrared Gas Analyzer
NWB	National Water Board

NWRC	National Water Resources Council
PCB	Poly chlorobiphenyl
sPCB	StatePollution Control Board
SAA	Semi-Automatic Analysis System
TC	Total Carbon
TCD	Thermal Conductivity Detector
TID	Thermionic Detector
TOC	Total Organic Carbon Meter
TWT	Table-Type Water Treatment Equipment
VZS	Vandose Zone Sampler

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

The Indian Government has placed the priority since the First Five Year Plan on the "provision of safe drinking water to all the people" among others. And the Eighth Five Year Plan (1992-96) still states that "The country has not yet been able to provide a sustainable source of safe drinking water to all the people, particularly in the rural areas" regarding "Drinking Water". As 80% of the rural water supply and 50% of the agricultural water depends on groundwater, the groundwater development has played very important roles for the supply of water in rural areas as well as for the development of agriculture, which is India's major industry. On the other hand, India, who is endeavouring the economic development, particularly by the industrialisation, in order to improve and strengthen the national economy, is facing environmental problems which are posed to by unsustainable development activities and expansion of settlement activities partly because of developing conditions of infrastructure.

In India, the Ministry of Environment and Forests is the national body to serve as the focal point in administrative structure for environmental problems, and has given much efforts for the prevention of water pollution recognising its critical impact on human being and ecology. Thus, CGWB, who is the apex national organisation for groundwater, is conducting monitoring water quality of groundwater in India and the detailed surveys for the 17 industrial estates where the degradation of water quality by the industrial wastes is specified. Recently, however, the water pollution problems have been increasing with diversified pollutants and toxic elements which may pose critical impact on ecology even with a small quantity, and CGWB can not respond to the problems to analyse required water samples within time framework with necessary accuracy with the equipment for water quality monitoring which CGWB possesses. Therefore, it is urgently needed for CGWB to improve and strengthen the equipment to solve the problems.

In such background, the Indian Government requested a grant aid from Japan in 1988 to supply drilling rigs and geophysical prospecting equipment necessary for the groundwater development in the Bhabar area which has a thick boulder formation locating at the foot of Himalayas. Upon this request, the Japan International Cooperation Agency (JICA) implemented the "India and Pakistan Project Formulation Study" in 1989, and the Japanese Government decided to supply four Cable Percussion Rigs and Geophysical Prospecting Equipment, such as Seismic Equipment, to India through a grant aid in 1989 and 1990 as the Phase-1 Project.

In 1992 the Indian Government again requested grant aid for the supply of drilling rigs and geophysical prospecting equipment necessary to promote further groundwater development in the Bhabar area. The Japanese Government decided again to supply three Cable Percussion Rigs and Geophysical Prospecting Equipment, such as Seismic Equipment, to India through a grant aid in 1992 as the Phase-2 Project.

In 1993 the Indian Government requested a grant aid related to the supply of the equipment for water quality monitoring as well as the equipment for tubewell construction for groundwater development in the Bhabar area and the alluvial plain area. Responding to this request, the Japanese Government decided to carry out a basic design study, and JICA dispatched a Basic Design Study Team to India, headed by Mr. Yuji Maruo, Senior Development Specialist, JICA, from December 1 to December 21, 1993 (for 21 days). The Study Team conducted a site survey in order to confirm the feasibility of the grant-aid project by examining the background of the request, the details and scope of cooperation, and the effects of the grant aid.

This Basic Design Study Report was prepared in Japan based upon the analysis on the results of the discussions and the site survey. The Report includes the appropriate Basic Design for the equipment, the implementation plan, the maintenance and management plan, and recommendations for the implementation of the Project. The Minutes of Discussions, the List of Study Team Member, the Itinerary of Field Survey, and the List of Persons Visited are attached as Appendices to this Report.

CHAPTER II

BACKGROUND OF PROJECT

CHAPTER II

BACKGROUND OF PROJECT

2.1 BACKGROUND OF PROJECT

2.1.1 National Development Plan

India began the First Five Year Plan (1951-56) shortly after the Independence in 1947 and India is currently into its Eighth Five Year Plan (1992-96). The basic ideas of Five Year Plan are believed to have had a two hold objective: "accelerating the economic development" and "the attainment of the social justice". The Eighth Five Year Plan, which was prepared by the Planning Commission and approved and endorsed by the National Development Council on December 23-24, seeks to give a new approach to planning in India. The Government of India has initiated a series of policy measures to combat such problems as mounting fiscal deficits, increasing non-plan expenditure and the chronic current account deficits. The Eighth Plan is indicative essentially that industry and trade will be increasingly freed from control. It is also stimulating the initiative and participation as a key element in the process of development. Those efforts are pointing to the wave of economic reforms which has been sweeping the developing world and will be very important for India too in nineties. Therefore, the Plan emphasises the constructing a long-term strategic vision of the future, anticipating future trends and achieving the highest possible level of development. Also the Plan suggests the necessity of withdrawal of public sector from the areas where their presence is not serving public purpose. Thus, such objectives are sought to give priority that "provision of safe drinking water and primary health facilities" as well as adequate employment generation, containment of population, growth, eradication of illiteracy, self-sufficiency in food, generation of agricultural surpluses for export and strengthening of the infrastructure.

2.1.2 Development Plan Related to the Project

(1) Development Plan for Groundwater

In India water is considered vital for realising full potential of agriculture and country's development. Therefore, it is very significant to develop appropriately and utilise sufficiently water resources and the development of water resources is being given the high priority.

The Government of India constituted National Water Resources Council (NWRC) in March, 1983, as an apex body for evolving national policies to develop use of water resources in conformity with the highest national interests, under the Chairmanship of Prime Minister and Union Ministers of Water Resources, Planning, Science and Technology, Agriculture and Cooperation, Rural Development, Urban development, Surface Transport, Environment and Forests; Chief Ministers of State Governments and Administrators of the Union Territories as Members and Secretary of Ministry of Water Resources as the Secretary. NWRC unanimously adopted the National Policy.

The Government of India also constituted the National Water Board (NWB) of NWRC on 24, September, 1990 to review the progress achieved in implementation of the National Water Policy and report to NWRC from time to time under the Chairmanship of Secretary, Ministry of Water Resources, and Secretaries of Union Ministries of Planning, Science and Technology, Agriculture and Cooperation, Rural Development, Urban Development, Surface Transport. Environment and Forests; Chairman, Central Water Commission; and Chief secretaries of States/Union Territories as Members.

The Ministry of Water Resources is responsible for establishing policy guidelines and programmes for the development and regulation of water resources. The Ministry was formed in October, 1985 and assigned the nodal role for development, conservation and management of water as a national resources. A "National Water Policy" adapted in September 1987, defines that water is the most crucial element. And the Policy assigned the highest priority to drinking water followed by irrigation, hydro-power, navigation, industrial and other uses. The Policy further recommends that the quality of surface and groundwater should be monitored.

Although one of the highest priorities is "to provide sustainable source of clean drinking water to all the people" in the Eighth Five Year Plan, it says that "The country has not yet been able to", "particularly in rural areas". Therefore, in the Plan, "Water quality monitoring is to be streamlined and given proper emphasis to ensure safe drinking water". Further, it points out the necessity of "replacement and rejuvenation of defunct handpumps/tubewells" and of "conservation of water and recharge of aquifers" on a large scale. It concludes "Much greater efforts are needed to provide adequate quantity and quality of water and to make the sources sustainable".

The total investment related to water is shown in Table-2.1.1 for the Eighth Five Year Plan.

Table-2.1.1 Total Investment Related to Water for Eighth Five Year Plan

(Unit: 10 Million Rs.)

	Total Budget	Irrigation and Flood Control	Water Supply and Sanitation
Union Government	247,865.00	1,500.00	5,968.00
States Government	179,985.00	30,945.10	9,847.26
Union Territories	6,250.00	80.19	895.77
Total	434,100.00	32,525.29	16,711.03

Source: Eighth Five Year Plan, 1992-96

(2) Regulations related to the Project

The Indian Government considers that "Unsustainable development activities, poverty and under development in pockets collectively pose threat to the environment and urgent remedial measures are now required for restoring the environment degradation and maintaining ecological balance". The Indian Government paid attention to problems related to environment in the beginning of the Fourth Plan (1969-1973) and committees on environmental coordination were set up in 1972 and 1980. On the recommendation by the latter committee, the Department of Environment was set up in 1980 and reformed as the Ministry of Environment and Forests in 1985 for planning, promotion and coordination of environmental forestry programme. In India there are about 30 major enactments related to protection of environment. "The Water (Prevention and Control of Pollution) Act, 1974" ; "The Air (Prevention and Control of Pollution) Act, 1981"; "The Factories Act"; and "Insecticides Act" are among them. And to focus the authority to prevent or limit damages, "Environment (Protection) Act, 1986" was enacted. The Government has given the priority to prevention of water pollution which can ill-affect the ecology critically. The Indian Government emphasises the importance of environmental protection in the Eighth Five Year Plan as "Environment, ecology and development must be balanced to meet the needs of the society. In the interest of sustainable development, it would be necessary to take measures to preserve, conserve and nature, the fragile and critical ecosystems".

The "Environment (Protection) Act" enacted in 1986 is pointed out to have those salient features in "India 1992" as follows:

(A) Conferring powers on the Central Government to:

1) Take all necessary measures for protecting quality of environment
2) Coordinate actions of states, officers and other authorities under this Act or under any other law related to the objects of this Act
3) Plan and execute a nationwide programme for prevention, control and abetment of environmental pollution
4) Lay down standards for discharge of environmental pollutants
5) Empower any person to enter, inspect, take samples and test
6) Establish or recognise environmental laboratories
7) Appoint or recognise government analysts
8) Lay down standards for quality of environment

9) Restrict areas in which any industries, operations, or processes may not be carried out or shall be carried out subject to certain safeguards
10) Lay down safeguards for prevention of accidents and take remedial measures in case of such accidents
11) Lay down procedures and safeguards for handling hazardous substances
12) constitute an authority or authorities for exercising powers
13) Issue directions to any person, officer or authority including the power to direct closure, prohibition or regulation of any industry, operation or process or stoppage or regulation of supply of electricity, water or any other services
14) Require any person, officer, state government or authority to furnish any prescribed information
15) Delegate powers to any officer of a state or authority

(B) Conferring powers on persons to complain to courts regarding any violation of the provisions of the Act, after a notice of 60 days to prescribed authorities.

(C) The Act makes it obligatory for the person in charge of a place to inform the prescribed authorities regarding any accidental discharge or apprehended discharge of any pollutant in excess of prescribed standards. Authorities on receipt of such information or otherwise shall take remedial measures to prevent or mitigate pollution caused by such accidents and expenses incurred by the authorities in respect of remedial measures are recoverable with interest from the polluter.

(D) It prescribes stringent penalties for violation of the provisions of the Act. No distinction is shown between governmental department and other companies.

(E) Jurisdiction of civil courts is barred under the Act.

The Central Pollution Control Board (CPCB) is the national apex body for assessment, monitoring and control of water and air pollution.

Twenty three states of the Union have already adopted the "Environment (Protection) Act" and the state Pollution Control Boards (sPCBs) have been constituted to collaborate with CPCB.

Regarding the environmental administration in India, some problems are pointed out.

(1) Some regulations related to environment were enacted very long ago. They seem lack of consistency because they do not clarify the objectives and achievement standards and they have been interpreted and applied from time to time.

(2) There are some regulations which are inappropriate because governmental policies have been altered, or economic, social and environmental conditions also have been changed.

(3) State government may enact their own regulations while they are enacting union regulations. Thus, the regulatory system tends to lose the unity.

(4) Generally, powers of authorities are weak. For example, no distinction is expected between governmental department and any other institute or size of polluting sources, and etc. So any pollution sources should be in accordance with the definitions of the Act. The achievement so far is not sufficient despite the endeavouring of CPCB.

(5) The reasons of poor achievement is believed to be caused by the lack of the personnel (particularly experienced) related to the environment prevention, the lack of analysis equipment, facilities and laboratories for environmental protection and monitoring, the lack of smooth coordination among institutes related.

(6) Although the revision of the regulations have been made, it is worried that slow enforcement of regulations, administration and assessment of the regulatory performance due to (5).

2.2 OUTLINE OF THE REQUEST

2.2.1 Executing Agency

The Central Ground Water Board (CGWB) under the Ministry of Water resources is the Executing Agency. As a national apex body, CGWB carries out and advises scientific development and management of groundwater resources from central perspective. CGWB deals with all matters related to groundwater resources in India such as hydrogeological surveys, exploration, assessment, development, and scientific management. Large-scale scientific development began in 1934 with the drilling of 1,500 wells in Uttar Pradesh State, a project site in the original request. The Exploratory Tubewells Organisation (ETO), formed in 1954 by the Government of India, was renamed as CGWB in 1970. And that was reorganised by merging with the Ground Water Wing of Geological Survey of India in 1972. Then CGWB could facilitate scientific functions. As a part of those activities, CGWB drills approximately 800 tubewells annually for the exploratory and delineation of various hydrogeological areas. Upon the request from the Ministry of Environment and Forests, CGWB also conducts water quality analysis of samples collected at about 16,000 hydrographic stations and conducts also detailed studies on the pollution mechanism in the specified 17 industrial estates.

2.2.2 Background of the Request

Under such circumstances, CGWB, having 16,000 hydrograph monitoring stations in the country, collects samples at the stations once a year and conducts water quality analysis at 12 Chemical Laboratories across the nation as a part of water management (The locations of the Laboratories are shown in Fig. 2.2.1). In addition to such routine tasks, CGWB conducts detailed studies on the possible pollution hazards at 17 industrial areas where the degradation of water quality were identified (Refer to Fig. 2.2.2) upon the request from the Ministry of Environment and Forests. According to the study results in 1992, a

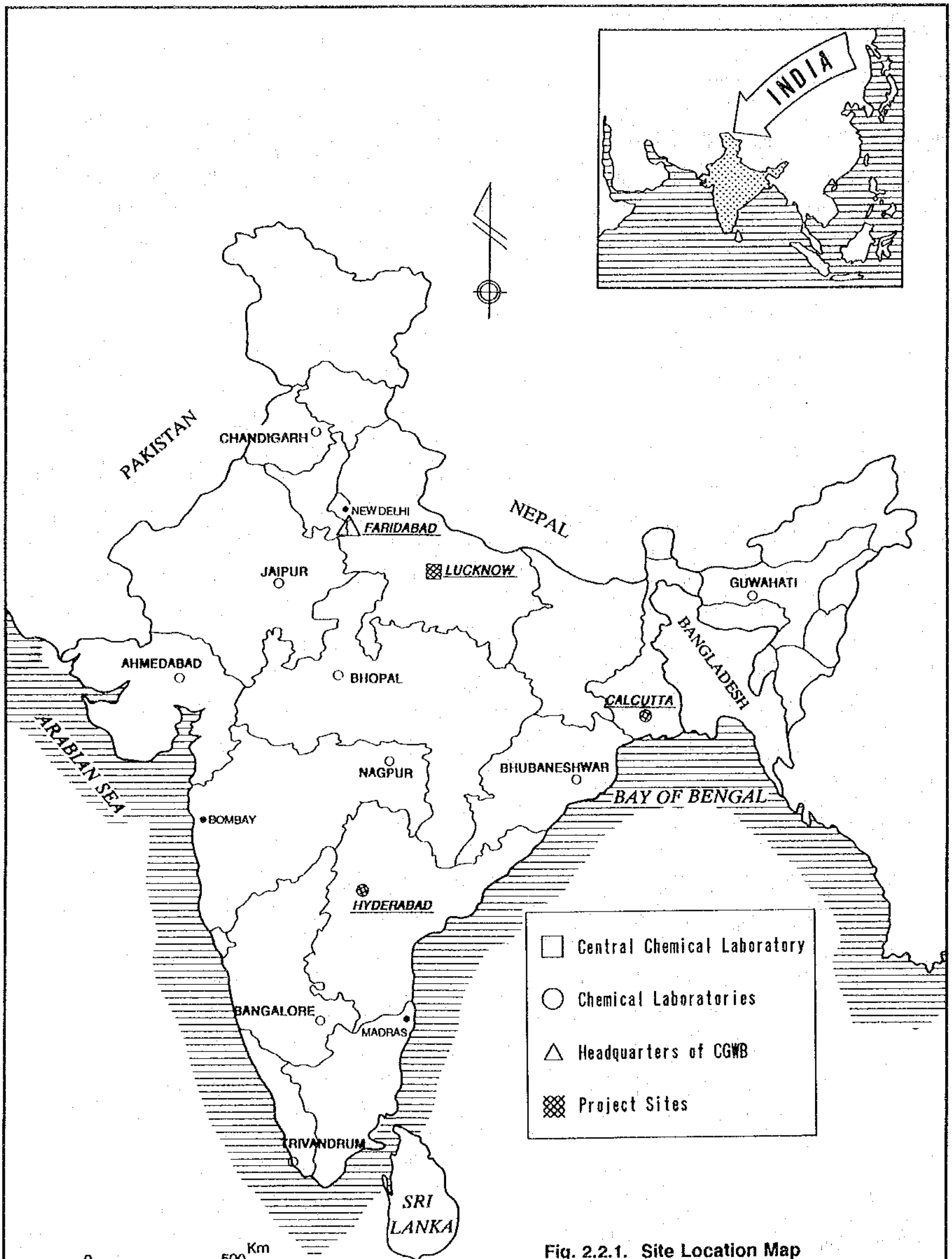


Fig. 2.2.1. Site Location Map

(CGWB Chemical Laboratories and Project Sites)

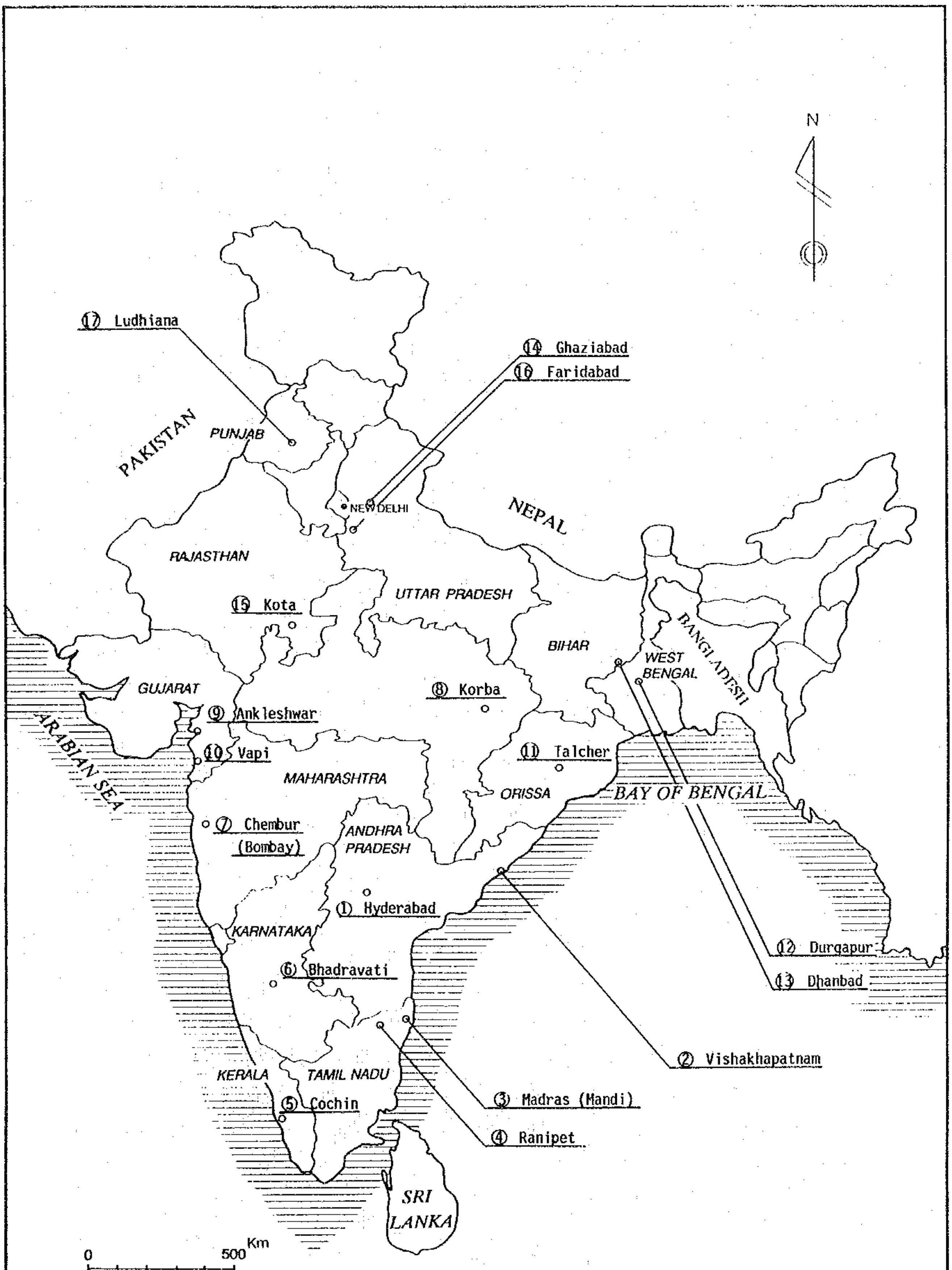


Fig. 2.2.2. Location Map of 17 Specified Industrial Estates

maximum 6.35 ppm of chromium was detected from seven water samples among 40 taken from the Kanpur observatory wells in UP State; a maximum 290 ppb of arsenic was detected from samples from observatory wells in Malda, in the West Bengal State. Industrial waste water is suspected to be the cause of water pollution. The suspicion of pollution by pesticides is also reported; although from shallow wells, a maximum of 1,250 ppm nitric acid from nitrogenous fertilisers was detected in the wells at Jaunpur in UP State. Based on these examples, pollution by industrial waste water and pesticides is suspected to be on the increase. However, CGWB lacks sufficient number of equipment for analysis necessary to conduct water quality tests at the observatory wells. Some samples of pollution reported are shown in Appendix-7 of this Report, as "Summary of Pollution Studies in India".

At the same time, India suffered severely from drought in 1987 nationwide. The Indian Government decided and the Cabinet approved to procure 22 units of domestic drilling rigs and 7 units of foreign drilling rigs to construct tubewells for the provision of safe and stable drinking water to relieve it. One area severely affected by the drought was located in Bhabar area having unique hydrogeological conditions of thick boulder formations, which had been left undeveloped. The Bhabar area, located at the foot of the Himalayas (see Fig. 2.2.3), is in an agricultural region highly populated with many poor people. The Indian Government has naturally placed its priority to relieve the situation there.

Although this area had the potential to supply groundwater, the development of groundwater was difficult because the percussion rigs CGWB possessed could not perform as practical means of groundwater development. Therefore, the Indian Government decided to request drilling rigs. In the framework of importing 7 foreign drilling rigs, as approved earlier by the Cabinet, the Indian Government requested the supply of Cable Percussion Rigs with a large capacity suitable for drilling in this area and their related to the equipment, and Geophysical Prospecting Equipment for groundwater exploitation, as a

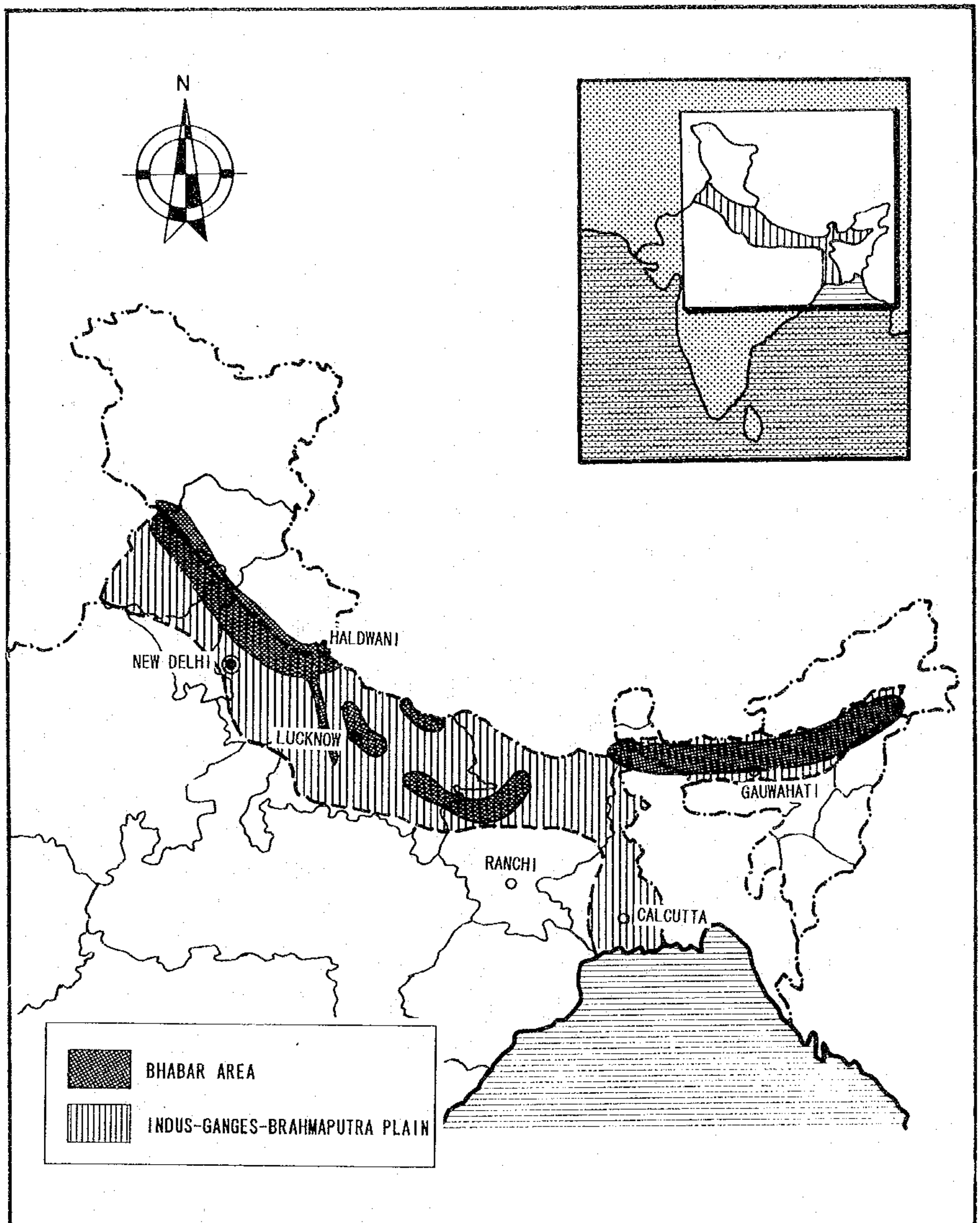


Fig. 2.2.3. Location of Bhabar Area and Indus-Ganges-Brahmaputra Plain

grant aid project from the Japanese Government. Responding to this request, the Japanese Government conducted the "India and Pakistan Project Formulation Study (Groundwater Development)" between August and September in 1989. Based on its report, the Japanese Government conducted "The Project for Exploitation of Groundwater in India (Phase-1)" in Part 1 (fiscal 1989) and Part 2 (fiscal 1990) as a grant aid programme.

To accelerate further groundwater development in the Bhabar area, the Indian Government requested once again in 1992 for the necessary drilling rigs and geophysical prospecting equipment as a grant aid from the Japanese Government. The Japanese Government decided to provide 3 more Cable Percussion Rigs and Geophysical Prospecting Equipment, such as Seismic Equipment through a grant aid in 1992 as the Phase-2 Project.

The Indus-Ganges-Brahmaputra alluvial plain extends to the area adjacent to the Bhabar area (see Fig. 2.2.3). Heavy alluvial deposits have accumulated on the plain, and the total depth of drilling in the area was limited to around 500 m. Recently CGWB started to deploy drilling rigs of larger capacity (900 m drilling capacity).

Under these conditions, the Indian Government requested a grant aid from Japan in January 1993, to supply equipment necessary to improve the water quality monitoring system for controlling water pollution, and to promote groundwater development using tubewell construction equipment in the Bhabar area located at the foot of the Himalayas, and in the area of the alluvial plain.

2.2.3 Outline of the Request

The outline of the original request is shown in Table-2.2.1.

Table-2.2.1 List of Equipment Requested in the Original Request

	Equipment	Major Specification	No. of Units
I Equipment for Water Quality Monitoring	(1) Inductively-Coupled Plasma Spectrometer (ICP)	Heavy Metal Analysis	3
	(2) Gas Chromatograph (GC)	Organic Compound Analysis	3
	(3) Auto-Analyser	Elements & Inorganic Compound Analysis	3
	(4) Atomic Absorption Spectrophotometer (AA)	Heavy Metal Analysis	2
	(5) Ion Meter (IM)	Elements & Inorganic Compound Analysis	13
	(6) Mass Spectrometer	Stable Isotope	2
	(7) Vadose Zone Sampler (VZS)	Sample Vadose Zone to Depth of 3 m	30
	(8) Field Kits for on-site Determination of Major Elements	Pack Type	100
	(9) Digital Continuous Water Level Recorder	Digital Type	100
	(10) Computer Software	Use for all above	1
II Tubewell Construction Equipment	(1) Cable Percussion Rig	Drilling Capacity: 300 m Target Area: Boulder Formation Tools: Open-hole Drilling Tools for Percussion Rigs, Necessary Accessories Others: Spare Parts for 3 Years	4
	(2) Open-hole Drilling Tools for Percussion Rigs	For the Existing Cable Percussion Rigs	4
	(3) Direct Rotary Drilling Rig for Deep Aquifer System	Type: Rotary Table Drilling Method Mud-Circulation Method Drilling Capacity: Approximately 900 m Bore: 8" Diameter Drill Pipe: 4-1/2" Tools: Necessary Accessories Others: Spare Parts for 3 Years	2

I Equipment for Water Quality Monitoring

The Ministry of Environment and Forests suggested that CGWB may issue annual reports on changes in water quality year by year over a long period. The purpose of the reporting is to specify the areas where changes or deterioration of water quality are observed in order to investigate the reasons so that appropriate remedial strategy is worked out. The Ministry also requested CGWB to conduct a detailed study on the groundwater quality and its deterioration in the 17 industrial areas where the pollution caused by the industrial disposal of wastes has been identified. As mentioned earlier, CGWB wishes to conduct long-term studies related to the interaction of groundwater, contaminants, and aquifers in the 17 industrial areas.

The objectives of the work will be to carry out the investigation periodically of water quality changes over time and space. By documenting the results as reports and maps, it is possible to educate and people on the aspects of the pollution, to enable scientists and government officers to take the necessary counter-measures to remove or reduce the ill effects of pollution on human beings.

CGWB understands that Groundwater pollution is controlled by those factors such as,

1) reactions in the top soil and unsaturated geological units (vadose zone),
2) the effect of soil moisture deficiency,
3) the laminar flow of pollutants,
4) gravity and viscosity effects, and
5) the slow movement of effluent.

CGWB further understands that such important processes as biological degradation, filtration, adsorption, oxidisation and reduction take place in the top soil and the vadose zone. Because of these reactions several constituents may be removed or added to filtration of water depending on the characteristics of pollutants given and nature of the formations where the pollutants move, since the storage capacity and moisture characteristics of the vadose zone play an important role in controlling the filtration of waste waters. In short, in order to grasp the process of pollution in unsaturated formations, it is necessary to understand characteristics of these formations. Therefore, a survey that includes the layers from the surface soil to the ground water level, constituents of the unsaturated formation, groundwater, solid waste, and liquid waste is necessary. Consequently, CGWB wished to include a vadose zone sampler for the unsaturated layer in its request for equipment.

The groundwater in the adjacent area is polluted because of the industrial disposal wastes at the 17 industrial sites. CGWB believes that the equipment for water quality monitoring will have the following effects if procured.

(1) to accurately evaluate the extent of damage to the groundwater quality regime due to unsystematic disposal of wastes,

(2) to suggest alternatives based on the evaluation results,

(3) to prepare abatement programmes,

(4) to lay implementation strategies and schedules, and

(5) to specify areas where the water quality has already degraded other than the 17 identified industrial area.

Hence CGWB believes it is necessary to conduct water quality analysis by linking data obtained through the equipment for water quality monitoring with existing groundwater quality data, hydrogeological surveys, and related studies.

Therefore, it is necessary to improve the observatory well network across the country and to observe the water quality in the various aquifers. Through these observations, CGWB expects to evaluate and calculate the hydrogeological parameters accurately. Through a sedimentological study of each area and an analysis of the soil, CGWB can evaluate how filtration,

absorption, oxidation, and reduction of materials occur in the surface soil and in the sediment formations.
Using the parameters obtained, as a result, a mathematical model can be created for each region. The ultimate goal of CGWB is to simulate the migration of contaminants, the anticipated water quality, and water resource availability at given times and space. As CGWB analyses groundwater quality on a regular basis, it is expected to publish reports and maps related to water quality.

From the perspective of water quality standards for drinking water, the equipment for water quality monitoring in CGWB is limited as follows.

1. An Atomic Absorption Spectrophotometer (AA) is used for heavy metal analysis: Accuracy is satisfactory but analysis capacity is limited.
2. Analysis for organic compounds, such as pesticides, is very difficult with the present equipment.
3. Accuracy and analysis capacity is limited because of the manual analysis for elements and inorganic compounds.

It is difficult for CGWB to obtain necessary accuracy and there are even some elements which cannot be analysed with present equipment. It is also difficult to obtain timely analysis results due to insufficient analysis capacity. For these reasons the Indian government has requested the supply of the equipment for water quality monitoring, which are shown in Table-2.2.2.

Table-2.2.2 List of Equipment for Water Quality Monitoring

Type of Elements	Equipment for Water Quality Monitoring
Heavy Metals	Inductively-Coupled Plasma Spectrometer (ICP)
	Atomic Absorption Spectrophotometer (AA)
Organic Compounds	Gas Chromatograph (GC)
Elements & Inorganic Compounds	Auto-Analyser
	Ion Meter (IM)
Peripheral Equipment	Vadose Zone Sampler (VZS)
	Mass Spectrometer and Others

Therefore,

1. In order to perform heavy metal analysis, CGWB wants to conduct the simultaneous analyses for multiple elements with the Inductively-Coupled Plasma Spectrometer (ICP), which has high analysis capacity and high analysis accuracy, together with AA for single element analysis.
2. CGWB wants to use the Gas Chromatograph (GC) for organic compound analysis.
3. CGWB wants to use the Auto-Analyser and the Ion Meter (IM) for element and inorganic compound analysis.
4. CGWB wants to use other equipment, such as the Mass Spectrometer for stable isotopes analysis; the Vadose Zone Sampler (VZS) for taking samples of solutions in the topsoil; the Digital Continuous Water Level Recorder for the automatic recording of groundwater levels; and the Portable Field Kits for on-site determination of major elements.

With the supply of these pieces of equipment, CGWB intends to construct a water quality monitoring network across the country, an analysis system to rapidly analyse water samples from the water quality network, and a data processing system which can produce data to analyse the water sample results and to construct pollution countermeasures.

II Equipment for Tubewell Construction

Hence the request for Cable Percussion Rigs and Open-Hole Drilling Tools was withdrawn by CGWB during the discussions in India due to its lower priority, this type of drilling rig is decided not to be included in the Project. Therefore, only Direct Rotary Drilling Rigs for Deep Aquifer System will be examined hereafter.

According to the request, the Project Site for the Direct Rotary Drilling Rigs for deep aquifer system is the great alluvial plain which is known as the Indus-Ganges-Brahmaputra alluvial Plain (or simply the Ganges Plain). It is noted that the good aquifers in the Plain exist generally in the Upper Siwalik formation and alluvium.

Since the middle of the 1980s, the possibility of existence of the good aquifer system laying in the depth of 600 to 900 m has been received interests through the review of the oil survey records in the Plain collected by the Oil and Gas Commission of India. According to the oil survey records, some geological profiles of the Ganges Plain were drawn such as Fig. 2.2.4 through Fig. 2.2.6. Fig. 2.2.5 was drawn by CGWB. These figures suggest the thickness of sediment increases towards north to the boarder to Nepal and the prospective of groundwater development seems to increase towards north. This may be confirmed with the fact that CGWB encounters flowing wells in Tarai and sub-Tarai belt of alluvium in Jammu & Kashimir, Uttar Pradesh, Bihar and West Bengal. However, Fig. 2.2.5. reveals the degradation of water quality of aquifers with depth. Therefore, the possibility of existence of fresh water will be more increased to the regions close to the border to Nepal where CGWB has encountered flowing wells.

Although CGWB is planning to drill and delineate the extent of deep-seated groundwater which is said to widely exist in the above mentioned alluvial plain, the number of available drilling rigs is limited to two at the present time.

Therefore, the objective of the programme for the Direct Rotary Rigs is to conduct a preliminary exploitation within the drilling capability of the said Rigs so that the possibility for a large scale development programme for the deep aquifer system will be studied by analysing hydrogeological information to be obtained through the development of groundwater of the area. Therefore, the following information may be needed during the preliminary exploitation.

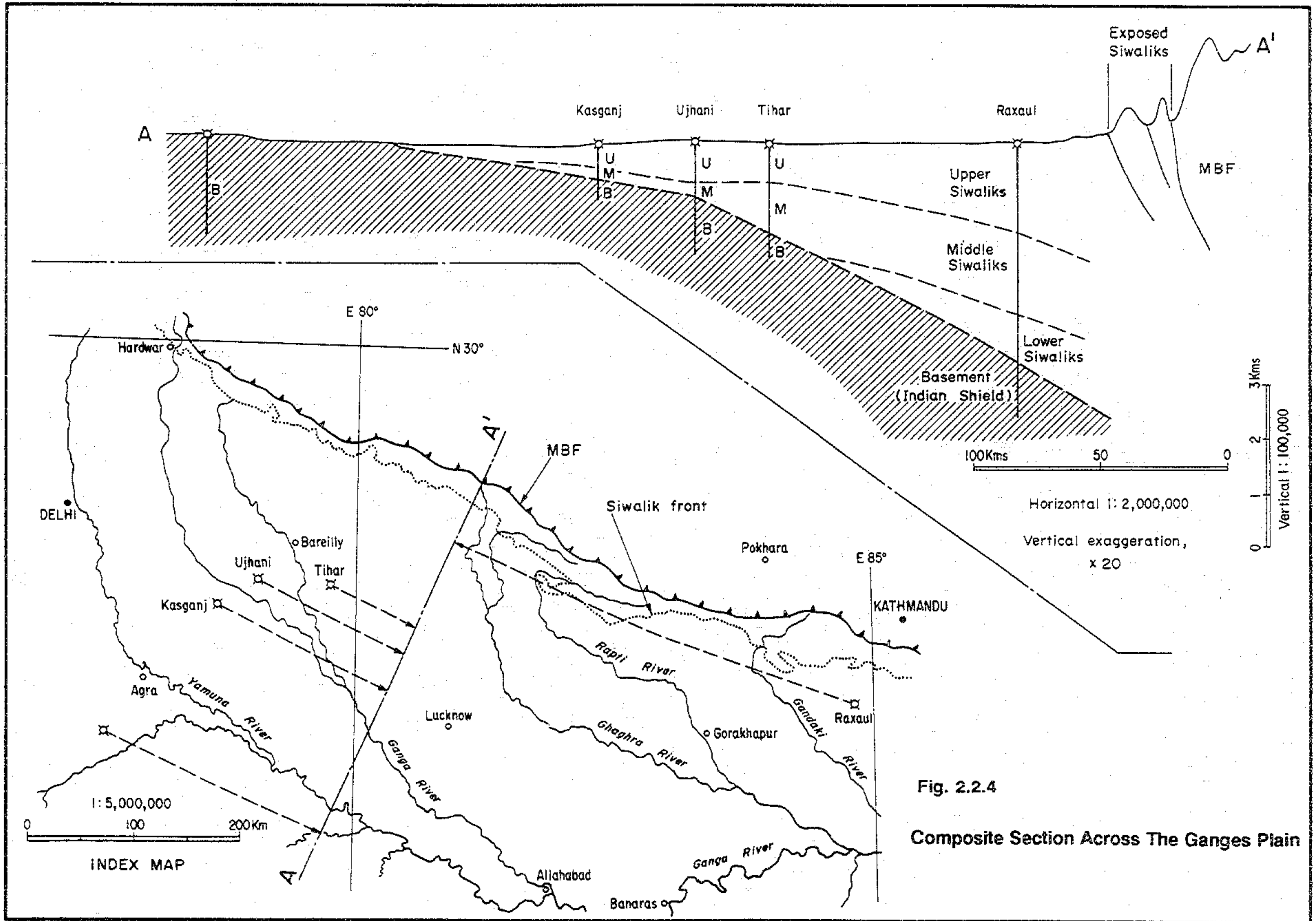


Fig. 2.2.4

Composite Section Across The Ganges Plain

Source : Land Resource Mapping Project, Geology Report His Majesty's Government of Nepal 1986

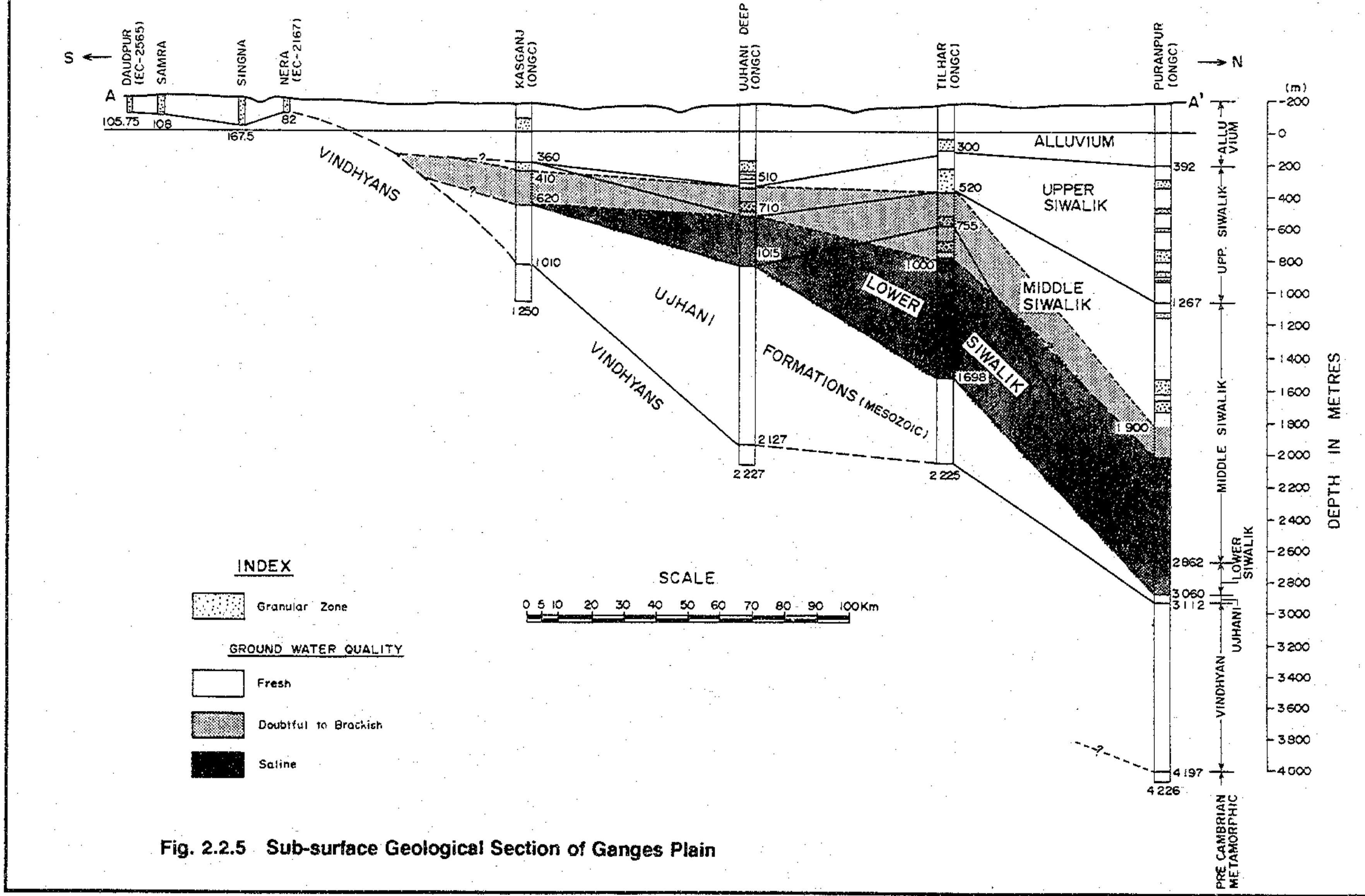


Fig. 2.2.5 Sub-surface Geological Section of Ganges Plain

Source : Tectonic Sub-surface Geology and Groundwater Occurence in Ganga Basin and Proposal for Deep Drilling with Special References Uttara Pradesh, Government of India 1985

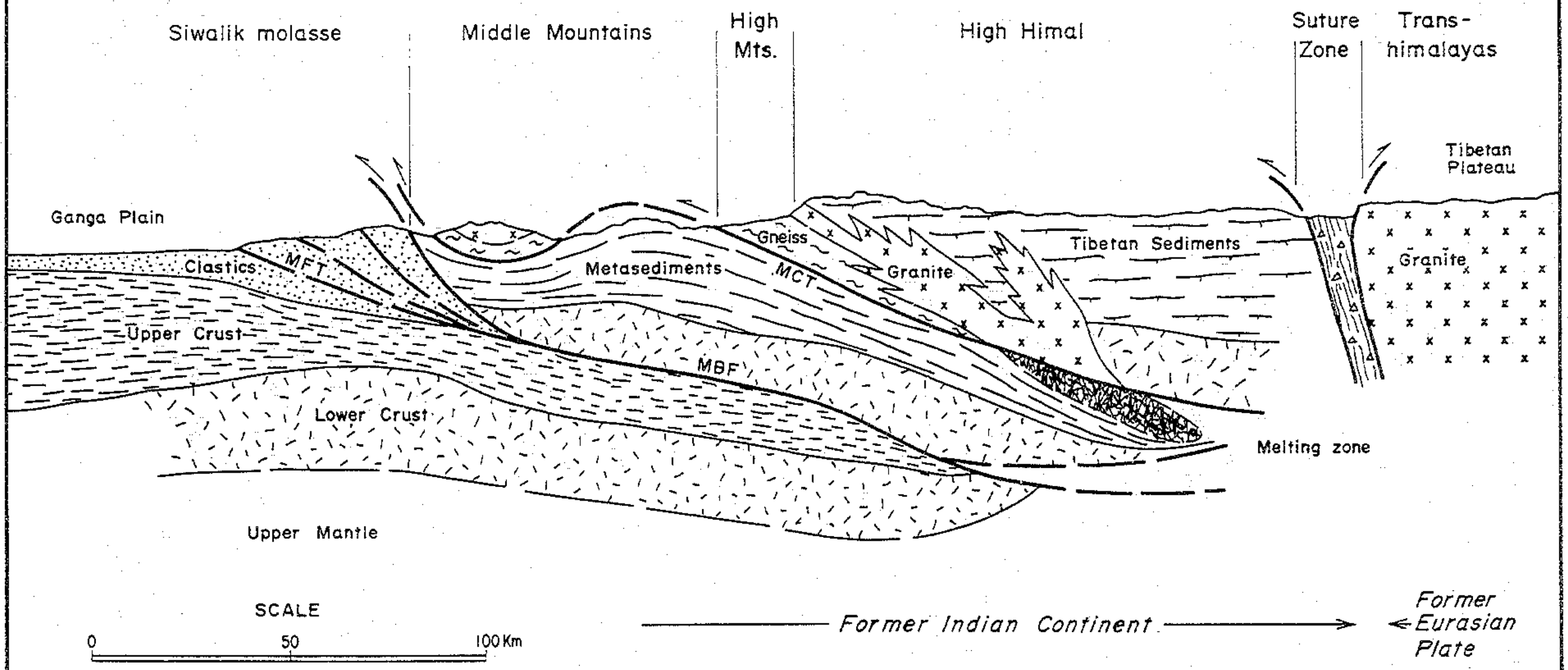


Fig. 2.2.6 Schematic Section, Ganges Plain to Tibetan Plateau

Modified after Andrieux *et al*, 1977 and Mitchell, 1979

Source : Land Resource Mapping Project, Geology Report His Majesty's Government of Nepal 1986

a) Geological study of the deep aquifer systems (structure, stratigraphy, distribution, continuity) and study of the mechanism of the groundwater cycle.

b) Study of hydrogeological constants of aquifers and surrounding formations and simulation analysis of the development assessment.

c) Water quality test of the groundwater of the deep aquifer.

d) Feasibility study of the groundwater at the depth of less than 600 m at the development site of the deep aquifer system.

e) Economic evaluation of development of the deep aquifer system.

As it will be discussed in 3.2.1., it is concluded not to include Direct Rotary Drilling Rigs in the Project. Therefore, the equipment for water quality monitoring will be discussed hereafter.

2.3 OUTLINE OF THE PROJECT AREA

2.3.1 Location of the Project Area

The Project Areas requested for the equipment for water quality monitoring are the three Chemical Laboratories located in Lucknow, Calcutta, and Hyderabad. And water samples will be analysed with the equipment in these three locations throughout the nation.

CGWB has an organisation for hydrochemical analysis. The Central Chemical Laboratory, as the central institute, is located at Lucknow and each Regional Directorate of Hydrogeological Wing has each a Chemical Laboratory. Therefore, there are 12 Chemical Laboratories including Lucknow. The location map of the Regional Offices was given in Fig.2.2.1. The Chemical Laboratories analyse water samples collected during the course of hydrogeological surveys, groundwater exploration, monitoring of hydrograph network stations, water supply investigation, and other activities. The equipment which CGWB currently possesses is shown in Table-2.3.1. The numbers of samples collected and hydrograph stations at each Chemical Laboratory are presented in Table-2.3.2, and the growth of the number of hydrograph stations is exhibited in Fig. 2.3.1.

Table-2.3.1 Equipment List for Chemical Analysis

Name of Equipment	No. of Units
Atomic Absorption Spectrophotometer (AA)	4
UV Spectrometer	12
pH Meter	75
Digital Flame Photometer	60
Colourimeter	75
Spectrophotometer	30
Electric Conductivity Meter	60

Table-2.3.2 The Number of Water Samples and Hydrograph Stations

CGWB Region Name	Head Quarters	Complete Analysis	Partial Analysis	Trace & Toxic Elements	Hydrograph Stations
Northern	Lucknow	708	1,328	269	1,605
Southern	Hyderabad	482	1,554	121	1,860
Eastern	Calcutta	791	886	216	1,546
Western	Jaipur	227	897	884	1,370
Central	Nagapur	452	1,296	-	1,444
North Eastern	Guwahati	-	614	-	548
North Western	Chandigarh	15	1,270	-	1,645
North Central	Bhopal	983	649	239	1,349
South Eastern	Bhubaneshwar	463	308	-	1,131
South Western	Bangalore	997	911	-	1,353
West Central	Ahmedabad	455	_	-	1,025
Kerala	Trivandrum	146	472	356	681
Pollution Directorate	Lucknow	19	348	143	_
Total	(18,500)	5,738	10,534	2,228	15,557

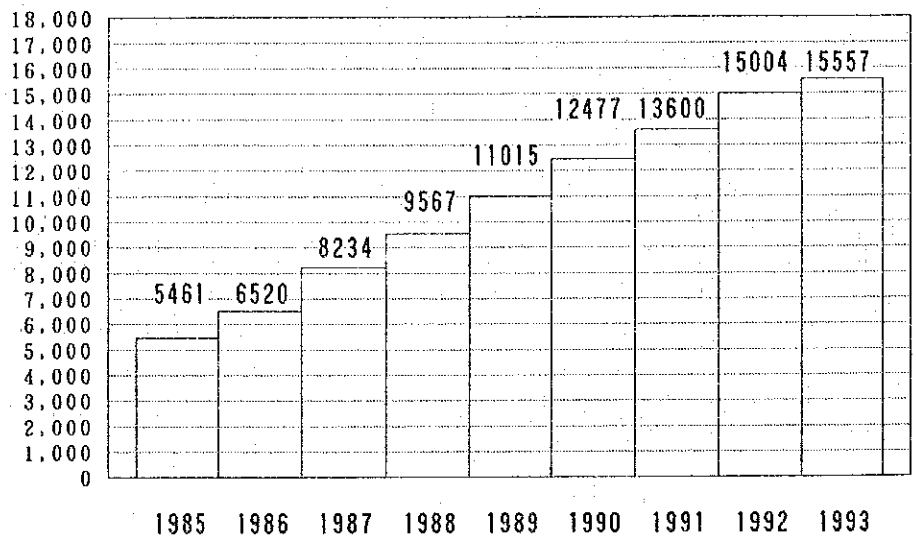


Fig. 2.3.1 The Number of Hydrograph Stations

The present conditions of Chemical Laboratories in Lucknow, Calcutta and Hyderabad were observed during the site survey. The observations are as follows.

(1) Buildings: CGWB may not have location problems in the three Project Sites because each Regional Office is equipped with regular type of air conditioners. However, it is observed that personnel as a custom in India enter the room without taking off their shoes, letting the room become dusty. It is recommended to take pre-cautions to avoid dust because ICP and AA are equipment highly sensitive to dust among the equipment requested. Special attention should be given to this point. CGWB may install the equipment at the present Chemical Laboratories because only about 50 m^2 of floor area is needed for the installation of the equipment (as will be discussed later). However, having its construction plan for new offices in Lucknow and Calcutta, CGWB is scheduled to complete the construction works in March 1995. The total floor areas are both in the neighborhood of 4,000 m^2 and 3,000 m^2 for Lucknow and Calcutta, respectively, and out of them the Chemical Section will occupy about 250 m^2. Therefore, it is judged that the construction plans for Lucknow and Calcutta will be sufficient for the installation of the equipment. CGWB

will not have problem of location for Hyderabad because CGWB is planning to install the equipment in the present office in Hyderabad.

(2) CGWB is using AAs, which were made in America during the 1970's and are no longer produced, in Lucknow, Calcutta, and Hyderabad. Almost half of the hollow cathode lamps have been consumed, and spare parts are very difficult to find. As a result, analyses depend on the only remaining hollow cathode lamps, which limits the items of analysis. The supply of spare parts are extremely difficult for the model in Hyderabad (Refer to Table-2.3.2).

(3) ICPs are also used in India. The number of ICPs is said to be roughly 20-30 pieces in the country, and the Japanese-made ICPs number approximately 10. ICPs have not been introduced to CGWB yet, but the experience tells ICP seems to be operative with regular air conditioners.

(4) CGWB is to a large extent using manual operation equipment such as the spectrophotometer, the flame photometer, the pH meter and the conductivity meter. An improvement in the peripheral equipment is desired at the stage of manual analysis (Refer to Table-2.3.2).

(5) CGWB is not using equipment such as GC for the analysis of organic compounds and pesticides.

(6) Indian companies produce reagents and standard reagents under license with British Standards; therefore, the supply of reagents and standard reagents is not considered a problem.

(7) Equipment such as beakers and measuring flasks are also produced under license with British Standards by Indian companies; therefore, this is not considered a problem.

(8) Pure water is supplied through distillation. Distilled water is produced by an ion exchange method; therefore, the water supply

is not considered a problem.

(9) In regard to the technical level of the personnel, the core members of each Laboratory are 4 to 5 Assistant Chemists, each with a Masters' Degree in Chemistry from a graduate school of a technical university, having strong academic background. Analysis has been conducted manually for a long time, and fairly careful operation is observed in the field which requires manual operation, such as preprocessing, and CGWB does not have any problem about this area. As they can use the very old type of AA which may not have been designed for easy operation, there poses no problems in using the equipment, including ICP. As GC is new to CGWB, an experienced person should be carefully selected to be in charge of GC. If internal recruiting proves difficult within CGWB, personnel must be hired from the outside who acquires basic knowledge.

(10) The important concern regarding facility is the unstable supply of electricity, with frequent power failures and voltage fluctuations. A stabiliser (Automatic Voltage Regulator:AVR) is used for all major pieces of electric and electrical equipment. AVR is necessary for all equipment when implementing the Project.

(11) Gases such as argon, hydrogen, and methane, are produced by Japanese companies in India are expected to be used in the Project; therefore, the supply of the gases is not considered to be a problem. These prices may be cheaper than the prices in Japan.

The specifications for the pressure regulator are different from those in Japan. Special care is required when delivering pressure regulators.

(12) As CGWB possesses only a limited number of analysis equipment with sufficient accuracy for water quality analysis, it is very difficult to analyse and process quickly. Therefore, it is necessary to provide equipment with a sufficient accuracy and

capacity of analysis. Also it is necessary to establish a nationwide water quality control system. In addition, it is necessary to establish a data bank to utilise the data obtained and compiled to prevent pollution or to remove pollutants. As the Indian Government continues to promote economic development through industrial and agricultural development, environmental problems are expected to grow worse. Therefore, urgent actions to solve those necessities are needed.

2.3.2 Socio-economic Conditions

(1) Population

The equipment for water quality monitoring aims towards water quality analysis throughout the nation. However, in this CHAPTER it is deemed that the Project Areas are Uttar Pradesh, West Bengal and Andhra Pradesh where Lucknow, Calcutta, and Hyderabad situate, respectively. Table-2.3.3 shows the populations of the States as of 31 March, 1991.

Table-2.3.3 Population Related to the Project

State	Population	Chemical Laboratory
Uttar Pradesh [1]	139,031,130 (16.47)	Lucknow
West Bengal [4]	67,982,732 (8.05)	Calcutta
Andhra Pradesh [5]	66,354,559 (7.86)	Hyderabad
Total	273,368,421 (32.38)	

The number inside [ ] shows the order of the state population surveyed in 1991
The number inside ( ) shows the ratio of the state population surveyed in 1991

(2) Surrounding Environment of the Project Areas, based on State

Each State in the Project Areas has such surrounding environment as follows.

1) Uttar Pradesh

Area: 294,411 km^2

Capital: Lucknow

Population: 139,112,000 (1991)

Language: Hindi and Urdu

Agriculture: 78% of the population is engaged in agriculture. Largest producer of foodgrains, sugarcane, and oilseeds. Wheat production was 18.356 million tons, rice 10.256 million tons, oilseeds 1.32 million tons, jute 1,000 tons, and sugarcane 103.562 million tons in 1991.

Industry: Factories number 270,418. The output is equivalent to 41.8 billion rupees. Factory employees number 1,445,000 people. There are 24 cotton spinning factories, and the major industries are textiles, mining, sugar refining, and electronics. Handicraft art is approximately 1/6th of the national production, and leather processing is a growing industry.

2) West Bengal

Area: 88,752 km^2

Capital: Calcutta

Population: 68,077,000 (1991)

Language: Bengali

Agriculture: More than 50% of the state's income and nearly 75% of the people are engaged in agriculture. 10.436.50 million tons of rice was produced in 1990, which is the largest production domestically, and 60.9% of jute and 22% of tea are produced in this state. Potatoes, oilseeds, and wheat are also produced.

Industry: 7,846 factories are registered in the West Bengal state (1989), and this is one of the largest industrial states in India. Major industries are steel plants, engineering, automobile, chemicals and pharmaceutical, aluminum, ceramics, textiles, and tea.

3) Andhra Pradesh

Area: 275,045 km^2

Capital: Hyderabad

Population: 66,508,000 (1991)

Language: Telugu and Urdu

Agriculture: About 69% of the population is engaged in agriculture. The total food grains yield in 1990 was 12.33 million tons. Rice production was 9.654 million tons and oilseeds was 9.654 million tons. Tobacco, sugarcane, cotton, chilies, and bananas are also produced.

Industry: Industrial products are machine tools, medical and pharmaceutical products, heavy electrical machinery, ships, fertilizers, electronic equipment, and watches.

Mining: Producing 98% of barytes, 41% of mica, 34% of quartz.

2.3.3 Natural Environment

(1) Geography

Geographically, India can be divided into three well marked regions: 1)Himalaya Mountains, 2)Indus-Ganges-Brahmaputra Plain and 3)Peninsular (see Fig. 2.3.2).

1) The Himalaya Mountains is the high mountainous which are covered with permanent snow represented by the Himalayas and bordering northern India. The glaciers located in the Himalayas are sources of many great perennial rivers.

2) Indus-Ganges-Brahmaputra Plain is the area between the Peninsular and the Himalaya Mountains. This is the great alluvial plains linking the Indus (Sutlej), the Ganges and the Brahmaputra plain, and spreading in a east-west direction in northern India. It is also a gently sloping, fertile and populous land with the maximum elevation of from 200 m to 300 m and an annual rainfall of from 750 mm to 2,500 mm, and major agricultural products come from this tract.

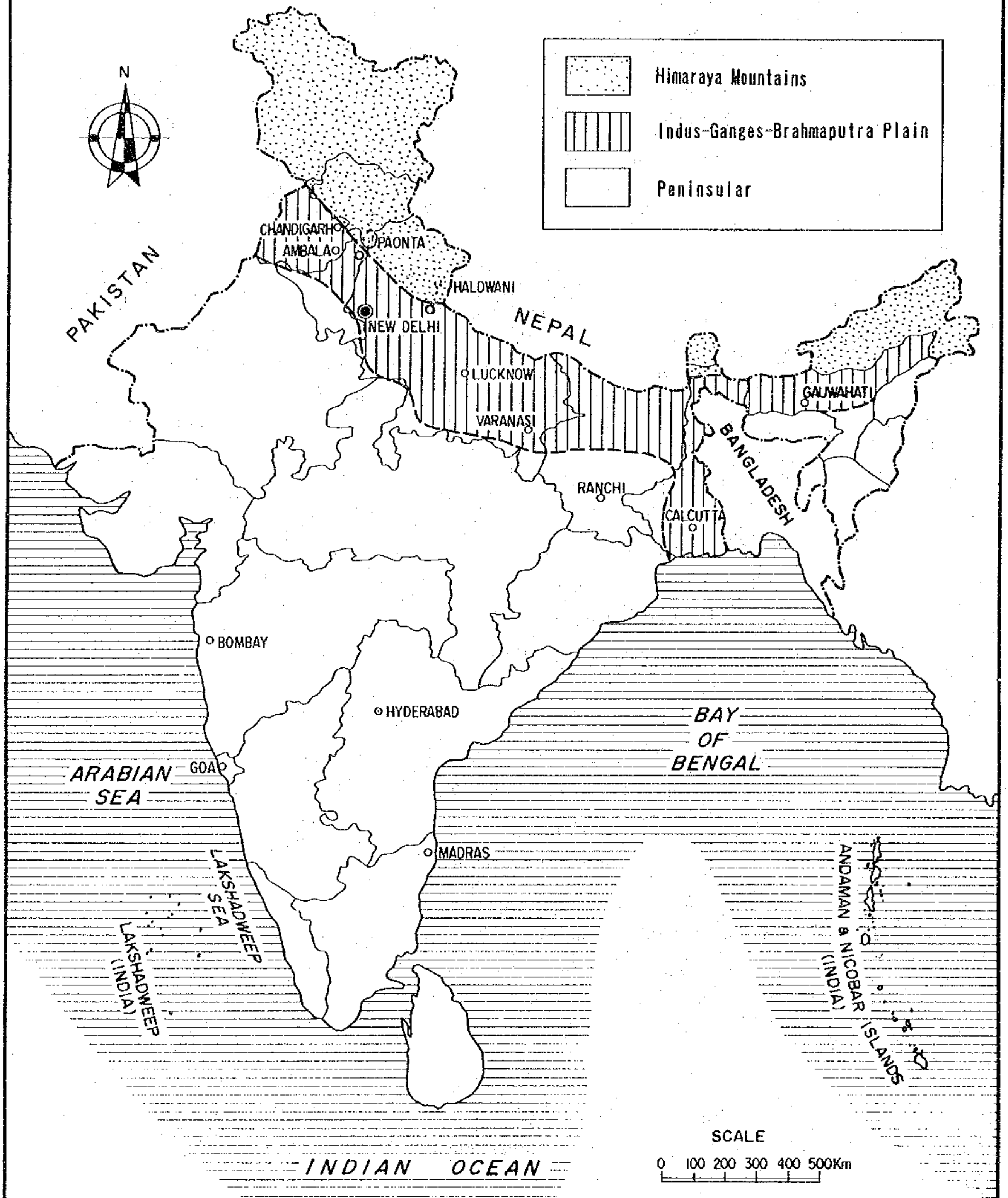


Fig. 2.3.2 Geographical Map of India

3) The Peninsular is the triangular area from middle to southern India and projecting into the Indian Ocean. There are some important mountain ranges like the Western and Eastern Ghats in the Peninsular. The former facing the Arabian Sea in the west of the Peninsular. The latter is mountain range with an elevation of from 2,000 m to 3,000 m at the meeting point with the Western Ghat. In the southern part Archaean rocks form erosional plateau while basaltic flows of tertiary age form the Deccan Trap. The Peninsular as a whole shows the table plateau with an elevation of from 500 m to 1,000 m.

Almost all Uttar Pradesh (Lucknow) and West Bengal (Calcutta) of the project areas are situated in the Ganges plain while Andhara Pradesh (Hyderabad) lies in the Peninsular.

(2) Climate and Hydrology

India belongs to the sub-tropical zone; tropical forests, savannah and steppe by Koeppen System; and is characterised by the prevalence of monsoons. The south-west monsoon which prevails over the country from June to September is responsible for more than 75 percent of the annual rainfall over India except for the eastern coast and Jammu and Kashmir. The annual rainfall distribution over certain parts of Assam and Western Ghats receive more than 4,000 mm annual rainfall, whereas less than 400 mm of rainfall is recorded in western India. The country, in general, receives annual rainfall ranging from 500 mm to 2,000 mm and the mean annual rainfall over the country is about 1,050 mm (See Fig. 2.3.3).

The rivers in India fall into two broad groups, viz. the rivers of Himalayan origin and those flowing in the Peninsular. The major Himalayan rivers are perennial which are snow fed and rise from the glaciers of the Himalayas. These rivers, before entering the plains, flow though deep gorges forming torrents and cascades. In the plains these rivers become sluggish and wide, and form the great alluvial plains and deltas with transported

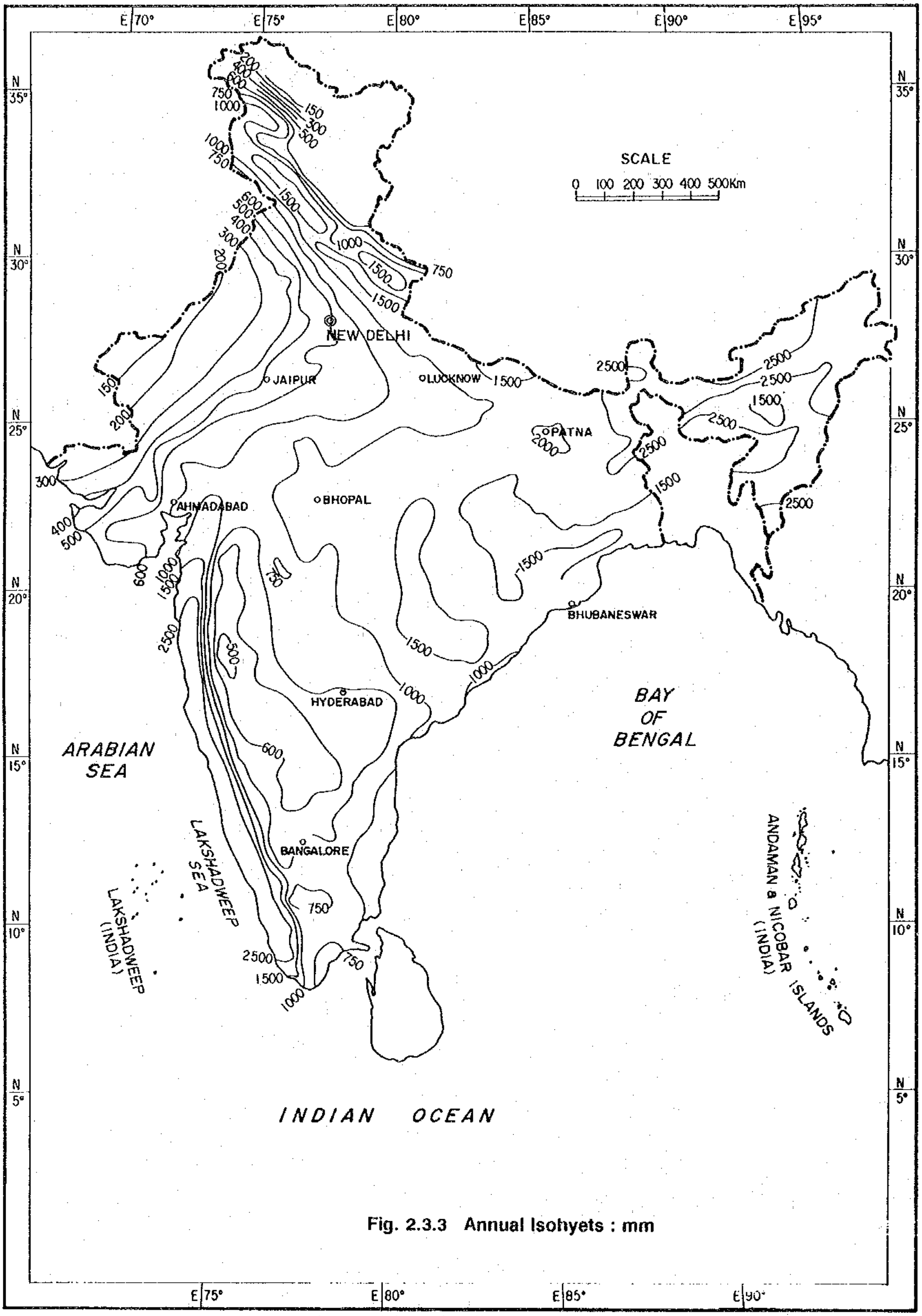


Fig. 2.3.3 Annual Isohyets : mm

Source : Government of India, Hydrogeological Map of India 1989 deposits. The major Himalayan rivers are world famous great rivers like the Indus, the Ganges and the Brahmaputra, and form the Indus-Ganges-Brahmaputra Plains as described before.

Almost all the peninsular have reached the mature stage of development and courses of rivers in the peninsular are well graded and the valleys broad. The major peninsular rivers like the Mahanadi, the Godavari, the Krishna and the Pennar-Palar rise in the Western Ghats and flow eastward to the Indian Ocean (Bengal Bay) having well defined deltas.

The Project Area consisting of Utter Pradesh and West Bengal lies in the Indus-Ganges-Brahmaputra Plains, receiving annual rainfall of from 750 mm to 1,500 mm, and Andhra Pradesh lies in the Peninsular receiving annual rainfall of 500 - 750 mm.

(3) Geology and Hydrogeology

It is noted that the collision between the Indian sub-continent and the Eurasian continent has occurred since early Eocene age of Paleogene. The Himalayas was formed by the upheaval of the marine (the Tethys Sea which had been between the Indian and the Eurasian continent before the collision) deposits by the collision, while the Indus-Ganges-Brahmaputra Plain was formed by the subsidence of the Tethys Sea floor into the subduction/collision zone. The Plain was formed by the filling up of the subsiding zone with the clastics (molasses) from the mountains being upheaved (the Himalayas). The Peninsular is still as it was at the time of the collision except for a part covered with the basaltic flow of Tertiary age (the Deccan Trap). Table-2.3.4 exhibits a conceptual stratigraphy in India.

1) The Himalaya Mountains are the mountains being upheaved (orogene) along the several great thrust faults. The Mountains consists of the Tethys Sea deposits which are mainly composed of strong folded, weakly metamorphic sedimentaries of Paleozoic and Mesozoic age, and weak folded, strong metamorphic sedimentaries

Table-2.3.4. Stratigraphy in India

GEOLOGICAL AGE			LITHOLOGY	
QUATERNARY	HOLOCENE		Unconsolidated pebble, boulder, sand, clay	
1.8my	PLEISTOCENE		Silt, clay, pebble (Lacustrine deposits) / Gravel beds	
NEOGENE TERTIARY	PLIOCENE MIOCENE		Boulder, conglomerate, sandstone shale, clay, soft sandstone reddish sandstone and shale	SIWALIK SEDIMENTS
23my			Red shale and sandstone	MURREE GROUP
PALAEOGENE TERTIARY	OLIGOCENE EOCENE		Limestone and shale (marine facies) grey to purple shale, carbonaceous shale, coal beds (continental facies)	
65my	PALAEOCENE		Predominamtly basic volcanics (Deccan trap) / Calcareous sandstone	
MESOZOIC	CRETACEOUS			
	JURASSIC		Sandstone, shale, limestone, ferruginous oolite	TETHYS (GONDWANA) SEDIMENTS
243my	TRIASSIC		Limestone, dolomite, shale, sandstone dark grey shale	TETHYS (GONDWANA) SEDIMENTS
PALAEOZOIC	PERMIAN CARBONIFEROUS		Predominantly volcanics with shale and siltstone, plant-bearing beds Quartzite, conglomerate/ diamictite, slate	TETHYS (GONDWANA) SEDIMENTS
	DEVONIAN SILURIAN ORDOVICIAN		Limestone (with marine fauna), siltstone shale (with plant fossils), variegated-siltstone/quartzite, matured quartzite, silty and calcareous shale, limestone, quartzite with marine fossils	TETHYS (GONDWANA) SEDIMENTS
570my	CAMBRIAN		Greenish grey sandstone, quartzite, grey & dark grey shale, siltstone bands of limestone, chert, phosphorite	VENDIAN
670my			Limestone, dolomite with stromatolite, dark grey shale/slate with minor-quartzite, diamictire, shale, limestone	VENDIAN
PROTEROZOIC 900my	III		Slate, phyllite quartzite, grey-shale, siltstone limestone, gypsum / Grey & purple quartzite, siltstone dark grey shale/ slate, phyllite, limestone / Metamorphosed in proximsty of granite	
1600my	II		Ortho-quartzite, basic Volcanics & limestone/dolomite with stromatolite, phosphorite, syngenetic sulphide mineralisation	
2500my	I		Regionally metamorphosed katazonal metasediments of green schist and amphibolite facies	
ARCHAEAN			Gneiss - granite complex with basic and ultra basic intrusives	

(Midland deposits) of proterozoic age. In the Himalaya Mountains, groundwater is available only in small springs from fissures of rocks and the small stream (surface water) originated in those springs.

2) The Indus-Ganges-Brahmaputra Plain is a great alluvial plain consisting of the clastics which have been deposited on the subsiding zone since Miocene age of Neogene (Siwalik formations and alluvium). It is noted that the Indus-Ganges-Brahmaputra Plain is one of the largest groundwater reservoirs in the world. The groundwater in the Plain is recharged mainly by the world famous great perennial rivers originated in the Himalayas, and is formation water occurring in a void of the clastic rocks deposited on the subsident zone. Therefore, good aquifers are formed especially in the loose Quaternary formations like upper Siwalik formation and alluvium. The discharge of a well in the Plain is from 25 to 40 lit/sec or more.
The tract rich in boulders (Himalaya Mountains) with from 10 to 30 km width is known as Bhabar area which is considered a hydrogeological unit by itself because of the following characteristics.

- Bhabar area is a recharging area of groundwater
- Groundwater level in Bhabar is very low (Groundwater is unconfined or weakly confined)
- In Bhabar, tubewell construction is very difficult

3) The Peninsular is the stable continent (craton) which mainly consists of Archean gneiss and granite, although its mid-western part is covered with the basaltic lava flows of Tertiary age. Major part of the Peninsular is marked hard rock where groundwater occurs in fissures and fractures of fissured rocks. Therefore, the groundwater potential in the Peninsular is generally low except for the basaltic flow area where is generally rich in fissures, and the caved limestone area. The discharge of groundwater of a well in the Peninsular is from 5 to 25 l/sec in the basalt and limestone area, and from 1 to 5

lit/sec in the other area, respectively.

2.3.4 Social Environment

(1) Infrastructure

1) Railways

In 1853,34 km of railway line was opened between Bombay and Thane. The purpose of the railway during the era of British colonialism was to connect production areas of primary products, such as raw cotton and jute, to ports for export. After the independence of India, large amounts of capital were invested in infrastructure development, and today railways have become one of the major means of transportation, although it continues to face many problems. As of 1991 the total length of railways was 78,608 km, and they carry 3.8 billion passengers and more than 300 hundred million tons of freight annually. Compared with 1951, the length, number of passengers, and volume of freights have increased 1.3, just under 3 times, and 3.5 times, respectively. The increase in freight tonnage is especially remarkable. The transportation capacity of passengers and freight has increased because of new trains introduced to lines that transport large numbers of passengers, the conversion of the single track to a multiple track, and the opening of new lines. There are three types of tracks: broad gauge (1,676 mm), meter gauge (1,000 mm), and narrow gauge (762 mm, 610 mm). The railroad is nationalised and divided and operated as nine branches based on region: Central (Bombay), Eastern (Calcutta), Northern (New Delhi), North Eastern (Gorakhpur), Northeast Frontier (Maligaon), Southern (Madras), South Central (Secunderabad), South Eastern (Calcutta), and Western (Bombay).

The Project Areas can be accessed by trains from New Delhi.

New Delhi - Kampur - Lucknow	Approximately 570 km (7 hours)
New Delhi - Kampur - Calcutta	Approximately 1,440 km (18 hours)
New Delhi - Hyderabad	Approximately 1,450 km (26 hours)

2) Roads

There were more than 290,000 buses and approximately 1.28 million trucks in India as of 1989. Comparing these figures with those of immediately after India's independence, the number has increased nine fold and 14 fold, respectively. As with railways, roads were built during the colonial period for the purpose of transporting primary industrial products. As part of road transportation, 60% of road transportation and 25% of road passengers use national highways. However, the length of national highways is 33,000 km, which represents only 2% of the total road length of 1.84 million kilometers. Currently, the road transportation ratio of the total means of transportation is 80% for passengers and 50% for freight. It is expected that these figures will increase in the future. There are 56 truck transportation companies.

The Project Areas are accessible by car, but, road transportation is not adequate except in Lucknow, where there is a distance of approximately 10 hour drive. It is anticipated to go through customs at Calcutta in the Project. It is considered adequate to utilise the Inland transportation - the transport along the paved national road from Calcutta to Lucknow and Hyderabad.

3) Airways

Air India, an international airline, connects India with the major cities in the world. Indian Airlines connects India with 67 cities within India and in the surrounding countries. The airline holds a major position in the transportation of passengers, freight and mail. There are several public and private domestic airlines which operate on a small scale.

Domestic air services are available every day to each Project Area from New Delhi, making it possible to access to the Project Areas by domestic airlines. Lucknow is accessible by railway and by road, but, it is more convenient for passengers to fly.

Flying is virtually the only means of transportation for some of the Project Areas like Calcutta and Hyderabad from New Delhi.

4) Electricity

The electrical standards in India are single-phase 220 V (50 Hz) and three-phase 440 V (50 Hz). Electrical energy has increased from 1,400 MW in 1947 to 69,000 MW at the end of March 1992. The actual plant load factor of thermal power stations during 1991-1992 was 55.3% . Thermal plants generate 72.7% of the electrical energy; 25.3% is generated from hydraulic power plants, and 1.9% from atomic power plants.

The electrical power conditions considered during facility planning in India are the voltage differences shown above, the different electric equipment used because of the different voltages, and power failures and voltage fluctuations.

5) Mail, Telephone, and Communication

The mail service in India began in 1837. There are over 148,000 post offices, with approximately 15% located in urban areas and 85% located in rural areas. Roughly 4 billion letters are handled annually. "Speed Post" was introduced in 1986. In this service, mail is delivered within a definite time frame, and failing this will result in the refund of the fee. Speed Post could be used to communicate with the Project Areas as it is available in approximately 60 cities, including Delhi, Lucknow, Calcutta, and Hyderabad.

There are 16,070 telephone exchanges throughout India. Telephone switchboards are connected by 27,000 km of coaxial cable, 37,000 km of microwave, 23,000 km of UHF, and 6,000 km of cables. Telephones are not common in rural areas, and telephone calls made at the central offices are common. The current use of facsimile machines is remarkable, with approximately 53,000 lines registered nationwide.

6) Water Supply and Sewerage

The coverage of water supply and sewerage facilities in urban areas is 83.8% and 46.8%, respectively, as of December 1990. One goal of the Eighth Five Year Plan (1992 to 1996) is to increase these figures to 100% and 75%, respectively.

The Ministry of Urban Development supervises six water supply and sewerage projects in Maharashtra, Gujarat, Punjab, Rajasthan, Uttar Pradesh, through loan assistance from the World Bank. Similarly, the Ministry coordinates projects funded by the World Bank conducted in Maharashtra, Kerala, Tamil Nadu, and Andhra Pradesh. The Ministry is also in charge of promoting simple sewage treatment equipment. Simple sewerage treatment equipment has been established in 500 locations in cities with populations less than 500,000 people, according to the Census conducted in 1981. Sewerage facilities will be developed in all cities by the completion of the current five-year program if simple sewerage treatment equipment is installed each year.

Authority for water supply and sewerage facilities in rural area was transferred to the Department of Rural Development from the Ministry of Urban Development in August 1985, and efforts are being made to provide water to the rural area. "Water supply problem villages" without a source of water numbered 161,722 in April 1985; however, water sources were developed in 158,745 villages by March 1992, and efforts are being made to supply water to another 2,968 villages. A "No Source Problem Village" is defined as a village with no hand pump or point source for a water supply population of 250 or more, within a walking distance of 1.6 km or within 100 m difference in elevation in a hilly areas. Even so, there are many villages not classified under this definition of "No Source Problem Villages", but water is still only provided to a limited number of residents. Therefore, improvement in water supply conditions, water quality (some water contains high concentrations of fluoride, iron and salinity), and some kind of water prone diseases including the guinea worm should be taken care of.

The coverage of sewerage facilities in rural areas is extremely low. The ratio was only 0.72% in April 1985, and had improved to only 2.73% by March 1993. Table-2.3.5 shows the coverage of water supply and sewerage facilities.

Table-2.3.5 Coverage of Water Supply and Sewerage Facilities

Time of survey	1985.3.31		1990.3.31		1992.3.31	
Population(P) and Coverage(C)	P	C	P	C	P	C
1.Water Supply in Rural Area	313.86	56.26	444.65	73.87	486.11	78.40
2.Sewerage in Rural Area	4.03	0.72	14.79	2.45	16.96	2.73
3.Water Supply in Urban Area	127.20	72.90	182.00	83.93	185.67	84.90
4.Sewerage in Urban Area	49.60	28.40	99.70	45.93	104.76	47.90

Source: Eighth Five Year Plan, 1992-1996

(2) Living Environment

1) Employment and Income

Table-2.3.6 shows the ratio of employees in the nine major industries.

The average annual income for factory workers in 1986 was quite different in each state. The following is the average annual wage in each state in the Project Areas. The national average was 9,900 Rupees.

Andhra Pradesh 7,774 Rupees
Uttar Pradesh 6,610 (1982)
West Bengal 13,706 "

Table-2.3.6. Ratio of Employees and Annual Growth in the Nine Major Industries

Items	Ratio of Employees			Annual Growth		
Industries	1977-78	1983	1987-88	1977-78	1983	1987-88
Agriculture	70.70	66.31	63.90	1.30	1.11	1.21
Mining	0.52	0.65	0.77	2.56	0.88	21.71
Manufacture	10.00	10.93	11.13	2.07	-0.90	0.99
Public Utility Service	0.26	0.32	0.34	3.67	3.26	3.47
Construction	1.82	2.47	3.96	1.92	1.25	1.59
Commerce	6.18	6.67	7.30	1.94	1.43	1.69
Transportation	2.13	2.71	2.78	2.25	1.20	1.72
Finance, Real Estate	0.55	0.73	0.83	2.96	2.25	2.60
Other Service	7.82	8.78	8.80	-	-	-
Grand Total	100.00	100.00	100.00	-	-	-

Sources: Eighth Five Year Plan, 1992-1996
(Note) The total also includes the industries not listed because of their small number of employees.

2) Health and Sanitation

The Indian Government has made efforts to improve the health and sanitation in rural areas in all of the Five Year Plans, and the government has achieved remarkable results over the 40 years since independence. Primary health centres and subsidiary health centres, which are the core of the rural medical care, did not exist before 1951; nevertheless, the number has increased to 22,229 as of March 31, 1991 (40,000 population/1 Health Center). Improvements in combating malaria, tuberculosis, and cholera, which traditionally have had high mortality rates, is remarkable.

Smallpox has been eradicated, and the death ratio per 1,000 people has decreased nationwide from 27.4 in 1951 to 9.6 in 1990. The average age has grown from 32 years between 1941-1951 to 61.1 years between 1991-1996, and the infant mortality rate decreased from 146 in the 1950's to today's rate of 80.

India is promoting a National Malaria Eradication Programme. The number of people suffering from malaria shortly after independence was 75 million. The number decreased to 10 million by 1965 and 1.81 million by 1991. At the present time people in India are no longer dying from malaria.

Leprosy is one of the serious public health and social problems in India. There are approximately 3 million patients throughout the nation, and an estimated 15-20% of the cases are infectious. Patients receiving regular medication as of March 31, 1991, numbered 1.69 million people.

It is estimated that 1.3% of the total population (approximately 11 million people) are infected by tuberculosis. Approximately 1.61 million new case of tuberculosis were reported for the year 1991.

CHAPTER III

OUTLINE OF THE PROJECT

CHAPTER III

OUTLINE OF THE PROJECT

3.1 OBJECTIVE

The objectives of the request were to supply equipment through a grant aid from Japan in order to accelerate some important activities of CGWB having high priority. This had remained behind schedule due to the difficulty of the procurement of equipment in India, among the groundwater management projects being implemented by CGWB.

The objectives of the request made by the Indian Government aimed as follows:

To conduct effective water management for the groundwater in India to combat the potential hazards of water degradation by the various sources of pollutants including the 17 industrial estates identified by the Ministry of Environment and Forests.

In order to achieve these projects, the Indian Government requested the following equipment from Japan suitable for the above projects and areas.

The equipment for water quality monitoring, including 3 ICPs, 2 AAs, and one GC.

As a result of the examination of the request, it is decided, as it will be discussed in the following section, that the objectives of the Project are the water quality monitoring projects which include the water quality analysis for the national groundwater for the development and preservation of groundwater and the water quality monitoring for the identified industrial estates described above and that the aims of the Project is to improve the operation system of CGWB for the above mentioned projects through the procurement of the necessary equipment for the implementation of the projects.

3.2 STUDY AND EXAMINATION OF THE REQUEST

3.2.1 Feasibility as a Grant-Aid Scheme

The feasibility of I. Equipment for Water Quality Monitoring and II. Direct Rotary Drilling Rigs for deep aquifer system is examined here and the feasibility of the equipment for water quality monitoring is confirmed but it is concluded that the equipment for tubewell construction is not necessary to be supplied further at the present time. Thus, the equipment for water quality monitoring will be examined hereafter.

The final request for the equipment for water quality monitoring is summarised in Table-3.1.1. The feasibility of the Project and the scope of the Project will be examined here as a grant aid scheme from the Japanese Government.

Table-3.1.1 List of Final Request for Equipment for Water Quality Monitoring

Type of Equipment
1. Inductively-Coupled Plasma Spectrometer (ICP)
2. Gas Chromatograph (GC)
a)ECD
b)FID, FPD, FTD
3. Auto-Analyser
4. Atomic Absorption Spectrophotometer (AA)
5. Ion Meter (IM)
6. Vadose Zone Sampler (VZS)
7. Total Organic Carbon Meter (TOC)
8. High Performance Liquid Chromatograph (HPLC)

As described before, CGWB is conducting water quality analysis for groundwater in India at 12 Chemical Laboratories located at the Regional Offices (shown in Fig. 2.2.1) and also conducting the detailed study at 17 industrial areas where water pollution is identified. The following are the present situations of CGWB regarding water quality analysis for groundwater based on the water quality standards, described for each analysis group.

(1) For heavy metal analysis, the accuracy is sufficient because of the use of AA, but the analysis capacity is limited.

(2) For organic compound analysis, virtually no organic compounds including pesticides, might have been analysed because the equipment CGWB possesses is very difficult to conduct the water quality analysis for this kind of analysis.

(3) For elements and inorganic compound analysis, the accuracy and capacity of analysis is not sufficient because the equipment for this kind of analysis is basically manually operated.

It is difficult for CGWB to obtain necessary accuracy and there are even some elements which can not be analysed with present equipment. It is difficult to obtain timely analysis results due to insufficient analysis capacity. CGWB is aiming at developing a water quality monitoring network throughout India and an analysis system which can quickly analyse water samples from the network. CGWB also hopes to develop a data processing system which can analyse the results and output data required for implementing remedy measures.

Through the site survey, the present situations regarding technical level and analysis equipment which CGWB possesses were observed. Generally CGWB is observed to possess the capability of carrying out the highly accurate analysis. When the Basic Design for the equipment is conducted in Japan later on, such factors should be taken into consideration as the accuracy and capacity of analysis necessary, the easiness in handling, and the availability of supply of consumable goods, so that CGWB will have no problem for operation, maintenance and management with the equipment. Regarding the budget, CGWB has paid the operation and maintenance costs for the equipment procured through the previous Japanese grant aid Projects, and operation and maintenance costs will correspond to 0.2% of total budget for CGWB as will be discussed in 4.5.2 in more details. Thus, it can be evaluated that CGWB is capable to allocate adequate budget for the Project. As discussed in 2.2.3 and to be discussed in later sections, significant effects are expected through the implementation of the Project. At the same time, the Project will contribute to an improvement in health and sanitation environment. Thus, implementing the Project through a grant aid is considered feasible and appropriate.

3.3 PROJECT DESCRIPTION

3.3.1 Executing Agency and Operational Structure

The execution agency is CGWB, and its Chemical Laboratories will conduct the water quality monitoring project. Fig.3.3.1 shows the organisational chart of the Chemical Laboratories. For implementation of the Project, all the Chemical Laboratories will be concerned including the Central Chemical Laboratory in Lucknow, and two other Chemical Laboratories in Calcutta and Hyderabad. Fig.3.3.2 through Fig.3.3.4 show the organisational chart of the Lucknow, Calcutta and Hyderabad Chemical Laboratories. In regard to the operation and maintenance of supplied equipment for the Project, it is necessary to standardise the method of analysis for all the Chemical Laboratories because all works for the Project co-relate to each other among Laboratories. Therefore, a systematic project operation is required by establishing a management and operational committee.

(1) Personnel of the Executing Agency

The number of CGWB personnel as of March 31, 1993, is shown in Table-3.3.1.

Table-3.3.1 Personnel Structure of CGWB

Group	Fixed number Sanctioned	Filled	Vacant
A	393	308	85
B	359	283	76
C	2,572	2,308	264
D	1,999	1,834	165
Total	5,323	4,733	590

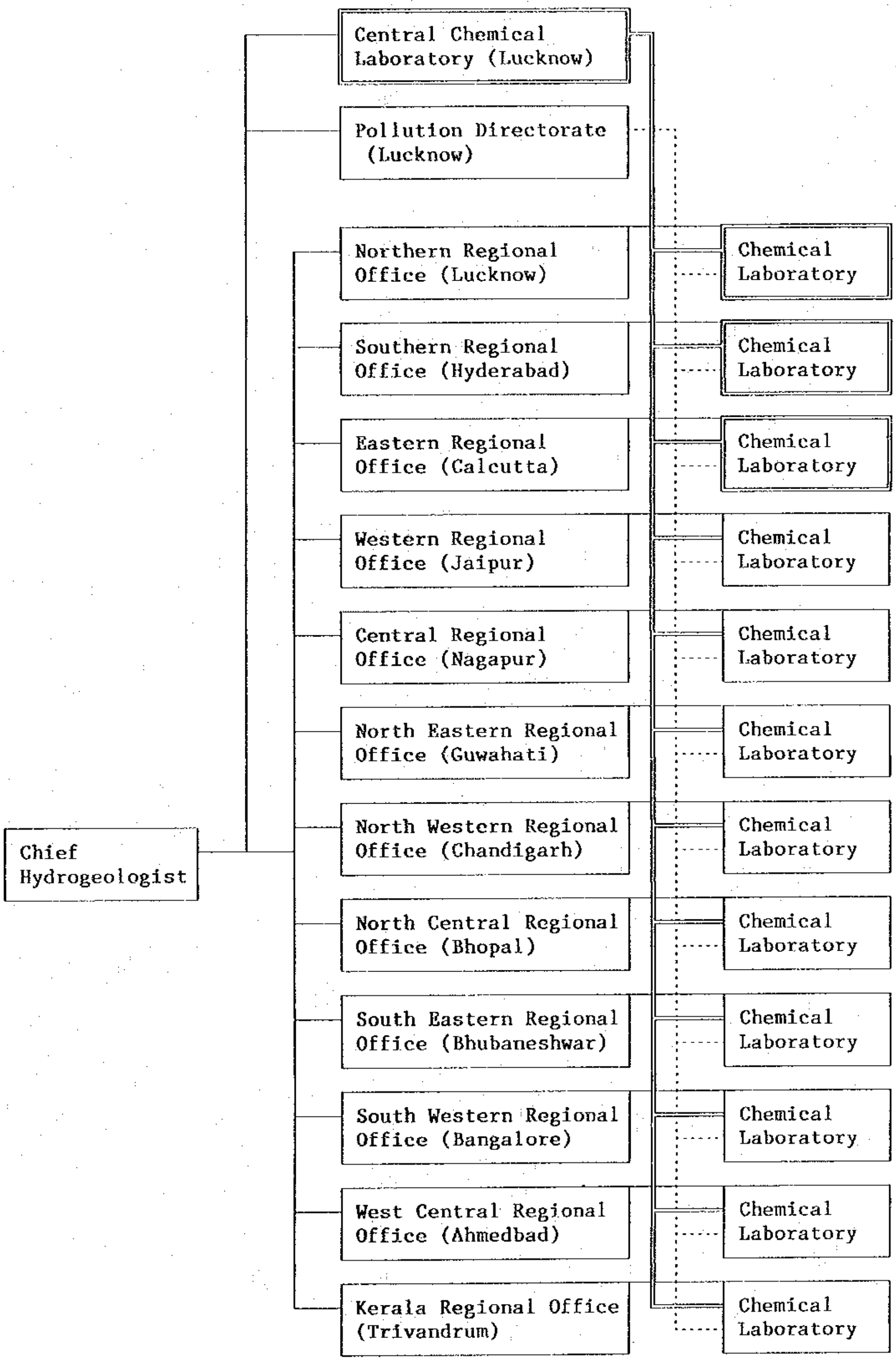
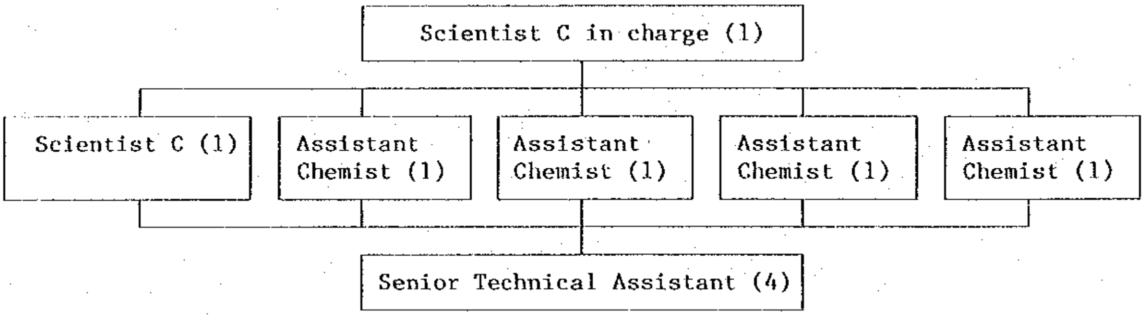
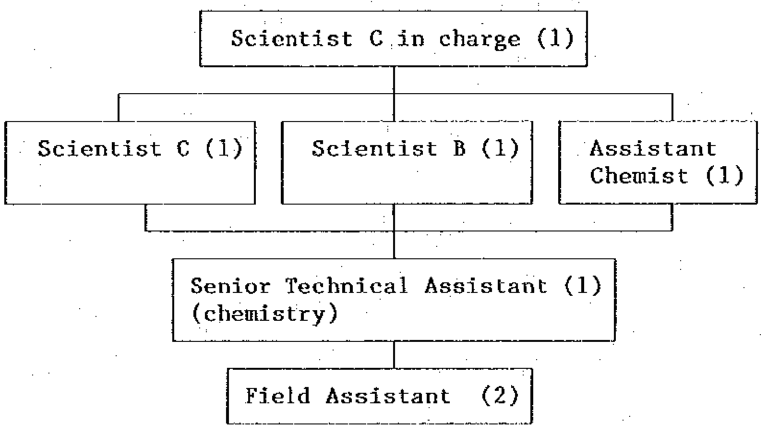


Fig. 3.3.1 Chart of CGWB Chemical Laboratories



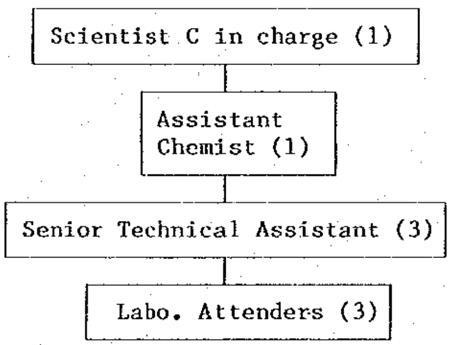
No. in parantheses denotes no. of persons

Fig. 3.3.2 Chart of Lucknow Chemical Laboratory



No. in parantheses denotes no. of persons

Fig. 3.3.3 Chart of Calcutta Chemical Laboratory



No. in parantheses denotes no. of persons

Fig. 3.3.4 Chart of Hyderabad Chemical Laboratory

Compared with March 31, 1992, the above number of personnel is exactly the same (4,733) in terms of the filled number of personnel. The sanctioned is slightly reduced (by 23 people). The change in the number of personnel based on group is roughly divided into the following: 40 person increase among the upper ranked employees (1 increase for A; 39 increase for B), and a 63 person reduction amonglower ranked employees (51 reduction for C; 12 reduction for D). Making a comparison in terms of the filled number of personnel, each group shows only a slight change which means the employment situation is fairly stable.

The number of employees involved in the Chemical Laboratories is A+B=74 people, C+D=25 people; and the total is 99 people.

(2) Budget Evaluation of the Executing Agency

The outline of the budget of CGWB is shown in Table-3.3.2.

Table-3.3.2 Budget of CGWB

(unit: million Rs)

	Items	1992/93	1993/94	1994/95
I	1. Salary, Wages & OTA	176.736	194.800	195.300
	2. Travel Expenses	22.202	24.000	23.500
	3. Office Expenses	15.518	18.800	22.800
	4. Professional Services	0.445	0.400	0.400
	5. Rent and Others	8.276	11.815	11.850
	6. Publication	1.157	3.600	3.600
	7. Works	84.001	75.000	85.000
	8. Machinery & Equipment	7.219	4.000	20.000
	9. Motor Vehicles	14.253	15.000	32.200
	10. Others	68.543	99.900	155.350
	Sub-total (1)	398.360	447.315	550.000
	(Ratio to the Previous Year)		(112.3%)	(123.0%)
II	1. Salary, Wages & OTA	0.000	23.600	13.300
	2. Travel Expenses	-	5.500	5.500
	3. Office Expenses	0.009	0.050	0.050
	4. Professional Services	-	-	0.050
	5. Works	8.514	20.000	30.000
	6. Machinery & Equipment	17.378	515.000	250.000
	7. Motor Vehicles	0.835	1.600	1.100
	Sub total (2)	26.737	565.750	300.000
	Total (1)+(2)	425.097	1,013.065	850.000
III	Drilling Cost, others (3)	82.993	63.300	96.000
	Grand Total (1)+(2)-(3)	342.104	949.765	754.000
IV	1. New Schemes of VIII Plan	-	0.400	29.300
	2. Construction of Building	-	2.500	30.000

I: Ordinary Budget
II: Budget for the Assistance to Drought Affected States
III: Recoveries, etc.
IV: Special Budgets

The figures in 1992/93, 1993/94 and 1994/95 are actual, estimated and planned, respectively. Table-3.3.2 reveals that the ordinary annual budget shows a steady increase against the previous year of 112.3% and 123.0% in 1993/94 and 1994/95, respectively. From the fact that the budget for salary, wages and overtime allowances (OTA) in 1994/95 stays almost the same as in 1993/94, it is evaluated that the efforts of CGWB to rationalise the management and operation. The budget for the assistance to drought affected states is very variable by nature includes in 1993/94 that for machinery and equipment of 515.0 million Rs. This figure may includes the procurement of the equipment by the Phase-2 Project. Recoveries, which cover the drilling cost for the tubewells constructed by CGWB and transferred to the State Governments, are to be paid by the State Governments. CGWB provides a special budget for the office construction. It is 30.0 million Rs. in 1994/95, corresponding to the construction plan for new Regional Offices. Although the budget strictly for the Chemical Laboratories could not be confirmed, it is evaluated that the budget for the Chemical Laboratories will not be a problem if the operation and maintenance cost is compared with the total ordinary budget; the operation and maintenance cost calculated in 4.5.2 is Rs. 1,260,000 or Rs. 9,201,000 (if depreciation is included) corresponding to 0.2% or 1.7% of the ordinary budget of CGWB for 1994/95, respectively.

3.3.2 Plan of Operation

As mentioned above, the feasibility for implementation of the Project was justified to supply the equipment for water quality monitoring as a Japanese grant aid Project through evaluation of the effects of the Project and the operational capability of CGWB. When determining the Basic Design as an optimal plan for the grant aid Project in regard to the equipment for water quality monitoring, the examination of the equipment based on the analysis for three groups of heavy metals, organic compounds, and elements and inorganic compounds was conducted to meet the requirement from the analysis elements, the detection levels and accuracy. The following are the conditions required for the selection of the equipment corresponding to each group of analysis.

(1) In Regard to the Equipment for Heavy Metal Analysis

1) Equipment which can be operated and used for analysis by CGWB technically.

2) Equipment which can be operated and maintained with operational capabilities of CGWB.

3) Equipment which possesses analysis accuracy and analysis capacity necessary for water quality monitoring.

4) Equipment which can be operated and used for analysis by the current CGWB personnel.

5) Equipment which can be expected to receive sufficient after-sales service from the manufacturer.

6) Equipment which matches the natural and social environment in India.

(2) In Regard to the Equipment for Organic Compound Analysis

1) Equipment which can be operated and maintained with operational capabilities of CGWB.

2) Equipment which possesses analysis accuracy and analysis capacity necessary for water quality monitoring.

3) Equipment which will be useful in the future taking the future operations of CGWB into consideration.

4) Equipment which can be operated and used for analysis by hiring a minimum number of people.

5) Equipment which can be expected to receive sufficient after-sales service from the manufacturer.

6) Equipment which matches the natural and social environment in India.

(3) In Regard to the Equipment for Element and Inorganic Compound Analysis

1) Equipment which can be operated and used for analysis by CGWB technically and leads to the overall technical improvement.

2) Equipment which can be operated and maintained with operational capabilities of CGWB.

3) Equipment which possess analysis accuracy and analysis capacity necessary for water quality monitoring.

4) Equipment which can be operated and used for analysis by present CGWB employees.

5) Equipment which matches the natural and social environment in India.

3.3.3 Location and Conditions of the Project Sites

As a result of an examination based on the request from India, the Project Sites for the equipment for water quality monitoring are the three Chemical Laboratories in Lucknow, Calcutta and Hyderabad, and the Project will relate to all 12 Chemical Laboratories as one organisation. The Ion Meter (IM), the Semi-Automatic Analysis System (SAA) and the Vadose Zone Sampler (VZS) will be provided at the nine other Chemical Laboratories as well as at Lucknow, Calcutta and Hyderabad.

(1) Reasons for Site Selection

Currently, CGWB has a total of 12 Chemical Laboratories, with the supervisory Central Chemical Laboratory located in Lucknow. A Directorate to deal with water pollution problems is stationed in

Lucknow. As CGWB is conducting nationwide groundwater quality control, an improvement in the water quality control system is necessary. In order to effectively allocate analysis equipment in such a large country, an analysis control system combined by the de-centralised type and the centralised type must be developed according to the characteristics of analysis equipment and analysis elements. For example, the de-centralised control type is suitable for the analysis of elements and inorganic compounds which requires immediate analysis after sampling because minimising travel time is crucial. In this case, as the function of CGWB is organised in the Regional Offices, it is better to install the analysis equipment in each Chemical Laboratory. On the other hand, a centralised control is adequate for stable element analysis, which may not restrict the travelling of samples. For the first stage of effective operation, the major equipment for water quality monitoring, mainly for heavy metal analysis suitable for centralised control, will be set up in the above three locations. The Central Chemical Laboratory is in charge of nationwide supervision and northern India. Hyderabad is in charge of southern India. Calcutta operates supplementary functions and is in charge of eastern India. These three Chemical Laboratories have been using AA and, therefore, are considered capable of using all of equipment including ICP which is to be supplied.

A portion of the equipment will be distributed to the other nine Chemical Laboratories. Through a combination of equipment for centralised control (for heavy metal analysis) and de-centralised control (for inorganic compound analysis), the capacity of the number of analysis processing equipment will be improved and the accuracy will also be maintained. By setting up equipment in all Chemical Laboratories, analysis items, which require analysis immediately after sampling, are analysed by equipment with a high analysis capacity. It will be another benefit of the de-centralisation to improve the overall level of the Chemical Laboratory.

(2) Site Shape

CGWB has construction plans of new Regional Offices for Lucknow and, Calcutta. The plans were approved in March, 1994 and construction is scheduled to be completed in 12 months (in March, 1995) after the approval including 16 weeks of the Detailed Design and Tendering. Each site is designed to provide floor area of 250 m^2 for the Chemical Laboratories.

(3) Situations of Infrastructure Development

Infrastructure in India is not developed sufficiently. In particular, the electrical supply is unstable, and special attention is required for voltage fluctuations and power failures. Thus, it is recommended to use AVR for the Project. Although road development is insufficient, it does not affect the Project.

3.3.4 Outline of Equipment

This is a preliminary selection of equipment for analysis of three element groups and Peripheral Equipment.

(1) Heavy Metal Analysis

1) Inductively-Coupled Plasma spectrometer (ICP) and Atomic Absorption Spectrophotometer (AA)

There are ICP and AA for analysis of water quality of drinking water with sufficient detection level. The characteristics of the two types of equipment were compared in Table-3.3.3. ICP is suitable for the analysis of multiple elements simultaneously in large amounts of water sample. On the other hand, it is necessary for AA to change the hollow cathode lamps and prepare an analytical curve (calibration curve) for each element.

Table-3.3.3 Comparison Table of ICP and AA

	ICP	AA
Analysis Principles	This is an emission spectrochemical analysis and can make qualitative analysis by the wavelength of the emission spectrum and quantitative analysis by the intensities of the spectra. ICP method vapourises a sample and emit the light.	This can determine the concentration of the element in the sample by measuring the intensity of the light which is absorbed by the ground state atoms dissociated in the sample which contain the objective element by flame or electrical heat.
Remarks	(1)The sample is nebulised with the nebuliser and carried by argon gas to the plasma flame. And the sample is vapoured, atomised excited, and then it emits the spectrum. The excitation effect of the sample is very high because plasma flame is high and stable temperature of 6 to 10 thousands °K, and outside temperature is higher. The sensitivity becomes very sharp and the spectrum intensity is also high. Therefore, a simultaneous analysis can be possible due to low self absorption having linearity for wide concentration range. (2)Little matrix effects and no pre-treatment is needed. (3)All elements emit spectra simultaneously in the sample. It is a simultaneous multiple element analysis. (4)It is necessary to prevent contamination of samples by reagents, solvents, devices and environment.	(1)The quantitative analysis for almost all metal elements from low concentrations to trace independently on the types of water samples. (2)The effects of matrix or ions are relatively small, and it is a selective analysis. (3)The qualitative analysis is difficult because a hollow cathode lamp is needed to match a peculiar wave length of element. (4)A diluted or condensed water sample can be analysed. (5)It is necessary to prevent carefully the contamination of reagents, solvents, devices, and environment.

Therefore, AA is suitable for the analysis of single element repeatedly. In case ICP is obliged to be used as a single element analyser for such particular elements as mercury, arsenic, selenium and antimony, ICP becomes a single-element analyser like AA. Therefore, it is recommended to analyse those elements with AA. Thus, the combined use of ICP and AA is desirable, and the request of CGWB seems very appropriate. A person able to use AA is considered capable of using ICP.

(2) Organic Compound Analysis

It is very important for CGWB to possess some pieces of equipment which enable CGWB to conduct water quality analysis for organic compounds with sufficient accuracy and analysis capacity. It is also very important to introduce basic equipment for the organic compounds analysis at the beginning, because there are too many types of equipment are available, which need experiences.

GC is suitable for the analysis of organic compounds and pesticides, and four types of detectors are very useful depending on elements to be analysed: ECD is used for elements which contain halogen (chlorine), such as PCB; FPD is used for elements containing phosphorous or sulphur; FID is used for organic solvents; and FTD is used for elements including nitrate or phosphorous.

The Total Organic carbon Meter (TOC) measures the total carbon and the total inorganic carbon in water sample, and it calculates the total organic carbon.

Therefore, it seems very reasonable and desirable to procure GC and TOC as a basic equipment for organic compounds analysis.

GC and TOC will be explained briefly as follows:

1) Gas Chromatograph (GC)

GC is generally suitable for the analysis of organic compounds. The analysing principle of GC is described briefly here. Suppose a Chromatograph system is prepared. The Chromatograph system is composed of the mobile phase and the stationary phase which are not mixed up with each other. When components of the sample are distributed in different ratios to the stationary phase and to the mobile phase which moves into the stationary phase, then each component of the sample usually has different velocity in the stationary phase, and the separation of each component occurs. This separation based on this principle is named Chromatograph.

GC is consisted of carrier gas as the mobile phase and of packed column as the stationary phase. In this system, water sample is injected into the carrier gas which is flowing at the constant flowing velocity. The injected sample is vapoured and sent to the column, and separated there into each component; and then detected with the detector.

GC has high resolution, high speed measurement, and easy to handle. On the other hand, this method is essentially determination by gas. Therefore, there is one limitation of this method that the method can be used for detection only for the elements which can be stable gaseous materials at the operation temperature.

<Apparatus>

Carrier gas should be maintained to flow at constant flow rate with the constant flow rate valve. The carrier gas should be chemically inactive and thermally stable. Therefore, He and N_2 are very popular gases for the carrier gas. Precaution should be given to the type of carrier gas which is a mismatch with the detector. The separation conditions of the components of the sample depend upon primarily the selection of the stationary phase and it is unlikely to be influenced with the type of carrier gas.

Samples (gas or liquid) are injected into the Sample injection port through silicon septum with syringe. The sample injection port is heated with heater so that the area can be maintained at the appropriate temperature because the injection volume of sample can be minimised. This is because the sample can be injected to the column with minimal spread of sample vapour and separation of peak can be very sharp if the injected sample is vapourised instantaneously.

Column is either packed column with packing materials in a glass capillary tube of 2 to 4 mm in diameter and 1 to 4 m length or open tubular column which is coated with the stationary phase on the inner wall of capillary of smaller diameter of 0.1 to 0.5 mm and 10 to 50 m long. The solved silica column has been in use recently because this is inactive, easily bent and difficult to break.

Detectors can detect each component, which is separated in the column, by responding to the amount of flow. There are two types of detectors: general type (which can respond to unspecified elements) and selective type (which can respond to particular compounds with high sensitivity). Also there are two types: if the component of sample is changed during the detection process or not.

Major detectors shall be described as follows:

i) Thermal Conductivity Detector: TCD

This is the most popular and the oldest type of detector. A constant electric current is applied to a bridge circuit and this detects the difference in electric resistance between the carrier gas tubular and the sample gas tubular. It is necessary for this detection to maintain the constant operation conditions in type and flow rate of carrier gas, temperature of the detector, the electric current of the circuit, and other conditions, because this is essentially the measurement of the change in the temperature of resistant. The response can be maximum when the difference in the heat conductivity between the carrier gas and sample components is maximum. Thus He and H_2 are well being in use because of high heat conductivity, and particularly, He is profound because of its inactivity chemically. TCD is virtually an all-round type detector unless the heat conductivity of the sample component is the same as that of the carrier gas.

ii) Flame Ionisation Detector: FID

The flowing gas from the column is mixed with H_2 gas and burned at the top of nozzle as shown in Fig. 3.3.5.

If some voltage is applied between the collector electrode and high voltage electrode on the top of nozzle, the ion current is very small when there is only carrier gas, but it will be sharply increased when ionised organic compounds by the hydrogen flame reach here. Therefore, organic compounds can be detected with very high sensitivity except such inorganic compounds which are not ionised by the hydrogen flame as shown in Table-3.3.4.

Table-3.3.4 Inorganic Compounds Which FID Cannot Detect

He, Ne, Ar, Kr, Xe, H_2, O_2, N_2, NH_3, NO, NO_2, N_2O,
CO, CO_2, H_2O, H_2S, COS, CS_2, $SiCl_4$, $SiHCl_3$, SiF_4

iii) Flame Photometric Detector: FPD

Compounds containing S and P can be selectively detected if the special flame of compounds containing S and P is measured by the photovoltaic multiplier through photo filter because the compounds containing S and P give special flames when those compounds are burnt in reductive hydride flame. The relations between the volume of sample and amount of response are linear for Phosphorus compounds and square proportional for Sulfur compounds (See Fig. 3.3.5).

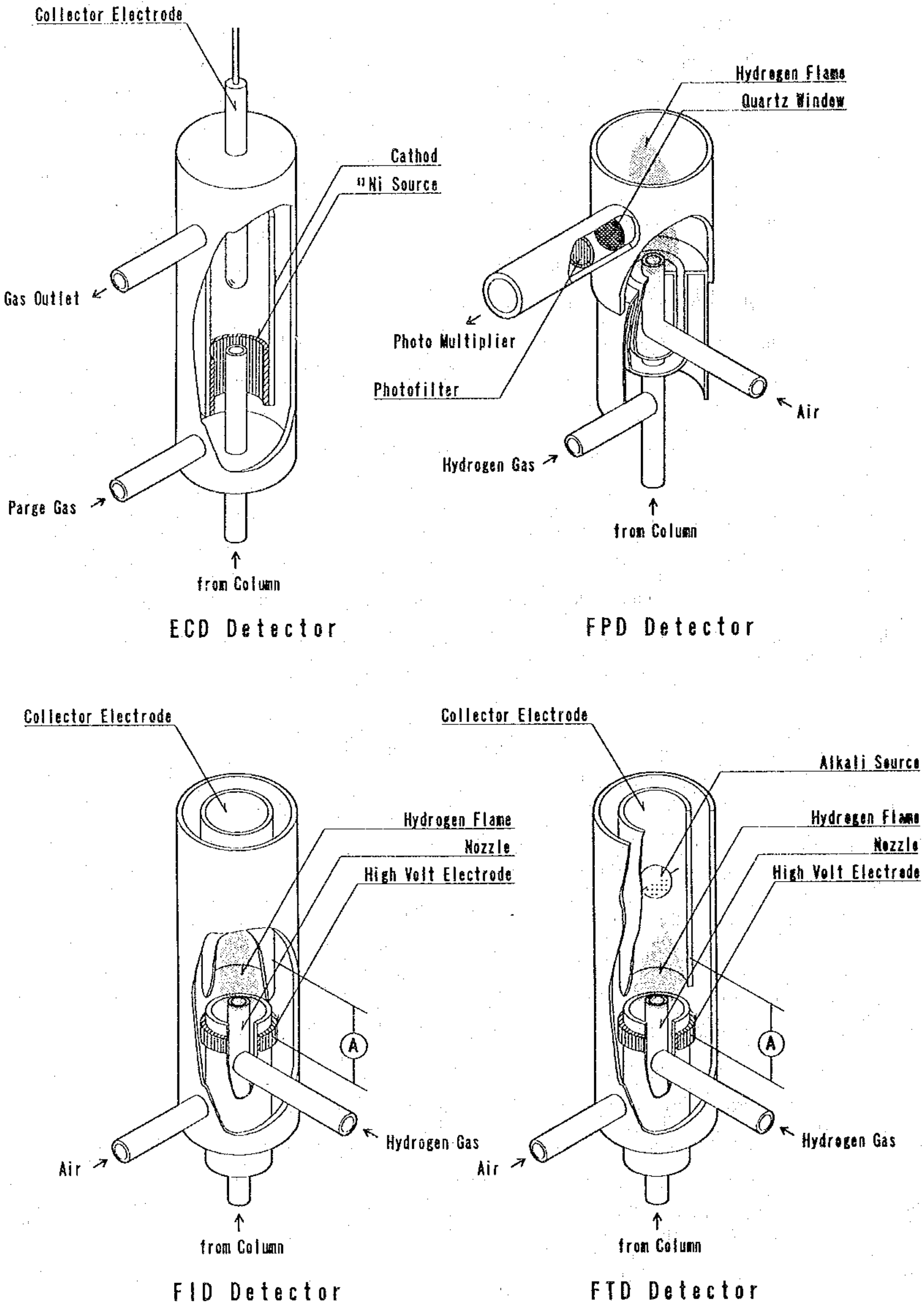


Fig. 3.3.5 Detectors of Gas Chromatograph

iv) Flame Thermionic Detector: FTD

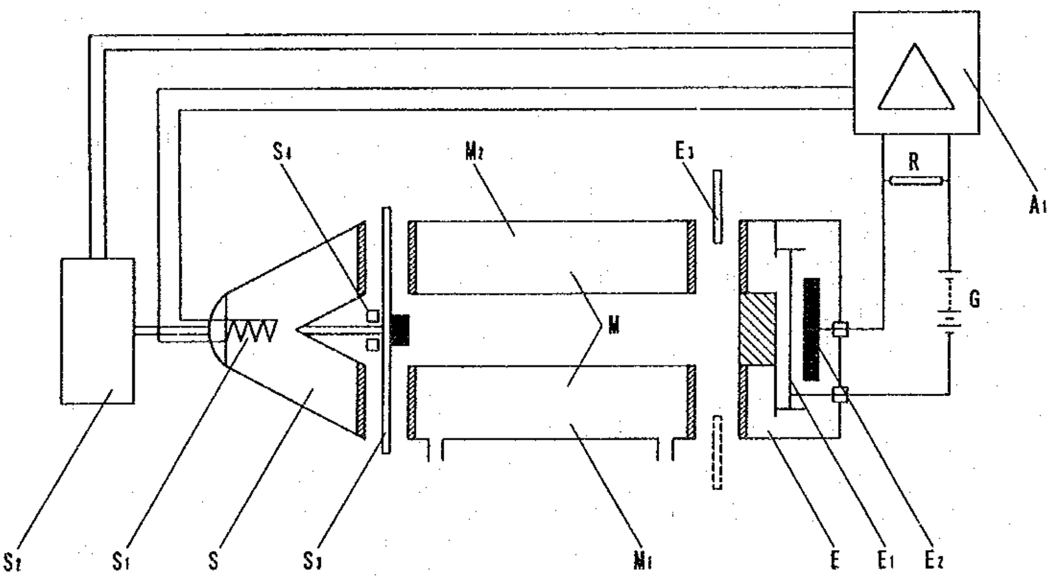
This is one sort of a Thermionic Detector: TID which detects the increase in the thermionic current caused by the electron flow between the chemical seed which occurs selectively on the heated surface of alkali metallic salt and the alkali metallic atom. The response will vary based on the gas content which is fed to the detector or heated temperature. FTD is well in use which uses hydrogen flame because the sensitivity is very good if the alkali source is attached to the collector electrode just above the nozzle of FID. This type of detector gives high response to the compounds containing N and P (See Fig. 3.3.5).

v) Electron Capture Detector: ECD

A constant current flows between electrodes if the carrier gas (N_2) is ionised by the beta ray from ^{63}Ni. If electrophillic materials arrive, the velocities of traverse become slower because the materials capture electrons and become negative ion. Also the negative tends to couple with positive ion very easily, and the current between electrodes tends to decrease. ECD can detect selectively the electrophillic materials if the reductionof the current is measured. ECD can detect compounds which contain halogen, P, nitro group and so on selectively with very high sensitivity although hydro-carbon cannot be detected (See Fig. 3.3.5).

2) Total Organic Carbon Meter (TOC)

TOC can evaluate the total organic carbon which indicates the degree of contamination of organic carbon. Most of TOC meters use the combustion infrared analysing method which enables to quantify the organic carbon in the water sample directly, speedily, and easily. In essence, the total carbon in the sample is to be burnt and decomposed to CO_2 in high temperature combustion column which is packed with oxidised Cobalt, and the concentration of CO_2 is detected by a non-dispersive infrared gas analyser (NDIR). The inorganic carbon can be decomposed in a low temperature combustion column or by acids, and the content can be determined similarly. The difference between the total carbon and the total inorganic carbon is defined and recorded as the total organic carbon. This method is being in use as an easy and highly accurate device to detect the contamination by excrement, organic solvents or other organic substances because this method is generally free from the existence of other materials and of high repeatability. NDIR is a type of infrared gas analyser which utilises the infrared absorption particular to the type of gas and NDIR is an analysing method to measure the infrared absorption at the unique frequency of the gas with filter or a selective detector by transmitting infrared from a continuous infrared source into the sample gas without dispersing with prism or diffraction grating. This type of detector is essentially to multiply electrically the displacement of a separating wall to the change in capacity of condenser as shown in Fig. 3.3.6. The displacement is caused by the pressure difference, that is the temperature difference between both sides of the wall caused by the difference in infrared absorption between the reference cell and sample cell.



E	Detecter	M	Mesuring Cell	S1	Source Element
E1	Film	M1	Sample Cell	S2	Mortor
E2	Pair Electrode	M2	Reference Cell	S3	Sector
E3	Zero Adjuster	R	High Resistance	S4	Bearing
G	Direct Current	S	Light	A1	Main Amplifier

Fig.3.3.6. Details of Infrared Gas Detector

(3) Element and Inorganic Compound Analysis

It is necessary to analyse elements for water quality analysis such as ammonium ion, nitric acid ion, nitrous acid ion, and phosphoric acid ion. However, at present time CGWB is conducting these analysis manually and may need to improve the analysis capacity.

There can be two approaches to the analysis of elements and inorganic compounds; one is chemical approach and another is electrical approach. The former is to analyse the water quality based on the chemical and physical properties. There are many means of analysis available. First the Auto-Analyser which CGWB requested will be examined and the Semi-Automatic Analysis System (SAA) will be recommended, instead, because SAA has the spectrophotometer as detector which CGWB is familiar with and which gives easy-to-handle and low-cost-operation.

The Ion Meter (IM) is a well established, easy-to-handle, and quick-to-analyse equipment to determine the concentration of ion for analysis of elements and inorganic compounds.

The combination of the SAA (Chemical Approach) and IM (Electrical Approach) seems very appropriate and desirable for analysis of elements and inorganic compounds. The Auto-Analyser, SAA and IM will be discussed as follows:

1) Auto-Analyser

The Auto-Analyser is an automatic analysis equipment which was originated and developed mostly in Europe in the 1960's before the introduction of equipment analysis. Principally the Auto-Analyser is an automated equipment of manual analysis which uses the Colourimeter, the Photometer, the Flame Photometer, and other equipment. Therefore, this type of equipment can be considered as an extension of the conventional chemical analysis method.

The Auto-Analyser is a piece of equipment described as follows:

The collected samples are arranged to have a colour development process (injection of reagent, mixture, heating, etc.) and extract process (dialysis, separation, dilution, distillation, etc.) automatically before they reach the detector. Therefore, each Channel can be set for each detection element having colour development and extract processes and detection part, and 3 elements can be simultaneously detected if it is a 3 Channel system. The disadvantage of this system, however, is this Channel must be set up for each element of such process as movement of samples, injection of reagents, mixing, heating, dialysis, separation, dilution, distillation, and detection. The detector is generally necessary to select individually. In case multiple elements are needed to be analysed, the same number of channels is also needed. In such a case, even the same detector can be used, but the detectors must be provided to meet the numerous requirements. This indicates that the user obviously is needed to provide relatively expensive devices in a channel. For example, the 4 Channel Auto-Analyser, having a system control up to 4 channels, can set up maximum 4 automatic analysing circuits at one time. If 3 Channel system is procured, as requested in the original Request, the user can detect 3 elements like NH_4, NO_3 and NO_2 but he is also requested to provide (expensive) custom-made 3 sets of the Colourimeters and other devices. If CGWB wishes to determine SO_4, Cl, F, B, SiO_2, PO_4, Na, K, pesticides as well as those three simultaneously, CGWB may need 3 units of 4 Channel Auto-Analysers.

It may be obvious that such approach will lead to very expensive investment. Next approach may be to procure one set of the Auto-Analyser for 12 elements. In this approach, the user can reduce the investment because he can use the same detector for different elements. But he is needed to rebuilt the system very frequently. Therefore, he must spend time as well as tubes and pipes as consumable materials for rebuilding the system. The cost of such consumable items may not be neglected at all.

By and large, the system is intended to be fully automatic, and there are many automation devices, such as liquid pumps, valves, and photo sensor, in the system, and the user may need to provide a back up service for the maintenance of the system to utilise this system at high efficiency. The user may need maintenance cost in this sense.

Other aspect of consideration is detection level. The concentration of pesticides will be very low in drinking water level and the Auto-Analyser cannot detect this low concentration. And this type of equipment does not seem to be suitable to the water quality analysis of groundwater because detectors of this system are the Colourimeters, the Photometers, the Flame Photometers which have limitations of repeatability and detection limits. Although this system is expensive, it can yield general level of accuracy. Thus, the system is concluded here not suitable for the analysis of water quality of groundwater.

2) Semi-Automatic Analysis System (SAA)

Here, having the Spectrophotometer as the detector which CGWB is familiar with, SAA is recommended instead of Auto-Analysers. This system provides the auto-injector, the auto sampler and the computer aided control and process unit. This will be discussed in 4.3.1 in more details.

3) Ion Meter (IM)

Another type of equipment, IM, is an electrical analysis device. This is to determine the concentration of the objective ion by measuring the voltaic difference between the indication and reference electrodes which are sunk in sampled liquid. The indication electrode responds to the contents of the objective ion, and the reference electrode indicates a constant electric potential independent upon the objective ion.

IM is important for portable on-site measurements during emergencies, the determination of the causes of pollution in water sample, and analysis of elements which require on-site sample analysis, such as cyanogen.

The measuring method of IM is characterised by the high sensitivity quantitatively and qualitatively. Also this method can be used for the equivalent analysis and the electrode reaction mechanism analysis very effectively. The method also has such advantages as an easy and speedy measurement for multi-elements, and an effective tool for testing of liquid properties to determine pre-treatment methods.

There are two types to determine the concentrations of the objective ion. One is a direct method which can determine the concentrations by using the pre-determined calibration curve, and the other is the titration method which can determine the ionic content by using acid-alkali reaction or oxidisation and reduction reaction to find the equivalent point. Usually the indication electrode uses ion selective electrode or platinum electrode which responds to the objective ion selectively and the reference electrode is the widely used saturated electrode and silver-chloride electrode.

The electrode having a film which responds to a specific ion is called an ion electrode (film electrode). The electrode potential is determined by the potential difference (film potential) between the difference of the ion concentration of two solvents of both sides of the film. The most popular electrode is a glass electrode which has a glass film and respond to hydrogen ion for determination of pH.

(4) Peripheral Equipment

An analysis of the behavior of pollutants in unsaturated formations is important to understand the pollution mechanism in groundwater. A Vadose Zone Sampler (VZS) is necessary to take soil samples from the surface down to 2 to 3 m below ground level to extract and analyse solutions.

When implementing the Project, the system should be preventive of environmental distributions. Therefore, the disposal of wastes should be treated within the allowable limits. Thus, the Table-Type Waste Treatment Equipment (TWT) is effective for the disposal of standard reagents, in particular, and the disposal of water sample of high concentration of toxic elements after analysis. Regular water samples may be discharged if it is discharged after a pH adjustment, because the concentration can be diluted sufficiently with a high volume of water.

As for gas disposal, after water quality analysis it may not be a problem. Generally, the exhaust gas for water quality analysis can be released into the atmosphere, so the same method will be used in India. Table-3.3.5 exhibits a list of the equipment for water quality monitoring.

Table-3.3.5. List of Equipment for Water Quality Monitoring

Type of Elements	Equipment for Water Quality Monitoring
Heavy Metals	Inductively-Coupled Plasma Spectrometer (ICP)
	Atomic Absorption Spectrophotometer (AA)
Organic Compounds	Gas Chromatograph (GC)
	Total Organic Carbon Meter (TOC)
Elements and Inorganic Compounds	Semi-Automatic Analysis System (SAA)
	Ion Meter (IM)
Peripheral Equipment	Vadose Zone Sampler (VZS)
	Table-Type Waste Treatment Equipment (TWT)

3.3.5 Operation and Maintenance Plan

It is required that the operation and maintenance be managed by the operational committee mentioned in 3.3.1. The details will be discussed later in CHAPTER IV. Here are outlined the items related to the operation and maintenance.

The operation and maintenance can be grouped as follows:

1) Provsion of regular examination and regular inspection.
2) Budget control for the operation and maintenance.
3) Procurement control for the consumable materials and spare parts for the smooth operation and maintenance.
4) Provision of technical training by inside or outside of CGWB for the self-reliance of the operation and maintenance.

As for 1), it is necessary to provide yearly regular examination, monthly regular inspection and daily inspection. It is necessary to establish a control system which enables CGWB to maintain equipment in good conditions with regular examination ledgers.

As for 2), the provision of budget including consumable materials and spare parts beforehand.

As for 3), it is necessary to provide parts ledgers for inventory control of spare parts proved by the provision of budget as well as the effective inventory control and exchange of information for inventory conditions among Chemical Laboratories.

As for 4), it should be continued because perpetual efforts for individual technical improvement is required.

3.4 TECHNICAL COOPERATION

The equipment for water quality monitoring to be procured in the Project are not being manufactured in India and AA, being used by CGWB, is old type of USA models of 1970's. AA of the Project should be well advanced and designed for easy operation by the improvement in many places compared to the existing type at CGWB. And ICP can be handled if the operator acquaints the treatment of AA. Therefore, it can be considered that the equipment to be procured by the Project can be operated through the rating test during the Commissioning from the experience with AA. Thus, it is concluded no technical transfer is needed.

CHAPTER IV

BASIC DESIGN

CHAPTER IV

BASIC DESIGN

4.1 DESIGN POLICY

This Project aims for CGWB to procure the equipment for water quality monitoring for groundwater of entire India to strengthen its water quality analysing scheme. The design policies for the equipment will be discussed regarding general considerations and detailed considerations, as follows.

4.1.1 General Considerations

The design policy shall be made in taking such general considerations as follows.

(1) Designing the Project shall have concept to formulate the basic structure of the water quality preservation in India.

(2) Therefore, the Project shall select the equipment to meet CGWB's requirements as priority order and beneficiaries by the implementation of the Project.

(3) The equipment for the Project shall be selected in taking practical considerations such as Indian natural and social environments (high temperature, the supply of electric power, regulations, procurement of consumable materials) and CGWB's present conditions (number of personnel and their technical experience) so that the equipment will be operated, managed, and maintained effectively.

(4) The equipment for the Project shall be selected to cover the requirement of CGWB to detect necessary elements with necessary precision for water quality analysis to construct the water

quality monitoring system for groundwater.

(5) The Project shall provide a technical support scheme and the supply of appropriate amount of spare parts considering the Indian situations to promote the effective implementation of the Project in addition to.

(6) Designing the Project shall intend to select the equipment to guide CGWB to an up-graded technological level to construct more sophisticated system for water quality monitoring with the experience of operation and management of the equipment and data obtained.

4.1.2 Detailed Considerations

(1) The equipment shall be categorised as follows:
   1) Equipment for water quality monitoring for drinking water
   2) Peripheral Equipment

(2) The equipment for water quality monitoring for drinking water shall be grouped: 1) Heavy metal analysis, 2) Organic compound analysis, and 3) Element and inorganic compound analysis

(3) The equipment shall be selected in accordance with the characteristics, detection level, and the analysis capability of each candidate type of equipment to meet the requirement of CGWB.

(4) The equipment shall cover the requirement of CGWB as described in (2).

(5) Each equipment shall be examined and confirmed for the viability of the equipment by the operational and maintenance capability of CGWB, the managerial situations such as procurement of consumable items (gases, standard reagents, printing papers, consumable parts, etc.).

(6) Then the necessary number of the equipment shall be numerated to

carry out the schedule made by CGWB.

(7) Finally, the buildings and facilities of the Project Sites for the installation of the equipment and the allocation plan of the equipment shall be examined to give the maximum effective management to the Laboratories, and based on this plan, the personnel plan, the operation and maintenance plan shall be formulated, accordingly.

4.2 STUDY AND EXAMINATION ON DESIGN CRITERIA

The design criteria shall be discussed as follows.

4.2.1 Number of Water Samples

The present total number of water samples (N_0) is about 18,500. If the project year is set after 5 years (1997-98), the estimated number of water samples in 1997-98 (N) will be 28,470 assuming the increase rate for five years will be the same as the increase rate of the number of the hydrological stations in the previous 4 years between 1989 and 1993 (See Fig. 2.3.1). During this period the number of the hydrological stations was increased from 11,015 to 15,557 (annual increase rate was 9.0% over the period) and N can be calculated as follows:

$$N = N_0 \times (1 + 0.09)^5 = 18,500 \times 1.539 = 28,470$$

4.2.2 Analysis Elements

The elements being analysed by CGWB are presented in Table-4.2.1.

Table-4.2.1 Elements Being Currently Analysed by CGWB

Analysis Method	Equipment Being Used	Inspection Elements
Manual Method	Spectrometer Colourimeter	B, Cl, F, CN, NO_3, NO_2, NH_4, TN, PO_4, TP, SiO_2, SO_4, CO_4, HCO_3, Ca, Mg, TH, K, Na
Equipment Analysis Method	AA	Fe, Mn, Ag, Cu, Zn, Co, Mo, Cd, Sr, Li, Rb, Cs, Cr, Pb

The table explains that currently CGWB is not analysing regularly organic compounds, particularly pesticides, and that CGWB is mostly analysing the normal items. Also the table tells that CGWB can obtain sufficient precision with AA for heavy metal analysis, but that CGWB cannot get enough accuracy for other element analysis with manual analysis with the Spectrometers or the Colourimeters. Of course, CGWB recognises this and CGWB wishes to increase the types of the detection elements and also improve the detection level remarkably through the implementation of the Project. CGWB wants to analyse the elements shown in Table-4.2.2 by the Project.

Table-4.2.2 Inspection Elements Which CGWB Wishes to Analyse

Group of Elements	Type of Elements	Analysis Equipment
Heavy Metals	Fe, Mn, Cu, Cr, Zn, Cd, Ni, Mo, Hg, Pb, Sb, etc.	ICP
	Fe, Mn, Cu, Cr, Zn, Cd, Ni, Mo, Hg, Pb, Sb, Al, As, Ba, Bi, Ca, Co, Li, Mg, Se, Sr, Ag, Sn	AA
Organic Compounds	Pesticides, Hydrogen Compounds, Organic Compounds	GC
Elements and Inorganic Compounds	B, Na, K, NO_3, NO_2, ON, PO_4, SiO_2, SO_4, Cl, F, NH_4, CN	Auto-Analyser
	Cl, F, NH_4, CN, Br, I, O_2, S, ORP, pH	IM
Stable Isotopes	H_1, D_2; O_{16}, O_{18}	Mass Spectrometer

4.2.3 Detection Level

CGWB expresses its desire of detection levels as shown in Table-4.2.3. The detection levels given in the table is quite reasonable.