CHAPTER I

INTRODUCTION

PURPOSE AND SCOPE

Water is an important and vital resources for human society, not only for its survival but also for its growth and development. With increasing tempo of all round development in the quality of life, social as well as industrial, an unprecedented demand on the available water resources all over the world is being witnessed.

In view of this increasing demand of water for various purposes like agricultural, domestic and industrial, a greater emphasis is being laid for a planned and optimal utilization of water resources. The resources of an area

remain constant whereas the demand for water continues to increase. It hardly needs to be emphasized that development and exploitation of water resources of any particular area cannot be unlimited, and beyond a certain point, a line has to be drawn. Also, each area has ~~been~~ its own water regime, due to the uneven distribution of rainfall both in time and space, the surface water resources are also unevenly distributed. This has necessitated an increased emphasis on a proper management strategy for the development of groundwater resources. No strategy however can be successfully planned and implemented in the absence of a correct and dependable appraisal of the hydrogeological conditions controlling the total availability of water. It is therefore, now realised that a detailed picture of the geological and other related controls for the availability of groundwater and surface water resources is fully obtained before embarking upon any developmental programme.

The complexity of the groundwater problem in hard rock terrain is often taken for granted as these areas are less attractive in comparision with the other areas where large well-defined formations acting as good aquifer are available. Out of the total area of the country, more than half is constituted of crystalline rocks. A large number of villages situated in these hard rock areas subsist apparently on a meagre supply of water, partly from surface sources and partly

from groundwater. In the summer months, both the resources nearly dry up causing much hardships. Attempts to improve their lot can hardly succeed if the problem of water potential is not tackled on a scientific basis.

The author has in this thesis attempted to present a detailed picture of the hydrogeological conditions prevailing in one of the small but important river basin of the Mainland Gujarat, namely the Heran river basin. In fact the investigated area comprises a sub basin of the lower Narmada valley, the river Heran forming a tributary of the main river system. The author selected this basin because, the terrain which falls within its limit ideally exhibits an interesting diversity in terms of geology and geomorphology. These two controlling factors, behave quite differently in the different parts of the basin, thereby, providing very interesting hydrogeological conditions in its different parts. The importance of meteorological conditions can not be minimised. Also the climatic factors like rainfall, temperature variations, humidity etc. have significantly played their role.

The author has attempted to make a full appraisal of the hydrogeological conditions of the river basin by critically examining the various controlling factors governing the water resources availability. The pattern of occurrence, distribution, movement and recharge of groundwater has been

studied and overall potential has been evaluated. The existing practice of groundwater and surface water development and management has also been reviewed in the light of the available potential and present level of exploitation.

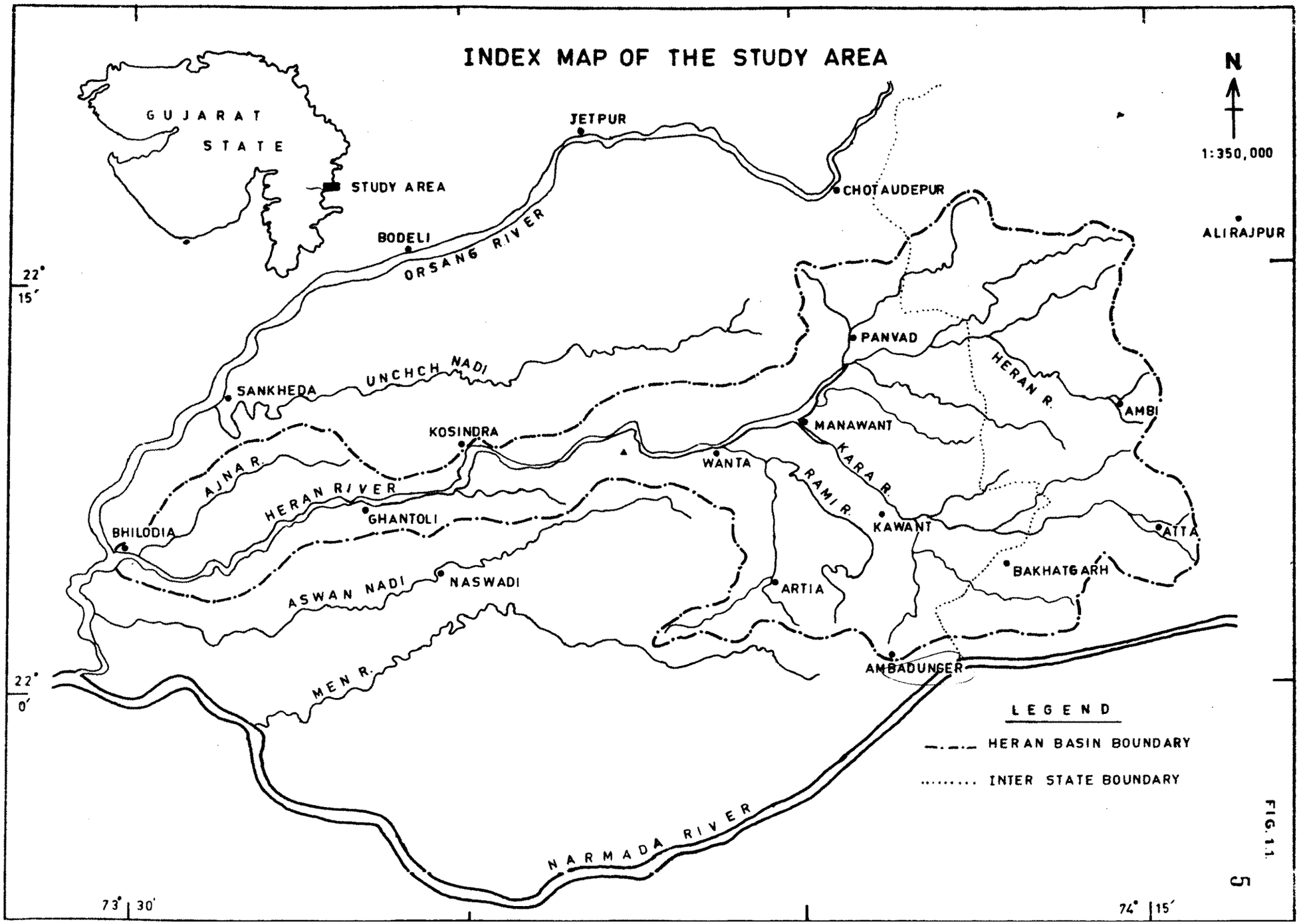
In this thesis the candidate has critically evaluated the following two aspects :-

1. Geo-environmental controls of water resources availability and distribution.
2. Evaluation of groundwater potential.

STUDY AREA

GEOGRAPHICAL LIMITS

The Heran basin area is located in the eastern parts of the Mainland Gujarat and Southwestern part of Madhya Pradesh (Fig. 1.1). The northern limits of the study area are marked by the rivers Unchch and Orsang, while to its south it is delimited by the Narmada and Aswan rivers. The basin area lies between the N Latitudes 22°05'00" and 22°15'48" and E longitudes 73°30'00" and 74°15'20". It is covered in the Survey of India Toposheets Nos 46F/12, 16; 46 J/3, 4 & 8. It comprises major parts of Chhota Udepur and Sankheda talukas and small portion of Jambugam, Naswadi, Tilakwada and Dabhoi


INDEX MAP OF THE STUDY AREA
GUJARAT STATE
STUDY AREA
JETPUR
CHOTAUDEPUR
ALIRAJPUR
BODELI
ORSANG RIVER
22° 15'
PANVAD
HERAN R.
UNCHCH NADI
SANKHEDA
AMBI
MANAWANT
KOSINDRA
WANTA
KARA R.
AJNA R.
HERAN RIVER
RAMI R.
GHANTOLI
KAWANT
ATTA
BHILODIA
BAKHATGARH
ASWAN NADI
NASWADI
ARTIA
AMBADUNGER
MEN R.
22° 0'
NARMADA RIVER
73° 30'
74° 15'
N
1:350,000
LEGEND
HERAN BASIN BOUNDARY
INTER STATE BOUNDARY
FIG. 1.1

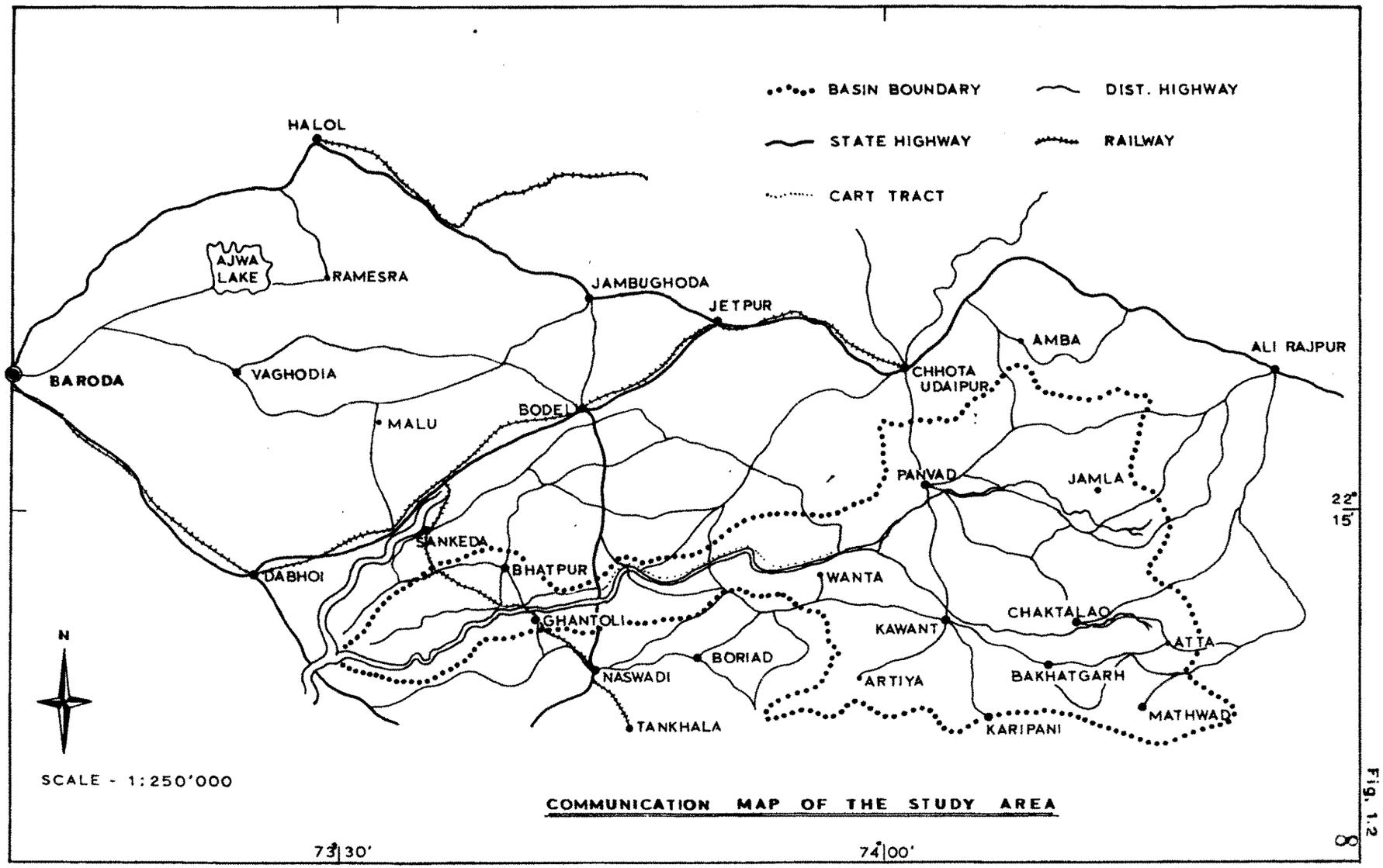
talukas of Baroda district. The eastern part falls within the Ali-Rajpur taluka of Jhabua district of Madhya Pradesh. Out of the total 1209 sq.km catchment, 748 sq.km is shared by the Baroda district of Gujarat State and 461 sq.km is shared by the Jhabua district of Madhya Pradesh.

COMMUNICATION

A good network of metalled and unmetalled roads criss-crosses the area connecting various towns and villages (Fig. 1.2). Several cart-tracks in the area are motorable in dry season. The major towns in and around the study area, viz., Sankheda, Kanwant, Bodeli, Chhota Udepur and Naswadi are well connected to Baroda through state highways. Baroda-Tankhala narrow gauge railway crosses Heran basin and connects several villages located in the lower part of the basin. Bus services of the State Transport connect almost all the villages in the study area. The upper part of the basin which falls under Madhya Pradesh state has relatively poor road links; the extensive hilly and humocky terrain with sparse population are the main reasons limiting the well defined communication links.

CLIMATE

The area experiences a dry tropical climate. The year is divisible into three seasons. The winter season is from



COMMUNICATION MAP OF THE STUDY AREA

Fig. 1.2

October to February; this is followed by the summer season from March to June. The period from June to September is the southwest monsoon (rainy) season. The mean maximum and minimum day temperatures experienced during the year range between 34°C and 19°C respectively. The average annual rainfall is 954 mm. The relative humidity varies from about 60 % to 85 % during the monsoon. It is around 25 % to 30 % in summer. Winds are generally light with some strengthening in force during the late summer and early part of the monsoon. Winds blow mostly from the south-west and west and from north - north-east during October-December. The mean annual wind speed is 5.6 km/hour. Skies are generally heavily clouded during the south-west monsoon season. Cloudiness rapidly decreases in the post monsoon season. Skies are mostly clear or lightly clouded during the period from December to May.

FLORA AND FAUNA

The eastern part of the basin which lies under Chhota Udepur and Jambugam talukas comprises numerous protected forests. Generally these forests are of Dry-mixed deciduous type, the dominant species being:

Tectona grandis (sag), Terminalia tomentosa (sadad), Adina cordofolis (Haladwan), Dalbergia latifolia (Sisam), Acacia catechu (Khair), Azadirchta indica (Neem), Diosphyros tupru

formations. The groundwater in consolidated formation areas is mainly confined to fractures and zones of weathering. Majority of aquifers are of phreatic water table types. Even the sandstone areas do not provide good aquifers since they are hard, compact and siliceous in nature. The average depth to groundwater table varies between 5 to 20 m below ground surface. The ground water in alluvial formation occurs in semi-confined to confined type of aquifers. The average depth to groundwater table is in between 15 to 35 m below ground surface.

SOCIO-ECONOMIC RELEVANCE

It has been observed that the availability of the groundwater resources has a direct bearing on the socio-economic development of the study area. In the zones having perennial supply of groundwater and surface water, the population is flourishing with better living conditions and a higher rate of literacy as compared to those areas which have meagre supply of water. The development of the groundwater resources has tremendously improved the agricultural produce raising the economic status of the people of these areas. While in the areas devoid of sufficient supply of groundwater, the agriculture has not been developed and the average lot has consequently remained economically poor. The social relations have also followed the trend of economic growth.

The groundwater potential has not been so far evenly developed so as to narrow down the wide economic gap between two categories. The area has got all potential for balanced development, provided the total water resources of the basin are scientifically identified and properly managed.

BRIEF GEOLOGY

The study area comprises rocks of Precambrian to Recent. The Precambrians which have been involved in repeated tectonic activities are represented by the basement gneissic complex, schists, phyllites, quartzites and Post Delhi granites. They are unconformably overlain by the Bagh sedimentary sequences of sandstones, shales and limestones of Cretaceous age. These Cretaceous formations are overlain by extensive basaltic and alkaline lava flows of Deccan Trap (Cretaceo-Eocene). Except in the upper reaches of the basin, most of the area investigated has a flat terrain covered by a thin veneers of soils and Quaternary alluvium and shows gently rolling topography.

PHYSIOGRAPHY AND DRAINAGE

The Heran river is a tributary of Orsang, which itself forms a major river sub basin of the lower Narmada valley. It rises in the hills of Jamla of Madhya Pradesh state at an elevation of 407 m and flows westerly upto its confluence

with Orsang near Bhilodiya at an elevation of 40 m. It is a perennial river, though most of the precipitation is received during monsoon season.

The basin forms a very gently falling ground in the lower reaches, while the upper reaches are highly rugged and hilly. In the eastern and southeastern parts of the basin, the hills attain maximum elevation of 540 m above MSL. In the central part, except for the group of Phenaimata hills which form prominent landmark, rest of the ground form a gently undulating country. The lower portion is almost flat except for a few hills of Songir. Out of the total basin area, about 517 sq.km is hilly and the remaining 690 sq.km is plain.

The overall drainage comprises a system of WSW flowing tributaries more or less parallel to the main river. These are Kara, Ajna and Rami (Fig.1.1) and the basin shows dominantly a dendritic to trellis pattern. The directions of the flow of streams of different orders are dominantly controlled by the fracture patterns of the rocks.

METHODOLOGY

Taking into account the prevailing hydrogeological conditions in the basin and the scope of the present study,

the author devised his own methodology for the investigation, which broadly consisted of following steps.

A. Collection of all background information available in various published and unpublished works, topographical sheets, airphotos and satellite imagery.

B. A critical appraisal of all available data and formulation of concepts and a strategy for investigation.

C. Collection of data pertaining to geology, geomorphology, hydrology and hydrogeology.

D. Compilation, analysis and review of the various data and preparation of a hydrogeological model.

DATA COLLECTION

Collection of various data pertaining to geology, hydro-meteorology and hydrogeological studies from various sources as under:

Geology: Previous geological literature, unpublished reports of government and semi-government organisations.

Hydro-meteorology: Data on rainfall, river discharge (Run-off) for a period of six year (1976-82) and annual variation cycle for climatological data on temperature, humidity, evaporation, wind velocity and solar radiations.

Hydrogeology: Case studies, reports, monographs and papers on the hydrogeological aspects in hard rock terrains, hydrogeological characteristics of aquifer systems etc. Collection of various records on hydrogeological field observations, tube well logs from different organisations.

DATA COMPILATION

(A) Study of Survey of India Toposheets for demarcation of basin boundary.
Identification of physiographic features, like hills, ridges, uplands, river terraces, levees, alluvial lowlands and drainage.
Morphometric analysis of various sub basins including drainage pattern, stream orders, Horton's analysis of drainage net and slope studies.
Identification of various landform features viz; hilly and forest areas, plain agriculture lands, waste lands, alluvium pockets and tracts etc.
Locations and classification of the existing wells
Preparation of Theisen's Polygon's for the calculation and analysis of precipitation.

(B) Study of Aerial Photographs and Satellite Imagery.
To delineate various lineaments i.e. fault, fractures, dykes, lithological contacts etc.

Landform features, buried river channels and surface water bodies.

Identification of dark tonal variations in air photos and MSS Band No.5 & 7 indicating groundwater occurrence.

Recognition of the dignostic terrain features for field studies.

FIELD STUDIES

The field studies have been carried out in two phases, as reconnaissance survey and detailed studies.

(A) Phase - I Reconnaissance Survey

Planning of groundwater and geological field survey, selection of various traverse, probable sites for establishing the observation wells for monitoring the seasonal groundwater fluctuations.

Taking appropriate traverses to check various litho-stratigraphic units their extents, fracture pattern, delineation and confirmation of major discontinuities, nature and extent of weathering zones, of various litho-units, stream controls, study of river terraces and river beds. Fixing and selection of observation wells at specified grid locations for well inventories and pump tests. Photography of typical features of hydrogeological interests.

(B) Phase-II Detailed Studies

Study of Hydrogeological characteristics of various lithological units such as the nature and type of water bearing strata by studying existing open well sections, study of surface and subsurface barriers (dykes) and their controls over groundwater movement and accumulation.

Identification of directions of groundwater flow, monitoring of seasonal fluctuations in the established observation wells, water sampling for the study of chemical quality.

Pump out test for determining the various aquifer parameters viz. sp. yield, sp. capacity, permeability, transmissibility and storage coefficient.

Resistivity survey to know the geo-electrical properties of the various formations, depth and thickness of low resistivity zones.

Delineation of buried river channels, hidden dykes, shear zones etc.

ANALYSIS AND INTERPRETATION OF RESULTS

AREA CATEGORISATION

Hydrogeological classification of the area from the point of view of groundwater occurrences as relatively favourable and unfavourable. The three important controls

being:

(A) Lithology: Categorisation of all the rocks/ formations in to hydrogeological groups as consolidated and unconsolidated.

(B) Structures: Scrutiny of the various structures and discontinuities present in various litho-units and their influence on groundwater flow. Categorisation of various structures and their approximate quantification

(C) Geomorphological: Categorisation of various geomorphological features and land forms on the basis of slope, weathering, drainage patterns and density and their contribution towards recharge.

HYDROGEOLOGICAL EVALUATION

(A) Analysis of groundwater level fluctuation data:

(i) Computation of reduced water level (RWL) with reference to existing bench marks in the study area and then plotting of reduced water level contours.

(ii) Evaluation of RWL contour pattern from area to area viz; lithological, physiographic or structural controls over depth of groundwater levels, movement and flow directions. Evaluation of streams i.e. their nature effluent/influent by analysing cross sections of water level in the observation wells.

(B) Pumping out Tests:

Evaluation of aquifer parameters by

(i) Plotting of time v/s Draw down curves.

(ii) Computation of co-efficient of Transmissibility (T), Co-efficient of storage (S) and Hydraulic conductivity (K) of the aquifer systems.

(iii) Appraisal of controlling factors responsible for the heterogenity encountered in aquifer properties.

(C) Groundwater Quality Assessment:

(i) Review of available data on chemical analysis and additional data obtained from selected samples from specific conditions to determine the percentage cations, anions, hydrogen ion concentration (pH) and Total dissolved solids (TDS)

(ii) Evaluation of groundwater quality in different areas of the basin by plotting ISO-TDS and ISO-CHLORIDE maps.

(iii) Appraisal of chemical variations related to geological conditions.

GROUNDWATER RECHARGE COMPUTATIONS

Estimation of Recharge Index (RI) by employing various approaches viz; Rainfall-Run-off relationship (Water Balance Approach) and Water Level Fluctuation approach etc. Quantification of groundwater reserves, an attempt to study the groundwater management aspects of the study area.

HYDROGEOLOGICAL MAP

Based on all the three governing factors viz; lithology, structures and geomorphology and their zoning with regards to groundwater potential by adding aquifer parameters from different locations.