CHAPTER XI

SUMMARY AND CONCLUSIONS

Groundwater has its own importance in meeting out the water supply requirements for domestic, irrigation, urban, rural, and industrial and agriculture uses. In India, there are areas where groundwater development has reached critical stage and adverse effects are eminent. The increasing demand of water/groundwater has stimulated investigation oriented towards quantification of water resource which is the base for formulating plans for its management, proper exploitation and conservation.

In this context, in India, almost every irrigation project in command areas is decided on the concept of gravity flow and weightage is not given to the existing groundwater resources. Imbalanced planning has created a hydrologic inequilibrium, resulting in water logging, salinity, alkalinity etc. particularly in the alluvial areas. In addition, the use of fertilizers, pesticides and insecticides in the fields have degraded the quality of shallow groundwater bodies at places in the command areas. The tail end reaches of canals are unable to irrigate the farmland because of paucity of the surface water in the reservoir of the dams/talao/ tanks etc. This paucity of water in reservoir is due to the vagaries of rainfall. Keeping this view in mind author has selected the area of Lalburra, which has been declared by the local authorities as draught prone area for geohydrological studies. The area is a part of Wainganga river basin.

The study area falls with in the Toposheet No. 64 C/1(1:50000 scale) of Survey of India. It lies between latitude 21°55’-22°0’and longitude 80°0’ E-80°5’ E. The area is
situated on south of Jabalpur, east of Seoni and west of Balaghat. The study area mainly consists of alluvium, clayey, loamy and silty sand. Only few outcrops are exposed at Patartharsahi, Salhe and Bakoda. Most of the exposures are of granite and gneissose granite, muscovite-biotite-schist. At Bakoda exposere Mangniferous quartzites are encountered where abandoned open cast mines of manganese are found near the banks of the querry. There is network of irrigation canals, which is the source of water for agriculture along with dugwells and most of them run dry in summers.

Lalburra area is approachable by road from Seoni and Balaghat District.

The present work is mainly concerned with the hydrogeological mapping of the area, delineation of areal extent of various aquifers with respect to their physical, structural and hydrological characters. The hydrological investigation has been carried out in three phase. In the first phase, review of the available previous literature and reconnaissance survey of the area has been done. In the second phase, pre and post monsoon well inventory data of 42 wells were collected. Water samples of surface water, groundwater and handpumps were sent to professionals for analysis as the facilities were not available in the Department. In the third phase, pumping test, electrical resistivity survey and groundwater budgeting has been done. The future development and management of groundwater is also suggested on the basis of the investigations carried out. The periodic variation of the depth to water table and quality has also been studied. The different areas have been demarcated for the dug well and handpump and artificial recharge structure etc. in the study area.

The study area is drained by river Sarathi and its tributary Atri Nala which almost becomes dry in the summer season. Wainganga river, which is a perennial river forms various fluvial features such as antecedent drainage characterized by narrow and deep
gorges. Its major tributary Sarathi river flows from west to south-east side of the study area, meets Wainganga River at its southeastern end.

The plain areas are useful for the paddy crops and are being used for the agriculture purposes. The maximum height is 340 m. from M.S.L. whereas the minimum height is 320 m. from M.S.L.

Drainage, its pattern and areal extent are very helpful in predicting the water potentiality, where the precipitation is poor and loss of water by evaporation is more.

The studies of the drainage basin morphometry and drainage pattern of the study area have been done on 1:50000 scale, of Toposheet of Survey of India No. 64C/1. Strahler (1964) method has been used for the ordering of the streams. The river Sarathi and Atri Nala are fourth order stream in study area. The total length of stream is 31.13 km and total number of streams is 15. Total number of third order basin is 4. Total area is 100 sq.km. The basin length is 10.53 kms. The average drainage density is 2.97 km / sq. km., the drainage texture is very coarse. The average stream frequency is 3.08 km. The maximum bifurcation ratio is 0.75. and the average length of overland flow is 0.22 km. The average elongation ratio is 0.78. The average basin circularity value is 0.67. The area has a dendritic drainage pattern. It indicates that the rocks of the area differ in uniform resistance in the horizontal direction.

The slope studies have been done using the Wenworth (1930) method. The average slope varies from 0 to 10° in the plain areas and 30 to 50° in hill slopes, plateau and steep slope / escarpment at hill crest slope. The area of valley fill with alluvium has 0 to 10° slopes.
The climate, topography and geology control the hydrologic characters of a region. Meteorological data are useful in determining the water balance of a basin and for the development and management of its water resources. Thus, the data of rainfall, temperature etc. have been collected from the various departments of Govt. of M. P. The average maximum temperature is $43^0$ C, whereas the minimum average temperature is $4^0$ C. The maximum temperature occurs in the months of May – June while the minimum temperature occurs in the month of January. The Evaporation / evapotranspiration is one of the most complex phase of hydrological cycle. It has been observed that the evaporation losses go on increasing from January to May. From the beginning of June the evaporation losses increase during September and October and this decreases in November and December.

Rainfall data was collected from SLR, Balaghat for the past 20 years from 1992 to 2011. It reveals that the average rainfall is 1430.87 mm. It is noted that in the span of 20 years the maximum rainfall was 2636.3 mm. in 1994 and the maximum rainfall was 969.5 mm in 2004. The mean monthly rainfall data shows that June to September are the principal rainy months which comprises of about 60% of the total annual rainfall. September and June receive about 20% of the total rainfall. Thus, the rainy season extends from June to September and the remaining rainfall accounts for December and January.

It is noticed that during the month of June, the rainfall is lost due to intense evaporation and only a small part of it goes to the soil moisture zone to fulfill its water requirements. A little of it goes as run off. In the month of July, a part of the rainfall is utilized for saturating the soil moisture zones in the paddy field area. The rest of it goes
mostly as run off and evapotranspiration losses and only a part of it go for the groundwater increment. During the month of August, maximum groundwater increment takes place.

September is another month when groundwater increment is possible due to infiltration in the command area. The rainfall, other than the rainy months, is more or less scanty and is just enough to meet out the partial requirement of the soil moisture zone.

Geology plays an important role in the Groundwater investigation of an area. Lithologic units, their distribution, mineralogical composition and texture along with the geological structures of the main factors in generation of spaces suited for storage and movement of groundwater. The groundwater potential depends upon these aquifer systems in the area. Therefore, it was necessary to consider the nature of geological formations present in and around study area.

The manganese ore of this area has attracted the attention of geologist from a very long time. Bose (1888-1889) investigated this area and described the rocks. They were included in the Chilpi Ghat series. Fermor (1909) suggested some stratigraphic changes. Systematic mapping was done by Burton (1912-1914) and he placed Sonewani series below the Chilpi Ghat series. A relation with the manganese bearing Sausar Series was also established mainly on the occurrence of similar manganese deposit in Balaghat area.

Major changes in the stratigraphy of this area were made after the discovery of Central India Sutures (CIS) (Yedekar et al 1990) and further investigations of the manganese bearing zones.

The stratigraphic sequence evolved after extensive studies of this area by geologists of G.S.I., MOIL, MECL and private sector places Tirodi formation of Sausar
Group as the oldest formation in this area. It has biotite schist, biotite gneiss, granite gneiss / migmatite, sericite-muscovite schist, quartzite and granitic basic intrusives.

Geomorphologically, the area is almost plain with some undulations and small hillocks. Only few outcrops are exposed at Patharshahi, Salhe and Bakoda. Most of the exposures are of granite, gneissose granite and muscovite-biotite-schist. At Bakoda exposures of manganiferous quartzite are encountered where abandoned open cast mines of manganese are found. Lineaments have been marked on the basis of the map obtained from M.P. Council of Science and Technology, Bhopal. The map is based on the study of satellite imageries. These lineaments can be utilized for artificial recharge of groundwater and will prove to be highly potential zones for groundwater storage. The rose diagram of the lineaments will be helpful in location of these potential zones.

The soils of Lalburra area are variable and occur on alluvial plains. The slope generally ranges from $0^\circ$ – $5^\circ$. The soils of this unit are deep, fine textured, clayey loamy, clayey, sandy and sandy loamy clayey and light brown to yellowish brown in colour.

The soils of study area are suitable for paddy crops and according to the potential of each soil group, the soil have been placed into different classes from irrigation view point. In the study area, about 95% area has normal soils and remaining 5% area is having scree on the hill/plateau slopes.

The organic carbon content varies from 0.36 to 0.48% with common range of 0.42 to 0.46% and the highest amount of 0.48% has been found in some localities. Generally, almost all the soil of the study are alkaline. The pH value varies from 6.2 to 6.7. The phosphorus content is ranging between 4.5 to 5.1%. The potassium content also varies from 447 to 590. The common crops grown are paddy, wheat, sugarcane, linseed,
vegetables, beans, etc. The groundwater exploration has been carried out by using geological method and electrical resistivity survey. Total 10 vertical resistivity sounding have been obtained in the study area using Schlumberger configuration and the resistivity data have been interpreted by using curve matching technique and inverse slope method.

At a glance these data reveals that the lithologic formations are alluvial soil zone, weathered zone of gneiss, granite, quartzite and muscovite biotite schist, fractured and jointed rock zone and massive rock zone.

The muscovite biotite schist and gneiss have secondary porosity and percolate the water to certain depth. The upper zone of these rocks is highly weathered and the rocks at deeper horizone are highly fractured and sheared. The resistivity value ranges from 12.8 to 500 ohm m., which reflects on the degree of fracturing. Compactness is in increasing order with respect to the depth. The lower range of resistivity of third and fourth layer at some places indicates that the formation may be highly weathered with moisture content, indicating good groundwater potential zone.

The groundwater occurs in the weathered zones of rock formations i.e. muscovite biotite schist, gneissose granite and granite. The thickness of alluvium increases along the river course whereas it decreases away from the river course. The thickness varies from 4m to 30 m in the study area.

The alluvial formation consists of sand, clay and gravel and is the major aquifer in the study area. It covers an area of approximately 100 sq. km. 42 dugwells have been selected for the well inventory.
In the pre-monsoon period (May-June) depth of water table ranges from 0-10m whereas it varies from 1-8m during post monsoon (October, November) period. The water level fluctuation during the entire year ranges from 0-6m.

The weathered rock zone is the second major aquifer of the study area. In this formation, the groundwater occurs under water table condition but at some places semiconfined aquifers are also found. In this formation the premonsoon (May-June) depth to water table ranges from 0.6 to 9.14m whereas in the post monsoon (October-November) depth of water table varies from 1.5 to 12.2m. The fluctuation of water table is from 1.2 to 15.2 in the entire year.

The premonsoon water table map shows that a number of mounts and basins are located in this area. Prominent mounts are around village Salhe, Murlikham and south east of Devgaon. Basins are located around village Belgaon and Babriya. River Wainganga is in the east of the study area and therefore groundwater in the form of base flow goes towards the river. Atri Nala and Sarathi River also flow towards River Wainganga. Hence, both surface and groundwater flows towards River Wainganga which is the main reason of water scarcity during summer in this area. In some years serious drought conditions develop specially when the rainfall is scanty. The post-monsoon water table contours do not show any major change and the conditions remain almost the same.

On the basis of pre- and post-monsoon well inventory data a fluctuation map has been prepared. Minimum fluctuation of 0-2 meters has been recorded near Dharawqasi and between Khurpuri and Babariya. Maximum fluctuation of 6-8 meters has been observed in Barghat. From the water table contour map, especially post-monsoon map, it is seen that
groundwater drains from Barghat to Bakoda and Manpur that may be the major reason of high fluctuation in this area.

A study of periodic variation in the water table has been carried out. In the dug well, the depth to water table below ground surface for the Pre monsoon period have been considered and the depth to water table map have been prepared. The inception of canal irrigation has been developed recharging of groundwater and the water table is rising in the area, year after year.

For the determination of aquifer characteristics, 10 dugwells have been selected for monitoring of water level for hydrograph analysis, situated in the study area at different locations. Each well has been pumping at constant rate and drawdown- recovery data have been measured and recorded.

To determine quality of water, 20 surface water samples have been collected. Out of 20 samples, 11 samples are from dugwell, 5 samples are from handpumps 4 samples are from tanks. The water samples analysed at Central Pollution Control Board Tatibandh, Raipur, C.G. The analytical data have been presented by the trilinear piper diagram scatterdiagram and water quality map. The statistical analysis of the chemical quality has been carried out.

On studying the chemical analysis data, it is clear that the effect of mineralization in the surface water is very low so the water is suitable for drinking and irrigation purpose and the results of surface water sample analysis of Lalburra area suggest that the water is polluted and can be used for drinking purpose after proper treatment.

The environment impact of extensive irrigation in the study area reveals the problems of soil alkalinity, water stagnation and deterioration of ground water quality. The
water table is rising in the area due to leakage and seepage of canal water and non utilization of existing groundwater resources. In addition, there is an inadequate drainage facility, excess release of canal water and presence of clayey and loamy soil layer which is also responsible for creating water logging condition in the study area. Though the area affected at present in quite small, it is likely to have very adverse impact on environment, if adequate remedial and curative measures are not taken to check its extension. There is urgent need to take proper steps to introduce water management plan for the groundwater development in the area.

Provision of adequate drainage facilities in the area should be provided, the quality of groundwater should be a monitored and pollution should be checked. The investigations and research done on the groundwater conditions of this area reveals a critical condition and it should be a matter of deep concern for the Govt. organizations and inhabitants of the area.

For the determination of aquifer characteristics, representative wells were selected for pumping test. Each well was pumped at a constant rate and the draw down recovery data has been recorded. The graphs of the data have been studied. There is no homogeneity in the aquifers. It is concluded that the aquifers of Lalburra area, groundwater as a whole, have varying groundwater potential. The alluvium has good porosity and good aquifer conditions, resulting in availability of groundwater at shallow depth. Because of the gentle slope towards east, the groundwater flows towards River Wainganga in the post monsoon period, as base flow.

A study of groundwater potential of the investigated area has been done and all the factors of it have been considered. The annual groundwater recharge, annual
groundwater draft and planning for future development and management of groundwater have been suggested by considering the groundwater budgeting, it is suggested that the exploitation of groundwater should be done by constructing shallow and deep tube wells at a number of places. The present study reveals that there is enough scope for future development in this area. Because of the typical geohydrological conditions in this area, there is need of artificially recharging the groundwater by suitable methods. For the utilization and management of groundwater resources, the conjunctive use of surface and groundwater should be done systematically.

GIS has become a useful tool in geohydrological studies. Various thematic maps were superimposed to study their interrelationship.

Drainage has not grossly affected the water table contour but at some places there is intimate relationship between drainage and water table contour. Post monsoon water table contour almost similar to the Premonsoon water table contour.

Lineaments, which can be identified by satellite imageries only, serve as important groundwater storage avenues. Four lineaments have been identified in this area, based on the map obtain from M.P. Council of Science and Technology. Out of the four lineaments major lineament is in NW-SE direction. Water table contours of pre and post monsoon and their respective hydraulic gradient have been related with the lineaments. A number of contours of both the periods cross the lineaments at several places by a proper planning this situation can be used for ground water recharge.

Looking at the relation of lineaments with drainage it is seen that the entire drainage of the area is form west to east which also includes river Sarathi and Atri nala. All the four lineaments cross the drainage at several places. This is the favorable conditions and
if proper planning has done at least two stop dam can be constructed in Sarathi River and Atri nala and number of check dam can be constructed wherever the drainage needs the lineaments. In this way a huge amount of groundwater can be stored in this area and ones the storage is in the lineaments groundwater water will not low towards river Wainganga. Proper groundwater management on scientific basis is required in this drought prone area, Balaghat, M.P.