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Remote sensing in ground water exploration for development of temple tourism in Vemulawada, Karimnagar District, Andhra Pradesh

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ABSTRACT
Tourism is one of the important economic sectors, which is not flourishing as desired due to acute water shortage and other facilities. Proper management of water resources both on surface and underground is essential in areas important for tourism for the development of that industry. Therefore, an effort has been made to address the problem encountered by assessment, exploration and management of water resources using integrated remote sensing based techniques in a prominent pilgrim centre, Vemulawada in Karimnagar district, Andhra Pradesh. High-resolution IRS-IC merged (PAN+LISS-III) satellite data is used and hydrogeomorphological /ground water prospects map is prepared by visual interpretation techniques. Ground truth information is integrated and final map is prepared to aid in ground water exploration. The entire study area is occupied by pink and grey granites of Archaean age intersected by dolerite dykes. On either sides of Maneru River and Mula vagu, the flood plain consists of unconsolidated sediments like sand, silt and clay. Valley fill along local streams comprises of cobbles, pebbles, gravel, sand and silt of recent age. The water demand vis-à-vis water resources availability is evaluated based on hydrogeological set up and field investigations. Both long and short term solutions are given for water resources development at Vemulawada. As a part of the crisis management, (short term measures) ten bore wells are dug in a valley fill near Vemulawada based on recommendations followed by vertical electrical soundings. The wells have yielded a cumulative discharge of 1300 LPM. With the help of remote sensing technology such value additions can be made to enhance the tourism sector in India.

INTRODUCTION

Tourism industry is perceived to be one of the most lucrative revenue boosting industries in the present times. Eco-tourism, health tourism, destination tourism, spiritual and religious tourism, temple tourism, adventure tourism, leisure tourism, cruise tourism, rural tourism, and cultural tourism are some of the most recently understood terminologies in the Indian tourism scenario and are an indication of the growing scope of the industry. According to the estimates published by the World Tourism Organisation (Malar Mathi & Paul Rajan 2007), the tourism industry is one of the largest industries World wide, and provides direct employment to 19 million people and generates indirect employment for 38 million persons. The overall value added employment in the tourism sector including hotel and restaurants is estimated to be close to Rs.80, 000 crores. A striking feature of Indian tourism is the average length of stay of foreign tourists in the country. The estimated average length of stay for foreign tourists is 31 days which is extraordinary when compared to international average (Malar Mathi & Paul Rajan 2007).

As per The New Indian Express, dated 1st November 2006, the Indian government proposes to spend over Rs.2900 crores in the next 5 years to boost the growth of tourism sector as the domestic tourist flow in Andhra Pradesh increased from 5.29 crores in 2001 to 8.95 crores in 2004 with international visitors going up from 58,000 in 2001 to 5.01 lakhs in 2004. As a result, employment generated across all sectors of the tourism industry increased from Rs.31.55 lakhs in 2001 to 53.91 lakhs in 2003 with an average growth rate of 16.26% per year. This trend continued as Andhra Pradesh attracted 11.17 crore domestic tourists in 2006 against 7.14 crore in 2003 which constituted 24% of total domestic travellers. In case of international tourists, the number was 6.69 lakhs in 2006. As global investors have found Andhra Pradesh ideal for setting up their units, it is now a global destination with little distinction between the visitor and the resident (www.aptourism.in). Keeping this in view, the Department of Tourism, Govt. of A.P. is preparing proposals for joint marketing initiatives with other States in the country. It is opined that this industry is going to be one of the fastest growing industries in the years to come.

Water is an essential prerequisite for development of any area of tourism interest be it for drinking, recreation, creation of wildlife habitat etc. The ever increasing demand for ground water has resulted in over-exploitation of ground water in certain areas. This in turn triggered a progressive lowering of water levels and consequent decline in yield and productivity of wells, drying up of shallow dug wells, deterioration of water quality and increasing the cost of lifting water from deeper levels, thus seriously affecting the socio-economic condition. The problem is further aggravated as many of the tourist / pilgrim centres are located on the hills / elevated places where the availability of ground water is restricted to secondary porosity. Sustainability of ground water based scheme is one of the important problems in the hard rock aquifers.

Use of satellite remote sensing for ground water exploration is an established procedure which has a long pedigree. Remote sensing in conjunction with the contemporary studies like hydrogeological and geophysical investigations is evolving increasingly as a powerful means to target potential ground water resources. In the recent years many workers (Baldev Sahai, Bhattacharya & Hegde 1991, Reddy, Vinod Kumar & Seshadri 1996, Reddy 1999, Prasad et.al., 2008) have used remote sensing and GIS techniques for ground water exploration. Overall around 90% success rate with respect to selection of sites for drilling has been reported using ground water prospect maps in 10 States of our country (RGNDWM Project Team 2009). However, application of remote sensing for ground water investigations for development of water resources in areas of tourism sector has not been attempted. In the present work, at the instance of the Endowments Department, Government of Andhra Pradesh, an integrated remote sensing based ground water investigation was taken up during 2003-2004 to meet the water demand at a renowned pilgrim centre in the northern Telangana region namely Vemulawada in Karimnagar District, Andhra Pradesh (APSRAC 2003).

STUDY AREA

Vemulawada in Karimnagar District is located in northern Telangana region and is about 150 Km north of Hyderabad city (Fig.1). Lord Raja Rajeshwara is the presiding deity of this temple. The study area falls in Survey of India toposheet number 56 J/15. Vemulawada, a mandal headquarters is located on the northern bank of Mula Vagu, a tributary to Maner River which ultimately joins the Godavari River between Manthani and Mahadevpur of Karimnagar District. The average annual rainfall of Vemulawada mandal is 885mm while the normal annual rainfall of the District is 968mm. Due to vagaries of monsoon, this mandal experienced 778mm in 2001, 557mm in 2002, 602mm in 2003, 584mm in 2004, 866mm in 2005 (DES, 2006), 1195mm in 2006, 1175mm in 2007 and 938mm in 2008 (Personal communication from DES). The cumulative departure for the last five years (2000 – 2001 to 2004-2005) from the normal rainfall of the mandal is -107% (CGWB 2007) indicating that the area is facing continuous drought situation.

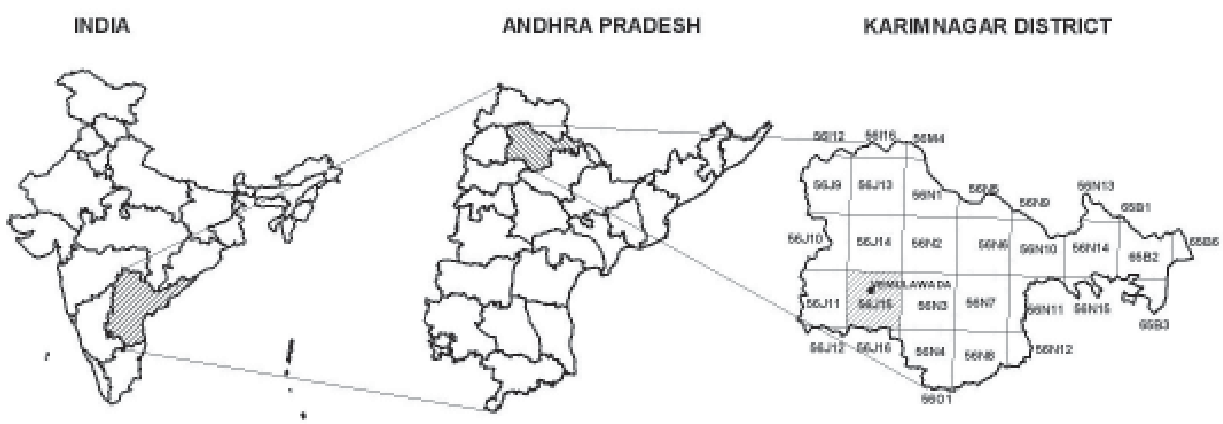

Figure 1. Location Map.

The primary objective of the study is to make an inventory of the existing water resources in and around the pilgrim centre and to suggest suitable sites for ground water exploration in order to have sustainable resources on long-term basis by integrating remote sensing and conventional techniques.

METHODOLOGY

Information on landforms is an important input for land management, soil mapping and identification of potential zones of groundwater occurrence (NRSA 1993). Apart from the landform characteristics, lithology/rock type and geologic structures also plays a significant role in identifying the groundwater potential zones. High resolution Indian Remote Sensing satellite, IRS-IC false colour composite, geo-coded PAN + LISS-III merged satellite data of 19.4.1999 and 21.2.1999 for Vemulawada (56J/15) is analysed. All the geomorphic units occurring in the study area are delineated based on the image characteristics by visual interpretation. For demarcating the geomorphic units, the toposheet is consulted to comprehend the relief variations and other topographic features. While generating the hydrogeomorphology map, the rock type is considered as a base unit. Different landforms are classified based on origin, landform characteristics, their aerial extent, depth of weathering, thickness of deposition showing the assemblage of different landforms corresponding to each rock type such as fluvial, denudational etc. The denudational landforms are further classified into shallow and moderate categories based on their depth of weathering, thickness of deposited material verified during field work based on stream cuttings, well sections etc. (NRSA 2008). Structural information like fractures, lineaments is mapped based on drainage network and image characteristics. Integrating different geomorphological units/landforms, lithological formations and geological structures, hydrogeomorphological map on 1:50,000 scale is prepared. Further, as part of the hydrogeological fieldwork, well inventory data such as depth of the wells, depth of weathering, thickness of deposited material, yields are collected. This data is used in finalising hydrogeomorphological / ground water prospects map of Vemulawada.

Geology and Hydrogeomorphology

A map showing the geology and structure is prepared along with drainage network (Fig.2). In general the drainage is dendritic to sub-dendritic in nature. The study area is underlined by unclassified granites and gneisses of Peninsular Gneissic Complex. The granitoids of the erstwhile Hyderabad State, forming northern part of Andhra Pradesh are divided originally into an older 'grey series' and younger 'pink series' that together formed the 'Peninsular Gneiss' (Ramam & Murty 1997). Almost the entire western half of the district is occupied by the Peninsular gneissic complex dominantly made of tonalite - granodiorite consisting of both pink and grey granites with migmatite (GSI 2002). The trend of the lineaments in Vemulawada area is mostly in N-S and NE-SW directions.

The landforms in the study area are broadly divided into two categories namely fluvial landforms and denudational landforms (Fig.3). As the depth of weathering and nature of soil cover plays a major role in the ground water prospecting, the pediplain is further sub-divided into pediplains with shallow (0-10m weathering) and moderate (>10m weathering) weathering based on their depth of weathering, thickness of the deposited material observed from well sections and nala /stream cuttings (NRSA 1993). Thus, eight geomorphic units are delineated. They are flood plain, valley fill, moderately and shallow weathered pediplains, pediments, residual and denudational hills. The description of each hydrogeomorphic unit occurring in this area is as follows.

FLUVIAL LANDFORMS

Flood Plain (FP):

This landform derived by fluvial process aided by means of mass wasting is included under fluvial landforms. This is a flat and smooth area observed along Mulavagu, Maneru Rivers and consists of unconsolidated fluvial sediments like gravel, sand, silt and clay. The thickness of alluvium is observed to be ranging between 2-8m with very good ground water prospects. Infiltration wells are present in this landform. The depth of these wells is ranging from 8m to 17m with yields ranging from 200-400 LPM. The villages included in this landform are part of Vemulawada, Reddipuram, Vardapalli, Shahabaspalli, part of Anpur and Chintalthana.

Valley Fill (VF):

It constitutes unconsolidated sediments such as boulders, cobbles, pebbles, gravel, sand and silt deposited by streams/rivers normally in a narrow fluvial valley. It forms moderately productive shallow aquifers with very good ground water prospects. But, the ground water prospects vary depending upon the thickness of the fill material and its composition.

This landform is not explored so far from ground water point of view at the time of investigation.

DENUDATIONAL LANDFORMS

Pediment (PD-D):

It is a narrow linear ridge with heap of boulders of dolerite composition or ridge standing above the ground level. Negligible to poor yields are expected in this landform. Moderate yields are expected in the upstream direction.

Pediplain Moderately Weathered (PPM-Gr):

It is a generally flat and smooth surface of weathered pediplain of granite with more than 10m deep weathered material usually covered with red soil. Moderate to good yields are expected in this geomorphic unit. Good yields are expected along fracture/lineament. Dug wells and bore wells are present in this landform with yields ranging from 100-200 LPM. In this unit Kudrapak, Rudraram and Charlavancha villages are present.

Pediplain Shallow Weathered (PPS-Gr):

It is a gently sloping flat and smooth surface of weathered granite with less than 10m of weathering generally covered with red soil. Poor to moderate yields are expected in this unit. Moderate yields are expected along fracture/lineament. Dug wells and bore wells are present in this geomorphic unit with yields range from 50 to 100 LPM. Part of Vemulavada and Chintalthana are located within this geomorphic unit.

Pediment (PD-Gr):

It is a gently sloping smooth surface of erosional bedrock between hill and plain with thin veneer of detritus. In general, the ground water prospects in this landform are poor with yields ranging from 10 to 50 LPM.

Residual Hill (RH-Gr):

It is a relict, isolated hill with low relief occupying considerably small area. The ground water prospects are negligible as it mainly acts as a run off zone.

Denudational Hill (DH-Gr):

It is a hill formed due to differential erosion and weathering so that a more resistant formation stands and occupies a large area. The ground water prospects are negligible in this area as it acts as a run off zone. Poor yields are expected along fracture/lineament.

Ground Water Occurrence:

Geo-hydrologically, the western half of the district is made of granite and gneisses, with moderate permeability, low specific yield and low ground water prospects (GSI 2002). The depth to the bedrock varies from few meters to 30m bgl and ground water occurs under unconfined conditions in weathered zone and under semi-confined conditions in the fractures and fissures with shallow aquifers tapping the weathered zone having very limited yields (CGWB 2007).

In general, the top soil in the study area mostly consists of red and sporadically black soils with thickness varying from 0.5 -1.5m. During the course of well inventory, it is observed that majority of dug wells and dug-cum-bore wells tap water from the weathered portions of the country rock varying from 16-20m in thickness and also from fractured zones (20-50m). Irrigation dug wells are either circular with 4-10m radius or rectangular (5X12m). Open wells tapping hard rock sustain pumping of 3-5 hours daily and yielding 30-140 cum/day for a drawdown of 2-4m and take 12-48 hours for full recovery. Most of the bore wells are of 150mm diameter and 40-60m deep. The yields from these wells range from 50-220 lpm. The geological and structural control plays an important role in the occurrence of ground water and the yield of the wells. The hydrogeological framework is mostly controlled by geological set up, the occurrence and distribution of rainfall, faults/fractures, openings available for recharge and movement of water through primary and secondary porosity of the formations. The ground water is thus developed by dug wells, bore wells, and dug-cum-bore wells. Infiltration wells and filter points are common along the Maneru River and Mula vagu and in general the ground water is potable.

Status of Water Supply:

In case of Vemulawada mandal, based on ground water availability (1789 Ha.m), utilization (1822Ha.m), balance (-33 Ha.m), the stage of development is 102% and is categorised as over-exploited (CGWB 2007). Scanty rainfall for the last several years and increase in the number of pilgrims visiting Vemulawada has resulted in decline in water resources. The existing water supply at Vemulawada temple is consisting of nine bore wells fitted with electric motors with Horse Power (HP) ranging from 1 to 5, two open wells with

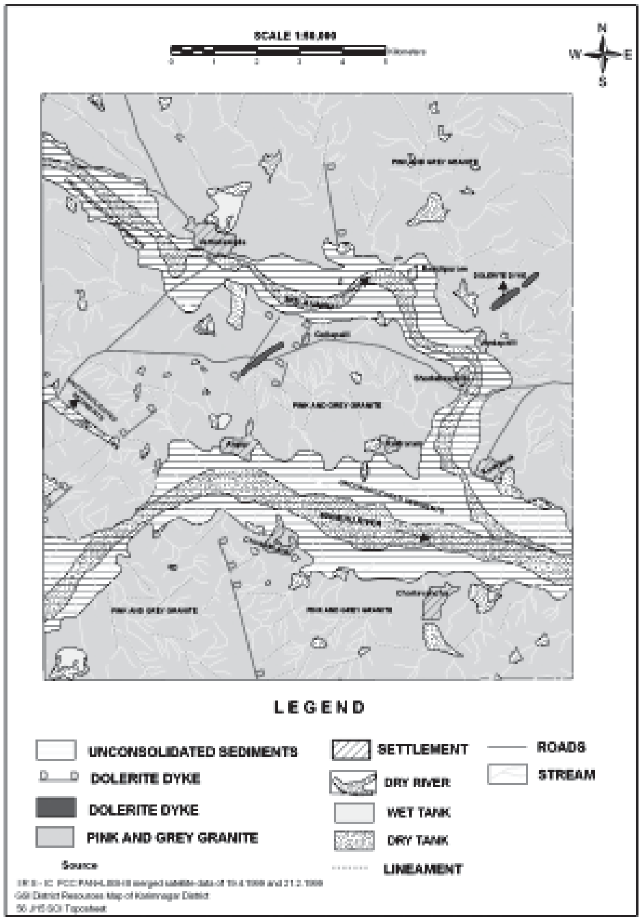

Figure 2. Geology and Structure map of Vemulawada and its environs, Karimnagar District, Andhra Pradesh.

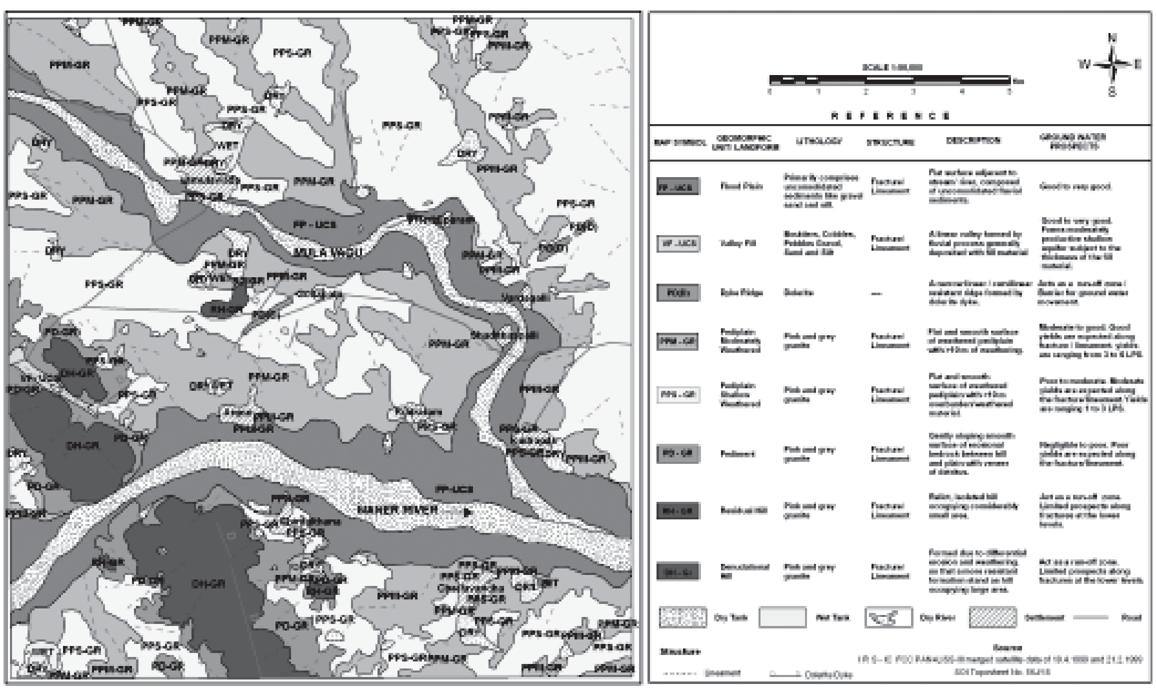

Figure 3. Hydrogeomorphology of Vemulawada and its environs, Karimnagar District, Andhra Pradesh.

10 HP motors each. In addition, there are seven bore wells fitted with hand pumps to cater the needs of the temple activities as well as the pilgrims. Majority of these wells have gone dry and remaining wells have dwindling yields due to failure of the monsoon for the last several years. As a result, water supply provided is only 50,000 litres per day as against the requirement of 1,00,000 litres/day. In view of the in-situ conditions of the study area and the current drinking water problem two suggestions i.e., long term and short-term solutions are made based on integrated remote sensing based study (APSRAC, 2003).

RESULTS:

Short-term Measures:

Based on hydrogeomorphology and related field studies, the following short term measures i.e. five potential areas have been identified to drill bore wells for crisis management.

a) Flood Plain near Sankepalli (in between Reddipuram and Sankepalli), b) Flood Plain near Sahabaspalli, c) Flood Plain near confluence of Mulavagu and Maneru river d) Valley fill behind Govt. Polytechnic and Degree College e) Pediplain Moderately Weathered near Vemulawada Bus Depot (2/4 Km stone).

Four bore wells are prioritized (one at Vemulawada Bus Depot and 3 bore wells behind Govt. Polytechnic College) while one infiltration well is proposed in the flood plain near Reddipuram to overcome the immediate problem.

Vertical electrical soundings are carried out at the identified sites (short term measures) to evaluate the thickness of fill material, depth of weathering, depth to the basement, depth at which water is likely to be struck etc. As a follow up of recommendations, three bore wells are drilled in a valley fill behind Govt. Polytechnic College by the Rural Water Supply Department, Govt. of A.P. on behalf of the temple authorities. As an example, the Vertical Electrical Sounding field curve along with the interpreted results, and the data related to lithology and drilling discharges are collected and compared in the Fig.4.

The depth probe was conducted using Schlumberger configuration extending current electrode separation up to 100m (AB/2) and potential electrode separation up to 10m (MN/2). The field curve was interpreted manually using master curves. The results indicated that the top layer consisting of clay with alluvium having a thickness of about 1.2m and resistivity of 13 Ohm metre, followed by alluvium layer with thickness of about 5.2m and resistivity of 30 Ohm metre. The third layer consisting of alluvium (coarse grain) layer with thickness of about 3.5m and resistivity of about 60 Ohm metre, followed by a fractured rock with 11.4m thick and resistivity of about 180 Ohm metre. The lithologs indicated the basement depth of 32m and in between a number of layers consisting of sand, weathered, semi-weathered formations and fractured rock with varying thicknesses are encountered. The drilling discharges showed

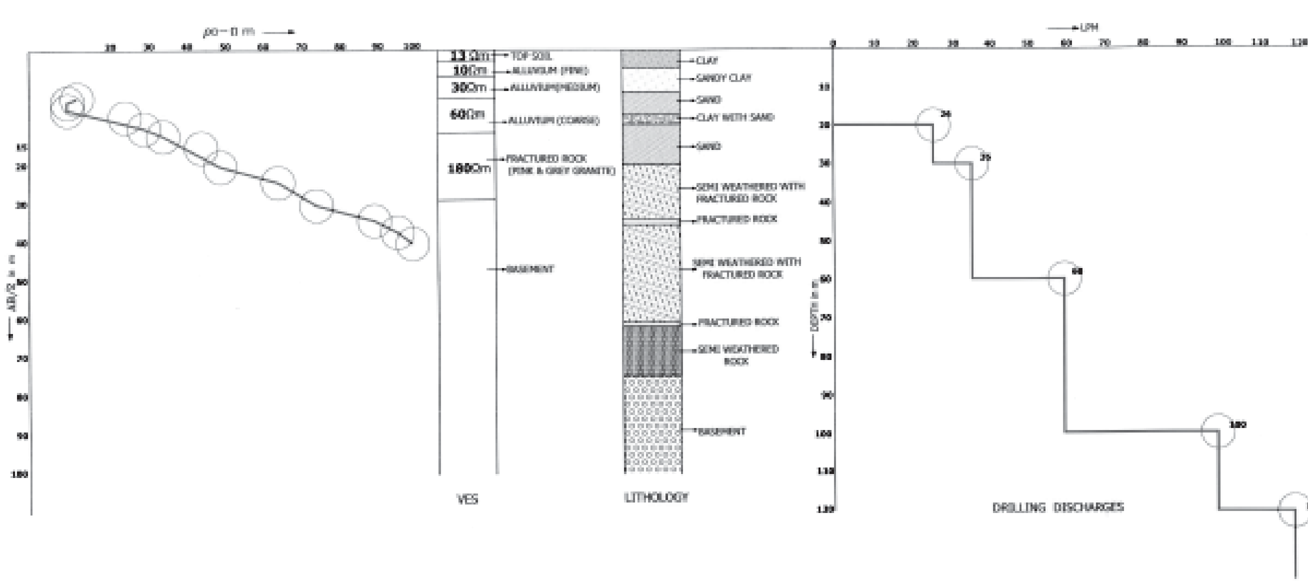

Figure 4. Comparision of VES results with Lithologs and Drilling Discharges.

progressive increase starting from 26 lpm, while the cumulative discharge recorded is about 120 lpm.

Two bore wells are drilled 50m depth each and one bore well 35m. The estimated cumulative yield is 300 LPM. Based on the drilling results, and on analysis of lithology in conjunction with the hydrogeomorphological studies, seven additional bore wells are drilled on recommendation, to the depth of 50m each to meet the demand. Among the total ten bore wells, 4 yielded 200 LPM each, 2 bore wells yielded 100 LPM and 120 LPM, 2 bore wells gave 80 LPM each and the remaining two bore wells less than 70 LPM each. Thus, the cumulative yield of all these ten bore wells is about 1300 LPM. Six high yielding bore wells out of ten are connected to a newly constructed Ground Level Storage Reservoir (GLSR) having a capacity of 1.00 lakh litres for daily usage of temple requirements including pilgrims. The remaining four are meant for stand-alone mode as and when required. The recommended depth of the bore wells and their corresponding yields are useful only for crisis management.

Long-term Solutions:

a) Bringing water from the dead storage of Lower Maneru dam from a distance of about 30 km, which is sustainable on long-term range. b) Two infiltration wells in the Maneru River near the confluence of Maneru and Mulavagu. c) Infiltration well existing near Anpur may also be utilised as one of the sources, since the pipeline already exists from Anpur to Vemulawada. These suggested long term plans can tackle the drinking water problem on sustainable basis.

Tourism is today projected as an engine of economic growth and an instrument for eliminating poverty, solving unemployment problem, opening up new fields of activity and upliftment of women in the society (Malar Mathi & Paul Rajan 2007). In this context, the potential of remote sensing in developing tourism infrastructure should be explored.

CONCLUSIONS

Remote sensing is not only helpful for ground water targeting but also useful in urban land use mapping and development of infrastructure / amenities. An earnest attempt is inevitable to explore the capability of remote sensing in new areas like tourism sector, which are not yet amenable to it, but could be within our reach. This will boost the tourism industry across all the sectors in generating revenue in the form of foreign exchange. The effective use of remote sensing will develop tourism on sustainable basis and makes Andhra Pradesh a sought-after tourism destination in the country.

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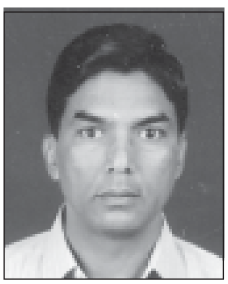

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