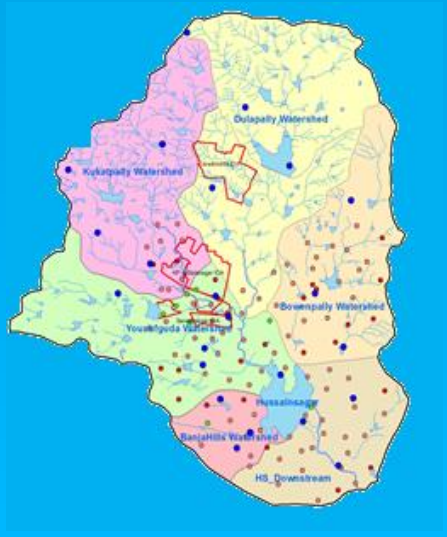
HYDROLGY PROJECT

GOVERNMENT OF ANDHRA PRADESH
GROUND WATER DEPARTMENT

Research and Development studies on impact of Urbanization, Ground Water Quality, Pollution and Management of Groundwater in Hussainsagar Micro-Basin, Musi Sub-Basin of Krishna River Basin, Andhra Pradesh.

PURPOSE DRIVEN STUDY (PDS)
HYDROLOGY PROJECT – II
(Loan No.: 4749-IN)



September 2013

GOVERNMENT OF ANDHRA PRADESH

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PURPOSE DRIVEN STUDY

UNDER

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September 2013 Hyderabad

FOREWORD

The Andhra Pradesh Ground Water Department is monitoring groundwater levels and groundwater regime in the State regularly since 1971. There are 5000 monitoring wells, including 1017 piezometers for groundwater level and quality monitoring. The Purpose Driven Study [PDS] as part of Vertical Extension is taken up under Hydrology Project-II [HP.II], to study the impact of urbanization on groundwater in Hussainsagar catchment, Rangareddy district.

The National Geophysical Research Institute [NGRI] is the consultant, whereas the Director, Ground Water Department is Principal Investigator and the Deputy Director, Ground Water Department, Rangareddy district is co-investigator for the project. Sri V.V.S.Gurunadha Rao, Scientists-G, NGRI was continuously engaged and guided the team in the study right from data collection, analysis, modeling and provided training to the Departmental staff on various aspects of study.

The Hussainsagar lake, which once used to supply fresh water to Hyderabad city was excavated in the year 1562. The catchment area of the lake constitutes about 287 sq.km, the lake lost its primacy as a source of water supply to the city due to rapid industrialization in parts of catchment area of Hussainsagar lake. Keeping this in view, a PDS study in Hussainsagar catchment is taken up to address the issues of groundwater availability, quality, solute transport etc., in time and space.

As part of PDS study 135 observation wells, including 25 purpose built piezometers were monitored for groundwater levels and quality. The water samples were analysed in water quality Level II+ lab of the Department for major Cations, Anions and Heavy Metals. The results were also validated. GIS tools, Modflow and Aquachem etc., were utilized for estimation of resources, prediction and chemical quality of groundwater.

It is hoped that this study will be useful for planners, administrators involved in managing metro water supply and pollution. The study also useful for other urban areas suffering with similar problems. The study also helps for planning holistic development of city in future keeping in view of the environmental consideration without affecting industrialization.

21st September-2013

(B. M. Murali Krishna Rao)
DIRECTOR

ACKNOWLEDGEMENTS

The office of the Deputy Director, Ground Water Department, Rangareddy District gratefully acknowledge and place on record the support extended by the Principal Secretary, Special Secretary, Irrigation and Command Area Development Department, Government of Andhra Pradesh.

The timely support given during study by Sri B.M.Murali Krishna Rao, Director; Dr.K.Venugopal, Joint Director is gratefully acknowledged. The cooperation extended during study by Sri K.Dhananjaiah, Deputy Director; Sri R.D.Prasad, Deputy Director; Sri C.Rakesh Chander, Assistant Director; Sri K.Padma Prasad, Assistant Director, Office of the Director, Ground Water Department, Hyderabad is immensely helpful. The other staff involved in Hydrology Project-II from Head Office who have given their assistance during field study, report preparation and conducting workshop is also acknowledged.

The study could not be completed successfully, without tireless efforts of Sri V.V.S.Gurunadha Rao, Scientist-G right from conception to completion and his dedicated team of Scientists. Sri K.Mahesh Kumar, Assistant Hydrologist, Ground Water Department whose modeling skills which he brought to the study is greatly appreciated and the Co-operation extended by Smt.P.Vijaya Durga, T.A (H) in modeling, GIS part of the report is duly acknowledged.

The team of officers from Office of the Deputy Director, Ground Water Department, Rangareddy District comprising of Sri S.Jitender, Assistant Director; Smt. M.Prameela, Assistant Director; Sri Md Idrees, Assistant Director; Sri D.Sunil Babu, Assistant Director; Sri J.Satayanarayana, Assistant Hydrogeologist; Sri G.Nageswara Rao, Assistant Hydrogeologist; Sri A.Arjun, Assistant Geophysicist; Sri A.Chandra Reddy, Assistant Geophysicist; Sri V.Kumar Babu Assistant Engineer(Mech) who were actively involved in the study, during field investigations, data collection is duly acknowledged.

Sri B.R.Kishen, Deputy Director (Retd), Dr.K.Murali Mohan, Assistant Director who were In-charge of the Water Quality Lab during the part of study is also acknowledged.

The office place on record, the appreciation for the services rendered by Sri N.Srinivasu, Deputy Director; Smt.Ch.Manjula, Assistant Director and Chemists and other supporting staff who are involved in water sample analysis of the study area and their presentation of chemical constituents with reference to space and time. The cooperation extended by EPTRI is also acknowledged.

We also wish to thank Sri P.Adi Reddy, Deputy Director[Retd], Sri B.Krishna Rao, Assistant Director[Retd], Late Sri Y.Prashanth Kumar, Assistant Hydrogeologist who have initiated the project in the initial stages.

We are indebted to the reviewers, Project Coordinate Secretariat (PCS), Ministry of Water Resources, New Delhi and TAMC for their suggestions and timely help.

We also remember with gratitude to all those who are associated with the study in many ways.

(**Ramesh Kumar)**
Co-Investigator and Deputy Director,
Ground Water Department,
Rangareddy District.

21st September,
Hyderabad.

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Study on Urban Hydrology, Groundwater Quality, Pollution & Management of Hussainsagar Catchment Area, Hyderabad

1.0 Background

Hussainsagar, the picturesque lake situated in between the twin cities of Hyderabad and Secunderabad which is an ecological and cultural landmark of Hyderabad. Lake was excavated in 1562 mainly to harvest drinking water from Musi River through Balakpur Canal. However with passage of time the lake lost its importance as a source of drinking water supply. The lake in the heart of Hyderabad city receives *domestic sewage and industrial effluents* through four streams draining the catchment area as shown in Fig. 1

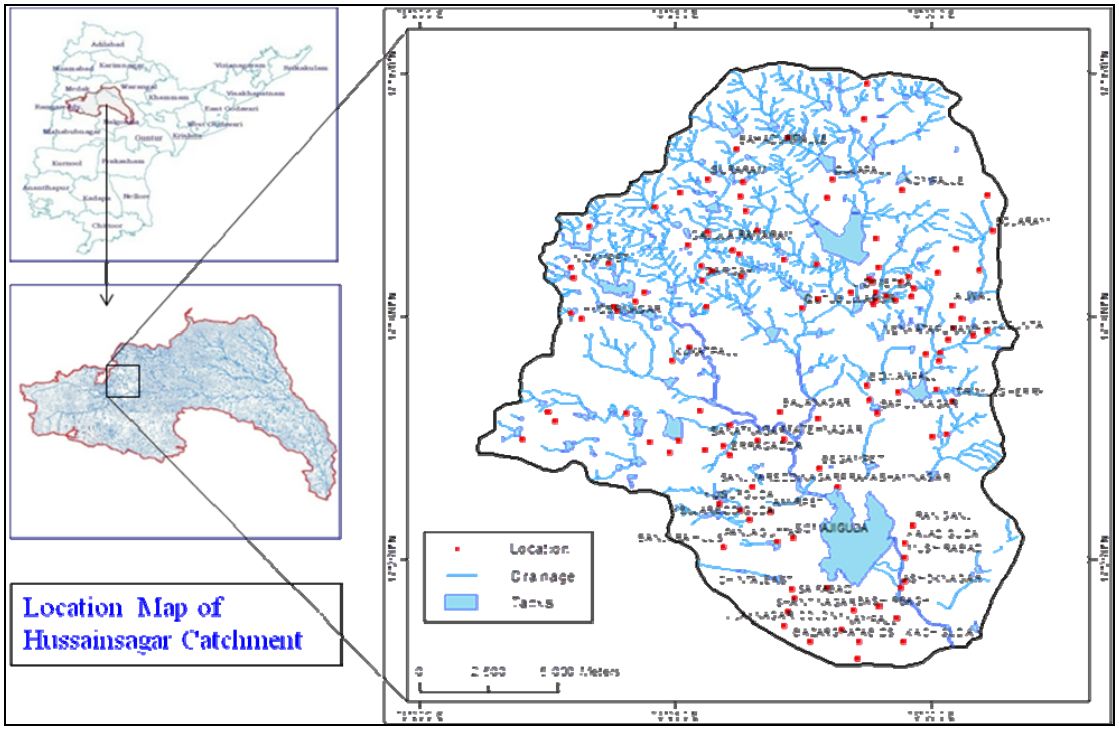


Figure 1 Location map of Hussainsagar Catchment

Hyderabad city is growing day by day with the alarming rate. The twin cities of Hyderabad-Secunderabad (herein referred to as ‘‘Hyderabad’’), is one of the fastest-growing urban agglomerations in India, with an annual population growth rate of more than 5% (UN, 2009). The city population, currently 6.8 million, is expected to exceed 10 million in 2015. At this rate, Hyderabad will rise from its current global rank of 31st to 22nd of the biggest urban agglomerations, overtaking Bangkok, Lima and Hong Kong (UN, 2009).

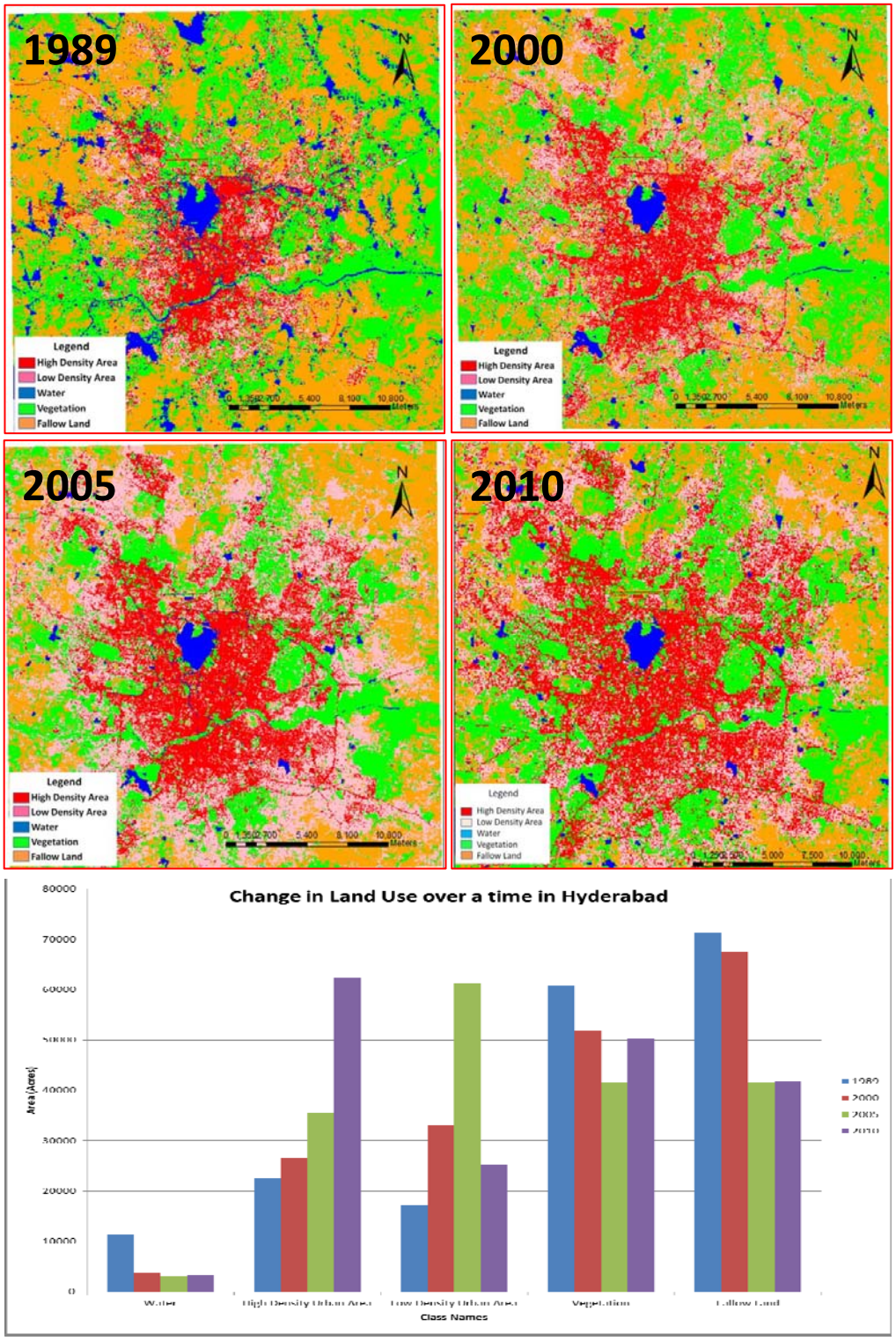


Figure 2 Change in Land Use over last 20 years(1989, 2000, 2005 & 2010) in Hyderabad

The LANDSAT image of Hyderabad of last 20 years was shown in figure2. Results of Identification and classification of the urban area into five classes as Water, High Density Urban Area, Low Density Urban Area, Vegetation (including agriculture) and Fallow Land over last 20 years is shown in figure 3.

The results shows that, considerable decrease in the area of water through the period, which also have reduced lakes in the city area. High population density area shows the trend of fast growth. The effect of this population growth can be seen on the water supply to Hyderabad. It has grown rapidly over the period 1950–2010 and is projected to increase further with the completion of additional projects by 2030. The extent of groundwater withdrawal for urban use is estimated to be 3.3 MCM per month, which has clearly caused drops in the groundwater table.

The figure 3 shows the relative contribution of the water sources for urban water supply in Hyderabad in the period 1950–2030. Absolute values were converted to percentages of total water deliveries to Hyderabad city.

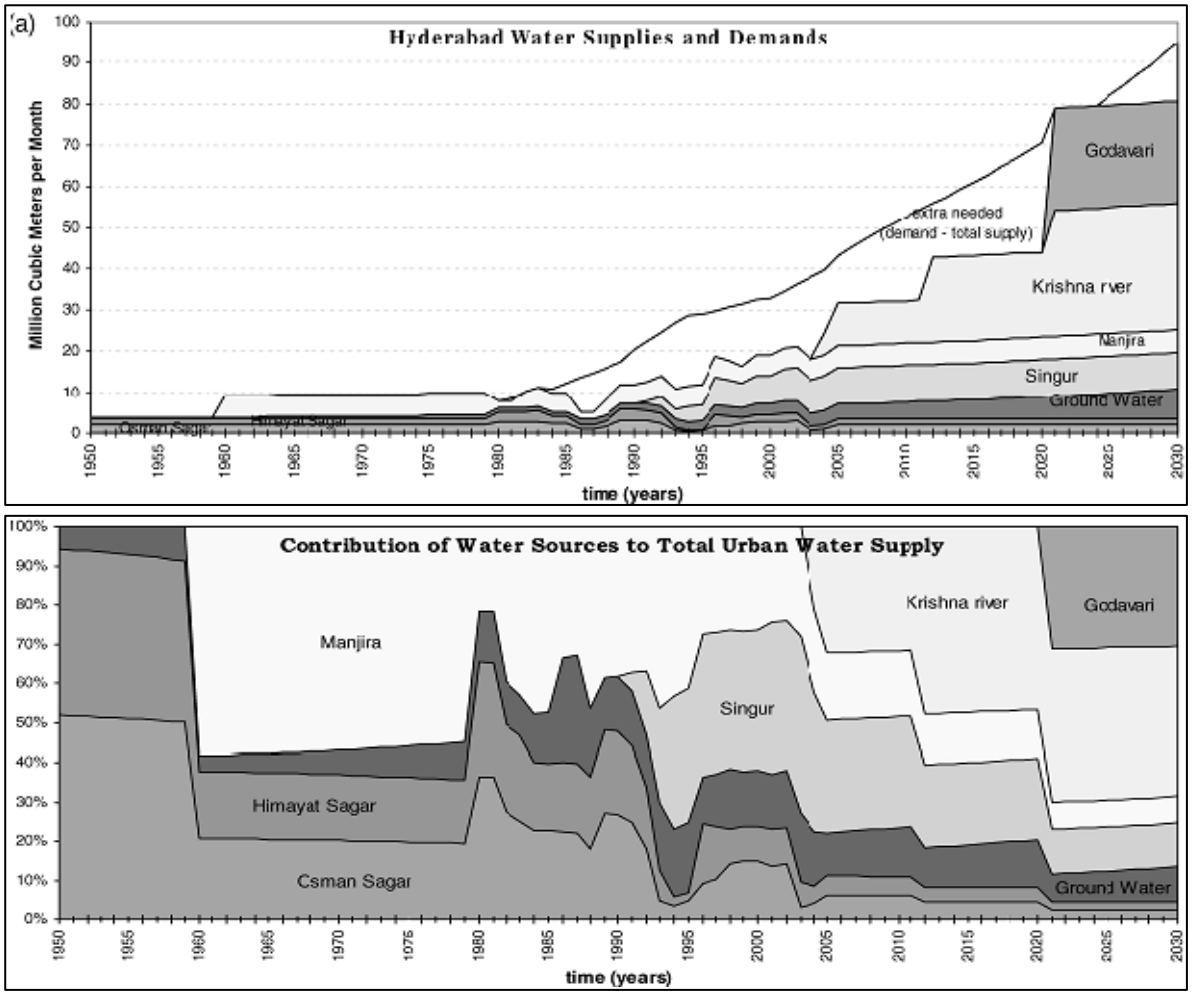
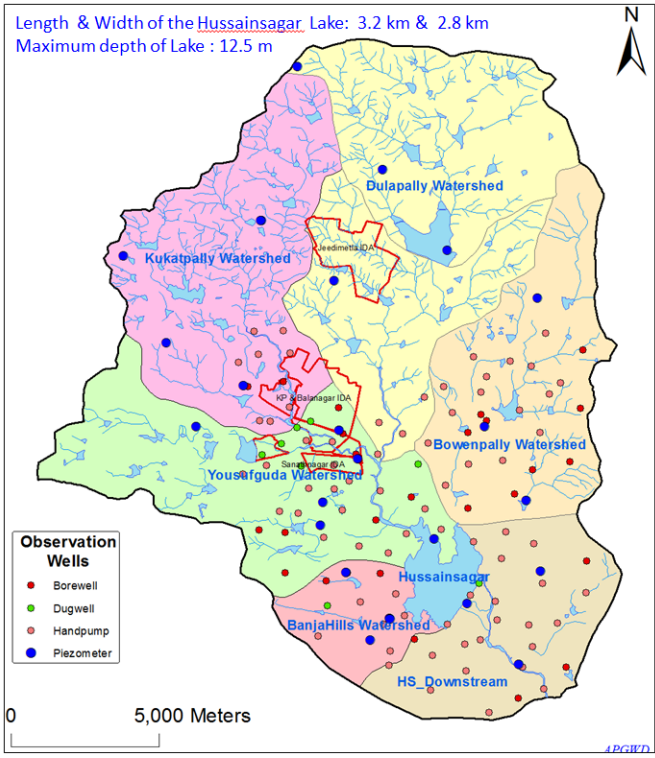


Figure 3 Hyderabad urban water supply patterns

2.0 Study Area

The catchment area of Hussainsagar is about 287 sq. km, falls into five sub watersheds namely Kukatpally, Dulapally, Bowenpally, Banjarahills and Yusufguda. The highest peak in catchment is at 642 m lies north of Nizampet and lowest contour is about 500 m at confluence of the stream outlet joining with Musi river in the downstream of Hussainsagar lake. The effective north south drop thus comes to 142m covering a distance of 17 km.

2.1 Salient Features of Hussainsagar Catchment Area



S.NO	Catchment Features	
1	Catchment Area	287 Sq km
2	Soil Type	Red Sandy, Sandy Loam
3	Stage of GW Development	102% (GEC 2007)
4	Normal Annual Rainfall	781 mm
5	Raingauges	9 (CPO) & 2 (AWS)
	Raingauge Density	1 per 25 sqkm

S.NO	Salient Features of Lake	
1	Volume of The Lake	28.6 MCM (~1 TMC)
2	Surface area of the Lake	5.7 X 10^6 m^2
3	Avg Depth of the Lake	5.2 m (1 – 12.5 m)
4	Max Opetrating Level	514.93 m (amsl)
5	Normal Operating Level	513.43 m (amsl)
6	Bund Level	518.16 m (amsl

S.NO	Watershed	Area (km^2)
1	BanjaraHills Watershed	13.31
2	Yousufguda Watershed	52.68
3	Kukatpally Watershed	55.81
4	Dulapally Watershed	81.18
5	Bowenpally Watershed	46.07
6	HS_Downstream	33.36
7	Hussainsagar	5.44
	Total	~ 287.85

S.NO	Nala	Inflows
1	Kukatpally Nala	~ 70 MLD
2	Picket Nala	~ 6 MLD
3	Banjara Nala	~ 10 MLD
4	Balkapur Nala	~ 15 MLD
	Total Dry Weather Flows	~ 101 MLD

Figure 4 Watersheds covering study area and salient features of Hussainsagar Catchment

Hussainsagar Lake has spread over 540 ha and due to encroachments presently the water spread area has shrunk to 450 ha. Its capacity is ~ 1 TMC (Thousand Million Cubic Foot) of water drained through 5 inlet streams. Kukatpally nala is the main feeding channel which brings in major bulk of water into the lake . Except rainy season most of the water mass enters into the lake through Kukatpally nala by way of domestic sewage and industrial effluents. The Watersheds and salient Features of study area and lake are shown in the Fig.4

2.2 Soils, Drainage, Geology and Geomorphology

No soil cover visible due to urbanization in most of the area, however the soils underneath are either red loamy or clay loamy with thickness 0.5 to 1.5m in general. Drainage is dendritic to sub-dendritic, flows from N and NW to S and SE following slope. The original drainage is disturbed due to varied LU and concretization.

The Hussainsagar catchment area has a rugged terrain underlained by Granites (Fig. 5). They are grey to pink, medium to coarse grained and porphyritic or non-porphyritic and massive in nature. Higher topographic levels forming denudational hillocks, sometimes dome shaped mounds (inselbergs) and bouldery outcrops. Totally urbanized Hyderabad city covers 90% of the catchment area. The engineering geological province demarcation indicates granite and gneiss country has low permeability, high bearing capacity (1000–2000 kg/cm^2) /compressive strength and good foundation characteristics, which are favorable for greater urbanization. The main natural hazard is the depletion of groundwater table due to erratic rainfall heavy runoff (complete urbanization but for few parks, no GW recharge zone) experiences drought situation leading to intense drinking water problem.

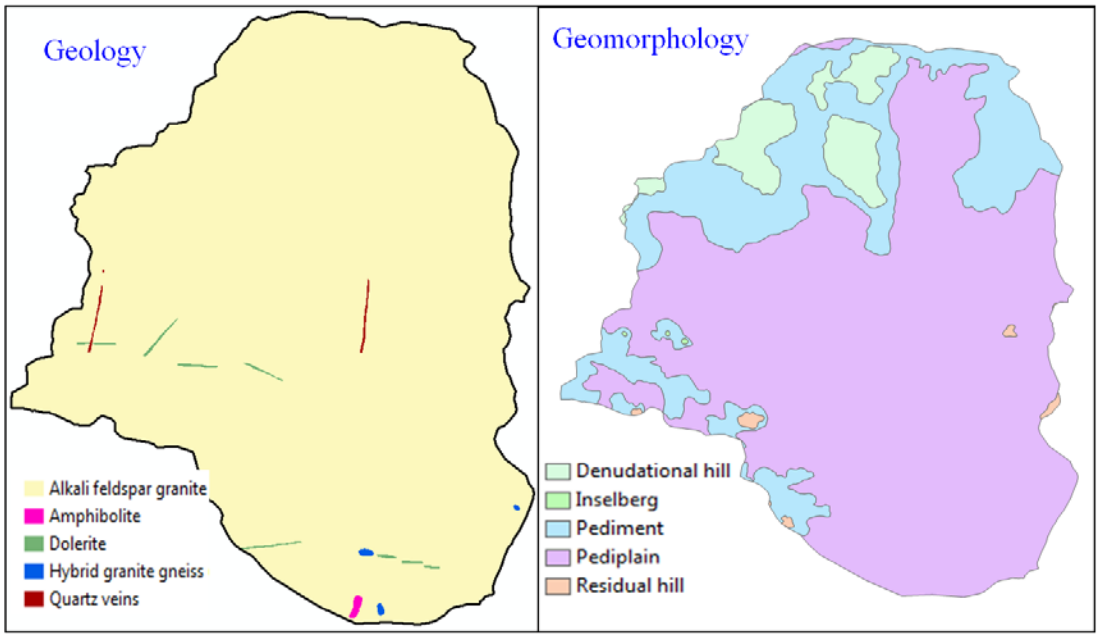


Figure 5 Geology and Geomorphology of the Study Area

3.0 Purpose Driven Study (PDS) and Duration

Purpose Driven Studies (PDS) being a component of vertical extension in the World Bank Assisted Hydrology Project Phase-II, Studies on Urban Hydrology,

Quality, Management and Pollution of Groundwater in Hussain Sagar Microbasin, in parts of Hyderabad and R.R.Districts, Andhra Pradesh have been under taken under PDS.

The Study was initiated during April 2009, carrying out the detailed complete well inventory and collecting water sample in Hussainsagar catchment. Study was completed with collection of water samples for Arsenic analysis in August 2012. Totally Eight sets of analyzed quality data are available for the study area.

The Ground Water Department has undertaken the studies with the consultancy support of NGRI. The Director, Ground Water Department is the Principal Investigator and Deputy Director, Ground Water Department, Ranga Reddy is Co-investigator for the study. The consultant is Dr. V.V.S. Gurunadha Rao, Scientist 'G', National Geophysical Research Institute (NGRI), Government of India, Hyderabad. NGRI has assisted in the investigations and in the completion of studies with their professional experience and technical manpower.

4.0 Environmental Problem of Hussainsagar

During last 4 decades the Kukatpally and Dulapally watersheds have undergone an extensive industrialization and consequent urbanization. In Kukatpally watershed there are three industrial areas viz., Kukatpally, Balanagar and Sanathnagar while in Dulapally watershed Jeedimetla industrial area was developed as a planned programme of industrialization in Hyderabad. Kukatpally and Balanagar Industrial areas have more than 300 industrial units under public and private sector. The range of products manufactured by these industries includes chemical reagents, organics, pharmaceuticals, drugs, biochemical, synthetic chemicals, detergents, aircraft batteries, distillation products, alloys, rubber products etc. Even to date also the industrial zone is expanding with the addition of new units.

In 1966, during the initial phase of industrialization of Lake Catchment a pipeline called Kukatpally main (K Main) was laid by the Municipal Corporation of Hyderabad (MCH) to carry the effluents from the industrial area downstream to the common effluent treatment plant at Amberpet. However, with the increasing number of units, the effluent load far exceeded the carrying capacity of the K Main resulting in leaking of the pipeline. Further, a number of units had started letting out their wastewater effluents directly into the stream. Further Increasing urbanization with settlement of industrial Labor has complicated the issue, as a large volume of domestic sewage started entering the lake through the Kukatpally stream. Thus once

a carrier of freshwater from the catchment, the Kukatpally stream started draining large volumes of domestic sewage and industrial effluents into the lake.

The problem of environmental degradation has further complicated by two ever-expanding slums along western bank of the lake. Traditional washing activities along eastern water front also one more source of constant pollution to the lake. To summarize, all the said typical problems are equally responsible for environmental degradation of the Lake Hussainsagar.

During 1993, Hyderabad Metro Water Supply and Sewerage Board (HMWS&SB) has come up with a project report on rejuvenation of Hussainsagar with several measures for improvement of lake water quality. During 1998, HMWS&SB has also constructed six diversion sewers on the streams entering into the lake to divert dry weather flows. A STP for secondary treatment with 20 MLD capacity has been commissioned during 2000 near Madarsa Makta in the reclaimed land of the Lake.

Initially the lake could absorb pollution impact but once its natural carrying capacity was reached its limits, adverse effects of the pollution started manifesting. Older sediments, which received the industrial effluents till 1995 for more than 3 decades are cause of concern with elevated adsorbed heavy metal concentration in the Hussainsagar lake bed sediments. The Lake water pollution has reached peak point during 1992 and the lake had become a cesspool of polluted water. *The biodiversity was adversely affected*. The sensitive fishes disappeared.

Pollution from uncontrolled domestic discharges has resulted in increase of nutrients (nitrates & phosphates) and depletion of Dissolved Oxygen has resulted in large fish kills and bad odor emanation from the lake. *With passage of time the lake lost its importance as a source of drinking water supply.*

5.0 Objectives of the Study

The Purpose Driven study object is to study Urban Hydrology, Groundwater Quality, Pollution Management and Quantification of Groundwater Resources (with special reference to dynamic resources) of Hussainsagar catchment area (in and around twin cities of Hyderabad and Secunderabad) falls under Musi Sub-basin, Krishna river basin, Greater Hyderabad city, Andhra Pradesh.

The main Purpose of the study is to assess the present status of groundwater pollution due to urbanization as well as industrial emissions and quantification of

groundwater resources (with special reference to dynamic resources) in Hussainsagar Catchment.

6.0 Methodology

At present the issue of urban environmental sustainability is becoming a critical issue because of urbanization and its associated environmental impacts that are happening at an unprecedented rate. The life style of urban populace demands a large amount of materials and energy to sustain their metabolism. Anthropogenic flows exceed natural flows. Due to the large growth rate of the exploration of essential materials, manmade flows are approaching and even surpassing natural flows of many substances. As a consequence, the flows, stocks and concentrations of certain substances such as heavy metals and nutrients are rising. New solutions are needed to overcome the problems of water scarcity, deteriorating water quality, lack of sufficient water supply systems, inappropriate handling of wastewater and inadequate storm water management flood risk etc.

There is a need to study the urban hydrology with reference to all the parameters mentioned in above paragraph. An attempt has made in the present study to assess the hydrological condition in respect of quantity and quality by considering the following themes in the catchment.

- Hussainsagar Lake and Urban Storm Water Runoff
- Lake Water Quality
- Groundwater Table Condition
- Groundwater Quality
- Geophysical Surveys - Electrical Resistivity Tomography
- Groundwater Flow Model

6.1 Hussainsagar Lake and Urban Storm Water Runoff

The full tank level (FTL) of the lake is maintained at 513.43 m (amsl) considering 1 in 5 dry years. The increased paving of roads, building complexes and intense housing blocks had provided scope for generating more surface runoff. Hyderabad has received rainfall of 263.6 mm and 246.2 mm during August 23rd & 24th, 2000 respectively and Hussainsagar Lake had flooded and all downstream areas have overflown and water rose up to 1-1.5 m water level on the roads.

From the analysis of August 2000 flood, considering the effective catchment area of about 100 sq km with the above rainfall, it had generated surface runoff of ~ 100 mm. which would amount to 100 x1000 x 1000 x 0.1 m^3 of surface water i.e., 1000 Ha.m. This 1000 Ha.m of Water spread over the lake surface area of 500 ha had given rise in water level in the lake by 2 m and on the next day it received same amount of rainfall which had further caused additional water level rise of 2 m in the lake. The discharge of surplus flows from the lake through downstream channel had taken nearly 10 days for discharging due to encroachments on the stream course leading to Musi River. The changes that took place in the Catchment of Hussainsagar lake from 1988 are shown in table 1.

Table 1Intercepted catchment details of Hussainsagar Catchment

S.No	Classification of Catchment Area	1988	2002	2011
1	Free Catchment (sq km)	104	75	70
2	Intercepted Catchment (sq km)	183	212	217
3	Total Area (sq km)	287	287	287

Emphasize that *increasing urbanization is posing a threat to the lake maintenance;* even at the present situation, an intense rainfall of 60-80 mm/day received in the catchment area may assume dangerous situation of flooding in the downstream of the lake.

6.1.1 Change in Rainfall Events

The Analysis of rainfall data of Hyderabad IMD station from 2000 to 2010 revealed that there is a considerable increase in number of rainfall events of 20 mm/hr and 40 mm/hr (fig. 6). And also the number of rainy days and monsoon rainfall is increasing. The increased 40mm/hr events are is resulting in more runoff and less infiltration which leads to flash floods.

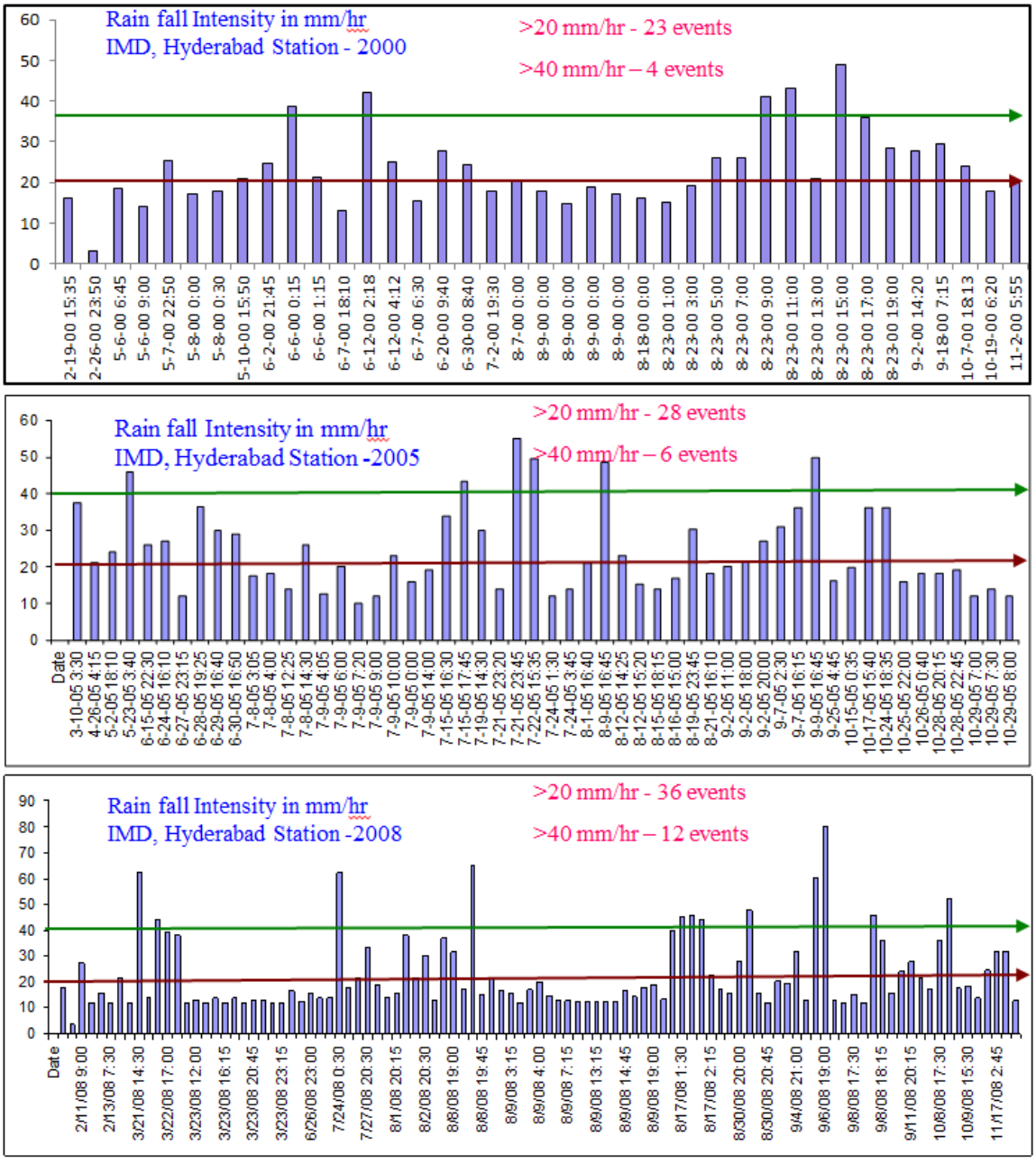
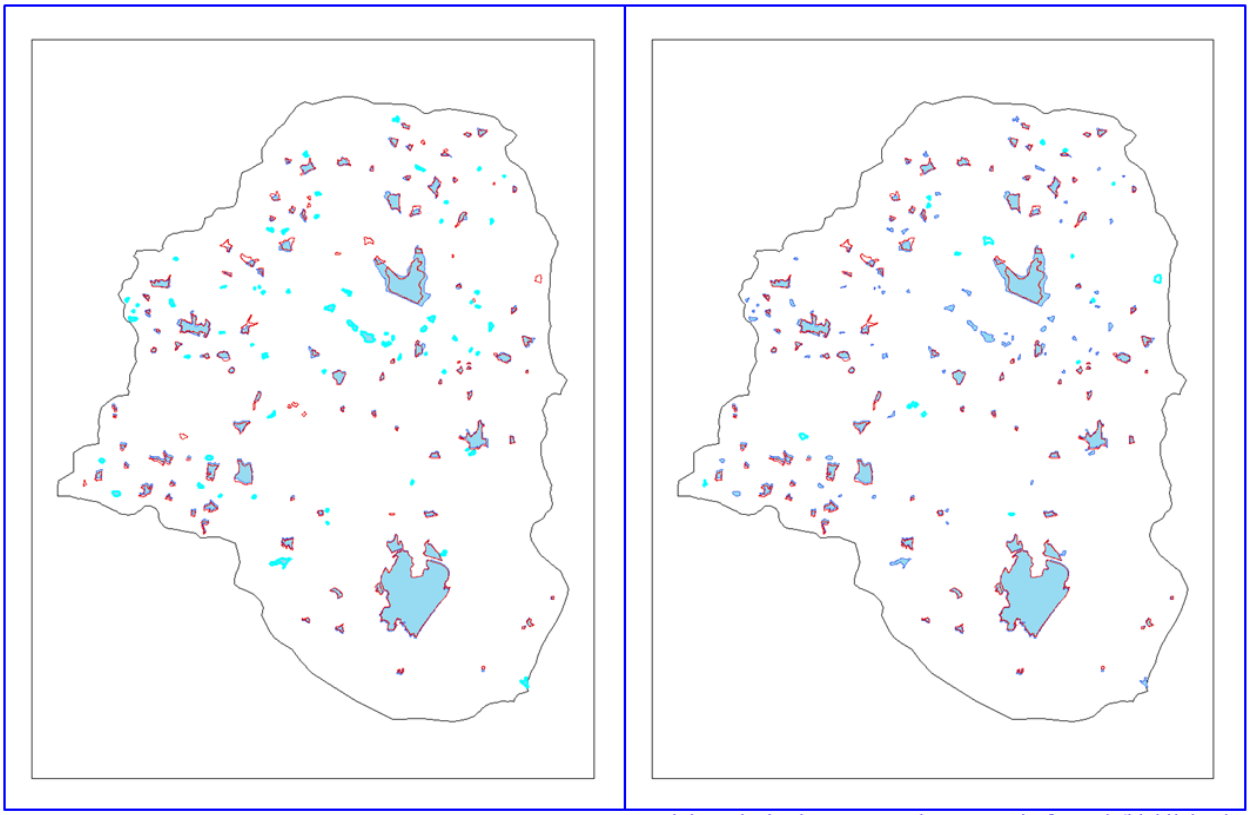


Figure 6 Graph showing events of Rainfall intensity during years 2000, 2005 and 2008

6.1.2 Reduction of Surface water bodies in the Catchment

The rapid urbanization and industrialization of Hyderabad resulted in drastic increase of the urban sprawl which in turn posed severe pressure on urban lakes by deteriorating water quality disturbing aquatic biodiversity and encroachment phenomenon converted them into land for construction finally resulting in the water body vanishing.

Comparison of Survey of India toposheets of 1974 and 2005-06 showed that 156 tanks occupying an area of 13.86 Sq.km was reduced to 109 tanks occupying an area of 12.06 Sq Km. Total 64 Tanks were disappeared and 17 new tanks were formed in the area (fig 7).



Spatial Analysis (Change Detection) shows 64 Tanks disappeared (highlighted in CYAN color) in 2006 when compared with 1974

Spatial Analysis shows 17 Tanks are newly formed (highlighted in CYAN color) in 2006 when compared with 1974

Figure 7 Temporal variations in Tanks in the study area

Table 2Statistics of the tanks during 1974 and 2006

	Survey Year (SOI toposheets)	No of Tanks	Area (Sq. km)	% decrease in Area
Tanks	**1974**	156	~13.86	
	2005-06	109	~12.06	**~ 13%**

6.2 Hussainsagar Lake Water Quality

Limnology of the lake water indicates that the lake is free from pollution up to 1970. During initial phase of industrialization, the lake had adsorbed some pollution impact, and once its natural carrying capacity has exceeded, the adverse impact of pollution has started manifesting during 1970s. The entry of pollution into the lake became unabated up to 1992 and the lake water has received peak pollution loads. Traditional cultural activities of Ganesh festival and Durga puja conclude by immersion of massive idols made of clay, plaster of paris etc. in the lakes.

The lake water has been sampled at 11 locations inside the lake for Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphorous (TP) and Total Nitrogen (TN) parameters as well as Total Phosphorus and Total Nitrogen in the sediment samples. Lake water quality has been measured during 2003, 2005 and 2007 and 2011 at the inlet channels. The ratio of COD/BOD has been found to be > 3 implying that there are some inorganic pollutants still entering into the lake water which is also confirmed by high TDS and other major ionic concentrations as well as heavy metal concentration. In general lake water quality was deteriorating over the years. The range of DO of lake water has been 1- 2 mg/l during pre-monsoon to 6 -8 mg/l during monsoon period. The average BOD of lake water has been reported > 20 mg/l during 2005, 2006 and 2007. Maximum values have been noticed from January to May period. Monsoon rains had improved the situation to some extent. The range of BOD of lake water had been 10-20 mg/l during most of the period with occasional increases after Ganesh idol immersion and summer period. The Nutrients, the total nitrogen and total phosphorous concentrations indicate that the lake was Nitrogen limiting with enrichment of phosphorous in lake water during 2003 & 2004. Further lake water monitoring showed deteriorating lake water quality during 2005 & 2007. The heavy metal analysis results also indicate entry of some industrial effluents into the lake water through Kukatpally nala.

The TDS of lake water has been 700 – 800 mg/l with dominant Chlorides and Sulphates. Heavy metals like Mercury, Arsenic, Selenium, Nickel, Chromium and Vanadium have been found in the lake water. Lake water quality supports the heavy metal concentrations of lake bed sediments analyzed during the study period. All the analyzes had indicated that the lake water may be placed under hyper eutrophic

condition, which is imperative for initiating quick restoration plans for remediation of the lake water.

Metal fractionation studies of lake bed sediments of Hussainsagar indicated that the behavior of Ni, Cr and Cd was similar in all samples. These three metals were found abundant in the exchangeable, bound to carbonate phase, reducible fractions and bound to organic matter whereas Aluminum is abundant in residual fraction.

6.3 Groundwater conditions in the Catchment Area

Groundwater occurs under phreatic conditions in the shallow weathered zone and under semi-confined to confined conditions in the fractured and sheared zones at deeper levels. In nature the aquifer system is slightly heterogeneous, with the rapid growth of population, the demand for water has been increased, which lead to construction of own public wells, as a result the water levels are declined.

Groundwater level and groundwater quality monitoring was carried out at 133 observation wells including 25 purpose built piezometers drilled under Hydrology Project II from 2009 to 2012. Depth to Groundwater level is varying from 5 m to 25 m bgl (fig 8) under phreatic condition in the catchment area. Groundwater level fluctuation varies from 4 to 15 m from pre monsoon to post monsoon respectively in the entire catchment. Maximum depth to groundwater level has been reported in Yousufguda (>50mbgl) watershed and Northern part of catchment. The groundwater level contours indicate predominant flow towards the streams and general flow towards the Hussainsagar lake.

Shallow water table conditions have been reported in the downstream area of Hussainsagar Lake which can be attributed to improved piped water supply by HMWS&SB in the catchment area which resulted in reduced groundwater exploitation.

The Average Water table for the Bowenpally watershed is deeper in the total catchment followed by Yousufguda, Dulapally, Kukatpally, and Banjarahills respectively (fig 9).

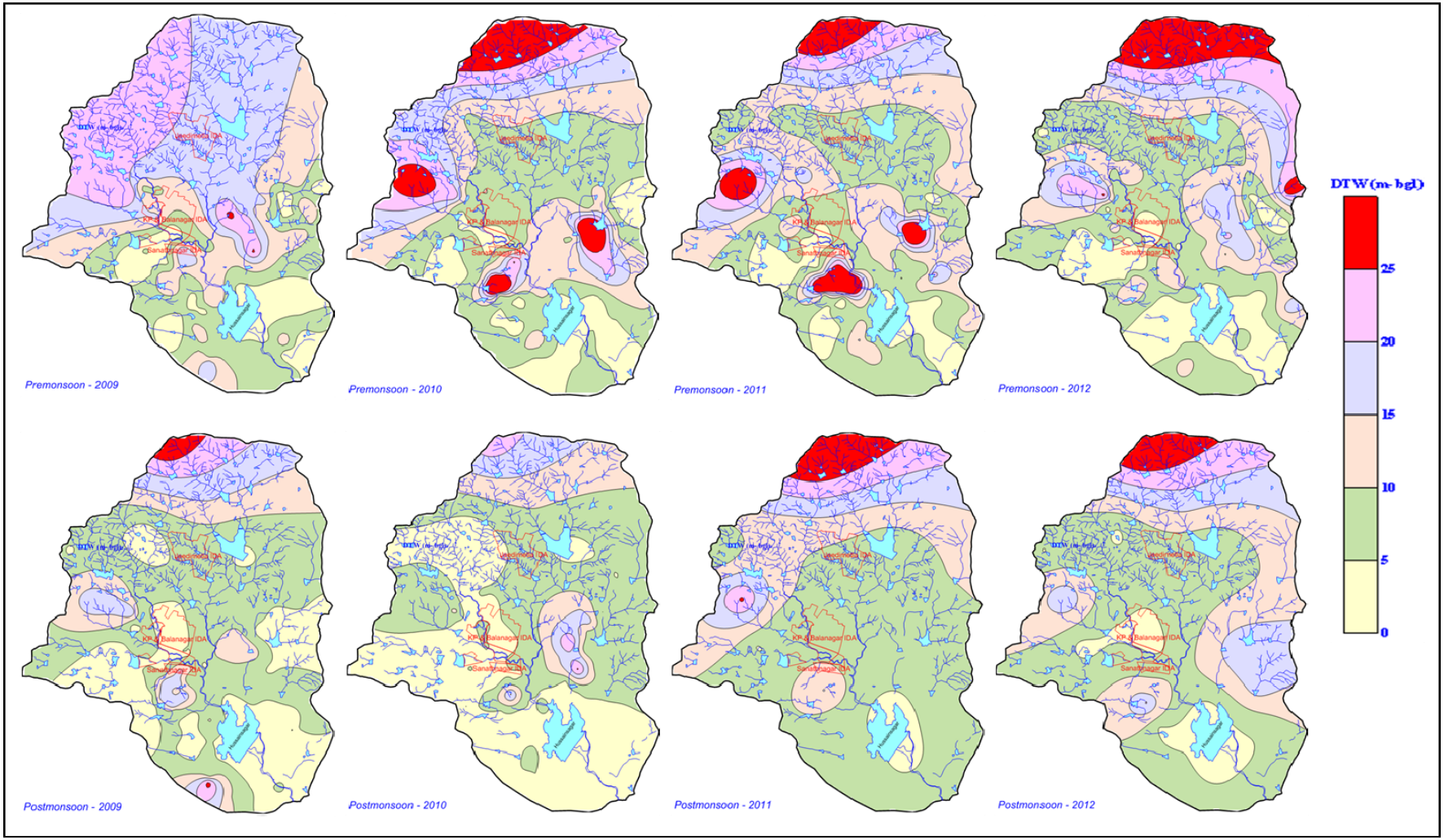


Figure 8 Map showing the Depth to water Table contours in Hussainsagar catchment

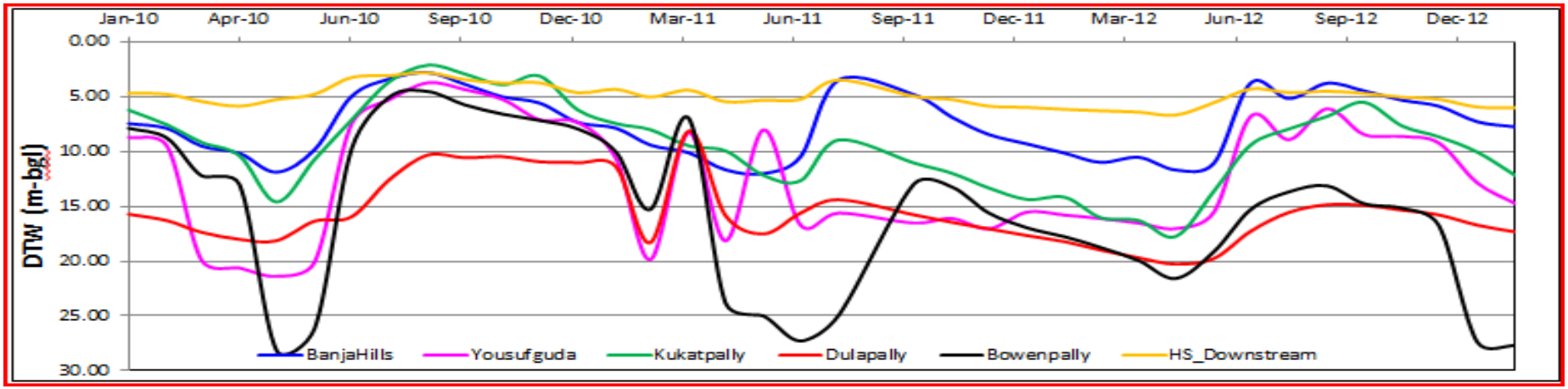


Figure 9 Watershed wise Depth to water level in Hussainsagar Catchment

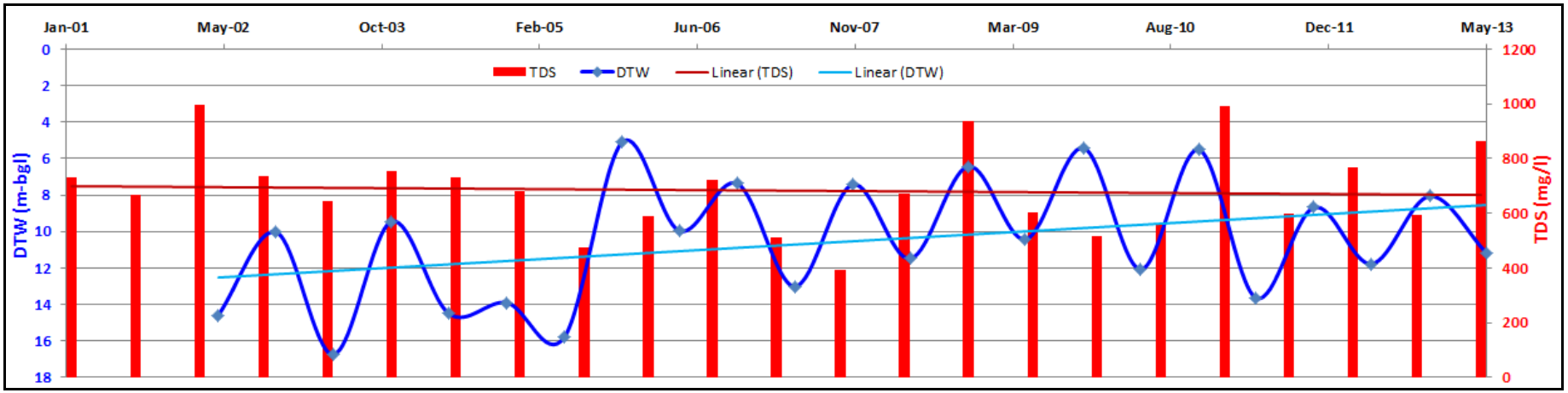


Figure 10 DTW Vs TDS in the Hussainsagar catchment from 2000 to 2013

Average groundwater level fluctuation during pre-monsoon to post monsoon generally varies from 2 to 10 m in Banjarahills watershed whereas the fluctuations are ranging from 4 to 14 m in Kukatpally watershed, where urbanization is rampant during the period. The average groundwater level fluctuation during pre-monsoon to post monsoon varied from 3 to 22 m in Yusufguda watershed whereas it is varying from 4 to 21 m in Bowenpally watershed. The groundwater level fluctuation was reported as 1 to 10 m during pre-monsoon to post monsoon in the downstream of Hussainsagar. Maximum pre monsoon to post monsoon groundwater fluctuation has been reported in the piezometers. It may be due to tapping of deeper fracture formations in Yusufguda and Bowenpally watersheds.

The historical data of the existing Piezometers was observed from 2001 to 2013. The depth to water table and corresponding TDS was shown in fig 10. The linear trend of depth to water table shows that there was a meager improvement during this period. Considerable water quality improvement was not observed.

6.4 Evaluation of Groundwater Quality

Groundwater samples collected in pre-monsoon and post monsoon during study period were analyzed for major ions in the Water Quality Level II+ lab of the Groundwater Department.

6.4.1 Statistical Analysis

A few samples were collected in duplicate for reconfirmation of the results and also for validation of the results and to know the instrument efficiency. The accuracy of the chemical analysis was verified by calculating ion-balance errors. The watershed wise Chemical analysis results of water samples were further subjected to statistical analysis and Minimum, Maximum and Averages are given in Table 3 to 6.

Table 3 Watershed wise Statistical Analysis of Chemical Parameters of 2009

	Parameter (mg/l)	Banjarahills Watershed			Yousufguda Watershed			Kukatpally Watershed			Qutbullapur Watershed			Bowenpally Watershed			Hussainsagar Downstream		
		MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG
Pre-monsoon 2009	TDS	189	960	548	189	1709	739.7	189	1683	769.1	653	1242	892	192	1485	846.7	253	1632	594.5
	Na	10	185	85.9	10	387	108	10	249	116.9	96	153	124.3	11	269	124	25	294	88.6
	K	5	10	6.22	3	60	7.4	4	11	6.1	5	6	5.67	5	9	5.54	5	20	6.46
	Ca	16	96	55.1	16	168	69.1	16	216	85.6	64	112	80	24	128	80.7	16	128	56.3
	Mg	10	78	24.44	5	107	39.2	19	78	31.7	34	88	55.3	10	92	46.2	15	78	30.9
	HCO3	106	418	248.9	106	489	259.7	104	308	239	317	395	343.3	103	527	302.9	61	368	193.4
	Cl	20	160	76.7	10	440	127.8	20	570	151.5	80	260	156.7	20	320	144.2	30	550	95.4
	SO4	11	75	37.44	15	255	75.7	12	270	84.1	50	145	86	15	230	78.5	23	101	54.5
	NO3	0.2	12.65	5.32	0.15	60	13.28	0.35	70	14.92	6.5	13.45	10.08	0.45	66.5	18.76	0.3	18.5	7.48
	F	0.45	1.72	1.12	0.37	2.77	1.635	0.54	2.55	1.337	1.29	1.66	1.423	0.34	3.49	2.05	0.41	4.06	1.713
Post-monsoon 2009	TDS	380	1274	642.2	180	3238	790.3	337	1773	857.6	290	1133	558.2	182	1670	885.4	227	1446	678
	Na	34	176	91.8	16	833	117.4	73	326	133.2	58	123	85.3	21	319	118.7	43	296	106.7
	K	5	13	6.79	4	25	6.29	5	11	6.46	5	12	6.33	5	9	5.5	5	26	6.83
	Ca	16	256	80.9	15	336	85.9	24	208	91.7	16	92	40	7	248	70.8	15	120	49.7
	Mg	5	72	24.2	5	92	37.2	0	83	36.2	5	96	34.5	17	192	74	5	136	48.3
	HCO3	95	340	240.8	30	560	219.7	44	340	230.7	100	295	190	100	480	273.2	90	380	249.6
	Cl	30	230	91.4	10	1110	168.7	60	640	188.5	20	230	95	15	420	165.4	30	500	120.3
	SO4	20	183	66.9	10	318	84.6	25	220	91.2	12	154	52.8	6	205	90.2	23	227	65.4
	NO3	1.95	64	14.9	0.3	92	15.73	0.9	56	19.24	4.1	27	9.2	0.45	80	23.66	0.1	25	9.73
	F	0.22	1.28	0.649	0.24	1.8	0.872	0.26	1.22	0.582	0.56	2.2	1.32	0.23	2.25	0.993	0.34	2.72	1.06

Table 4 Watershed wise Statistical Analysis of Chemical Parameters of 2010

	Parameter (mg/l)	Banjarahills Watershed			Yousufguda Watershed			Kukatpally Watershed			Qutbullapur Watershed			Bowenpally Watershed			Hussainsagar Downstream		
		MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG
Pre-monsoon 2010	TDS	163	749	453.2	168	1920	752.2	184	1837	711.8	239	947	481.9	172	2054	829.6	277	1338	551.4
	Na	19	140	77.8	23	339	101.4	26	277	121.5	38	120	74.6	22	241	113.3	38	257	86.3
	K	5	13	6.62	5	16	6.13	5	8	5.86	5	6	5.43	5	9	5.96	5	32	7.93
	Ca	8	80	37.2	16	392	86.9	8	192	66	16	64	36.6	16	336	98.4	16	112	48.8
	Mg	5	49	21.23	5	112	36	7	88	30.86	5	78	29.3	10	83	38.7	5	78	28
	HCO3	87	372	167.7	60	407	232.8	58	363	201.9	36	296	173	58	477	262.9	50	421	208.2
	Cl	14	110	59.2	20	780	156.6	20	620	152.9	10	190	72.9	20	590	159.2	30	430	89.2
	SO4	16	113	50.6	13	220	79.3	15	217	72.9	10	119	38.4	15	288	88.6	20	157	59.9
	NO3	2	36	15.94	0.95	315	38.8	0.45	180	40.4	0.2	56	15.73	3	383	64.8	1	110	23.36
	F	0.28	1.3	0.693	0.31	2.06	1.071	0.29	1.29	0.814	0.79	2.33	1.516	0.29	2.55	1.257	0.33	2.39	0.9
Post-monsoon 2010	TDS	215	1190	665.2	218	1853	798	215	1677	734.5	322	883	542.3	276	1472	774.8	209	1139	604.3
	Na	10	126	84.7	11	331	106.3	10	219	93.3	31	105	70.5	10	272	102.9	17	198	89
	K	5	14	7.92	5	25	7	5	8	5.87	5	11	6.5	5	11	5.89	5	27	7.4
	Ca	32	168	87.4	32	320	104	40	200	94.9	24	72	53.3	24	216	87.7	24	128	61.6
	Mg	5	58	27.3	0	136	31.6	10	92	32.2	10	68	32.33	5	73	39	10	68	29.23
	HCO3	125	400	265.3	66	515	265.8	125	396	268.9	200	360	280.5	95	450	265.4	70	396	224.6
	Cl	20	220	85.4	20	510	130.8	5	530	119.7	10	150	53.3	10	290	111.5	10	290	84.7
	SO4	9	155	67.3	14	377	81.1	9	189	54.3	7	88	35.8	8	181	82.4	11	142	60.9
	NO3	1.1	82.5	15.6	1.2	82.5	20.5	0.8	58	20.67	2.1	22.5	6.53	0.55	104	22.3	0.25	49.8	9.93
	F	0.23	1.44	0.713	0.23	1.96	0.982	0.24	1.5	0.693	0.82	2.21	1.383	0.28	2.44	1.318	0.23	2.38	1.003

Table 5 Watershed wise Statistical Analysis of Chemical Parameters of 2011

	Parameter (mg/l)	Banjarahills Watershed			Yousufguda Watershed			Kukatpally Watershed			Qutbullapur Watershed			Bowenpally Watershed			Hussainsagar Downstream		
		MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG
Pre-monsoon 2011	TDS	248	877	562.1	237	1805	715.8	292	1696	783.9	237	954	533	311	1466	787.2	248	1715	645.5
	Na	12	150	83.1	3	370	113.3	23	266	117.6	22	153	81.9	35	274	117.4	7	383	111.6
	K	4	14	7.07	4	15	7.08	4	7	5.71	4	7	5.43	4	10	5.81	5	26	7.67
	Ca	16	144	67.4	24	240	80.4	24	224	97.7	24	80	48	24	200	97.2	24	136	64.8
	Mg	0	44	23	0	73	28.46	10	63	28.86	10	58	29.7	5	68	29.9	10	73	25.43
	HCO3	50	492	216.4	55	500	239.6	82	445	236.3	78	342	203.6	58	410	226.2	90	370	235.3
	Cl	20	190	83.6	30	370	123.8	10	520	162.1	10	210	85.7	60	330	150.7	20	660	121
	SO4	10	96	43.5	5	445	76.5	19	160	63	6	80	29.7	40	370	77.5	3	159	55
	NO3	0.4	31	10.29	0.4	84	12.45	1.3	95	20	0.5	36	8.73	0.6	65	24.4	0.1	69.5	8.65
	F	0	1.44	0.742	0	2	1	0	1.8	0.842	0.81	3	1.45	0	2.48	1.275	0.32	2.4	1.076
Post-monsoon 2011	TDS	399	749	594	232	1184	780.3	458	672	569	327	864	556.3	303	819	600	367	1850	787.8
	Na	53	103	81.6	27	355	132	73	117	97.8	62	119	81	43	93	60	68	237	119
	K	2	4	2.6	1	13	4.57	2	3	2.333	2	2	2	2	4	3	2	4	2.75
	Ca	24	88	62.4	24	128	70.9	24	80	42.7	24	96	58	32	128	90.7	24	264	88
	Mg	24	39	32	10	78	35.6	19	44	30.67	15	53	28	15	39	27.67	15	68	34
	HCO3	120	252	184	90	515	200.7	130	335	190.7	147	275	207	120	275	181.7	100	267	152
	Cl	50	140	100	20	350	171.4	70	140	96.7	20	190	92.5	50	150	110	60	430	172.5
	SO4	33	150	71.6	31	161	74.6	34	75	57.2	14	42	25	37	104	68.3	49	530	174
	NO3	2.15	11.4	8.59	0.4	70	17.7	2.3	19.46	7.5	0.45	15	6.1	1.4	35	15.72	1.35	10.4	4.975
	F	0.38	1.1	0.596	0.36	1.6	0.796	0.16	0.95	0.637	1	1.7	1.25	0.5	1.9	1.2	0.55	2.1	1.17

Table 6 Watershed wise Statistical Analysis of Chemical Parameters of 2012

	Parameter (mg/l)	Banjarahills Watershed			Yousufguda Watershed			Kukatpally Watershed			Qutbullapur Watershed			Bowenpally Watershed			Hussainsagar Downstream		
		MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG
Pre-monsoon 2012	TDS	227.8	947.2	565.9	225.3	1721.6	689	180.5	1440	667.4	310.4	1676.8	660.4	428.8	1171.2	731.2	205.4	1401.6	574.6
	Na	22.1	104	64.4	20.68	330.3	102.5	13.87	206.2	93.3	39.6	367.7	105.6	34.1	163.6	93.4	16.9	291.6	77.9
	K	0.85	14.2	5.2	0.8	16	3.9	0.9	15.94	4.2	1.31	3.63	2.29	1.23	9.1	3.61	1.5	28.4	6.9
	Ca	32	152	77.3	8	120	68.1	24	176	64.3	16	56	36.6	40	176	78.2	32	104	60
	Mg	0	48.6	25.93	0	209.1	35.4	7.3	72.9	38.4	19.45	102.1	47.9	14.6	82.7	42.3	4.86	68.1	30.46
	HCO3	88.1	278.8	171	26	440.4	202.6	65	405.7	203.2	81.5	294	178.2	79.3	314.8	210.6	44.3	310.6	171
	Cl	30	160	94.2	20	620	132.6	20	380	128.6	10	530	138.6	50	280	147.7	30	560	114
	SO4	15	155	75.2	1.7	395	78.3	16	440	77.2	10	93	47	39	150	71.3	8	185	58.6
	NO3	0.4	32	13.23	0.3	55.5	10.13	0.3	40	9.97	4	19.5	9.5	0.35	66.5	17.9	0.15	40	8.66
	F	0.21	1.1	0.579	0.23	2.1	0.887	0.21	1.4	0.614	0.56	2	1.367	0.29	2.6	1.207	0.22	2	0.782
Post-monsoon 2012	TDS	698	1171	984	367	2672	1102.2	360	826	699.4	278	986	621	749	986	838.7	236	742	481.3
	Na	94	143	116.5	32	259	136	46	128	97.8	36	127	88.5	43	107	66.7	19	104	75.3
	K	2	5	2.75	0	10	3.5	2	3	2.6	2	4	2.5	1	4	2.333	1	4	2.333
	Ca	104	168	148	48	520	149.3	48	112	86.4	32	96	70	88	168	122.7	32	80	50.7
	Mg	19	58	36.25	15	122	47.8	15	44	29.2	10	63	29.25	29	73	50.3	10	39	21.33
	HCO3	260	374	314.3	90	475	279	190	413	274.8	110	379	282.5	260	333	303.3	120	320	206
	Cl	90	220	155	50	1100	288.3	20	180	104	20	220	95	90	180	136.7	20	100	56.7
	SO4	61	250	152.8	38	370	118.8	21	125	79.6	20	70	40.15	61	120	82	10	72	45.7
	NO3	1.55	26	19.35	4.18	20.6	12.05	0.41	20.3	7.85	0.53	6.5	3.425	14.43	23.1	18.74	0.99	10.83	5.32

Based on the Cation and Anion percentage, the groundwater in the study area is categorized as "Na-Ca and HCO_3 – Cl-SO_4 "facies in the order of dominance for the all sampling periods. The following **figure 11** supports the above conclusion.

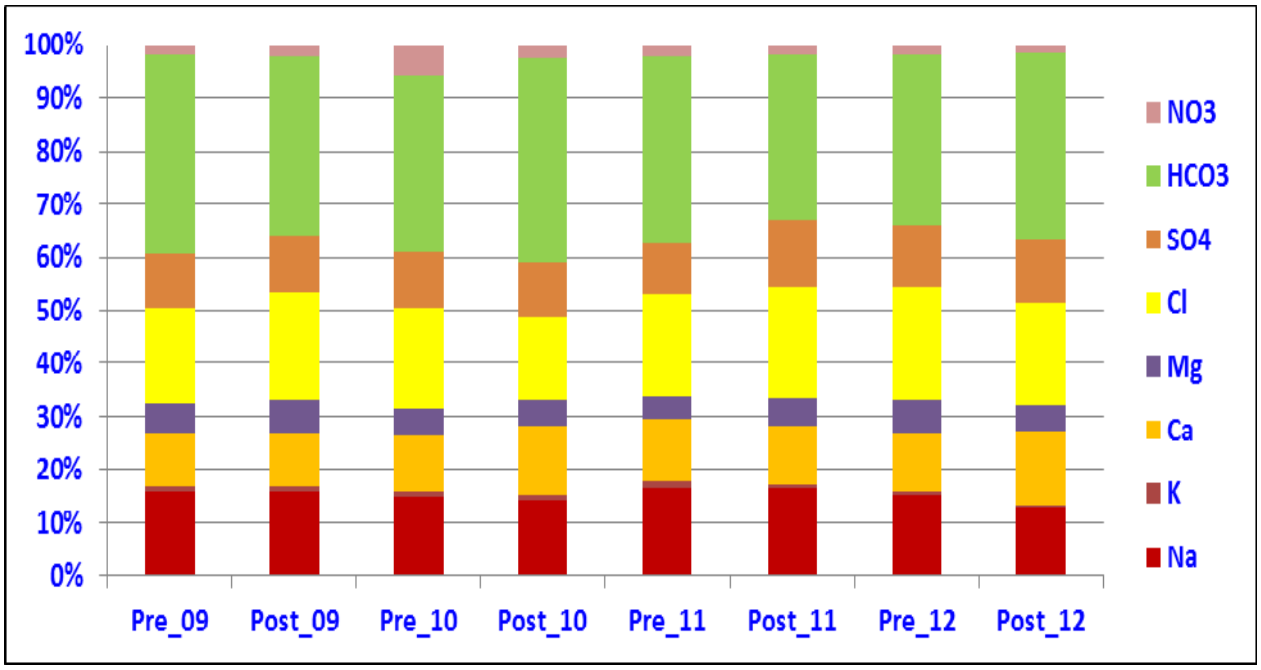


Figure 11 Diagram showing the % contribution of each chemical parameter to total Ions

6.4.2 Correlation Matrix

Correlation analysis is a bivariate method that describes the degree of relationship between two variables. For this purpose, Spearman's rank correlation coefficient has been calculated using quality parameters of groundwater samples of the study area presented in **Table 7**. The correlation coefficient value will always be between -1.0 and +1.0. A positive value corresponds to an increasing and a negative value corresponds to a decreasing monotonic trend between two water quality parameters. A high correlation coefficient (near 1 or -1) means a good relationship between two variables and its value around zero means no relationship between them.

Table 7 Correlation coefficient matrix of chemical data (2009-2012)

Pre-monsoon 2009										
	TDS	F	Na	K	Ca	Mg	Cl	SO4	HCO3	NO3
TDS	1.00	0.34	0.92	-0.14	0.72	0.83	0.94	0.86	0.70	0.55
F		1.00	0.38	-0.21	0.14	0.28	0.20	0.18	0.43	0.12
Na			1.00	-0.16	0.49	0.66	0.85	0.77	0.70	0.41
K				1.00	-0.12	-0.09	-0.10	-0.13	-0.17	-0.08
Ca					1.00	0.44	0.70	0.70	0.31	0.66
Mg						1.00	0.77	0.66	0.67	0.32
Cl							1.00	0.81	0.54	0.39
SO4								1.00	0.42	0.63
HCO3									1.00	0.20
NO3										1.00
Post-monsoon 2009										
	TDS	F	Na	K	Ca	Mg	Cl	SO4	HCO3	NO3
TDS	1.00	-0.07	0.84	0.09	0.61	0.59	0.94	0.91	0.53	0.48
F		1.00	0.06	-0.11	-0.26	0.05	-0.12	-0.15	0.15	-0.13
Na			1.00	0.11	0.22	0.35	0.81	0.72	0.54	0.21
K				1.00	-0.04	0.05	0.07	0.10	0.10	0.02
Ca					1.00	0.08	0.58	0.65	0.10	0.53
Mg						1.00	0.50	0.47	0.43	0.36
Cl							1.00	0.88	0.30	0.30
SO4								1.00	0.28	0.47
HCO3									1.00	0.09
NO3										1.00
Pre-monsoon 2010										
	TDS	F	Na	K	Ca	Mg	Cl	SO4	HCO3	NO3
TDS	1.00	0.07	0.81	0.10	0.75	0.84	0.93	0.89	0.54	0.58
F		1.00	0.19	-0.07	-0.06	0.05	-0.03	-0.05	0.26	-0.02
Na			1.00	0.10	0.30	0.67	0.70	0.72	0.58	0.32
K				1.00	0.00	0.12	0.08	0.08	0.08	0.04
Ca					1.00	0.43	0.76	0.67	0.25	0.64
Mg						1.00	0.77	0.72	0.50	0.40
Cl							1.00	0.84	0.28	0.43
SO4								1.00	0.31	0.57
HCO3									1.00	0.25
NO3										1.00

Post-monsoon 2010										
	TDS	**F**	**Na**	**K**	**Ca**	**Mg**	**Cl**	**SO4**	**HCO3**	**NO3**
TDS	1.00	0.08	0.83	-0.03	0.79	0.82	0.93	0.86	0.57	0.65
F		1.00	0.18	-0.18	-0.11	0.14	-0.02	0.00	0.27	-0.02
Na			1.00	-0.01	0.41	0.60	0.74	0.66	0.61	0.44
K				1.00	0.00	-0.12	-0.05	0.02	0.01	-0.10
Ca					1.00	0.48	0.78	0.78	0.23	0.67
Mg						1.00	0.76	0.65	0.56	0.45
Cl							1.00	0.86	0.35	0.54
SO4								1.00	0.26	0.50
HCO3									1.00	0.11
NO3										1.00
Pre-monsoon 2011										
	TDS	F	Na	K	Ca	Mg	Cl	SO4	HCO3	NO3
TDS	1.00	0.07	0.92	0.23	0.72	0.53	0.87	0.77	0.49	0.51
F		1.00	0.10	-0.11	-0.10	0.18	0.06	0.04	0.01	0.06
Na			1.00	0.30	0.48	0.43	0.80	0.71	0.50	0.36
K				1.00	0.04	0.10	0.22	0.25	0.16	-0.07
Ca					1.00	0.06	0.59	0.60	0.24	0.57
Mg						1.00	0.56	0.34	0.29	0.20
Cl							1.00	0.57	0.25	0.40
SO4								1.00	0.07	0.41
HCO3									1.00	-0.12
NO3										1.00
Post-monsoon 2011										
	TDS	F	Na	K	Ca	Mg	Cl	SO4	HCO3	NO3
TDS	1.00	-0.14	0.78	0.35	0.81	0.70	0.92	0.80	0.51	0.28
F		1.00	0.07	-0.12	-0.15	-0.38	-0.22	-0.17	0.13	-0.05
Na			1.00	0.36	0.33	0.29	0.62	0.50	0.74	0.04
K				1.00	0.13	0.30	0.33	0.11	0.17	0.19
Ca					1.00	0.56	0.75	0.79	0.27	0.32
Mg						1.00	0.83	0.55	-0.10	0.39
Cl							1.00	0.78	0.22	0.26
SO4								1.00	0.17	0.01
HCO3									1.00	-0.09
NO3										1.00

Pre-monsoon 2012										
	TDS	F	Na	K	Ca	Mg	Cl	SO4	HCO3	NO3
TDS	1.00	0.15	0.85	0.19	0.45	0.80	0.92	0.72	0.57	0.43
F		1.00	0.23	0.02	-0.07	0.07	0.12	0.01	0.18	-0.05
Na			1.00	0.16	0.10	0.54	0.79	0.51	0.54	0.19
K				1.00	0.08	0.11	0.13	0.21	0.08	0.13
Ca					1.00	0.13	0.33	0.45	0.32	0.51
Mg						1.00	0.80	0.62	0.32	0.31
Cl							1.00	0.68	0.32	0.25
SO4								1.00	0.13	0.19
HCO3									1.00	0.24
NO3										1.00
Post-monsoon 2012										
	TDS	F	Na	K	Ca	Mg	Cl	SO4	HCO3	NO3
TDS	1.00	0.00	0.54	0.72	0.92	0.87	0.95	0.88	0.10	0.32
F		1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na			1.00	0.35	0.22	0.32	0.33	0.39	0.65	0.21
K				1.00	0.74	0.55	0.80	0.56	-0.26	0.17
Ca					1.00	0.77	0.95	0.88	-0.19	0.24
Mg						1.00	0.85	0.69	0.05	0.35
Cl							1.00	0.83	-0.20	0.18
SO4								1.00	-0.08	0.21
HCO3									1.00	0.19
NO3										1.00

The value of TDS indicated the good positive correlation with Na^{+2}, Mg^{+2}, Cl^{-} and SO_4^{-2}. A Good Positive correlation was observed between Cl- & Na^{+2}, SO_4^{-2} and Ca^{+2} & Cl, SO_4^{2}.

6.4.3 Physico-chemical Parameters of Groundwater

Groundwater samples collected for pre-monsoon and post monsoon during study period were analyzed for major ions in Groundwater level II+ lab. The average values of the chemical parameters are tabulated in **Table 8 (& fig 12)**.

Table 8 Average Values (mg/l except pH) of the chemical parameters during 2009-2012

	Pre monsoon 2009	Post monsoon 2009	Pre monsoon 2010	Post monsoon 2010	Pre monsoon 2011	Post monsoon 2011	Pre monsoon 2012
pH	8	7.89	7.89	8	7.74	8.19	8.07
TDS	717.8	765.6	673.9	715.3	695.1	655.9	654.7
Na	106.1	113.2	98.9	96.3	109.3	100	90.2
K	6.43	6.6	6.47	6.8	6.71	3	4.67
Ca	69.4	72.8	70.6	85.6	79	66.2	67.2
Mg	37.05	45.1	32.4	32.25	27.54	31.86	35.65
Cl	121.7	146.6	126.6	106.3	126.1	126.6	127.3
SO4	68.6	78.6	71	70	64.2	76.7	70
HCO3	251.7	241.4	221.3	257.7	231.7	187.9	192.8
NO3 as N	12.6	16	37.7	17.3	14.38	10.53	11.64
F	1.676	0.9	1.028	1.013	1.052	0.884	0.898

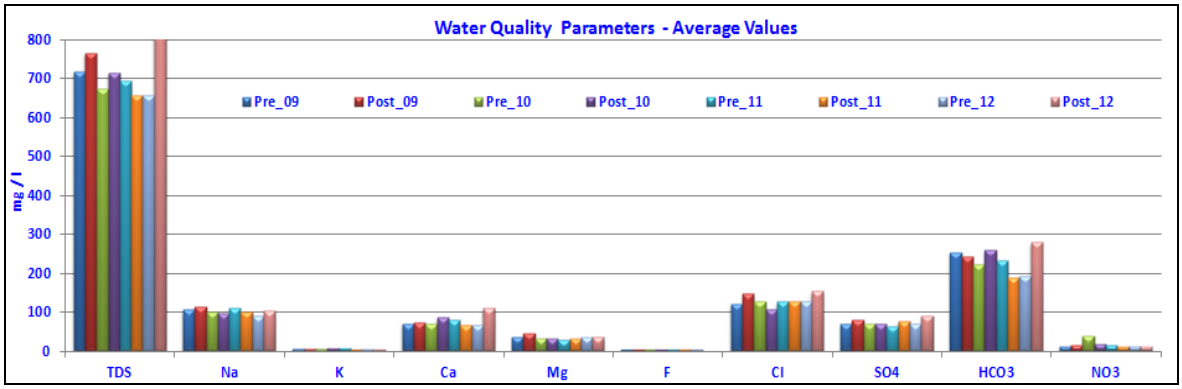


Figure 12 Average Values of Chemical Parameters during Study Period

Elevated TDS concentration > 1000 mg/l could be clearly seen in the Kukatpally watershed during the study period. This may be due to leaching of solid waste in the industrial area and also disposal of effluent and its interaction with groundwater. In 2011, TDS in Post-monsoon is less than the Pre-monsoon due to good rainfall. The analysis from most of the Data Sets is -TDS is highly correlated with Cl, So4 and Mg.

Chloride concentration > 250 mg/l was also reported in Kukatpally, Yusufguda and near Rasoolpura adjacent to old airport areas.

Sulphate (SO4) concentration was reported elevated and confined to industrial areas of Sanathnagar & Balanagar during the study period.

The Nitrate as Nitrogen was exceeding 10 mg/l indicates impact of urban solid waste disposal practices; also indicate maturity of urbanization in the respective areas and its non-scientific sewerage disposal practices.

Fluoride concentrations are found to be within limits except at a few locations. In general wherever slightly lower concentrations of all constituents reported may be attributed to the improved pipe water supply system in the catchment area during study period.

The Spatial Distribution of TDS, NO3 as N, Fluoride and Total hardness was shown in the Following Figures 13 to 20.

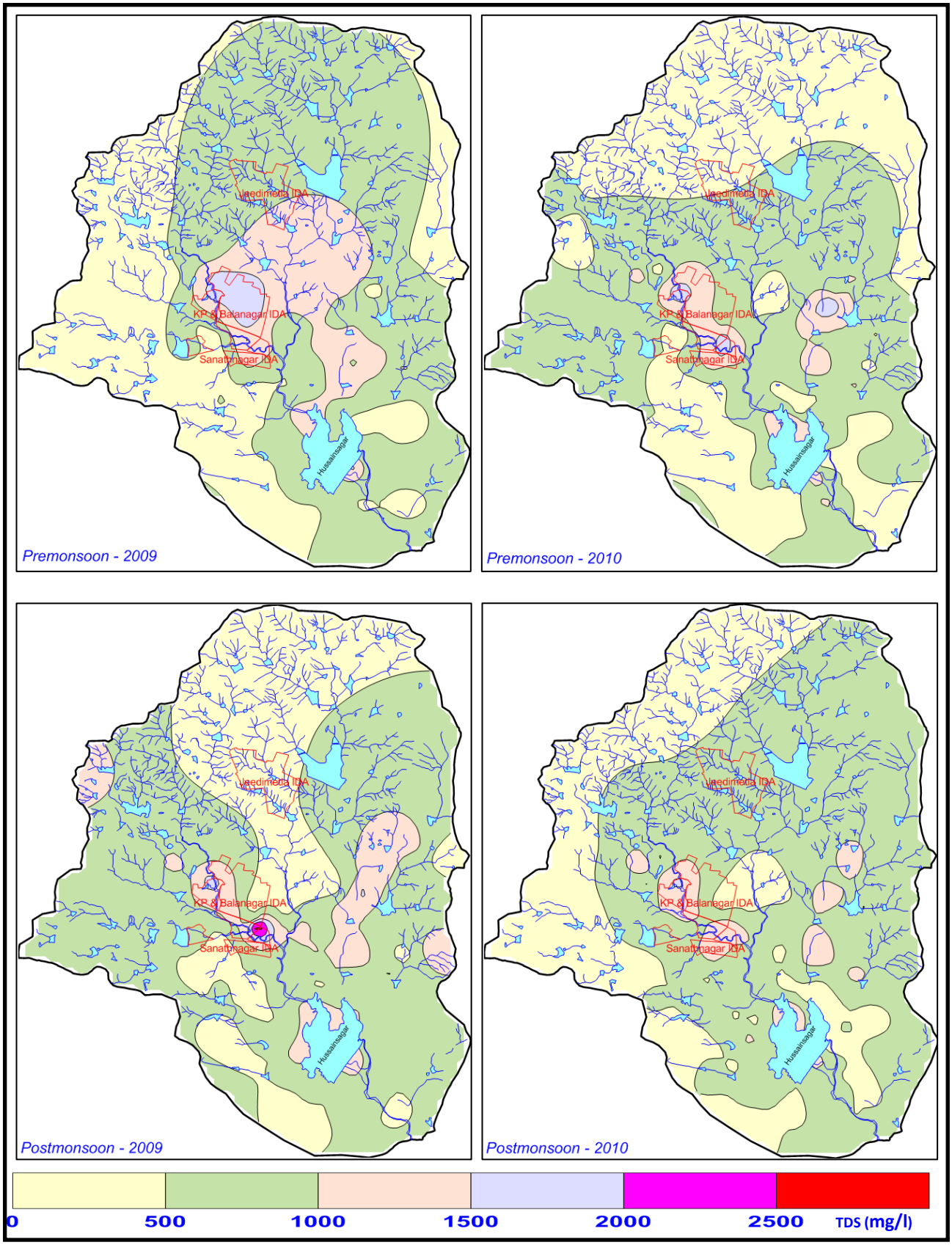


Figure 13 Spatial Distribution of TDS in the Study area 2009 -2010

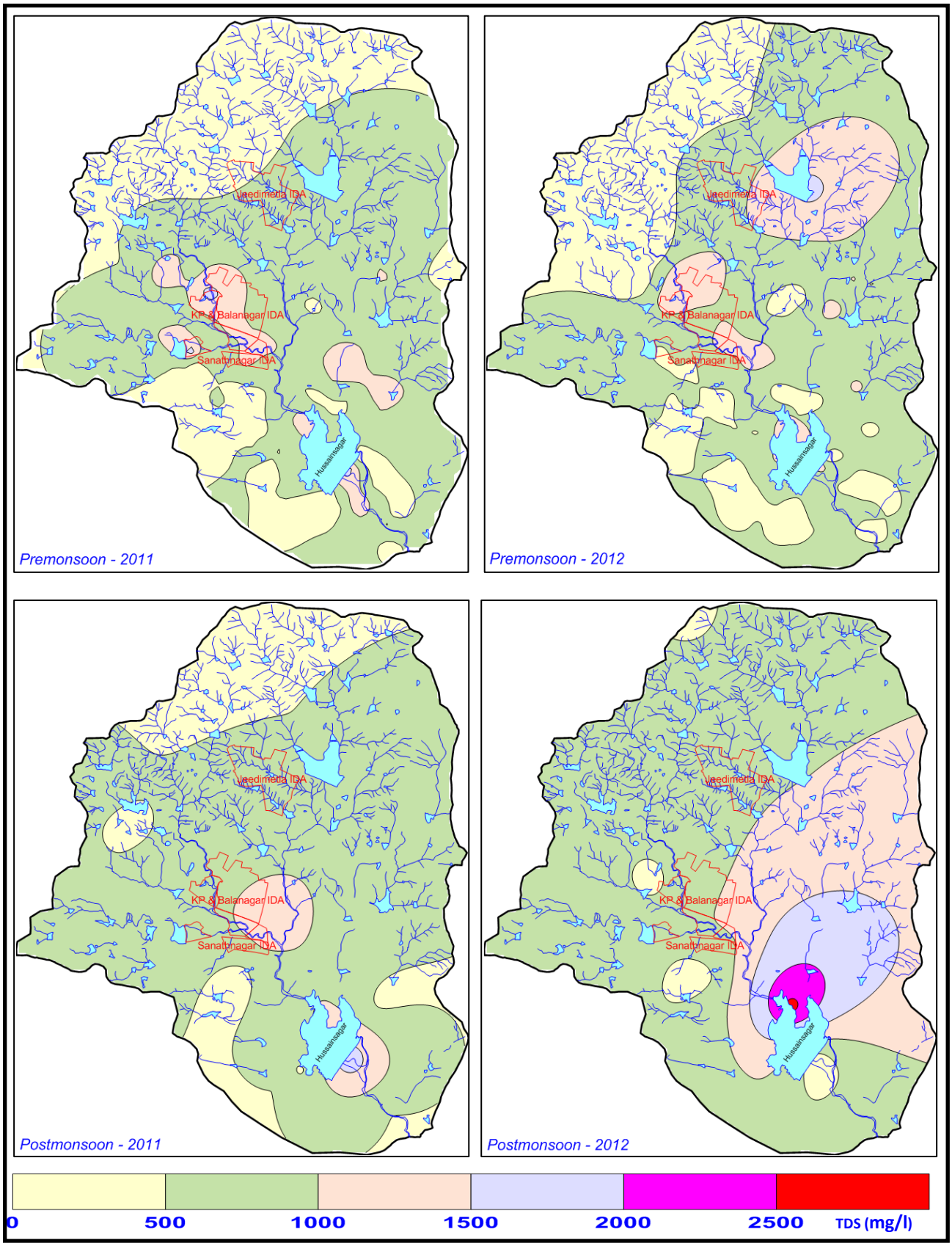


Figure 14 Spatial Distribution of TDS in the Study area 2011 -2012

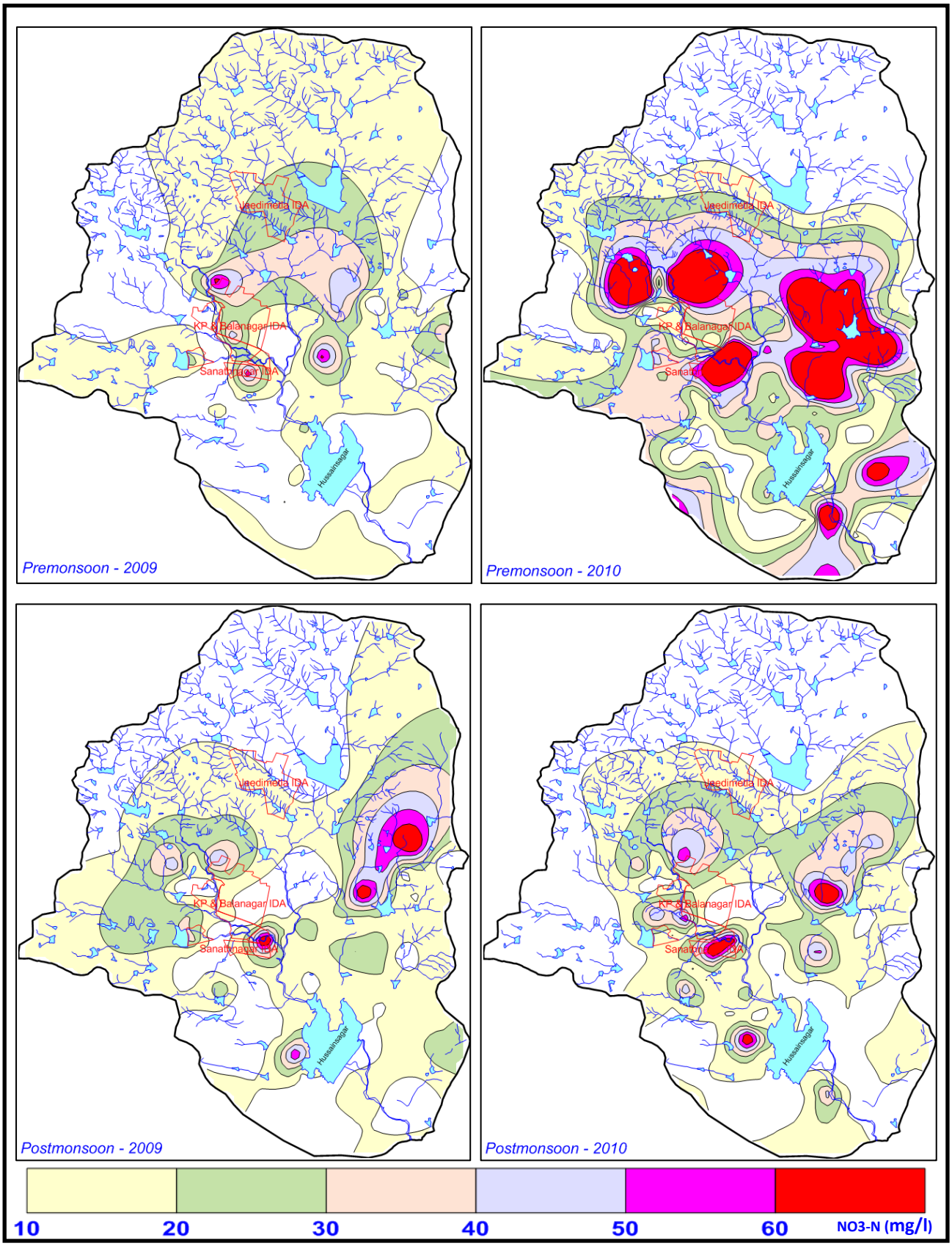


Figure 15 Spatial Distribution of NO3-N in the Study area 2009 -2010

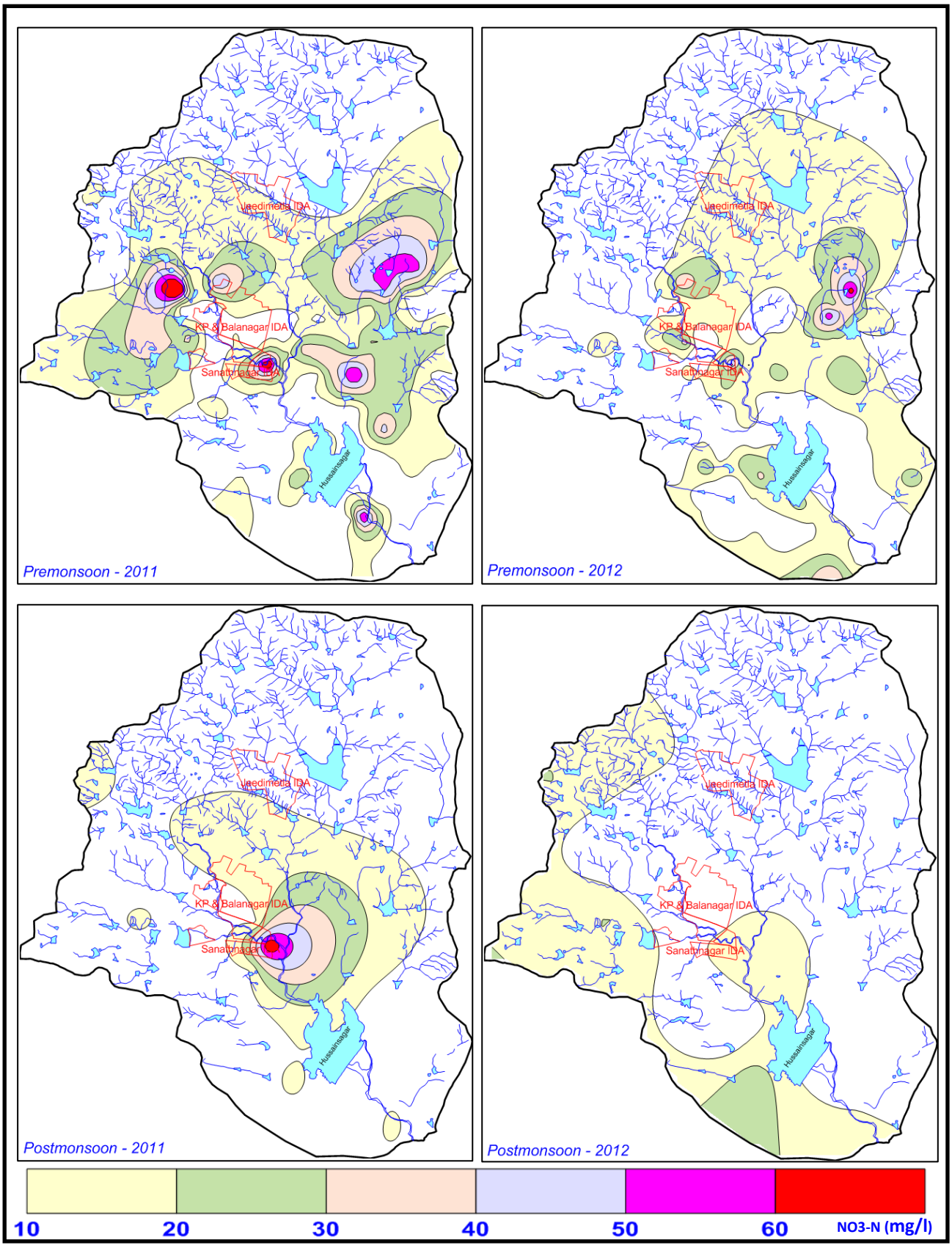


Figure 16 Spatial Distribution of NO3-N in the Study area 2011 -2012

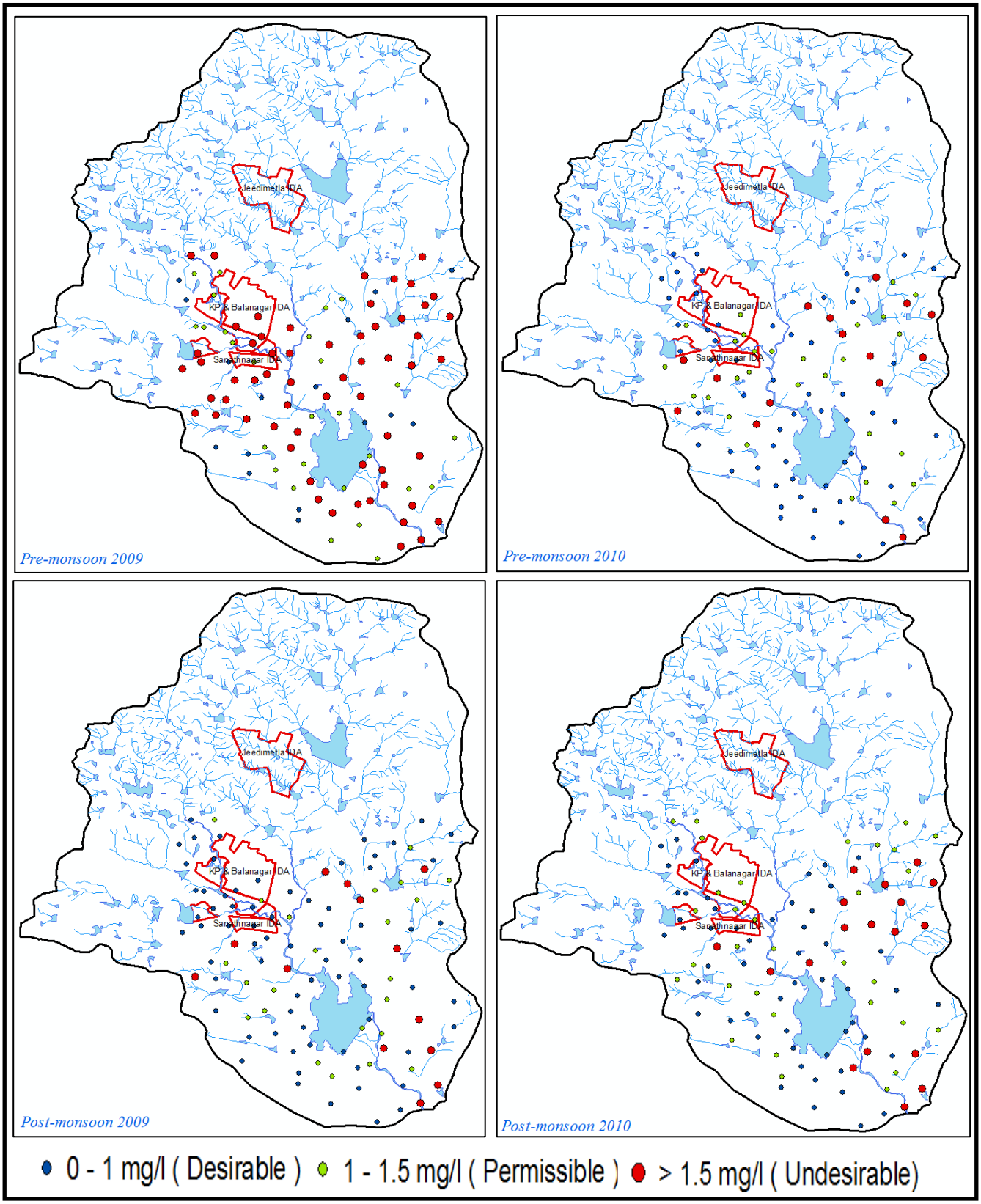


Figure 17 Spatial Distribution of Fluoride in the Study area 2009 -2010

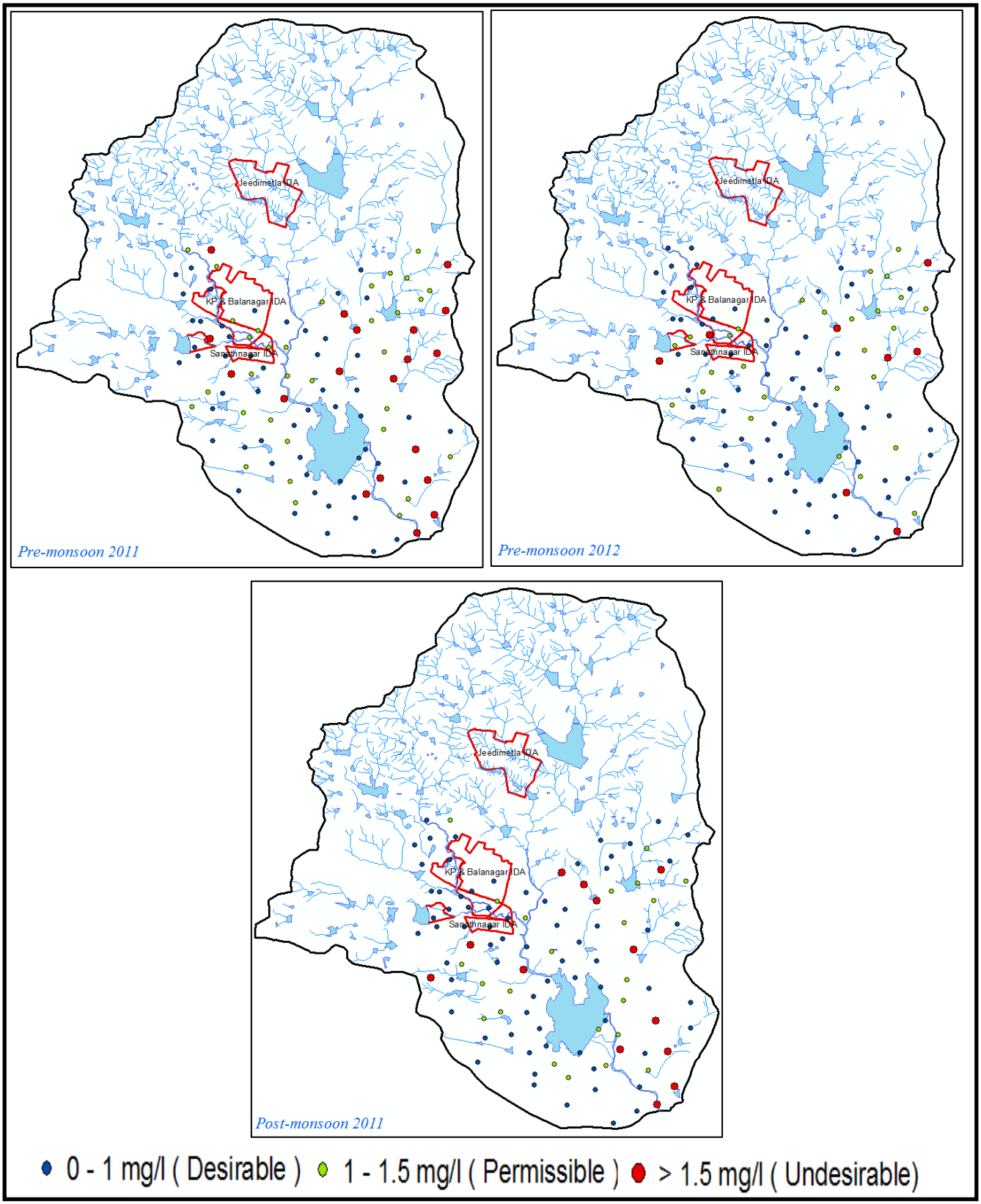


Figure 18 Spatial Distribution of Fluoride in the Study area 2011 -2012

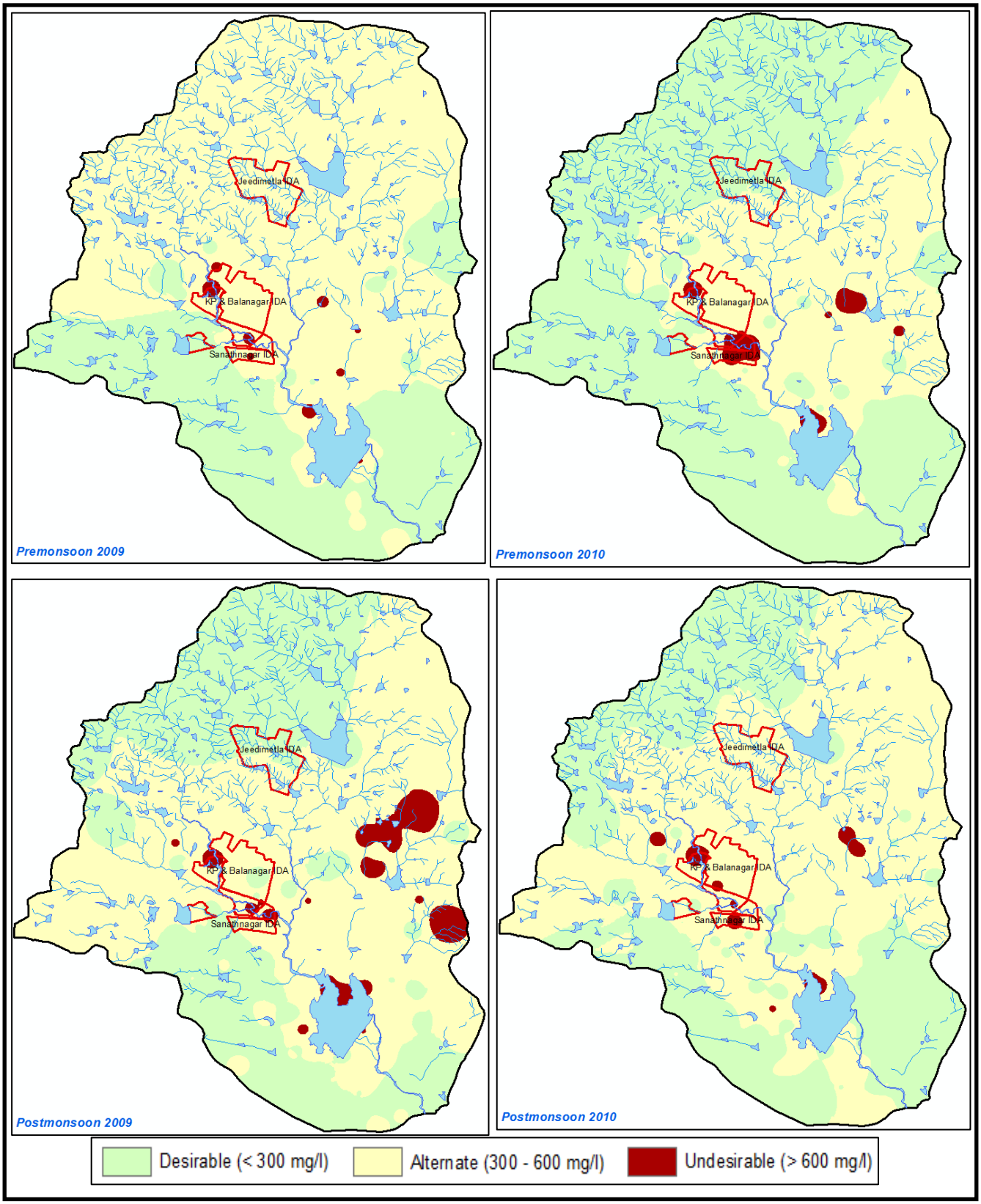


Figure 19 Spatial Distribution of Total Hardness in the Study area 2009 -2010

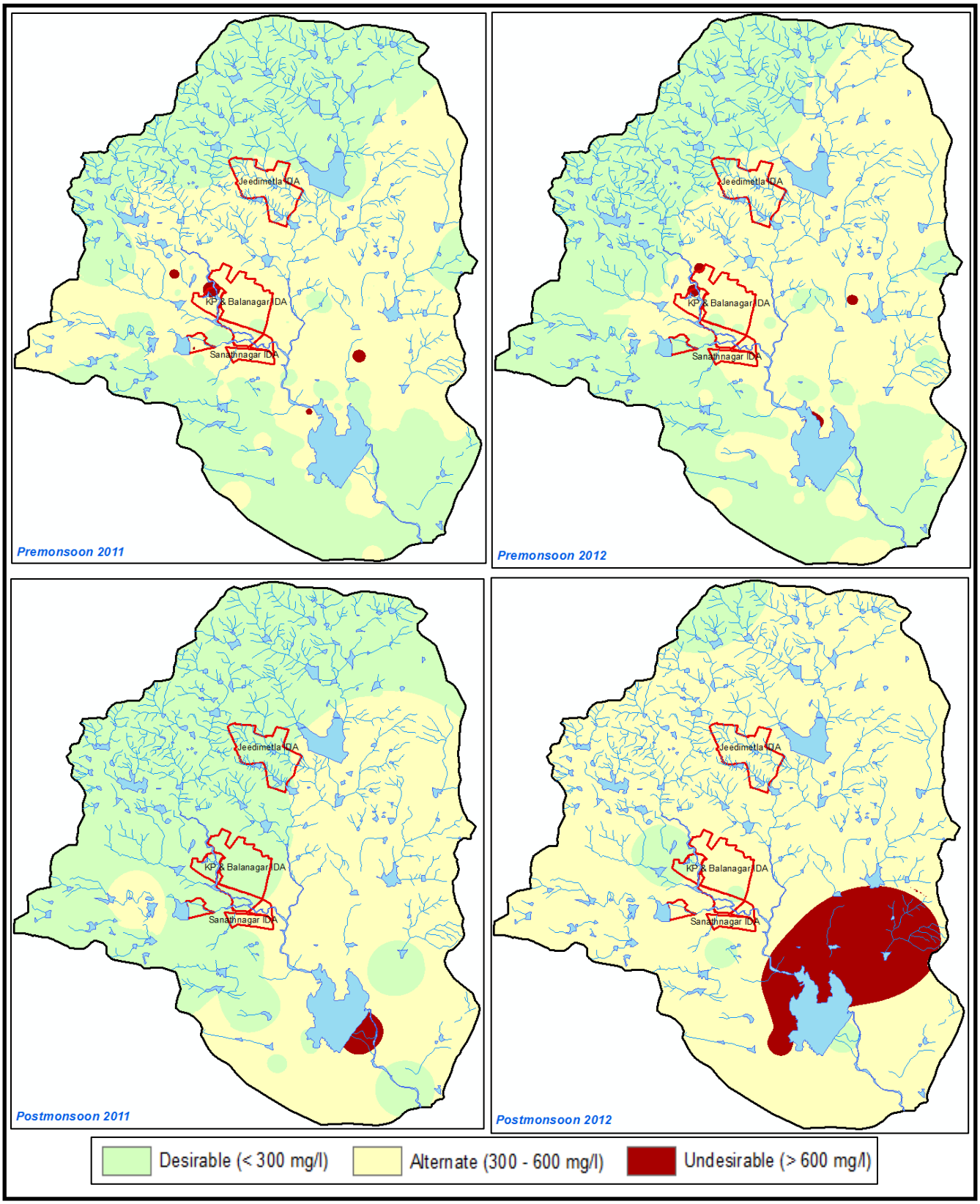


Figure 20 Spatial Distribution of Total Hardness in the Study area 2011 -2012

Groundwater quality in respect of heavy metal concentration in 2012 indicated slightly reduced concentration when compared to 2003. Comparison of Arsenic concentrations was shown in fig 21.

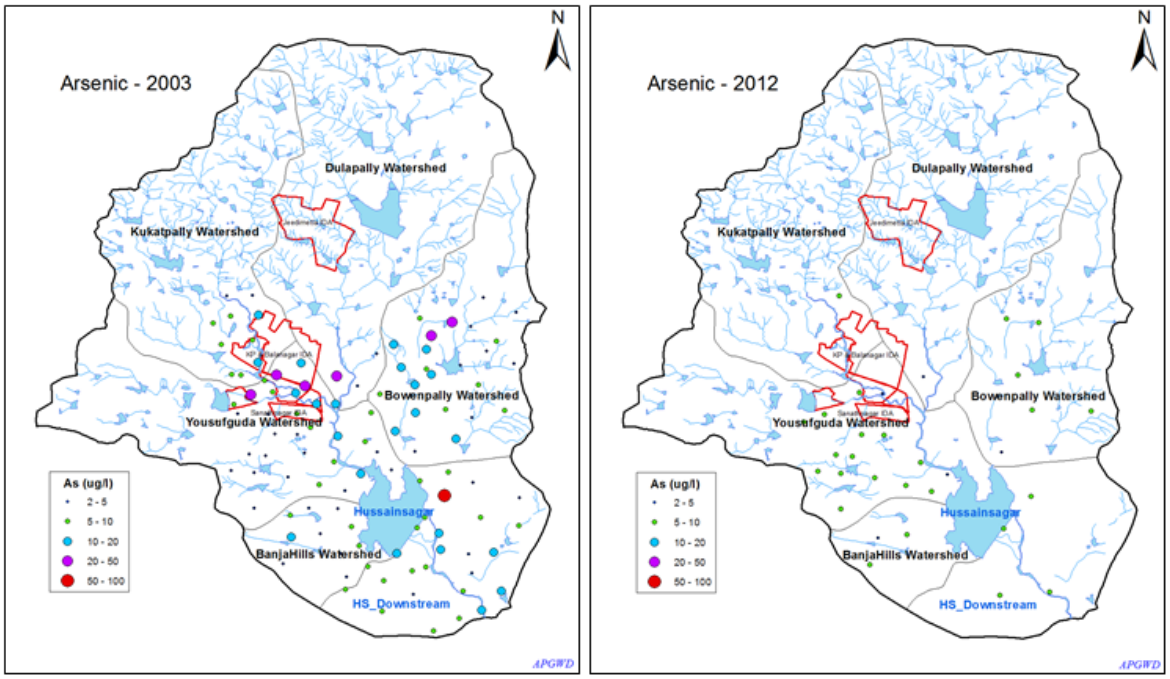


Figure 21 Arsenic Concentrations in ug/l during 2003 and 2012

The scenario demands continuous surveillance of waste water disposal from unauthorized discharges from small scale industries in Balanagar, Jeedimetla and Sanathnagar industrial development areas into the Kukatpally nala. It impacts very much on the Hussainsagar lake water.

6.5 Geophysical Investigations in the Catchment

The Electrical Resistivity Tomography (ERT) imaging has been carried out at 12 locations in the catchment area. The thickness of weathered and fractured formations inferred from the ERT images indicate that the Hussainsagar catchment area has weathered and fractured aquifer formations underlain with hard basement rocks (fig. 22). The Vertical Electrical Sounding (VES) data and borehole lithologs are compared and used to prepare the Maps. The Maps showing the Spatial and Vertical distribution of Litho units are shown in figure 23 & 24. The thickness of weathered and fractured formations varies from 20 to 50 m in catchment on an average.

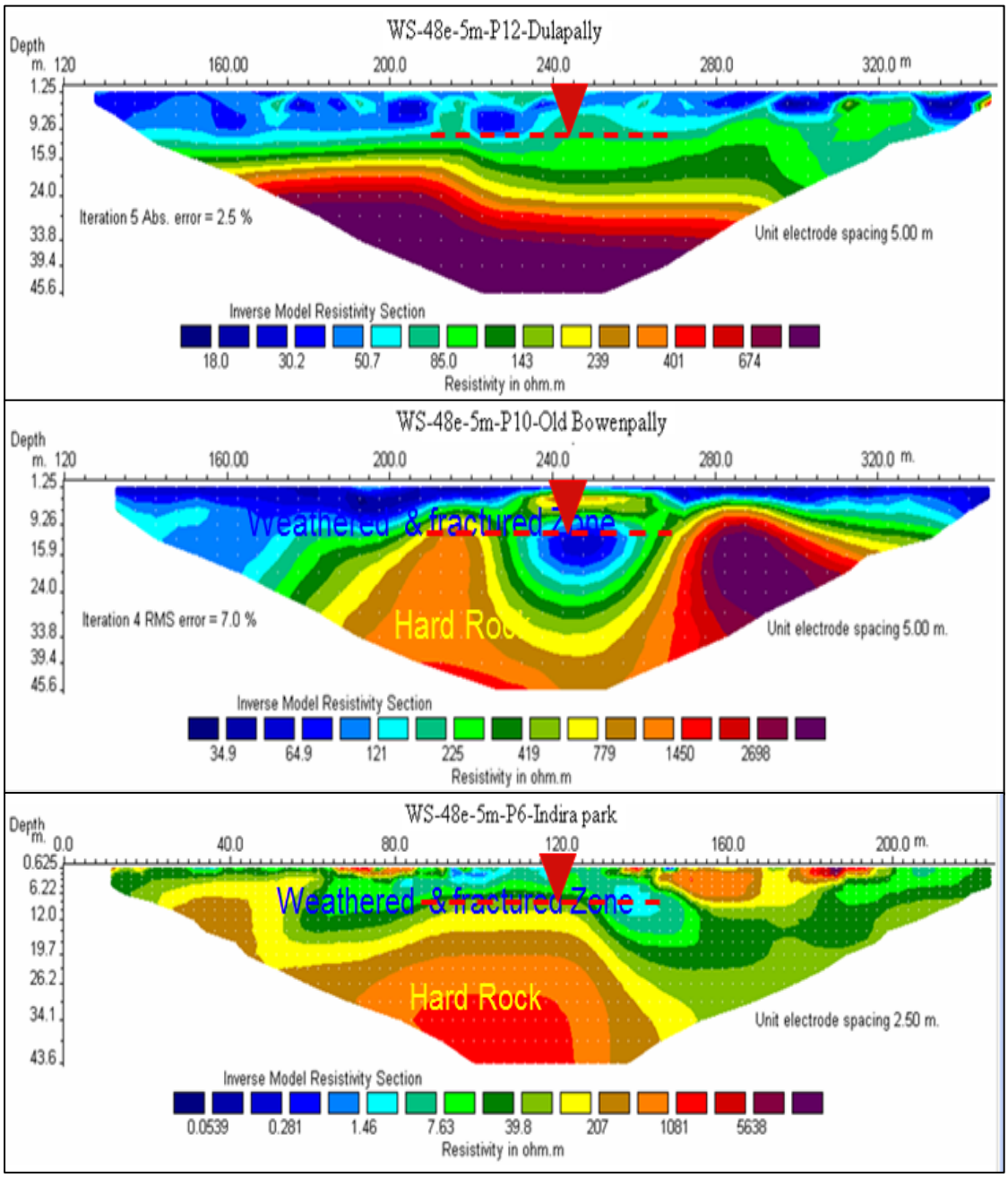


Figure 22 Electrical Resistivity Tomography data showing subsurface variation

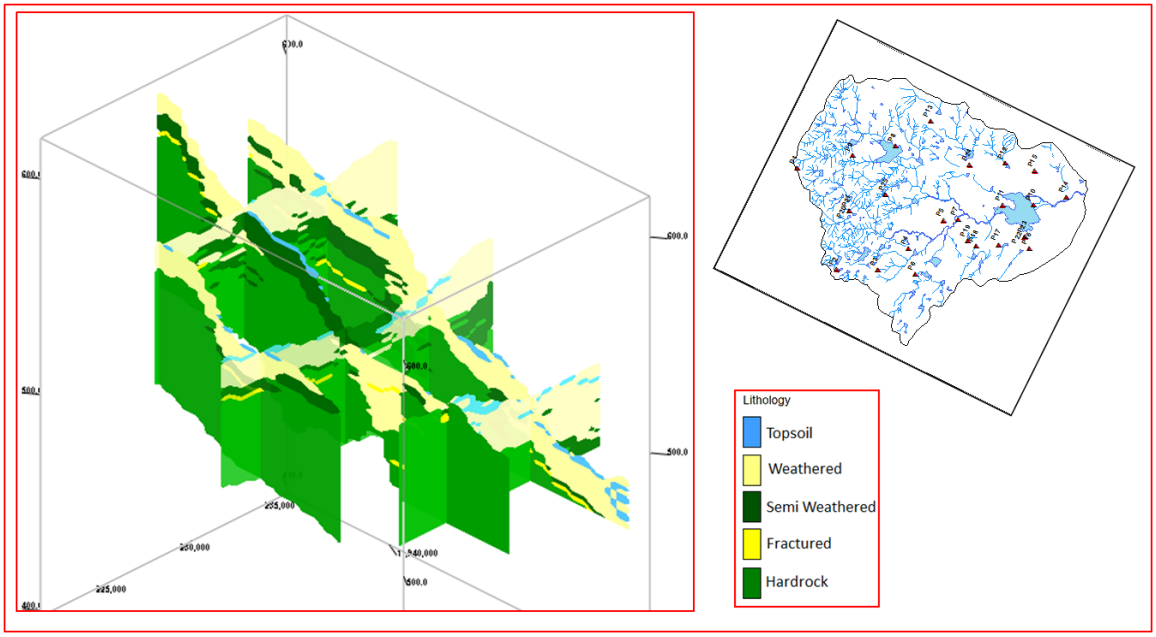


Figure 23 Fence Diagram showing the Spatial and Vertical distribution of the Layers

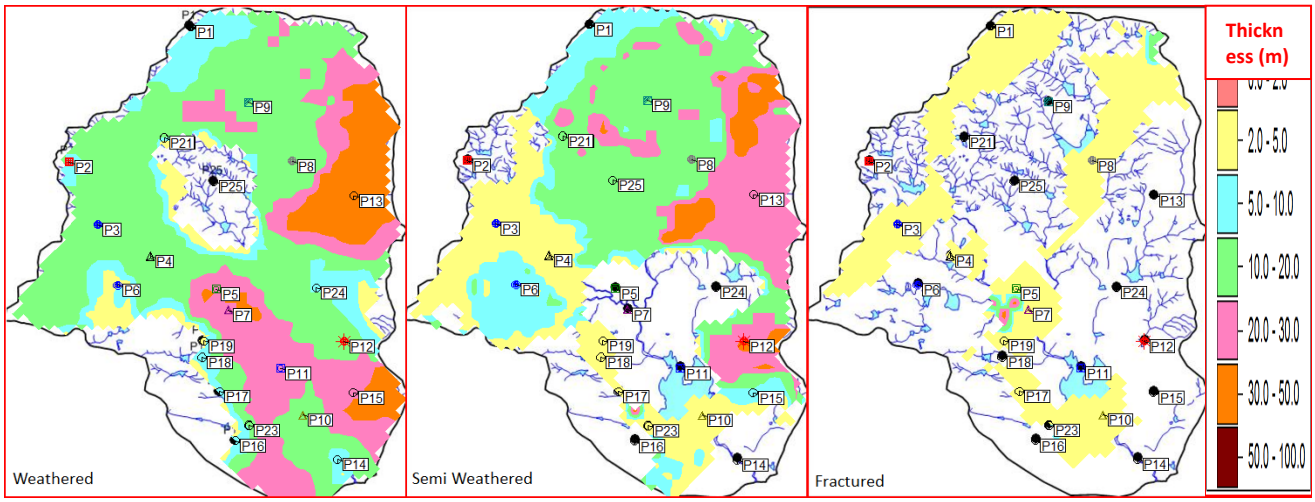


Figure 24 Isopach Maps showing the spatial variation of Thickness of different Litho units

6.6 Groundwater Information System (GWIS)

Salient features of the web based Groundwater information system on the Hussainsagar catchment area provides information on location of observation wells, depth to groundwater levels, frequency of monitoring, groundwater quality of individual wells with regard to major ion concentrations and aquifer mapping data in the form of ERT images. The groundwater level and water quality data provided from 2009 to 2012 period. The web based system will be uploaded to Ground Water department website (http://apsgwd.gov.in/) for data dissemination.

6.7 Groundwater Flow & Mass Transport Modeling

Groundwater flow model was simulated to calculate the groundwater balance in the catchment and to find the groundwater and lake water interaction.

The groundwater flow model in the Hussainsagar catchment area has been conceptualized as a two layered weathered and fractured aquifer system. The total thickness of weathered and fractured aquifer is varying from 60 to 70 m. The groundwater flow model has cell sizes of 240 m x 240 m and 120 m x 120 m (Fig. 25). The fine grid spacing has been chosen around the stream courses and Hussainsagar. The simulated permeability of the saturated weathered and fractured granitic rocks is varying from 3 to 3.5 m/day and in the major part the area the permeability is 3 m/day and along stream channels it was assumed little higher value i.e., 3.5 m/day. The elevated permeability values along the stream channel have been justified in view of presence of lineament/ fracture zone as well as saturated condition due to continuous flow of urban sewage and industrial discharges in the streams throughout the year. The permeability has been assumed to be one tenth of the horizontal permeability in the vertical direction.

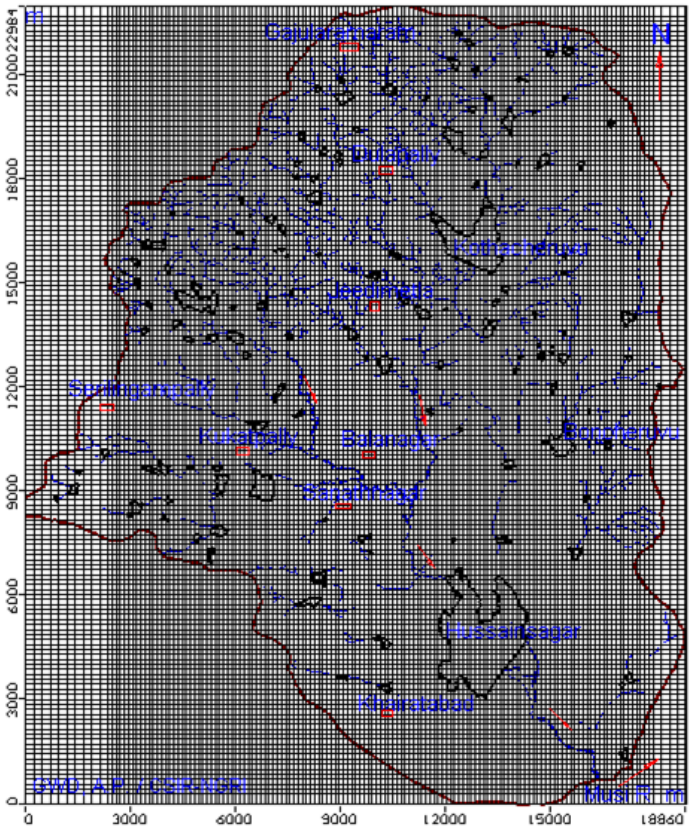


Figure 25 Grid map of the Groundwater Flow Model Domain, Hussainsagar Catchment

Constant head boundary condition was assigned to the stream at the confluence of Musi River with a groundwater head of 500 m (amsl) near Amberpet. The river boundary condition for the Kothacheruvu was simulated with a river head of 558 m with the lake bottom as 556 m(amsl), whereas Hussainsagar lake was assigned average lake operating level of 512 m (amsl) with lake bottom as 507 m(amsl) with a lake bed hydraulic conductance of 50 m^2/day in the groundwater flow model. Kukatpally & Jeedimetla streams flowing perennially had been simulated with river stages of 1 m in streams and hydraulic conductance of 5 m^2/day between stream bed and aquifer. Yusufguda, Banjarahills, Picket nala in the upstream and downstream channel from Hussainsagar up to Musi river course have also been simulated with similar hydraulic features in the flow model.

The area receives an average annual rainfall of 750 mm/yr mostly during south west monsoon. Moderate slopes and paved areas from the urban area in the catchment do not allow much groundwater recharge to the groundwater table. The virgin areas in the catchment area are in the northern part have been assigned a groundwater recharge @ 95 mm/yr based on earlier studies of Dulapally watershed (Narasimha Reddy et al, 1989). Moderate groundwater recharge for the paved areas in the urban zones around the Hussainsagar lake have been assigned with a recharge @ 55 mm/yr and even lower recharge has been assumed @ 50 mm/yr in the downstream of Hussainsagar in the groundwater flow model. Groundwater withdrawal has been measured in selected urban centers for arriving at the average groundwater pumping rate in the catchment area. The average groundwater pumping @ 50 m^3/day was assigned at major pumping centers representing high rise buildings in the catchment. A slightly lower groundwater withdrawal has been considered in the core city area close to the Hussainsagar where the surface water supply by HMWS&SB has improved considerably from the Krishna and Manjira distribution network during last decade.

The computed groundwater level contours in the Hussainsagar catchment area simulated in groundwater flow model have been showing the trend of observed water level contours during pre-monsoon 2010 (Fig. 26). Computed vs. observed hydraulic heads at 35 observation wells in the Hussainsagar Catchment area has been found matching closely (Fig. 27). The groundwater velocity field has been computed from the flow model by assuming an effective porosity of 0.1. The computed groundwater velocity field represents a maximum groundwater velocity of < 15 m/yr in the Hussainsagar catchment, which implies that migration as well as

remediation of groundwater contamination if any, in the catchment would be a very slow process.

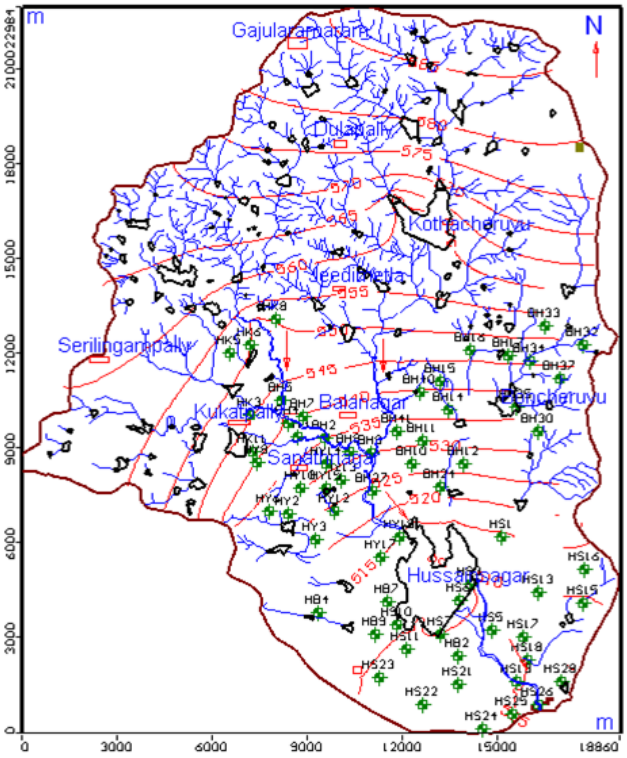


Figure 26 Computed Groundwater level contours m (amsl) in Hussainsagar Catchment Area – June 2010

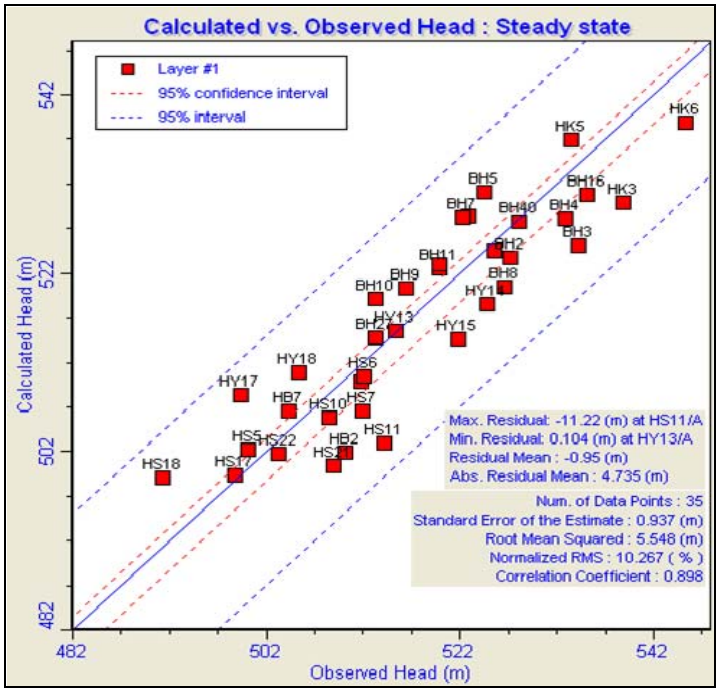
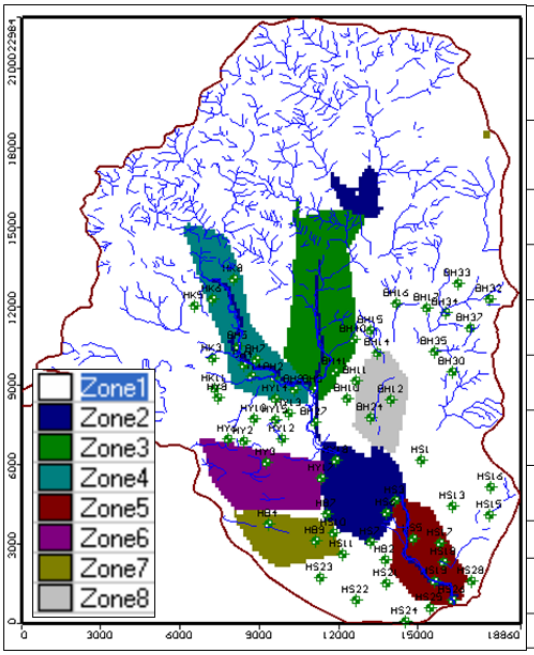


Figure 27 Computed vs. Observed Groundwater levels in Hussainsagar Catchment Area – June 2010

6.7.1 Zone Budget

The groundwater flow model has been further used to compute the groundwater balance for the entire catchment area of Hussainsagar. Different zones were assigned in the catchment and zone budget was computed (Fig.28). The significant feature was the computation of lake water – groundwater interaction in the Hussainsagar and also from different stream channels passing in different zones. The zone budget indicated that the seepage from the lake bed will be about 10 MLD in addition to the surface water evaporation from the lake @ 6mm/day over 450 ha surface area. The planned withdrawal for horticulture from the lake was about 10 MLD. Thus the Hussainsagar lake would require inflows of ~ 50 MLD for maintaining FTL. HMDA has already made renovation of the existing tertiary treatment plant of HMWS&SB of 20 MLD and initiated construction of two STPs (Tertiary Treatment Plants) one on Kukatpally nala and another one on Picket nala with a combined capacity of 30 MLD.



In flow	Out flow
	Constant Head = 506.19 m^3/day
Recharge = 48392.00 m^3/day	Wells = 29614.00 m^3/day
	ET = 320.14 m^3/day
River Leakage = 65.20 m^3/day	River Leakage = 9944.90 m^3/day
Zone 2 to 1 = 2942.40 m^3/day	Zone 1 to 2 = 7466.30 m^3/day
Zone 3 to 1 = 3019.00 m^3/day	Zone 1 to 3 = 1620.60 m^3/day
Zone 4 to 1 = 2270.20 m^3/day	Zone 1 to 4 = 7782.40 m^3/day
Zone 5 to 1 = 1577.10 m^3/day	Zone 1 to 5 = 2132.70 m^3/day
Zone 6 to 1 = 1372.00 m^3/day	Zone 1 to 6 = 856.52 m^3/day
Zone 7 to 1 = 347.11 m^3/day	Zone 1 to 7 = 107.99 m^3/day
Zone 8 to 1 = 1353.60 m^3/day	Zone 1 to 8 = 986.48 m^3/day
Total = 61338.00 m^3/day	Total = 61338.00 m^3/day

Figure 28 Groundwater Zones and water balance simulated in Hussainsagar Catchment Area

6.7.2 Mass Transport Model

The process of groundwater flow is generally assumed to be governed by the relations expressed in Darcy's law and the conservation of mass. The purpose of Mass transport model in groundwater is to compute the concentration of a dissolved chemical species in an aquifer at any specified time and place. Changes in chemical concentration occur within a dynamic groundwater system primarily due to four distinct processes i.e. advective transport, Hydrodynamic dispersion, Fluid sources, Reactions

Using the computed velocity field from the groundwater flow model, a mass transport simulation was carried out using MT3D software.

The source loading from the Jeedimetla, Balanagar and Sanathnagar industrial effluent discharges through Kukatpally nala in the upstream of have been assigned TDS concentrations of 1500 mg/l to the stream nodes passing through Sanathnagar and Balanagar areas. TDS concentration of about 1800 mg/l to the stream nodes passing through the Jeedimetla and after joining with Kukatpally nala up to the Hussainsagar lake and in downstream stream of Hussainsagar up to Musi river at the groundwater table during 50 years of mass transport simulation (Fig. 29). The longitudinal dispersivity was assumed as 20 m and longitudinal to horizontal and longitudinal to vertical was assumed as 0.1 and 0.01 respectively in the Mass Transport in 3 Dimensions (MT3D) model. The effective porosity in the granitic weathered and fractured medium was assumed as 0.1. Initial average background TDS concentration of groundwater has been assumed as 700 mg/l for the catchment area.

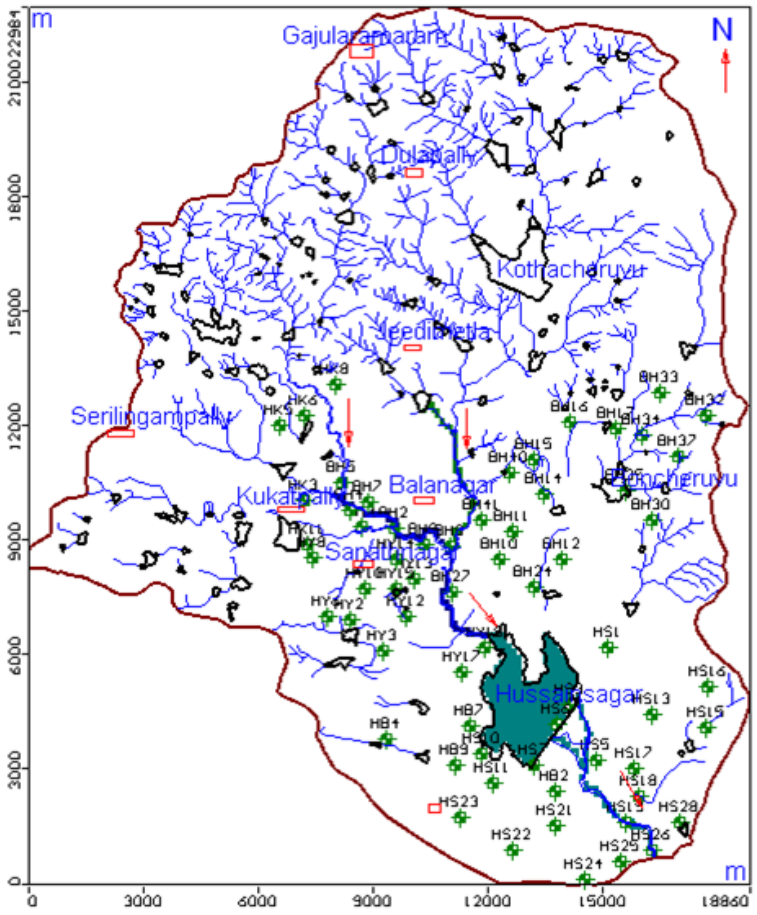


Figure 29 TDS (mg/l) loading nalas & Hussainsagar Lake since 1980 – Mass Transport Model

The computation of migration of TDS concentration plume from the Kukatpally nala, Hussainsagar Lake and along the stream in the downstream of Hussainsagar was made for next 50 years in the mass transport model. The respective migration pattern during different years of simulation was presented in Figure 30 & 31. All the computed contaminant migration patterns during the periods represent a business as usual scenario without any remediation intervention by either government or public. The width of the TDS concentration plume along Kukatpally nala would be about 400 m. The maximum groundwater velocity computed from the groundwater flow model was 15 m/year and average groundwater velocity could be even lower. The movement of TDS plume from the lake would be spreading to Indira park and Ashoknagar areas in the downstream of the lake.

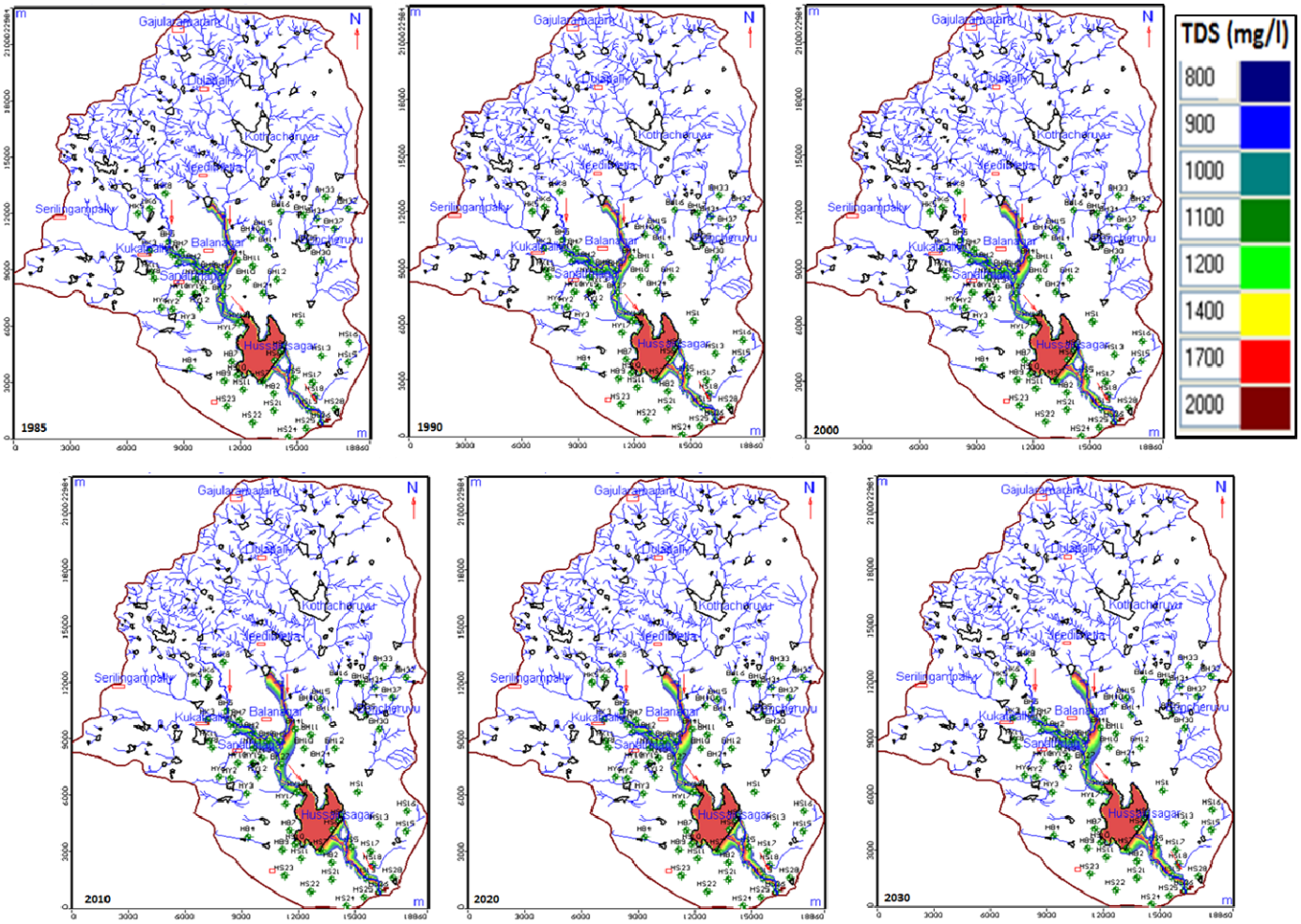


Figure 30 Computed TDS (mg/l) during 1980 – 2030 in First Layer (Scenario 1)

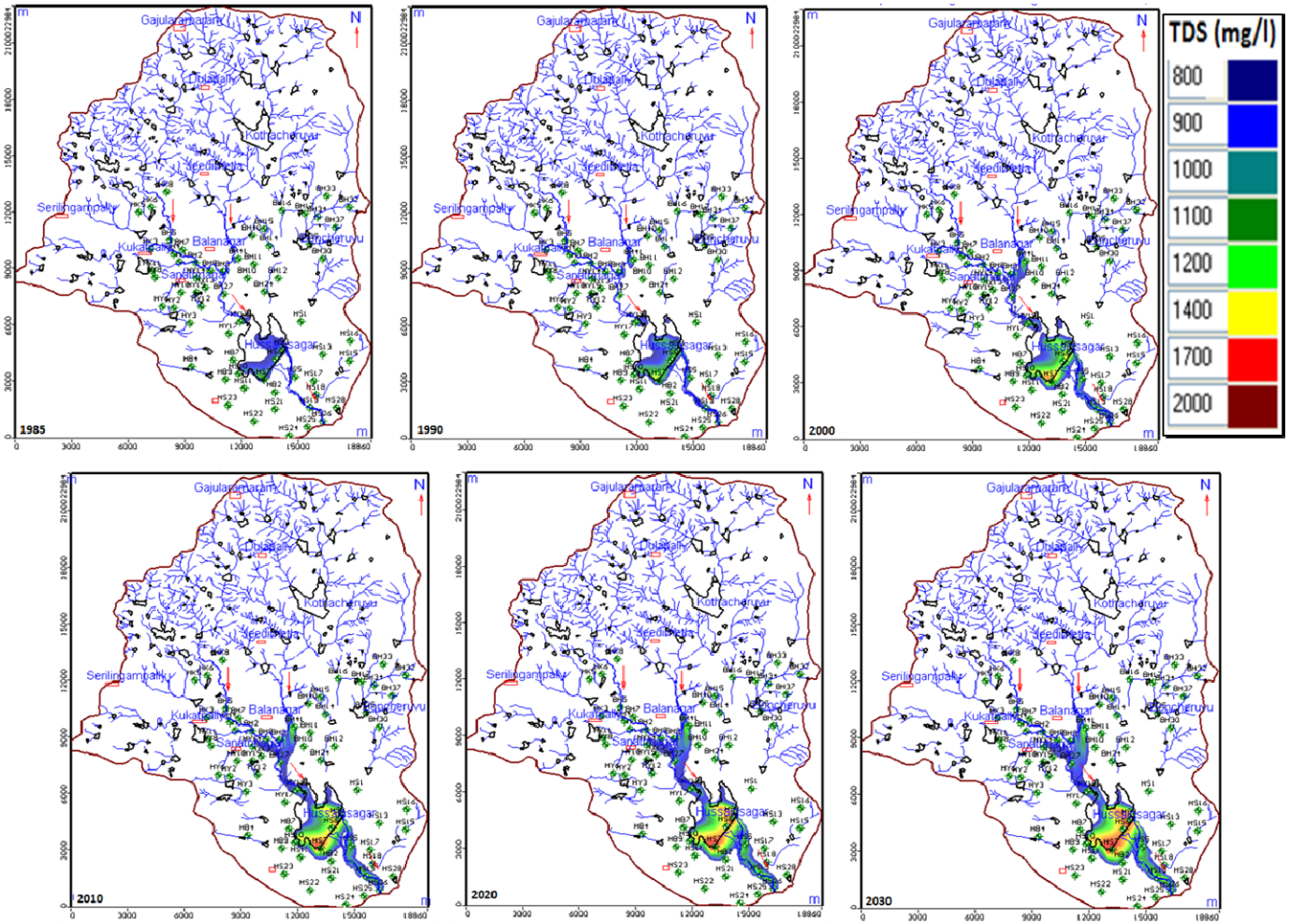


Figure 31 Computed TDS (mg/l) during 1980 - 2030 in Second Layer (Scenario 1)

Already HMDA with JICA assistance has started restoration of Hussainsagar lake contamination. In the context, modernization of sewer lines and diversion of sewage bypassing the Hussainsagar Lake has been implemented. If all things go as per the master plan, it may take another couple of years to completely restore the lake water in Hussainsagar. As groundwater velocity is very low it may take few more years to contain the groundwater contamination.

A second scenario was carried out to assess the impact of the restoration measures from the year 2010 in Mass transport model with reduced TDS loading as a result of restoration measures along Kukatpally nala as well as from the Hussainsagar Lake. The predicted TDS concentration plume up to 2040 indicated slight reduction of plume width with lower concentrations as compared with business as usual scenario (Fig. 32).

The groundwater flow model has been further used to compute the groundwater balance for the entire catchment area of Hussainsagar. Different zones were assigned in the catchment and zone budget was computed. The significant feature was the computation of lake water – groundwater interaction in the Hussainsagar and also from different stream channels passing in different zones. The zone budget indicated that the seepage from the lake bed will be about 10 MLD in addition to the surface water evaporation from the lake @ 6mm/day over 450 ha surface area. The planned withdrawal for horticulture from the lake was about 10 MLD. Thus the Hussainsagar lake would require inflows of ~ 50 MLD for maintaining FTL. The HMDA has already made renovation of the existing tertiary treatment plant of HMWS&SB of 20 MLD and initiated construction of two STPs (Tertiary Treatment Plants) one on Kukatpally nala and another one on Picket nala with a combined capacity of 30 MLD.

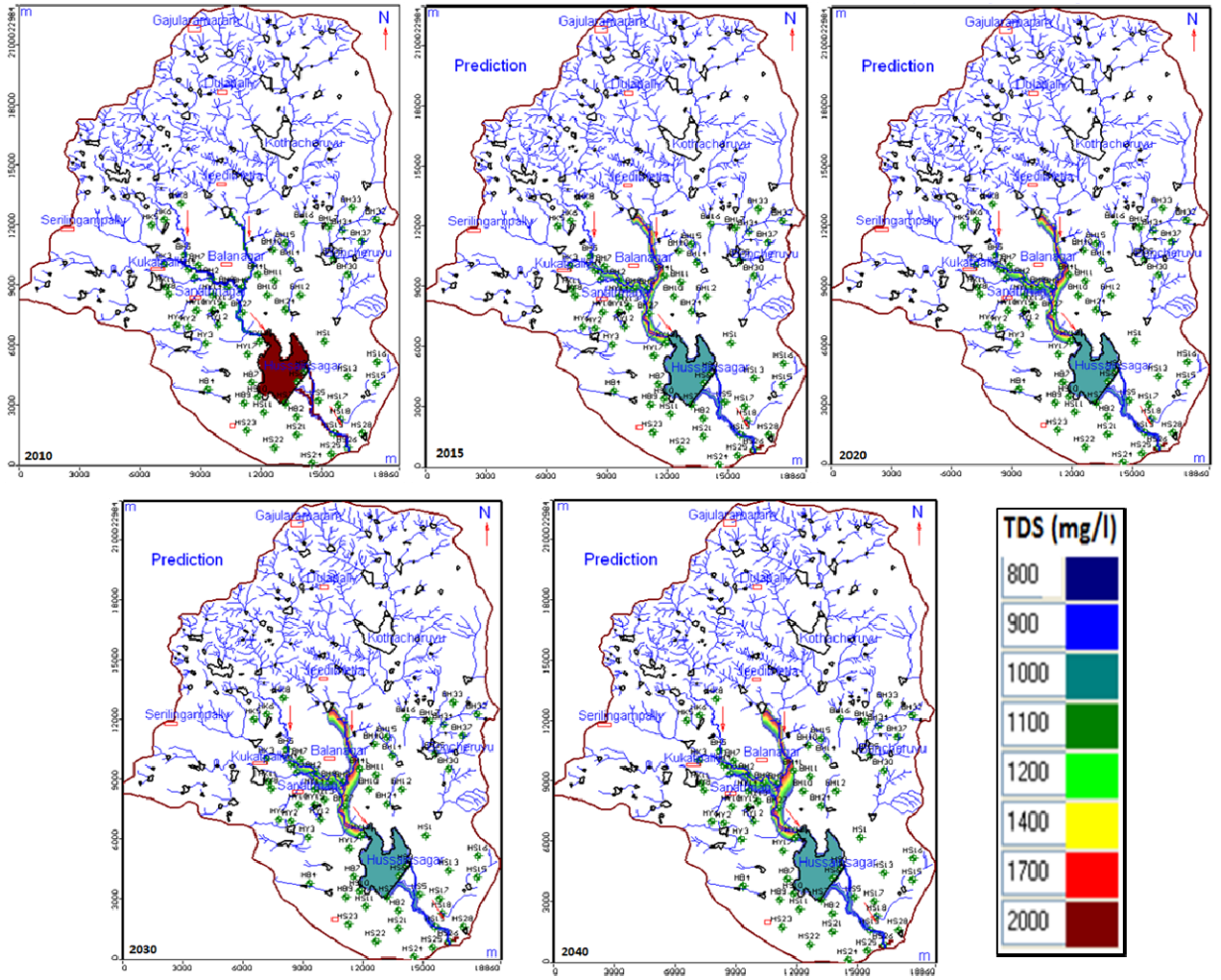


Figure 32 Computed TDS (mg/l) during 2010 – 2040 in First Layer (Scenario 2)

7.0 Conclusions & Recommendations

Increasing industrialization / urbanization is posing a threat to the lake maintenance. Even if an intense rainfall of 60-80 mm/day received in the catchment may assume dangerous situation of flooding in the downstream.

Further utilities suggested below may also be considered for implementation immediately.

a. Sewerage facilities: Construction and up gradation of sewerage treatment plants to meet the inflow capacity, capacity enhancement of interception and diversion works, and construction of sewer lines
b. Recycled water (treated wastewater) supply facilities: Construction of reservoirs, pumping stations and pipelines
c. Lake Environment improvement: Desilting/ dredging and disposal of sediments, shoreline improvement, surplus weir repair, drainage improvement, etc.
d. Slum development: Construction of solid waste management facilities, public toilets and sewerage networks
e. Public awareness and community participation on environment and sanitation, Capacity building.

8.0 Areas of Concern & Recommendations

- Stopping clandestine discharges in streams flowing through industrial areas.
- Operation of Tertiary Treatment plants for removal of Phosphates and Nitrates
- Dredging of the lake bed sediments and sending them to TSDF as they are holding toxic heavy metals

- Construction of contour drains to divert the excess storm water flows through the Lake to minimize flooding in the adjacent areas of the Hussainsagar
- Clearing of stream channel for allowing surplus flows freely to the downstream region till it joins the Musi river
- Reduce the amount of impervious surface area, thereby reducing runoff and utilize the landscape to naturally filter and infiltrate runoff before it leaves the development site. Construction of Rain gardens in open spaces on the granitic terrain is ideal for enhancing infiltration rate.
- Natural detention basin designs: Natural detention designs incorporate features of natural wetland and lake systems, such as gradual shoreline

slopes, a border of wetland vegetation and areas of open water -- in contrast to conventional designs which feature dry bottoms or riprap-edged wet basins. Natural designs are much more effective in removing storm water pollutants than conventional wet and dry bottom basins.

- Infiltration practices: Where soils are sufficiently permeable, infiltration trenches and basins dramatically reduce surface runoff volumes and naturally recharge groundwater.
- Permeable pavements: The use of permeable paving blocks is a recommended alternative for low traffic parking areas, emergency access roads, and driveways to reduce runoff volumes.
- Natural landscaping: Natural landscaping approaches utilize native plants, particularly wildflowers and wetland species, as an alternative to conventional turf grass and ornamental plants, to reduce storm water runoff and to reduce the maintenance needs of conventional turf grass landscaping.
- Reduced imperviousness via alternative residential streetscapes: The area of impervious surfaces in a residential development can be reduced in several ways: utilizing narrower streets; reducing setbacks between streets and homes, thereby reducing the length of driveways; and by reducing sidewalk widths.
- Reduced imperviousness via alternative parking lot designs: Impervious surfaces also can be reduced in parking lots by downsizing individual parking stalls, sharing parking between adjacent users, adjusting peak demand assumptions, and/or banking parking until it is needed.

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ANNEXURES

A 1 Observation wells in Hussain Sagar Lake Catchment area, Banjara Hills Watershed

Obs. No.	Well Type	Location	Latitude ^{0}N	Longitude ^{0}E	RL m (amsl)
HB1	HP	Makka High School, Hakimpet	17.40489	78.41803	536.36
HB2	HP	Near Shahbazkhan Raza enclave, Masab tank	17.40164	78.48256	519.30
HB3	HP	Opposite of Care Hospital, Ahmed Nagar	17.40417	78.43800	580.20
HB4	DW	At H.No.8-2-613/75/M/326, Uday Nagar	17.41342	78.44081	541.99
HB5	HP	Road No. 10, X-road, Banjara Hills	17.41461	78.45081	547.24
HB6	BW	RK Estates, Road. No. 4, Banjara Hills	17.42097	78.44033	589.00
HB7	HP	Hanuman Temple, Rajnagar.opposite Raj Bhavan	17.41714	78.46156	514.78
HB8	BW	In Chakilam construction, Saboo show Room, Somajiguda	17.42333	78.45675	521.13
HB9	HP	Saptamatha Temple, Chintal Basthi.	17.40781	78.45781	526.40
HB10	BW	Opposite Vengal Rao park, Punjagutta	17.42347	78.44672	539.00
HB11	HP	MNG Institute Neilofour Hospital	17.39961	78.45994	532.00

(DW = Dug Well, HP= Hand Pump, BW = Bore Well, Pz = Piezometer)

A 2 Observation wells in Hussain Sagar Lake Catchment area, Kukatpally Watershed

Obs. No.	Well Type	Location	Latitude ^{0}N	Longitude ^{0}E	RL m (amsl)
HK1	DW	Near Bharath Nagar Railway station	17.46283	78.42686	545.87
HK2	HP	Near Bapu Vidyaniketan, Musakipet, Moosapet	17.46953	78.42342	548.80
HK3	HP	Inside Hanuman Temple, Janatha Nagar, Moosapet	17.46975	78.42019	552.83
HK4	BW	In Agricultural pond, Below tank bund, IDL pond	17.48014	78.41661	556.00
HK5	HP	Adjacent Ramalayam, Opp. Sri Satyasai ITI, Kukatpalli	17.48758	78.41367	558.21
HK6	HP	Opposite Sundaya Nilayam,Prakasam Nagar, Old Kukatpalli	17.49003	78.41972	553.94
HK7	HP	Inside Sri Chittaramma Temple, Kukatpalli	17.49697	78.4185	558.00
HK8	HP	Near Papireddy Nagar Bus stop, Adj. Loyola school, Kukatpalli	17.49714	78.42731	564.93
HK9	HP	Channareddy Nagar, near IDPL land, Qutbullapur	17.4905	78.42947	558.00
HK10	BW	Smasan ghat, Shaktipuram,near RSI, Kistappavagu	17.48181	78.42725	547.00
HK11	DW	Opposite Pochamma Temple, near Maisamma cheruvu, Bubbugudem	17.45947	78.42094	551.77

(DW = Dug Well, HP= Hand Pump, BW = Bore Well, Pz = Piezometer)

A 3 Observation wells in Hussain Sagar Lake Catchment area, Yusufguda Watershed

Obs. No.	Well Type	Location	Latitude ^{0}N	Longitude ^{0}E	RL m (amsl)
HY1	BW	Opposite L.V.Prasad Hospital, Jubilee Hills	17.42350	78.42786	596.00
HY2	HP	Jawahar Nagar, besides Krishnakanth park, Yusufguda	17.44172	78.43178	555.33
HY3	HP	Yellareddy guda road, Tawakal Nagar, Imamguda, Ameerpet	17.43428	78.43972	538.76
HY4	BW	Opposite KVB Reddy Bhawan, Yusufguda checkpost	17.43581	78.42786	554.00
HY5	BW	Police lines, Yusufguda	17.43653	78.41997	563.00
HY6	HP	Hanuman Temple, Gandhi statue, Rahamath Nagar, Yusufguda	17.44228	78.42619	549.40
HY7	HP	Near community hall, Vinayaka Nagar	17.45358	78.41511	551.11
HY8	HP	Near e-seva centre, Motinagar	17.45625	78.42219	553.98
HY9	DW	8-4-396/5,telephone booth, Erragadda	17.45603	78.43275	549.60
HY10	HP	Inside Mental Hospital, Erragadda	17.44925	78.43508	546.05
HY11	HP	Baba Saheb Residential Welfare Association, Ambedkar Nagar, Panjagutta	17.43158	78.45033	528.84
HY12	HP	Welfare Association building, SR Nagar Colony	17.44253	78.44539	535.44
HY13	HP	Opp.Bajrang plastic corporation, Subash nagar, Sanath Nagar	17.45156	78.44736	533.77
HY14	HP	Inside Sanath Nagar Police Station	17.45614	78.44261	546.32
HY15	HP	CBZ apartment, near Delhi Public School, Sanjaygandhi Nagar	17.44908	78.44283	539.37
HY16	BW	Besides Shivaleela apartments, Begumpet	17.43964	78.45542	529.00
HY17	HP	Near community hall-library, Begumpet	17.42950	78.45925	515.46
HY18	HP	Quarters near Methodist colony, Hussain Sagar Junction	17.43539	78.46472	518.10

(DW = Dug Well, HP= Hand Pump, BW = Bore Well, Pz = Piezometer)

A 4 Observation wells in Hussain Sagar Lake Catchment area, Bowenpally Watershed

Obs. No.	Well Type	Location	Latitude ^{0}N	Longitude ^{0}E	RL m (amsl)
BH1	BW	Modern Water Service Center, Balanagar	17.46581	78.44542	540.00
BH2	HP	At Supergas company Godown, Sanathnager IDA	17.46347	78.44219	531.35
BH3	HP	M.P.School, Zinkalwada, Moosapet	17.46372	78.43433	537.71
BH4	DW	H.No.5-261, Padmavathi house, Moosapet	17.46769	78.43150	540.07
BH5	HP	At Weaker section colony IDPL, Balanagar	17.47403	78.42914	541.97
BH6	BW	Inside, Yellamma Temple, Balanagar IDA	17.47369	78.44422	551.00
BH7	DW	Inside Krishna Industry, Balanagar	17.46969	78.43567	526.29
BH8	BW	Inside Pochamma Temple, Fathenagar	17.45953	78.44953	538.45
BH9	HP	Pochamma Temple, old Airport road, Ferozguda	17.45956	78.45611	526.28
BH10	DW	TTD college, backside Airport, Begumpet	17.45656	78.46833	524.47
BH11	HP	Opposite Dasanjaneya Temple, New Bowenpalli	17.46294	78.47136	533.46
BH12	HP	At Hotel Green point, Tarbund 'X' road	17.45650	78.48367	526.83
BH13	BW	Indra empair Aparment, SAIL colony Bowenpalli	17.46625	78.48344	536.00
BH14	HP	CMR Model School, Sitarampur	17.47225	78.47869	533.98
BH15	HP	Plot no 5/41/177, Raja Rajeshwari colony, Bowenpalli	17.48025	78.47619	539.42
BH16	HP	Near Military Dairy, old Bowenpalli	17.48925	78.48514	552.20
BH17	HP	MPP school, Kanajiguda	17.48794	78.49631	550.33
BH18	HP	At 3 Temples, Indiranagar, Hasmathpet.	17.48319	78.48917	553.61
BH19	HP	Near Community hall, Koyabasti-Hasmathpet	17.47858	78.48744	549.96
BH20	BW	Gurudwara, Manovikas nagar Secunderabad	17.46981	78.48919	541.00
BH21	HP	Tiru Thulkanthaman Temple, Mudfort	17.45764	78.49408	535.41

(DW = Dug Well, HP= Hand Pump, BW = Bore Well, Pz = Piezometer)

A 4 Observation wells in Hussain Sagar Lake Catchment area, Bowenpally Watershed (Contd….)

Obs. No.	Well Type	Location	Latitude ^{0}N	Longitude ^{0}E	RL m (amsl)
BH22	BW	Inside JBS, Secunderabad	17.44747	78.49772	534.00
BH23	BW	Hanuman temple, opposite Hotel Paigah Secunderabad	17.44314	78.48342	527.00
BH24	*HP*	Beside Begumpet Police station, Indiranagar, Rasulpura	17.45017	78.47678	521.75
BH25	HP	Ambedhkar nagar, north of Hussain Sagar lake	17.43300	78.48517	520.00
BH26	HP	Govt.School, Patigadda, Opp. Sanjeev park Railway Station	17.43672	78.47533	523.00
BH27	HP	Darga, Shamlal, Begumpet	17.44853	78.45678	528.31
BH28	BW	Hanuman Temple, back of petrol bunk Shamla	17.44658	78.46636	526.00
BH29	HP	Prakasham nagar, opposite lane, Airport, Begumpet	17.44303	78.47047	527.00
BH30	HP	Hanuman Temple, Tirumalagirry, Secunderabad	17.46625	78.50547	550.45
BH31	BW	At Military Dispensary, Tirumalagirry, Secunderabad	17.47358	78.51775	567.00
BH32	BW	Faculty of Aeronautical Eng. EME(4B), Monabad	17.49128	78.51839	572.84
BH33	HP	Near Darga, Kottabasti	17.49653	78.50708	563.38
BH34	HP	At Nalla pochamma Temple, Dondi	17.48636	78.50281	551.50
BH35	HP	At Victory Apartment, RTC colony, Tirumalagirry	17.47297	78.49911	544.50
BH36	HP	Hanuman Temple, China Kamala village	17.47794	78.50828	556.33
BH37	HP	Adjacent Graveyard, East-Marredpalli	17.48139	78.51161	541.67
BH38	BW	Gurudwar, (2T) Military are Marredpalli Secunderabad,	17.45725	78.51444	553.00
BH39	BW	Hanuman Temple Picket Laxmi Nagar	17.45494	78.50317	541.00
BH40	HP	Naseeruddin baba Darga, old Bowenpally	17.47692	78.47022	556.83
BH41	HP	Adjacent Defense compound wall, Anthammaguda	17.46581	78.46358	535.12
BH42	HP	At Gandhi statue, Raju colony, Balanagar	17.46931	78.45650	542.00

(DW = Dug Well, HP= Hand Pump, BW = Bore Well, Pz = Piezometer)

A 5 Observation wells in Hussain Sagar Lake Catchment area,Hussain Sagar downstream Watershed

Obs. No.	Well Type	Location	Latitude ^{0}N	Longitude ^{0}E	RL m (amsl)
HS1	HP	Opp. Municipal Karmika Sangham, Secunderabad	17.43589	78.49503	519.65
HS2	HP	At Nallapochamma Temple, Adj. classic cafe, Bansilalpet	17.42789	78.49372	524.90
HS3	DW	Bhagyanagar, Goseva sadan, lower tank bund, Secunderabad	17.42211	78.48586	511.72
HS4	HP	On road at Rajiv Gandhi Nagar, Gandhi Nagar	17.41475	78.49175	520.55
HS5	HP	Opp. Stichware mens ware, Jawaharnagar, Ashoknagar	17.40917	78.49244	500.17
HS6	HP	Mysamma Temple, Thathanagar, lower tank bund	17.41775	78.48275	512.12
HS7	HP	At Gaganmahal crossing, near Saduram eye hospital, Liberty	17.40772	78.47717	511.87
HS8	HP	Adj. St. Joseph's junior college, St.No.8, Himayatnagar	17.40300	78.48719	509.87
HS9	HP	Inside Govt. Model high School, Adjacent LB stadium	17.39825	78.47278	519.04
HS10	HP	Near Govt. library, Khairatabad	17.41047	78.46419	517.13
HS11	BW	Inside Ravindrabarathi, Lakdikapul	17.40333	78.46728	514.11
HS12	HP	Railway Institute, Near Secunderabad railway station, Bhoiguda	17.43244	78.50353	532.85
HS13	HP	Opp. Sadguru Sainath tent house, Bapujinagar, Musheerabad	17.42025	78.50625	521.71
HS14	HP	Opp. Vindhya Electricals, Ramnagar gundu	17.40819	78.51069	598.52
HS15	HP	At Sairam cyber cafe, Arts college, Rly. station Buddhanagar	17.41736	78.51942	511.59
HS16	BW	Inside Dattatreya Swamy Temple, Adj. Railway station, Sitaphalmandi	17.42700	78.51956	514.27
HS17	HP	At RTC colony, Adj. RTC high School, Musheerabad	17.40761	78.50203	498.74
HS18	HP	At Pochamma Temple, Akshayanagar, Chikkadapally	17.40100	78.50322	491.30
HS19	HP	At Avanthi degree and PG college, Barkatpura	17.39472	78.50006	487.07
HS20	BW	At Police Station, Badichowdi, Hyderabad	17.47175	78.48747	539.00
HS21	HP	Opp. Balaji offset printers, King koti, Beside Govt. Hospital	17.39356	78.48292	508.90
HS22	HP	At Mutyalamma Temple, Adj. APPSC Compound wall, Nampally	17.38775	78.47219	503.23
HS23	HP	Adjacent Dolphin apartment, Opp. Srikrishna Mandir Bazarghat chowrasta	17.39536	78.45947	511.60
HS24	HP	Opp. Saibaba Temple, Esamia bazaar, at Chaderghat	17.38089	78.48997	484.49
HS25	BW	Opp. Hindu Smasanghat, Amberpet	17.38533	78.49883	483.08
HS26	HP	Near Laxmi theatre, Golnaka, Amberpet	17.38811	78.50661	483.33
HS27	HP	At Durga Temple, Durganagar, Moosarambagh	17.38081	78.51892	480.42
HS28	BW	Near gayatri apartment, Gaga bowili, Baghamberpet (Batukammakunta)	17.39481	78.51339	486.65

(DW = Dug Well, HP= Hand Pump, BW = Bore Well, Pz = Piezometer)

A 6 Piezometers (HPII) & Reduced Level in Hussain Sagar Lake Catchment area, Depth of Piezometers 60-90 m

Piezo No.	Location	Latitude ^{0}N	Longitude ^{0}E	RL m (amsl)
P1	MDO Office, Qutubullapur (V) and (M)	17.57836	78.42870	618.82
P2	ZPHS, Nizampet	17.52015	78.37882	595.36
P3	JNTU, Kukatpally, Hyderabad	17.49370	78.39178	554.59
P4	Government Junior College, Kukatpally	17.48060	78.41514	549.61
P5	Central Institute of Tool and Design (CITD), Balanagar	17.46703	78.44442	539.87
P6	Primary School, Kaithalapur, Near Borabanda	17.46820	78.40092	561.38
P7	GHMC, Ward Office, Fathenagar	17.45826	78.44998	537.02
P8	Electric Sub Station, Jeedimetla, Subashnagar	17.52138	78.47414	558.87
P9	Dulapally A.P. Forest Academy	17.54631	78.45753	586.09
P10	Indira park, Ashok nagar, Lower tank bund, Hyderabad	17.41428	78.48333	502.44
P11	Sanjeevaiah Park, Near water spread area of Hussian Sagar, Khairtabad	17.43397	78.47328	527.36
P12	Govt. Jr. College, West Marredpally Opp. Padmavathi Kalyana Mandapam	17.44565	78.50130	541.45
P13	Veternary Hospital, Old Alwal	17.50732	78.50466	593.88
P14	Fever Hospital (Correnty), Nallakunta, Hyd	17.39562	78.49899	487.18
P15	Gandhi Medical College and Hospital, Musheerabad, Secendrabad	17.42402	78.50562	517.04
P16	Government Polytecnic College, Masab Tank, Hyd.	17.40300	78.45381	526.49
P17	Vengal Rao park, Srinagar Colony	17.42376	78.44650	541.30
P18	Director Women and Child Welfare, Yousufguda, Hyd	17.43811	78.43861	535.43
P19	STDC Chest Hospital, Erragadda, Sanathnagar, Hyd	17.44498	78.43937	543.86
P20	ZPH School, Gajularamaram, Qutubullapur, Municipality	17.53081	78.42066	581.38
P21	ZPH School, Gajularamaram, Qutubullapur, Municipality (OB Well)	17.53083	78.42057	581.51
P22	Ground Water Department, Khairathabad HP-ll (CMU)	17.40963	78.45972	516.27
P23	Ground water Department, Khairathabad HP-ll (CMU) (B Well)	17.40953	78.45984	516.46
P24	NIMH, Hasmathpet, Bowinpally	17.46814	78.48861	532.01
P25	HMWS & SB Pump House Shapurnagar	17.51259	78.44285	575.40

A 7 Comparison of groundwater levels in Hussain Sagar Lake Catchment area, Banjara Hills Watershed During Premonsoon 2009 – Postmonsoon 2012

Well NO	Well Type	RL	Depth to Water Table (m – bgl)								Groundwater Level (m – amsl)							
			Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012	Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012
BH1	BW	540		3.9	6.56		6.6		4.45			536.1	533.44		533.4		535.55	
BH2	HP	531.35	4.55	4.2	2.89	4.55	2.26		2.05		526.8	527.15	528.46	526.8	529.09		529.3	
BH3	HP	537.71	2.8	2.3	2.64	2.8	3.1		7.49		534.91	535.41	535.07	534.91	534.61		530.22	
BH4	DW	540.07	5.51	4.66		5.51	6.81		5.05		534.56	535.41		534.56	533.26		535.02	
BH5	HP	541.97	16.05								525.92							
BH6	BW	551																
BH7	DW	526.29	3.9	1.75		3.9	3.02		2.65		522.39	524.54		522.39	523.27		523.64	
BH8	BW	538.45	10.85	8.13	3.63	10.85	12.08		10.65		527.6	530.32	534.82	527.6	526.37		527.8	
BH9	HP	526.28	6.6	4.1	13.4	6.6	6.44		3.65		519.68	522.18	512.88	519.68	519.84		522.63	
BH10	DW	524.47	11.5	8.1		11.5	12.25		9.88		512.97	516.37		512.97	512.22		514.59	
BH11	HP	533.46	13.7		10.78	13.7	11.06		9.3		519.76		522.68	519.76	522.4		524.16	
BH12	HP	526.83	26.43	5.05	13.75	26.43	7		9.72		500.4	521.78	513.08	500.4	519.83		517.11	
BH13	BW	536		13.5	10.05		16.33		21.6			522.5	525.95		519.67		514.4	
BH14	HP	533.98	25.7	11.7		25.7	18.48		12.45		508.28	522.28		508.28	515.5		521.53	
BH15	HP	539.42	16.4	9.65	13.4	16.4	16.4		18.75		523.02	529.77	526.02	523.02	523.02		520.67	
BH16	HP	552.2	15.1	8.5		15.1	9.46		18.4		537.1	543.7		537.1	542.74		533.8	
BH17	HP	550.33	4.8	3.22	15.15	4.8	4.72		4.4		545.53	547.11	535.18	545.53	545.61		545.93	
BH18	HP	553.61	17.6	4.52	4.69	17.6	7.96				536.01	549.09	548.92	536.01	545.65			
BH19	HP	549.96	10	2.26	18.4	10	10		17.51		539.96	547.7	531.56	539.96	539.96		532.45	
BH20	BW	541																
BH21	HP	535.41	12.28	4.25		8.1	14.53		19.62		523.13	531.16		527.31	520.88		515.79	
BH22	BW	534			19.35	7.2	7.2						514.65	526.8	526.8			

Well NO	Well Type	RL	Depth to Water Table (m – bgl)								Groundwater Level (m – amsl)							
			Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012	Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012
BH23	BW	527		6.75		4.19	10.11		6.23			520.25		522.81	516.89		520.77	
BH24	HP	521.75	11.11	7.83	13.82	4.52	11.81		12.6		510.64	513.92	507.93	517.23	509.94		509.15	
BH25	HP	520	3.8	4.15	5.78	4.75	7.29		5.15		516.2	515.85	514.22	515.25	512.71		514.85	
BH26	HP	523	3.48	3.04		2.28	4.89				519.52	519.96		520.72	518.11			
BH27	HP	528.31	14.22	6.7	12.87	5.15	6.62				514.09	521.61	515.44	523.16	521.69			
BH28	BW	526		5.74		4.95	8.11		6.1			520.26		521.05	517.89		519.9	
BH29	HP	527	9.03	4.58	10.29	4.3	7.06		5.55		517.97	522.42	516.71	522.7	519.94		521.45	
BH30	HP	550.45	12.25	2.99	10.68	6.45	9.1		8.45		538.2	547.46	539.77	544	541.35		542	
BH31	BW	567		2.2		6.8			3.27			564.8		560.2			563.73	
BH32	BW	572.84	2.25	3.2		7.4			28.05		570.59	569.64		565.44			544.79	
BH33	HP	563.38	15.5	9.8		7.54	14.77		12.49		547.88	553.58		555.84	548.61		550.89	
BH34	HP	551.5	1.22	1.72	2.59	6.92	1.92		4.5		550.28	549.78	548.91	544.58	549.58		547	
BH35	HP	544.5	5.45			6.85					539.05			537.65				
BH36	HP	556.33	5.28	0.43	3.68	6.38	9.9		1.02		551.05	555.9	552.65	549.95	546.43		555.31	
BH37	HP	541.67	16.15			7					525.52			534.67				
BH38	BW	553				7.2			8.6					545.8			544.4	
BH39	BW	541				7.2								533.8				
BH40	HP	556.83	26.95								529.88							
BH41	HP	535.12	15.4	11.07		10.05	12.75		9.2		519.72	524.05		525.07	522.37		525.92	
BH42	HP	542		7.3	10.88	6.17	10.56		6.98			534.7	531.12	535.83	531.44		535.02	
HB1	HP	536.36	9.25	4.1	5.13	2.3	14.01		5.25		527.11	532.26	531.23	534.06	522.35		531.11	
HB2	HP	519.3	8.06	3.14	2.36	1.44	9.69		3.96		511.24	516.16	516.94	517.86	509.61		515.34	
HB3	HP	580.2	2.85			2.81	2.81		2.52		577.35			577.39	577.39		577.68	
HB4	DW	541.99	1.35		6.2	1.2	1.76		1.97		540.64		535.79	540.79	540.23		540.02	
HB5	HP	547.24	11.8	1.83	1.8	4.26	5.5				535.44	545.41	545.44	542.98	541.74			

Well NO	Well Type	RL	Depth to Water Table (m – bgl)								Groundwater Level (m – amsl)							
			Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012	Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012
HB6	BW	589		6.35	2.98	1.68	2.38		2.05			582.65	586.02	587.32	586.62		586.95	
HB7	HP	514.78	9.1	5		4.58	11.65				505.68	509.78		510.2	503.13			
HB8	BW	521.13	3.18								517.95							
HB9	HP	526.4	10.6								515.8							
HB10	BW	539							1.72								537.28	
HB11	HP	532	6.88	6.5	5.02	5.04	9.64				525.12	525.5	526.98	526.96	522.36			
HK1	DW	545.87	2.86			2.56	3.19		3.73		543.01			543.31	542.68		542.14	
HK2	HP	548.8	11.67								537.13							
HK3	HP	552.83	12.34	9.29		4.5	15.05		12.65		540.49	543.54		548.33	537.78		540.18	
HK4	BW	556			4.7								551.3					
HK5	HP	558.21	24.88	19.88	25.38	11.18	11.18		26.61		533.33	538.33	532.83	547.03	547.03		531.6	
HK6	HP	553.94	8.28	6.38	8.13	1.4	11.03		6.93		545.66	547.56	545.81	552.54	542.91		547.01	
HK7	HP	558		5.95	10.81	2.61	12.9		7.4			552.05	547.19	555.39	545.1		550.6	
HK8	HP	564.93	17.9	7.15		5.45	18		15.05		547.03	557.78		559.48	546.93		549.88	
HK9	HP	558	8.89	4.05	10.34	3.23	10.71		7.25		549.11	553.95	547.66	554.77	547.29		550.75	
HK10	BW	547		5	10	5.53	9.94		6.45			542	537	541.47	537.06		540.55	
HK11	DW	551.77	3.48	3.58							548.29	548.19						
HS1	HP	519.65	2.18	1.6	5.9	2.44	10.26		6.85		517.47	518.05	513.75	517.21	509.39		512.8	
HS2	HP	524.9	1.28	0.68	1.18	0.58	1.58		1.22		523.62	524.22	523.72	524.32	523.32		523.68	
HS3	DW	511.72	1.5	1.2	3.84	1.6	1.47		3.3		510.22	510.52	507.88	510.12	510.25		508.42	
HS4	HP	520.55	4.78	3.88	5.29	3.74	4.72		5.25		515.77	516.67	515.26	516.81	515.83		515.3	
HS5	HP	500.17	4.12	2.49	5.42	3.22	5.95		7.4		496.05	497.68	494.75	496.95	494.22		492.77	
HS6	HP	512.12																
HS7	HP	511.87	4.72	1.81	3.12	1.62	2.47		1.15		507.15	510.06	508.75	510.25	509.4		510.72	
HS8	HP	509.87	6.04	4.46	6.09	4.18	6.82		3.74		503.83	505.41	503.78	505.69	503.05		506.13	

Well NO	Well Type	RL	Depth to Water Table (m – bgl)								Groundwater Level (m – amsl)							
			Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012	Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012
HS9	HP	519.04	6.91								512.13							
HS10	HP	517.13	6.48	3.72		3.15	8.24		3.03		510.65	513.41		513.98	508.89		514.1	
HS11	BW	514.11	7.9	7.65			14.64		9.05		506.21	506.46			499.47		505.06	
HS12	HP	532.85	1	1.6		1.73	2.29		1.5		531.85	531.25		531.12	530.56		531.35	
HS13	HP	521.71	5.54	3.39	4.62	2.66	6.37		4.8		516.17	518.32	517.09	519.05	515.34		516.91	
HS14	HP	498.52	2.6	2.05	2.4	1.9	2.65		2.48		495.92	496.47	496.12	496.62	495.87		496.04	
HS15	HP	511.59	6.59	3.22	8.92	3.96	11.77		8.08		505	508.37	502.67	507.63	499.82		503.51	
HS16	BW	514.27	4.6	6.74			9.4		17.03		509.67	507.53			504.87		497.24	
HS17	HP	498.74	14.38	4.29							484.36	494.45						
HS18	HP	491.3	2.26	2.07	2.25	2.13	2.37		1.85		489.04	489.23	489.05	489.17	488.93		489.45	
HS19	HP	487.07	7.2	5.81	6.16	3.92	7.4		5.01		479.87	481.26	480.91	483.15	479.67		482.06	
HS20	BW	539																
HS21	HP	508.9	5.25	4.91	5.29	3.15	6.67		6.9		503.65	503.99	503.61	505.75	502.23		502	
HS22	HP	503.23	11.49	10.06					6.9		491.74	493.17					496.33	
HS23	HP	511.6	18.31	27.48	2.17	1.43	6.93		12		493.29	484.12	509.43	510.17	504.67		499.6	
HS24	HP	484.49	5.45	3.35	6.91	3.65	6.41		5.81		479.04	481.14	477.58	480.84	478.08		478.68	
HS25	BW	483.08																
HS26	HP	483.33	6.54	4.01		4.23	5.3		4.5		476.79	479.32		479.1	478.03		478.83	
HS27	HP	480.42	3.05	0.1	3.16	2.31	4.52		5.07		477.37	480.32	477.26	478.11	475.9		475.35	
HS28	BW	486.65		3.18		0.52	0.83					483.47		486.13	485.82			
HY1	BW	596																
HY2	HP	555.33	14.81	17.85	17.98	6.85	19.04		14.22		540.52	537.48	537.35	548.48	536.29		541.11	
HY3	HP	538.76	11.43	7.44	8.78	5.11	9.01		8.2		527.33	531.32	529.98	533.65	529.75		530.56	
HY4	BW	554		3.13			16.64		15.15			550.87			537.36		538.85	
HY5	BW	563		5.3		5.1	5.1					557.7		557.9	557.9			

Well NO	Well Type	RL	Depth to Water Table (m – bgl)								Groundwater Level (m – amsl)							
			Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012	Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012
HY6	HP	549.4	5.2	3.12	6.68	3.42	7.27		4.28		544.2	546.28	542.72	545.98	542.13		545.12	
HY7	HP	551.11	1.08	0.2	2.48	1.18	1.9		2.1		550.03	550.91	548.63	549.93	549.21		549.01	
HY8	HP	553.98	6.35	6.03	10.67	5.66	8.65		3.5		547.63	547.95	543.31	548.32	545.33		550.48	
HY9	DW	549.6	3.3	4.48	3.86	2.61	3.33		3.26		546.3	545.12	545.74	546.99	546.27		546.34	
HY10	HP	546.05	3.7	20.5		0.53	3		1.43		542.35	525.55		545.52	543.05		544.62	
HY11	HP	528.84	3.11	2.1	2.6	2.47	1.77		3.15		525.73	526.74	526.24	526.37	527.07		525.69	
HY12	HP	535.44	8.05	17.9	24.5	21.25	48.7				527.39	517.54	510.94	514.19	486.74			
HY13	HP	533.77	18.2	5.11	26.25	3.88	23.1		12.5		515.57	528.66	507.52	529.89	510.67		521.27	
HY14	HP	546.32	20.1	17.24							526.22	529.08						
HY15	HP	539.37	17.1	15.77							522.27	523.6						
HY16	BW	529		7.38		4.94	50		13.1			521.62		524.06	479		515.9	
HY17	HP	515.46	15.52	10.9							499.94	504.56						
HY18	HP	518.1	12.08	5.77	12.63	6.13	11.75		7.82		506.02	512.33	505.47	511.97	506.35		510.28	
P1	Pz	618.82		29	41.42	22.55	34	36.65	40.65	33.00		589.82	577.4	596.27	584.82	582.17	578.17	585.82
P2	Pz	595.36		4.5	18.94	3.55	4.75	4.75	4.1	4.75		590.86	576.42	591.81	590.61	590.61	591.26	590.61
P3	Pz	554.59		18.5	30.4	9.55	35.1	26	23.4	19.35		536.09	524.19	545.04	519.49	528.59	531.19	535.24
P4	Pz	549.61		3.48	5.71	3.4	6.2	6.05	3.8	5.40		546.13	543.9	546.21	543.41	543.56	545.81	544.21
P5	Pz	539.87		5.54	5.54	3.1	6.25		3.7	3.95		534.33	534.33	536.77	533.62	539.87	536.17	535.92
P6	Pz	561.38		2.83	6.95	1.6	5	4.75	3.75	3.70		558.55	554.43	559.78	556.38	556.63	557.63	557.68
P7	Pz	537.02		10.43	13.12	5.7	12.8	9.05	9.2	8.60		526.59	523.9	531.32	524.22	527.97	527.82	528.42
P8	Pz	558.87		4.07	5.54	3.55	5	5.2	4.35	5.10		554.8	553.33	555.32	553.87	553.67	554.52	553.77
P9	Pz	586.09		14.08	16.42	10.6	13.55	16	18.6	16.95		572.01	569.67	575.49	572.54	570.09	567.49	569.14
P10	Pz	502.44		2.05	2.54	1.9	3.15	3.55	2.6	3.30		500.39	499.9	500.54	499.29	498.89	499.84	499.14
P11	Pz	527.36		2.38	4.22	2.23	3.5	3.1	2	2.30		524.98	523.14	525.13	523.86	524.26	525.36	525.06

Well NO	Well Type	RL	Depth to Water Table (m – bgl)								Groundwater Level (m – amsl)							
			Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012	Pre-monsoon 2009	Post-monsoon 2009	Pre-monsoon 2010	Post-monsoon 2010	Pre-monsoon 2011	Post-monsoon 2011	Pre-monsoon 2012	Post-monsoon 2012
P12	Pz	541.45		10.23	22.31	8.94	22.7	6.85		16.90		531.22	519.14	532.51	518.75	534.6		524.55
P13	Pz	593.88		5.52	9.03	4.9	8.75	9.6	12.35	10.45		588.36	584.85	588.98	585.13	584.28	581.53	583.43
P14	Pz	487.18		4.96	5.99	4.66	6.7	5.6	3.6	5.95		482.22	481.19	482.52	480.48	481.58	483.58	481.23
P15	Pz	517.04		5.28	7.23	4.65	7.45	6.6	5.65	5.85		511.76	509.81	512.39	509.59	510.44	511.39	511.19
P16	Pz	526.49		5.83	9.8	5.35	10.1	6.55	3.1	6.15		520.66	516.69	521.14	516.39	519.94	523.39	520.34
P17	Pz	541.3		4.32	8.45	2.65	7.9	5.6	3.2	4.50		536.98	532.85	538.65	533.4	535.7	538.1	536.80
P18	Pz	535.43		20.46	80	9.5	50			20.65		514.97	455.43	525.93	485.43	535.43		514.78
P19	Pz	543.86		12.16	18.45	9.35	17.65	15.3	7.8	12.50		531.7	525.41	534.51	526.21	528.56	536.06	531.36
P20	Pz	581.38		2.3	8.94	1.5	7.4	11.5	7.85	4.40		579.08	572.44	579.88	573.98	569.88	573.53	576.98
P21	Pz	581.51		2.3	8.95	1.5	7.4	11.55	4.35	4.40		579.21	572.56	580.01	574.11	569.96	577.16	577.11
P22	Pz	516.27		9.81	14.61	6.03	15.7	7.6		5.20		506.46	501.66	510.24	500.57	508.67		511.07
P23	Pz	516.46		9.82	14.65	6	15.8		4.3	5.20		506.64	501.81	510.46	500.66	516.46	512.16	511.26
P24	Pz	532.01			56.8	4.9	50			18.15			475.21	527.11	482.01	532.01		513.86
P25	Pz	575.4			9.15	5.15	8.1	7.95	5.45	6.35			566.25	570.25	567.3	567.45	569.95	569.05

A 8 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Banjarahills Watershed - Premonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HB1	7.98	762	267	120	51	28.00	1.19	90	5	112	29	399
HB2	8.09	800	339	110	61	17.00	1.69	122	5	96	29	359
HB4	7.72	429	211	50	30	5.35	0.77	49	10	72	10	221
HB5	7.95	378	166	60	27	3.80	1.25	52	5	56	10	181
HB6	7.89	189	106	20	11	0.20	0.45	10	5	32	10	121
HB7	7.76	826	418	80	60	12.65	1.35	112	7	32	78	400
HB8	8.38	620	190	110	34	5.45	1.53	185	5	16	10	81
HB9	8.15	531	256	60	32	10.40	1.01	86	9	72	10	221
HB10	7.70	628	279	110	48	0.40	1.16	87	5	96	15	302
HB11	8.08	371	198	40	20	3.15	0.85	30	5	48	24	218

A 9 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Kukatpally Watershed – Premonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HK2	7.85	448	255	35	31	2.85	1.50	62	6	48	22	210
HK3	8.02	636	210	90	78	20.50	1.40	90	5	80	24	298
HK4	7.56	691	308	140	27	0.35	0.96	119	6	56	34	279
HK5	7.82	324	155	30	28	6.85	0.57	31	6	40	19	178
HK6	7.82	864	300	150	72	19.00	1.37	151	11	88	29	339
HK7	7.97	794	280	140	73	17.00	1.95	128	6	72	39	340
HK8	8.01	584	293	50	50	10.00	2.55	99	4	56	24	238
HK9	7.63	1478	203	290	270	70.00	1.45	230	6	216	29	659
HK10	7.80	1683	282	570	200	2.30	1.08	249	5	184	78	780
HK11	8.04	646	221	90	62	24.50	1.51	94	5	104	10	301

A 10 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Yusufguda Watershed – Premonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HY1	7.71	195	106	20	16	0.15	0.47	12	6	16	19	118
HY2	7.79	533	210	70	54	13.35	2.35	53	5	80	24	298
HY3	7.82	515	280	60	29	0.90	1.85	74	5	48	29	239
HY4	7.94	412	221	30	32	6.10	1.77	55	5	64	10	201
HY5	7.91	386	181	50	29	4.75	1.62	45	5	48	19	198
HY6	7.58	403	150	60	39	10.05	1.70	79	5	48	5	141
HY7	7.64	450	224	40	35	8.65	1.60	68	5	56	15	202
HY8	7.86	415	193	40	43	7.40	2.24	56	5	56	15	202
HY9	7.87	321	177	30	19	2.60	0.84	31	5	40	19	178
HY10	8.04	473	221	60	40	5.30	2.70	58	5	56	24	238
HY11	7.84	505	249	50	42	7.65	2.23	61	5	64	24	258
HY12	7.90	189	115	10	15	0.35	0.37	10	60	24	15	122
HY13	7.85	666	241	90	57	24.50	1.60	91	5	64	39	320
HY14	7.83	1280	182	310	150	60.00	1.03	158	5	168	58	658
HY15	7.85	595	161	90	95	20.50	1.70	75	5	72	29	299
HY16	8.03	781	398	90	51	7.25	2.77	115	5	56	53	357
HY17	8.06	646	321	60	54	10.75	1.94	85	5	72	34	319
HY18	7.67	1530	316	410	197	23.50	1.42	202	6	128	107	759

A 11 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – Premonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
BH1	8.13	1267	465	230	150	9.60	2.18	328	5	40	44	280
BH2	7.84	1555	302	400	255	20.00	1.55	193	6	152	102	798
BH3	8.03	653	231	100	105	6.50	1.22	87	5	80	29	319
BH4	8.03	522	291	50	30	2.85	1.15	66	7	48	34	259
BH5	7.92	189	104	20	12	0.35	0.54	10	6	16	19	118
BH6	8.00	1709	489	440	240	11.75	1.70	387	3	36	88	451
BH7	7.86	1344	359	260	125	51.50	1.65	207	9	80	50	405
BH8	7.96	1050	405	180	96	14.70	1.70	165	5	80	63	458
BH9	8.00	960	399	190	49	6.85	1.70	116	5	56	88	501
BH10	7.95	832	361	100	60	22.00	1.45	124	5	80	44	380
BH11	7.95	1306	237	210	230	66.50	1.89	194	6	128	68	599
BH12	8.12	941	407	150	52	15.50	3.49	182	5	48	53	337
BH13	7.88	1466	527	280	160	12.80	2.37	243	6	104	88	621
BH14	7.85	617	183	110	55	23.00	0.94	55	6	112	19	358
BH15	7.85	1018	307	160	90	45.00	1.04	88	9	112	78	600
BH16	7.78	1485	359	320	170	45.00	2.25	269	6	128	63	578
BH17	8.11	556	258	70	29	12.10	1.90	79	6	72	19	258
BH18	7.85	192	103	20	15	0.45	0.34	11	6	24	15	122
BH19	7.99	1018	331	190	114	19.50	2.10	154	6	112	44	460
BH20	8.14	614	254	80	53	15.00	1.93	55	5	72	44	360
BH21	8.07	1235	464	250	102	9.10	3.25	243	5	72	63	438
BH22	7.71	838	290	140	81	21.50	1.45	136	5	72	44	360
BH23	8.11	1030	446	160	74	13.40	2.32	206	5	56	53	357
BH24	7.91	1210	401	280	78	16.50	2.13	142	5	104	92	637

A 11 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area,
Bowenpally Watershed – Premonsoon 2009 (Contd….)

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH25	7.85	253	119	30	32	0.35	0.51	25	5	24	19	138
BH26	7.83	858	112	140	18	1.00	1.39	139	13	64	53	377
BH27	8.05	457	224	50	90	7.80	1.60	62	5	40	29	219
BH28	7.89	499	210	60	50	11.00	0.92	49	5	80	19	278
BH29	7.56	1024	294	230	95	21.00	2.40	112	12	112	63	538
BH30	7.73	774	338	100	47	20.00	2.44	94	5	72	53	397
BH31	7.59	845	234	140	90	36.00	2.40	147	5	80	34	339
BH32	7.66	268	117	40	22	3.00	0.58	29	6	32	15	142
BH33	7.63	442	205	70	30	1.75	1.55	56	5	56	19	218
BH34	7.86	1005	349	180	80	25.50	2.05	123	5	128	49	521
BH35	7.90	646	252	100	59	12.80	2.68	93	6	64	34	299
BH36	7.91	742	284	130	70	9.45	1.90	110	5	56	49	341
BH37	8.09	742	309	120	70	6.55	2.80	110	5	120	10	341
BH38	7.96	896	347	140	95	13.85	3.12	102	5	80	68	479
BH39	7.97	435	268	20	18	5.95	2.31	54	5	32	34	219
BH40	7.63	1242	395	260	145	13.45	1.29	153	6	112	88	641
BH41	7.93	781	318	130	63	10.30	1.32	124	6	64	44	340
BH42	7.98	653	317	80	50	6.50	1.66	96	5	64	34	299

A 12 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Hussain Sagar downstream Watershed – Premonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HS1	8.60	310	119	50	23	1.70	0.55	39	15	16	24	138
HS2	8.33	611	290	60	46	8.45	2.22	118	5	48	24	218
HS3	7.98	896	368	190	48	1.85	1.42	148	5	88	39	380
HS4	8.44	698	252	110	59	8.80	1.86	131	5	40	39	260
HS5	8.32	640	211	80	82	18.50	2.07	119	5	64	19	238
HS6	8.48	1632	320	550	101	0.35	2.80	294	7	128	78	640
HS7	8.30	463	224	50	34	2.35	1.36	55	20	56	19	218
HS8	8.42	406	158	50	49	4.00	1.91	52	5	40	24	198
HS9	8.33	508	61	110	76	10.45	2.00	71	5	72	15	242
HS10	8.01	960	416	160	75	6.45	1.72	162	5	72	53	397
HS11	8.37	513	184	50	44	4.70	1.66	55	5	40	44	280
HS12	8.30	269	72	30	50	0.45	0.41	40	5	24	15	122
HS13	8.36	659	178	100	60	13.50	2.47	116	6	72	19	258
HS14	8.35	504	147	70	52	2.90	1.50	51	5	56	34	279
HS16	8.38	606	139	90	70	13.90	1.22	79	5	48	44	300
HS17	8.40	488	111	70	58	7.50	1.25	64	5	64	19	238
HS18	8.34	397	138	40	30	0.30	1.71	40	5	48	24	218
HS19	8.44	672	182	110	70	8.35	2.18	102	6	56	39	300
HS21	7.99	646	250	110	53	11.10	1.37	85	5	72	34	319
HS22	8.12	550	210	80	61	11.00	1.10	86	6	48	29	239
HS23	8.19	343	170	30	23	8.10	0.76	28	8	48	19	198
HS24	8.34	599	164	70	54	12.40	1.20	86	5	64	29	279
HS25	8.37	838	253	120	78	12.50	2.00	136	5	56	53	357
HS26	8.37	608	206	60	50	7.85	4.06	86	10	48	39	280
HS27	8.36	581	151	80	60	12.20	2.61	107	5	40	29	219
HS28	8.39	548	163	60	52	6.05	3.25	76	5	48	34	259

A 13 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Banjarahills Watershed – Postmonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
HB1	7.76	774	300	130	61	14.60	0.57	94	5	120	24	398
HB2	7.93	819	370	90	83	14.10	0.56	83	5	120	39	460
HB3	7.71	659	290	90	45	13.00	0.22	80	5	88	29	339
HB4	7.70	429	170	60	51	6.80	0.26	47	13	80	5	221
HB5	7.87	493	200	60	55	11.00	0.50	66	5	88	5	241
HB6	8.00	408	225	40	26	1.95	1.09	53	5	72	5	201
HB7	7.73	1274	242	230	183	64.00	0.68	119	5	256	24	738
HB8	8.09	646	290	80	55	11.20	0.99	176	6	24	15	122
HB9	7.90	640	240	110	47	14.35	0.32	79	10	104	15	322
HB10	7.44	710	320	90	88	3.00	1.06	89	6	112	19	358
HB11	7.93	380	210	30	20	5.75	0.30	34	5	56	19	218

A 14 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Kukatpally Watershed – Postmonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
HK1	8.27	525	220	80	47	6.70	0.24	128	12	32	10	121
HK2	7.90	787	340	90	57	23.00	0.43	95	11	80	49	401
HK3	7.93	909	285	150	90	31.50	0.53	88	5	112	58	518
HK4	7.42	723	315	150	28	0.90	0.26	102	7	64	44	340
HK5	7.42	1254	240	300	118	51.50	0.27	148	6	168	58	658
HK6	7.99	704	240	140	66	10.85	0.52	102	10	80	29	319
HK7	8.00	826	290	120	88	24.50	0.48	121	6	120	19	378
HK8	7.99	672	240	100	56	22.50	1.04	75	5	144	0	360
HK9	8.10	934	205	120	143	56.00	0.68	161	5	64	53	377
HK10	7.46	1773	250	640	191	5.45	0.44	244	6	208	83	860
HK11	7.38	915	190	200	108	34.50	0.76	90	5	152	34	519

A 15 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Yusufguda Watershed – Postmonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HY1	7.80	392	170	50	43	5.05	0.95	47	6	64	10	201
HY2	7.92	678	190	100	76	32.00	1.30	78	5	104	24	358
HY3	7.61	516	239	80	40	1.55	1.02	65	5	72	19	258
HY4	8.05	525	250	50	40	12.25	0.50	68	5	96	5	261
HY5	7.93	598	275	70	49	10.70	1.70	76	5	96	15	302
HY6	8.10	404	150	60	33	12.25	0.86	61	5	64	5	181
HY7	7.70	500	235	60	30	9.90	0.96	68	6	72	15	242
HY8	7.82	511	195	80	51	9.75	0.92	54	5	88	15	282
HY9	7.90	253	120	20	12	9.75	0.47	24	6	40	10	141
HY10	7.91	371	200	30	41	0.55	1.80	58	5	40	15	162
HY11	8.07	404	180	50	40	5.80	1.27	43	5	64	15	222
HY12	8.44	180	95	20	14	0.35	0.31	16	6	24	10	101
HY13	7.49	710	250	110	61	22.50	0.97	89	5	96	29	359
HY14	7.95	678	210	120	64	22.00	0.87	69	5	120	19	378
HY15	7.47	630	170	130	79	14.50	0.99	88	5	104	10	301
HY16	8.06	864	260	110	71	16.50	1.70	127	5	112	29	399
HY17	8.07	672	250	120	55	12.10	0.81	85	5	104	19	338
HY18	7.68	1101	310	260	130	11.15	0.58	176	5	96	58	478

A 16 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – Postmonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH1	7.55	3238	560	1110	318	13.50	1.20	833	4	144	92	737
BH2	7.51	1498	266	400	259	16.50	0.88	172	7	176	88	801
BH3	7.64	606	240	80	86	7.45	0.84	70	5	80	29	319
BH4	7.77	749	370	80	57	10.45	0.69	93	7	72	49	381
BH6	7.89	189	120	10	10	0.30	0.34	19	6	24	10	101
BH7	7.95	1587	410	380	224	13.50	0.69	371	5	72	63	438
BH8	7.47	1683	200	400	201	92.00	0.82	221	6	208	78	840
BH9	8.02	973	370	180	86	11.00	1.10	157	5	88	49	421
BH10	7.60	1024	340	220	69	19.50	0.55	120	5	80	83	540
BH11	7.66	819	330	120	66	18.50	0.60	129	5	48	58	358
BH12	7.40	1229	355	250	127	31.00	0.74	211	9	96	63	498
BH13	7.97	1011	420	180	73	9.00	2.25	189	5	56	58	378
BH14	8.10	1267	480	210	105	26.50	1.74	319	5	48	44	300
BH15	7.81	191	112	20	6	0.45	0.34	21	5	12	17	100
BH16	7.69	1069	248	230	134	32.00	0.40	72	5	168	63	678
BH17	7.87	1523	340	330	169	55.00	0.82	218	6	168	73	719
BH18	7.96	992	240	170	108	49.00	0.52	136	6	136	34	479
BH19	7.88	1670	200	420	205	80.00	0.23	161	6	248	83	960
BH20	8.05	966	270	190	141	17.50	1.44	135	7	104	49	461
BH21	7.87	851	250	150	86	30.00	1.50	85	5	80	68	479
BH22	7.51	1062	330	230	94	19.50	2.00	180	5	72	63	438
BH23	7.24	672	284	90	70	9.95	0.49	85	5	96	24	338
BH24	7.96	1024	370	190	90	17.00	0.91	176	5	39	104	524

A 16 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area,
Bowenpally Watershed – Postmonsoon 2009 (Contd….)

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH25	7.81	1069	340	250	81	14.00	0.64	118	5	58	136	703
BH26	7.51	597	226	80	50	20.00	0.56	76	5	24	80	388
BH27	7.49	1018	332	200	110	16.50	0.59	152	25	58	80	473
BH28	8.07	526	275	40	46	7.80	1.06	68	5	24	64	322
BH29	7.78	420	180	50	40	9.15	0.50	48	5	15	64	300
BH30	8.01	723	290	110	60	14.50	1.33	57	5	24	136	618
BH31	7.41	730	340	90	51	12.50	1.46	106	5	29	88	433
BH32	7.86	182	108	15	10	0.55	0.34	21	6	10	20	107
BH33	7.76	1171	245	190	110	78.00	0.82	136	6	34	192	872
BH34	7.54	467	240	60	21	4.05	1.02	56	5	15	72	333
BH35	7.81	508	200	60	49	16.00	1.30	43	5	24	80	388
BH36	7.48	625	230	110	65	8.50	1.90	76	6	24	88	421
BH37	7.41	928	290	160	124	20.50	0.88	113	5	49	112	582
BH38	7.40	1350	285	370	170	17.00	0.35	92	5	112	160	936
BH39	7.70	220	100	25	30	0.95	0.44	31	5	7	28	132
BH40	8.06	445	280	20	12	6.60	1.52	58	5	34	32	216
BH41	7.68	1133	295	230	154	27.00	0.56	123	6	92	96	624
BH42	8.57	408	140	70	35	5.80	0.82	62	5	34	16	151
BH42A	8.02	1005	440	120	77	24.50	1.07	158	23	63	64	420

A 17 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Hussain Sagar downstream Watershed – Postmonsoon 2009

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HS1	7.95	525	250	60	39	8.50	1.30	76	7	24	56	290
HS2	7.92	652	320	80	34	10.00	1.50	114	5	15	80	366
HS3	7.41	883	340	210	38	2.00	0.60	142	6	44	80	438
HS4	7.94	691	290	110	53	9.50	1.14	128	6	29	56	302
HS5	7.89	659	260	90	68	14.50	1.53	108	5	24	72	355
HS6	8.02	1421	380	400	133	4.50	1.02	280	9	39	136	655
HS7	7.61	529	255	70	33	6.00	0.93	103	26	15	40	202
HS8	7.87	838	335	130	56	20.00	1.44	116	8	44	88	471
HS9	7.91	493	160	90	60	8.80	1.50	75	5	15	64	300
HS10	7.60	762	340	100	73	9.05	0.49	106	8	44	72	405
HS11	7.94	653	310	80	50	8.50	1.15	105	5	39	48	294
HS12	8.00	504	150	80	71	15.00	0.83	61	5	88	10	261
HS13	7.93	691	255	100	71	18.00	1.53	119	6	72	24	278
HS14	8.12	602	230	100	60	9.00	1.64	87	5	48	39	280
HS15	7.90	749	220	120	97	25.00	0.93	85	5	72	53	397
HS16	7.90	636	245	80	60	20.00	0.53	81	5	72	34	319
HS17	7.96	515	195	70	67	9.75	0.62	73	5	88	5	241
HS18	8.08	484	205	80	48	1.85	1.25	62	5	56	24	238
HS19	7.58	227	90	30	38	0.95	0.34	43	5	24	5	81
HS21	7.74	653	250	100	77	9.40	0.80	96	5	72	29	299
HS22	7.86	429	180	80	37	0.10	0.47	79	6	56	5	161
HS23	7.99	396	198	50	23	3.85	0.83	85	5	32	10	121
HS24	8.05	672	300	80	60	12.50	0.51	94	5	80	29	319
HS25	8.09	698	265	120	59	12.40	0.67	103	6	48	49	321
HS26	8.09	659	303	80	55	10.25	2.72	95	11	48	44	300
HS27	7.54	1024	266	200	123	32.50	0.47	191	25	88	34	359
HS28	8.10	646	303	90	66	0.25	1.80	101	8	48	39	280

A 18 Groundwater Quality in the Piezometers (HPII) in Hussain Sagar Catchment – Post-monsoon 2009*
(* Piezometers drilled during October 2009 & Monitoring started)

(All Values are in mg/l except pH)

Piezo No.	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
P1	8.54	290	100	20	21	4.1	2.2	74	5	16	5	60
P2	7.86	1267	250	350	220	2	0.28	326	8	48	39	280
P3	8.2	492	150	100	54	9.35	1.22	83	5	40	24	200
P4	8.23	471	150	130	25	1.5	0.49	113	5	40	5	120
P5	8.58	492	80	90	96	3.9	0.82	127	9	24	10	100
P6	8.49	934	70	300	60	30	0.86	151	6	40	73	400
P7	8.5	1100	85	250	134	60	0.93	145	10	128	53	540
P8	8.38	627	125	160	74	4.8	0.92	110	12	40	34	240
P9	8.23	446	200	70	21	6.85	1.9	85	5	24	24	160
P10	8.28	1446	150	500	227	7.6	0.77	296	14	48	87	480
P11	7.91	1696	35	700	250	8.1	0.37	77	8	336	78	1160
P14	8.66	422	90	70	54	6	1.2	86	5	24	19	140
P16	8.73	440	95	90	25	9.25	1.28	102	5	16	19	120
P17	7.75	800	325	110	97	10.5	1	110	9	96	34	380
P19	8.45	275	30	40	36	8.2	1.34	51	5	32	5	100
P20	8.36	337	44	60	50	11.05	0.93	73	5	24	10	100
P22	7.97	678	194	90	106	26	0.34	113	7	48	39	280
P23	7.72	672	230	100	65	22.6	0.56	111	6	48	39	280

A 19 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Banjarahills Watershed – Premonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HB1	7.70	749	335	86	52	86	0.66	94	5	96	34	380
HB2	7.90	800	421	106	40	9	0.91	94	5	64	63	420
HB4	7.60	449	184	58	51	36	0.33	54	13	72	10	220
HB5	8.00	163	87	14	17	2	0.32	19	6	16	10	80
HB6	8.10	448	223	48	33	27	0.72	58	5	64	15	220
HB7	7.40	749	372	96	51	24	0.79	103	5	80	39	360
HB8	8.80	302	90	38	25	4	0.86	88	5	8	5	40
HB9	7.40	196	99	19	16	11	0.34	22	6	20	12	100
HB10	7.60	525	150	96	112	4	1.30	95	6	72	5	200
HB11	7.90	326	198	20	20	7	0.54	33	5	32	24	180

A 20 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Kukatpally Watershed – Premonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HK2	7.90	406	209	30	37	30	1.16	78	8	40	10	140
HK3	7.60	710	282	110	74	45	0.66	89	6	8	83	360
HK4	7.60	749	356	140	23	2	0.29	139	6	48	44	300
HK5	7.80	1235	354	240	115	180	0.58	215	6	136	39	500
HK6	7.84	184	96	20	15	3	0.39	26	6	20	7	80
HK7	7.80	877	363	140	79	45	0.71	167	7	104	15	320
HK8	7.49	666	236	140	42	48	1.00	128	5	72	15	240
HK9	7.37	1203	240	250	205	158	0.91	194	6	152	34	520
HK10	7.37	1837	310	620	217	14	0.67	277	6	192	88	840
HK11	7.66	556	222	70	72	43	0.99	70	5	104	5	280

A 21 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Yusufguda Watershed – Premonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HY1	8.02	168	80	25	13	1	0.31	25	6	16	7	70
HY2	7.57	433	181	60	38	38	1.50	53	5	64	15	220
HY3	7.64	467	274	40	29	1	1.20	56	5	56	24	240
HY4	7.56	411	200	40	35	32	0.62	45	5	80	5	220
HY5	7.66	509	260	50	34	35	1.57	62	5	80	15	260
HY6	7.53	385	103	90	35	40	1.35	63	5	56	5	160
HY7	7.46	527	230	80	34	37	1.05	77	6	88	5	240
HY8	7.80	397	175	50	40	25	1.56	49	5	64	10	200
HY9	7.37	723	282	150	24	52	0.64	84	6	80	44	380
HY10	7.58	460	233	50	39	15	2.06	62	6	80	5	220
HY11	7.76	478	213	60	50	26	1.75	60	5	64	19	240
HY12	7.65	446	194	60	32	42	0.87	76	5	64	5	180
HY13	7.60	515	281	20	45	53	1.42	64	6	64	24	260
HY14	7.60	1517	300	460	147	90	0.67	134	5	256	63	900
HY15	7.62	595	219	90	70	52	1.49	66	5	88	24	320
HY16	7.74	762	360	110	57	18	1.64	116	7	88	29	340
HY17	7.90	511	200	100	34	24	0.78	62	6	88	10	260
HY18	7.38	1190	340	230	214	42	0.82	181	5	88	78	540

A 22 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – Premonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH1	7.63	1830	352	586	195	44	1.09	339	6	96	112	700
BH2	7.49	1382	274	394	200	40	1.15	167	7	160	78	720
BH3	7.85	659	300	67	89	28	0.99	89	6	64	39	320
BH4	7.93	355	194	38	22	3	0.54	31	10	56	15	200
BH6	7.72	742	297	115	88	29	1.13	100	6	72	44	360
BH7	7.85	1594	407	413	214	26	0.45	308	6	80	92	580
BH8	7.69	1453	262	317	158	315	1.04	100	7	184	112	920
BH9	8.11	864	364	125	87	47	1.46	154	6	56	49	340
BH10	8.09	794	364	125	49	29	1.13	92	5	56	68	420
BH11	7.87	794	377	96	58	52	0.73	110	6	72	49	380
BH12	7.58	1312	316	210	232	203	1.17	213	9	144	49	560
BH13	7.99	883	370	160	55	38	2.55	170	6	40	53	320
BH14	7.97	1427	477	280	180	56	1.61	229	6	112	83	620
BH15	7.86	749	271	90	91	109	0.85	66	6	144	19	440
BH16	7.89	659	332	50	54	64	0.60	43	5	112	34	420
BH17	7.94	1107	423	180	110	82	2.23	241	7	88	29	340
BH18	8.03	742	300	110	66	63	0.94	99	8	104	24	360
BH19	7.42	2054	153	590	288	383	0.29	207	8	336	78	1160
BH20	7.91	1056	348	220	110	56	1.40	130	8	104	68	540
BH21	8.01	640	275	80	69	45	1.54	54	6	72	49	380
BH22	7.73	1088	330	269	88	51	2.29	217	6	88	68	500
BH23	7.88	470	199	67	55	16	0.80	67	5	56	19	220
BH24	7.55	928	340	192	68	45	1.34	168	5	72	44	360

A 22 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – June 2010 (Contd….)

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH25	7.53	1075	387	240	68	45	0.97	111	5	112	78	600
BH26	7.72	333	142	48	30	22	0.47	44	5	48	10	160
BH27	7.79	774	165	192	128	38	0.92	94	6	112	29	400
BH28	8.04	388	202	38	30	16	1.21	55	5	48	15	180
BH29	7.70	369	153	48	36	34	0.48	47	7	48	15	180
BH30	7.70	1043	160	298	120	128	1.16	72	5	224	24	660
BH31	7.49	666	322	86	42	34	1.70	101	5	72	29	300
BH32	7.92	172	87	20	15	3	0.35	22	6	16	10	80
BH33	7.88	781	320	130	62	45	0.98	115	5	128	10	360
BH34	7.84	534	229	80	39	39	1.13	53	5	104	10	300
BH35	7.60	870	282	190	67	68	1.08	111	5	112	39	440
BH36	7.43	640	260	100	67	31	1.89	91	6	88	19	300
BH37	7.35	736	295	130	73	19	1.27	117	5	64	39	320
BH38	7.81	877	303	180	93	31	1.85	122	5	48	73	420
BH39	7.68	319	127	40	55	8	0.51	57	6	32	10	120
BH40	7.95	390	253	10	15	24	1.52	38	5	40	29	220
BH41	7.51	947	296	190	119	56	0.79	120	6	64	78	480
BH42	7.55	493	229	60	50	19	0.97	83	6	64	10	200

A 23 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Hussain Sagar downstream Watershed – Premonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
HS1	7.78	477	271	50	20	8	0.55	57	10	80	10	240
HS2	7.66	531	276	60	40	11	1.40	97	6	72	5	200
HS3	7.54	316	109	50	56	8	0.43	45	8	32	15	140
HS4	7.67	504	201	90	42	23	0.79	78	6	64	15	220
HS5	7.73	516	211	50	86	36	1.37	102	5	32	24	180
HS6	7.72	444	140	110	45	1	0.56	75	6	64	5	180
HS7	7.62	470	226	50	45	25	0.61	41	32	40	34	240
HS8	7.56	1120	396	200	97	110	1.32	168	15	80	73	500
HS9	7.40	280	105	40	50	4	0.39	52	6	24	10	100
HS10	7.86	535	295	20	61	34	0.83	99	5	40	24	200
HS11	8.40	277	85	40	49	2	0.37	51	6	24	10	100
HS12	8.32	316	90	50	60	2	0.38	65	6	24	10	100
HS13	7.70	678	243	100	75	79	1.50	105	6	88	19	300
HS14	7.88	467	159	90	60	17	1.01	56	5	40	34	240
HS16	7.72	552	196	80	75	50	0.69	60	5	64	34	300
HS17	8.49	413	64	70	57	23	0.79	64	5	40	19	180
HS18	8.01	381	205	30	45	1	1.07	43	6	40	24	200
HS19	7.87	553	233	70	74	24	1.65	105	6	40	24	200
HS21	7.46	532	180	90	68	43	0.84	89	5	48	24	220
HS22	7.71	550	263	60	50	33	0.63	85	7	64	19	240
HS23	7.58	299	160	30	23	6	0.46	38	11	40	10	140
HS24	8.07	638	280	70	69	54	0.53	90	6	56	39	300
HS25	8.05	710	285	110	75	39	0.91	116	6	32	53	300
HS26	7.95	469	238	50	45	9	2.39	70	14	24	34	200
HS27	7.75	659	230	120	86	27	1.14	116	6	40	39	260
HS28	8.44	319	50	50	63	1	0.33	66	6	24	10	100

A 24 Groundwater Quality in Piezometers (HPII) in Hussainsagar Catchment – Pre-monsoon 2010

(All Values are in mg/l except pH)

Obs. No.	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
P1	8.69	316	156	20	20	5.40	2.33	75	5	16	10	80
P2	8.30	545	62	140	70	19.50	0.86	102	6	40	24	200
P3	8.59	404	58	100	40	3.45	1.29	70	5	32	19	160
P4	8.60	541	103	140	35	0.45	1.00	111	5	24	29	180
P5	8.16	1101	323	240	152	9.00	1.27	259	5	24	58	300
P6	8.86	1005	374	160	57	5.00	1.89	263	16	16	39	200
P7	8.16	1427	66	350	163	105.00	0.95	174	7	136	97	740
P8	8.63	685	136	180	38	0.20	1.43	117	5	16	58	280
P9	8.68	303	105	20	10	2.90	1.96	51	6	24	15	120
P10	8.13	1338	259	430	157	1.55	0.95	257	14	64	78	480
P11	7.69	1920	126	780	220	8.45	0.44	75	9	392	88	1340
P12	8.54	367	59	60	60	5.00	0.84	38	6	32	29	200
P13	8.14	710	58	150	70	58.00	1.81	53	5	120	34	440
P14	8.52	451	155	60	38	2.65	1.21	77	6	24	29	180
P15	8.46	516	150	60	65	10.35	1.11	147	6	16	10	80
P16	8.67	481	130	80	19	8.40	1.13	107	6	16	24	140
P17	8.56	329	92	60	28	2.30	1.28	70	6	16	15	100
P18	8.46	188	75	20	18	0.95	0.32	23	6	16	12	90
P19	8.37	355	60	60	37	8.75	1.49	34	5	72	5	200
P20	8.46	300	81	30	35	8.90	0.93	51	5	24	15	120
P21	8.44	308	76	40	34	8.60	0.95	54	5	32	10	120
P22	8.40	704	146	110	113	24.00	0.29	140	9	24	44	240
P23	8.57	685	114	110	112	23.50	0.28	124	9	24	49	260
P24	8.26	774	86	240	106	18.00	1.02	94	6	72	53	400
P25	8.55	239	36	30	17	2.60	1.61	38	5	32	5	100

A 25 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Banjarahills Watershed – Postmonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
HB1	7.43	520	244	40	39	17.00	0.69	74	7	80	10	240
HB2	7.56	800	396	80	58	14.00	0.91	85	5	96	49	440
HB4	7.67	607	285	80	35	10.00	1.44	80	5	72	29	300
HB5	7.46	473	177	60	45	16.00	0.32	54	13	80	10	240
HB6	7.94	215	125	20	9	1.10	0.23	10	6	32	15	140
HB7	7.71	538	241	60	44	12.50	0.56	71	7	96	5	260
HB8	7.41	1190	205	220	106	82.50	1.08	126	5	168	58	660
HB9	7.53	606	290	70	43	10.00	1.07	88	5	88	15	280
HB10	7.64	587	250	80	33	16.00	0.38	69	10	96	15	300
HB11	7.54	774	364	90	99	1.35	1.27	94	6	120	24	400

A 26 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Kukatpally Watershed – Postmonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
HK1	8.05	546	275	60	31	8.45	1.50	135	13	32	10	120
HK2	7.67	960	375	130	48	37.50	0.81	124	6	112	49	480
HK3	7.41	986	240	180	69	55.00	0.91	125	5	120	49	500
HK4	7.74	736	372	120	24	0.80	0.29	107	6	80	34	340
HK5	7.49	1472	396	340	114	40.50	0.44	154	6	200	78	820
HK6	7.97	346	167	40	18	7.10	0.40	39	7	48	15	180
HK7	7.80	838	330	120	66	22.50	1.09	116	7	120	24	400
HK8	7.65	794	300	70	52	45.00	1.50	110	5	104	29	380
HK9	7.26	979	175	180	117	58.00	1.09	141	5	128	34	460
HK10	7.82	1677	330	530	189	6.40	0.71	219	6	184	92	840
HK11	8.16	781	278	140	83	11.75	0.90	83	12	152	10	420

A 27 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Yusufguda Watershed – Postmonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
HY1	8.36	218	66	30	15	1.20	0.23	11	6	40	10	140
HY2	7.96	896	230	140	75	52.50	0.97	111	5	128	34	460
HY3	7.76	749	358	80	44	17.50	1.27	91	10	104	29	380
HY4	8.26	516	240	60	38	10.00	0.85	56	5	88	15	280
HY5	8.14	584	260	60	39	18.50	1.03	69	9	104	10	300
HY6	8.15	504	175	70	40	21.00	1.19	79	5	80	5	220
HY7	8.32	423	122	60	31	7.90	0.99	59	5	64	10	200
HY8	7.98	566	235	60	52	18.00	0.74	64	6	88	19	300
HY9	7.90	832	335	110	48	29.00	0.81	96	6	144	19	440
HY10	8.10	509	240	70	29	6.80	1.86	62	5	72	19	260
HY11	8.36	427	152	40	33	7.65	1.40	41	6	80	10	240
HY12	7.89	609	250	90	47	12.50	0.85	80	5	96	15	300
HY13	7.71	588	282	70	38	9.50	0.74	100	5	80	10	240
HY14	8.03	1549	145	360	241	82.50	0.51	154	6	272	49	880
HY15	7.92	826	272	140	78	24.50	1.27	103	6	128	24	420
HY16	8.26	909	385	100	79	26.50	1.64	115	6	120	39	460
HY17	8.44	350	160	50	20	5.35	0.57	68	6	48	0	120
HY18	8.31	922	310	130	100	10.00	0.90	129	5	120	34	440

A 28 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – Postmonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH1	8.25	1376	515	270	131	8.90	1.12	331	5	56	53	360
BH2	8.14	1299	325	310	173	17.50	1.23	155	7	160	68	680
BH3	7.92	600	235	80	72	11.40	0.83	76	6	88	19	300
BH4	8.23	1184	360	170	81	65.00	0.74	159	7	120	68	580
BH5	8.29	215	125	20	9	1.05	0.24	10	6	40	10	140
BH6	8.46	1043	245	210	132	19.00	1.02	216	10	56	49	340
BH7	7.92	1504	270	310	164	80.00	1.03	220	6	216	39	700
BH8	8.43	992	340	160	85	15.00	1.44	163	6	96	44	420
BH9	8.21	321	135	50	36	1.40	0.34	39	6	40	15	160
BH10	8.09	838	365	100	51	25.00	0.79	108	5	80	53	420
BH11	7.81	1427	355	260	170	57.50	0.92	272	11	136	44	520
BH12	8.33	986	335	150	83	19.50	2.44	198	6	40	58	340
BH13	7.89	941	440	90	84	20.50	2.11	155	5	72	53	400
BH14	8.03	730	235	70	84	40.00	0.72	68	6	112	34	420
BH15	8.22	845	315	100	78	32.50	0.49	55	5	136	49	540
BH16	8.11	1389	350	270	163	48.50	1.13	197	6	144	73	660
BH17	8.27	781	265	100	77	33.00	1.07	96	6	96	39	400
BH18	8.03	1472	170	290	181	104.00	0.28	181	6	216	53	760
BH19	8.37	800	198	110	127	15.00	1.55	111	7	88	39	380
BH20	8.28	595	245	70	77	10.00	1.43	56	6	80	34	340
BH21	8.08	1165	410	240	98	14.00	2.09	190	5	80	73	500
BH22	8.37	303	100	40	54	0.55	0.35	51	6	24	15	120
BH23	7.99	979	450	100	83	22.50	1.40	178	5	64	53	380
BH24	8.38	276	135	20	26	0.95	0.46	32	6	48	5	140

A 28 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – Postmonsoon 2010 (Contd….)

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
BH25	8.08	618	255	80	61	13.00	0.78	102	5	64	24	260
BH26	7.53	960	330	170	114	15.00	1.00	169	8	72	49	380
BH27	7.92	501	215	60	53	9.30	1.12	69	5	48	29	240
BH28	8.30	340	170	30	30	5.35	0.48	45	8	40	15	160
BH29	8.05	597	270	70	53	10.50	1.96	48	5	112	19	360
BH30	7.67	620	225	110	51	13.00	1.60	84	5	80	24	300
BH31	8.33	499	190	60	45	6.90	1.80	57	7	88	10	260
BH32	8.11	877	218	140	100	44.50	1.32	104	5	128	34	460
BH33	7.69	483	230	60	28	8.45	1.20	44	5	80	19	280
BH34	8.12	483	235	40	44	10.00	1.40	43	5	72	24	280
BH35	7.73	608	215	100	66	12.80	1.87	79	7	80	24	300
BH36	7.83	909	360	130	109	12.80	1.17	125	5	96	49	440
BH37	7.96	781	410	70	70	6.25	2.03	124	5	40	58	340
BH38	7.92	794	320	100	94	15.50	2.40	101	5	72	53	400
BH39	8.49	365	158	10	8	6.20	1.52	10	5	32	44	260
BH40	7.91	883	300	150	88	22.50	0.82	105	6	72	68	460
BH41	7.64	520	300	30	40	5.30	0.87	57	6	48	39	280

A 29 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Hussain Sagar downstream Watershed – Postmonsoon 2010

All Values are in mg/l except pH

Obs. Well	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
HS1	7.84	531	255	50	43	11.15	1.04	60	7	64	29	280
HS2	8.30	557	240	60	38	7.55	1.45	89	5	56	24	240
HS3	8.34	301	70	40	41	1.05	0.33	41	6	32	15	140
HS4	8.11	575	260	80	55	4.05	0.87	95	6	48	29	240
HS5	8.45	478	150	60	78	3.90	1.61	79	5	56	15	200
HS6	8.47	1107	235	200	142	8.70	0.73	182	14	128	34	460
HS7	8.48	477	175	40	60	10.00	0.58	56	27	64	15	220
HS8	8.06	1088	291	190	101	49.80	1.64	152	7	96	68	520
HS9	8.41	209	110	10	11	1.65	0.23	17	6	32	10	120
HS10	8.32	813	280	80	155	9.65	0.55	112	14	96	34	380
HS11	8.21	787	305	140	68	10.00	0.73	80	5	72	63	440
HS12	8.33	310	85	50	60	0.55	0.36	54	6	32	10	120
HS13	8.39	592	175	70	71	14.00	1.50	101	6	80	10	240
HS14	8.04	583	220	80	72	12.05	2.30	98	5	48	29	240
HS15	7.83	607	220	80	97	10.00	1.07	79	6	72	29	300
HS16	8.21	589	225	70	69	17.00	0.76	73	5	72	29	300
HS17	8.37	432	115	50	69	4.80	0.72	61	7	56	15	200
HS18	8.43	391	150	40	53	0.25	1.16	46	6	56	15	200
HS19	8.49	736	250	100	61	9.70	1.16	116	7	72	34	320
HS21	8.04	595	215	80	62	19.00	0.80	74	6	80	24	300
HS22	8.03	536	230	60	53	12.50	0.65	80	7	72	15	240
HS23	8.40	323	140	20	18	6.45	0.35	38	9	40	15	160
HS24	7.98	685	280	100	53	15.00	0.50	89	6	72	39	340
HS25	7.97	883	325	150	76	19.00	0.90	123	8	56	68	420
HS26	8.16	561	265	70	51	4.80	2.38	76	14	48	34	260
HS27	7.80	813	335	110	82	15.00	1.14	117	6	64	53	380
HS28	8.10	599	310	80	38	0.25	1.80	93	9	48	34	260

A 30 Groundwater Quality in PDS piezometers in Hussain Sagar Catchment – Post-monsoon 2010

(All Values are in mg/l except pH)

Piezo No.	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
P1	8.31	422	261	10	15	4.35	2.21	86	5	24	19	140
P2	8.16	380	197	20	36	8.80	0.44	61	6	48	10	160
P3	7.16	315	180	20	18	4.75	0.29	27	8	56	10	180
P4	8.05	384	252	10	19	3.25	0.37	54	5	56	10	180
P5	7.98	992	460	130	106	3.75	0.96	200	7	56	49	340
P6	8.09	506	340	20	14	2.40	0.28	49	25	88	10	260
P7	7.91	928	210	140	121	51.50	0.84	121	7	104	49	460
P8	8.02	582	262	90	52	2.15	1.03	85	11	56	29	260
P9	7.61	525	360	20	7	2.80	1.55	59	5	64	29	280
P10	8.11	1139	374	290	73	6.15	0.66	198	6	80	63	460
P11	7.31	1853	268	510	377	15.00	0.52	154	6	320	78	1120
P12	7.69	444	248	10	46	9.50	0.57	28	8	64	29	280
P13	8.08	516	95	100	60	28.00	1.79	46	6	72	29	300
P14	8.53	454	150	60	32	0.90	1.09	88	5	24	24	160
P15	8.10	585	266	60	62	10.50	1.02	144	6	32	15	140
P16	8.10	554	286	60	28	8.00	0.75	96	6	48	24	220
P17	7.14	1024	400	140	141	13.50	0.81	98	12	136	58	580
P18	7.72	1555	320	360	173	54.50	0.98	82	7	192	136	1040
P19	7.79	430	225	30	34	8.65	1.41	34	5	72	19	260
P20	7.72	461	295	5	19	9.65	0.91	54	5	56	24	240
P21	7.59	475	300	10	17	9.80	0.90	59	5	72	15	240
P22	8.15	575	226	80	67	10.00	0.39	103	7	32	34	220
P23	7.85	691	320	70	70	12.00	0.42	100	7	72	34	320
P24	7.71	851	258	170	120	10.00	0.47	94	5	128	34	460
P25	7.58	322	200	20	13	2.10	1.82	31	6	56	10	180

A 31 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Banjarahills Watershed – Premonsoon 2011

All Values are in mg/l except pH

Obs. No	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HB1	7.62	495	245	50	30	10.0	0.7	60	6	72	19	260
HB2	7.62	570	230	110	35	5.3	0.94	50	5	64	44	339
HB3	7.65	621	235	110	44	12.5	0.3	60	5	72	44	359
HB4	7.38	538	161	120	41	12.2	1.44	57	5	104	10	300
HB5	7.81	248	143	20	19	0.4	0.34	26	14	32	15	140
HB6	7.62	538	270	50	38	10.0	0.26	85	7	88	5	240
HB7	7.68	864	190	190	96	31.0	0.6	111	8	136	24	440
HB8	8.35	465	230	70	24	1.5	1.09	150	5	16	0	40
HB9	7.72	631	293	80	40	11.5	1.1	109	5	88	10	260
HB10	7.46	877	492	120	13	1.0	0.4	125	9	144	15	420
HB11	7.74	363	220	30	10	2.2	1.3	12	6	56	29	260

A 32 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Kukatpally Watershed – Premonsoon 2011

All Values are in mg/l except pH

Obs. No	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HK1	7.85	685	357	80	41	4.7	1.52	166	12	32	24	180
HK2	7.66	621	300	70	36	12.5	0.86	78	6	56	44	319
HK3	7.28	941	256	200	64	34.5	0.95	130	6	136	29	460
HK4	7.38	826	445	120	19	1.3	0.3	116	7	96	39	399
HK5	7.44	1459	131	350	158	95.0	0.46	217	6	224	29	680
HK6	7.37	672	244	130	57	9.2	0.48	115	7	88	15	280
HK7	7.38	973	375	210	49	8.5	1.1	151	7	136	24	440
HK8	7.18	672	210	140	36	21.0	1.8	60	5	88	44	399
HK9	7.01	1165	250	230	125	55.0	1.09	220	5	160	10	440
HK10	7.48	1696	406	520	160	1.7	0.75	266	6	200	63	759
HK11	11.86	1805		110	445	12.4	0.98	370	11	240	5	620

A 33 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Yusufguda Watershed – Premonsoon 2011

All Values are in mg/l except pH

Obs. No	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HY1	8.09	243	139	30	5	0.4	0.3	5	6	32	24	180
HY2	7.39	640	255	80	71	15.0	0.98	58	5	96	34	380
HY3	7.62	395	217	50	13	1.3	1.25	51	9	64	10	200
HY4	7.70	319	185	30	10	2.7	0.88	33	5	56	10	180
HY5	7.85	309	170	30	17	2.6	1.2	11	8	40	29	220
HY6	7.55	418	183	50	25	12.2	1.23	69	5	72	0	180
HY7	7.59	456	110	110	23	18.0	1	55	6	72	15	240
HY8	7.84	458	260	50	15	2.2	0.8	56	8	64	19	240
HY9	7.45	704	330	100	30	11.9	0.96	90	8	96	29	360
HY10	7.51	508	230	70	37	7.1	1.86	37	6	88	24	320
HY11	7.70	445	161	90	33	6.1	1.42	24	7	80	24	300
HY12	7.52	327	185	30	18	2.0	0.75	36	5	56	10	180
HY13	7.43	672	330	80	31	12.5	0.86	97	6	96	19	320
HY14	7.51	1146	122	350	148	32.5	0.68	158	8	176	29	560
HY15	7.72	653	260	90	70	12.5	1.25	71	6	104	24	360
HY16	7.79	717	276	140	55	6.5	1.68	95	6	96	29	360
HY17	7.82	787	290	170	41	10.2	0.62	102	6	112	29	400
HY18	7.60	1216	313	280	190	9.7	0.93	147	6	160	58	639

A 34 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – Premonsoon 2011

All Values are in mg/l except pH

Obs. No	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH1	7.84	1171	500	200	91	8.2	1.25	315	6	48	29	240
BH2	7.40	1075	350	200	140	15.0	1.2	160	7	112	53	499
BH3	7.61	607	290	60	51	11.6	0.82	91	6	80	19	280
BH4	7.75	482	257	60	25	1.5	0.76	65	7	56	24	240
BH5	BW											
BH6	7.44	781	383	90	75	4.5	0.32	136	6	96	19	320
BH7	7.68	1562	303	370	325	12.4	1.06	337	12	80	73	499
BH8	7.44	1344	199	290	126	84.0	1.1	221	7	160	44	579
BH9	7.94	928	410	140	62	12.7	1.48	190	6	56	44	319
BH10	7.49	883	430	140	33	6.0	0.36	127	6	88	49	419
BH11	7.72	870	269	150	48	40.0	0.8	132	5	72	53	399
BH12	7.44	1466	107	290	370	65.0	0.92	210	10	200	49	699
BH13	7.66	890	331	160	71	16.0	2.48	157	6	72	44	359
BH14	8.12	774	410	60	56	13.0	2.16	125	5	64	44	339
BH15	7.61	749	295	90	72	23.0	0.78	69	6	152	15	440
BH16	7.58	806	212	140	48	46.0	0.56	63	5	144	34	500
BH17	7.43	1101	237	220	110	53.0	1.3	151	6	128	53	539
BH18	8.03	637	300	60	40	18.5	1.07	93	6	80	24	300
BH19	7.48	678	262	100	65	15.0	0.28	108	6	88	19	300
BH20	7.55	877	200	190	97	30.5	1.5	134	7	136	15	400
BH21	7.66	634	180	120	67	20.0	1.46	64	6	96	29	360

A 34 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area,
Bowenpally Watershed – Premonsoon 2011 (Contd….)

All Values are in mg/l except pH

Obs. No	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
BH22	7.49	1312	374	330	95	21.5	2.06	274	5	88	53	439
BH23	7.58	508	166	110	60	2.5	0.38	92	6	56	15	200
BH24	7.39	1056	314	230	68	30.0	1.6	218	5	80	39	359
BH25	7.66	531	150	150	27	5.9	0.42	64	6	80	19	280
BH26	7.60	481	255	50	41	1.2	0.78	46	7	72	24	280
BH27	7.85	536	139	130	56	9.5	1.1	75	7	64	24	260
BH28	7.68	480	190	80	37	8.3	1.14	36	5	56	39	299
BH29	7.37	365	140	80	27	0.5	0.51	50	8	48	15	180
BH30	7.55	1024	201	270	97	30.5	1.96	169	5	168	5	440
BH31	7.34	666	208	120	46	25.0	1.62	104	5	112	5	300
BH32	7.61	311	74	80	50	0.6	1.8	58	7	32	10	120
BH33	7.46	864	156	170	70	56.0	1.3	139	6	136	10	380
BH34	7.40	531	168	120	40	9.1	1.24	64	6	88	15	280
BH35	7.24	646	157	130	54	29.0	1.42	69	5	104	24	360
BH36	7.44	710	308	120	46	6.8	1.3	120	8	104	10	300
BH37	7.32	710	254	160	58	2.6	1.2	111	5	72	34	320
BH38	7.60	896	361	160	75	8.0	2.03	132	6	56	68	419
BH39	7.69	704	195	130	74	25.0	2.2	72	5	88	44	399
BH40	7.61	385	254	10	6	6.6	1.5	48	5	48	19	200
BH41	7.65	954	230	210	80	36.0	0.81	153	7	72	58	419
BH42	7.59	691	342	90	43	5.8	0.85	113	6	80	24	300

A 35 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Hussain Sagar downstream Watershed – Premonsoon 2011

All Values are in mg/l except pH

Obs. No	pH	TDS	HCO_3	Cl	SO_4	NO_3 - N	F	Na	K	Ca	Mg	TH
HS1	7.47	973	231	170	108	47.5	1.06	169	7	128	19	400
HS2	6.99	736	370	110	13	8.7	1.5	129	5	88	19	300
HS3	7.33	301	134	40	37	1.1	0.38	45	6	32	15	140
HS4	7.21	436	248	50	3	4.3	0.8	57	6	56	19	220
HS5	7.71	524	215	70	69	5.5	1.6	98	5	48	19	200
HS6	7.47	1715	287	660	104	0.3	0.75	383	12	128	49	519
HS7	7.54	408	225	30	35	3.1	0.59	65	26	56	10	180
HS8	7.38	1536	366	320	118	69.5	1.63	309	7	136	49	539
HS9	7.28	248	150	20	9	1.1	0.32	7	6	24	29	180
HS10	7.46	838	405	100	74	7.1	0.56	148	14	72	39	339
HS11	7.43	268	165	20	9	1.3	0.73	24	5	48	10	160
HS12	7.88	618	160	130	86	12.6	0.38	105	6	88	10	260
HS13	7.47	678	278	90	72	12.7	1.61	127	6	80	15	260
HS14	7.74	529	265	70	39	1.2	2.34	82	5	48	29	240
HS15	7.63	621	282	80	70	3.6	1.02	115	6	40	34	240
HS16	7.49	646	282	80	63	11.2	0.74	87	5	80	29	320
HS17	7.66	415	167	60	53	4.2	0.7	68	7	56	10	180
HS18	7.85	410	200	50	44	0.1	1.1	57	6	48	19	200
HS19	7.65	717	313	110	57	7.7	1.16	141	7	72	19	260
HS21	7.57	704	269	120	64	11.0	0.82	127	6	72	24	280
HS22	7.46	625	299	90	40	4.3	0.68	116	7	64	19	240
HS23	7.35	356	174	40	22	6.1	0.34	46	9	56	10	180
HS24	7.60	749	343	100	51	11.8	0.52	115	6	72	39	339
HS25	7.63	326	125	50	52	0.8	0.92	63	8	32	10	120
HS26	7.73	532	277	50	53	2.5	2.4	83	14	40	34	240
HS27	7.42	838	298	150	90	12.7	1.12	157	6	80	29	320
HS28	7.58	625	314	80	53	0.3	1.82	107	9	48	34	260

A 36 Groundwater Quality in PDS piezometers in Hussain Sagar Catchment – Pre-monsoon 2011

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO_3	Cl	SO_4	NO_3-N	F	Na	K	Ca	Mg	TH
P1	8.35	329	145	10	16	5.2	2	55	5	32	15	140
P2	7.81	355	90	60	60	10.5	0	55	5	48	10	160
P3	8.20	474	164	110	39	1.9	1	89	6	24	29	180
P4	7.59	537	230	100	22	5.9	1	85	6	48	29	240
P5	7.82	1056	325	210	162	7.6	1	291	7	48	19	200
P6	8.23	979	255	210	75	36.0	1	245	15	24	44	239
P7	8.04	819	100	130	131	60.0	2	150	6	56	44	319
P8	8.47	646	156	160	35	0.5	1	106	6	24	53	279
P9	8.18	489	220	90	14	4.7	1	76	5	40	29	220
P10	7.93	1638	310	550	159	4.5	2	346	16	96	73	539
P11	8.01	941	90	290	161	17.0	1	139	9	80	58	439
P12	8.25	451	120	90	60	11.0	0	35	4	96	10	281
P13	8.01	616	58	120	66	50.5	1	67	5	88	29	340
P14	8.42	477	140	80	43	3.4	2	54	5	32	44	259
P15	8.67	454	90	50	61	7.8	1	110	6	32	10	120
P16	8.48	387	95	60	32	7.6	1	49	4	32	29	200
P17	8.52	498	116	90	24	10.5	1	61	5	56	29	260
P18	8.51	286	55	50	18	4.9	1	12	6	32	29	200
P19	8.56	237	62	30	30	2.2	0	3	4	48	15	180
P20	8.45	292	82	10	28	11.3	1	23	4	32	24	180
P21	8.01	292	125	20	29	11.9	1	42	4	32	15	140
P22	8.30	477	50	60	83	19.0	1	81	6	24	34	200
P23	8.57	524	130	70	71	17.5	0	89	6	24	39	219
P24	8.74	768	190	150	90	10.8	0	141	6	24	58	299
P25	8.66	237	78	30	14	2.3	3	22	4	40	10	140

A 37 Groundwater Quality in PDS piezometers in Hussainsagar Catchment – Post-monsoon 2011

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
P1	8.44	327	156	20	14	4.05	1.7	62	2	24	15	122
P2	8.14	589	150	130	75	12.5	0.16	74	3	72	29	299
P3	8.39	458	130	90	38	4.85	0.95	73	2	24	34	200
P4	8.33	576	160	140	34	3.55	0.67	107	2	24	39	220
P5	7.96	1184	515	190	98	8.7	1.6	355	3	48	10	161
P6	8.51	986	280	200	38	11.35	0.91	194	13	64	44	341
P7	8.06	1114	155	240	113	70	0.44	134	5	128	63	579
P8	8.52	864	275	190	42	0.45	1	119	2	80	53	418
P9	8.45	477	147	90	17	4.9	1.2	80	2	32	29	199
P10	7.42	1850	267	430	530	1.35	0.55	237	4	264	68	938
P11	8.01	1050	90	350	161	17	0.43	122	3	96	78	560
P12	8.27	303	120	50	37	1.4	0.5	44	3	32	15	142
P13	8.07	678	150	130	64	35	1.9	43	2	128	29	439
P14	8.53	524	110	110	60	10.4	1.1	97	2	24	34	200
P15	8.39	367	100	60	57	5.7	2.1	68	2	32	15	142
P16	7.95	505	252	50	33	9.4	0.39	53	2	72	24	278
P17	8.28	568	120	110	150	2.15	1.1	103	3	40	29	219
P18	8.45	232	95	20	34	0.4	0.36	27	3	24	15	122
P19	8.17	362	170	40	31	5.85	1.2	29	1	72	10	221
P20	8.24	504	215	70	65	2.3	0.66	117	2	24	19	138
P21	7.54	672	335	80	61	2.35	0.66	114	2	80	19	278
P22	8.33	749	190	140	68	11.4	0.38	96	2	88	39	380
P23	8.33	749	190	140	68	11.4	0.38	96	2	88	39	380
P24	7.8	819	275	150	104	10.75	1.2	93	4	112	39	440
P25	7.89	557	250	70	27	15	1.1	63	2	96	15	301

A 38 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Banjarahills Watershed – Premonsoon 2012

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
HB1	7.65	704	236	130	55	19	0.48	80	1.58	104	29.172	380
HB2	7.84	723.2	308	100	71	10.25	0.47	59	2.01	104	43.758	440
HB3	7.87	632.32	234	120	47	10.2	1.1	73	0.85	72	38.896	340
HB4	7.94	449.92	183	60	61	4.7	0.45	45	14.2	80	9.724	240
HB5	7.93	227.84	100	30	31	0.4	0.21	25	3.59	40	4.862	120
HB6	6.9	697.6	187	120	73	30	0.34	76	4.62	120	19.448	379
HB7	7.52	947.2	240	160	147	32	0.93	86	1	152	43.758	559
HB8	7.68	684.8	129	120	118	30.5	0.44	67	12.12	96	34.034	380
HB9	7.79	429.44	171	60	39	10	0.33	41	7.87	72	14.586	240
HB10	7.88	613.12	168	110	95	14.5	0.61	55	2.96	96	29.172	360

A 39 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Kukatpalli Watershed – Premonsoon 2012

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
HK1	8.35	857.6	326	100	48	7.4	1.4	192	16	24	43.758	240
HK2	8.25	806.4	345	100	50	24	0.85	107	3.26	72	53.482	400
HK3	7.76	934.4	406	160	38	14.5	0.59	117	2.82	96	58.344	480
HK4	7.51	870.4	304	190	75	6.6	0.27	111	4.43	112	38.896	439
HK5	8.34	180.48	73	20	16	0.55	0.21	17	4.36	24	9.724	100
HK6	8.6	723.2	288	110	51	12	0.55	88	15.94	24	72.93	360
HK7	8.41	193.92	82	20	17	0.6	0.22	22	4.33	28	7.293	100
HK8	7.94	729.6	300	120	40	15	0.86	99	1.05	64	48.62	360
HK9	7.86	1363.2	200	380	169	40	0.84	186	8.2	176	53.482	659
HK10	7.8	1440	180	330	440	2.9	0.56	206	6.3	152	72.93	679
HK11	8.25	315.52	163	30	30	2.15	1.1	40	1.62	56	4.862	160

A 40 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Yousufguda Watershed – Premonsoon 2012

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
HY1	7.5	225.28	116	20	27	0.4	0.23	25	3.39	32	9.724	120
HY2	6.21	627.2	281	120	30	1.15	1.2	61	1.37	96	29.172	360
HY3	6.62	524.8	235	70	38	9.105	0.76	51	2.47	88	19.448	300
HY4	6.98	305.28	151	30	30	3.115	0.37	27	2.59	24	29.172	180
HY5	6.56	561.92	232	90	60	3.57	1.2	65	2.35	104	9.724	300
HY6	7.48	474.24	178	90	52	2.15	0.51	52	1.75	88	9.724	260
HY7	7.61	691.2	276	120	70	4.65	2.1	111	2.51	56	38.896	300
HY8	7.7	457.6	182	70	50	6	0.82	54	2.67	72	14.586	240
HY9	8.08	487.68	178	70	50	13.5	0.61	45	4.86	88	14.586	280
HY10	7.75	488.32	215	70	47	4.25	1.5	56	2.21	80	14.586	260
HY11	8.48	492.8	160	50	50	5.15	1.5	48	3.02	72	24.31	280
HY12	7.3	240	122	20	33	0.3	0.25	21	3.47	40	9.724	140
HY13	7.37	729.6	270	100	70	22.5	1.2	88	3.03	96	34.034	380
HY14	8.38	558.08	187	100	1.7	11.85	0.54	63	1.96	104	9.724	300
HY15	7.65	723.2	210	120	120	15.5	0.84	86	2.45	120	19.448	379
HY16	8.31	761.6	238	100	70	16	1.1	100	3.4	96	34.034	380
HY17	8.65	475.52	120	80	35	5.185	0.56	106	3.69	40	9.724	140
HY18	7.98	780.8	240	140	138	6.4	0.52	108	1.53	72	48.62	380

A 41 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Bowenpally Watershed – Premonsoon 2012

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
BH1	8.27	1286.4	440	260	153	8	1.3	308	5.1	64	43.758	340
BH2	7.2	1094.4	274	270	166	5.35	1.1	144	8.1	96	72.93	540
BH3	8.47	552.96	155	70	73	5	1.7	70	2.59	80	19.448	280
BH4	8.25	678.4	240	80	45	35	0.56	77	7	72	43.758	360
BH6	7.79	972.8	231	200	185	13	1	146	8.3	112	38.896	439
BH7	8.79	548.48	140	80	63	1.5	0.62	100	11.73	72	4.862	200
BH8	7.78	1196.8	260	250	110	55.5	0.68	190	8.7	104	63.206	520
BH9	7.77	1459.2	356	380	195	9.5	0.89	314	6.9	88	58.344	460
BH10	7.95	979.2	260	240	60	27	0.82	116	1.28	80	77.792	520
BH11	8.14	678.4	275	110	55	10.5	0.67	98	1.55	88	24.31	320
BH12	7.75	684.8	206	130	75	17.5	0.87	82	1.91	88	34.034	360
BH13	8.48	844.8	224	160	82	10.8	1.8	163	9.1	40	48.62	300
BH14	8.11	928	284	180	97	22	1.2	112	7.4	72	72.93	480
BH15	8.19	428.8	180	50	39	11.35	0.58	34	3.34	80	14.586	260
BH16	7.91	633.6	226	90	63	20	0.46	36	2.07	88	48.62	420
BH17	8.01	1049.6	262	170	70	66.5	1.2	146	8	80	72.93	500
BH18	8.08	659.2	171	130	60	26	0.73	72	3.15	80	38.896	360
BH19	8.03	1171.2	178	260	150	57.5	0.29	101	3.7	176	63.206	699
BH20	7.99	889.6	237	190	111	19	1.3	117	5.54	88	53.482	440
BH21	8.08	691.2	215	110	55	30	1.3	65	3.04	104	34.034	400
BH22	7.75	1120	289	280	111	18.7	1.5	164	6.4	72	82.654	520
BH23	8.1	458.88	147	90	62	4.5	1.2	74	1.62	40	24.31	200
BH24	8.24	748.8	259	160	57	9.8	0.99	121	5.5	40	53.482	320
BH25	8.03	697.6	274	140	42	6.9	0.78	105	1.96	40	53.482	320

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
BH26	7.98	394.88	165	60	32	6.4	0.48	41	1.94	48	24.31	220
BH27	7.83	774.4	211	180	91	11	0.69	112	5.3	72	43.758	360
BH28	8.34	393.6	138	40	35	3.8	0.97	41	1.5	40	29.172	220
BH29	8.72	323.2	87	40	26	5.5	0.51	33	1.97	72	0	180
BH30	7.74	742.4	280	160	45	6	1.2	66	1.66	96	48.62	440
BH31	7.6	665.6	234	130	73	5.95	1.3	93	2.4	88	24.31	320
BH32	8.01	619.52	128	190	79	0.35	2.6	140	2.74	40	19.448	180
BH33	7.75	684.8	165	160	65	20	1.2	91	2.53	80	34.034	340
BH34	7.8	474.24	120	110	50	11.05	1.1	42	2.22	80	19.448	280
BH35	8.06	832	315	180	39	9.6	1.3	98	3	104	43.758	440
BH36	7.77	659.2	193	130	58	20.5	1.5	80	4.85	96	24.31	340
BH37	7.59	755.2	267	160	68	5.75	0.99	107	2.56	72	43.758	360
BH38	8.35	542.72	177	70	46	4.6	1.6	86	1.23	40	34.034	240
BH39	8.08	736	220	140	79	19.5	1.6	73	2.32	72	58.344	420
BH40	8.88	382.08	178	20	10	5.25	1.4	46	1.31	40	24.31	200
BH41	7.9	844.8	233	180	93	19.5	0.56	93	3.05	56	77.792	460
BH42	7.98	516.48	230	80	34	5.9	0.91	66	3.63	56	29.172	260

A 42 Groundwater quality analyses for major ion concentration in Hussainsagar catchment area, Hussainsagar Downstream Watershed – Premonsoon 2012

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
HS1	8.35	504.96	81	150	32	1.45	0.22	67	10.79	32	38.896	240
HS2	8.09	612.48	311	100	19	0.65	0.94	92	3.4	64	29.172	280
HS3	8.66	341.76	99	40	40	2.05	0.23	45	9.89	48	9.724	160
HS4	7.99	665.6	278	160	8	0.7	0.46	101	4.39	48	43.758	300
HS5	8.12	394.88	175	60	33	3.25	1.4	68	2.37	56	4.862	160
HS6	7.89	1401.6	212	560	78	0.4	1.4	292	9.5	72	68.068	460
HS7	8.29	537.6	104	110	60	26.5	0.36	62	22.87	88	9.724	260
HS8	8.17	998.4	281	180	185	12.5	1.76	143	28.4	88	53.482	440
HS9	8.39	205.44	44	30	25	1.75	0.34	17	4.19	40	4.862	120
HS10	8.1	704	279	100	70	14.5	0.87	104	7.47	48	48.62	320
HS11	8.72	526.72	94	120	32	8.5	0.76	43	1.77	72	34.034	320
HS12	7.95	459.52	121	90	67	10.7	0.94	55	1.89	64	19.448	240
HS13	8.27	597.76	196	110	71	10.5	1.3	96	2.89	56	29.172	260
HS14	8.41	387.84	56	80	51	5.05	0.88	57	1.51	32	24.31	180
HS15	7.91	742.4	209	150	67	23.5	0.67	92	4.1	104	29.172	380
HS16	8.05	535.68	130	110	73	15	0.61	56	1.5	80	24.31	300
HS17	8.57	400.64	75	70	59	9.85	0.78	51	4.05	64	9.724	200
HS18	8.2	625.92	222	120	73	4.75	0.74	84	8.11	48	43.758	300
HS19	8.54	289.28	79	40	43	1	0.3	29	3.31	32	19.448	160
HS21	7.98	513.28	188	70	70	10.5	0.65	74	2.71	64	19.448	240
HS22	8.03	500.48	172	90	45	11.5	0.46	59	5.89	56	29.172	260
HS23	8.24	526.08	175	90	61	11.5	0.31	46	11.95	72	29.172	300
HS24	7.97	780.8	219	110	83	40	0.38	96	5.84	80	48.62	400
HS25	8.27	697.6	269	120	62	10.2	0.69	102	6.53	40	53.482	320

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
HS26	8.18	510.08	183	100	50	5.05	2	67	13.33	56	24.31	240
HS27	7.98	520.96	171	90	68	9.55	1.73	61	14.63	56	29.172	260
HS28	8.44	524.8	141	70	71	3.3	1.5	64	12.11	48	34.034	260

A 43 Groundwater Quality in PDS piezometers in Hussainsagar Catchment – Premonsoon 2012

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
P1	8.74	310.4	81	10	29	4	1.9	56	1.82	16	19.448	120
P2	8.52	195.2	65	20	16	0.3	0.3	14	3.04	24	14.586	120
P3	8.54	359.68	81	60	36	4.1	1.4	56	1.35	24	24.31	160
P4	8.67	593.92	153	140	37	3	0.95	104	1.68	32	39	240
P5	9.04	1164.8	266	220	121	10.95	0.5	330	0.8	16	38.896	200
P6	8.65	825.6	126	210	72	11.55	1.6	160	2	24	58	299
P7	8.4	896	177	220	86	27	0.51	166	4.6	8	77.792	340
P8	8.56	1676.8	294	530	89	12	1.4	368	3	40	102.102	520
P9	8.33	527.36	108	110	41	11.75	1.4	71	1.78	16	53.482	260
P10	8.18	633.6	226	130	70	2.2	1	109	2	40	38.896	260
P11	7.91	1721.6	26	620	395	5.7	0.31	134	5.5	80	209.066	1060
P13	8.16	549.76	79	130	67	26	1.7	42	1.66	80	34.034	340
P14	8.92	609.92	160	70	74	10	0.91	65	15.45	80	29	319
P15	8.53	291.84	50	50	43	0.15	0.22	40	2.3	32	14.586	140
P16	8.72	245.12	88	30	15	1	0.35	22	4.18	56	0	140
P17	8.35	646.4	151	130	155	1.25	0.94	95	2.13	64	34.034	300
P18	8.45	382.72	150	60	35	6.9	1.4	37	1.47	32	34.034	220
P19	8.43	448.64	120	100	61	6.25	0.64	80	0.86	48	14.586	180
P20	8.38	450.56	170	70	55	6.2	0.64	89	0.9	40	14.586	160
P21	8.39	503.04	198	80	41	9.85	0.35	90	1.14	32	29.172	200
P23	8.51	513.28	122	90	51	9.75	0.38	84	1.36	32	34.034	220
P24	8.53	761.6	146	170	98	11.5	1.2	127	4.45	48	48.62	320
P25	8.5	364.8	122	40	33	8.1	2	40	1.45	32	29.172	200

A 44 Groundwater Quality in PDS piezometers in Hussain Sagar Catchment – Post-monsoon 2012

(All Values are in mg/l except pH)

Obs. No	pH	TDS	HCO3	Cl	SO4	NO3	F	Na	K	Ca	Mg	TH
P1	8.45	446	264	20	20	3.48		78	2	56	10	180.8713
P2	8.15	826	190	180	117	20.3		114	3	112	29	398.7721
P3	8.37	749	273	130	65	4.11		96	2	96	34	379.4218
P4	7.92	360	216	20	21	3.34		46	3	48	15	181.4822
P5	8.16	1069	475	160	100	6.15		259	0	48	39	280.2273
P6	8.27	1005	338	200	80	20.6		178	5	72	53	397.7118
P7	8.03	960	362	160	80	20		154	3	104	39	419.9548
P8	8.27	986	377	220	70	0.53		127	2	96	63	498.7389
P9	7.83	774	379	110	40	6.5		113	4	96	29	358.8499
P10	8.4	236	120	20	10	0.99		19	4	32	15	141.56
P11	7.71	2672	90	1100	370	11.27		136	10	520	122	1799.424
P12	7.81	749	333	90	65	14.43		50	1	112	49	481.0597
P13	7.39	781	260	140	61	23.1		43	2	88	73	519.9216
P14	8.02	742	320	100	72	10.83		103	2	80	39	360.0716
P15	8.3	466	178	50	55	4.13		104	1	40	10	140.9492
P16	7.65	698	260	90	61	25		94	5	104	19	337.6672
P17	7.89	909	282	110	250	1.55		108	2	152	24	478.0056
P18	7.77	540	250	60	45	10.1		57	2	88	19	297.7451
P19	7.24	367	159	50	38	4.18		32	1	64	15	221.4043
P20	7.76	749	282	90	125	11.11		105	2	72	44	360.6824
P21	7.38	813	413	100	70	0.41		128	3	104	24	358.2391
P22	7.57	1171	341	220	155	26		121	2	168	58	657.8167
P23	7.81	1158	374	200	145	24.85		143	2	168	44	600.2153
P24	7.81	986	317	180	120	18.7		107	4	168	29	538.4996
P25	8.58	278	110	30	30.6	3.19		36	2	32	15	141.56

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during Premonsoon 2003 (after NGRI)

Well No	Latitude ^{0}N	Longitude ^{0}E	Beryllium	Aluminium	Vanadium	Chromium	Manganese	Cobalt	Nickel	Copper	Zinc	Arsenic
BH1	17.465806	78.445417	0.5	69.4	24	5.6	519.4	3.6	127.6	2.1	99.2	12.7
BH2	17.463472	78.442194	0.6	48.3	12.1	4.2	1036	2.5	108.9	3.2	2801	9.7
BH3	17.463722	78.434333	0.4	96.0	7.8	4.4	27.3	4.3	106.8	2.7	117.5	5.7
BH4	17.467694	78.431500	0.3	48.3	13.4	5.0	7.2	4.5	86.87	3.4	50.1	5.5
BH5	17.474028	78.429139	0.4	61.8	21.6	6.6	1592	2.1	101.1	3.5	139.4	9.4
BH6	17.473694	78.444222	0.4	114.8	10.0	5.0	213.8	3.0	80.1	2.9	2613	6.4
BH7	17.469694	78.435667	0.4	68.6	34.7	6.2	9.7	4.5	82.9	8.0	134.7	14.7
BH8	17.459528	78.449528	0.3	110	17.3	4.8	36.6	1.9	79.0	3.8	280.7	8.8
BH9	17.459556	78.456111	0.3	59	14.7	5.6	187.4	3.0	97.3	7.3	1038	6.6
BH10	17.456556	78.468333	0.3	43	11.8	4.5	5.9	5.0	69.1	2.4	40.3	4.9
BH11	17.462944	78.471361	0.3	85	9.1	4.4	17.5	4.9	69.3	3.2	192.3	5.7
BH12	17.456500	78.483667	0.3	54	10.7	5.1	26.2	3.9	79.2	4.9	1134	6.5
BH13	17.466250	78.483444	0.3	411	11.1	8.9	33.0	4.7	71.3	8.7	93.7	6.9
BH14	17.472250	78.478694	0.4	61	14.7	5.6	40.4	4.2	77.6	3.7	145.3	8.1
BH15	17.480250	78.476194	0.3	209	12.0	6.6	7.5	4.4	80.7	7.7	234.1	6
BH16	17.489250	78.485139	0.2	44	7.7	4.9	14.2	4.2	76.9	6.1	1880	4.2
BH17	17.487944	78.496306	0.4	52	63.2	6.6	15.0	4.0	85.4	16.4	1142	16.6
BH18	17.483194	78.489167	0.3	64	32.2	6.0	154.6	1.9	134.6	7.7		14.7
BH19	17.478583	78.487444	0.2	36	12.7	5.2	25.7	4.3	73.2	11.0	3178	6.2
BH20	17.469806	78.489194	0.5	843	16.7	10.6	104.4	10.5	143.3	25.4	2552	6.8
BH21	17.457639	78.494083	0.3	35	7.8	4.8	31.4	4.9	60.6	13.8	361.2	4.2
BH22	17.447472	78.497722	0.3	76	24.8	5.6	5.74	4.6	69.9	7.64	124.4	6.1
BH23	17.443139	78.483417	0.2	64	4.5	3.8	3.6	5.2	57.1	4.5	41.8	3.1
BH24	17.450167	78.476778	0.3	64	17.6	5.8	169.9	4.2	74.6	4.4	192.2	7.5
BH25	17.433000	78.485167	0.2	29	10.0	4.5	12.8	4.4	95.2	2.3	43.1	5.1
BH26	17.436722	78.475333	0.3	55	8.6	4.0	21.2	4.7	70.7	2.2	45.2	3.5
BH27	17.448528	78.456778	0.3	52	11.4	5.7	360.4	3.5	83.1	3.5	243.2	6.8
BH28	17.446583	78.466361	0.3	31	8.3	4.5	10.2	5.0	64.4	1.9	43.6	4.1
BH29	17.443028	78.470472	0.4	43	4.0	4.2	9.4	4.9	65.5	19.5	77.9	3.4

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No.	Latitude ^{0}N	Longitude ^{0}E	Selenium	Strontium	Molybdenum	Silver	Cadmium	Antimony	Barium	Mercury	Thallium	Lead
BH1	17.465806	78.445417	27.3	19460	4.1	0.04	1.2	1.2	217.1	1.7	0.3	2.2
BH2	17.463472	78.442194	24.7	17010	6.8	0.04	1.3	1.2	111	2.6	0.3	1.9
BH3	17.463722	78.434333	6.4	16460	5.2	0.09	1.3	1.4	125	1.0	0.1	2.8
BH4	17.467694	78.431500	8.3	14420	5.2	0.03	1.1	1.3	202.1	2.3	0.2	4.6
BH5	17.474028	78.429139	9.3	32580	6.3	0.02	1.0	1.3	60.7	3.6	0.3	1.8
BH6	17.473694	78.444222	7.8	14870	7.8	0.04	1.0	1.3	75.2	2.8	0.2	2.1
BH7	17.469694	78.435667	23.3	24860	9.6	0.05	1.3	1.4	144.8	3.5	0.4	2.1
BH8	17.459528	78.449528	53.8	25870	8.5	0.04	1.3	1.3	278.4	3.2	0.4	1.2
BH9	17.459556	78.456111	13.1	16580	6.2	0.02	1.2	1.2	192.5	1.5	0.2	2.9
BH10	17.456556	78.468333	4.1	9017	4.9	0.03	1.0	2.7	131.4	2.8	0.2	84.4
BH11	17.462944	78.471361	3.1	7424	4.4	0.05	1.0	1.4	104	2.3	0.3	4.8
BH12	17.456500	78.483667	12.5	17020	7.5	0.04	1.1	1.6	147.3	2.4	0.1	2.4
BH13	17.466250	78.483444	8.6	10210	9.3	0.04	1.7	1.4	53.2	1.9	0.1	13
BH14	17.472250	78.478694	11.5	22170	4.5	0.04	1.8	0.2	106.5	3.1	0.4	1.6
BH15	17.480250	78.476194	8.0	15780	4.5	0.06	1.9	1.3	157.6	2.5	0.1	5.4
BH16	17.489250	78.485139	7.5	13830	3.4	0.03	1.1	1.3	178	3.4	0.2	2.2
BH17	17.487944	78.496306	26.9	77590	2.9	0.0003	1.1	1.4	90.5	3.3	0.2	2.3
BH18	17.483194	78.489167	22.2	46850	4.2	0.03	2.0	2.6	113.3	2.6	0.4	6.4
BH19	17.478583	78.487444	8.8	14630	2.9	0.01	1.4	1.6	133.8	3.2	0.2	2.3
BH20	17.469806	78.489194	9.6	14510	14.3	0.01	2.1	1.5	197.1	3.1	0.3	332.6
BH21	17.457639	78.494083	1.0	8164	5.7	0.005	1.1	1.3	10.0	3.8	0.2	1.9
BH22	17.447472	78.497722	9.3	12080	7.9	0.08	1.1	1.2	87.2	1.9	0.3	3.1
BH23	17.443139	78.483417	4.1	3411	3.6	0.01	1.1	1.4	67.4	1.8	0.2	2.3
BH24	17.450167	78.476778	9.3	17150	7.3	0.01	1.2	1.3	240.9	2.0	0.4	1.7
BH25	17.433000	78.485167	5.1	11150	11.3	0.005	1.1	1.3	91.6	3.6	0.2	1.1
BH26	17.436722	78.475333	3.0	7608	4.2	0.03	1.2	1.2	42.2	2.5	0.2	1.07
BH27	17.448528	78.456778	17.0	14200	13.2	0.03	1.3	1.3	127.3	2.7	0.2	1.5
BH28	17.446583	78.466361	6.9	12140	5.3	0.04	1.2	1.3	133.6	2.9	0.1	5.4
BH29	17.443028	78.470472	3.04	5513	4.1	0.03	1.1	1.3	94.7	2.4	0.3	1.6

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Beryllium	Aluminium	Vanadium	Chromium	Manganese	Cobalt	Nickel	Copper	Zinc	Arsenic
BH30	17.466250	78.505472	0.3	97.0	7.6	4.5	16.2	4.2	73.9	6.4	1277	4.0
BH31	17.473583	78.517750	0.4	64.1	6.3	4.7	8.1	4.3	71.5	4.1	64.4	3.5
BH32	17.491278	78.518389	0.2	150	10.3	4.3	3.6	5.2	51.3	3.6	58.9	2.8
BH33	17.496528	78.507083	0.2	68.1	1.5	4.3	42.9	5.1	74.8	5.8	176.8	2.8
BH34	17.486361	78.502806	0.3	72.3	6.2	5.6	53.2	4.3	81.3	7.4	447.2	3.2
BH35	17.472972	78.499111	0.2	54.2	4.0	5.0	13.2	5.0	71.3	10.7	149.1	2.2
BH36	17.477944	78.508278	0.2	62.8	5.1	5.4	328.8	4.4	81.2	4.3	40.7	3.0
BH37	17.481389	78.511611	0.5	113.0	7.0	5.7	34.6	4.3	72.9	5.6	270.3	4.1
BH38	17.457250	78.514444	0.3	50.0	19.0	7.4	6.9	4.5	76.0	2.4	43.1	4.0
BH39	17.454944	78.503167	0.3	80.2	10.1	6.1	5.2	4.9	65.7	5.8	283.5	3.1
BH40	17.476917	78.470222	0.2	60.0	2.5	5.8	24.5	4.9	62.9	5.7	1150	2.3
BH41	17.465806	78.463583	0.2	72.0	9.5	6.0	12.7	4.8	68.4	2.6	183	3.4
BH42	17.469306	78.456500	0.2	65.5	30.8	7.0	159	2.7	99.1	11.4	2600	13.0
BH42A	17.469306	78.456500	0.2	54.9	15.2	7.0	8.5	3.6	77.6	8.6	905.6	6.4
HS1	17.435889	78.495028	0.3	106.5	14.5	10.2	10.0	4.2	75.0	6.3	116.9	5.5
HS2	17.427889	78.493722	0.4	214.8	17.0	14.0	208.6	4.2	82.9	7.0	112.4	111.2
HS3	17.422111	78.485861	0.3	219.5	15.8	10.0	45.1	4.3	78.9	8.7	47.1	5.7
HS4	17.414750	78.491750	0.3	190.1	11.5	10.2	21.8	4.0	68.7	12.5	38.8	6.2
HS5	17.409167	78.492444	0.2	275.7	31.5	15.3	27.6	2.8	111.5	9.5	146.2	8.3
HS6	17.417750	78.482750	0.2	147.5	14.2	11.4	319.5	3.7	54.6	10.4	43.2	4.1
HS7	17.407722	78.477167	0.2	235.6	24.0	21.2	19.6	3.9	89.7	11.8	44.7	6.8
HS8	17.403000	78.487194	0.3	296.3	8.1	9.8	65.6	4.3	53.2	7.9	84.5	4.0
HS9	17.398250	78.472778	0.2	170.2	12.3	12.3	35.7	4.4	66.6	12.7	111.3	5.4
HS10	17.410472	78.464194	0.4	292.3	12.0	16.2	26.9	4.2	87.2	14.4	1649	5.0
HS11	17.403333	78.467278	0.2	233.6	11.6	12.1	13.8	4.7	59.9	9.5	616.8	4.3
HS12	17.432444	78.503528	0.2	143.4	4.6	13.6	20.4	4.7	58.8	7.2	58.0	3.2
HS13	17.420250	78.506250	0.3	266.6	8.7	12.2	26.0	4.3	64.4	14.9	281.9	4.3
HS14	17.408194	78.510694	0.5	344.8	11.8	16.4	206.9	2.6	81.8	14.9	3774	6.1
HS15	17.417361	78.519417	0.4	176.1	10.5	14.9	18.5	4.3	65.9	10.0	109.9	4.2

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Selenium	Strontium	Molybdenum	Silver	Cadmium	Antimony	Barium	Mercury	Thallium	Lead
BH30	17.466250	78.505472	7.5	21170	7.04	0.07	1.3	1.48	134.7	2.6	0.2	5.3
BH31	17.473583	78.517750	8.2	11890	4.2	0.03	1.1	1.2	294.2	4.8	0.4	2.6
BH32	17.491278	78.518389	3.0	1573	3.1	0.006	1.1	1.4	42.3	2.9	0.1	1.5
BH33	17.496528	78.507083	3.7	3224	4.6	0.02	1.4	1.3	94.8	2.4	0.2	2.2
BH34	17.486361	78.502806	6.3	10710	5.1	0.06	1.3	1.3	246.6	2.2	0.3	2.3
BH35	17.472972	78.499111	2.0	4973	3.54	0.03	1.1	1.2	45.7	2.3	0.2	1.6
BH36	17.477944	78.508278	4.3	8844	12.3	0.03	1.2	1.2	204	2.2	0.06	2.3
BH37	17.481389	78.511611	7.8	13700	14.2	0.04	1.4	1.3	205.7	3.5	0.3	3.5
BH38	17.457250	78.514444	10.3	13570	3.7	0.003	1.2	1.2	45.6	2.8	0.3	1.3
BH39	17.454944	78.503167	7.4	10690	5.5	0.02	1.1	1.2	62.0	2.3	0.2	1.8
BH40	17.476917	78.470222	6.5	5975	4.4	0.03	1.2	1.3	54.1	2.4	0.4	1.1
BH41	17.465806	78.463583	10.7	17220	5.7	0.03	1.1	1.4	274.5	2.4	0.2	1.4
BH42	17.469306	78.456500	33.9	48640	5.5	0.03	2.4	1.7	388.2	3.3	0.3	1.5
BH42A	17.469306	78.456500	18.0	20790	5.23	0.01	1.3	1.3	194.5	3.8	0.5	1.7
HS1	17.435889	78.495028	12.1	13630	4.03	0.07	1.4	1.3	155	4.0	0.5	2.9
HS2	17.427889	78.493722	8.2	10030	8.6	0.08	1.2	1.4	118.5	2.6	0.6	5.8
HS3	17.422111	78.485861	14.2	12930	6.3	0.03	1.2	1.4	151	2.8	0.2	7.4
HS4	17.414750	78.491750	15.0	8590	5.5	0.02	1.1	1.3	98.5	2.9	0.2	4.7
HS5	17.409167	78.492444	17.2	25740	3.5	0.1	1.7	1.4	141.9	5.1	0.4	7.3
HS6	17.417750	78.482750	13.1	11030	4.7	0.09	1.2	1.3	55.2	2.1	0.2	7.1
HS7	17.407722	78.477167	28.4	9319	11.4	0.05	1.7	1.6	183.9	3.1	0.3	7.7
HS8	17.403000	78.487194	7.9	8006	4.6	0.06	1.5	1.3	107	2.1	0.4	8.0
HS9	17.398250	78.472778	9.7	5934	7.1	0.004	1.3	1.4	90.1	5.6	0.2	6.6
HS10	17.410472	78.464194	8.5	18740	8.6	0.07	1.5	1.5	257.5	3.8	0.3	9.9
HS11	17.403333	78.467278	10.0	14070	4.2	0.08	1.2	1.4	94.7	2.0	0.4	5.6
HS12	17.432444	78.503528	7.7	3251	17.6	0.03	1.4	1.4	64.5	2.3	0.2	7.7
HS13	17.420250	78.506250	10.0	7074	9.2	0.08	1.6	1.4	130.1	2.2	0.5	36.2
HS14	17.408194	78.510694	14.0	15580	8.06	0.16	2.9	1.9	176.7	1.7	0.6	10.3
HS15	17.417361	78.519417	12.0	6715	4.9	0.08	1.2	1.6	147.2	1.8	0.2	6.5

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Beryllium	Aluminium	Vanadium	Chromium	Manganese	Cobalt	Nickel	Copper	Zinc	Arsenic
HS16	17.427000	78.519556	0.3	184.1	9.03	11.6	19.3	4.3	79.4	32.1	573.2	3.4
HS17	17.407611	78.502028	0.4	187.7	8.3	14.2	14.4	4.6	72.6	5.4	121	3.1
HS18	17.401000	78.503222	0.3	114	6.6	10.4	91.1	4.1	62.6	6.2	599.1	3.2
HS19	17.394722	78.500056	0.2	123.9	13.6	11.0	251.2	4.0	64.2	24.0	2891	5.0
HS20	17.471750	78.487472	0.3	90.8	13.8	10.0	232.5	3.4	70.1	11.7	184.2	4.4
HS21	17.393556	78.482917	0.4	62.7	6.2	10.7	17.03	4.6	58.4	2.6	201.3	2.8
HS22	17.387750	78.472194	0.2	83.8	9.2	10.0	8.9	4.5	82.0	21.6	507.3	4.8
HS23	17.395361	78.459472	0.4	65.6	6.7	10.4	70.9	4.7	63.6	8.9	2768	4
HS24	17.380889	78.489972	0.2	168.9	32.7	10.9	14.8	3.6	78.2	7.0	57.6	5.3
HS25	17.385333	78.498833	0.5	210.8	14.6	13.0	354.1	3.8	67.6	21.0	317.2	5.7
HS26	17.388111	78.506611	0.4	101.7	15.2	11.8	219.3	3.5	65.0	8.8	217.6	6.8
HS27	17.380806	78.518917	0.3	85.5	14.5	13.1	29.3	4.2	70.2	8.5	2674	7.6
HS28	17.394806	78.513389	0.4	100.5	17.9	15.7	706.8	1.3	73.9	25.7	65.86	6.5
HK1	17.462830	78.426860	0.5	282	44.5	26.3	17.7	0.3	132.6	10.1	50.0	13.4
HK2	17.469528	78.423417	0.3	172	33.3	14.5	13.4	4.3	65.0	6.6	294.2	4.8
HK3	17.469750	78.420194	0.2	116.2	22.2	13.8	16.46	2.7	66.1	6.1	44.0	5.3
HK4	17.480139	78.416611	0.3	158.2	11.0	15.2	41.4	4.0	67.4	6.5	28.1	5.0
HK5	17.487583	78.413667	0.2	104.7	11.8	13.3	17.9	4.2	64.6	4.6	1166	5.0
HK6	17.490028	78.419722	0.3	133.4	14.5	14.7	599.7	4.4	67.8	8.2	163.3	4.8
HK7	17.496972	78.418500	0.4	117.4	6.2	12.5	336	4.5	58.3	6.6	606.8	3.5
HK8	17.497139	78.427306	0.4	422.4	8.3	16.5	50.3	4.5	67.6	11.2	745.7	3.8
HK9	17.490500	78.429472	0.2	103.8	20.6	15.1	36.3	3.5	78.0	9.0	206.5	7.5
HK10	17.481806	78.427250	0.2	87.9	4.5	6.8	25.2	4.9	47.8	3.7	1329	4
HK11	17.459472	78.420944	0.3	180.7	12.5	12.7	10.8	4.3	65.0	3.6	42.4	4.9
HB1	17.404889	78.418028	0.3	66.3	11.6	10.8	36.2	4.1	76.7	7.0	411.7	4.7
HB2	17.401639	78.482556	0.2	24.6	3.15	8.5	2307	3.7	84.4	8.3	263.3	4.2
HB3	17.404170	78.438000	0.2	47.2	12.3	5.1	134.2	4.6	60.1	4.1	36.5	3.1
HB4	17.413417	78.440806	0.2	53.4	15.1	10.4	433.7	3.6	64.1	4.8	45.8	6.2
HB5	17.414611	78.450806	0.2	75.2	4.03	6.3	29.5	4.9	50.8	5.7	146.8	3.3

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Selenium	Strontium	Molybdenum	Silver	Cadmium	Antimony	Barium	Mercury	Thallium	Lead
HS16	17.427000	78.519556	9	11020	4.34	0.04	1.48	1.9	55.5	3.6	0.2	10.8
HS17	17.407611	78.502028	8.9	9762	9.5	0.12	1.7	1.5	101.2	4.8	0.2	8.8
HS18	17.401000	78.503222	12	15540	4.5	0.006	1.4	1.3	191.8	2.9	0.2	6.8
HS19	17.394722	78.500056	7.3	9442	8.1	0.02	1.8	1.4	156.2	2.9	0.4	4.5
HS20	17.471750	78.487472	5.9	17640	5.1	0.08	1.3	1.4	216.9	2.0	0.2	4.5
HS21	17.393556	78.482917	3.8	6428	7.1	0.06	1.3	1.3	62.4	3.9	0.3	4.3
HS22	17.387750	78.472194	14.3	8295	7.9	0.02	1.5	1.3	138	3.6	0.3	4.3
HS23	17.395361	78.459472	10.1	4289	15.7	0.08	1.3	1.3	74.4	2.8	0.3	4
HS24	17.380889	78.489972	9.5	21180	16.7	0.03	1.3	1.3	432.6	3.3	0.4	18
HS25	17.385333	78.498833	6.4	18630	8.1	0.07	1.5	1.2	276.8	4.6	0.4	8.4
HS26	17.388111	78.506611	14.6	11460	14.5	0.08	1.4	1.2	113.4	3.3	0.4	4.5
HS27	17.380806	78.518917	20.1	15050	5.1	0.06	1.3	1.4	98.0	2.2	0.5	5.9
HS28	17.394806	78.513389	11	24000	5.3	0.02	1.6	1.5	214.3	2.4	0.3	5.2
HK1	17.462830	78.426860	30.4	32410	18	0.12	2.0	1.4	312.6	9.7	0.5	9.1
HK2	17.469528	78.423417	8.2	12010	4.8	0.04	1.3	1.4	172.5	3.0	0.5	4.2
HK3	17.469750	78.420194	8.6	15220	8.7	0.02	1.3	1.2	131.5	6.5	0.1	7.7
HK4	17.480139	78.416611	11.9	15170	7.7	0.03	1.2	1.4	258.8	5.1	0.2	5.5
HK5	17.487583	78.413667	11.3	13390	5.0	0.05	1.3	1.3	141.8	5.2	0.4	3.9
HK6	17.490028	78.419722	9.2	11030	49.2	0.07	1.8	1.4	110.5	4.3	0.3	5.0
HK7	17.496972	78.418500	7.7	7523	23.9	0.04	1.3	1.3	179	5.4	0.2	2.8
HK8	17.497139	78.427306	12.6	9275	6.2	0.19	1.6	1.6	112.1	2.8	0.3	8.8
HK9	17.490500	78.429472	7.8	14420	8.6	0.08	1.2	1.4	72.5	3.8	0.2	2.7
HK10	17.481806	78.427250	10.8	7444	14.5	0.02	1.1	1.7	43.57	4.0	0.3	12.7
HK11	17.459472	78.420944	8.6	15980	10.1	0.07	1.3	1.4	150.5	4.6	0.3	3.6
HB1	17.404889	78.418028	7.6	13020	7.5	0.06	1.6	1.3	172	5.0	0.3	4.3
HB2	17.401639	78.482556	5.8	11270	6.5	0.03	1.2	1.5	276.7	2.5	0.3	3.6
HB3	17.404170	78.438000	7.7	6375	10.8	0.004	1.2	1.3	10.5	3.6	0.3	2.9
HB4	17.413417	78.440806	5.9	5318	14.0	0.03	1.3	1.6	125.8	3.2	0.5	2.7
HB5	17.414611	78.450806	4.6	2636	12.4	0.03	1.1	1.3	46	4.7	0.2	3.3

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Beryllium	Aluminium	Vanadium	Chromium	Manganese	Cobalt	Nickel	Copper	Zinc	Arsenic
HB6	17.420972	78.440333	0.3	32.3	9.56	8.5	23.4	4.4	62.7	4.4	27.2	4.6
HB7	17.417139	78.461556	0.3	72.4	9.07	8.6	397.6	2.1	57.5	4.7	291.9	4.9
HB8	17.423333	78.456750	0.2	36.2	2.09	5.4	13.5	4.8	47.5	2.9	35.4	2.9
HB9	17.407806	78.457806	0.2	53.5	6.44	9.6	11.4	4.6	55	8.4	441.7	3.6
HB10	17.423472	78.446722	0.3	52.5	3.5	8.3	49.8	2.4	59.5	7.6	651.2	3.2
HB11	17.399611	78.459944	0.2	65.0	6.0	10.1	3827	1.9	58.7	8.9	416.1	3.7
HY1	17.423500	78.427861	0.3	18.9	3.1	20.2	3.8	5.0	48.2	2.8	74.8	2.9
HY2	17.441722	78.431778	0.3	26.6	4.1	9.1	10.3	4.9	53.7	2.9	90.7	2.8
HY3	17.434278	78.439722	0.4	73.7	4.4	15.3	2001	0.5	72.5	2.1	975.8	2.7
HY4	17.435806	78.427861	0.3	85.0	2.1	14.6	125.8	4.7	69.4	4.3	2033	2.1
HY5	17.436528	78.419972	0.2	144.1	12.4	12.4	21.6	5.1	52.2	2.2	182.5	2.7
HY6	17.442278	78.426194	0.4	147.4	2.73	10.5	299.6	3.3	629.5	5.3	1186	2.8
HY7	17.453583	78.415111	0.2	52.2	2.9	11.2	22.5	5.0	54.5	3.4	106.7	2.2
HY8	17.456250	78.422194	0.2	80.8	2.0	11.7	50.7	4.5	59	4.8	1338	2.9
HY9	17.456028	78.432750	0.2	81.9	2.3	12.9	52.0	4.5	57	4.8	1368	2.3
HY10	17.449250	78.435083	0.2	226.6	3.5	10.4	382.4	2.6	54.7	3.6	62.2	3.0
HY11	17.431583	78.450333	0.4	220	11.7	26.0	147.7	3.9	75.6	10.9	1445	4.7
HY12	17.442528	78.445389	0.2	88.5	6.1	15.1	52.9	4.5	73.1	7.4	1252	3.5
HY13	17.451556	78.447361	0.3	236.4	9.0	25.9	43.0	4.3	91.5	11.7	922.8	4.3
HY14	17.456139	78.442611	0.3	115.4	8.5	19.5	303.1	3.1	94	16.1	9512	5.5
HY15	17.449083	78.442833	0.3	113.7	2.3	13.0	18.5	4.8	59.2	6.7	194.8	2.5
HY16	17.439639	78.455417	0.5	100.2	9.5	19.2	20.9	3.9	93.5	8.3	87.7	5.7
HY17	17.429500	78.459250	0.3	55.3	4.2	12.0	114.7	4.5	64.3	3.5	270.2	3.4
HY18	17.435389	78.464722	0.3	144.6	24.4	18.0	23.4	3.6	83.1	5.7	193.5	8.9
HSW1	17.454417	78.501278	0.2	252.7	8.4	19.3	86.6	1.3	124.1	8.4	44.7	5.7
HSW2	17.452472	78.503028	0.3	132.4	7.0	18.2	71.3	1.0	116	9	48.3	6.0
HSW3	17.441111	78.478444	0.3	108.1	8.4	17.1	104.8	1.1	102	7.4	36.7	6.0
HSW4	17.450306	78.476833	0.1	203.6	9.44	15.7	112.8	1.3	86.8	7.5	36.5	6.1
HSW5	17.445139	78.487083	0.2	163.1	9.4	22.7	99.9	1.3	99.9	10.1	40.3	6.0

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Selenium	Strontium	Molybdenum	Silver	Cadmium	Antimony	Barium	Mercury	Thallium	Lead
HB6	17.420972	78.440333	11	8344	36.3	0.03	1.4	1.4	97.0	3.0	0.2	3.5
HB7	17.417139	78.461556	14.6	14280	11.06	0.001	1.3	1.5	127.1	3.4	0.3	3.2
HB8	17.423333	78.456750	5.6	6359	20.3	0.001	1.2	1.2	89.6	4.0	0.6	1.3
HB9	17.407806	78.457806	3.7	5468	12.4	0.07	1.5	1.4	88.1	4.1	0.2	3.1
HB10	17.423472	78.446722	9.2	8469	4.75	0.01	1.2	1.3	77.4	2.3	0.2	1.6
HB11	17.399611	78.459944	9.0	9091	44.76	0.05	1.8	1.4	197.4	3.1	0.3	2.4
HY1	17.423500	78.427861	10.7	5448	10.3	0.002	1.4	1.3	89.8	3.6	0.2	1.5
HY2	17.441722	78.431778	5.3	7962	7.2	0.01	1.3	1.5	101.8	3.0	0.5	0.7
HY3	17.434278	78.439722	28.3	11070	9.8	0.01	1.4	1.4	76.8	28.7	0.3	3.7
HY4	17.435806	78.427861	24.5	4512	15.8	0.027	1.6	2.1	48.6	15.2	0.5	5.8
HY5	17.436528	78.419972	20.5	2412	4.1	0.0003	1.1	1.4	35.2	9.6	0.2	3.7
HY6	17.442278	78.426194	23.1	5778	9.9	0.05	1.4	1.4	141.4	8.6	0.2	4.8
HY7	17.453583	78.415111	24.3	5393	16.6	0.005	1.3	1.2	62.6	6.6	0.2	2.5
HY8	17.456250	78.422194	22.5	6001	8.4	0.01	1.4	1.4	153.6	4.5	0.1	2.8
HY9	17.456028	78.432750	21.8	5882	8.05	0.004	1.6	1.4	142.5	5.2	0.4	4.1
HY10	17.449250	78.435083	21.9	11320	7.0	0.01	1.2	1.2	147.3	6.1	0.3	2.6
HY11	17.431583	78.450333	33.6	5072	40.4	0.09	1.9	1.6	67.7	12.9	0.3	3.5
HY12	17.442528	78.445389	20.4	8689	5.04	0.05	1.4	1.5	149.5	10.9	0.4	4.6
HY13	17.451556	78.447361	26.7	10260	7.1	0.1	1.6	1.5	141.4	10.7	0.3	11.2
HY14	17.456139	78.442611	39.9	21610	5.7	0.05	7.8	1.5	283.9	7.5	0.5	7.4
HY15	17.449083	78.442833	27.7	6255	14.0	0.02	1.3	1.3	76.0	4.5	0.4	4.2
HY16	17.439639	78.455417	56.0	21490	19.0	0.2	1.5	1.5	203.2	9.5	0.2	18.5
HY17	17.429500	78.459250	29.2	12000	7.4	0.06	1.1	1.3	183.4	4.8	0.3	7.7
HY18	17.435389	78.464722	40.3	27670	4.4	0.09	1.4	1.6	86.6	6.6	0.4	5.8
HSW1	17.454417	78.501278	9.4	8311	1.2	0.4	1.1	0.1	95.4	4.7	0.2	9.3
HSW2	17.452472	78.503028	10.3	4689	1.8	0.5	1.3	0.1	46.5	5.3	0.06	4.9
HSW3	17.441111	78.478444	10.0	7347	0.8	0.4	1.0	0.1	76.2	4.8	0.4	4.1
HSW4	17.450306	78.476833	10.6	9474	0.7	0.4	0.7	0.1	94.5	4.5	0.2	7.1
HSW5	17.445139	78.487083	12.2	7017	2.3	0.4	1.2	0.1	66.5	4.4	0.1	6.8

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Beryllium	Aluminium	Vanadium	Chromium	Manganese	Cobalt	Nickel	Copper	Zinc	Arsenic
HSW6	17.466861	78.479917	0.3	169.5	14.4	19.3	117.7	1.6	98.5	9.4	50.4	7.6
HSW7	17.470417	78.488139	0.2	251.9	12.4	18.1	131.6	1.44	92.4	8.3	41.7	6.9
HSW8	17.479444	78.495722	0.2	75.1	10.4	15.2	168.7	1.3	88.9	6.0	20.03	5.8
HSW9	17.463472	78.455750	0.3	209.1	37.5	24.9	1135	2.0	171.7	5.2	108.9	14.6
HSW10	17.464167	78.448278	0.6	1140	19.1	37..3	770.7	5.8	113.9	12	11370	9.85
HSW11	17.386639	78.505083	0.3	125.9	11.3	17.8	170.1	1.3	133.8	5.5	538.7	7.6
HSW12	17.403222	78.489250	0.2	262.6	9.2	16.3	88.5	1.2	98.2	7.8	76.1	6.7
HSW13	17.422639	78.486472	0.2	107.4	9.4	18.1	189.8	1.4	83.6	12.8	38.0	6.7
HSW14	17.408472	78.475250	0.3	53.1	15.5	17.6	16.5	1.0	118.2	8.2	27.5	12.9
HSW15	17.416361	78.462111	0.2	61.4	10.5	18.3	140.9	1.1	95.5	5.7	33.1	5.8
HSW16	17.409917	78.449500	0.2	36.5	6.7	15.5	149.6	1.0	81.7	5.2	21.3	4.5
HSW17	17.423444	78.447250	0.1	69.0	5.3	14.5	79.4	0.7	73.5	5.9	16.6	4.4
HSW18	17.436917	78.445694	0.2	65.2	5.4	16.6	71.4	0.9	70.4	6.0	33.2	4.0
HSW19	17.440944	78.458028	0.2	94.7	10.2	20.2	219.8	1.3	83.4	17.2	64.4	5.8
HSW20	17.449889	78.453806	0.3	54.2	6.8	16.4	85.7	1.0	76.9	4.7	25.3	5.1
HSW21	17.439611	78.430500	0.2	56.7	6.3	15.3	114.1	0.97	76.7	7.5	33.6	4.8
HSW22	17.462694	78.426917	0.2	41.4	5.9	14.1	17.2	0.7	70.3	5.8	19.3	5.0
HSW24	17.453333	78.416806	0.2	57.6	8.3	17.4	6.8	0.8	81.7	6.7	14.9	5.8
HSW25	17.474028	78.427833	0.2	97.9	9.1	21	181.1	1.44	108.1	11.1	51.2	5.2

A 45 Heavy metals (µg/l) in Groundwater & Surface water in Hussain Sagar Lake Catchment Area during June 2003 (after NGRI) (Contd)

Well No	Latitude ^{0}N	Longitude ^{0}E	Selenium	Strontium	Molybdenum	Silver	Cadmium	Antimony	Barium	Mercury	Thallium	Lead
HSW6	17.466861	78.479917	9.6	16930	0.9	0.4	1.2	0.03	110.7	4.4	0.3	7.8
HSW7	17.470417	78.488139	9.2	9316	1.8	0.5	1.03	0.1	109	4.2	0.06	5.4
HSW8	17.479444	78.495722	8.9	8557	1.2	0.4	1.0	0.006	115	4.2	0.3	3.5
HSW9	17.463472	78.455750	373.8	11680	7.0	0.4	1.0	0.2	52.1	5.4	0.4	7.3
HSW10	17.464167	78.448278	42.9	5429	4.1	0.4	11.1	0.1	91.9	3.4	0.32	4.2
HSW11	17.386639	78.505083	21.3	5569	0.8	0.4	1.8	0.3	62.3	5.9	0.05	3.4
HSW12	17.403222	78.489250	22.3	5236	3.9	0.6	1.3	0.02	66.9	3.6	0.15	3.8
HSW13	17.422639	78.486472	14.1	5826	0.9	0.4	1.2	0.1	73.4	4.8	0.05	5.4
HSW14	17.408472	78.475250	27.8	5312	7.2	0.4	1	0.6	42.5	5.2	0.06	2.7
HSW15	17.416361	78.462111	18.4	3945	1.1	0.4	1.2	0.1	52.3	4.5	0.36	3.4
HSW16	17.409917	78.449500	13.1	3397	3.2	0.4	1.1	0.05	60.5	5.6	0.2	2.1
HSW17	17.423444	78.447250	7.7	2173	4.2	0.4	0.9	0.01	36	4.4	0.2	2.4
HSW18	17.436917	78.445694	10.4	2886	1.3	0.4	0.8	0.1	44	6.3	0.3	3.7
HSW19	17.440944	78.458028	176.6	4618	0.9	0.4	9.9	0.08	53	3.1	0.3	4.4
HSW20	17.449889	78.453806	23.1	4725	1.1	0.4	0.9	0.1	52	4.0	0.2	2.8
HSW21	17.439611	78.430500	28.8	2716	0.7	0.4	1.8	0.1	43	4.9	0.2	4
HSW22	17.462694	78.426917	8.5	2358	3.1	0.4	1.0	0.05	31	4.3	0.3	2.1
HSW24	17.453333	78.416806	8.7	3086	4.7	0.4	1.3	0.05	40	4.8	0.2	4.1
HSW25	17.474028	78.427833	15.7	4561	1.9	0.5	1.2	0.05	52	4.8	0.05	4.1

A 46 Arsenic (µg/l) in Groundwater in Hussain Sagar Lake Catchment Area during December 2012

(< 5.0 ug/l is Below detection Limit (BDL))

S.NO	Obs.No	Arsenic	S.NO	Obs.No	Arsenic	S.NO	Obs.No	Arsenic
1	HB1	BDL	37	HY15	6.4086	73	BH34	BDL
2	HB2	BDL	38	HY16	6.2854	74	BH35	BDL
3	HB3	6.9016	39	HY17	6.9016	75	BH36	BDL
4	HB4	5.1762	40	HY18	5.0530	76	BH37	BDL
5	HB5	5.9157	41	BH1	BDL	77	BH38	6.1622
6	HB6	BDL	42	BH2	5.4227	78	BH39	BDL
7	HB7	BDL	43	BH3	8.2573	79	BH40	BDL
8	HB8	BDL	44	BH4	BDL	80	BH41	BDL
9	HB9	BDL	45	BH6	BDL	81	BH42	5.0530
10	HB10	BDL	46	BH7	BDL	82	HS1	BDL
11	HB11	BDL	47	BH8	BDL	83	HS2	8.2573
12	HK1	BDL	48	BH9	BDL	84	HS3	BDL
13	HK2	BDL	49	BH10	BDL	85	HS4	BDL
14	HK3	BDL	50	BH11	BDL	86	HS5	BDL
15	HK4	BDL	51	BH12	BDL	87	HS6	6.0389
16	HK5	BDL	52	BH13	BDL	88	HS7	BDL
17	HK6	BDL	53	BH14	BDL	89	HS8	BDL
18	HK7	BDL	54	BH15	BDL	90	HS9	BDL
19	HK8	6.0389	55	BH16	6.0389	91	HS10	BDL
20	HK9	BDL	56	BH17	6.2854	92	HS11	BDL
21	HK10	BDL	57	BH18	BDL	93	HS12	BDL
22	HK11	BDL	58	BH19	BDL	94	HS13	BDL
23	HY1	8.5159	59	BH20	7.2713	95	HS14	BDL
24	HY2	10.182	60	BH21	5.9157	96	HS15	BDL
25	HY3	8.5159	61	BH22	0.8627	97	HS16	BDL

A 46 Arsenic (µg/l) in Groundwater in Hussain Sagar Lake Catchment Area during December 2012 (Contd…)

(< 5.0 ug/l is Below detection Limit (BDL))

S.NO	Obs.No	Arsenic		S.NO	Obs.No	Arsenic		S.NO	Obs.No	Arsenic
26	HY4	6.8498		62	BH23	5.1762		98	HS17	BDL
27	HY5	8.3308		63	BH24	BDL		99	HS18	BDL
28	HY6	9.8118		64	BH25	BDL		100	HS19	6.0389
29	HY7	7.7754		65	BH26	No sample		101	HS21	6.2854
30	HY8	7.9605		66	BH27	BDL		102	HS22	BDL
31	HY9	BDL		67	BH28	BDL		103	HS23	BDL
32	HY10	6.6646		68	BH29	BDL		104	HS24	BDL
33	HY11	6.8498		69	BH30	BDL		105	HS25	BDL
34	HY12	BDL		70	BH31	BDL		106	HS26	BDL
35	HY13	BDL		71	BH32	BDL		107	HS27	BDL
36	HY14	BDL		72	BH33	BDL		108	HS28	BDL

A 47 Surface Water quality samples of inlet channels into the Hussainsagar Lake - August 2009

All values in mg/l

Sample	Location	BOD	COD	pH	TDS
HSW1	Outlet Viceroy Hotel	10.1	12.5	8.3	1600
HSW2	Inlet- Begumpet	8.4	16.7	7.9	1620
HSW3	Inlet Kukatpally	41.2	121.6	8.5	1210
HSW4	Inlet Yusufguda	47.1	133.3	8.4	1120
HSW5	Inlet Necklace road	37.3	92	8.6	750
HSW6	Inlet Khairatabad	27.6	111	8.3	680

A 48Pesticide Residues in Surface water samples of inlet channels into the Hussainsagar Lake - August 2009

All values in µg/l

Location	α-BHC	β-BHC	γ-BHC	δ-BHC	Heptachlor	Aldrin	Heptachlor Epoxide	γ-Chlordane	α-Endosulphan	4,4 DDE	Dieldrin	Endrin	4,4 DDD	4,4 DDT	Endrin Aldehyde
HSW1	BDL	5.35	5.35	5.49	5.79	5.66	BDL	5.49	BDL	5.5	5.52	5.77	5.49	5.61	5.68
HSW2	BDL	5.36	5.35	5.53	6.0	5.54	BDL	5.5	BDL	5.59	5.67	5.75	5.49	5.68	5.59
HSW3	5.36	5.37	5.37	5.59	6.56	5.61	BDL	5.54	BDL	5.57	5.54	5.77	5.49	5.61	5.59
HSW4	15.75	16.03	16.03	19.11	6.93	13.46	BDL	13.16	BDL	10.45	11.43	BDL	6.72	7.84	9.77
HSW5	5.74	5.75	5.56	5.96	6.58	5.72	5.69	5.81	BDL	5.52	5.55	5.49	5.51	5.68	5.66
HSW6	5.35	5.35	5.35	BDL	6.54	6.22	BDL	5.52	5.45	5.51	5.56	5.74	5.5	5.63	5.61