Study of the shallow groundwater regime in the Pune Municipal Corporation area, Maharashtra

Hydrogeological Investigations

Scientific Investigation Report 2006-07

Groundwater Surveys and Development Agency
Water Supply and Sanitation Department,
Government of Maharashtra.

Study area

Indrayani R.
Pimpri Chinchwad Corporation
Charholi Bk.
Dighi
Pavana R.
Dhanori
Kalas
Loahgaon
Wagholi
Mula R.
Balewadi
Kirkee Cant.
Baner
Sus
Awhalwadi
Kharadi
Vadgaon Sheri
Manjari Kh.
Mundhava
Pashan
Pune Cant.
Bavdhan Bk.
Manjari Bk.
Mutha R
Bhugaon
Bavdhan Kh.
Kotharud
Hadapsar
Mula-Mutha R
Warje
Pune City
Shewalwadi
Hingane Kh.
Mohammadwadi
Vadgaon
Fursungi
Dhanawadi
Wadgaon Kh.
Nanded
Ambegaon Bk.
Kondhave Bk.
Undri
Uruli-dewachi
Khadakwasla Reservior
Katraj
Narhe
Autadwadi Handewadi
Dhayari
Ambegaon Kh.
Gujar Nimbalkarwadi
Wadachiwadi
Yewalewadi
Bhilarewadi
Mangadewadi
N
0 1 2
kilometers

Pune city: salient features

- Area: 450 sq. km
- Population: > 3 million
- Total slums: 553 (notified: 347)
- Slum dwellers: 34% of 3 million

Issues: Water supply

- Water supply: 797 MLD
- Per capita per day supply: 195 liters
- Leakage in distribution network
- Insufficient distribution network
- Pipeline with smaller diameter
- Low pressure
- Inequitable distribution

Activities undertaken

1. Hydrogeological surveys to ascertain the groundwater potential in the PMC area.
2. Fixing of observation wells and monitor the groundwater levels
3. Aquifer Performance test
4. Geochemistry- major ions, trace elements, pesticides, organic constituents, etc.
5. Interpretation of data and submission of report on the groundwater regime

Deliverables

1. Report on hydrogeological conditions of the study area along with hydrogeological map of the study area, with water table contour for two seasons
2. Basic data on groundwater withdrawal structures in the study area

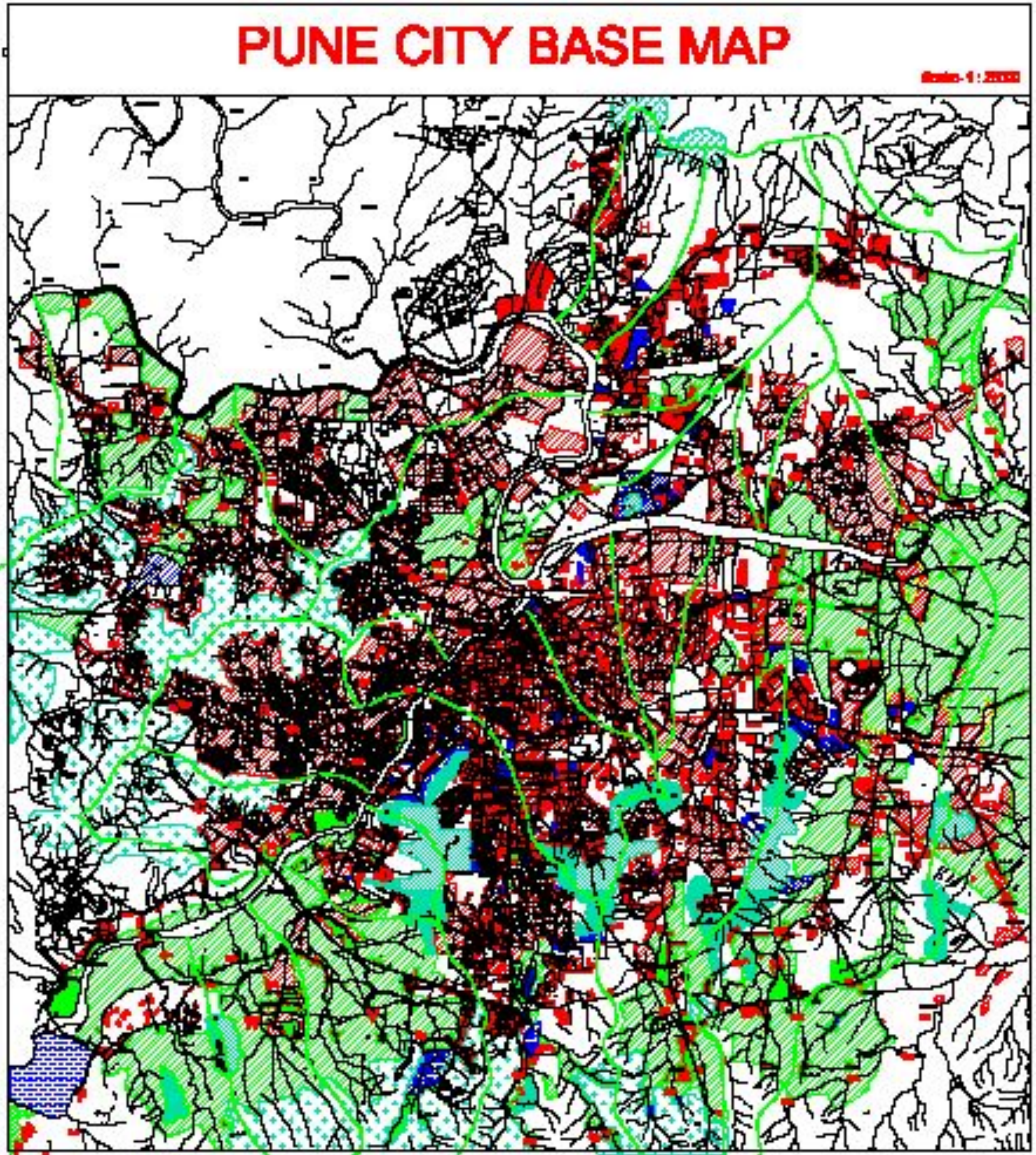
3. Base line data on the groundwater quality in table form, iso-TDS map for the study area.
4. Report discussing the general groundwater quality in the study area, Hot Spot areas, and
5. The recommendations for bringing improvement in the groundwater quality

The study area

Physical environment

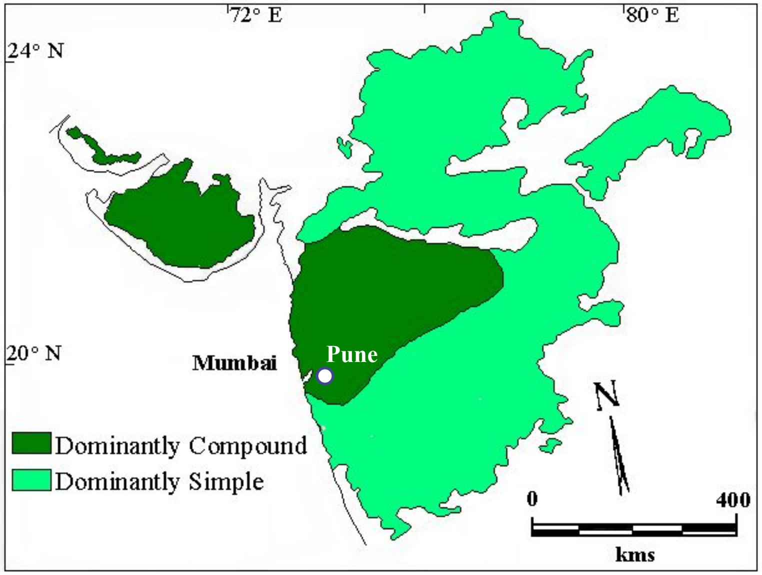
Ward Map

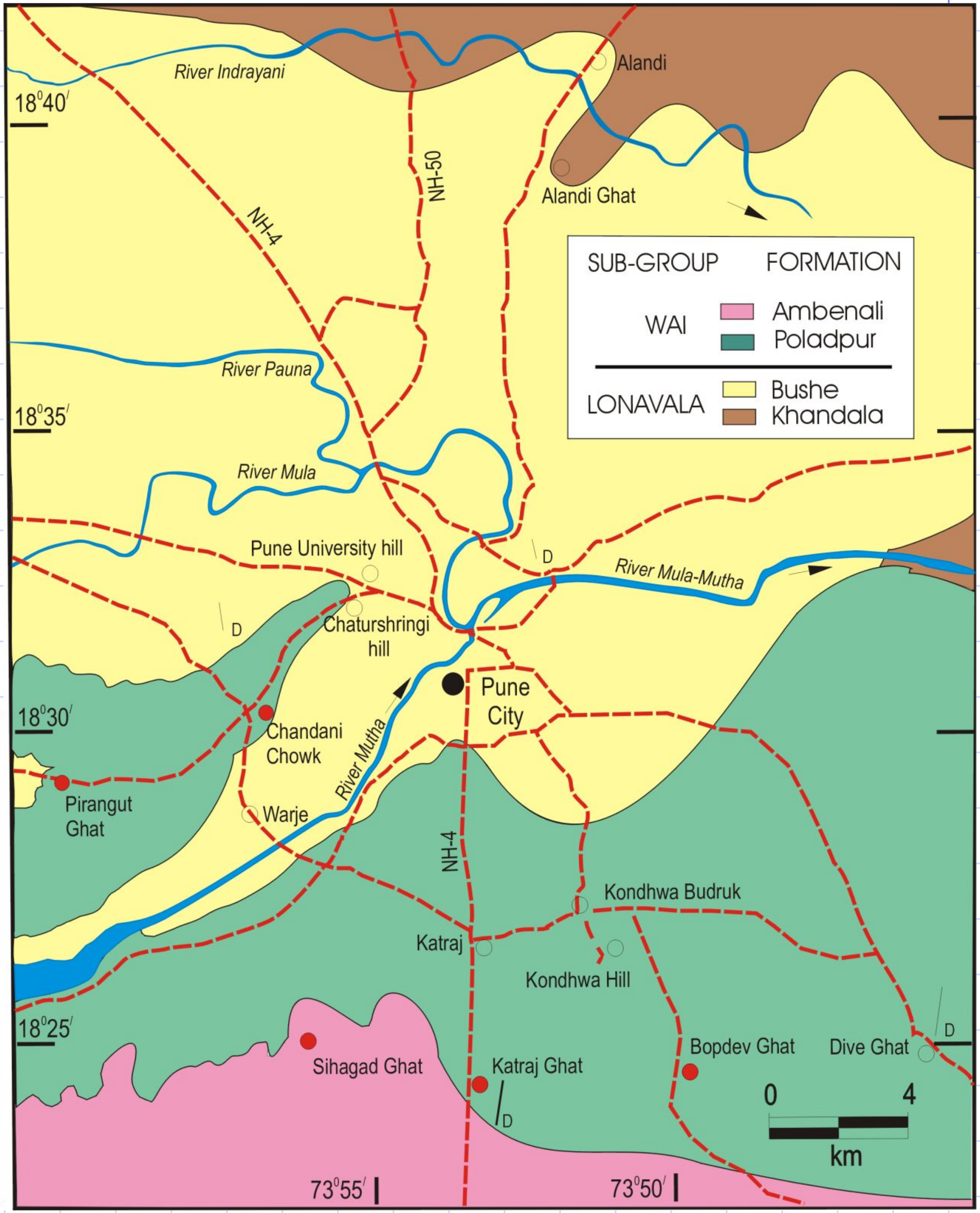
LU-LC Map



Geology

Pune city and surroundings

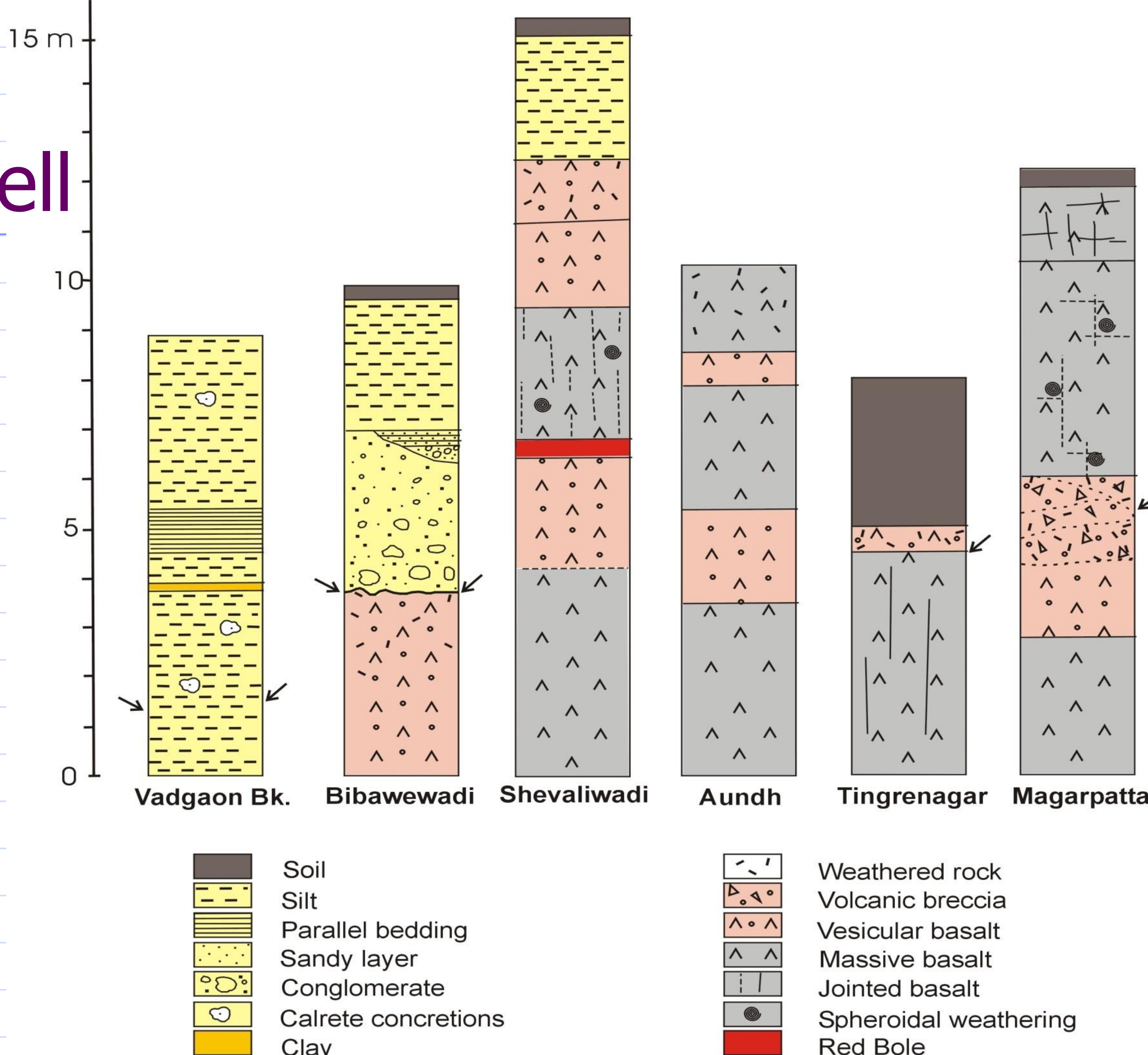




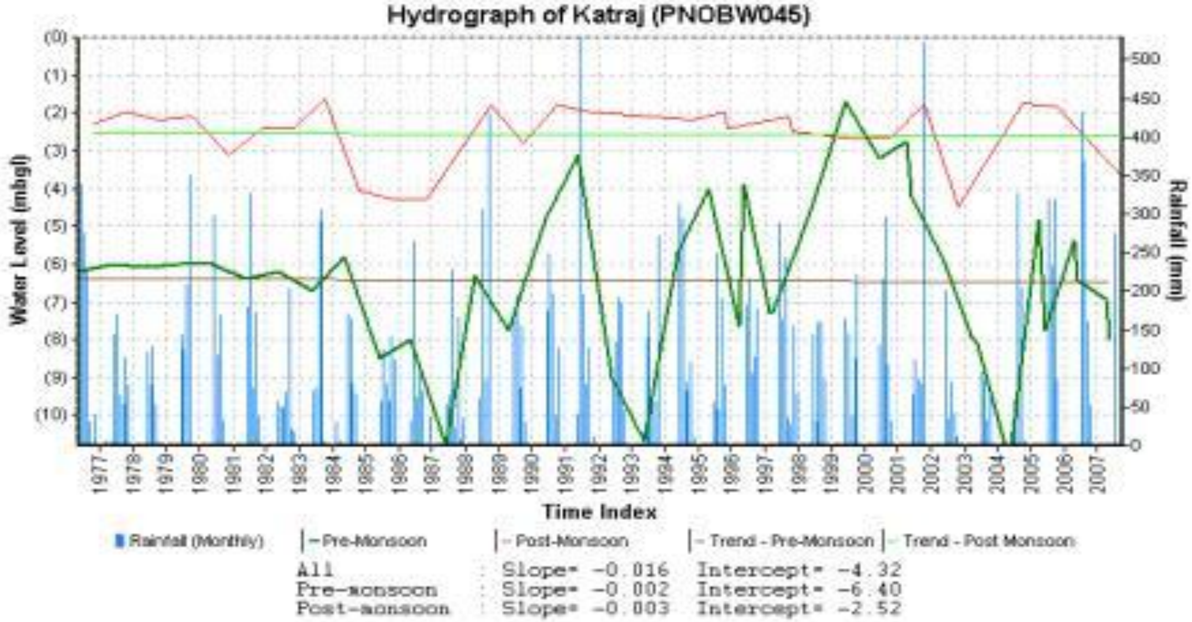
Hydrogeology

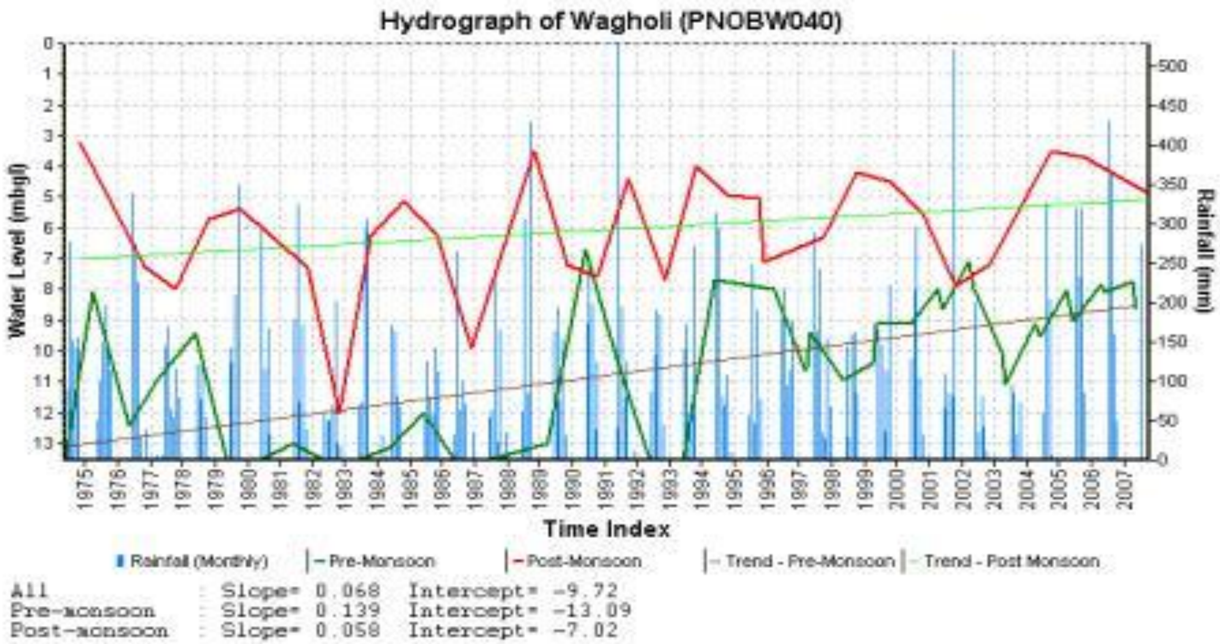
- Well inventory- DW: 399, BW 4820
- DW- depth3 to 20 m, Dia- Avg 6.1
- BW- depth 10 to 130 m
- SWL- 3.9 to 6.2 m
- Aquifer types: Basalt, Basalt+ Alluvium, Alluvium
- Observation wells fixed: 86

Dug Well Logs

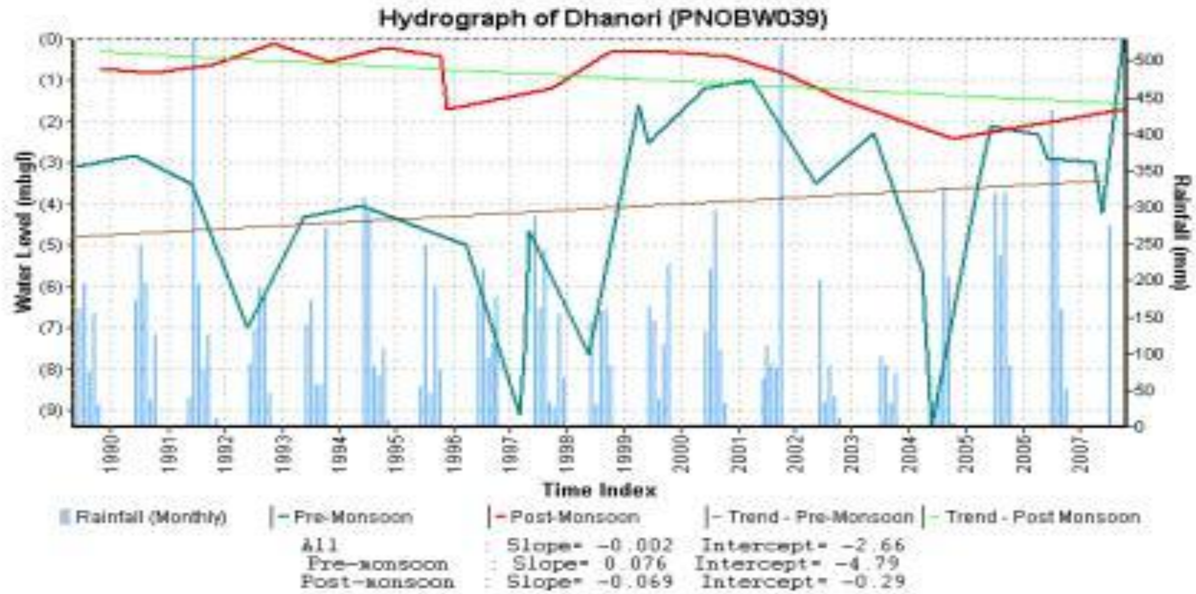


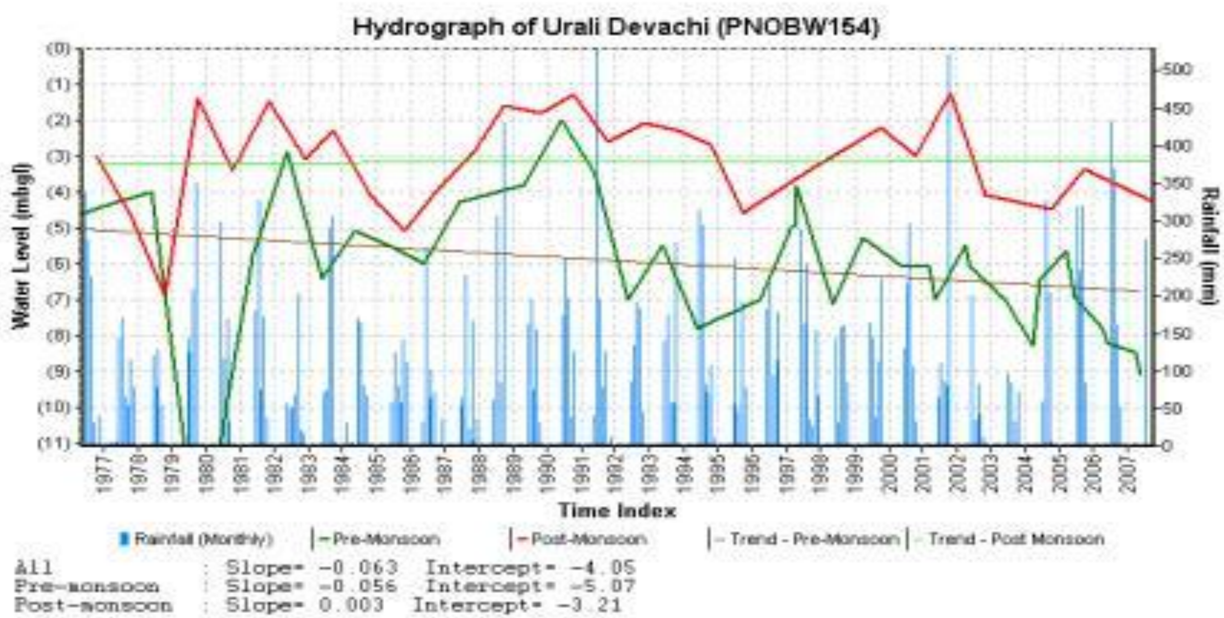
Observation Dug Well Hydrographs



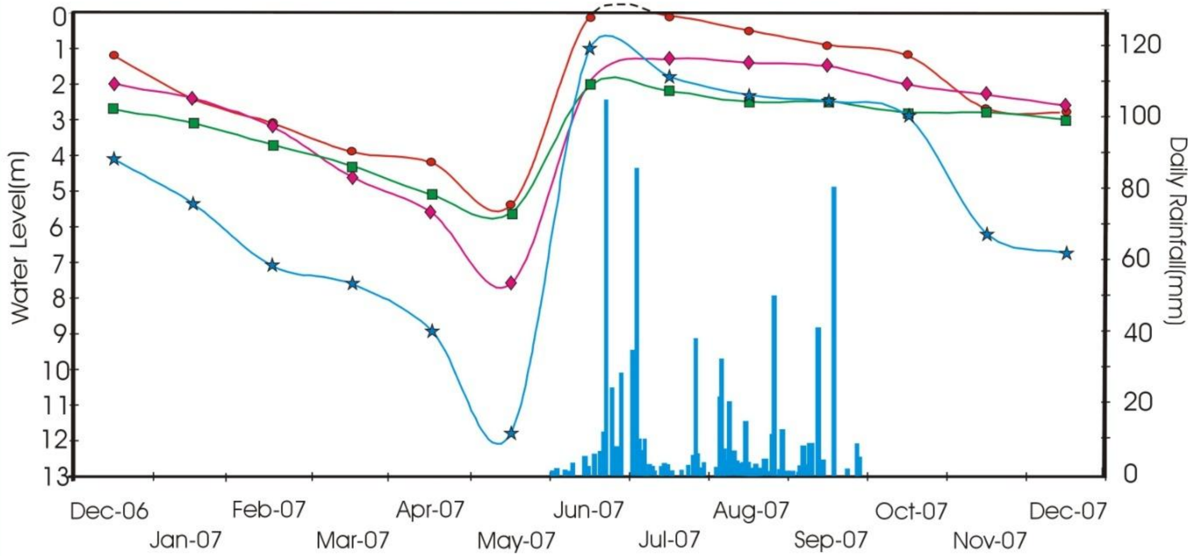


Observation Dug Well Hydrographs

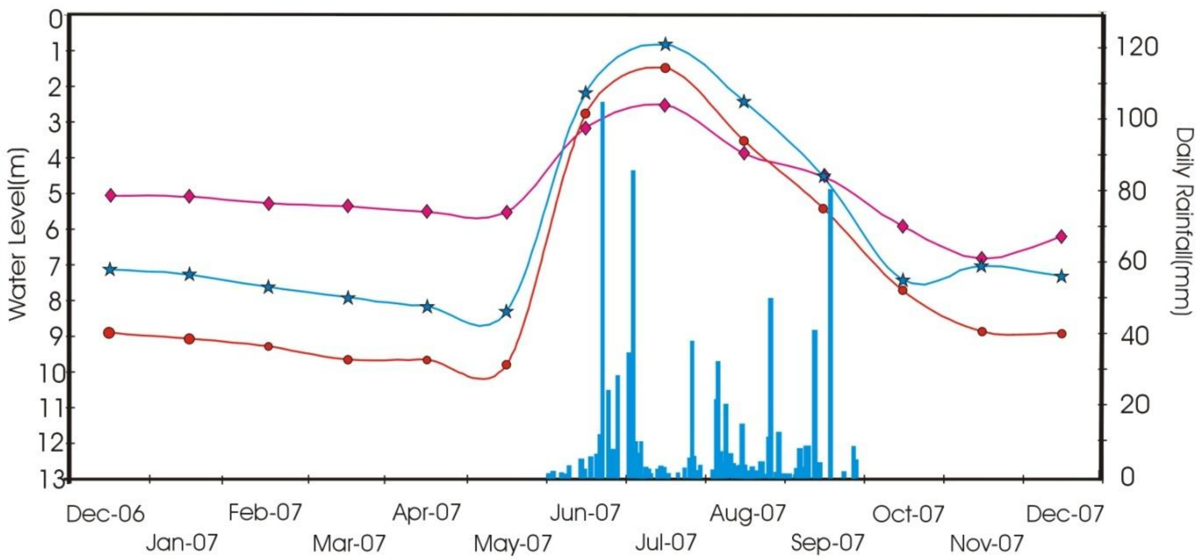




Annual Dug Well Hydrographs

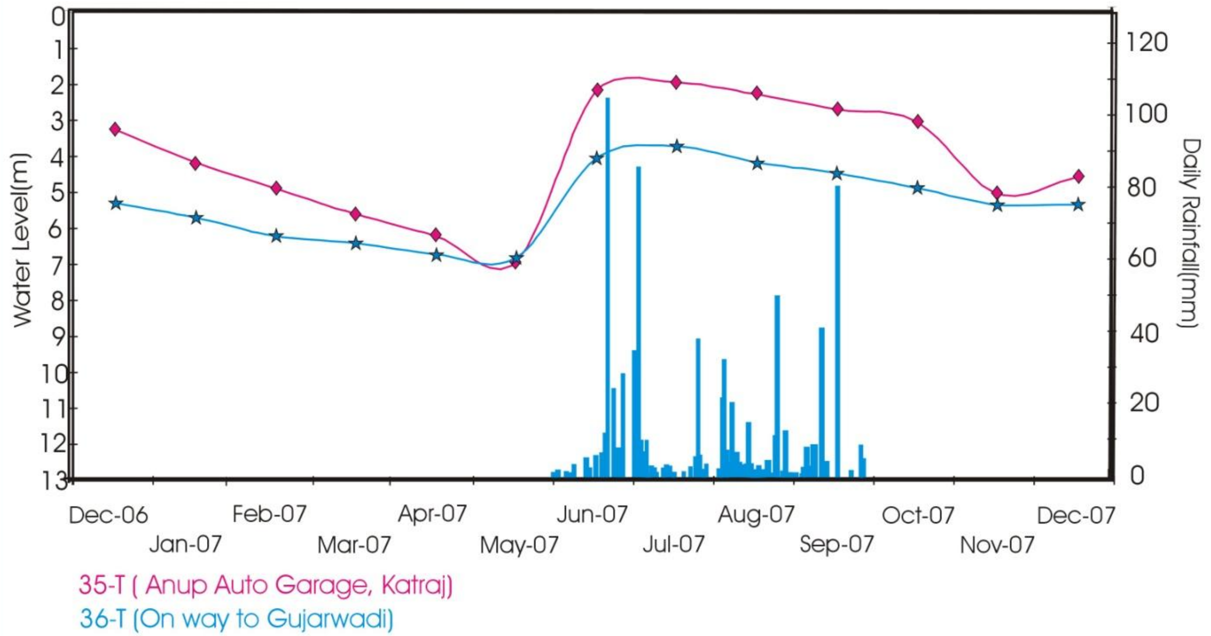


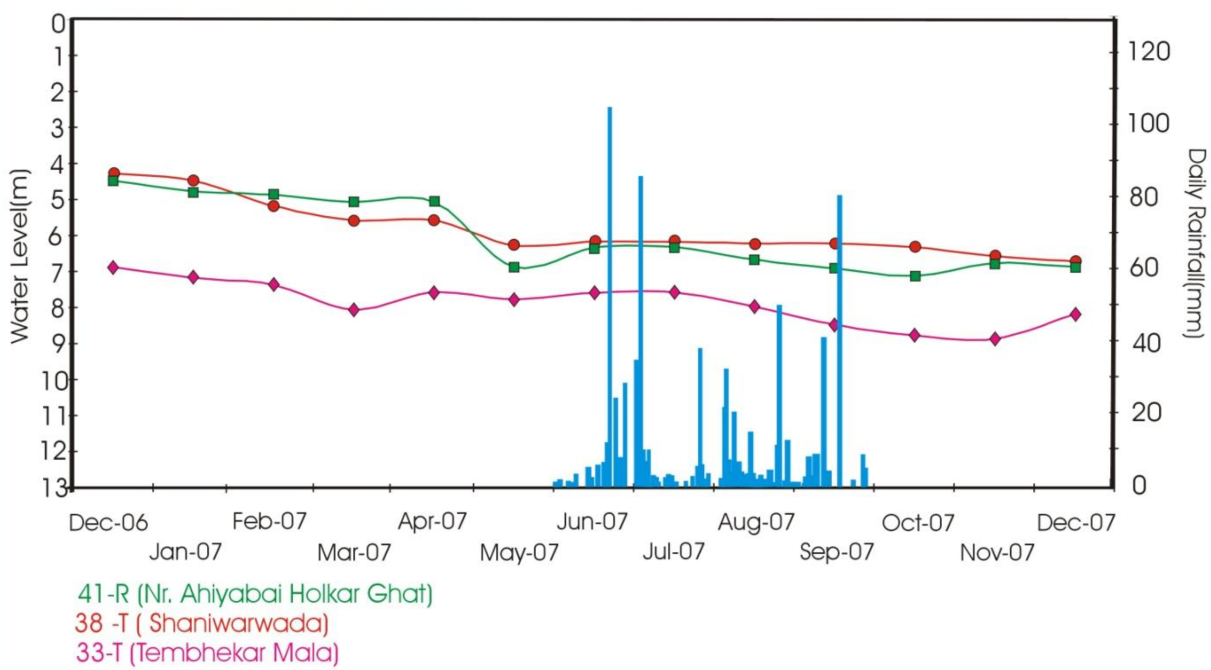
59- O (On the way Undri to vadachiwadi)
50-P (Near Sharad Pawar Garden, Kondhwa Bk)
58-O (Grampanchyats well, Pisoli)
63-FV (Grampanchyats Well, Vadachiwadi)



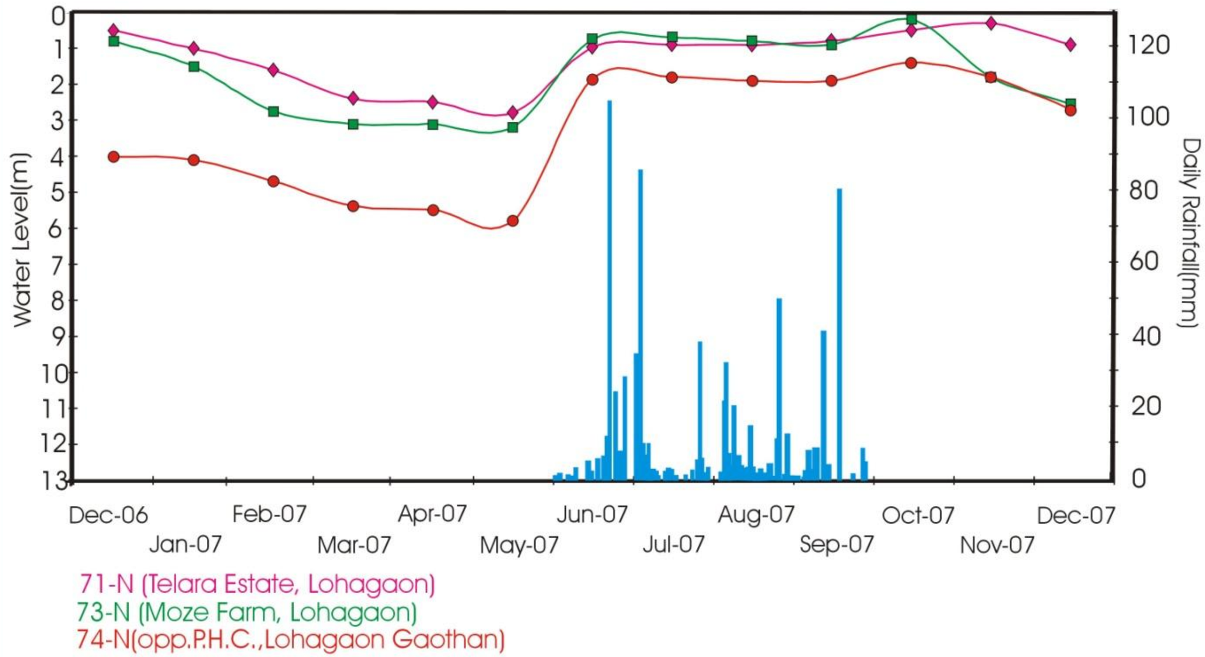
5-C (Kakade City, Karve Road)
7-E (I.A.R.I., Baner)
6-F (Sanker Residency,Baydhan)

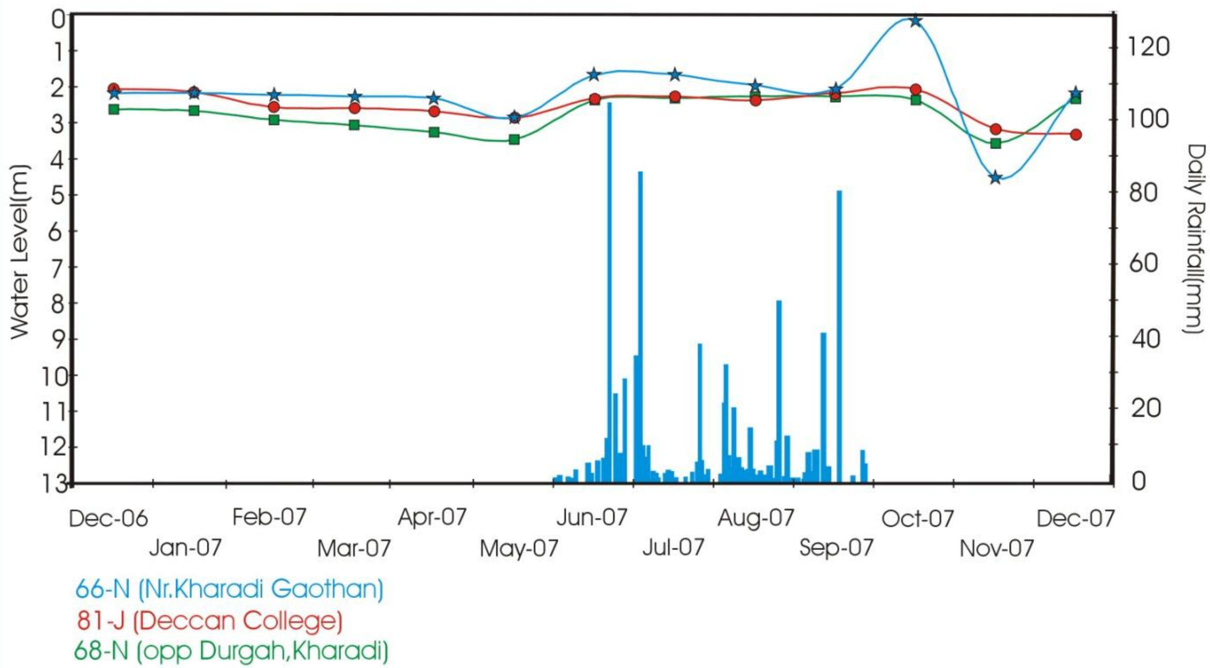
Annual Dug Well Hydrographs





Annual Dug Well Hydrographs





Hydrograph results

- **The hydrographs are typical of unconfined phreatic aquifers.**
- **Recharge to these aquifers is primarily from the Monsoon rains**
- **Effects of water conservation structures such as those at Katraj and Wagholi are responsible for Pre- and Post Monsoon rising water level trends.**

- Pattern of rise and fall of water levels is directly related to the amount and duration of precipitation, seasonal fluctuation and water abstraction for different water uses.
- There exists minimal lag between rainfall and recharge i.e. the aquifers get recharged quickly.

Five Aquifer Performance Tests

- **APT was conducted at different locations (Aundh, Kothrud, Mohammadwadi, Hadapsar, Wadgaon sheri)**
- **Pumping durations lasted for 180 minutes and the recuperation time was varied from 210 to 305 minute.**
- **Limitations: heterogeneous nature of the basaltic aquifer**
- **Depth of the dug wells -7.4 to 16.70 m**
- **Large diameter dug wells -5.6 to 6.6 m**

Results

Basalt

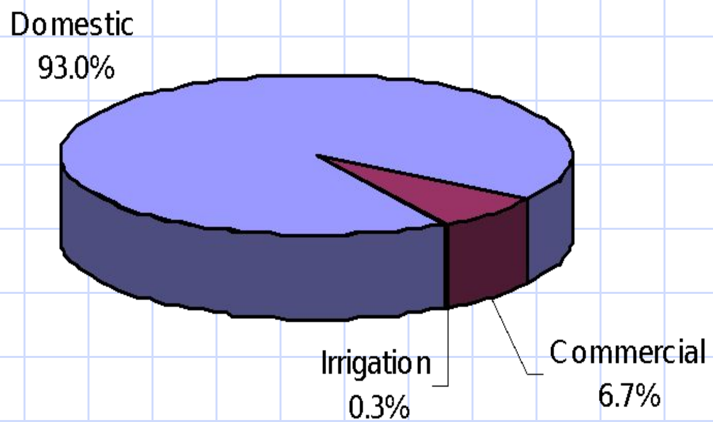
- Specific capacity - 47 to 54 lpm/m
- Transmissivity - 31 to 34m^2/day
- Percentage of storage coefficient - 2.6 to 3.9

Alluvium

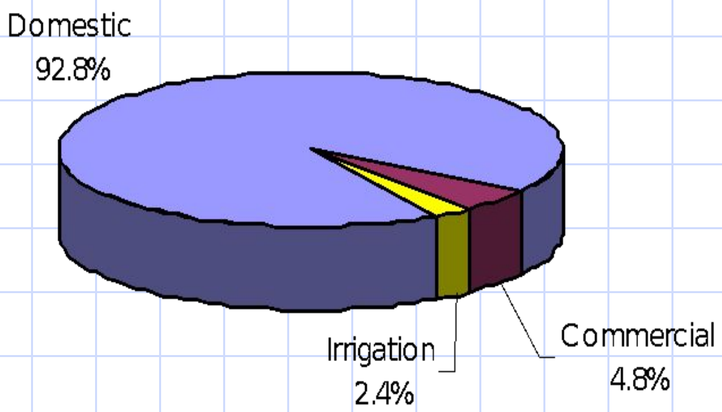
- Specific capacity - 67 to 229 lpm/m
- Transmissivity - 29 to 139 m^2/day
- Percentage of storage coefficient - 6.8 to 7.6

Groundwater use

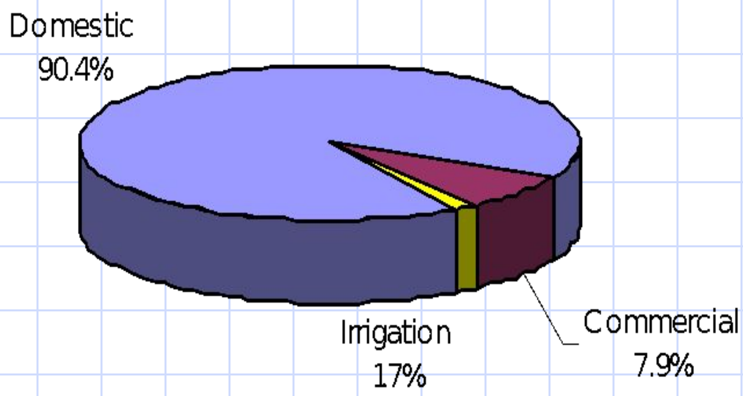
Shivajinagar-Balewadi



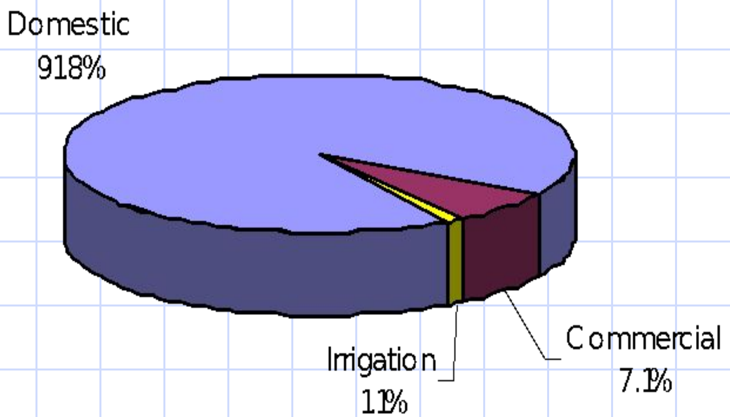
Dighi-Kharadi area



Pune city area

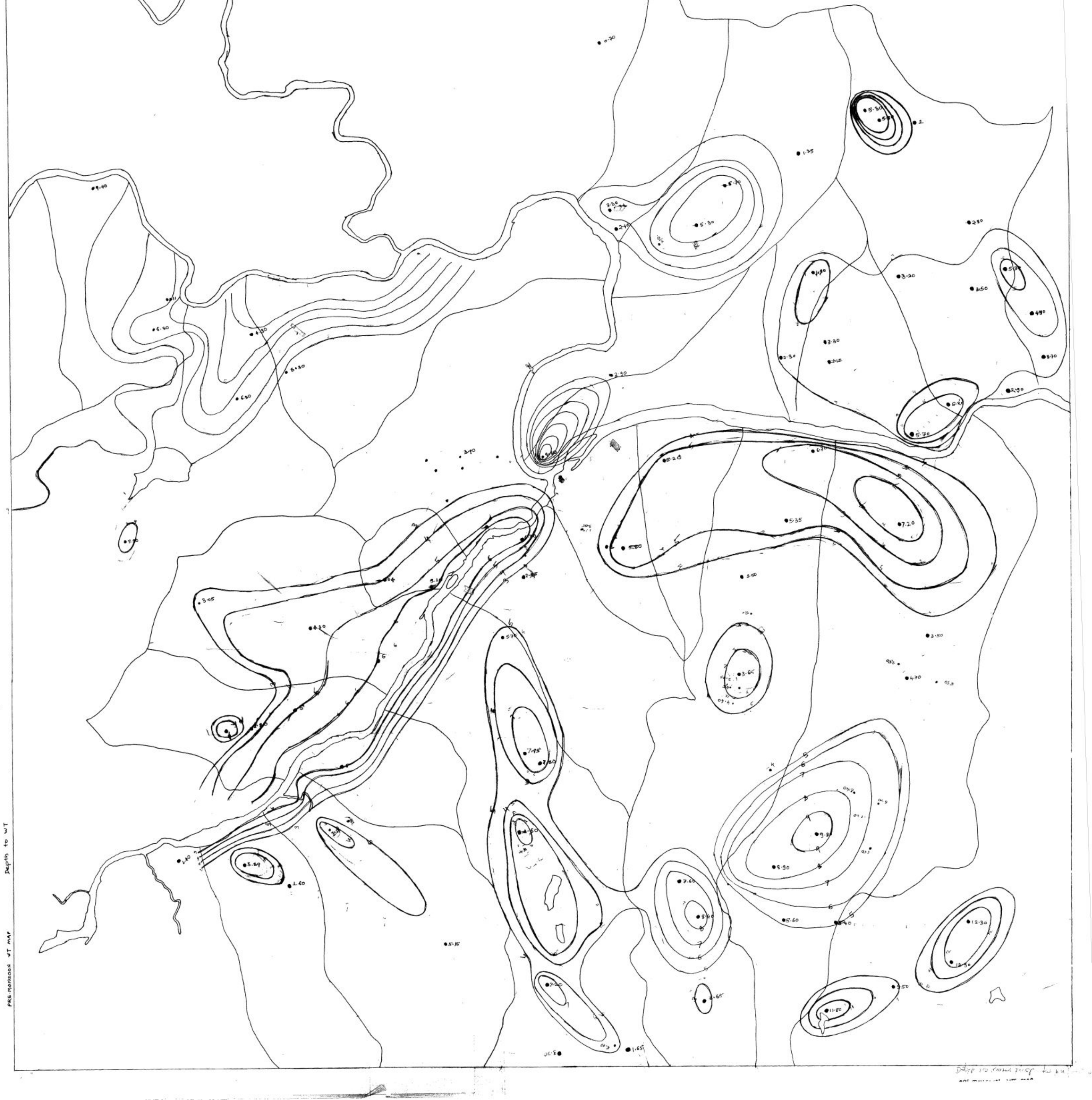


PMC



WTC Map

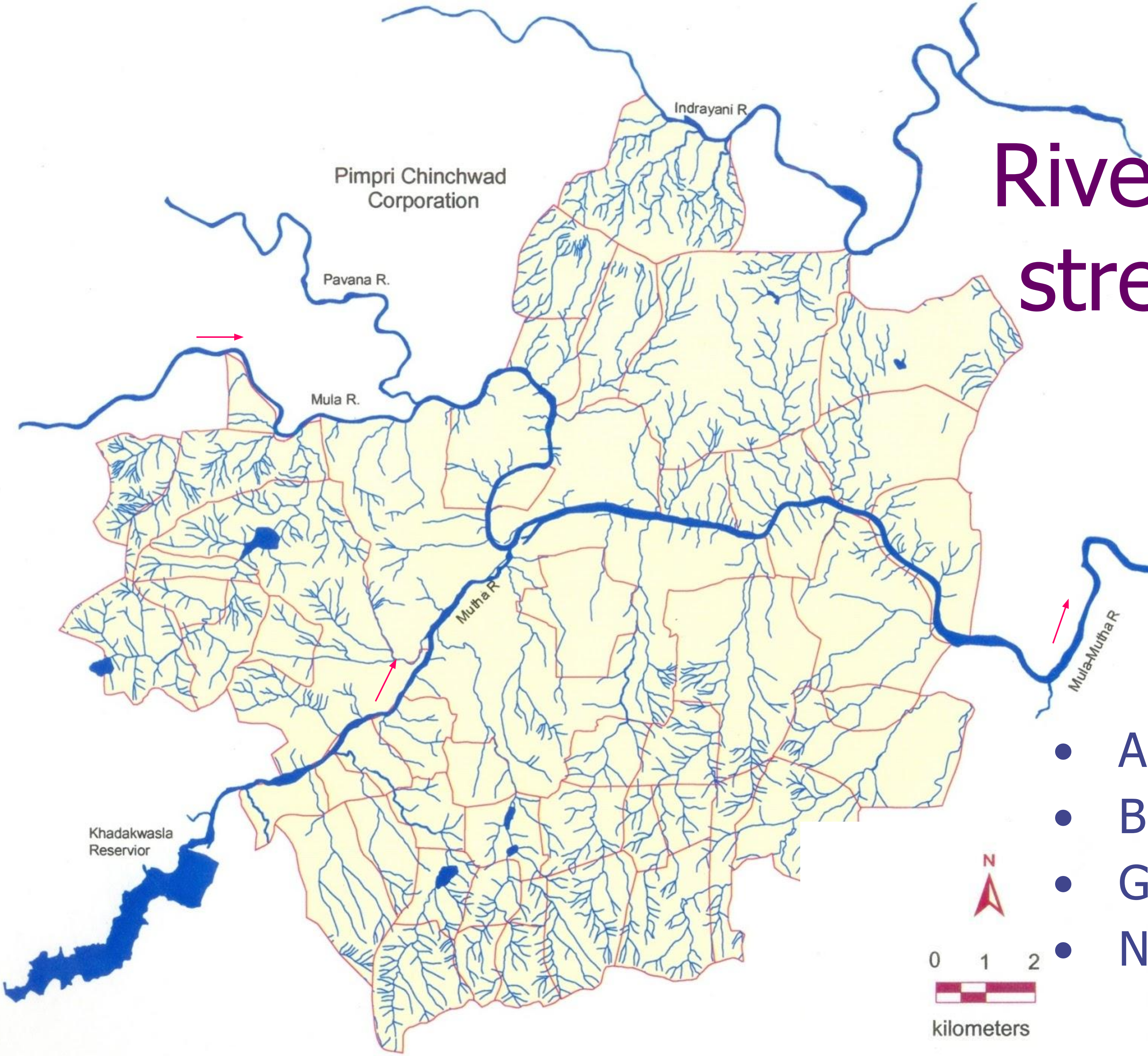
Pre Post Monsoon DTW Maps



Groundwater Assessment

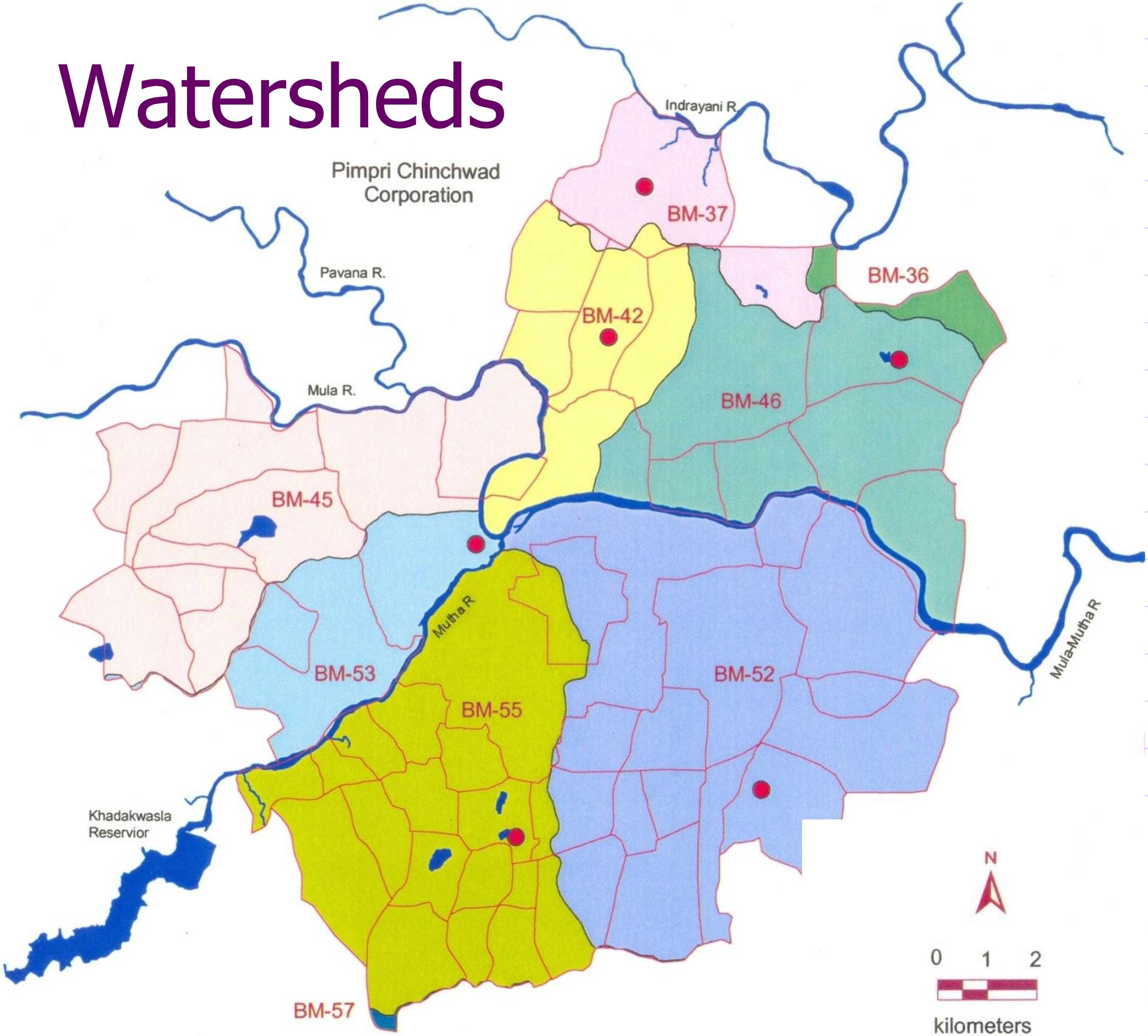
The urban dilemma

Rivers and streams



- Ambil oda
- Bhairoba nala
- Gaikwad nala
- Nagzari nala

Watersheds



Indrayani R.
Pimpri Chinchwad Corporation
BM-37
Pavana R.
BM-36
BM-42
Mula R.
BM-46
BM-45
Mutha R
BM-53
BM-52
Mula-Mutha R
BM-55
Khadakwasla Reservior
N
0 1 2
kilometers
BM-57

GW Draft calculations

- The watershed wise classification of pumping device -handpumps and motor pump types was undertaken.
- Motorised pumps classified into submersible pumps, jet pumps and centrifugal pumps.
- Performance charts of pump types for various manufacturers were used for comparison.
- Head was calculated using depth of the footwall plus height to the tank on bunglow/building.
- Discharge (LPM) was calculated for individual abstraction structures (Table) depending on the pump type fitted and by calculating the head in meters

- Since most dugwells are not deeper than 20 m and are fitted with centrifugal pumps a total head of 15 m was considered for calculating discharges.
- For bore wells fitted with jetpumps and used for domestic purposes discharges for multistage pumps were generalized and used for calculation of discharges.
- Once discharges were calculated for individual abstraction structures they were converted for daily draft by multiplying the same with daily hours of pumping obtained from the well inventory form.

- Information on the state of groundwater use (perennial: 365 days), seasonal: 275 days and occasional: 120 days) specified in the well inventory forms was used to reclassify operation days per well for monsoon and non-monsoon seasons.
- The season wise draft per day per well in cubic meters was calculated for command and non-command area in the study area and used in the GEC97 software (Sulochana et al., 1998).
- Drafts for dugwells fitted with power pumps, borewells fitted with handpump and borewells fitted with power pumps were calculated separately.

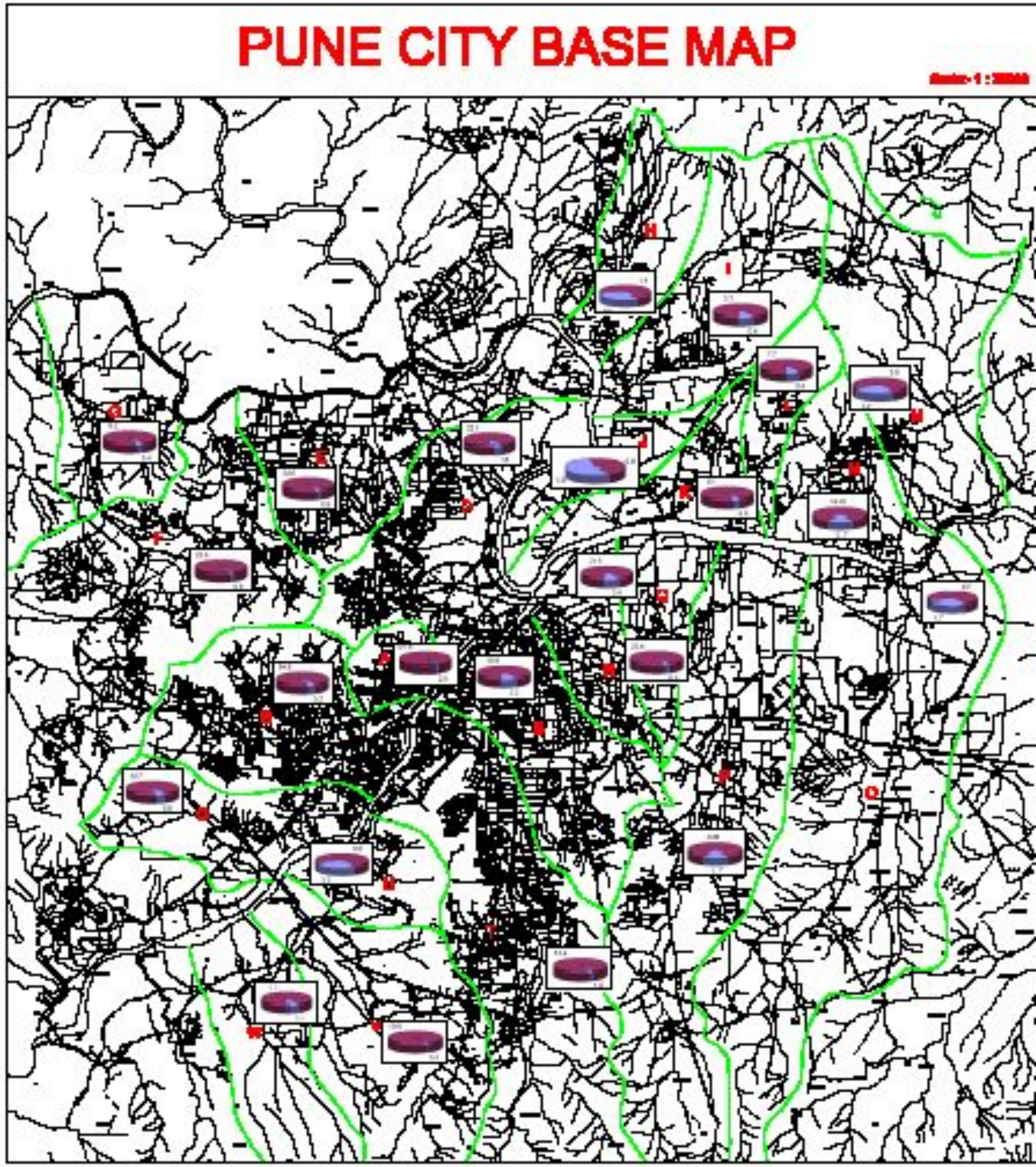
Average discharges of motorized pumps

Pump HP	Jet pumps (multistage)			Submersible Pumps			Centrifugal Pumps			
	Head in meters			Head in meters			Head in meters			
	60	70	80	60	70	80	10	15	20	25
	Discharge in LPM			Discharge in LPM			Discharge in LPM			
0.5	--	--	--	8	--	--	100	80	--	--
0.75	--	--	--	**24**	20	**10**	--	--	--	--
1.0	500	350	--	42	33	15	210	180	120	--
1.5	--	--	--	70	50	30	318	245	140	110
2.0	520	450	370	80	70	60	430	370	260	--
3.0	--	--	--	**90**	80	70	800	520	320	270
5.0	--	--	--	124	120	114	1110	820	615	520
7.5	--	--	--	--	--	--	--	--	1020	750

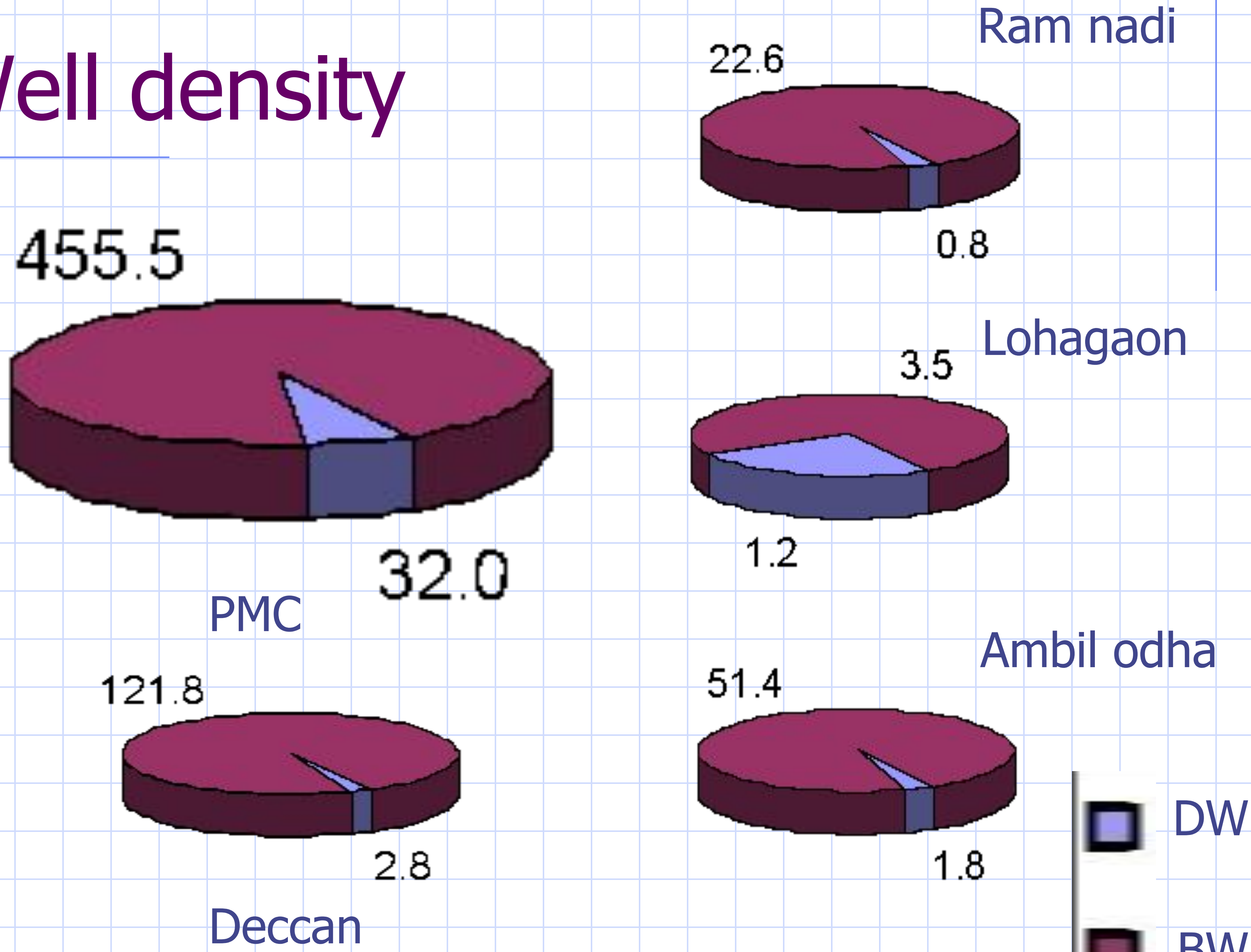
Urban miniwatersheds

- 6 Elementary watersheds
- 23 urban miniwatersheds
- Total Annual recharge- 2406.68 Ham
- Rainfall recharge (2353.7 Ham) Canal (52.9 Ham)
- Gross Draft- 195.65 Ham
- Stage of Development – 0.10 (J) to 53.06 (A)
- All categorised as Safe
- Waterlevels in Command rising for both Pre and Post Monsoon
- Waterlevels falling and rising for Pre and Post Monsoon respectively for NC

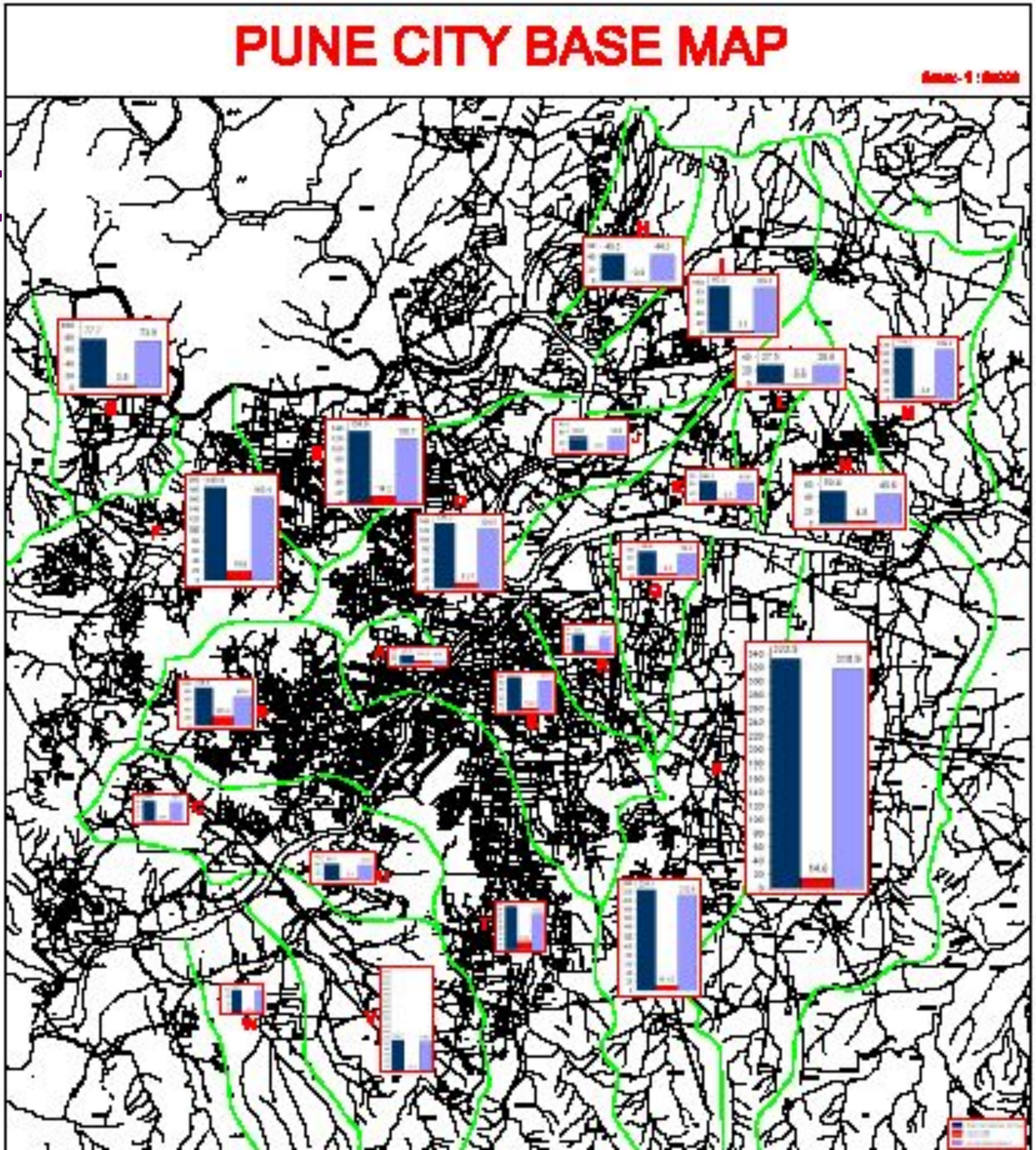
Well density



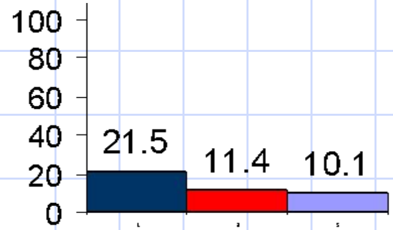
Well density



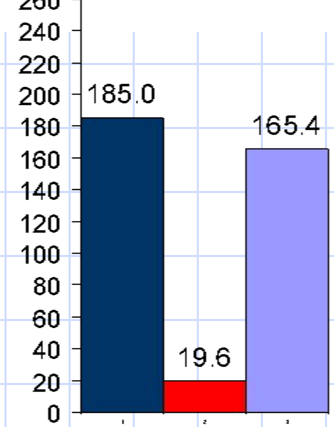
Assessment Results



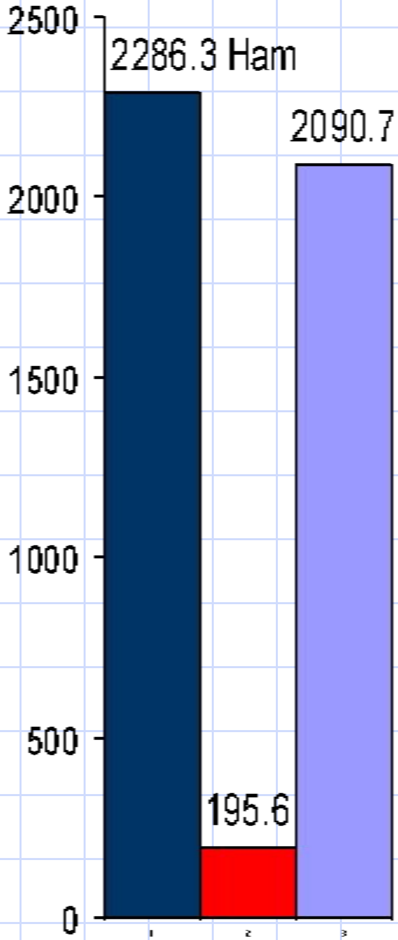
Results



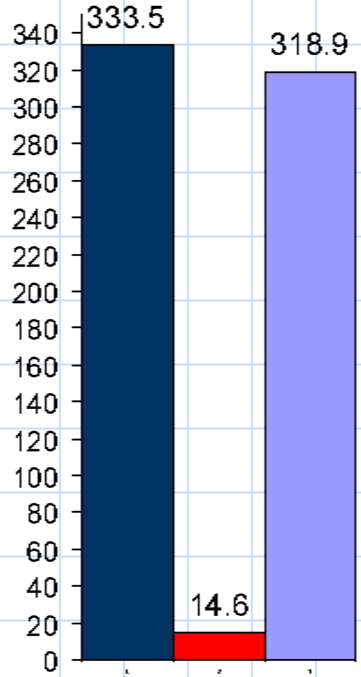
Deccan



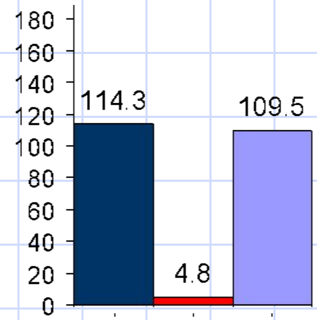
Ram nadi



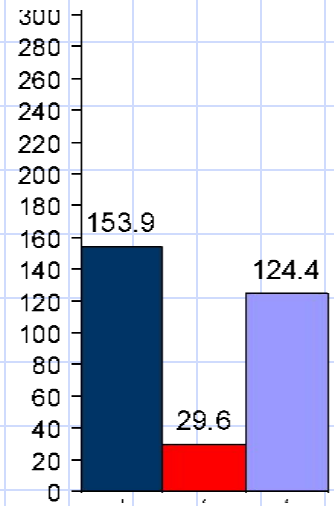
PMC



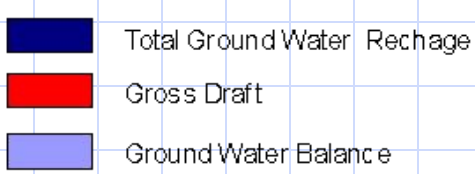
O-Watershed



Lohagaon



Ambil odha



Groundwater chemistry

Urban hotspots

Major Ion geochemistry

- 71 Samples during Post Monsoon
- 65 GW and 6 Surface water
- Sampling based on landuse-landcover pattern
- Analyses at GSDA Lab

- 125 Samples during Pre Monsoon
- 106 GW and 19 Surface water
- Sampling density increased as per requirement
- Analyses at GSDA Lab

Post Monsoon	Ground Water Min	Ground Water Max	Surface Min	Surface Max
pH	6.8	8.9	6.9	8.4
E.C. µs/ cm^2	50	1751	433	562
T.D.S	32	1121	277	360
Turbidity	0.1	2	1.2	10
COD	0.8	24	5	101
DO	0.7	8	1	6.8
BOD	0.2	22	2	70
Total Hardness	20	706	144	236
Ca Hardness	12	462	60	113
Ca	5	176	24	43
Mg	2	113	13	42
Na	2	242	20	68
K	0.1	23	2.3	9
Fe	0.1	2.2	0.2	3.3
Total Alkali	26	680	148	256
CO_3	4	20	6	6
HCO_3	26	640	148	250
Cl	6	190	38	71
F	0.1	1.2	0.1	1.1
SO_4	1	200	27	40
NO_3 -N	0.1	21.4	0.4	3
SAR	0.1	7.23	0.61	1.53

Pre Monsoon	Ground Water Min	Ground Water Max	Surface Min	Surface Max
pH	7	8.8	6.7	8.9
E.C. µs/ cm^2	67	10700	183	2920
T.D.S	43	6848	117	1869
Turbidity	0.06	78	0.7	5
COD	0.8	100	6	114
DO	1.8	40	0.4	28
BOD	0.2	50	1.2	80
Total Hardness	56	2440	96	1036
Ca Hardness	28	1280	68	640
Ca	11	512	27	256
Mg	4	348	2	119
Na	3	3150	10	560
K	0.1	83	0.2	14
Fe	0.1	6	0.2	1.5
Total Alkali	40	840	76	280
CO_3	4	32	8	14
HCO_3	40	840	76	272
Cl	10	4558	15	743
F	0.1	1.2	0.1	0.9
SO_4	3	840	1	660
NO_3 -N	0.1	18	0.6	4
SAR	0.07	27.7	0.44	7.57

- Pre, Post EC Map
- Iso-chloride Pre Map
- Hardness Pre, Post Map
- Sulphate Pre Map

Drinking water standards exceeded

Post Monsoon

- pH- 05 (>8.5 IS 10500:91)
- TDS- 00 (2000 mg/l)
- COD- 24
- DO- 02
- BOD- 13
- Hardness- 00 (600 mg/l)
- Ca- 00 (200 mg/l)
- Mg-01 (100 mg/l)
- Fe- 02 (1 mg/l)

Pre Monsoon

- pH- 07
- TDS- 02
- COD- 36
- DO- 03
- BOD- 07
- Hardness- 03
- Ca- 02
- Mg-03
- Fe- 23

Bacteriological contamination

- Major Hot spot with > 80% source affected

- Groundwater Potential Map (including,High yielding DW/BW, Water Market)

Summary and conclusions

- **Significant alteration of the urban hydrogeological cycle**
- **changes in LU-LC**
- **infiltration of storm water runoff**
- **leaks in water and wastewater infrastructure**
- **destruction of wetlands**
- **changes in the recharge-discharge relationship of GW**

Rising water table

- Long term monitoring of GW levels in the Katraj, Wagholi and Urali Devachi obs. wells indicate rise in the groundwater levels
- There is a gradual depletion in the surrounding fringe areas
- Import of groundwater into the urban miniwatershed through canals and piped water supply has had a water table 'rebound' effect in the Pune city

Implications for civil structures

- implication of rising water table vis-à-vis foundations and other civil structures
- civil structures affect and disrupt natural groundwater flow and affect quality considerably
- damage to civil structures in turn depends on the groundwater quality and extent of water level rise

Water logging and salinisation

- Rising water levels has lead to water logging especially in low-lying areas
- Water logging could potentially lead to salinisation of soils, rendering them unfit for agriculture as well as unsafe for civil engineering
- Shallow groudwaters can also reduce infiltration, alter surface runoff and indirectly contribute to storm water discharges

GW- an important alternative source

- Groundwater continues to be an ‘unsung hero’ by supplying sizable urban populations with drinking water
- groundwater assessment of the urban miniwatersheds indicates that there is very little groundwater draft from the urban areas in comparison to the recharge
- surplus amount of groundwater for commercial exploitation

GW based water markets

- The potential for substituting GW for surface water in water supply schemes within the study area is rather high
- High GW potential zones have been identified in the study area.
- Some private entrepreneurs have realized this potential
- Private water supply on a local scale has already mushroomed in certain pockets.
- GW based water market is a booming trade in and around the city.

GW – Sectoral reallocation

- Surplus groundwater resource within the study area leaves a lot of scope for increased groundwater allocations for domestic, commercial and agricultural sectors.
- The competing demands for water in different sectors are ever increasing and groundwater of suitable quality can substitute for surface water

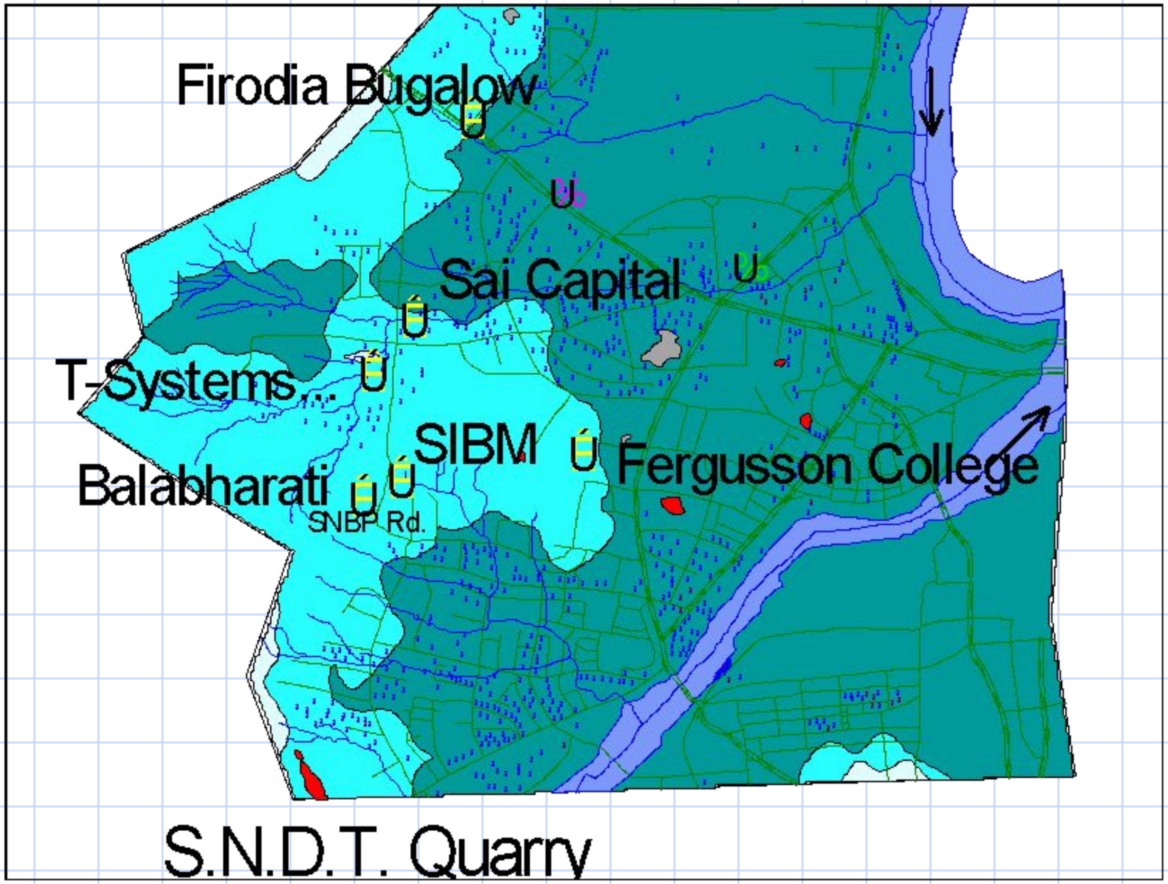
Roof top Rainwater Harvesting

- Anywhere but not every where!
- Rooftop rainwater harvesting systems - most popular for drinking water particularly by individual household
- Roof top rainwater systems can also be modified and used for groundwater recharge through abandoned DW, abandoned or poor yielding BW, recharge pits and recharge trench.

Precautions

- Raw storm water should not be used directly for artificial groundwater recharge
- Suitably designed, area specific filters needs to be used to filter the particulate matter
- Particulate lead, hexavalent chromium and other toxic pollutants need to be monitored in ambient air, soil and water in pollution prone areas.
- Active participation of Citizen's Groups, NGO's, Ward Samitis, etc. should carry out the recharge measures following technical guideline and monitor the quality and allied aspects of water recharged

SLUGGER-DQL MAP OF THE PROJECT AREA SHOWING RECHARGE POTENTIAL



RESULT: RTRWH

The zone where there is transition between the moderate-good recharge potential can be utilized for roof top rainwater harvesting.

- Symbiosis Institute of Business Management
- T-Systems
- Sai Capital
- Balbharati building.
- Firodia Bungalow
- Ferguson College campus

RTRH - action plan

- In Sector 2, the area between Dighi–Kharadi is suitable for RTRH with surface storage.
- A massive programme should be initiated to generate awareness in this area and implement roof top rainwater harvesting schemes
- Similarly in "D" urban miniwatershed several areas with good potential for RTRH SIBM, T-Systems, Sai Capital Balbharati building, Firodia Bungalow, etc. have been identified (Shetty and Dumale, 2007; Duraiswami et al., In prep.).
- The identification of city based institutions and NGO that could design and implement the RTRH

Roof top Rainwater Harvesting

- With rapid urbanisation several quarries were opened in the vicinity of the city
- Lakaki Lake - the Model Colony experiment
- SNDT hill quarries are potentially good sites for artificial recharge.
- Pune University quarry
- Several abandoned quarries in Sus Road, Katraj and Dhanori-Dighi-Vimanagar area


2007 5 28

GW- Quality Hotspots

- Rising water table and leaching of soil leading to increased residence time of ions in groundwater
- Subsurface civil structures have begun to affect and disrupt natural groundwater flow and affect quality considerably
- Inadequate treatment of sewage and discharge of concentrated sewage into natural drainage

GW- Quality Hotspots

- Mixing of natural waters with urban drainage
- Recharge to groundwater from urban drainage
- Open defecation around slums and leakages from latrines and sewers are a source for faecal contamination of surface and groundwater
- Inorganic inputs and use of pesticides in agricultural practices

GW- Quality Hotspots

- Destruction and reduction of wetlands, training of streams, rivers, etc. that were acting as natural filters of water
- Non-availability of minimum flow in streams and rivers thereby reducing their dilution capability considerably

A greener Pune- only way to survival!

Thank You