Potential of Soil-Aquifer-Treatment in Contaminant Removal and Groundwater Recharge – Gujarat Experience

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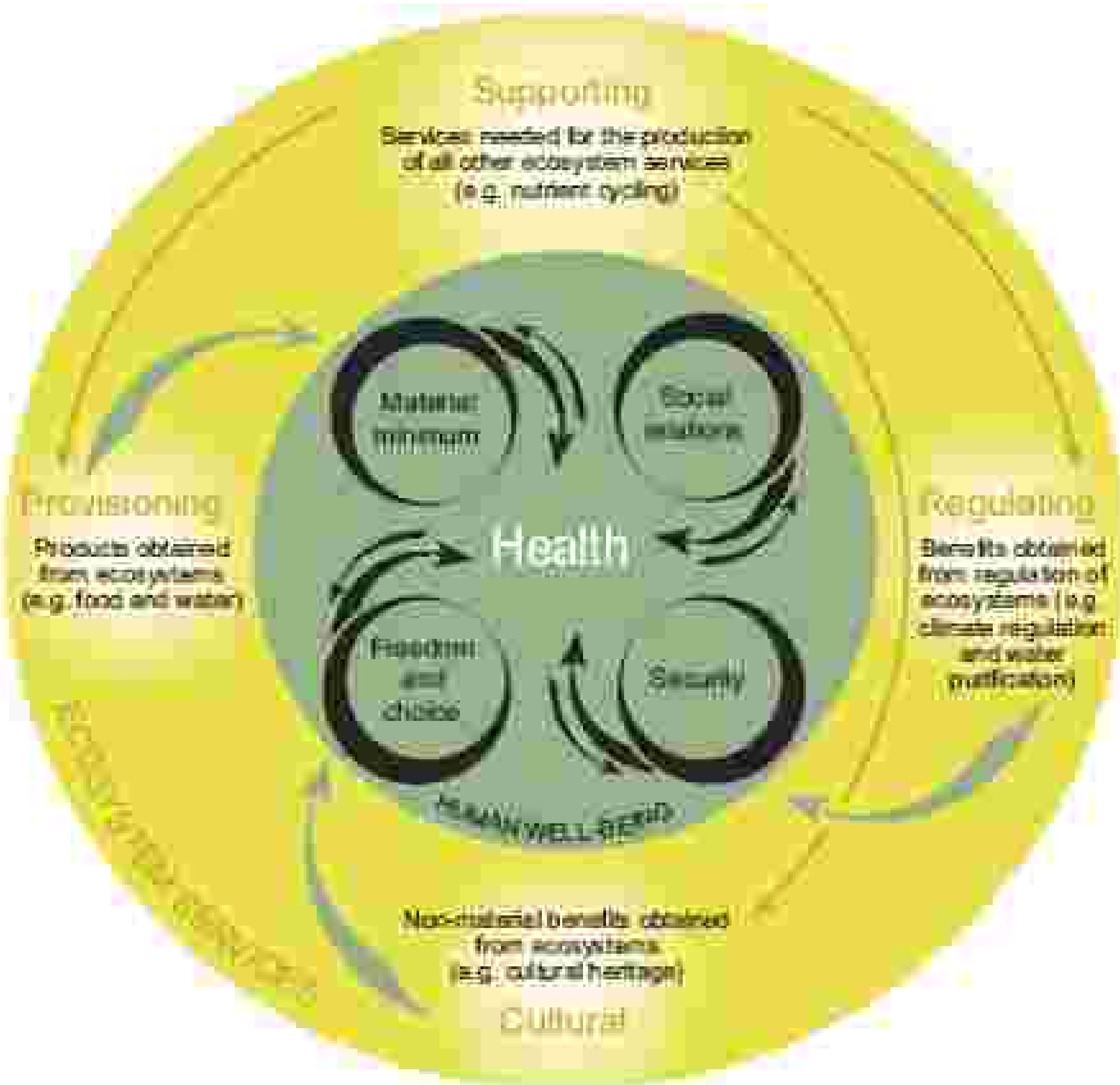
ECOSYSTEMS AND HUMAN WELL-BEING



In a very fundamental sense, ecosystems are the planet's life-support systems - for the humans and for all other forms of life.

Ecosystem services are indispensable to the well-being of all people, everywhere in the world.

Important Ecosystem Services

Through numerous biological, chemical, and physical processes Ecosystems provide important Services

Provisioning :

- **Products/ goods obtained from ecosystems** (e.g. food, water, feed, fibre, fuel, pharmaceutical products, and wildlife)

Supporting:

- **Services needed for the production of all other ecosystem services** (e.g. nutrient cycling)

Regulating:

- **Benefits obtained from regulation of ecosystems** (e.g.climate regulation and water purification)

Cultural:

- **Non-material benefits obtained from ecosystems** (e.g. cultural heritage)

Many goods pass through markets, but other services rarely do.

Millennium Ecosystem Assessment, 2005

1. *Most ecosystem (~60%) are being degraded or used unsustainably*.
2. Direct drivers of change in ecosystems are: habitat change (land use change and physical modification of rivers or water withdrawal from rivers), overexploitation, invasive alien species, pollution, and climate change.
3. Indirect drivers are: population change, change in economic activity, socio-political factors, cultural factors, and technological change.
4. There is *established but incomplete* evidence that changes being made in ecosystems are increasing the likelihood of nonlinear changes that have important consequences for human well-being.
5. *Lack of knowledge* and information about different aspects of ecosystems constrain effective management of ecosystems.

Drivers of Change in Ecosystems: Indian Context

- ~16% of global population on ~2.4% terrestrial area of Earth.
- Population will increase by >40% by 2050.
- Aspire to become a developed nation by 2020.
- Requirements of food production, industrial & mining products, water & energy sources, various services including disposal of waste products etc necessitate massive development of infrastructure involving imports, redeployment/ alterations of natural resources.
- As a consequence, our ecosystems will have to be highly managed and engineered.

Rapid Urbanisation and Industrialisation Requires

Pollution watchdogs to

- **Ensure appropriate treatment and disposal of industrial and domestic waste**
- **Monitor and prevent the loading of pollutants in atmosphere, soil and water**
- **Investigate the movement and mixing of natural (Arsenic, fluoride and salinity etc.) and anthropogenic pollutants from point sources (industrial or urban agglomeration) and**
- **Offer the guidelines and solutions that can protect the environment and also sustain the development.**

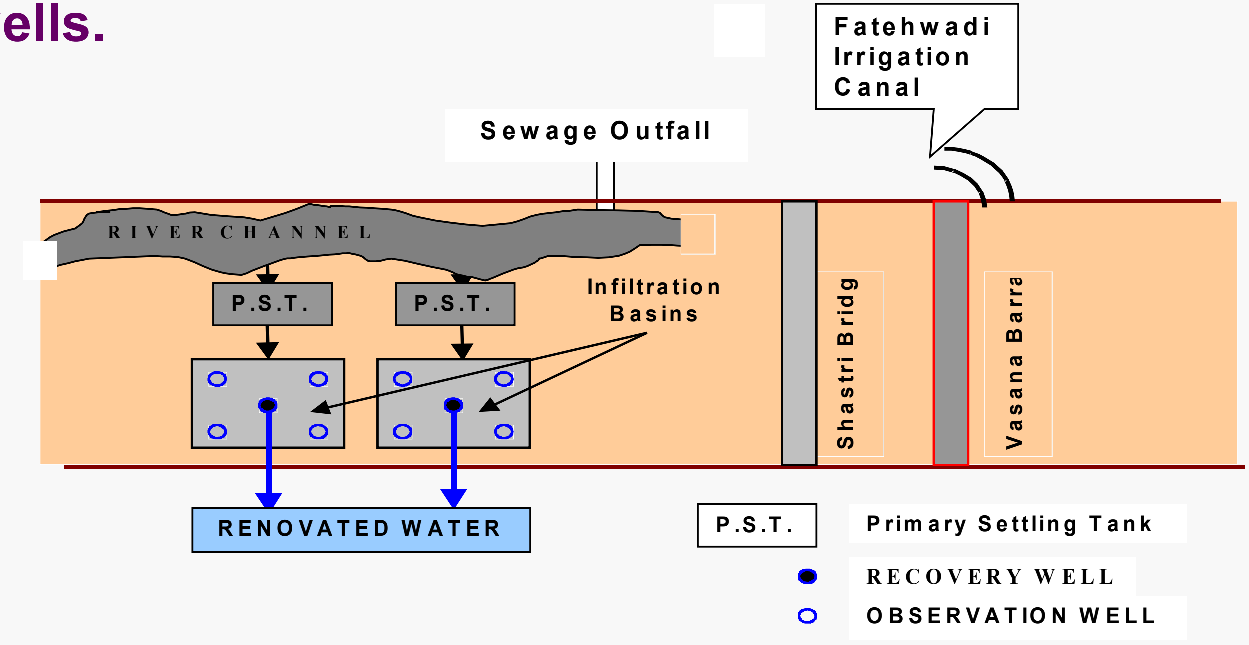
Selected Constituents in Domestic wastewater

Constituent	Typical Conc.[1]	Approximate contribution and source	
		Black water	Grey Water
Wastewater	100-200 lit/person/d	24-45% Toilet	55-75% Kitchen, bath, laundry
Carbon Organic C Inorganic C	 20-200 12-24	 50-70% -	30-50% Some Detergents
Chloride	20-50	30-70% Salt	30-70% Salt, Some bleaches
Nitrogen (Org. N and NH_4^+)	20-60	70-90% Urea and proteins	10-30% NH_4^+ salts in cleaners
Phosphorous	7-15	Nucleic acid and ATP	Detergents and dish soaps
Potassium	7-15	60-80%	20-40%
Sodium	40-80	20-50% Salt	50-80% Salts in cleaning products
Sulphur	5-10	20-40% Proteins	60-80% Detergents

[1] All quantities reported in mg/litre, except for water flow rate. From Wilhelm et al (1994)

Soil-Aquifer-Treatment (SAT) or Geo-purification systems

- Planned water reuse is important in water deficit areas where sewage effluent is an important water resource and also where stream or other water resources need to be protected.
- Comprise three principal facilities (i) infiltration basins; (ii) series of pumping (production) wells; (iii) series of observation wells.

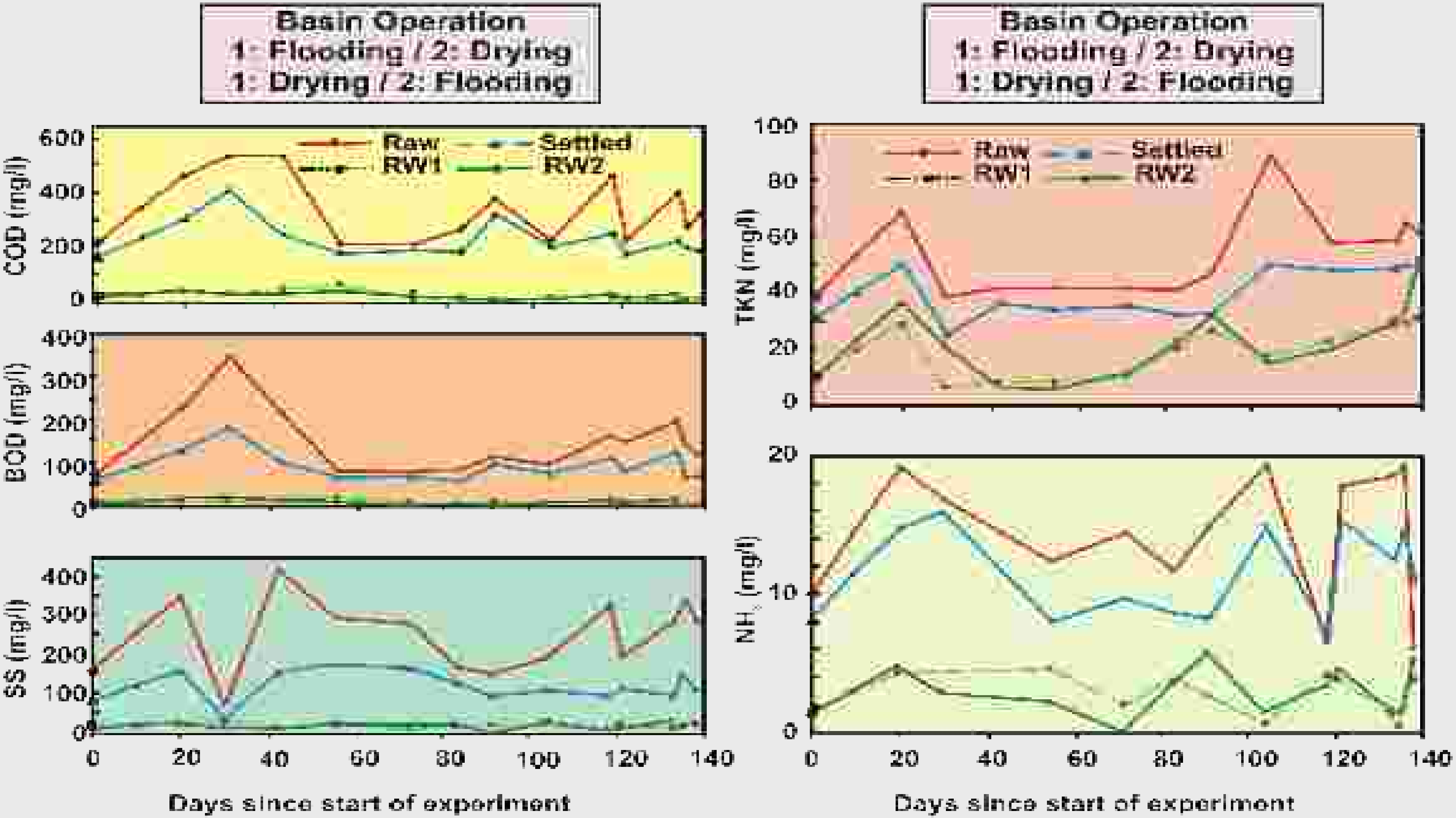


SCHEMATIC OF THE PILOT SCHEME FOR WASTEWATER RENOVATION THROUGH SOIL AQUIFER TREATMENT (SAT) IN SABARMATI RIVERBED

Basin under flooding.
Inflow
Primary Treated waste water

Basin under drying

SAT Renovated Water



Ahmedabad SAT experiment: Performance in respect of COD, BOD, SS, TKN and NH_x-N

Ahmedabad SAT Results

Parameter	Influent (mg/l)	Effluent (mg/l)
BOD	100	8-10
COD	230	14-24
SS	110	12-18
TKN	40	22
Total Phosphate	6	0.2
Bacteria (FC)	3×10^6 (MPN)	72 (MPN)
Viruses	44 (MPN)	~Nil (MPN)

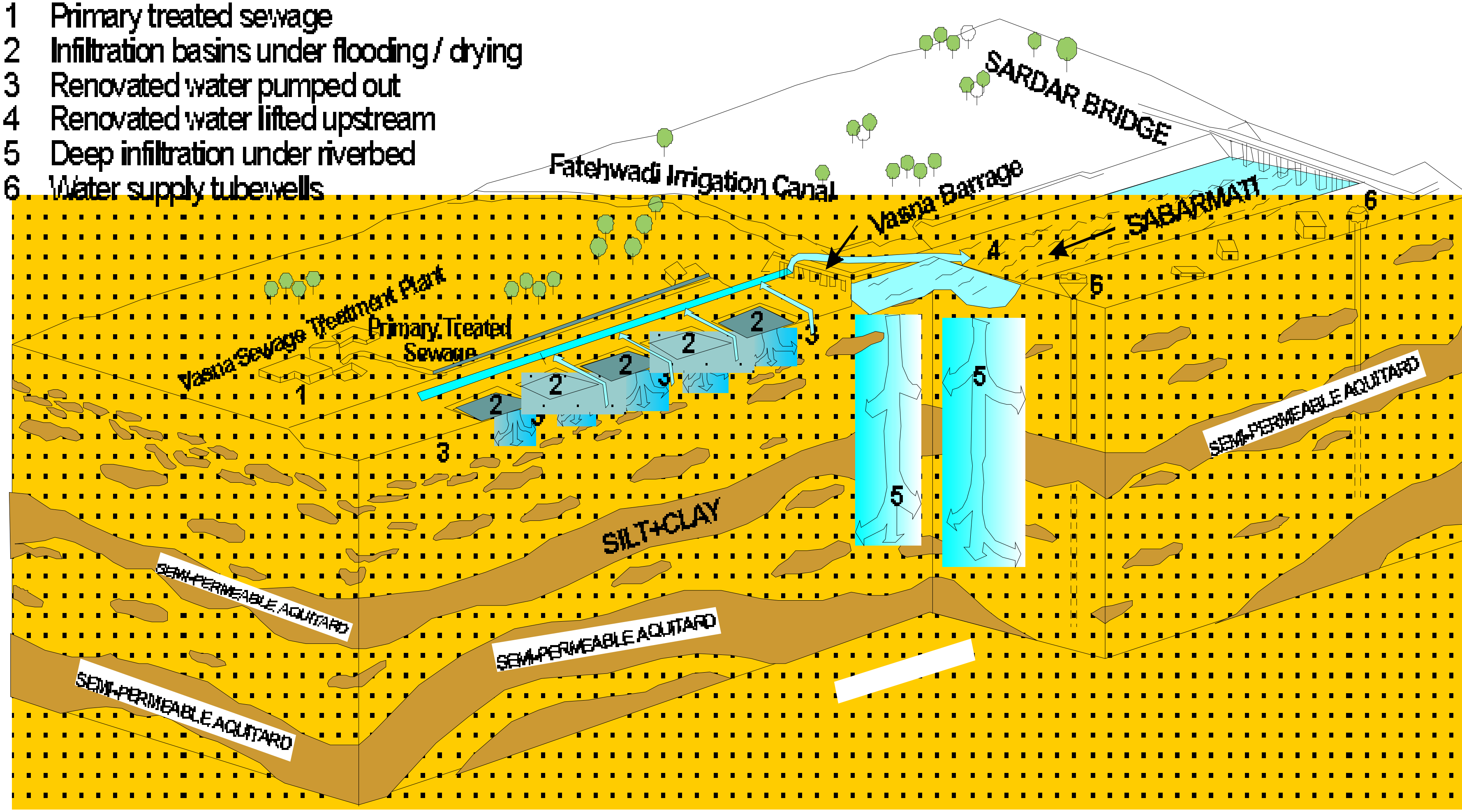
- The limit of SS concentration for optimal total infiltration (output) using primary effluent was found 30 – 35 mg/l as against 10 mg/l reported by Rice (1974) using secondary effluent.
- System operated at an average HLR of 0.08 m/day (30 m/yr.)

Cost analysis of SAT system vis-à-vis other conventional wastewater treatment systems (System capacity: 55 MLD)

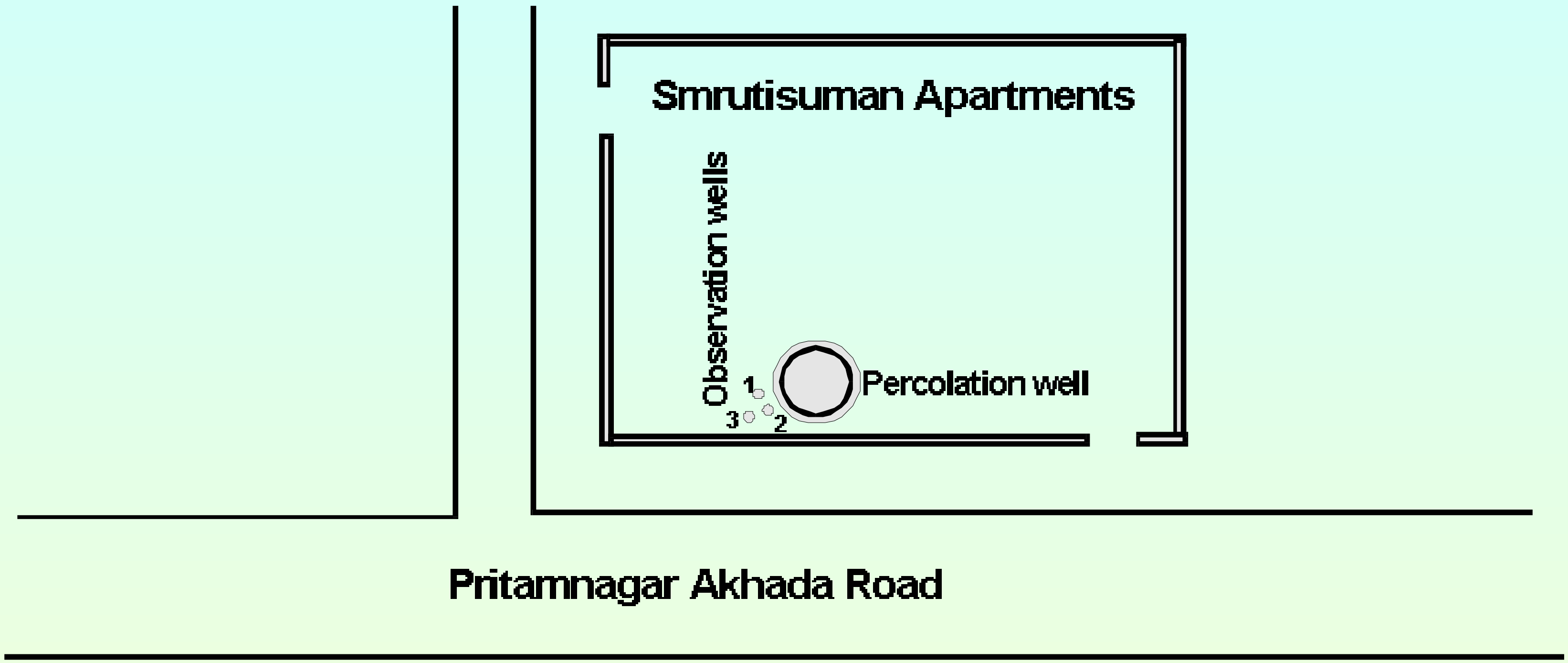
Treatment System	Capital Cost	O & M cost	Total annualised Cost (TAC)	Unit Cost	Cost Ratio (TAC) wrt SAT
	(Rs. Lacs)			(Rs. /m^3)	
ASP (Conv.)	1,434	519	754	3.75	1.4
ASP (EA)	1,462	668	908	4.52	1.7
AFFR	1,557	386	641	1.92	1.2
SAT	1,450	296	553	1.50	--

SCHEMATIC OF RIVERBED SAT WASTEWATER RENOVATION AND RIVERFRONT DEVELOPMENT SYSTEM FOR AHMEDABAD

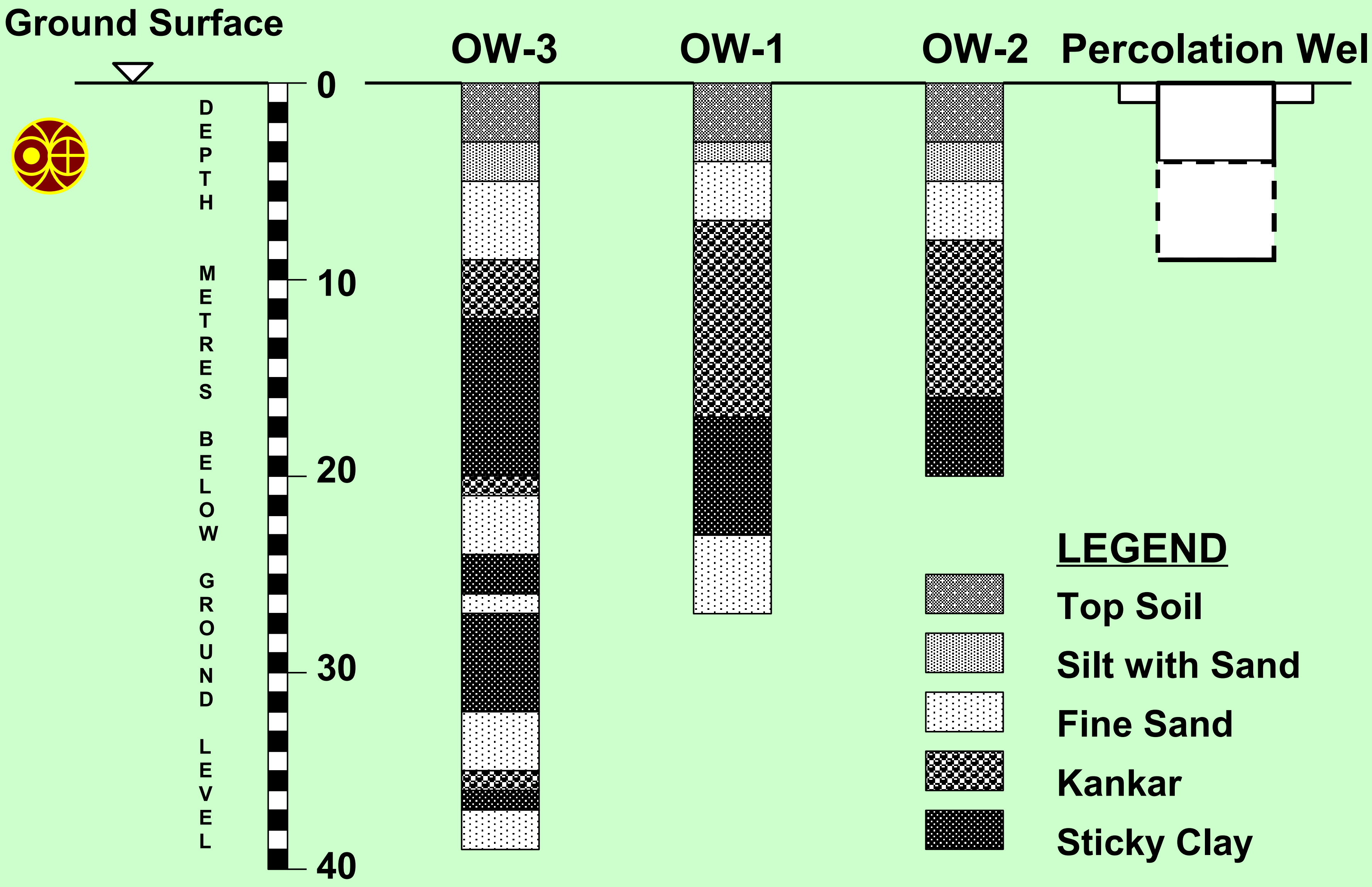
1 Primary treated sewage
2 Infiltration basins under flooding / drying
3 Renovated water pumped out
4 Renovated water lifted upstream
5 Deep infiltration under riverbed
6 Water supply tubewells



Renovation and Recharge of Grey Water



Schematic arrangement of Percolation and Observation Wells (Not to Scale)



Percolation and observation wells for recharge of grey water at Smrutisuman Apartments, Ahmedabad

Akshaydhara, the solution!

- **The *Akshaydhara* is an environmentally sustainable alternative system for managing urban water supply and sanitation.**

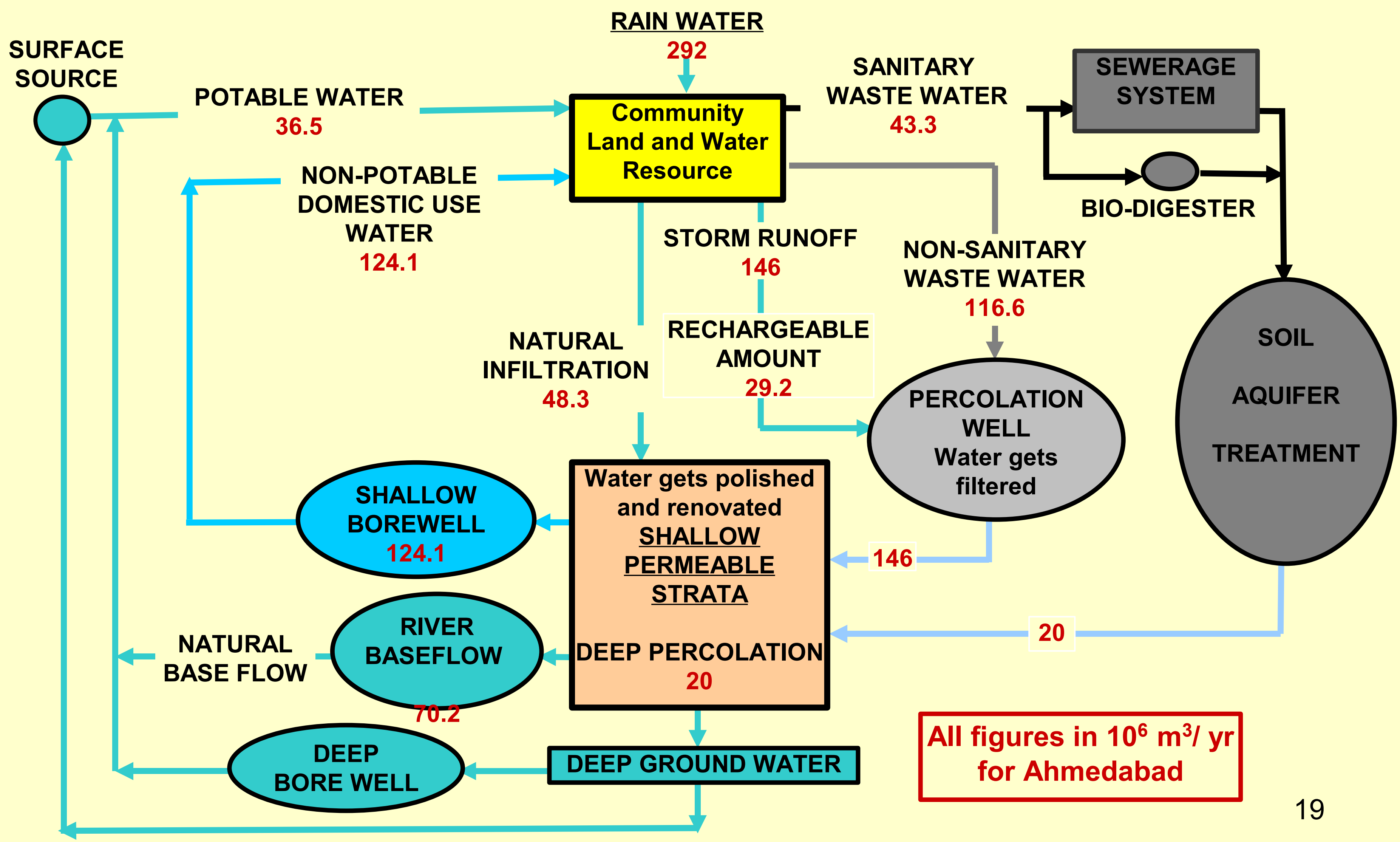
- **The key element of *Akshaydhara* is the manipulation of shallow (<20m deep) soil-aquifer system to effect renovation of storm- and domestic waste- water and its subsequent transmission to surface water bodies through natural subsurface flow thereby maintaining their pristine quality perennially.**

Akshaydhara components

- **Soil-aquifer-treatment systems using infiltration basins;**
- **Percolation wells;**
- **Local networks for supply of renovated wastewater for non-potable applications;**
- **Local networks of small bore sewers for wastewater disposal into centralised low capacity systems.**
- **Several experimental initiatives have been undertaken in the last decade in Ahmedabad to validate the *Akshaydhara* concept.**

AKSHAYDHARA

A SYSTEM FOR TOTAL WATER MANAGEMENT



All figures in 10^6 m^3/ yr for Ahmedabad

New Tools for Monitoring Environmental Impacts and Warning Signals

1. Isotopic tracers in conjunction with other chemical analyses and flow path modelling can help determine origin, movement, mixing and flushing of various pollutants particularly in soils and ground waters.

2. Even the limited application of stable isotopes of oxygen ($\delta^{18}O$) and hydrogen (δD) can help in accurately estimating the travel time for pollutants through surface and subsurface pathways.

3. Offering such information can be vital for planning and setting up the industrial units at appropriate locations and in prediction of the chemical impacts of the non-point source pollutants.

Books on Pollution Investigations Using Isotopes

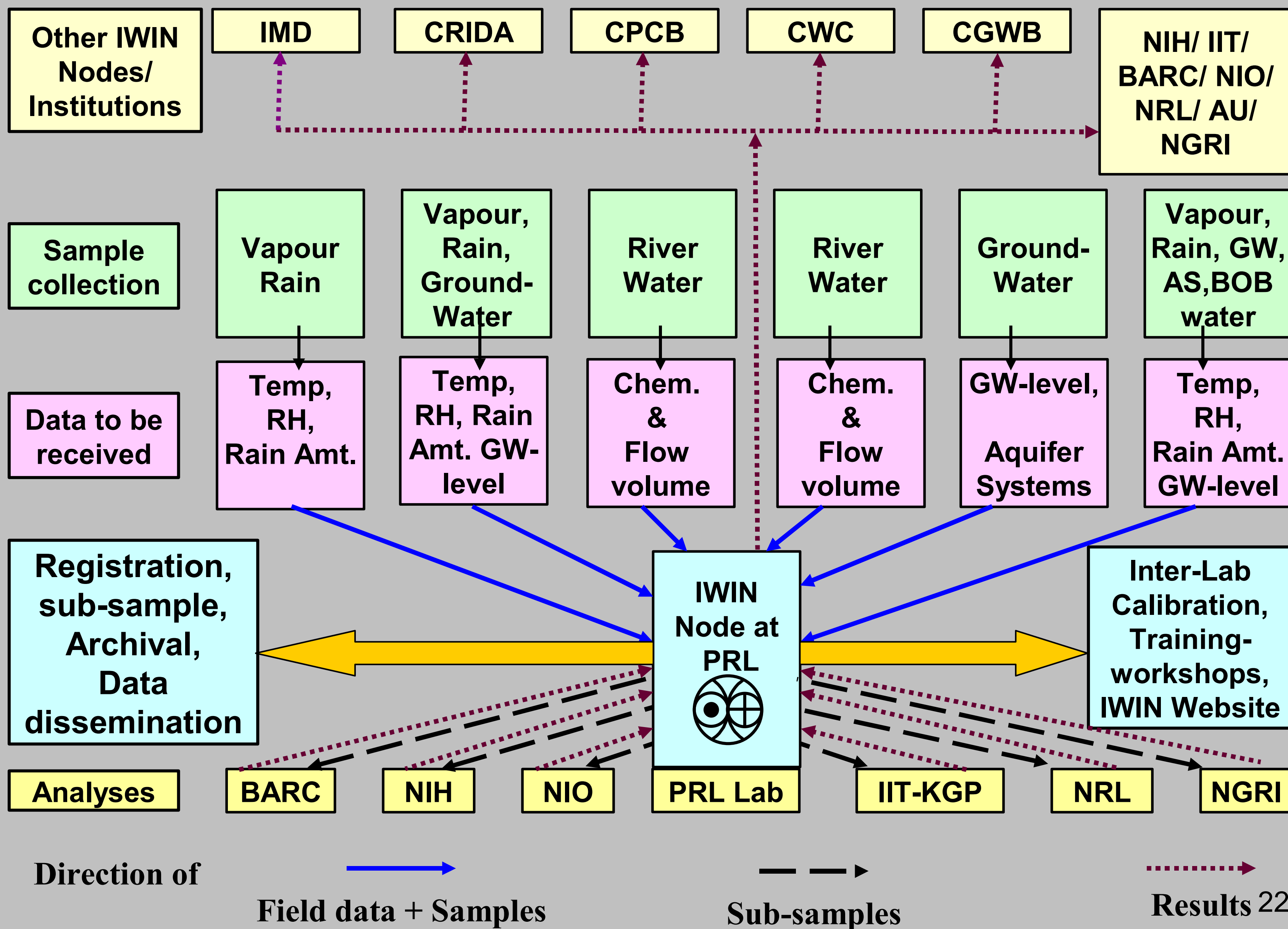
Application of Isotope Techniques to Investigate Groundwater Pollution
Proceedings of a final Research Co-ordination Meeting held in Vienna, 2-5 December 1997. 16 papers.
IAEA-TECDOC-1046, Vienna, 1998, 262 pages.

Nuclear Techniques in the Study of Pollutant Transport in the Environment. Interactions of Solutes with Geological Media (Methodological Aspects)
Final reports of a Co-ordinated Research Programme (1987-1992).

12 papers. **IAEA-TECDOC-713 Vienna, 1993, 343 pages.**

Isotope Ratios as Pollutant Source and Behaviour Indicators
Proceedings of a symposium held in Vienna, November 18-22, 1974. 34 papers. **STI/PUB/382 Vienna, 1975, 489 pages.**

IWIN - Task Organisation



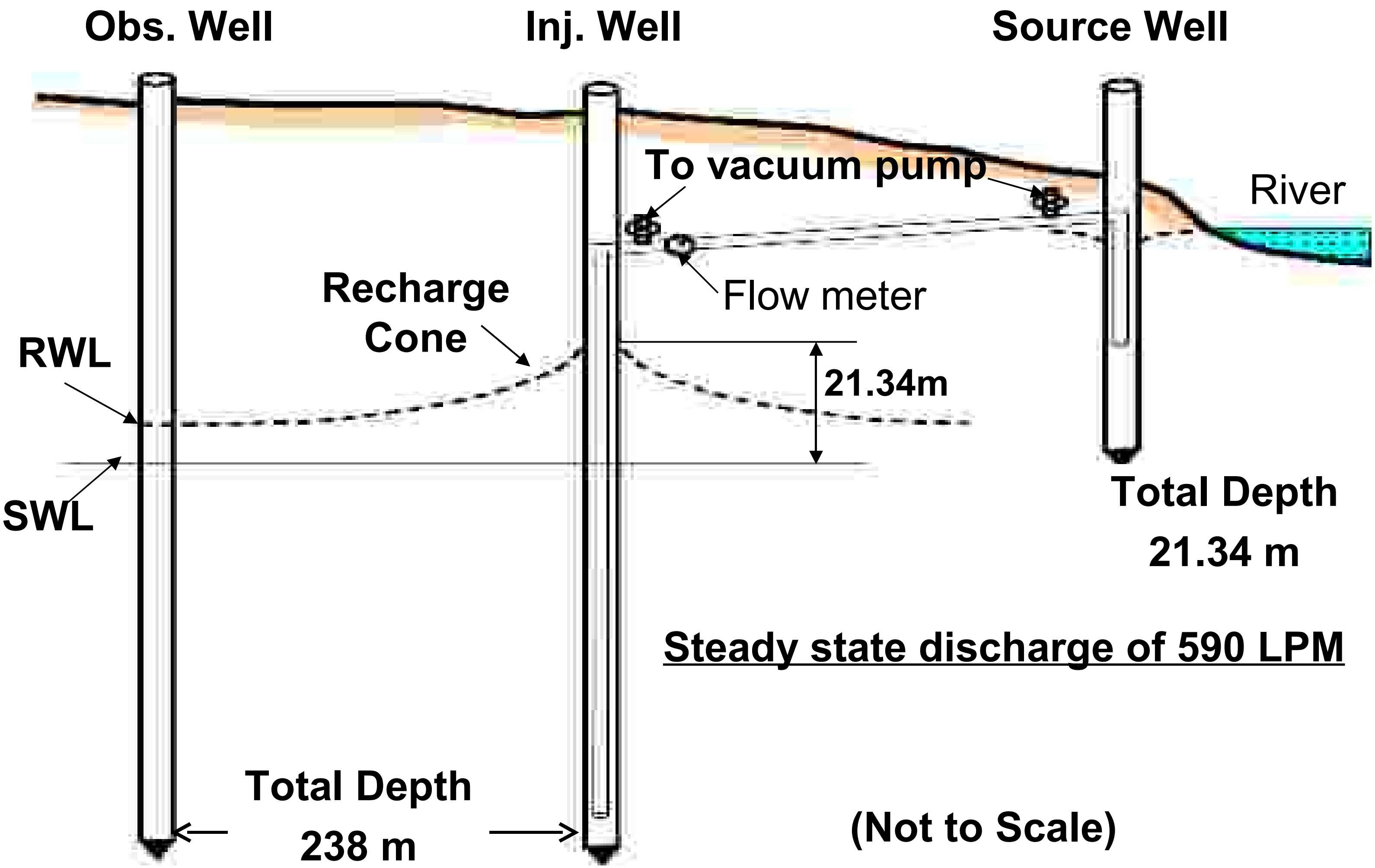
Thanks…

A paradigm shift

Indiscriminate consumption	Restricted and judicious consumption
Highly subsidised regime	Moderately subsidised cost of water. Users pay excessively for extravagant consumption
Centralised systems of water supply and sewerage.	Decentralised systems: Rainwater harvesting and Infiltration structures
Govt. responsibility	Community participation
Common treatment for grey and dark water	Separate handling of grey and dark water
Primary and secondary Sewage treatment and discharge in streams.	Soil Aquifer Treatment after conventional sewage treatment and subsequent reuse.

Strong legal compulsion favoring conservation, renovation and reuse

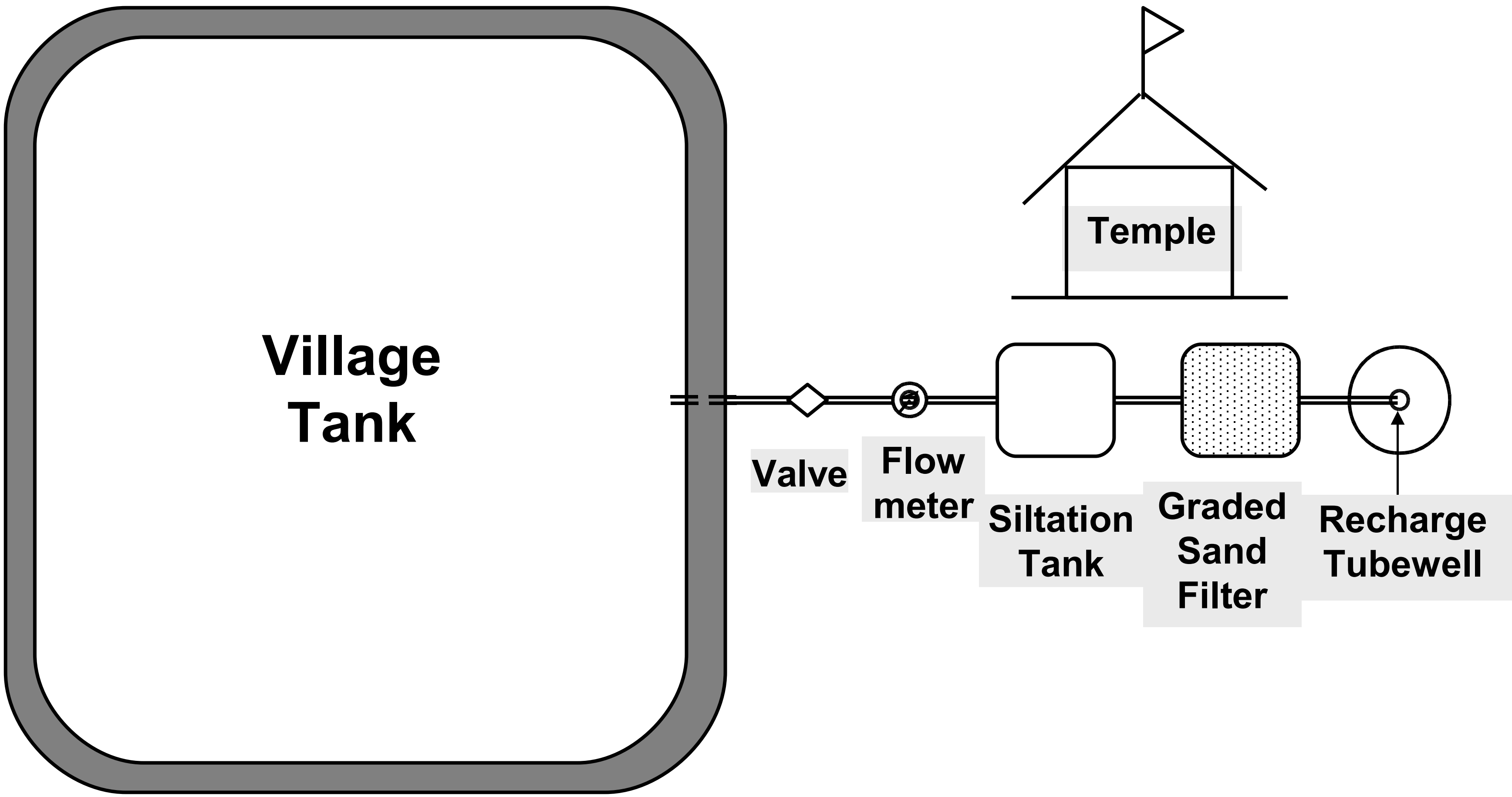
Artificial Recharge Experiment - Ahmedabad



Steady state discharge of 590 LPM

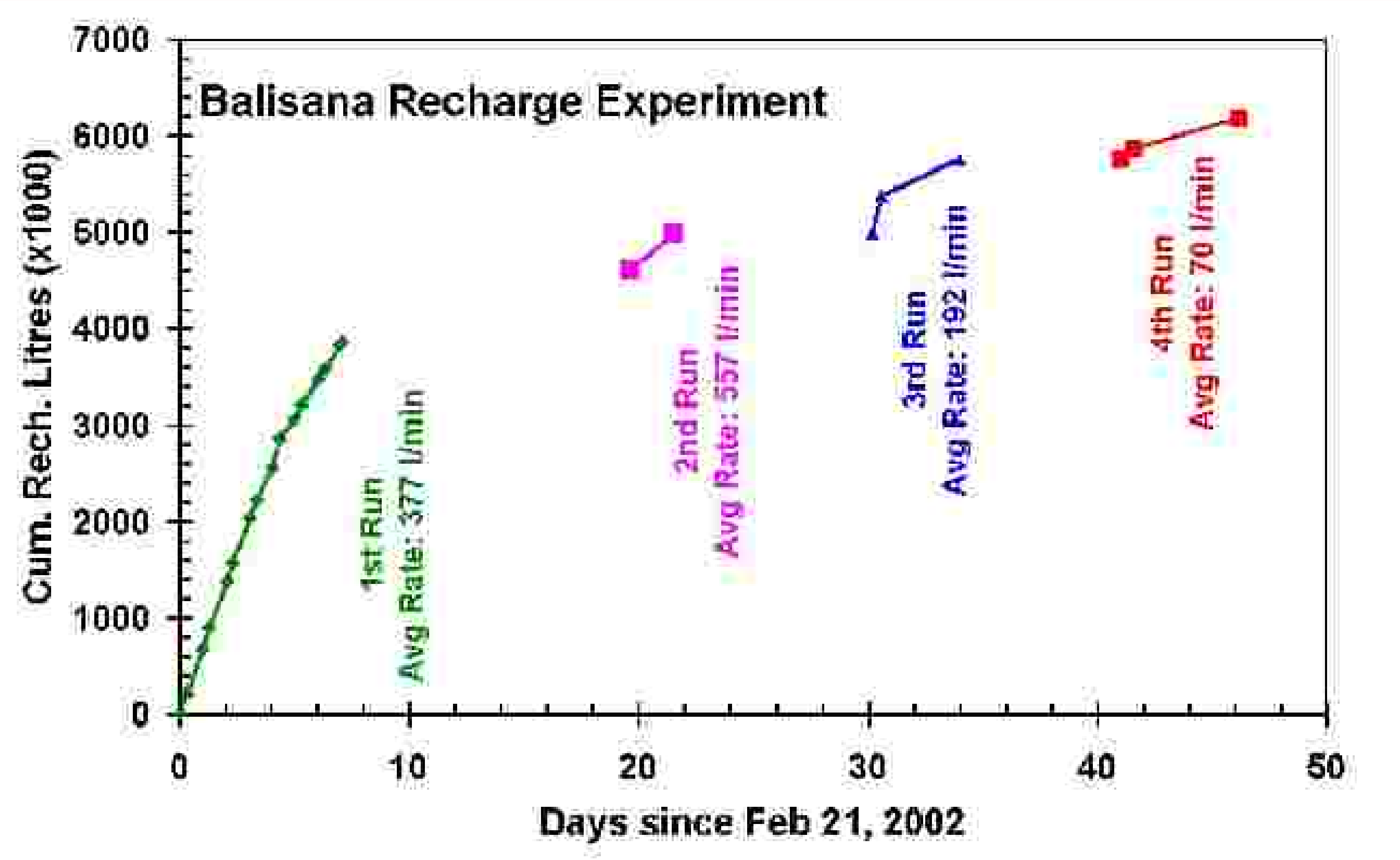
(Not to Scale)

Artificial Groundwater Recharge Setup at Balisana Village, North Gujarat

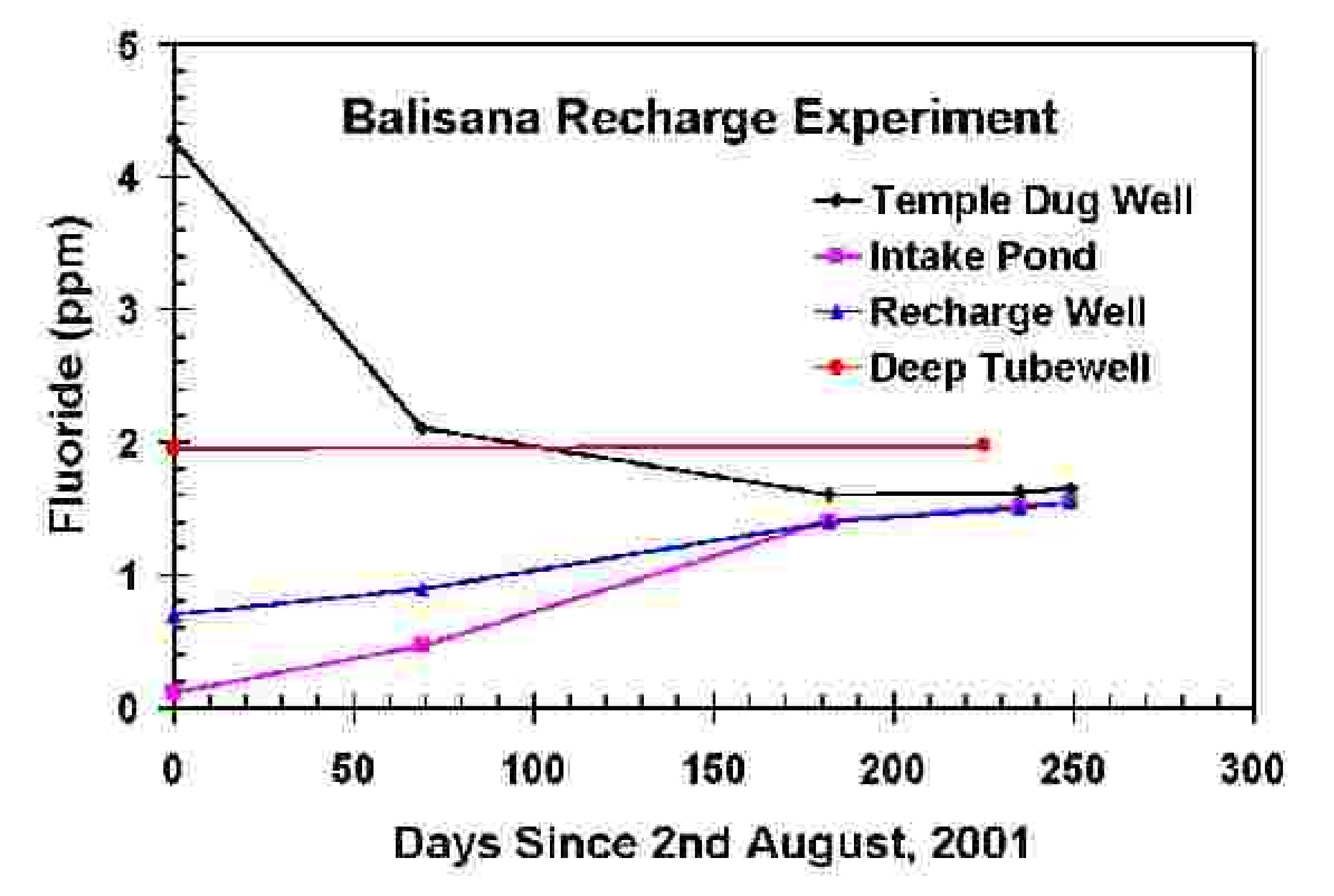


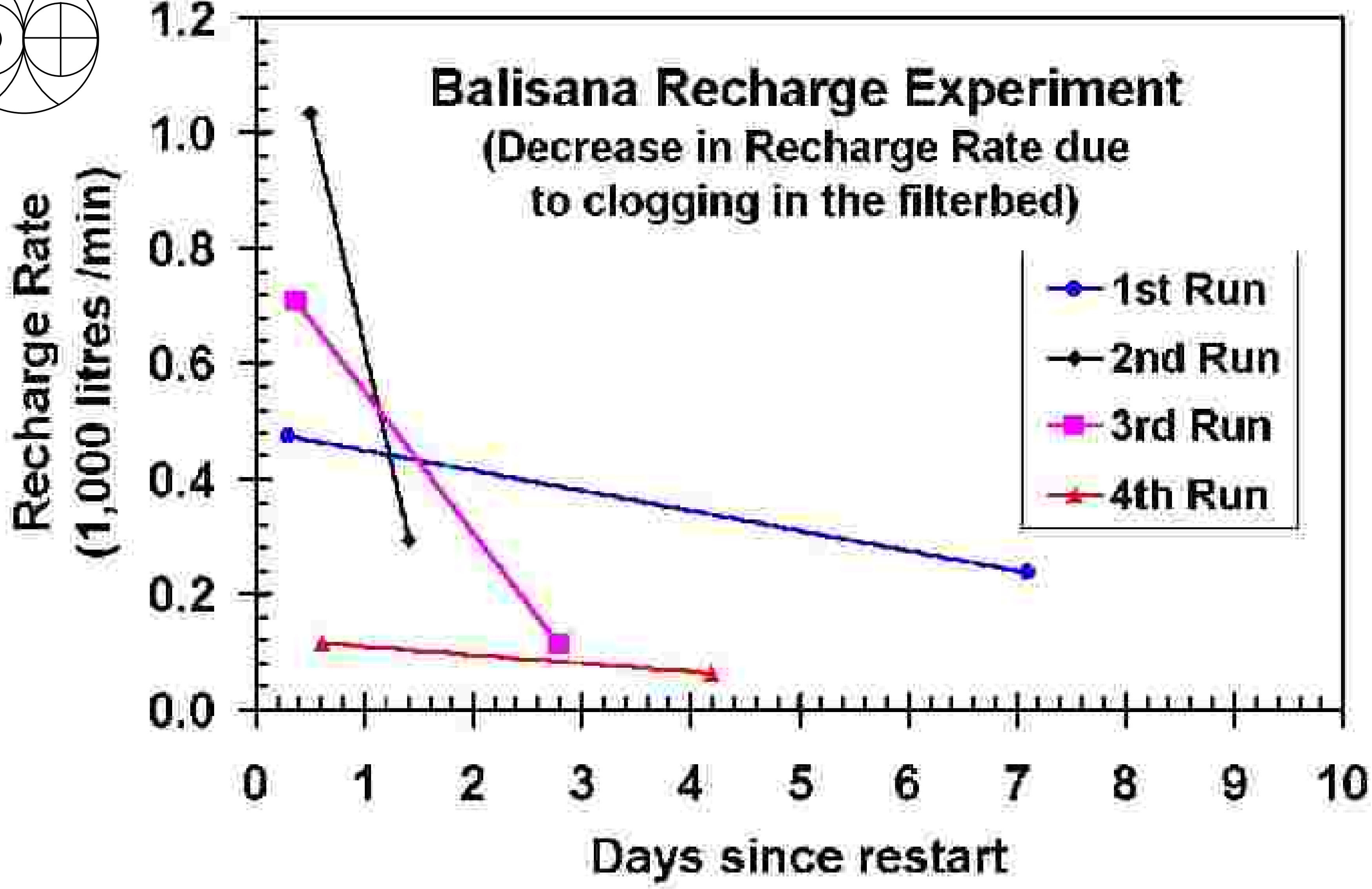
SCHEMATIC SKETCH (NOT TO SCALE)

Variation of Groundwater Recharge



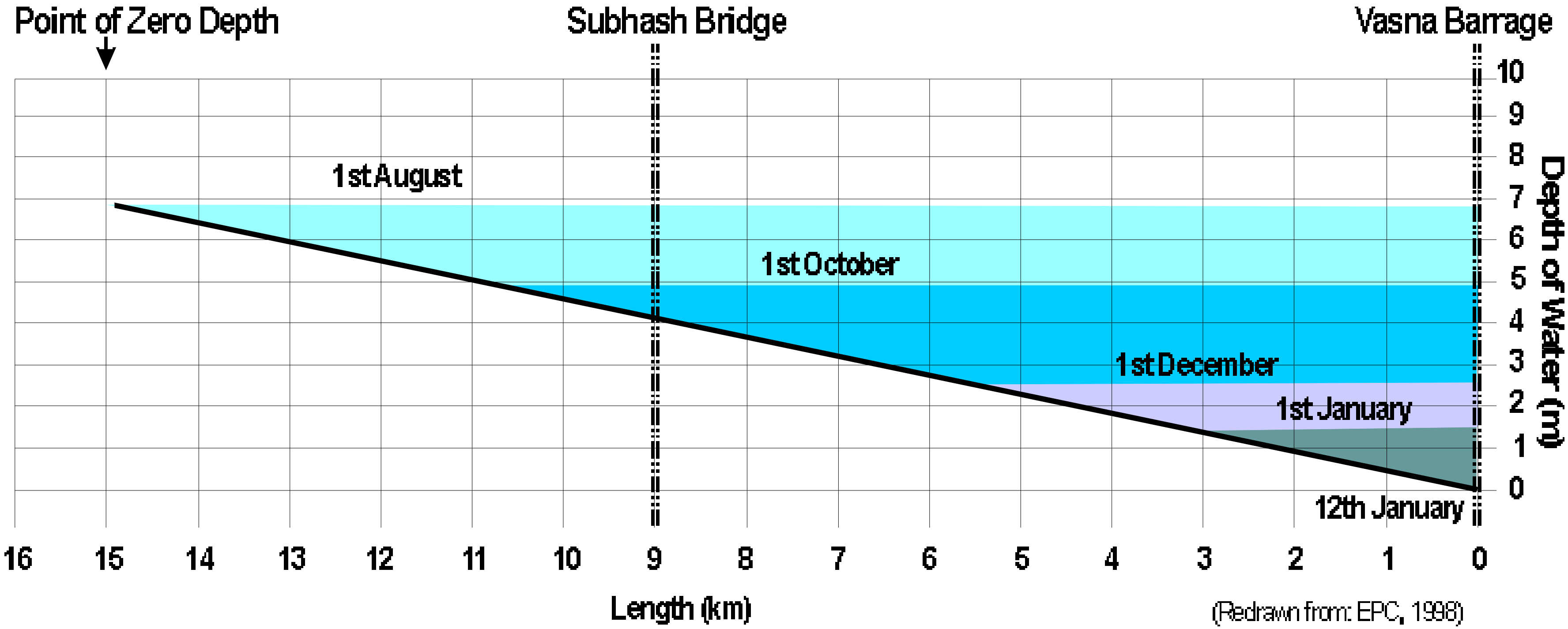
Change of fluoride concentration during recharge experiments



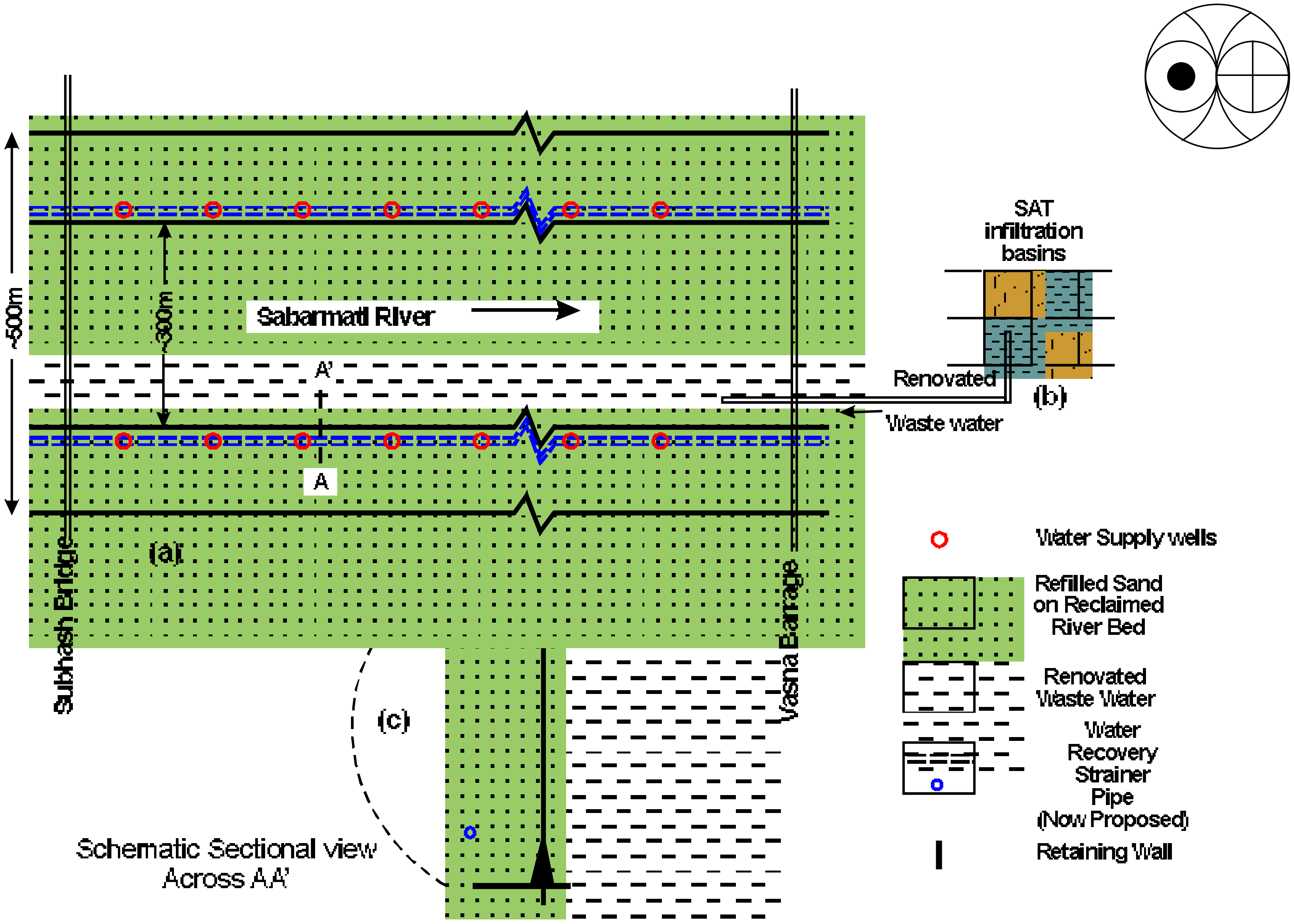


Balisana Recharge Experiment
(Decrease in Recharge Rate due
to clogging in the filterbed)
Recharge Rate
(1,000 litres /min)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
9
10
Days since restart
1st Run
2nd Run
3rd Run
4th Run

Schematic Water Retention Diagram



(Redrawn from: EPC, 1998)



SAT
infiltration
basins
Sabarmati River
~500m
~300m
A'
A
Renovated
Waste water
(b)
(a)
(c)
Subhash Bridge
Vasna Barrage
Schematic Sectional view
Across AA'
Water Supply wells
Refilled Sand
on Reclaimed
River Bed
Renovated
Waste Water
Water
Recovery
Strainer
Pipe
(Now Proposed)
Retaining Wall