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GLOBAL WATER PARTNERSHIP

URBAN WATER-SUPPLY SECURITY IN THE DEVELOPING WORLD

groundwater use trends and the sanitation nexus

Prof Dr STEPHEN FOSTER

GW-MATE Director

(IAH President)

bnwpp Bank-Netherlands Water Partnership Program

DFID Department for International Development

URBAN WATER-SUPPLY SECURITY
growing dependence on groundwater

- rapid growth of urban population (at 3-6%/a) and water demand (at even faster rates) are a reality (not just megacities but also medium-sized towns)
- in many areas demand situation is likely to be exacerbated in most climate-change scenarios (increased temperatures and frequency/intensity of drought affecting surface water-supplies)
- municipal water utilities widely struggle to finance, develop and operate major new water-supply schemes
- thus local groundwater resources (wherever available) become key facet of 'coping' and 'adaptation' strategy

GROUNDWATER IN THE URBAN ENVIRONMENT

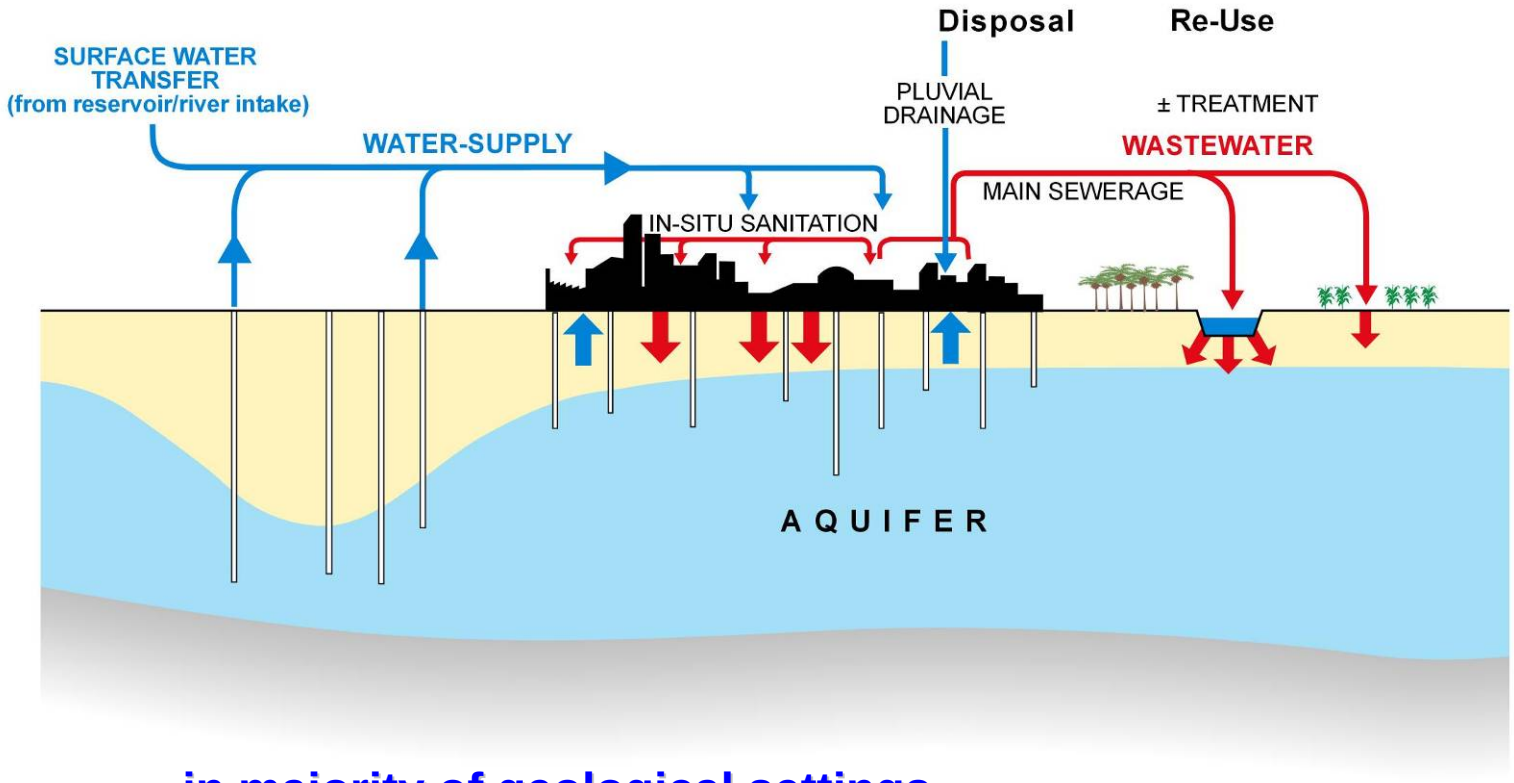
a few general facts

GROUNDWATER AND THE CITY
an intimate but often unrecognised relationship

some groundwater extraction for utility water-supply but major wellfields only possible in favourable hydrogeological settings

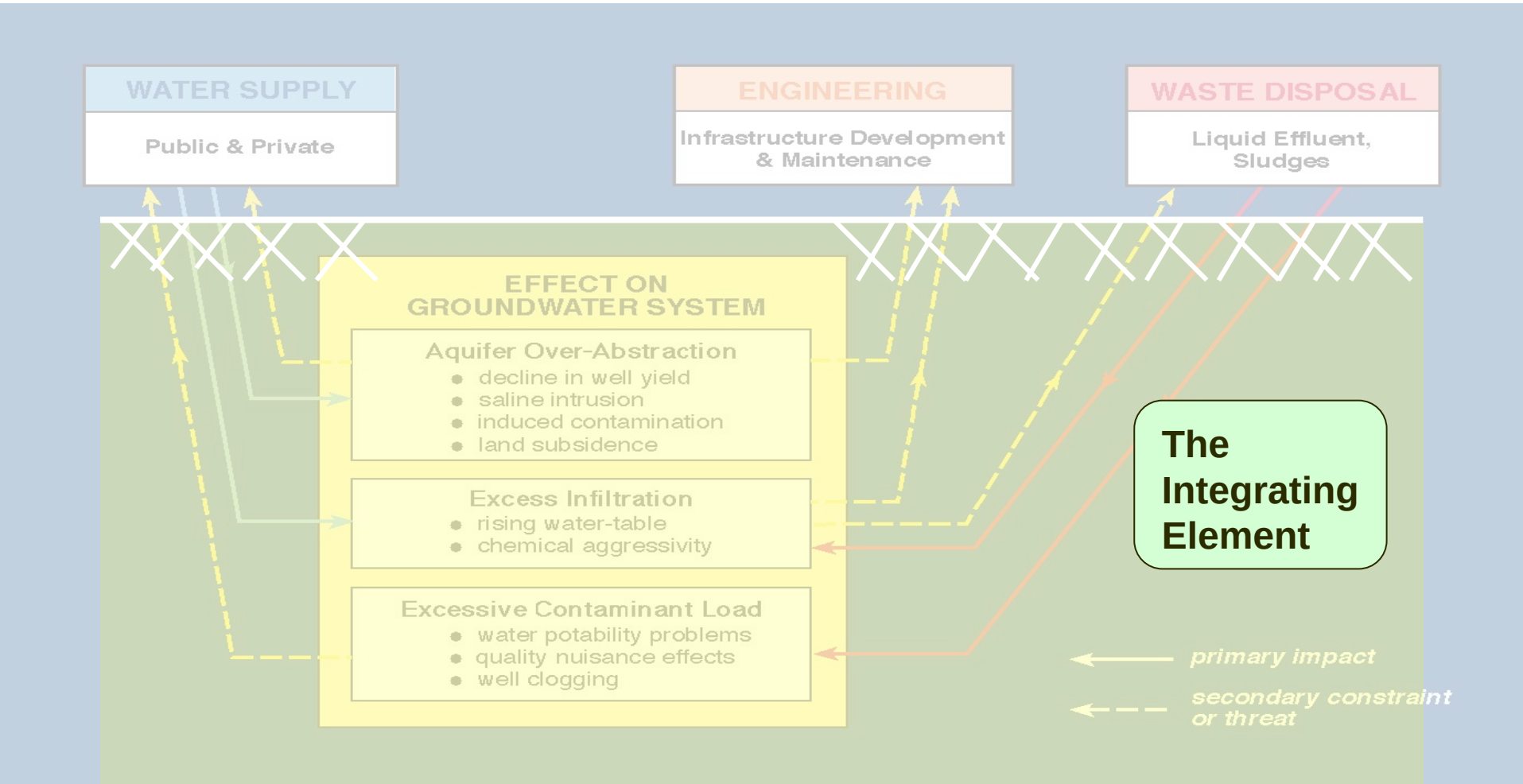
moderate community/private groundwater extraction - but extensive in-situ sanitation and some industrial site effluent discharge to ground introducing major contamination

some wastewater discharge to streams with limited re-use generating groundwater recharge but some contamination



…… in majority of geological settings
but varies with water-supply and sanitation arrangements

GROUNDWATER AND THE CITY
‘urbanisation impacts on groundwater’ and ‘groundwater impacts the urban infrastructure’



without planning – “one person’s solution becomes the another person’s problem”

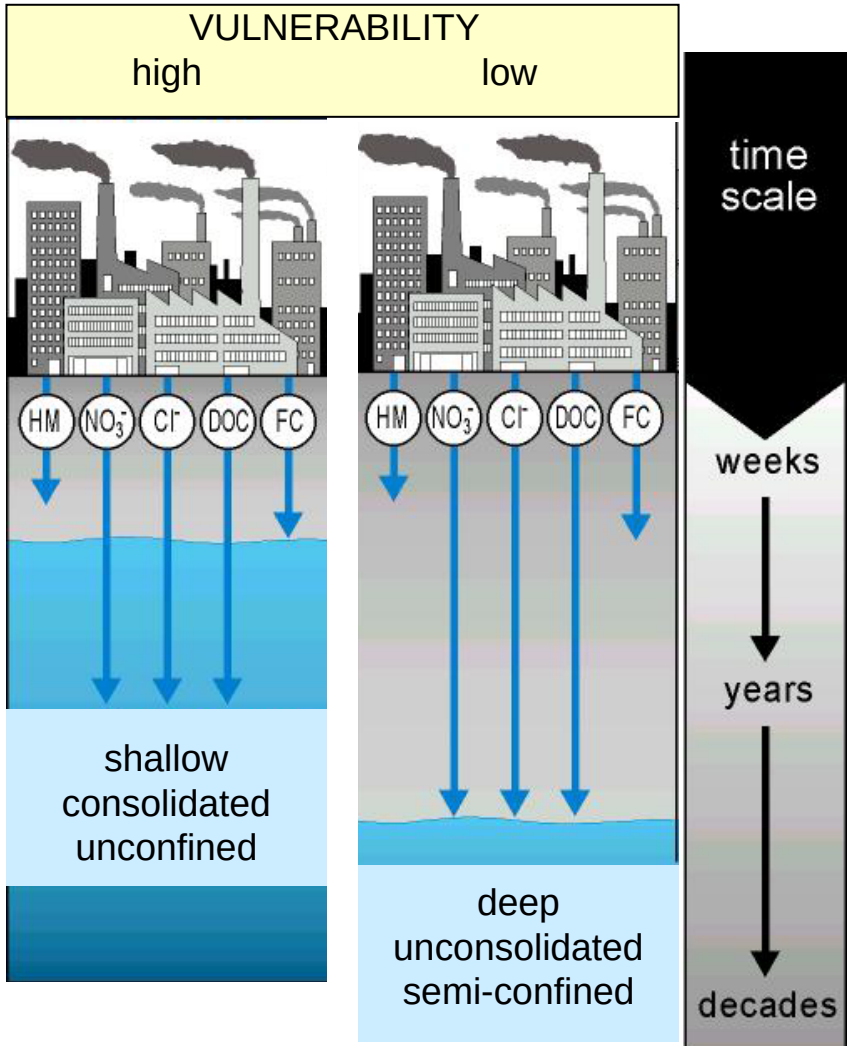
GROUNDWATER & THE CITY
the unspoken relationship

- much water use / effluent disposal is unregulated or 'illegal'
- little discussed by urban 'infrastructure sector'
- conflicts thus arise :
  - private versus utility 'water-supply tensions'
  - low-cost sanitation versus groundwater quality

WASTEWATER & GROUNDWATER
an intimate but concealed relationship

- wastewater handling and re-use normally result in large volumes of 'incidental infiltration' to aquifers
- occurs both where urban area is served by on-site sanitation and by mains sewerage system
- usually most significant 'reuse' of urban wastewater volumetrically
- but still rarely planned and often not even recognised

URBAN GROUNDWATER POLLUTION
aquifer vulnerability controls



IN-SITU SANITATION versus LOW-COST GROUNDWATER SUPPLY

- in-situ sanitation often results in excess N load and risk of FC/DOC pollution to shallow aquifers

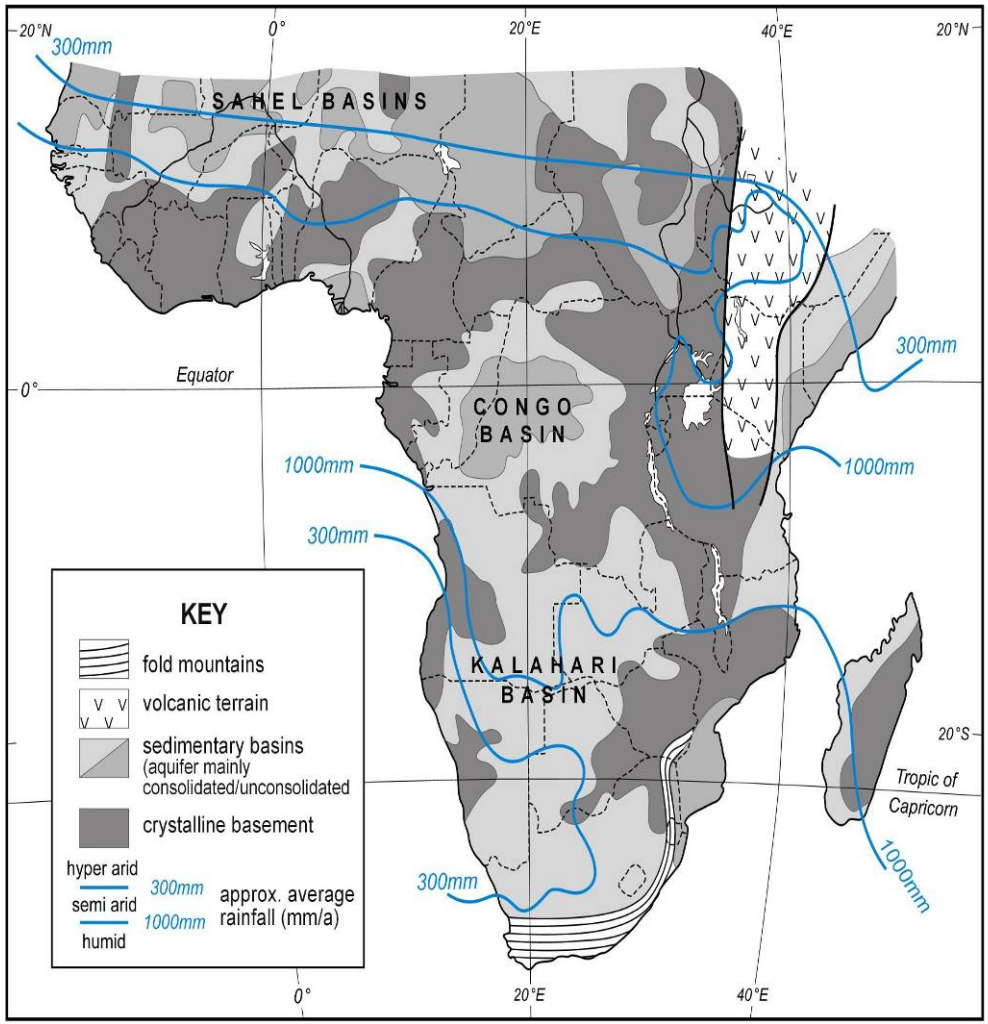
- questioning compatibility with low-cost urban water-supply but much urban water-use does not require potable quality standard

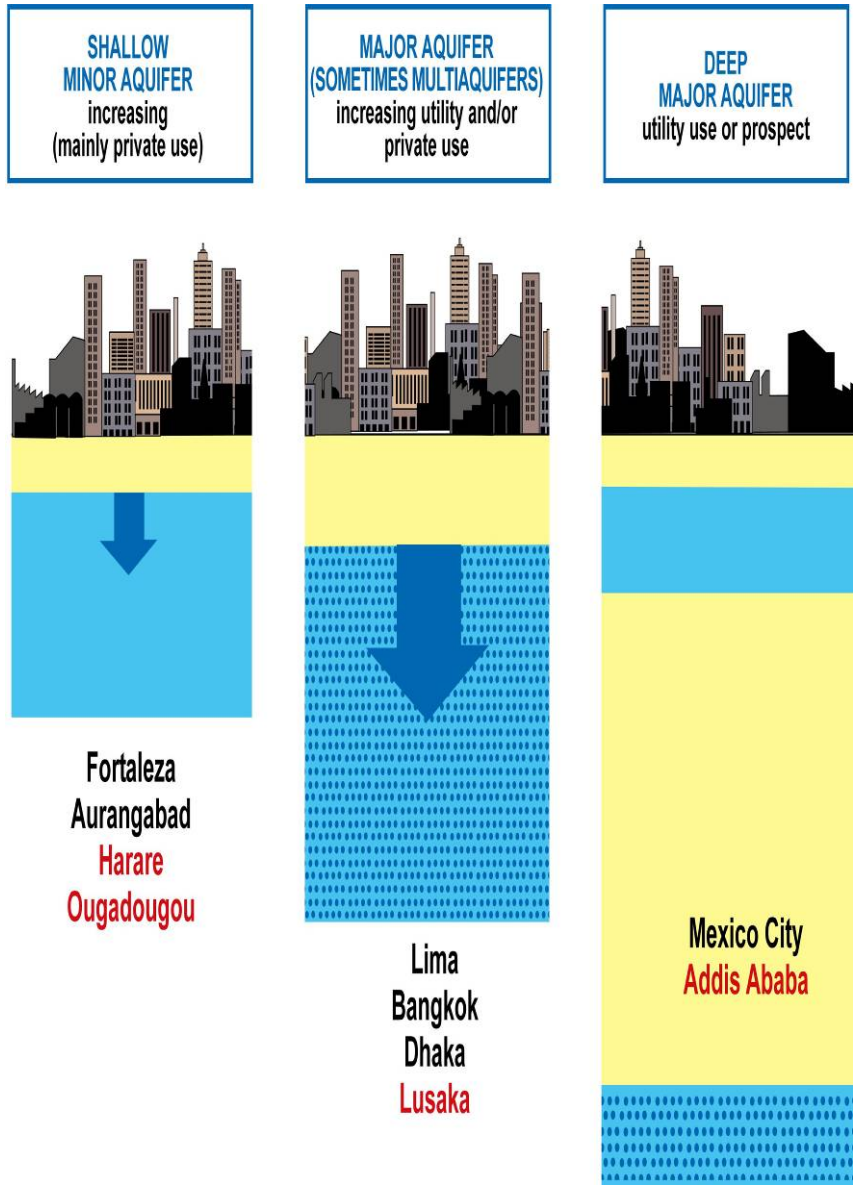
- mitigation of problem partly possible by :
  - proper maintenance of in-situ sanitation units
  - improved in-situ sanitation unit design
  - prioritising mains sewage in areas of vulnerable groundwater

URBAN WATER-SUPPLY IN SUB-SAHARAN AFRICA

role of groundwater and sanitation nexus

URBAN GROUNDWATER USE
variation of hydrogeological settings and scenarios





SUB-SAHARAN AFRICA
STATUS OF URBAN WATER-SUPPLY PROVISION
AICD Water Sector Review – World Bank (2008)

Macro International D & H 2007 Surveys
63 large-sample household surveys covering
30 countries some having 'time sequential data'
(by extrapolation provides no. of water users but not volume used)

- **proportion of users with access to improved water source decreasing recently *(due to rapid population growth)***
- **38% of users served by mains piped-supply to dwelling**
- **29% use municipal stand-posts (within 500m of dwelling)**
  (maximum nationally Burkina Faso at 52%)
- **24% collect from stand-alone public/private waterwells**
  (maximum nationally Nigeria at 48%)
  (this is most rapidly growing category –
  1.5%/yr on average and over 5.0%/yr in some countries)
- **balance made up from expensive water vendors or collection from unsafe surface water sources**

SUB-SAHARAN AFRICA : URBAN GROUNDWATER
estimated use in selected megacities

overall groundwater use not only includes stand-alone wells but a variable proportion of mains piped-supply and stand-post supplies plus private industrial and commercial use

CITY	POPLN (million)	MUNICIPAL UTILITY WATER-SUPPLY (Ml/d)		PRIVATE/ COMMUNITY GW USE (Ml/d)	TOTAL GW USE (propn)
		SW	GW		
Dar-es-Salaam	**3.2**	**300**	**30**	**80**	**27 %**
Nairobi	**3.6**	**520**	**10**	**90**	**16 %**
Addis Ababa	**4.4**	**180**	**50**	**70**	**40 %**

but in general monitoring and statistics of groundwater use are very poor and estimates are often dated and usually based on many assumptions

SUB-SAHARAN AFRICA : URBAN SANITATION REALITIES
and risks for groundwater

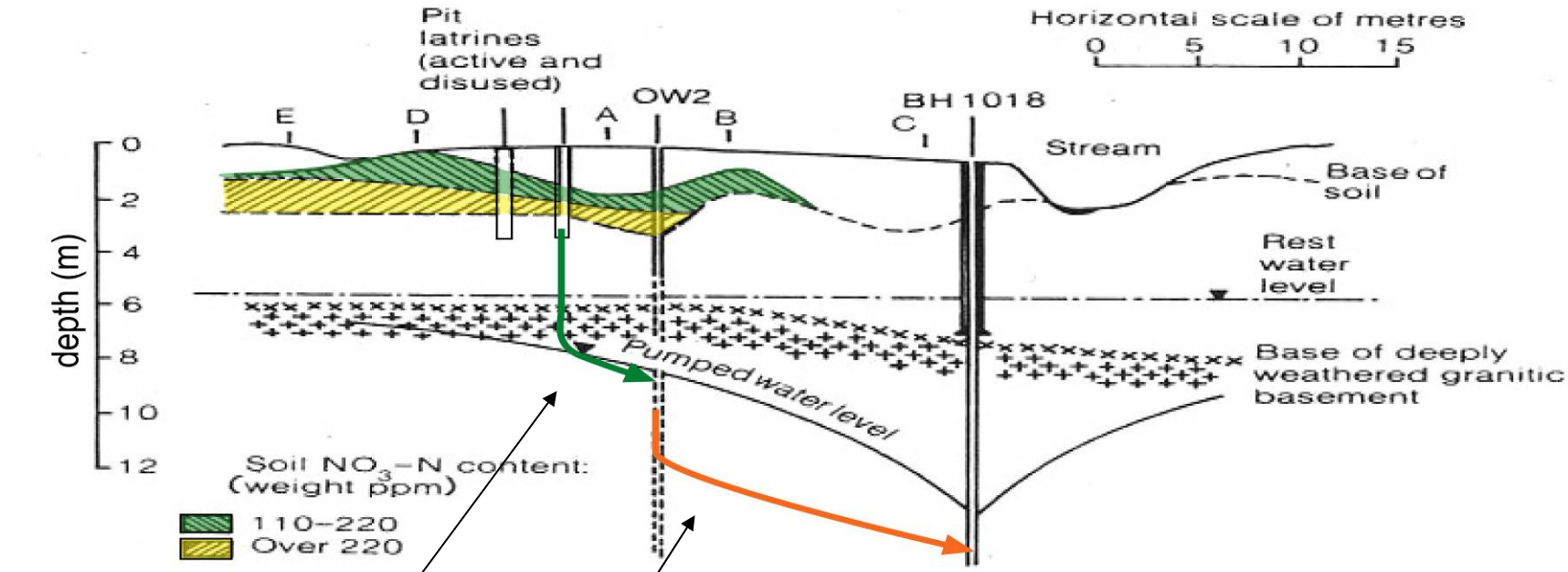
AICD Water Sector Review 2008 – World Bank
Macro International D & H 2007 Survey

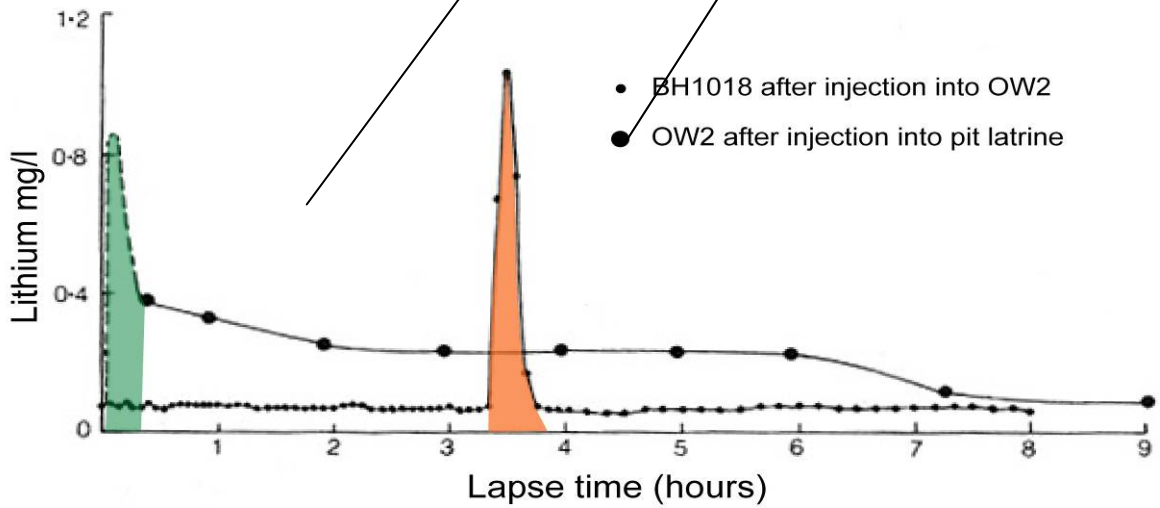
- **65% dependent upon pit latrines**
  (with very low level of latrine emptying)
- **25% use flush toilets mainly to septic tanks**
- **10% have no sanitation whatsoever**
- **propn on main sewerage systems very low except in a few megacities and a couple of countries**

IMPLICATION

- ***heavy contaminant load to groundwater (principally NO3/NH4 & DOC) especially in densely-populated districts***
- ***also pathogenic pollution risk especially in vulnerable areas with shallow water-table***
- ***also impacts from industrial effluent disposal and spillages***

MOCHUDI – BOTSWANA
Weathered Basement Aquifer
impact of pit latrines on shallow groundwater quality

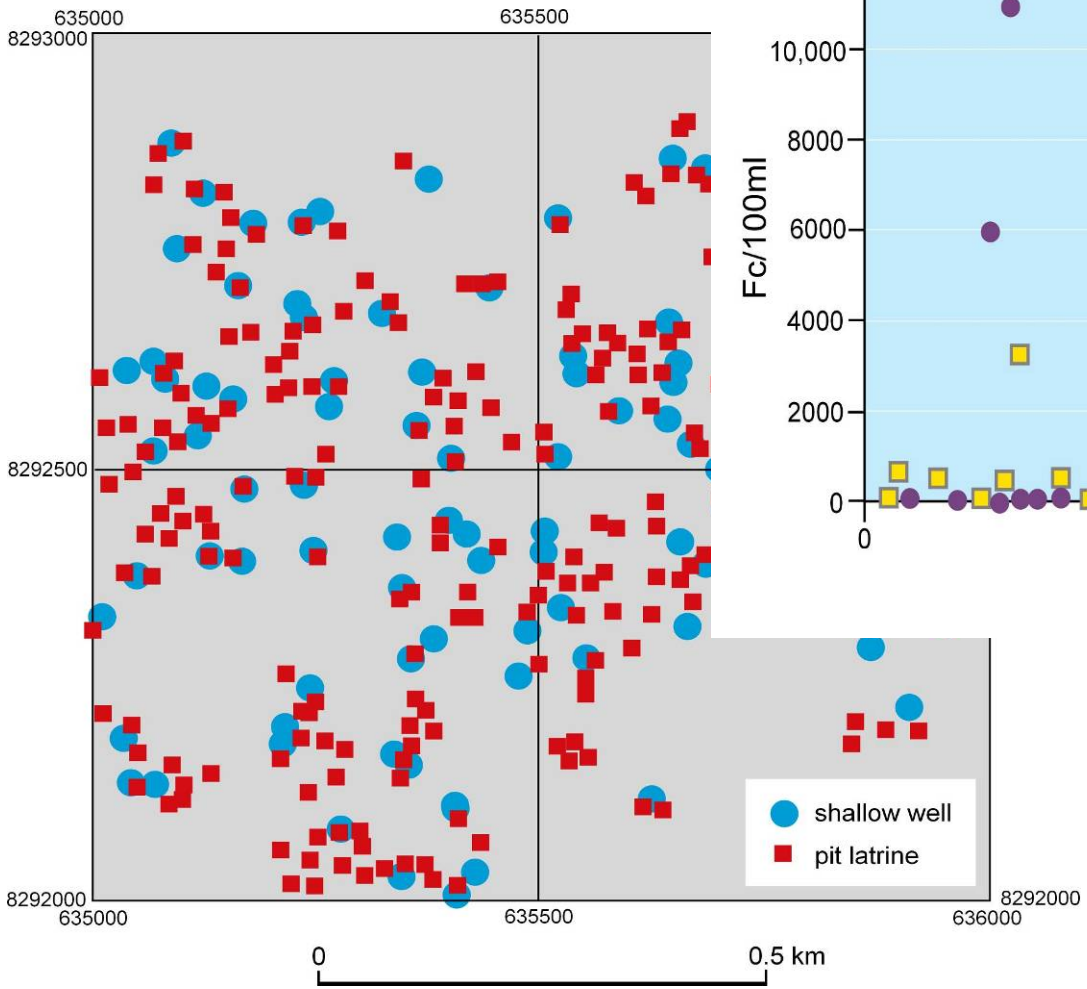


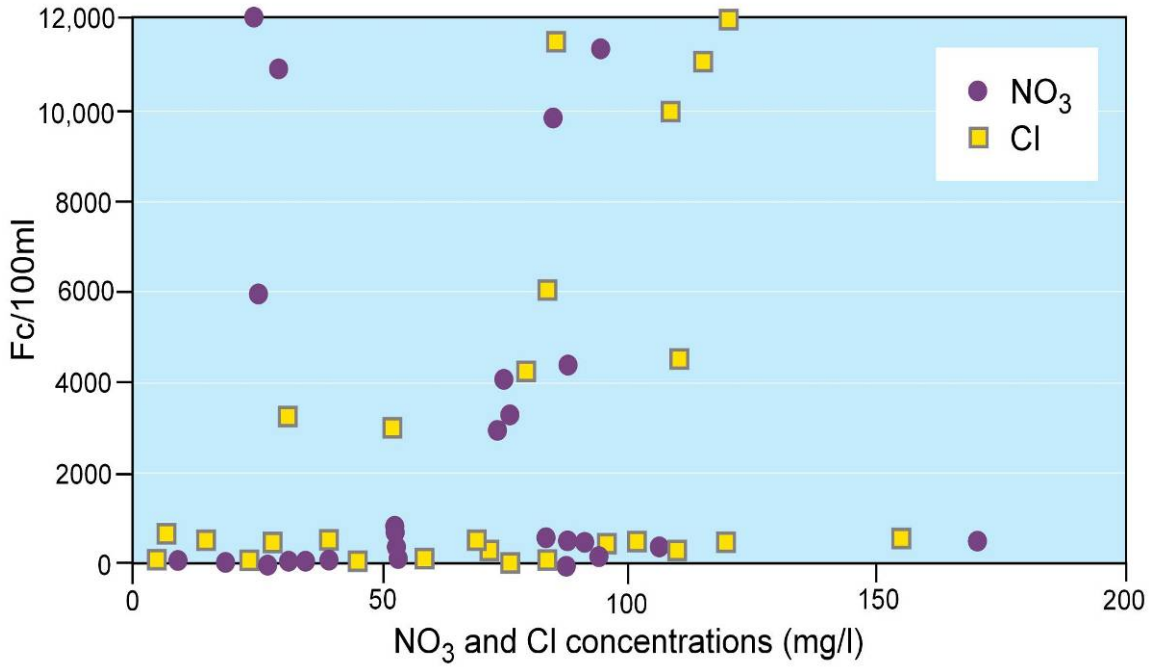


NO3 = 600-800 mg/l
FC up to 500/100 ml
(some FC strains antibiotic-resistant)

(Lewis, Farr & Foster, 1980)

LUSAKA – ZAMBIA
DOLOMITIC LIMESTONE AQUIFER
distribution of shallow waterwells and excreta pit latrines with impact on groundwater quality (NO3, Cl & FC)





detailed data from John Laing & Misisi Compounds (Nkhuwa, 2006)

SUB-SAHARAN AFRICA : URBAN GROUNDWATER USE
policy implications of socio-economic drivers

- urban households still have to survive on small budgets *(US$ 130-300 per month)* raising questions of affordability / cost recovery for major new utility mains water-supply systems

- waterwell construction costs need to reduce and success rates increase for major 'take-off' of self-supply from groundwater

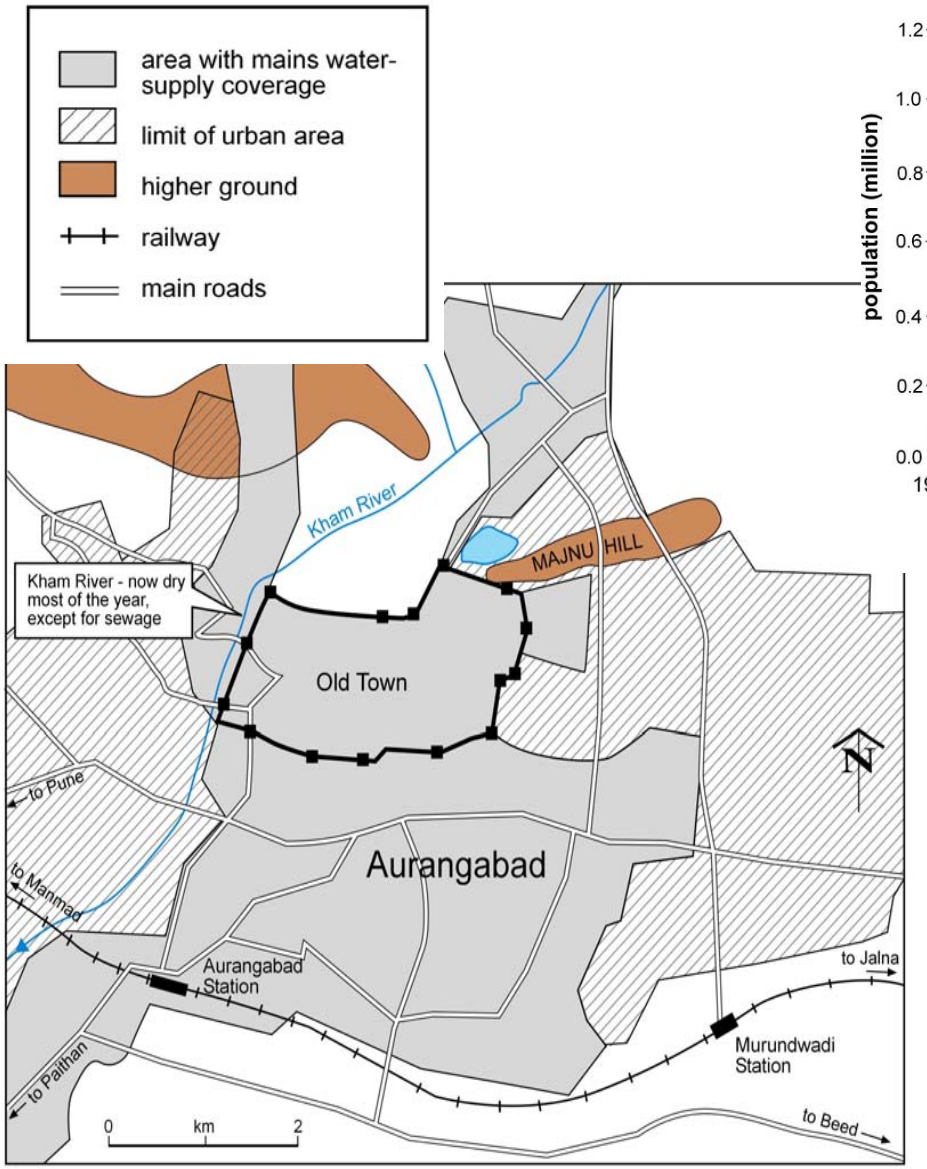
- thus most probable future scenario is much increased use of low-cost facilities like urban community waterwells with / without local reticulation to standposts depending on yield *(minm capital cost for 200 + persons of about US$ 20 / cap)* together with pit latrine sanitation

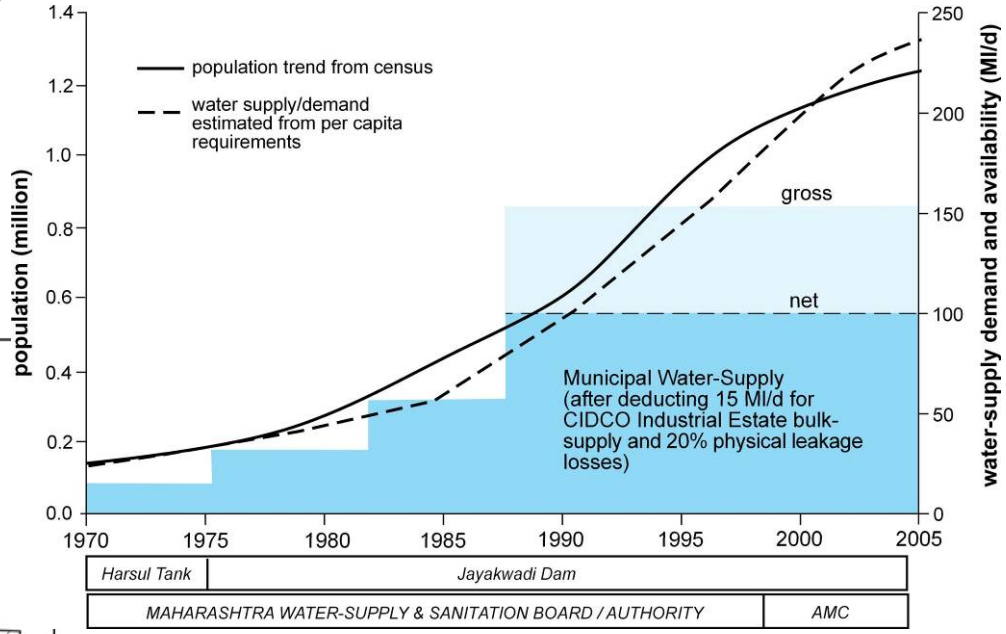
- concomitant need for much improved monitoring, management and protection of existing municipal utility groundwater supplies to provide sound basis for their optimisation / extension

URBAN WATER-SUPPLY IN ASIA

role of groundwater

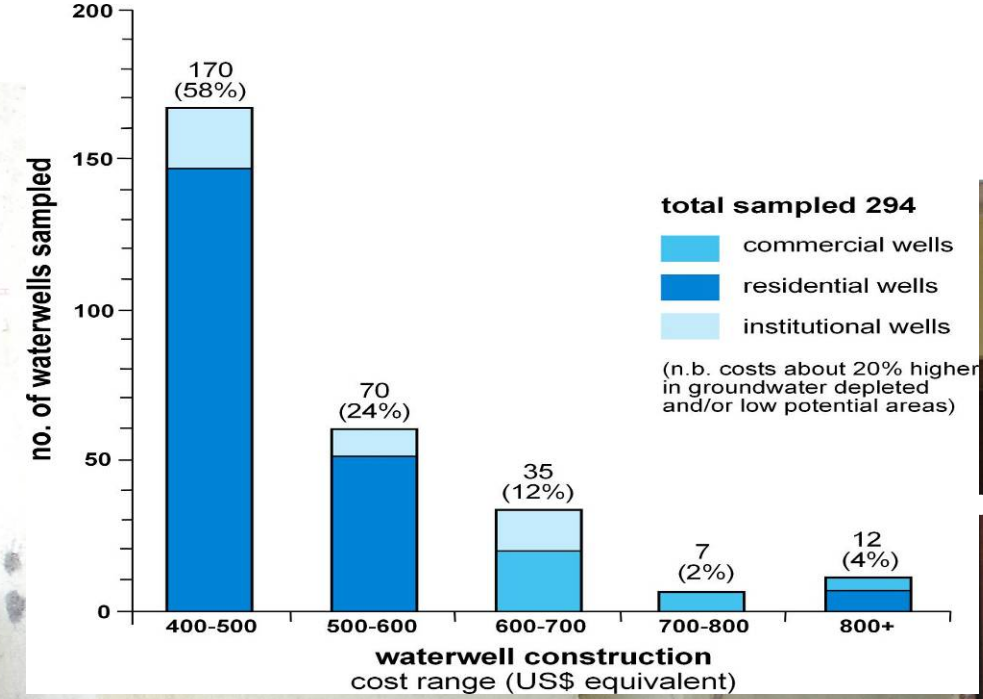
PRIVATE SELF-SUPPLY FROM GROUNDWATER
Aurangabad – India





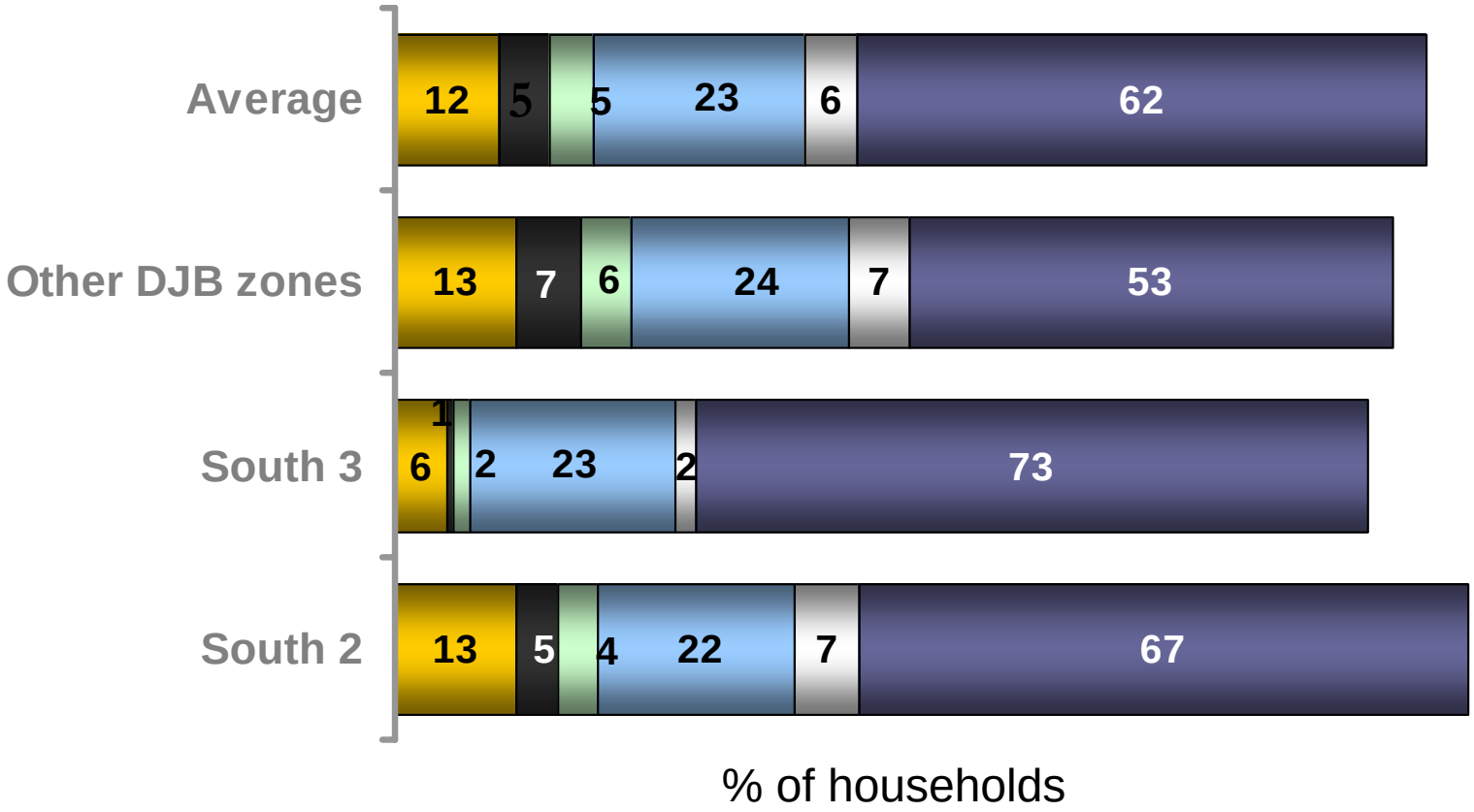
- utility surface water-supply of 120 Ml/d is highly-subsidised and preferred, but has high losses and very poor service level (less than 1 hr/day)
- city underlain by shallow minor aquifer (but locally depleted with 35% waterwell failure rate and only 5% wells yielding 2 + l/s)
- but groundwater self-supply has reached 38% of total urban water use

PRIVATE SELF-SUPPLY FROM GROUNDWATER
Aurangabad - India

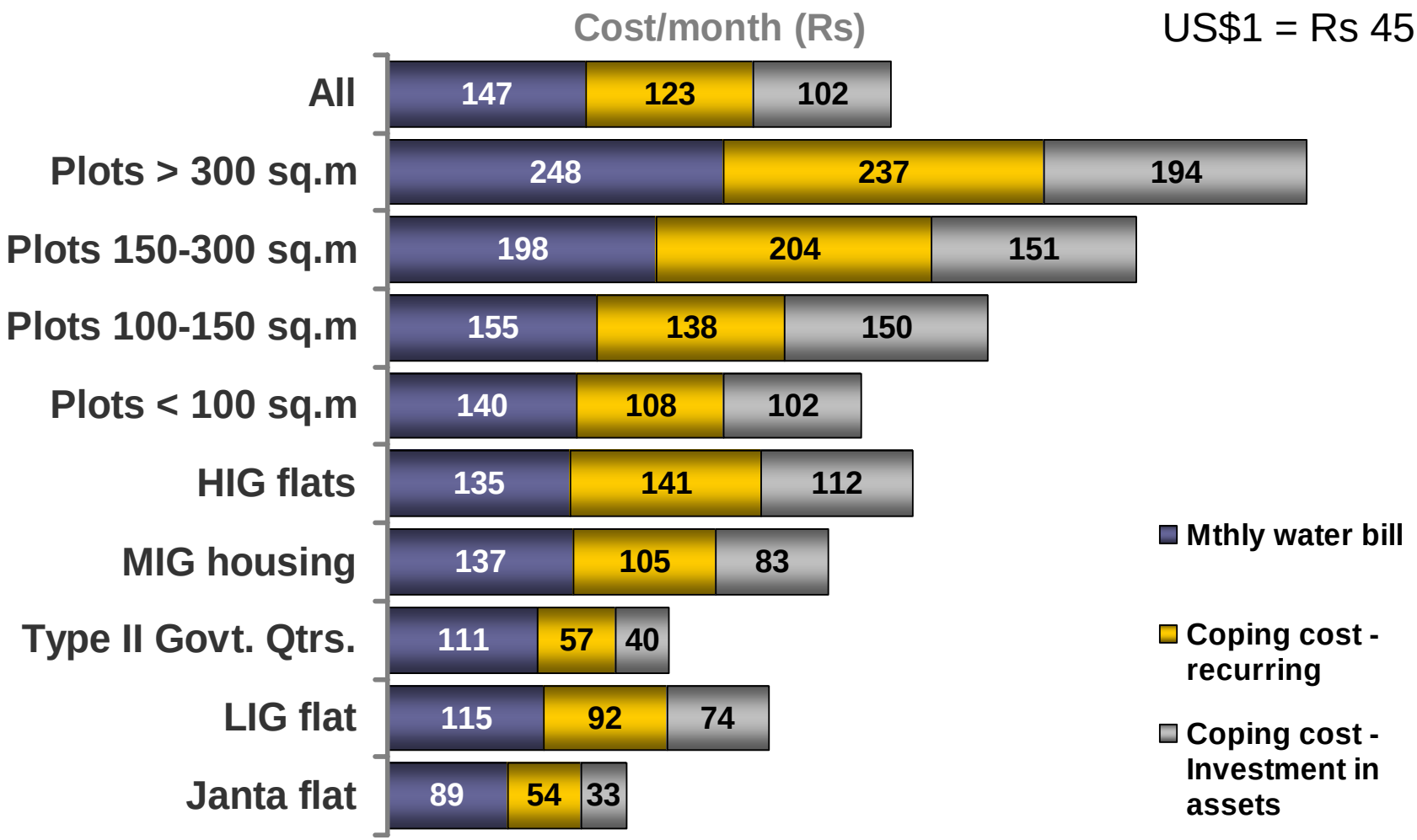


- 10-15,000 private waterwells operating (most residences have one) – 'urban coping strategy' (US $ 15 m+ invested) also 820 municipal handpump tubewells in low-income areas
- running costs are less than full economic cost of new municipal sources and about 50% of tanker prices (implications for water-supply investment, electrical energy policy and potential public health risk)

DELHI-INDIA
sources of water-supply in selected predominantly-residential urban zones

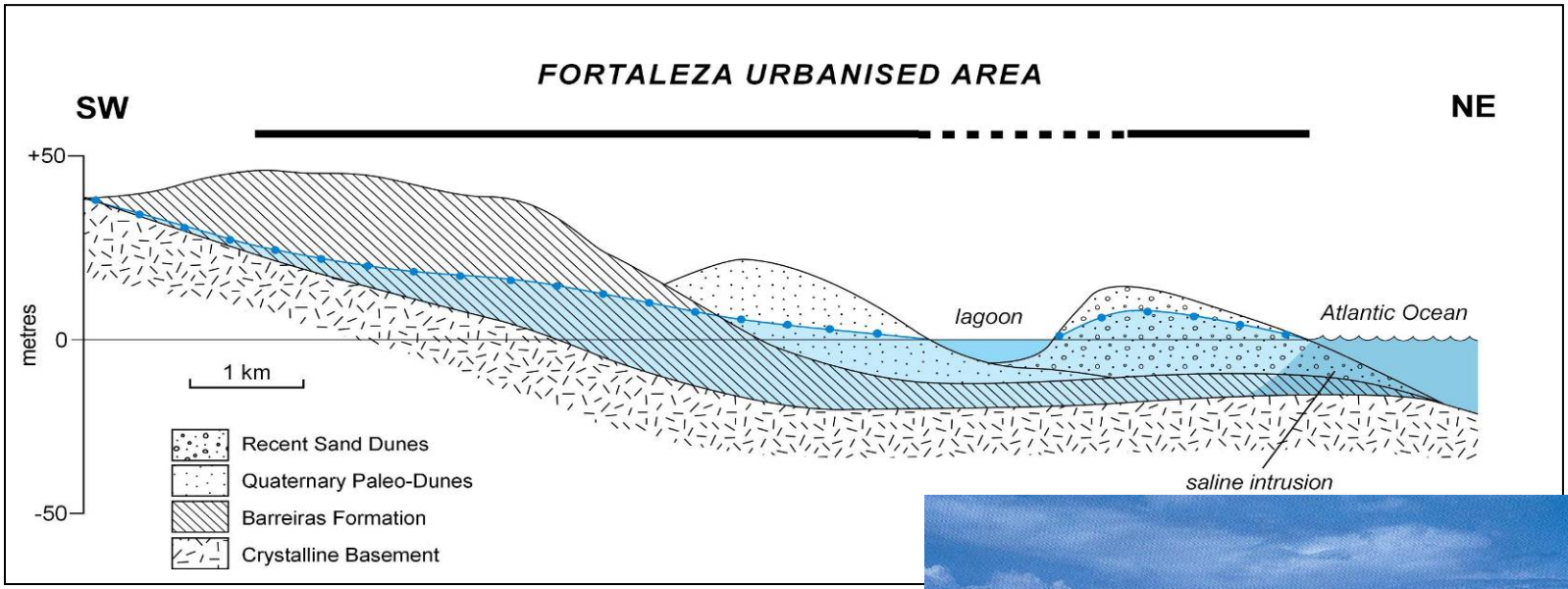


DELHI-INDIA
estimation of water-supply 'coping costs' in 'authorised' urban zones



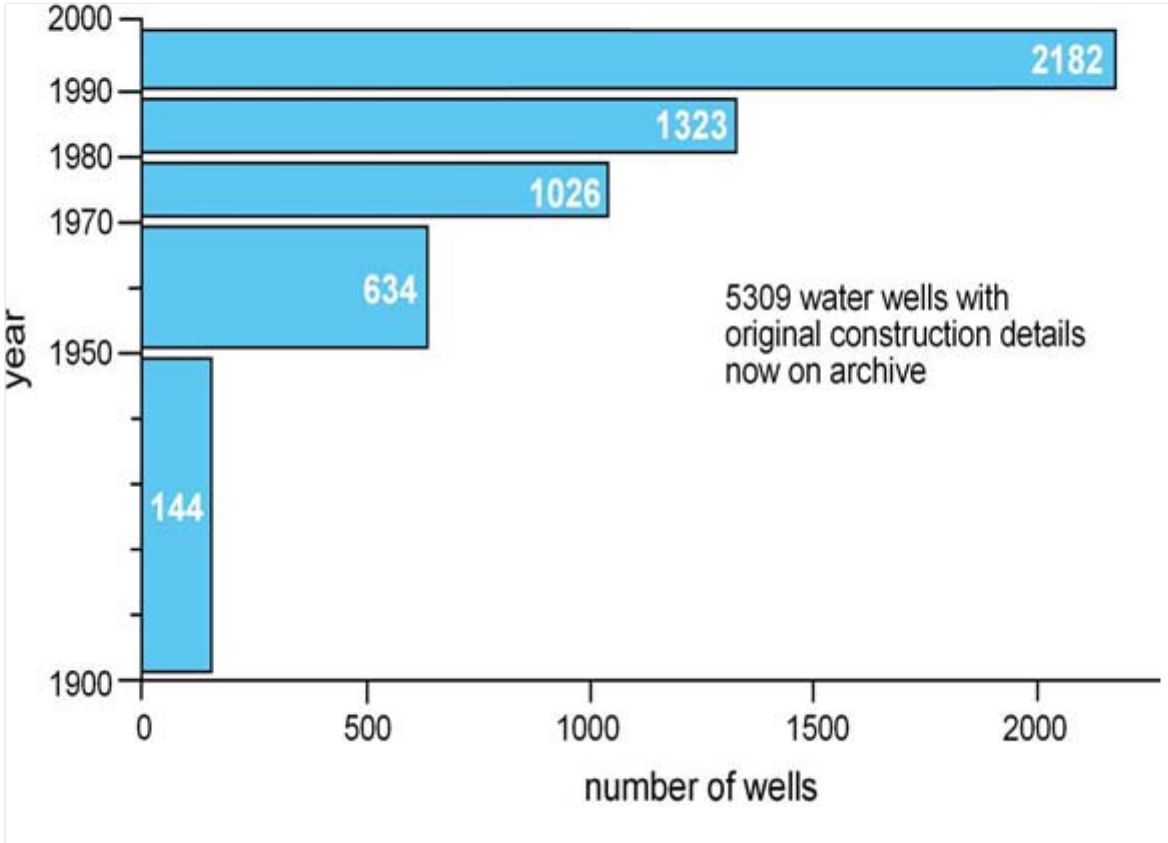
URBAN WATER-SUPPLY
IN LATIN AMERICA
role of groundwater and sanitation nexus

PRIVATE SELF-SUPPLY FROM GROUNDWATER
Fortaleza - Brasil



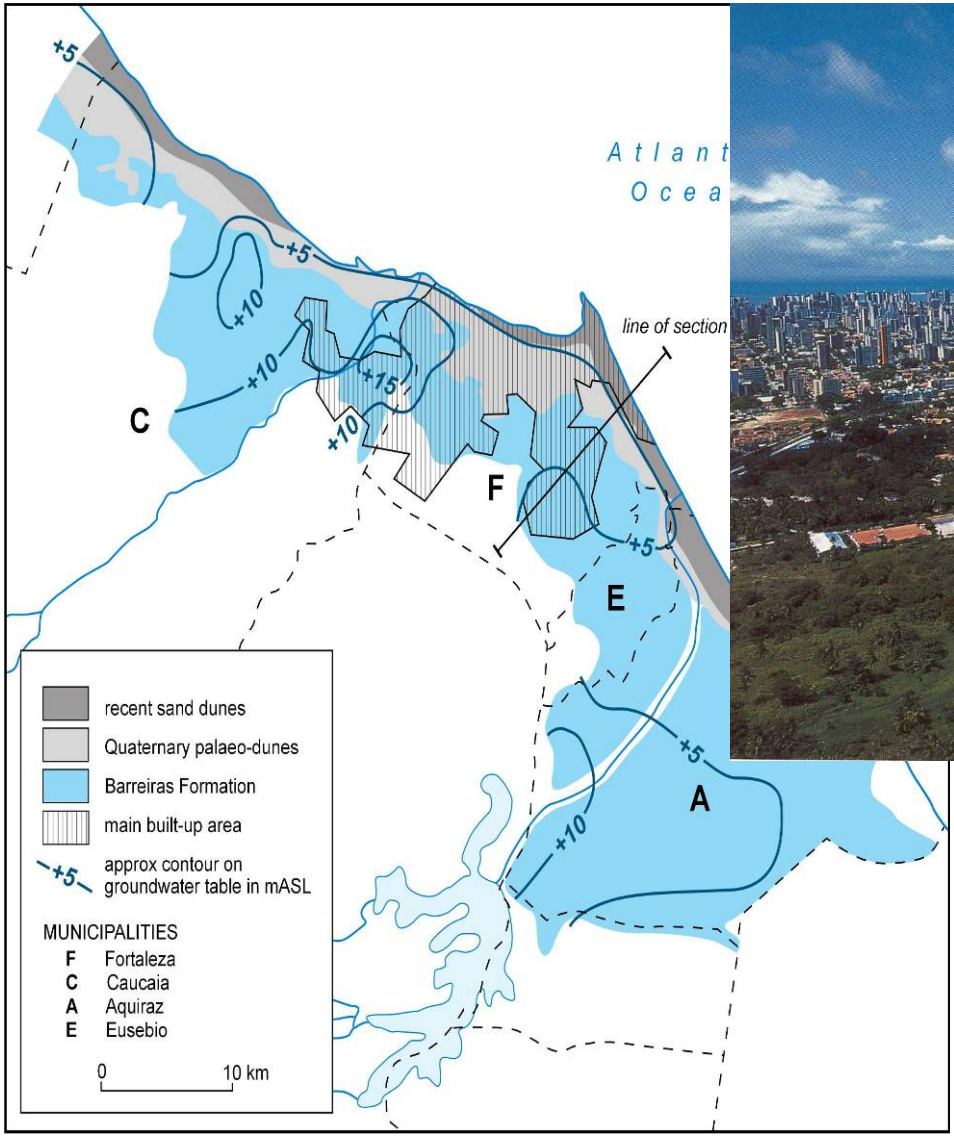
- city population 2.1 million
- utility mainly surface water-supply of 570 Ml/d but this 'collapsed' in some past drought episodes (eg. 1998)
- some 45-60% of all consumers have also constructed waterwells into underlying coastal dune sands

PRIVATE SELF-SUPPLY FROM GROUNDWATER
Fortaleza - Brasil



- at least 8,950 (probably 12,000) waterwells (85% domestic, 10% industrial/commercial)
- capable of providing 30-40 % of utility water-supply, but current abstraction equivalent to 15-20% (*less than* physical leakage from water mains)
- private waterwell investment US$ 23 million

PRIVATE SELF-SUPPLY FROM GROUNDWATER
Fortaleza – Brasil

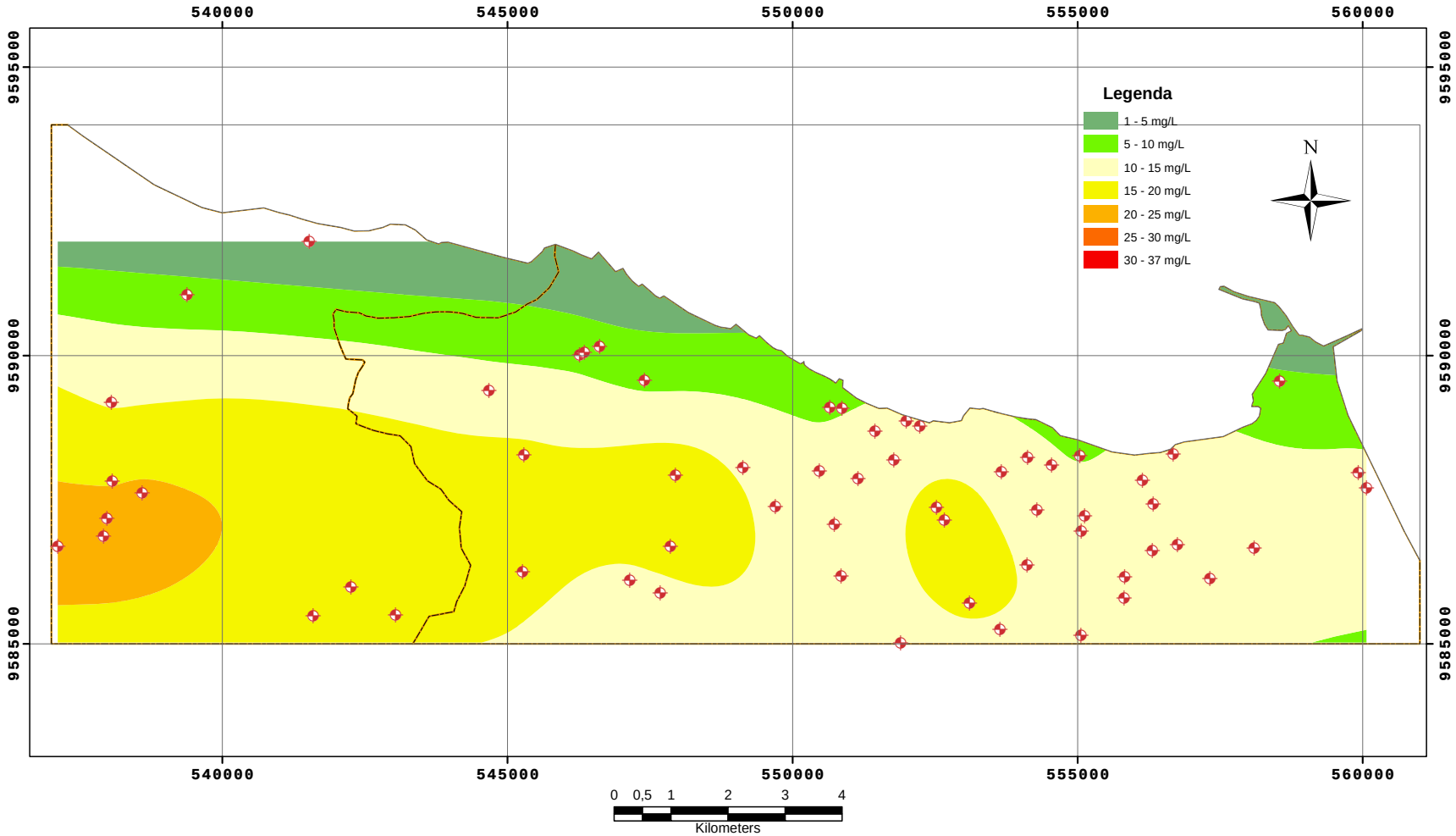


- most multi-residential dwellings have high-yielding tubewells
- used to substitute for utility water when social tariff (US$ 0.26/m3 for 10 m3/family/month) exceeded
- consequent difficulty in collecting sewerage charges

FORTALEZA-BRASIL

results of 2008 groundwater quality survey

- groundwater NaCl type with locally excessive salinity (reducing in wet season)
- NO3 is principal contaminant – but occasional waterwells with excessive NH4
- slightly acidic with pH generally less than 6.2



PRIVATE SELF-SUPPLY FROM GROUNDWATER
the often forgotten urban policy dimension

- major phenomena in fast-growing urban areas where waterwell construction low-cost – improving access for some groups of users
- but massive private domestic self-supply :
  - can distort utility water operations with major implications for finance/investment
  - may encounter sustainability problems
  - can represent a public health hazard
- what management measures should be taken :
  ? enhance recharge, reduce pollution load, discourage/prohibit use, regulate/charge for use, improve private well construction standards ?

URBAN GROUNDWATER USE

policy and management implications

URBAN GROUNDWATER MANAGEMENT
a major challenge for groundwater specialists

- evaluation of urban groundwater recharge, resource potential/sustainability, susceptibility to degradation
- assessment of aquifer pollution vulnerability and investigation of groundwater pollution risks
- groundwater pollution control and mitigation measures (especially improving design/operation of in-situ sanitation units)
- guidelines on appropriate waterwell construction/operation, effective wellhead protection, groundwater use 'quality precautions', recharge enhancement, etc
- improved groundwater source/aquifer monitoring

ABOVE ALL MORE HOLISTIC APPROACH NEEDED

URBAN GROUNDWATER MANAGEMENT
who should be responsible ?

- urban groundwater affects everybody but often responsibility of no 'body' and often 'invisible link' between various facets of urban infrastructure
- more significant in overall water-supply than appreciated (more so in climate change scenarios)
- need for holistic vision – broad stakeholder involvement essential but who should take management lead (municipal authority, water resource regulatory agency, public health ministry, water utility, groundwater department ??)

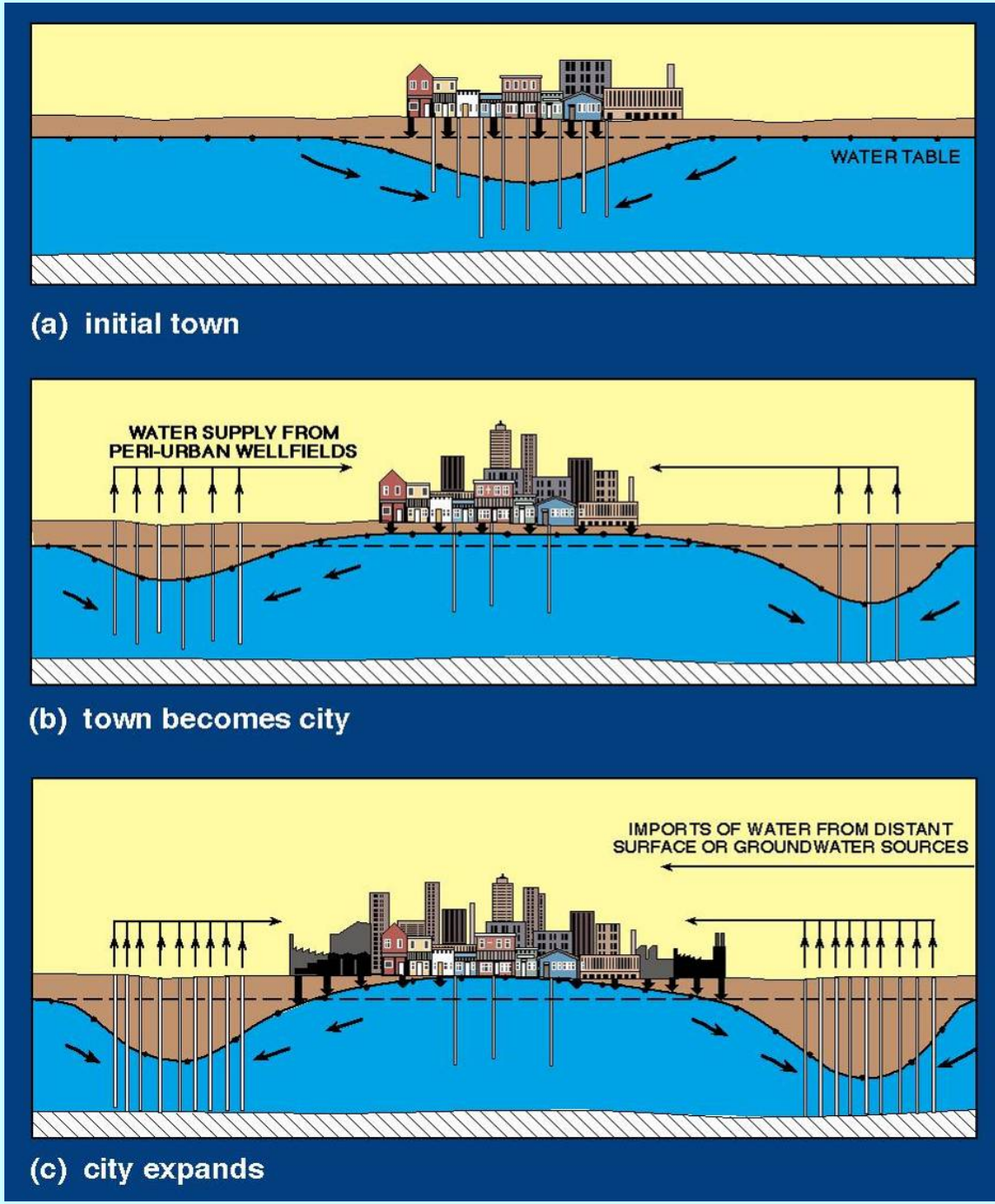
URBAN GROUNDWATER & SANITATION

two corollaries :

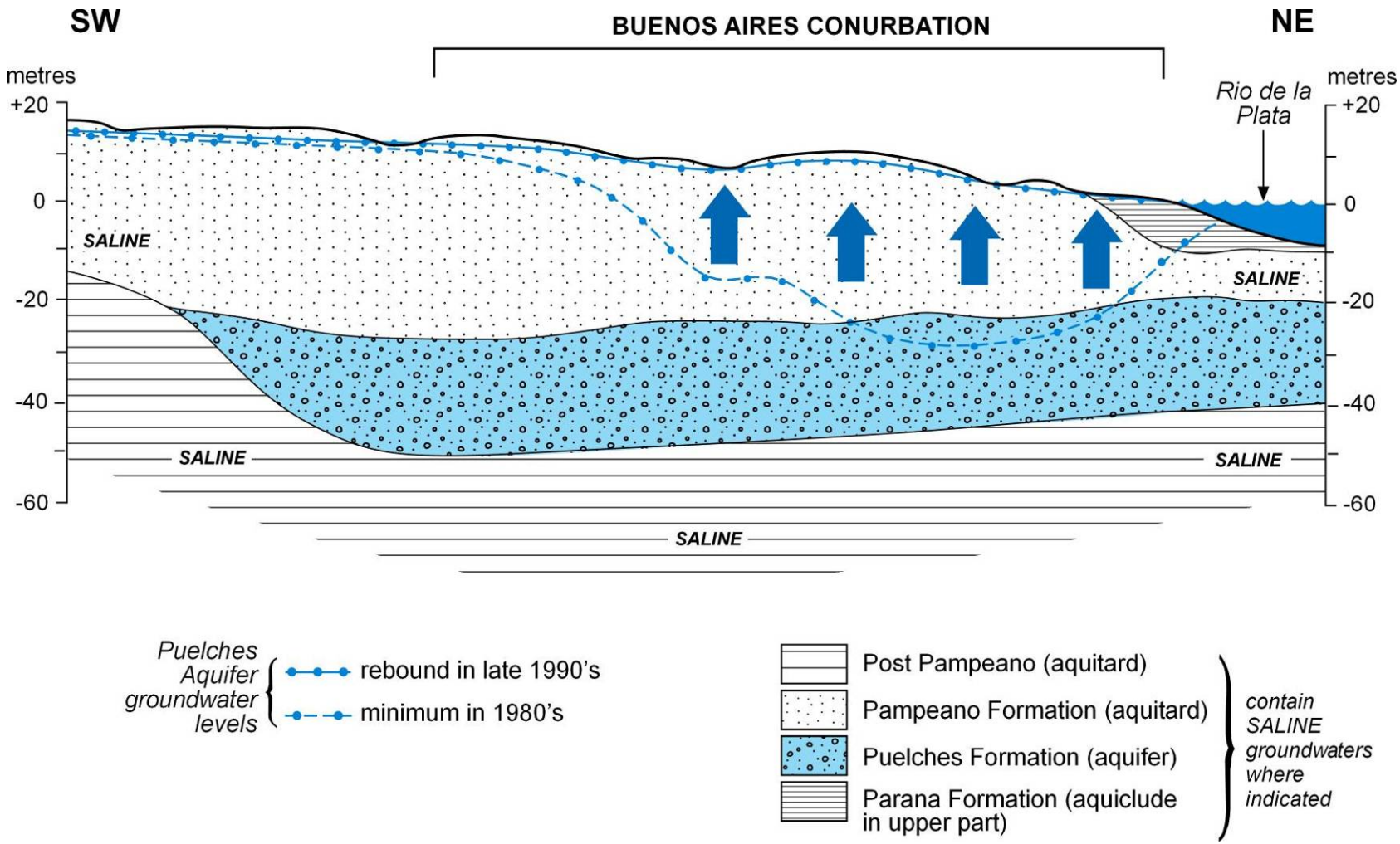
- **groundwater table rebound**
- **sewage effluent generation and reuse**

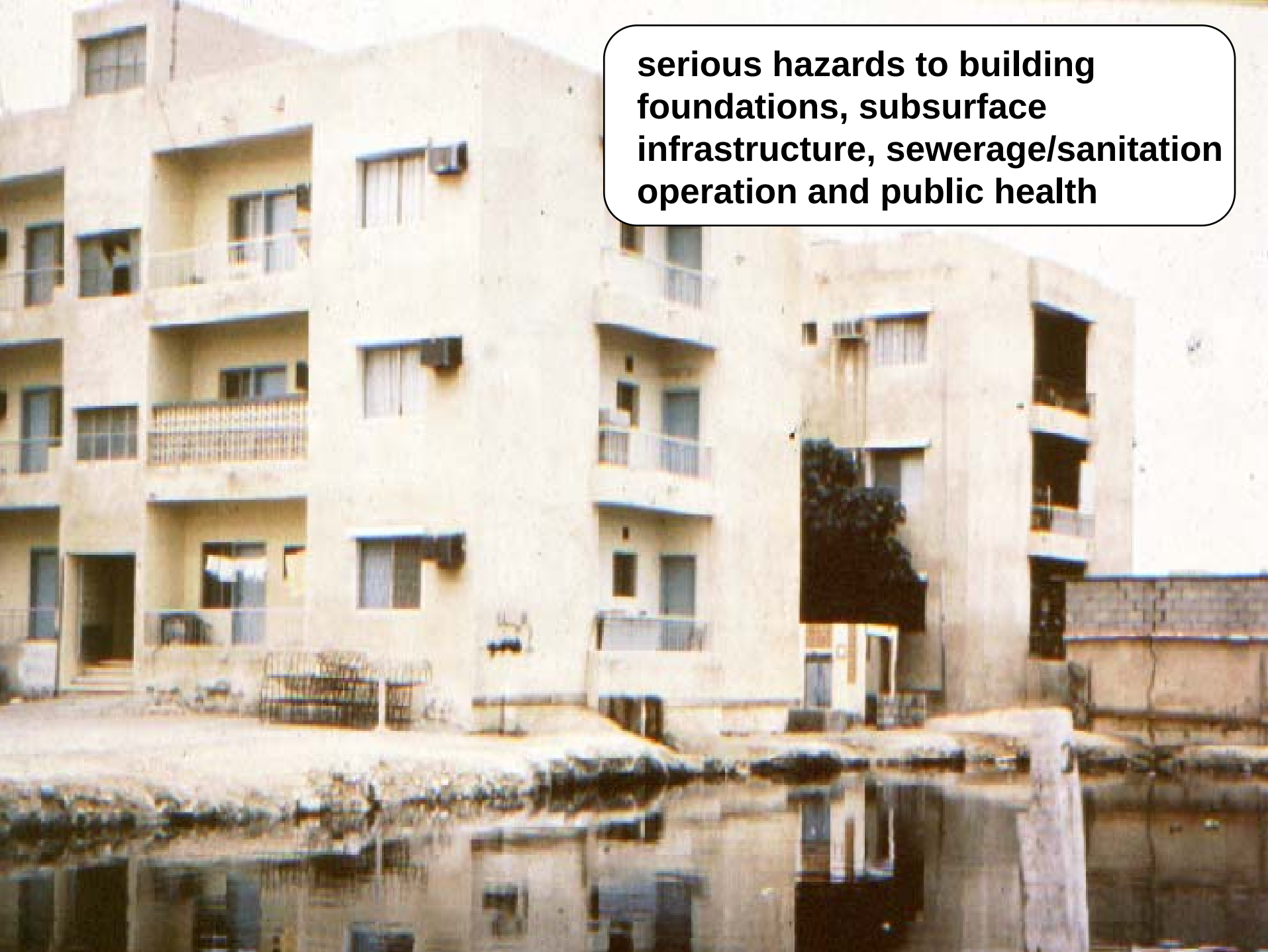
GROUNDWATER & THE CITY

- an evolving (often unsustainable) relationship
- groundwater table rebound – the ‘sting in the tail’



GRAN BUENOS AIRES
groundwater conditions and water-table rebound



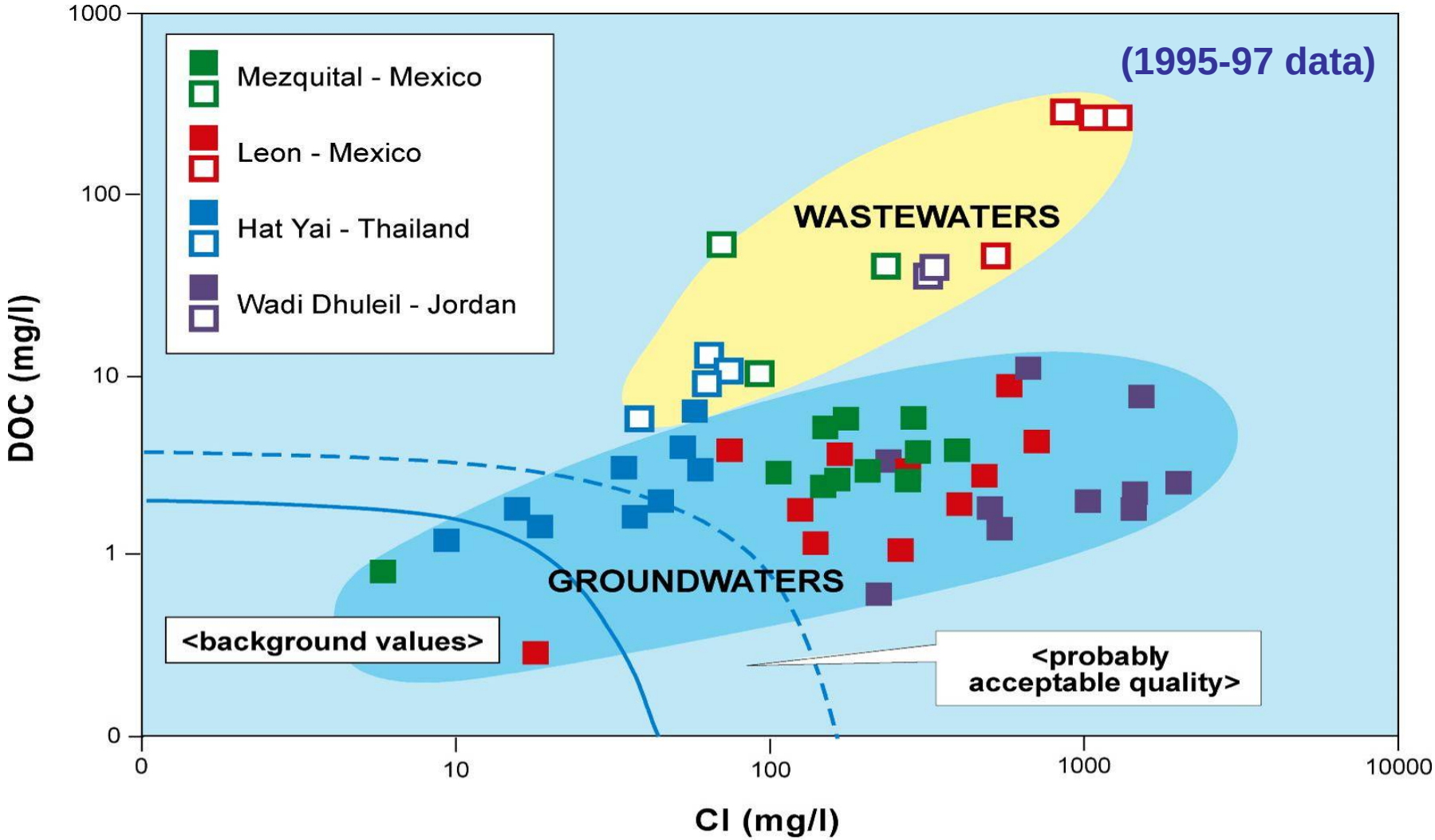

serious hazards to building foundations, subsurface infrastructure, sewerage/sanitation operation and public health

WASTEWATER FROM MAINS SEWERAGE
water resource context in developing nations

- downstream riverbed infiltration and/or uncontrolled use for agricultural irrigation generally results in a major incidental groundwater recharge (especially in drier climates)
- urban wastewater thus represents both:
  - a major recharge benefit for groundwater resources
  - significant pollution hazards for some groundwater

need to reduce hazards while conserving benefits

WASTEWATER RECHARGE AND GROUNDWATER influence on DOC and Cl concentrations



also usually accompanied by excessive NO3 or NH4 concentrations


inadequate wellhead protection, waterwell construction and/or high vulnerability aquifers increase risk

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