Global Water Partnership

GW·MATE

GROUNDWATER RESOURCES
critical focal points requiring conjunctive vision and management

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CONJUNCTIVE USE OF GROUNDWATER & SURFACE WATER
scope and relevance to developing economies

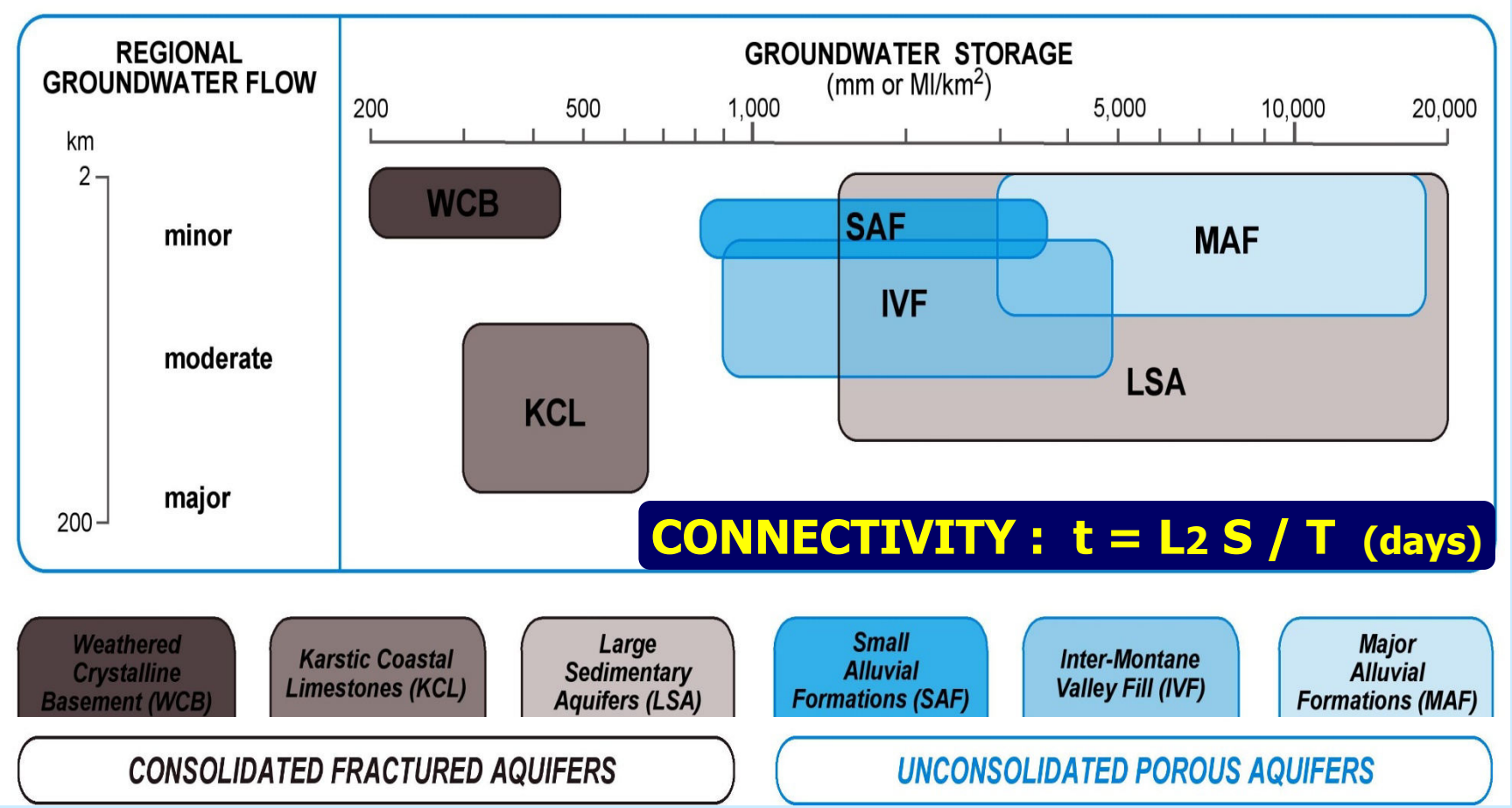
- **no rigorous definition**
  provision of 'water-supply demand centre' in parallel from surface water and groundwater sources to improve water-supply security and water-resource use efficiency
  groundwater/surface water can be hydraulically independent or link

- ***spontaneous development quite widespread :***
  - **part of urban water-supply expansion**
  - **private coping strategy in irrigated agriculture**

  but to achieve optimum results requires scientific planning

- ***potential benefits include :***
  - **much greater water-supply security in drought or emergency**
  - **larger net yield for somewhat increased investment**
  - **reduced environmental impact (low-flow conservation)**

GROUNDWATER STORAGE
very wide variation in size and connectivity

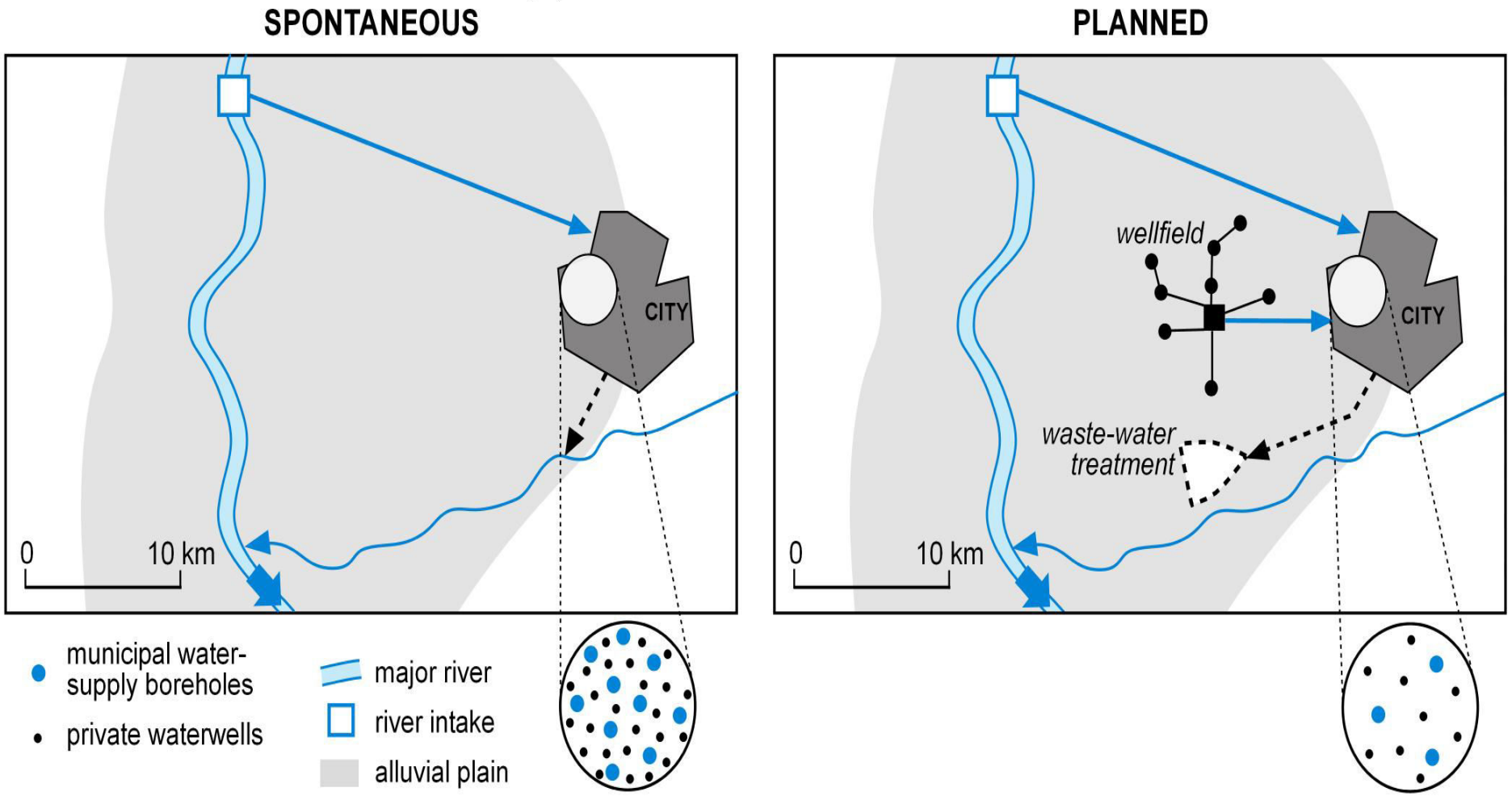


CRITICAL HYDROGEOLOGICAL SETTINGS REQUIRING 'CONJUNCTIVE VISION'

- alluvial plains with shallow water-table aquifer
- piedmont fans with surface water-dependent recharge
- mid-catchment aquifers providing river baseflow

URBAN
WATER-SUPPLY

CONJUNCTIVE USE FOR MAJOR URBAN WATER-SUPPLY
from spontaneous development to planned strategy



LIMA-PERU
successful application of conjunctive use, demand and supply side measures

720 Ml/d
(+320 Ml/d private)

CONJUNCTIVE USE IN URBAN WATER-SUPPLY
impediments to optimum development

- *split responsibility for surface and groundwater management (and even development)*
- **urban water engineers often prefer (superficially) simple operational set-ups**
- *urban water-service utilities institutionally or politically constrained as regards development of protected peri-urban wellfields*

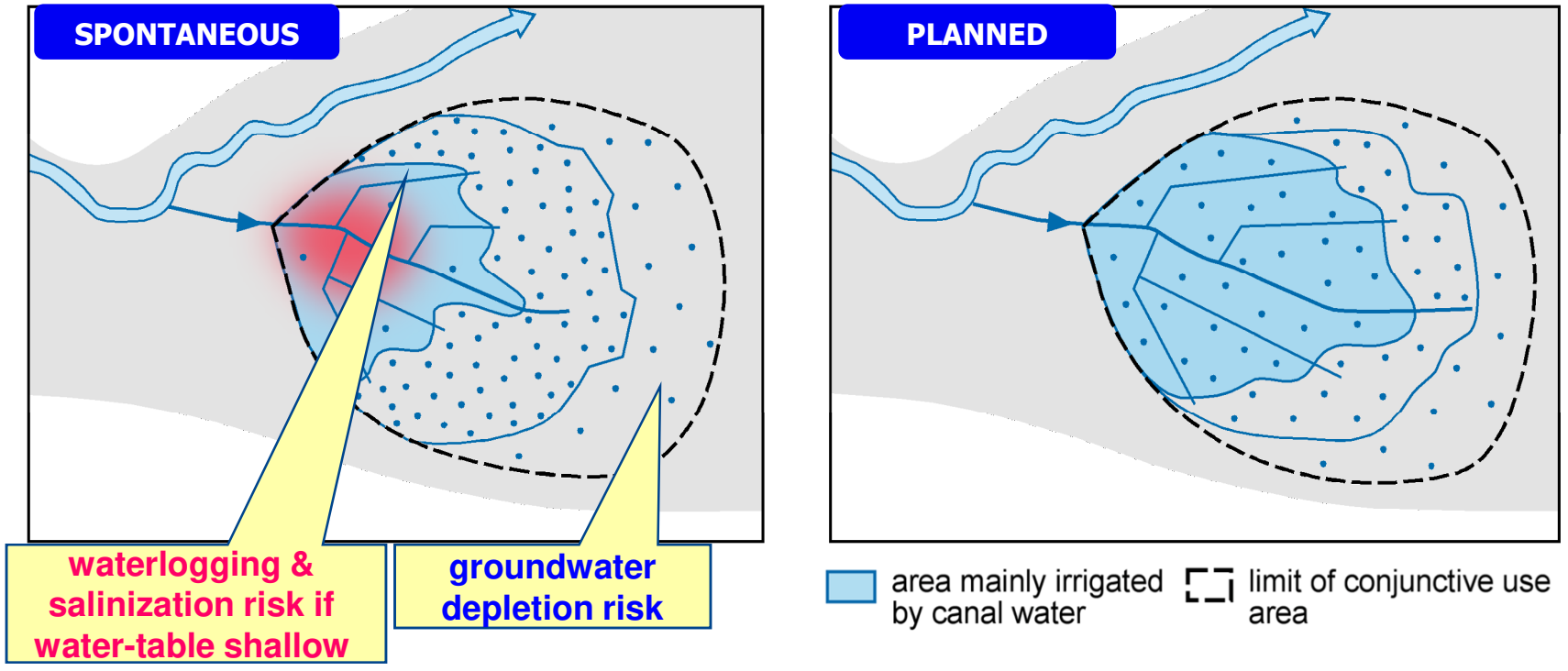
IRRIGATED AGRICULTURE

CONJUNCTIVE USE FOR IRRIGATED AGRICULTURE
current reality on alluvial plains of developing world

- *widely practised on spontaneous basis – in response to inadequate irrigation canal-water availability both spatially and temporally*
- **usually implemented unplanned and often in 'crisis mode' – in response to surface water drought in order to mitigate crop-losses**
- *results in groundwater providing a large proportion of total water-supply even in major irrigation canal commands – but with little management investment*
- **need to move from *'spontaneous conjunctive use' to 'sustainable conjunctive management'* – especially to combat problems of increasing salinisation and as climate-change adaptation strategy**
- **institutional reform often needed to achieve transformation**

CONJUNCTIVE USE FOR IRRIGATED AGRICULTURE

managed evolution from spontaneous to planned development



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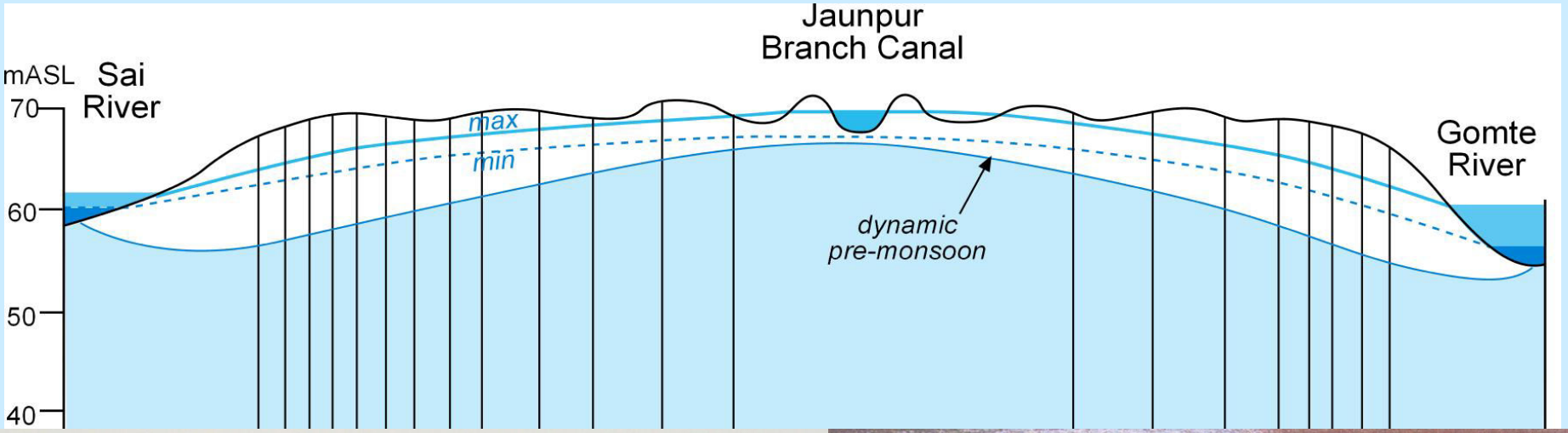
CONJUNCTIVE USE FOR IRRIGATED AGRICULTURE
common impediments to planned conjunctive use

- *socio-political sensitivity and unwillingness to reduce surface-water use and rights in head-water sections*
- **inadequate understanding of conjunctive use benefits by local irrigation engineers and academic centres**
- *some state water agencies tend to 'mirror' historical irrigation realities and perpetuate status quo*
- **large cost differential (x 10-20) to irrigation users between canal water and groundwater**

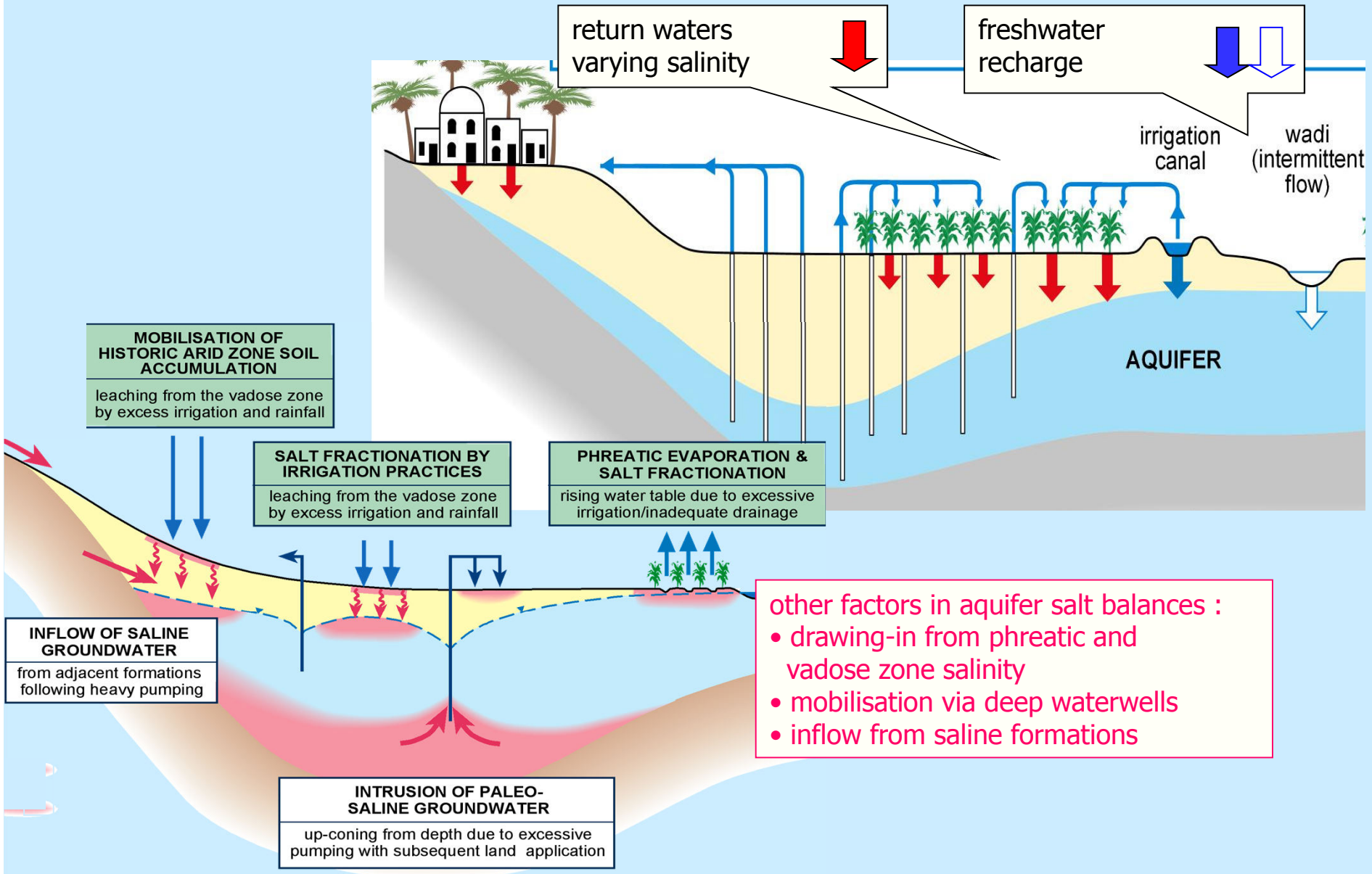
GANGETIC PLAIN OF UTTAR PRADESH-INDIA
modification of hydrogeological regime



CONJUNCTIVE USE OFSURFACE WATER & GROUNDWATER approach in Uttar Pradesh

- *engineering and management measures to*
  - *reduce 'upstream' canal-water losses and over-irrigation*
  - *improve canal-water distribution and 'downstream' irrigation service levels*
- **farmer education and financial investment for sodic-land mitigation (including stimulus for increased groundwater use in 'upstream areas')**
- **reducing groundwater extraction in 'downstream' areas with improved canal-water availability**
- *crop diversification to improve water productivity*

GROUNDWATER SYSTEM SALINISATION
factors entering into aquifer salt balances in arid areas



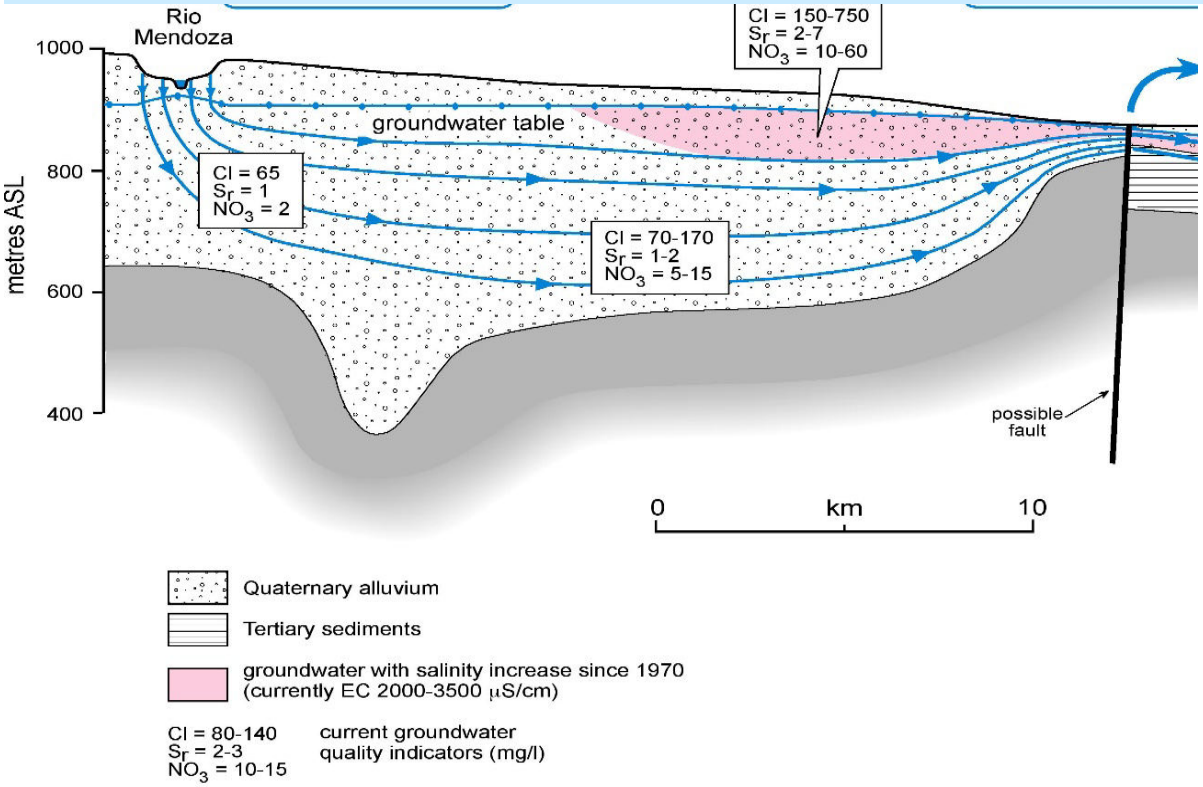
other factors in aquifer salt balances :
- drawing-in from phreatic and vadose zone salinity
- mobilisation via deep waterwells
- inflow from saline formations

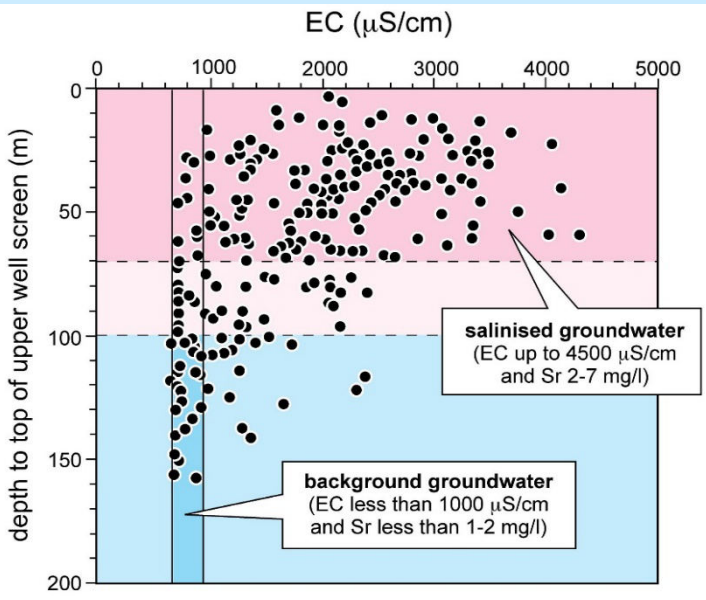
CONJUNCTIVE USE FOR IRRIGATED AGRICULTURE
Mendoza Oases - Argentina

Central Oasis
(Montecaseros)

Carrizal Valley

ARGENTINA-MENDOZA VITICULTURE PRODUCTION
locally threatened by increasing groundwater salinity





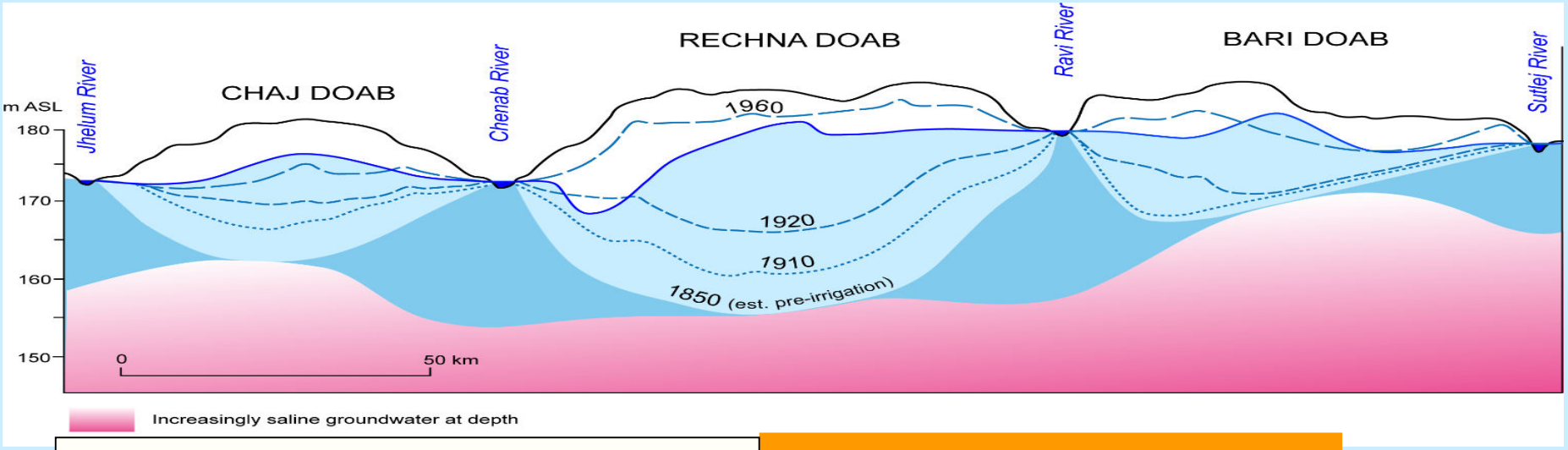
CARRIZAL AQUIFER

- mobilisation of salinity from vadose zone in areas cleared of desert vegetation for irrigated agriculture
- salt fractionation during irrigation-water cycling
- some zones now only suitable for onion and garlic cultivation

PAKISTAN PUNJAB

growing groundwater dependence for staple crop production

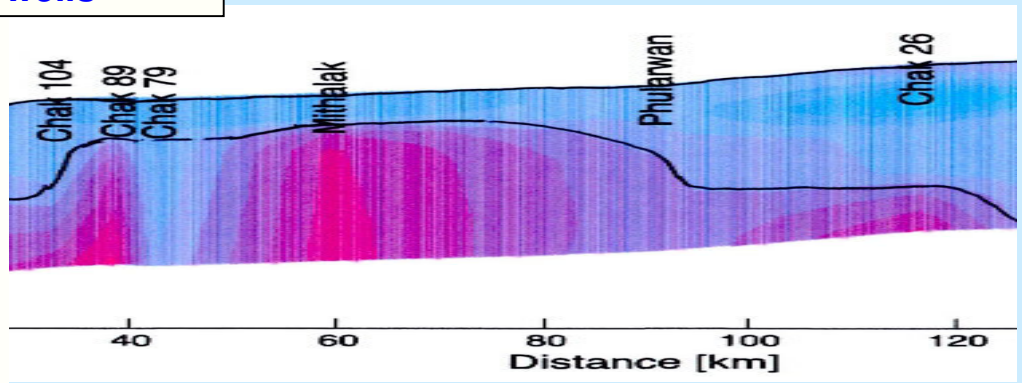
but continuing long-run battle with the 'salinity dragon'



arid zone with fresh groundwater recharge primarily from riverbed and irrigation canal seepage – but freshwater salinity increasing due to salt fractionation in irrigated soils, extensive phreatic evaporation and use of deep irrigation waterwells

50 % OF TOTAL IRRIGATION WATER-SUPPLY FROM WATERWELLS

LONG-SECTION OF CHAJ DOAB



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critical focal points requiring conjunctive vision and management

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www.worldbank.org/gwmate

www.gwpforum.org

www.iah.org

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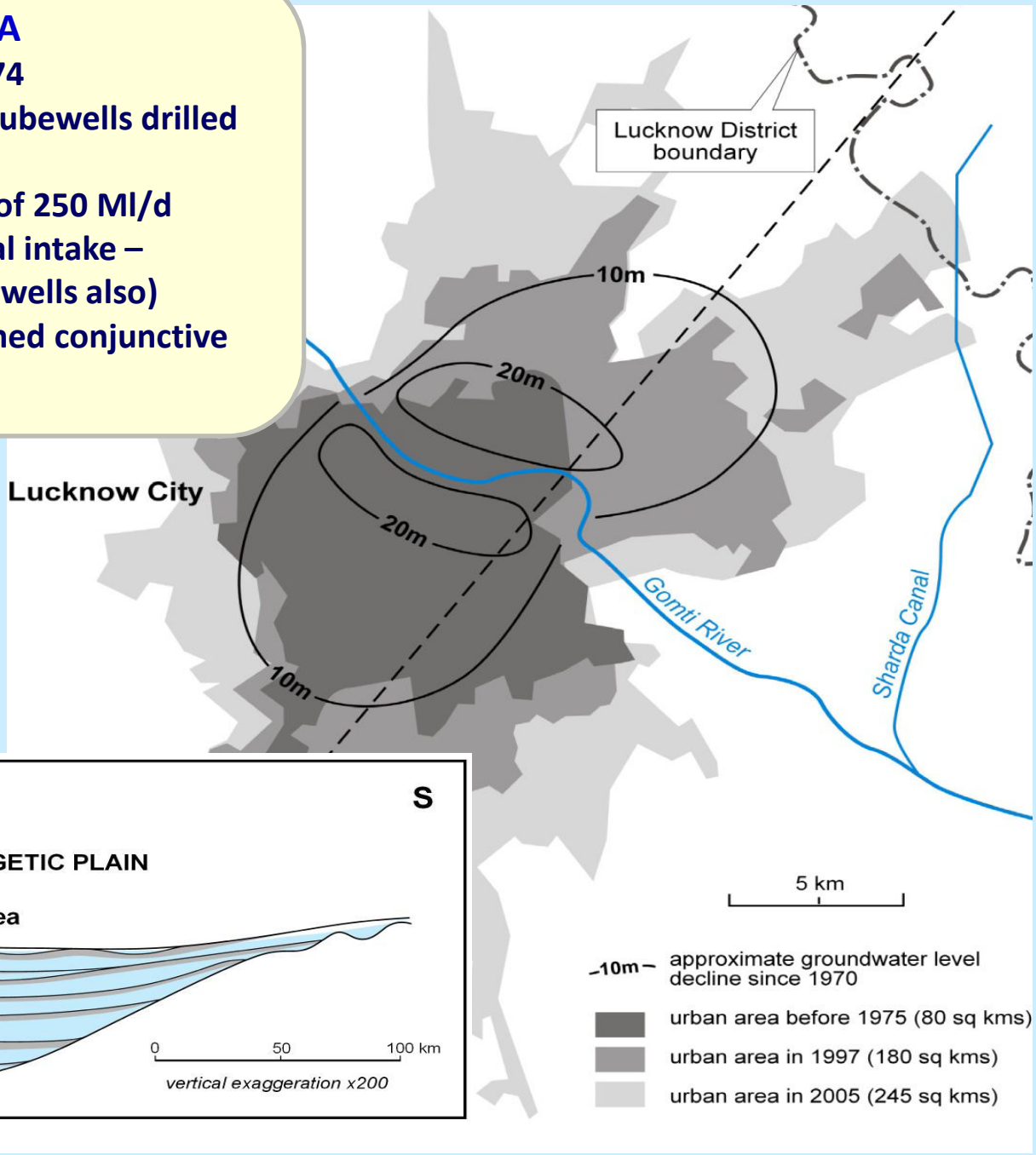
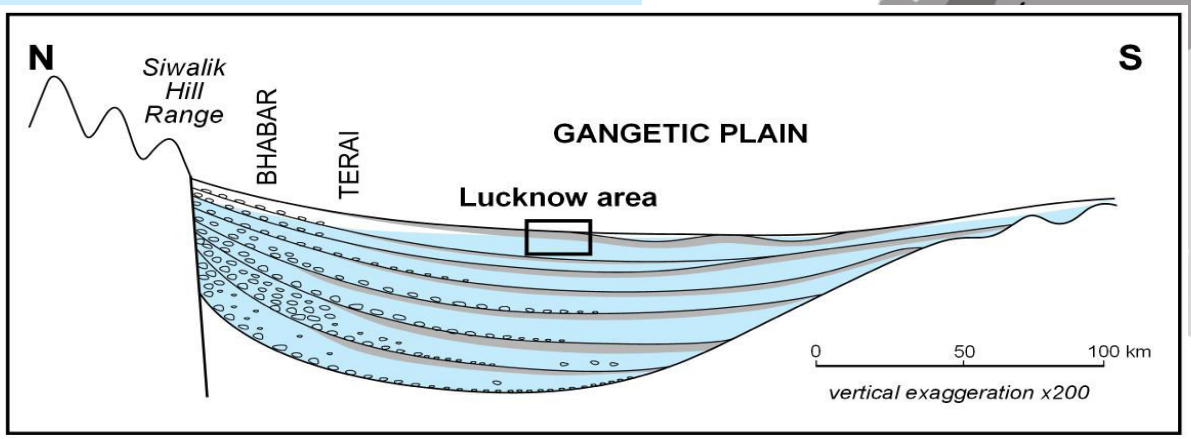
LUCKNOW – INDIA

- Gomti River supply alone until 1974
- then progressive in-situ LJS deep tubewells drilled with urban expansion
- by 2009 (popln 3.0 M) 500 DTWs of 250 Ml/d capacity and 250 Ml/d Sardhar Canal intake – 6 hr/day supply (1100 private waterwells also)
- great need for investment in planned conjunctive (with protected wellfields)



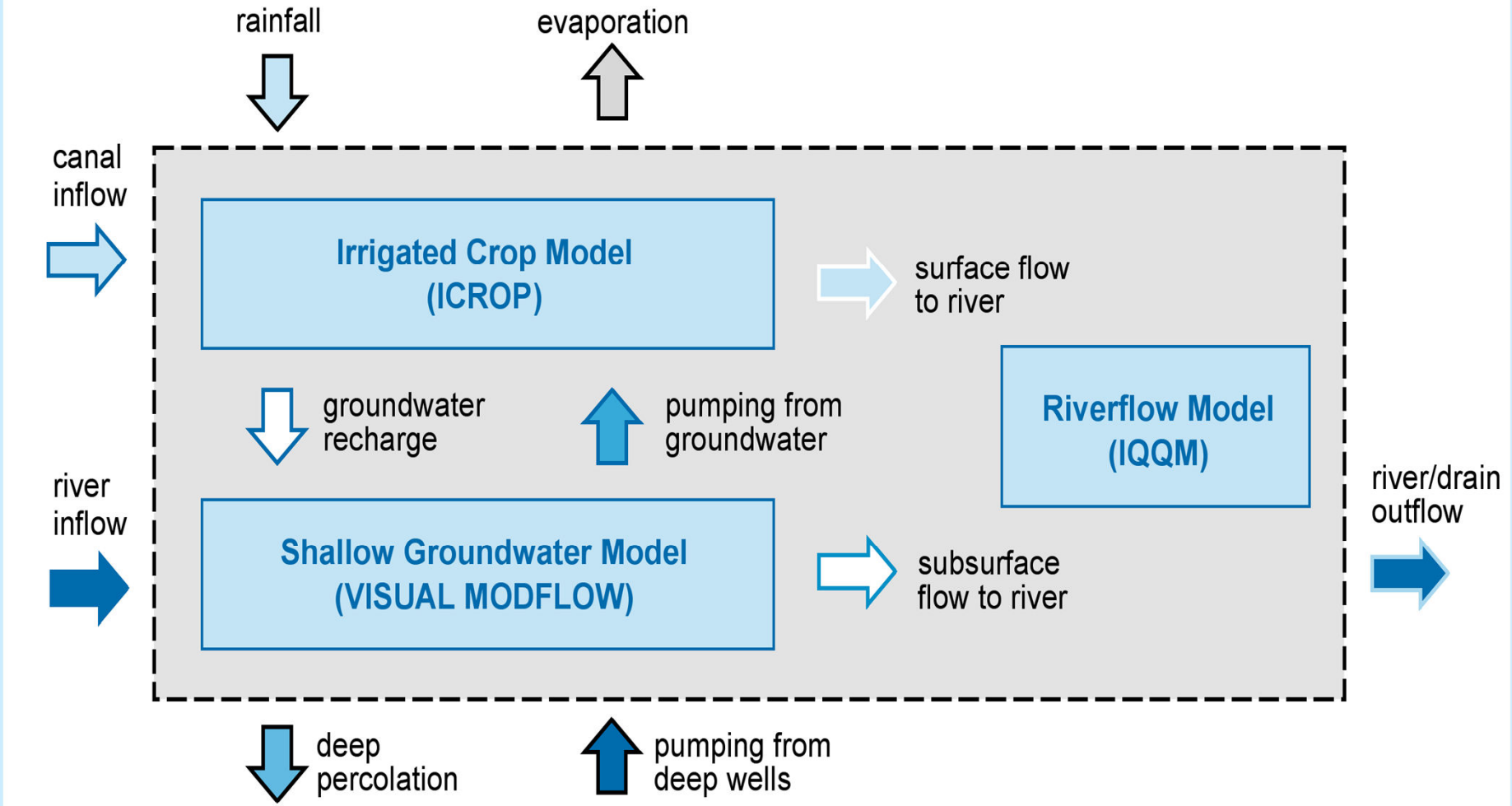


GANGETIC PLAIN OF UTTAR PRADESH-INDIA
Soil Water-Logging & Salinisation

sh Bhumi Sudhar Nigam

Prepared by :
State Water Resources Data & Analysis Centre
Lucknow, Uttar Pradesh

CONJUNCTIVE USE IN IRRIGATED AGRICULTURE
use of integrated water-use numerical models



linked soil-water/groundwater/surface-water modeling now possible at range of scales, but still a major challenge to apply results in practical water management at field level

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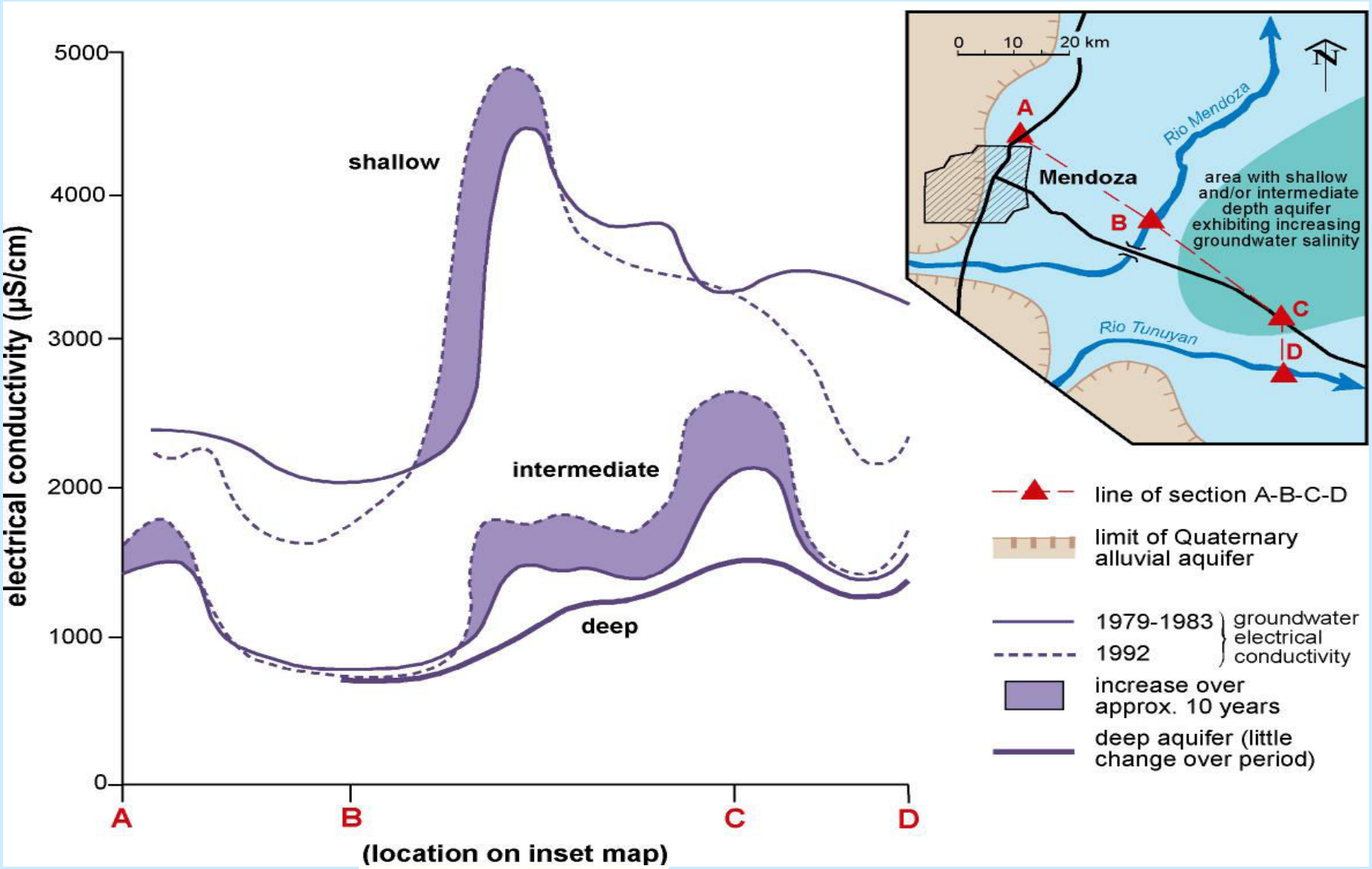
CONJUNCTIVE USE FOR IRRIGATED AGRICULTURE
approach in Mendoza – Carrizal Aquifer

- *declare 'areas of restriction' to prevent further growth in numbers of irrigation waterwells*
- **constrain spatial transfer of groundwater use rights from 'down-gradient' areas to 'terrenos chacra'**
- *augment riverbed recharge and divert excess riverflows to valley to reduce groundwater pumping*
- **intensify monitoring of groundwater levels, use and salinity – as basis to ensure continued aquifer drainage**
- *caution about cumulative effects of improving irrigation efficiency (widespread adoption of 'drip technology') since total groundwater resource consumption increasing* **(even if licensed abstraction fixed)**

ARGENTINA-MENDOZA : VITICULTURE PRODUCTION
locally threatened by increasing groundwater salinity

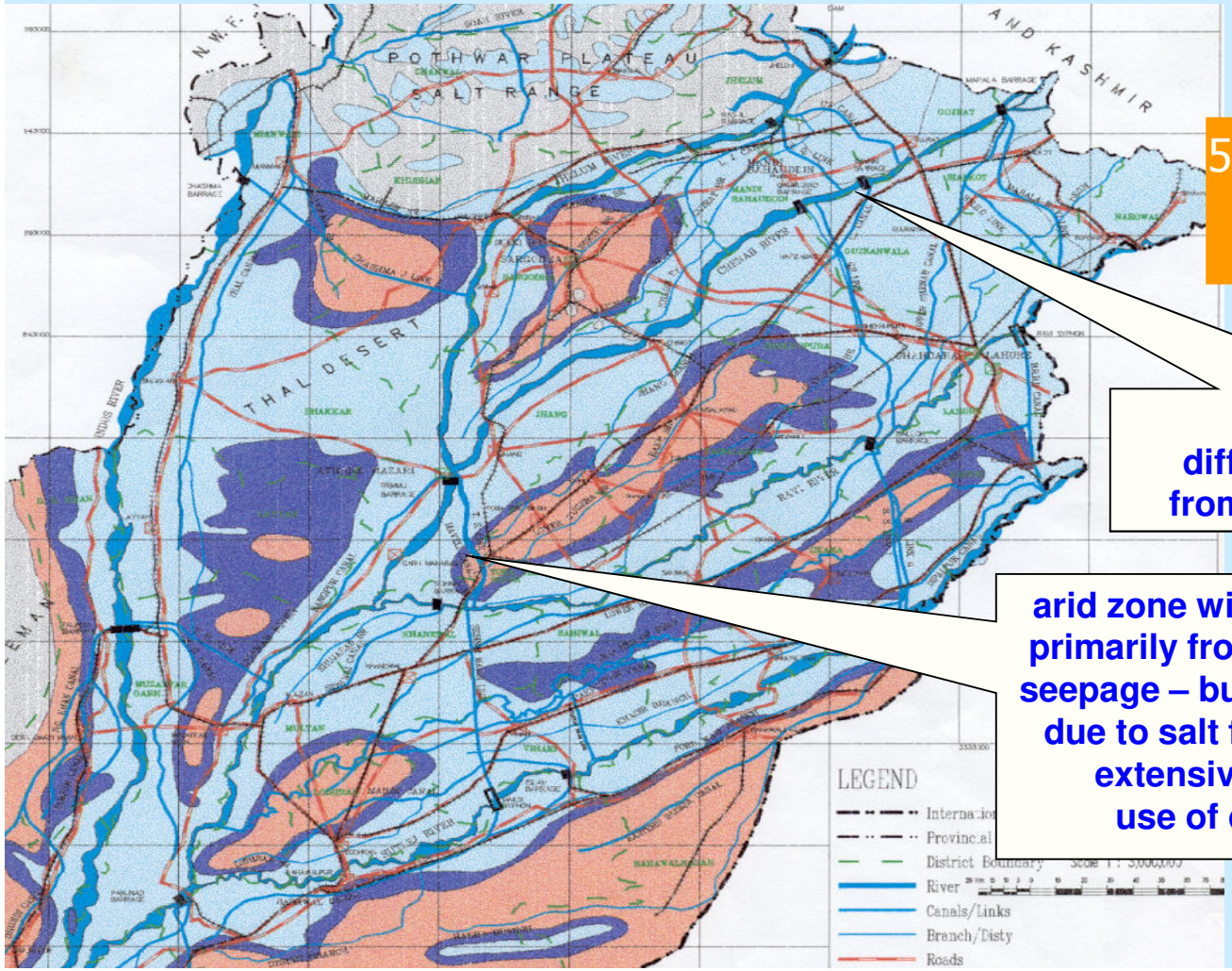


Central Oases

PAKISTAN PUNJAB

growing groundwater dependence for staple crop production

but continuing long-run battle with the 'salinity dragon'



50 % OF TOTAL IRRIGATION WATER-SUPPLY FROM WATERWELLS

semi-arid zone with diffuse groundwater recharge from annual monsoonal rainfall

arid zone with fresh groundwater recharge primarily from riverbed and irrigation canal seepage – but freshwater salinity increasing due to salt fractionation in irrigated soils, extensive phreatic evaporation and use of deep irrigation waterwells