USING ENVIRONMENTAL TRACERS TO UNDERSTAND THE RESPONSE OF GROUNDWATER RESOURCES IN NW INDIA TO SUSTAINED ABSTRACTION

Groundwater Resilience to Climate Change and Abstraction in the Indo-Gangetic Basin

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Background:

- 20 million boreholes access groundwater resources for drinking water, irrigation, industry across the IGB
- 1 billion people are highly dependant on this resource
- Increased pressure on groundwater resources in this region due to population growth, rising incomes, food security, high levels of abstraction and climate change
- The *resilience* of groundwater resources will play a large role in determining the future availability of water in this region

The Indo-Gangetic basin

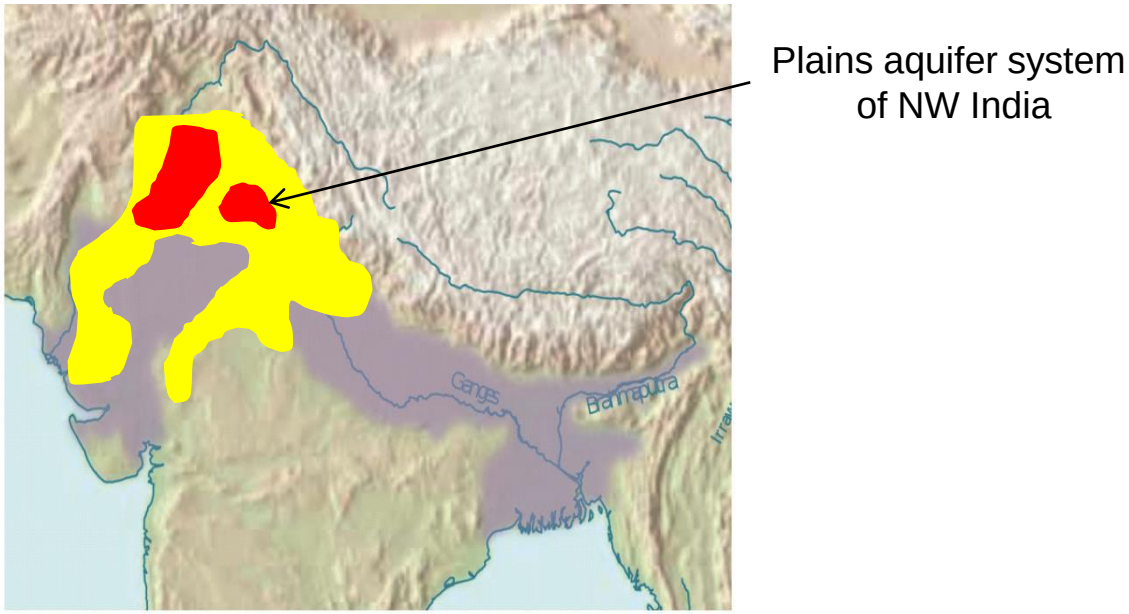


Figure 1. The location of the Indo-Gangetic basin (left) and estimated groundwater depletion (mm.a^{-1}) for year 2000: ■300-1000, ■100-300

Data Source: Wada et al., 2010. Global depletion of groundwater resources. Geophysical Research Letters, 37, L20402, 1-5.

Some major groundwater issues in the region

1. Increased Groundwater Abstraction

- Falling groundwater levels
- Tension between agricultural and growing ‘high value’ urban and industrial users
- Public vs private interests and allocation

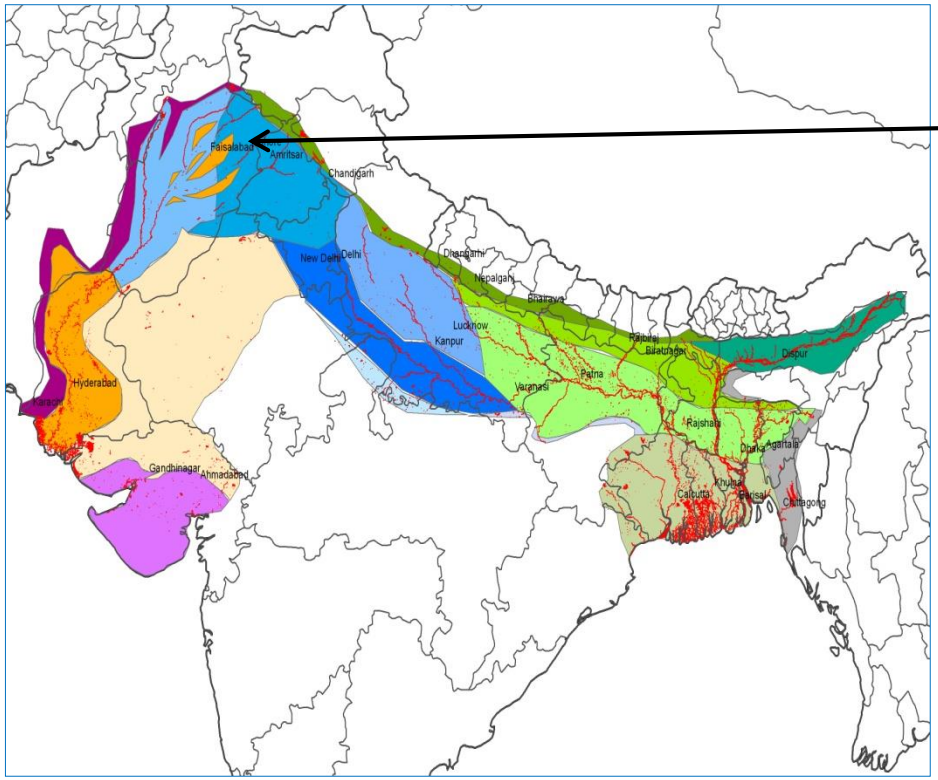
Some major groundwater issues in the region

2. Water Quality

- Arsenic, fluoride, salinity, microbial contamination from flooding
- Contamination from agriculture and waste water
- Rising salinity levels
- Salinisation problems in irrigated soils

Regional setting

Highly abstracted unconsolidated layered alluvial aquifer system



Draft typology map of the Indo-Gangetic Basin

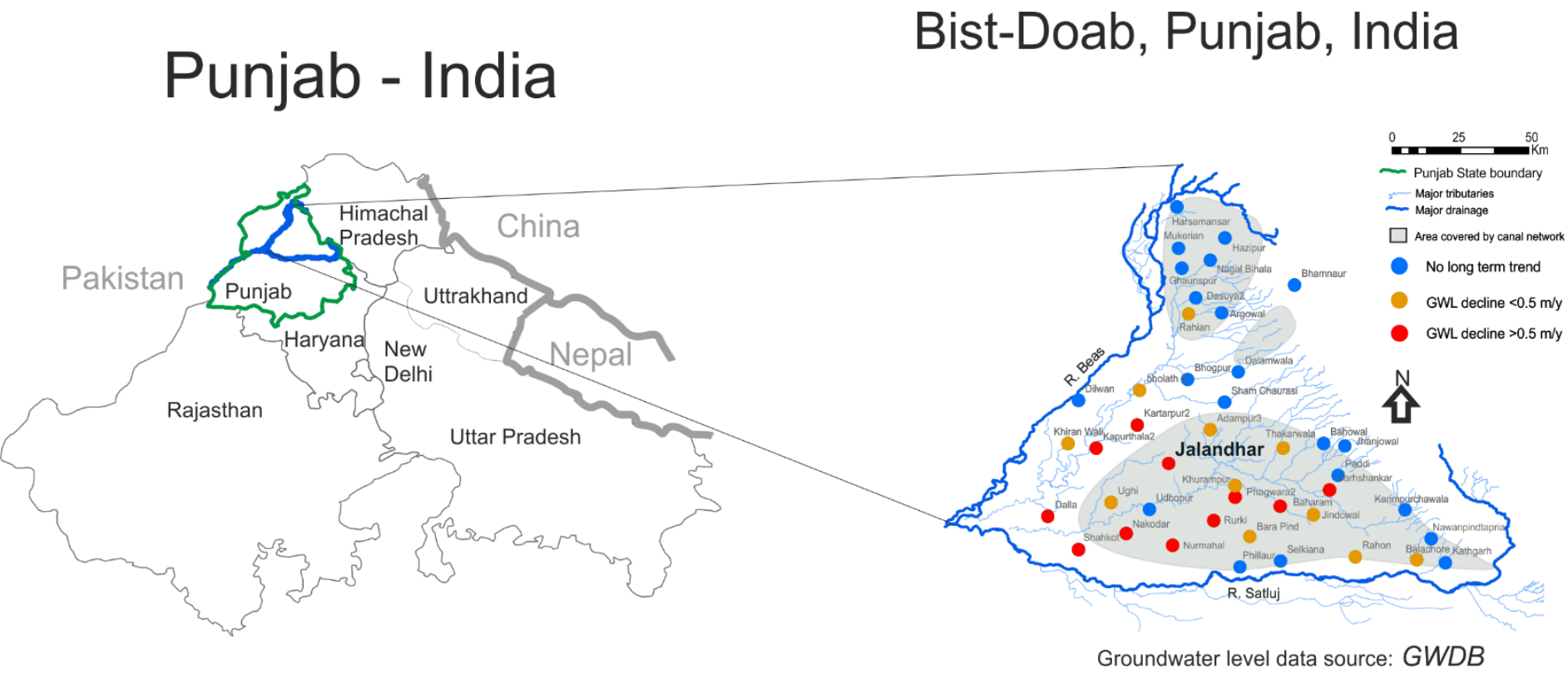
Criteria:

Multi-layered, extensive,
thick unconsolidated
alluvium aquifer – coarse sediment
Falling groundwater levels
Groundwater salinity at depth
Extensive irrigation
Surface water groundwater interaction

Resilience:

+High productivity/storage aquifer
+moderate potential meteoric recharge
- High abstraction including some cities
- Significant long-term trends in falling water table
- Saline groundwater at depth

Long-term trends in groundwater levels

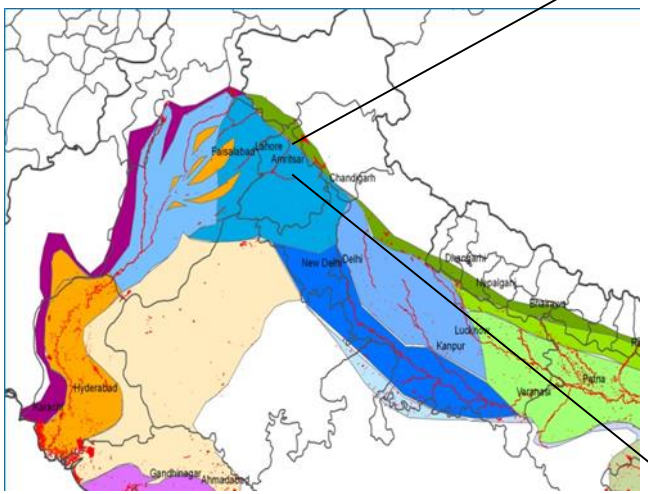


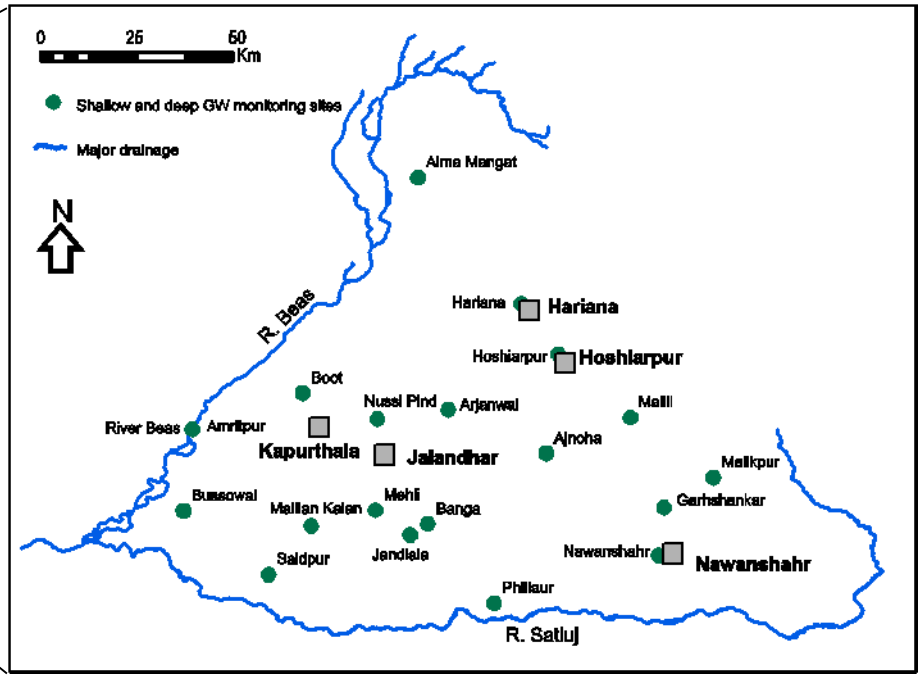
Groundwater level data source: *GWDB*

Objective of this study

- O1: To collate new *evidence* on recharge processes, groundwater quality, groundwater residence times, to understand the connectivity of the layered aquifer system and the impact of high levels of pumping in the alluvial plains aquifer on natural flow regimes
- Q1: What are the major sources of GW recharge across the aquifer?
- Q2: Is there evidence of vertical leakage to depth within the layered alluvial system?
- How?: repeated sampling of shallow and deep piezometers using a suite of environmental tracers

Study area – Bist Doab, Punjab, India

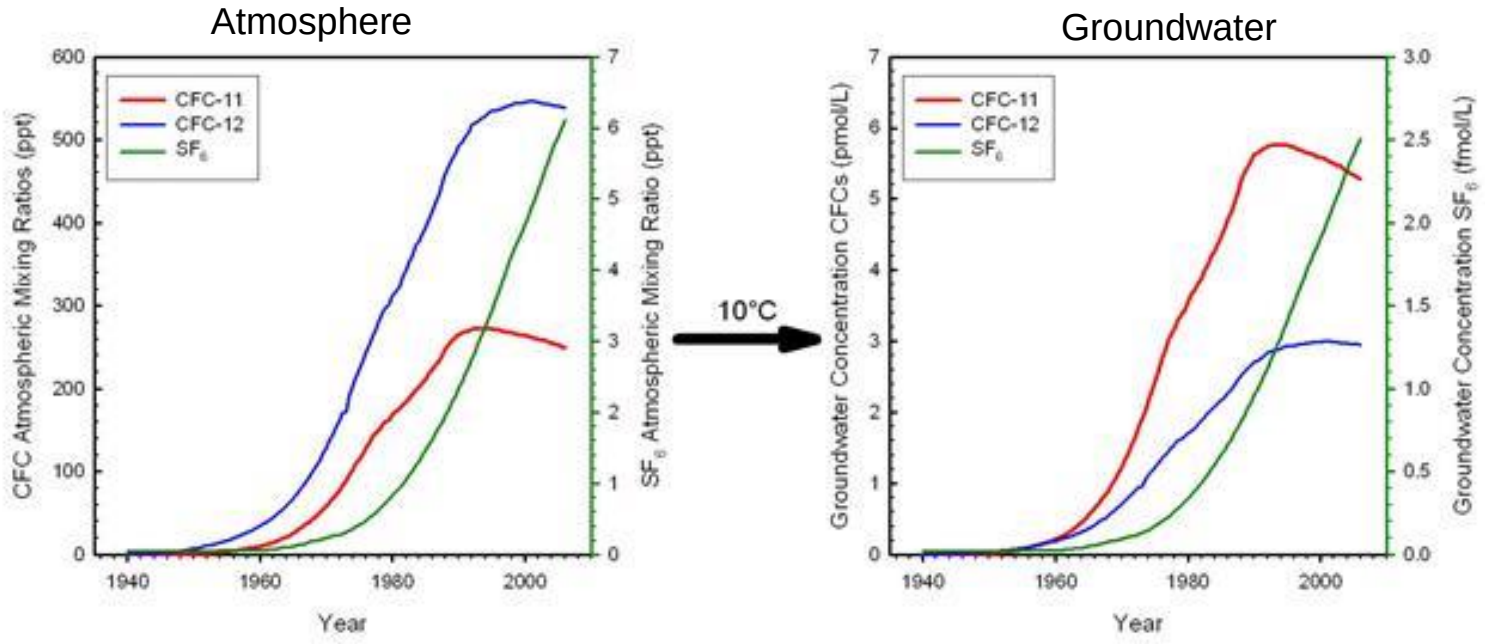




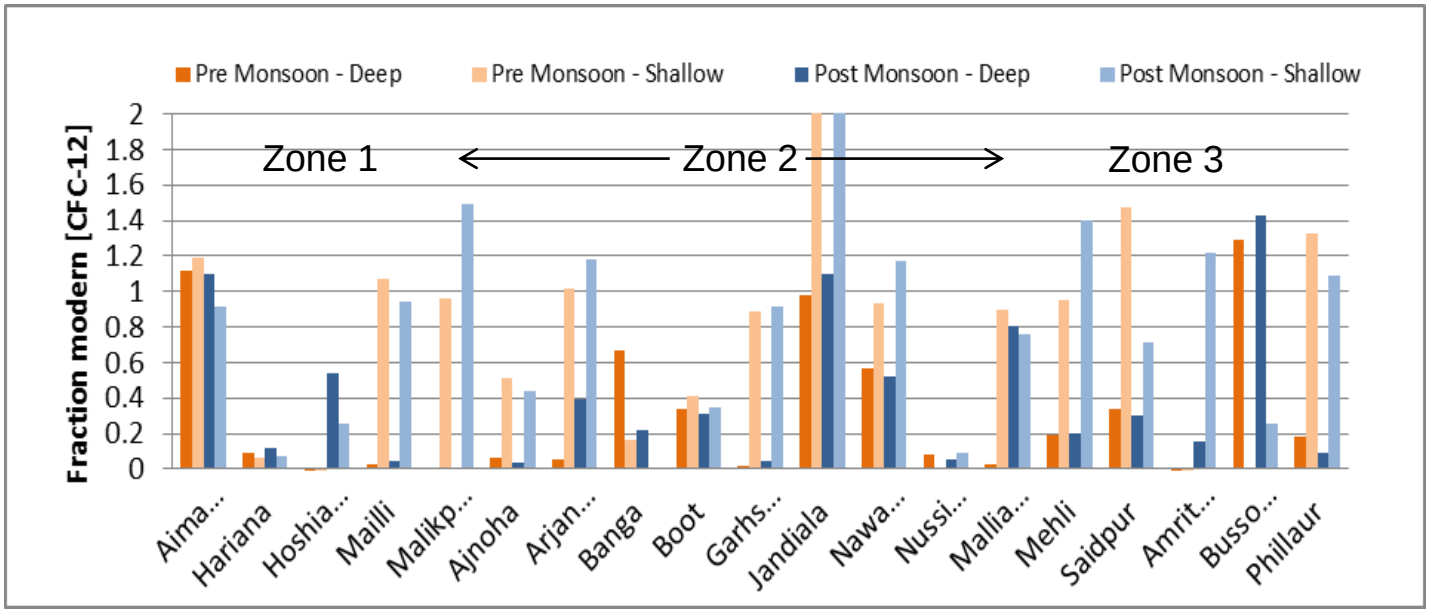
- Sampling from paired shallow (<50 mbgl) and deep (>100 mbgl) tube wells at 19 locations across the catchment
- Pre and post monsoon sampling

Tracers used in this study

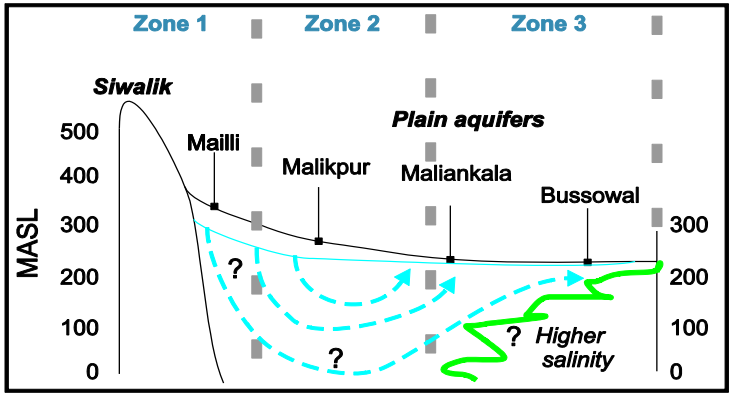
- CFCs, SF6 – groundwater residence time tracers
- Inorganic chemistry: e.g. Cl, NO3 and trace elements
- Stable isotopes – recharge sources



Groundwater residence time tracer results



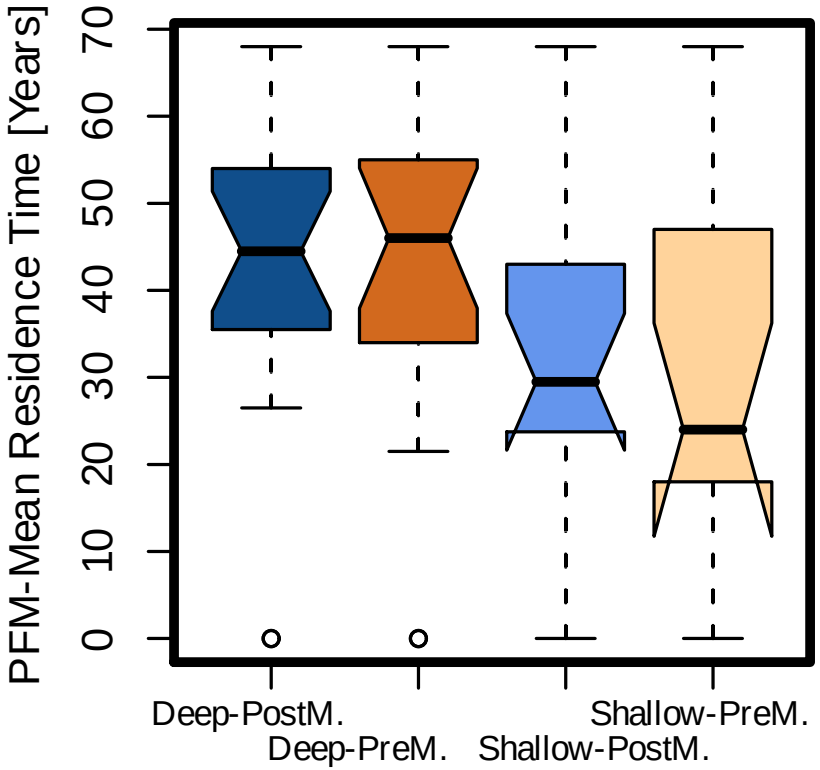
Traditional conceptual model of GW flow

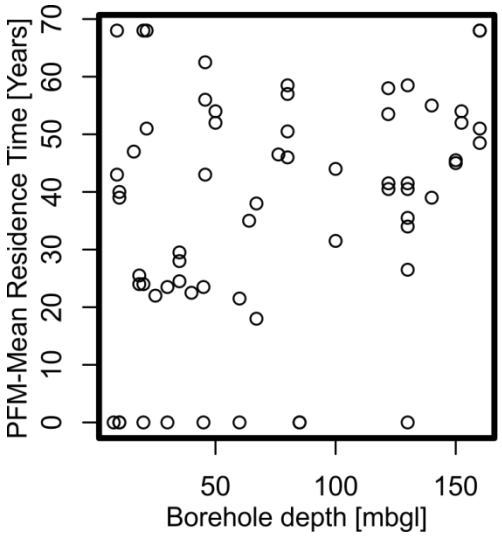


Z1: Higher rainfall (900 mm/a) and areal/surface recharge
Z2: 700 mm/a rainfall, recharge from irrigation and canals
Z3: 600 mm/a rainfall, shallow gw limited recharge potential

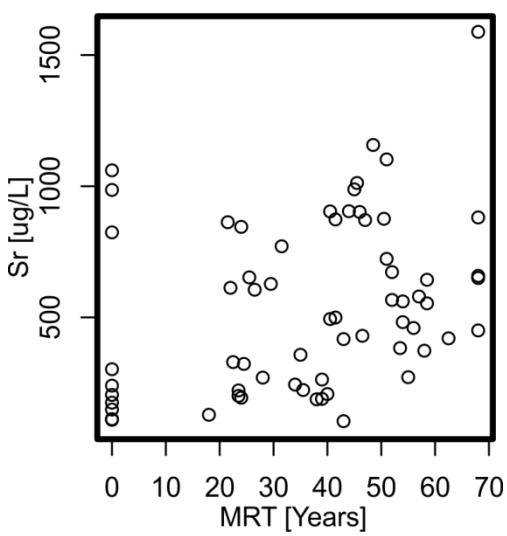
Groundwater residence time tracer results – anthropogenic and natural

CFC-12 data

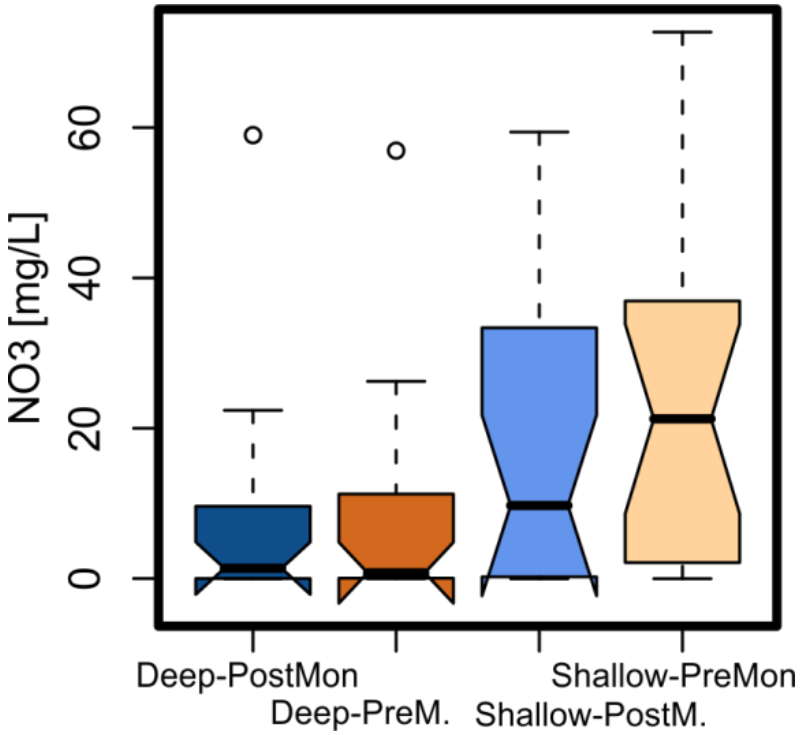


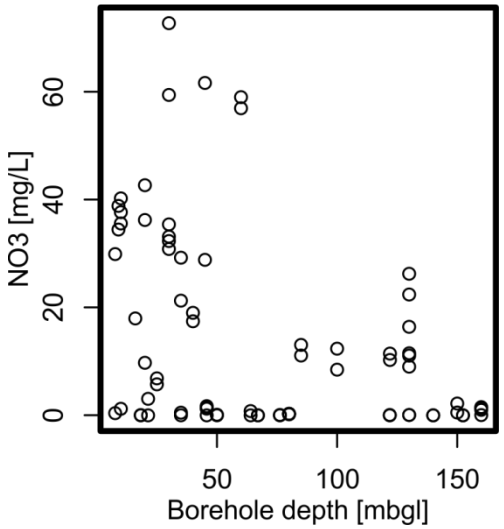


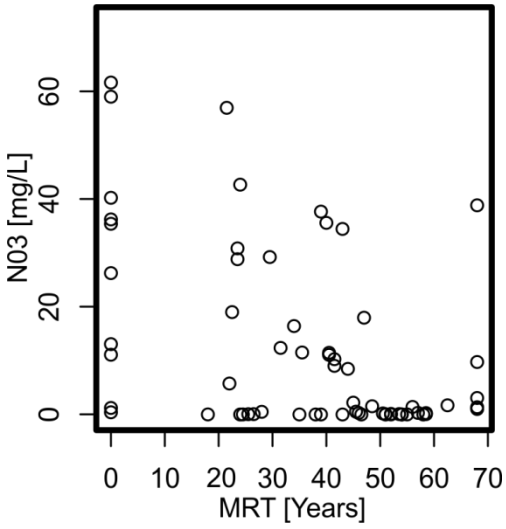
Trace elements
(e.g. Sr, Mo, As, U)



Groundwater nitrate variations*

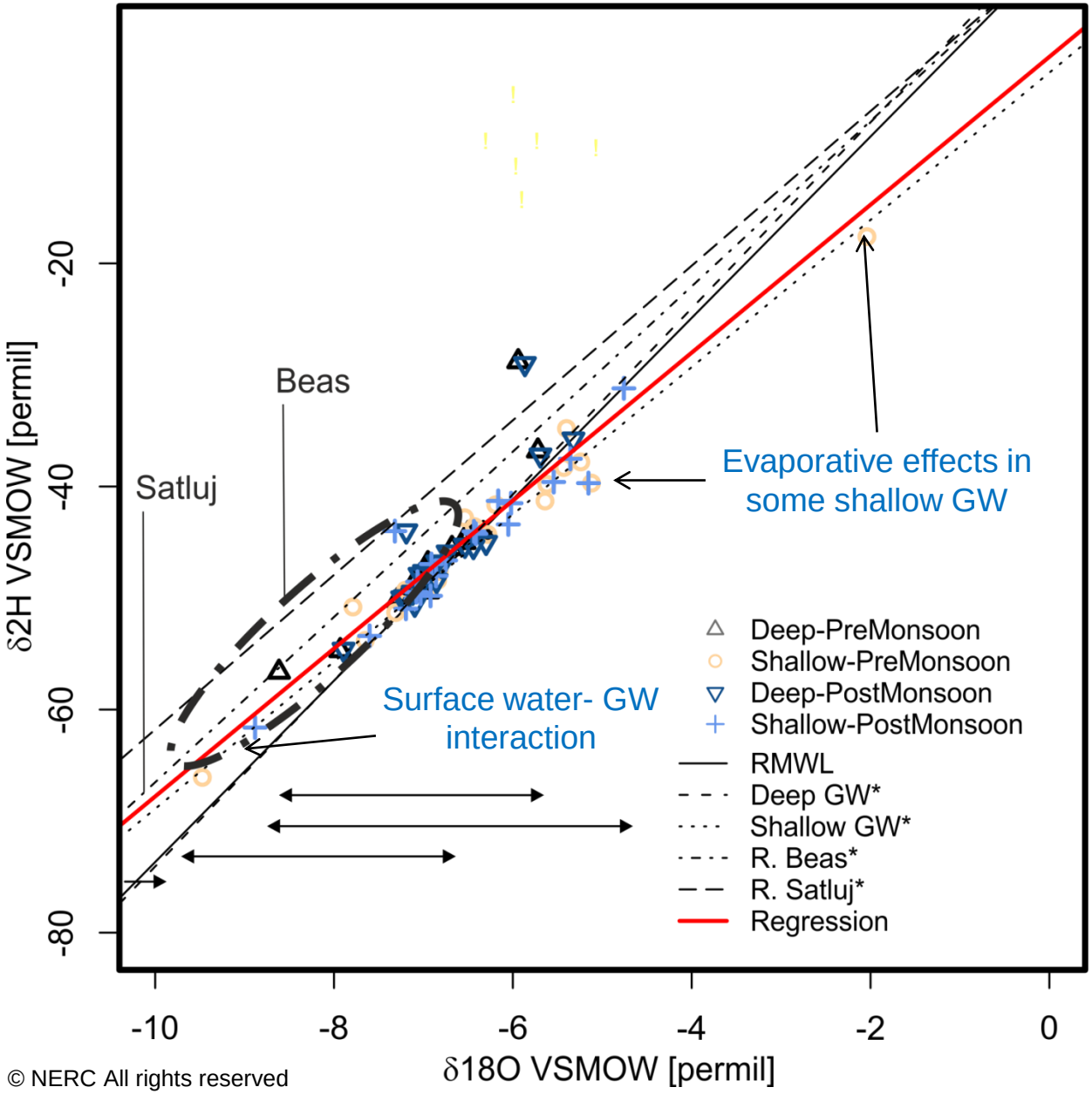






*See the same trends for Cl and SEC – conservative behaviour, aerobic

Stable isotope results



- Large overlap between shallow and deep GW isotope signatures,
- No significant difference between pre-post monsoon conditions in deep or shallow sites (most sites)
- A few shallow sites show evidence of surface water recharge – R. Beas alluvial aquifer
- Evaporative enrichment in some shallow sites
- No evidence of significant recharge from R. Satluj and related canal system in the south of the catchment

Initial findings

- Long term GWL data shows evidence of enhanced recharge potential
- *But* there are significant parts of the catchment where abstraction is outstripping recharge potential leading to long term loss of shallow groundwater security – cost implications for access to shallow GW
- Clear evidence, from a range of independent groundwater tracers, that there is significant vertical leakage and recharge from shallow sources to depth (>150) mbgl induced by pumping
- The natural regional groundwater flow regime is highly perturbed due to pumping and the system can be considered highly isotropic under pumped conditions
- This has implication for long term groundwater *vulnerability* of deeper aquifers and *water resource* management
- Reduced shallow groundwater levels in some regions is good news: lower salinity build up, soil waterlogging and of course flooding

Thanks for listening

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