Quantification of Baseflow Enhancement due to Managed Aquifer Recharge

Quantification de l'amélioration du débit de base due à la recharge gérée des aquifères

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Objective:

Parameterization of Baseflow Enhancement of Rivers in proximity to an **Injection Well** (Aquifer Storage and Recovery Systems), using **numerical groundwater models**.

State of the art:

- **Streamflow Depletion Function (SDF)**
  – Glover and Balmer (1954) and revised by Bruce Hunt (1999)
- **Baseflow Enhancement analysis with Numerical Model**
  -- Ferencz, S. et al. (2024)

Hypothetical Model:

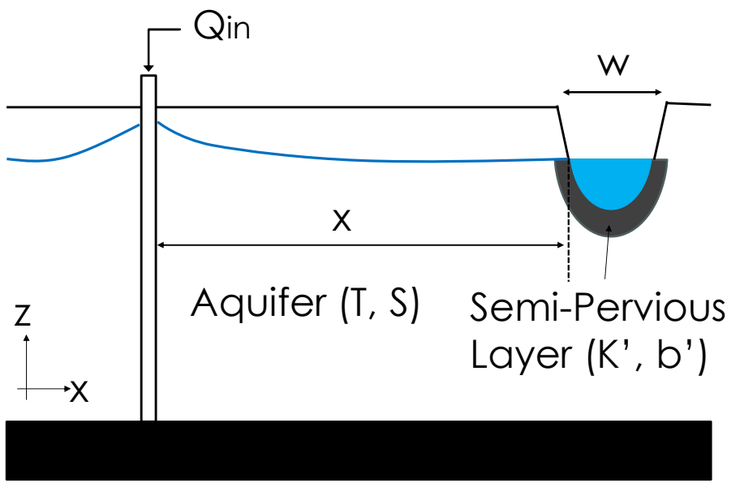

Fig 1. Hypothetical model (modified from *Bruce Hunt 1999*)

Parameterization:

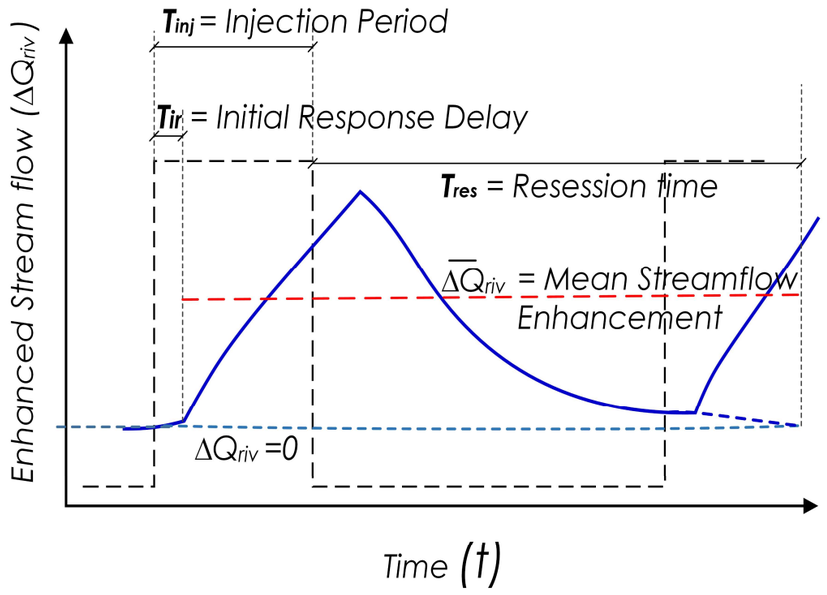

Fig 2. The Stream flow enhancement curve by periodic injection and its components

The metric:

Baseflow enhancement ratio (BFER)

$$BFER = \frac{Total\ volumetric\ RAE\ enhancement}{Total\ injected\ volume} = \frac{(RAE_{inj}(t) - RAE_{baseline}\ \Delta t(t))}{\sum Q_{in}.\Delta t}$$

Given,

RAE(t) = River Aquifer Exchange (River Leakage in MODFLOW)
t = time
Qin = Injection rate

Sensitivity:

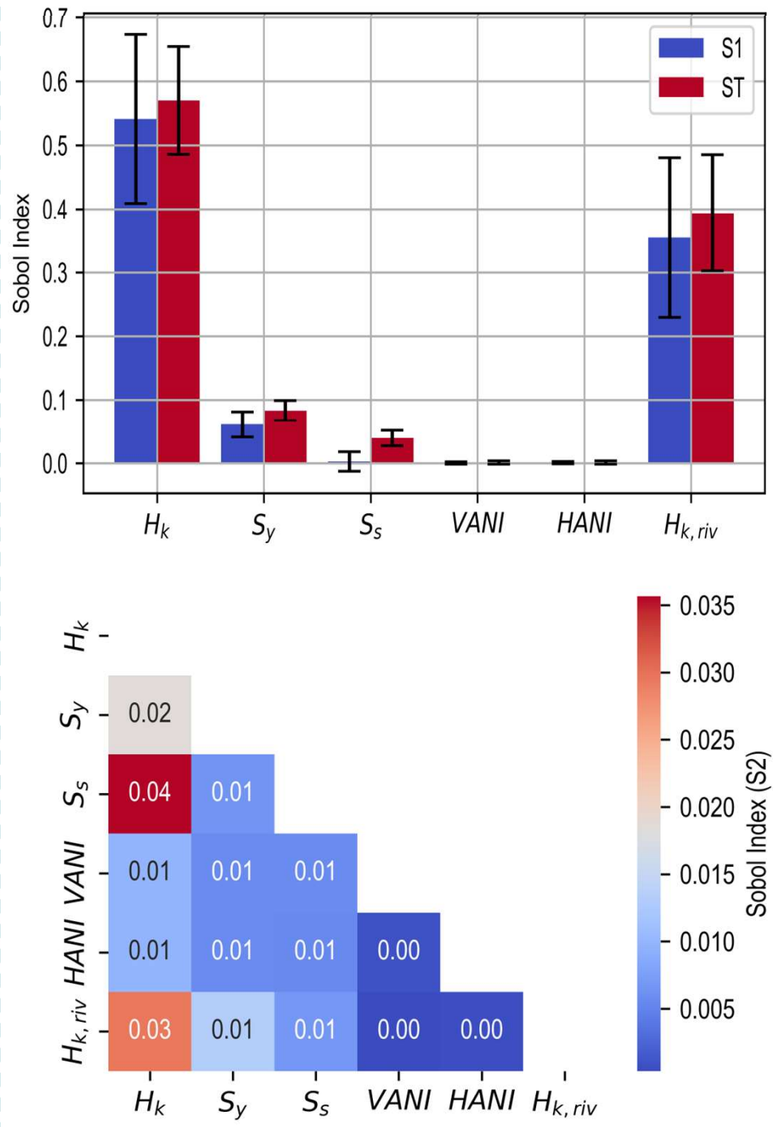

Fig 3. Sensitivity (Sobol's Index) of BFER to the Aquifer and River Parameters (**Hk** – Aquifer hydraulic conductivity, **Sy** – specific yield, Ss – Specific Storage, **VANI** – Vertical anisotropy, **HANI** – Horizontal anisotropy, **Hk,riv** – River bed hydraulic conductivity)

Implementation:

The methodology has been implemented in the Varuna River Basin, India, using a calibrated MODFLOW model.

The VRB has an alluvial aquifer system and semi-arid climate, and the river is connected to the shallow aquifer with a mean annual baseflow contribution of ~3-12% of total streamflow.

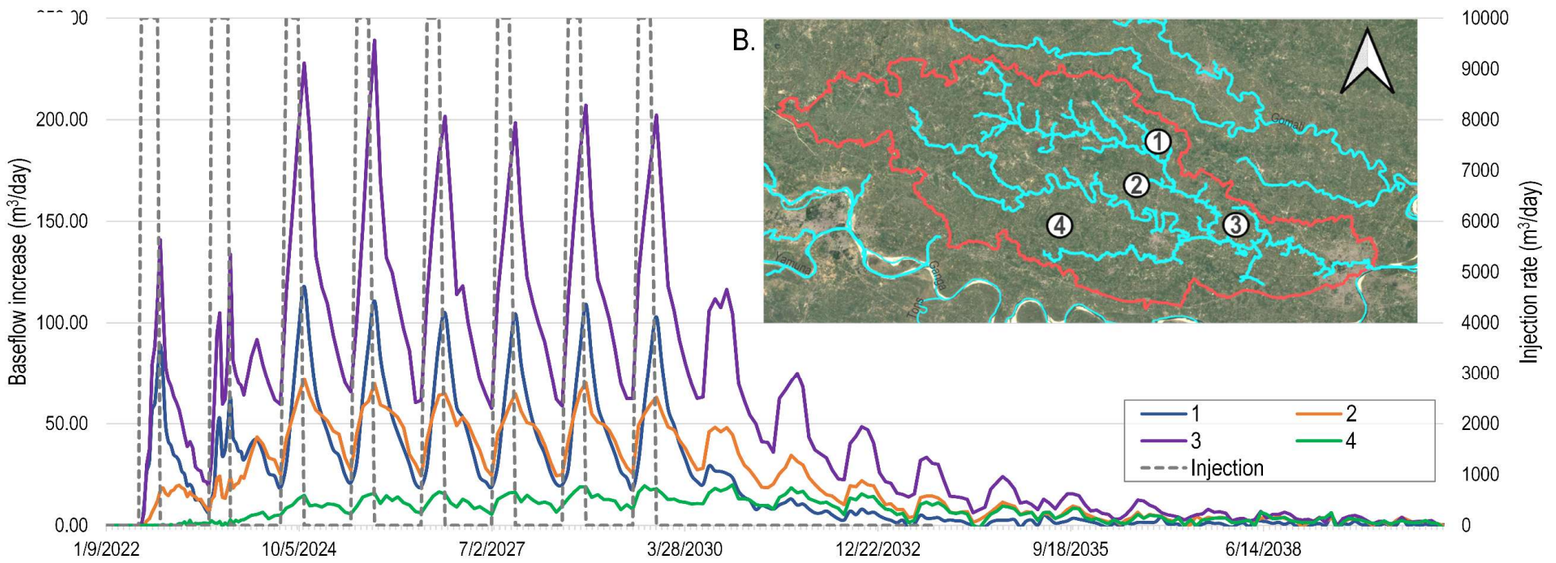

Fig 4. The Stream flow enhancement curve by periodic injection in VRB

BFER (Baseflow enhancement ratio)

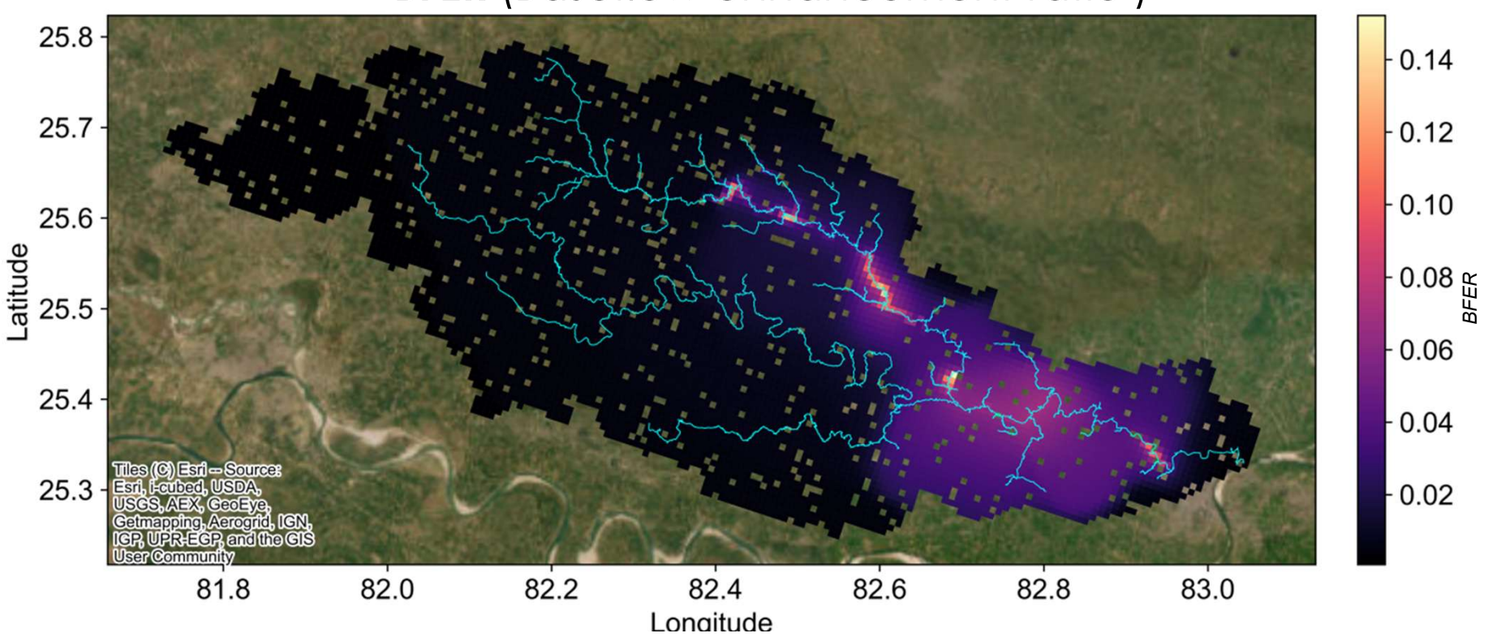

Fig 5. BFER in Varuna River Basin (INDIA)

Conclusion:

- The BFER **eliminates the need for model simulation during decision-making,** which is essential for decision-support tools.
- The BFER is sensitive to aquifer hydraulic conductivity and river bed conductivity followed by storage co-efficient.
- Since the methodology is based on the numerical groundwater model, it is **widely applicable in all terrain and complex hydrological systems**.