Assessing Baseflow and Groundwater-Level Declines in the Requena-Utiel Aquifer System Using TETIS-Derived Recharge

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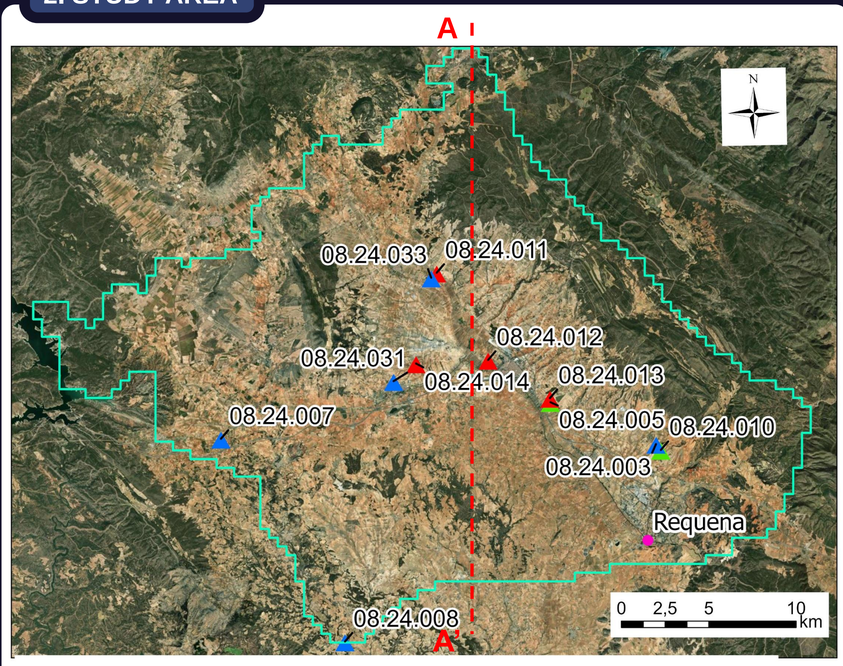
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1. INTRODUCTION

The Requena-Utiel region has historically been **characterized by rainfed** viticultural production. However, groundwater exploitation has progressively increased, intensifying after 2000 with the expansion of **modern irrigation** systems and currently **exceeding 1000 registered wells across the whole aquifer system**. Concurrently, **significant declines** have been observed both in the **discharge** of the Magro River and in the **piezometric levels** of the Cretaceous aquifer.

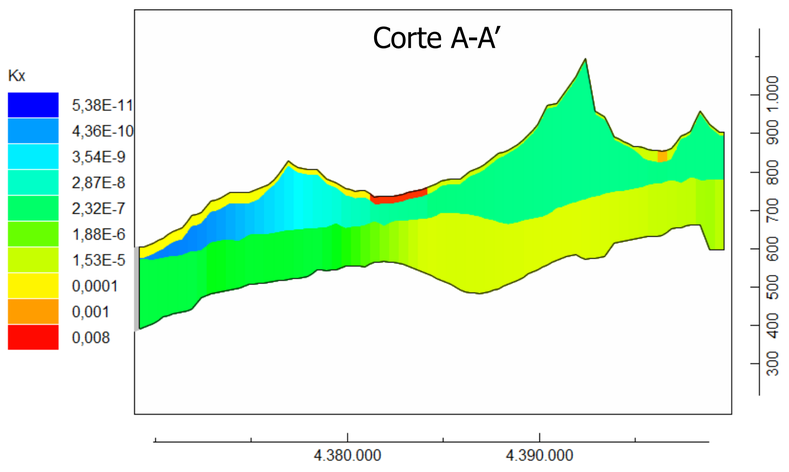
Purpose: Building a 3-layer **MODFLOW 6** groundwater flow model capable of reproducing both types of observations, using recharge estimated with the distributed hydrological model **TETIS**, **pilot-point** parameterization and **PEST**-based calibration. Ultimately, it could serve as a tool for water resources management.

2. STUDY AREA



- Requena
- MF6 model domain
  Domain covers nearly 70% of the aquifer system

Piezometer
- Calibration + Updating data
- Calibration data
- Updating data



3. METHODOLOGY

1 Baseflow separation

Forata st.:
Period: 2000-21

Requena st.:
Period 1: 1951-79
Period 2: 2004-22

2 Modelling surface runoff - **TETIS**

Calibration: Forata st.
Validation: Requena st.
Both for period: oct-2015 to dec-2022

OUTPUT
1951-22 recharge maps were clipped to the MF6 model domain and resampled to a 500 m resolution

3 Steady + Transient by **PEST**

PARAMETERIZATION
Defining pilot points: Kx, Kz, Sy, SS
Others: GHB, SFR, DRN conductance

TARGETS
Average baseflow (period 1951-79)
Head measurements and springs

4 Modelling Updating (period: **1990 - 2022**)

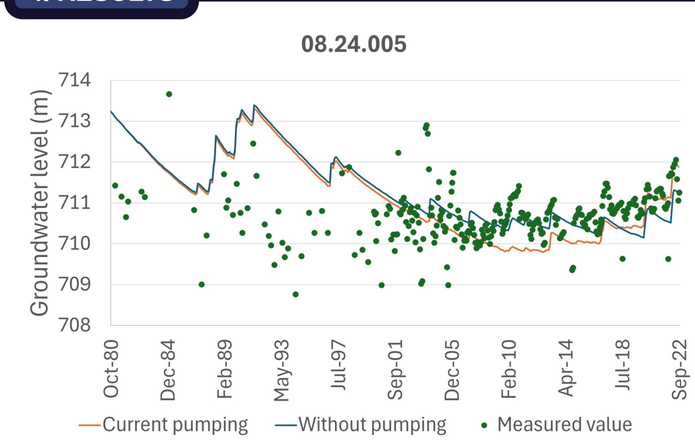
TARGETS
Head measurements from 5 new piezometers
Baseflow values obtained through separation method

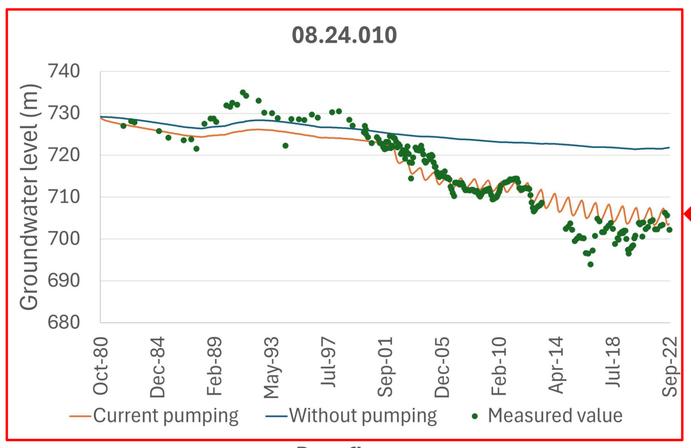
UPDATING
Just a **small group of parameters**

Great uncertainty!

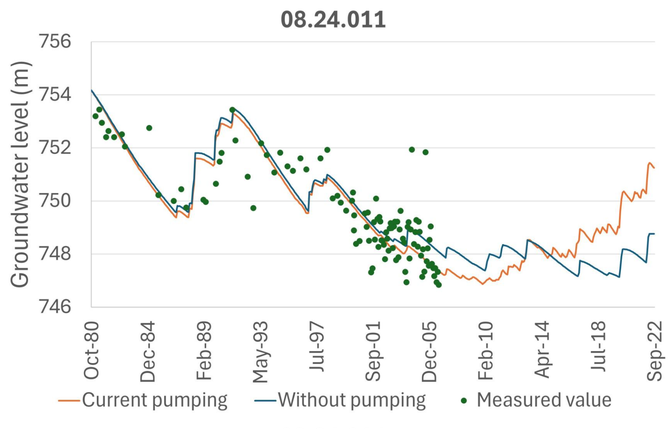
- ❖More than 800 new pumping wells within the modeled domain
- ❖Unknown depth and rate extraction
- ❖Rates based on the granted water extraction permits
- ❖Assuming that most of wells located at the deeper aquifer

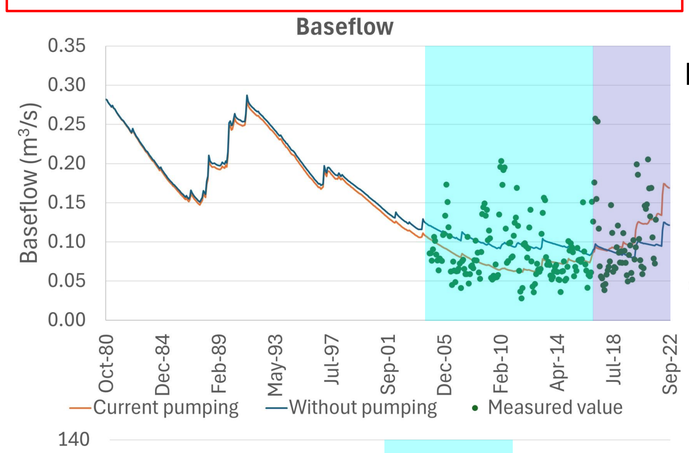
4. RESULTS

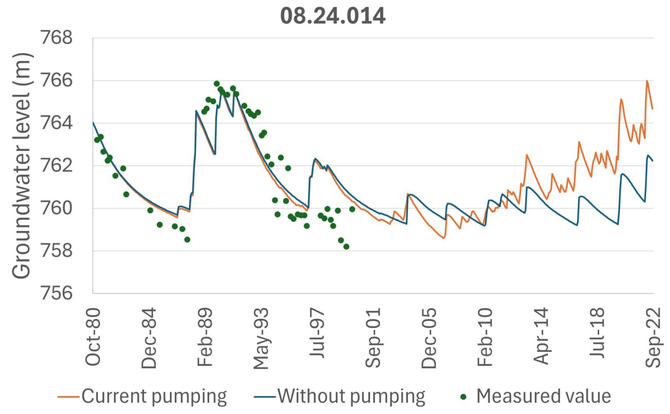


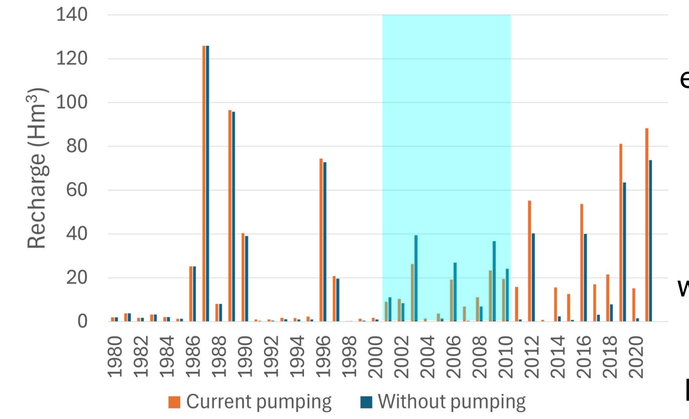


It is located in the deep aquifer, where most of the wells are found









Since 2004, baseflow has been more than 10% higher in the without-pumping scenario but from 2018 onward current pumping consistently shows higher baseflow

This could be explained by the fact that, between hydrological years 2001-2010, the without-pumping scenario shows some years of higher recharge

5. CONCLUSIONS

- ❖Baseflow in the without-pumping scenario exceeds the current scenario from 2001 onward, with the gap widening to **a peak difference of 35% in 2011**. This gap then progressively narrows, and from 2018 onward baseflow under current pumping remains consistently **higher than without pumping** — by **up to 41% in 2022** — likely driven by increasing irrigation returns.
- ❖Piezometer 08.24.010, located in the deep aquifer, exhibits a marked decline, in contrast to 08.24.005, near the Magro River, where the gap between the current-pumping and without-pumping scenarios widens from 2018 onward — a year with sustained below-normal SPI-12 conditions (4 of 12 months ≤ -1.0), ruling out climate as the driver. Concurrent rises in both scenarios during 2020 and 2022 instead coincide with sustained wet conditions (SPI-12 ≥ 1.0 for at least 6 months each year). **The widening gap indicates increasing irrigation returns** associated with the expanding technified irrigation area, consistent with the baseflow pattern.
- ❖Net recharge in the 'current pumping' scenario is lower than in the 'without-pumping' scenario in some years during 2001-2010, reflecting the balance between increased evapotranspiration due to **elevated Kc values in irrigated pixels** (**dominant effect when the irrigated area is small**) and **irrigation return flow** associated with pumping (**dominant effect from 2011 onward**, when the irrigated area expands significantly).
- ❖The lack of geological modeling studies, data on the evolution of the irrigated area, and unknown pumping depths and rates constitute the main source of uncertainty for this study; therefore, greater resources must be invested in data collection and the preparation of complementary studies.

6. REFERENCES

[1] Xie, J., Liu, X., Wang, K., Yang, T., Liang, K., Liu, C. 2020. Evaluation of typical methods for baseflow separation in the contiguous United States. Journal of Hydrology, 583, 124628. doi:10.1016/j.jhydrol.2020.124628. **[2]** Francés, F., Vélez, J. I., Vélez, J. J. 2007. Split-parameter structure for the automatic calibration of distributed hydrological models. Journal of Hydrology, 332(1–2), 226–240. doi:10.1016/j.jhydrol.2006.06.032. **[3]** Pool et al. 2021. Hydrological modeling of the effect of the transition from flood to drip irrigation on groundwater recharge using multi-objective calibration. Water Resources Research, 57, https://doi.org/10.1029/2021WR029677 **[4]** Doherty, J. E., Hunt, R. J. 2010. Approaches to highly parameterized inversion: A guide to using PEST for groundwater-model calibration. U.S. Geological Survey Scientific Investigations Report 2010–5169, 59 p.

7. ACKNOWLEDGEMENTS

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