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Numerical Modelling of an ATES installation in the UK Chalk Aquifer

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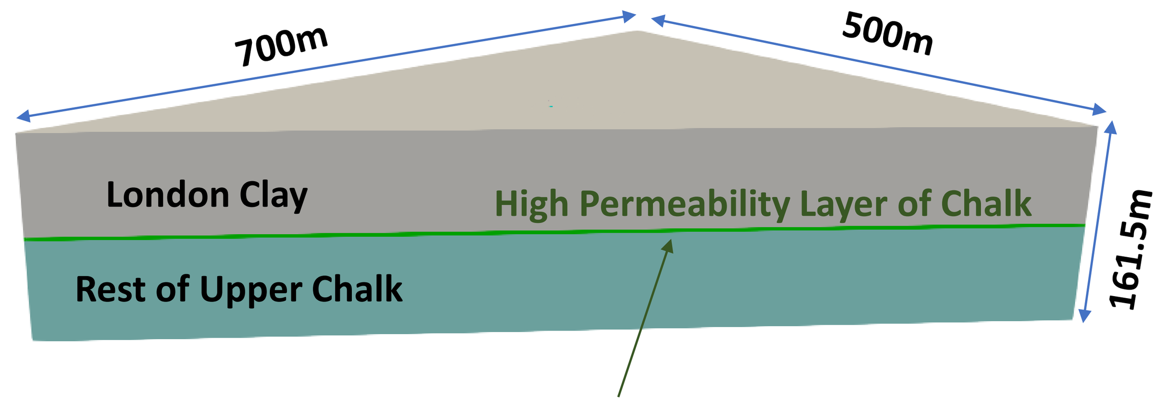
1. Introduction

Figure 1: Plan-view of WRQ with cold wells shown in blue and warm wells shown in red.

- Installation at Wandsworth Riverside Quarter (WRQ), London, U.K.
- Operating since 2013 with 8 wells (Figure 1)
- Utilises the Chalk aquifer (Figure 2)
- Well-balanced system: energy balance ratio of 0.009 but low thermal recovery: Average of 23% (Regnier et al., in review)



In this model, a high-permeability horizon that is 3m thick has been emplaced from a depth of 79.25m to 82.25m.

Figure 2: A subsurface model of WRQ. The target aquifer is the Chalk, with the London Clay acting as an aquitard. The Chalk is a dual porosity aquifer containing fractures and karstic features (Arthur et. Al., 2010).

2. Questions

Why is the thermal recovery of the WRQ installation low?

How have the fractures/karstic features within the Chalk contributed to thermal interference and/or to increased conductive heat losses to non-flowing intervals above and below the plumes?

3. Aims

- Accurately model subsurface fluid flow and heat transport in the WRQ installation
- Understand why efficiency of the installation is low
- Apply this research to future installations in the Chalk and other fractured/karstic systems

4. Numerical Modelling

- Surface Based Modelling (SBM) used in the models
- SBM allows for grid free boundary representation to accurately capture subsurface geological heterogeneity
- Imperial College Finite Element Reservoir Simulator (IC-FERST) is the flow simulator
- Dynamic Mesh Optimisation (DMO) optimises the mesh to best capture pressure and temperature fields through time while preserving geological heterogeneity (Figure 3) at lower computational cost than equivalent fixed-mesh simulations

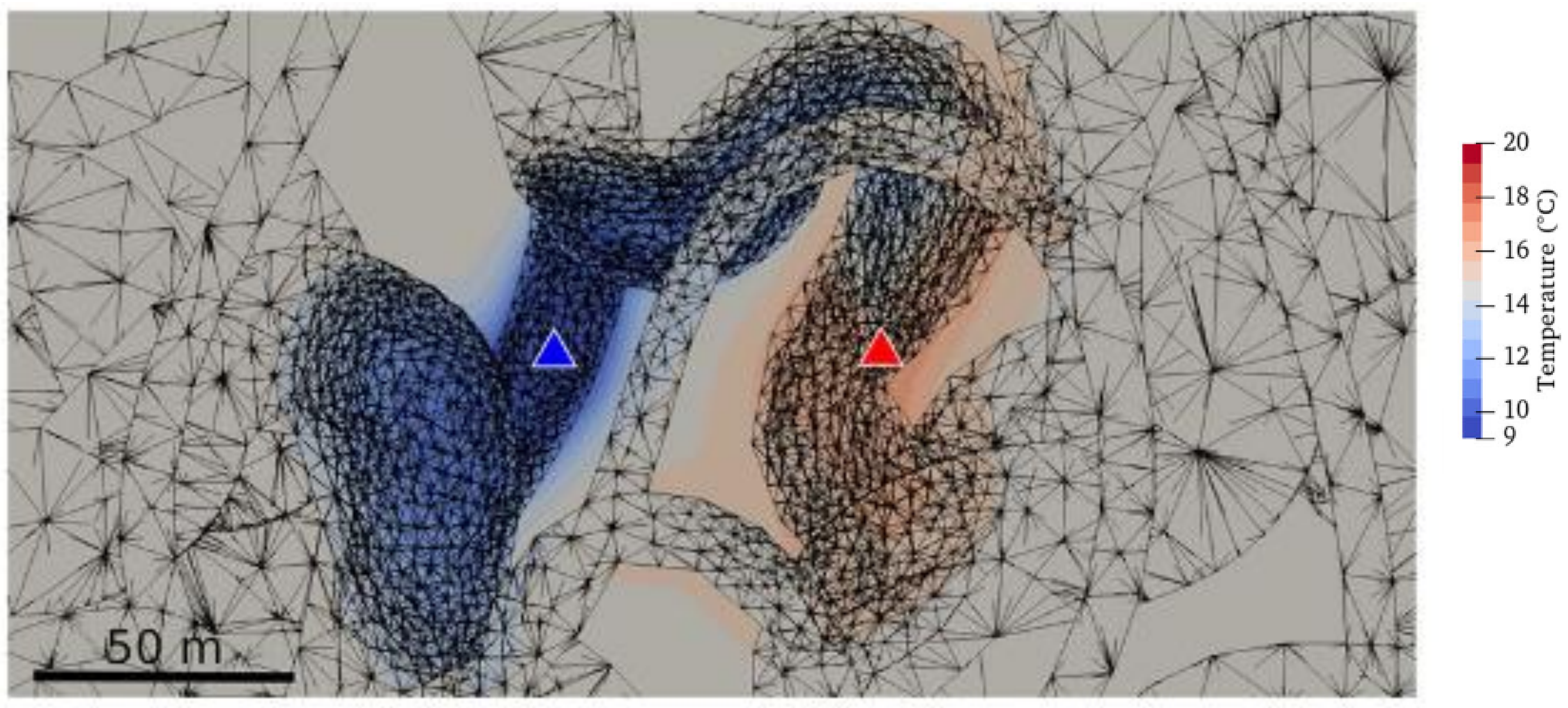


Figure 3: Plan-view of a different simulated ATES installation in channelised sand bodies. Surrounding mudstones are omitted for visualisation purposes. Blue triangle indicates cold well location and red triangle indicates warm well location (Regnier et al., 2022).

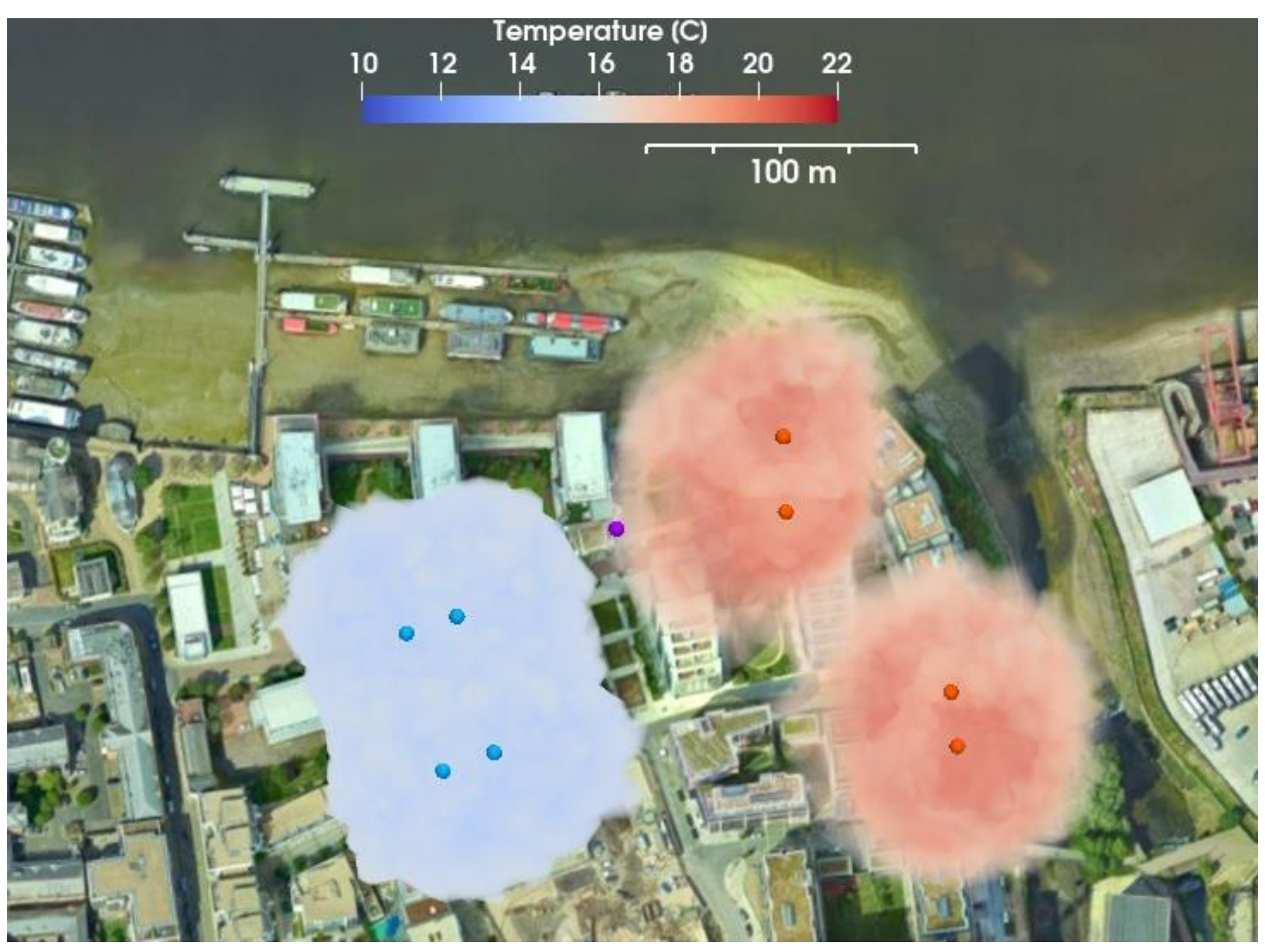


Figure 6: Simulation of WRQ ATES installation using the model shown in Figure 2. For this scenario, thermal interference occurred.

5. Completed Work

- Created an initial model of the subsurface using SBM based on flow profiles from each well (Figure 4)
- Conducted a mesh sensitivity analysis to find the appropriate mesh resolution on a fixed mesh (Figure 5)

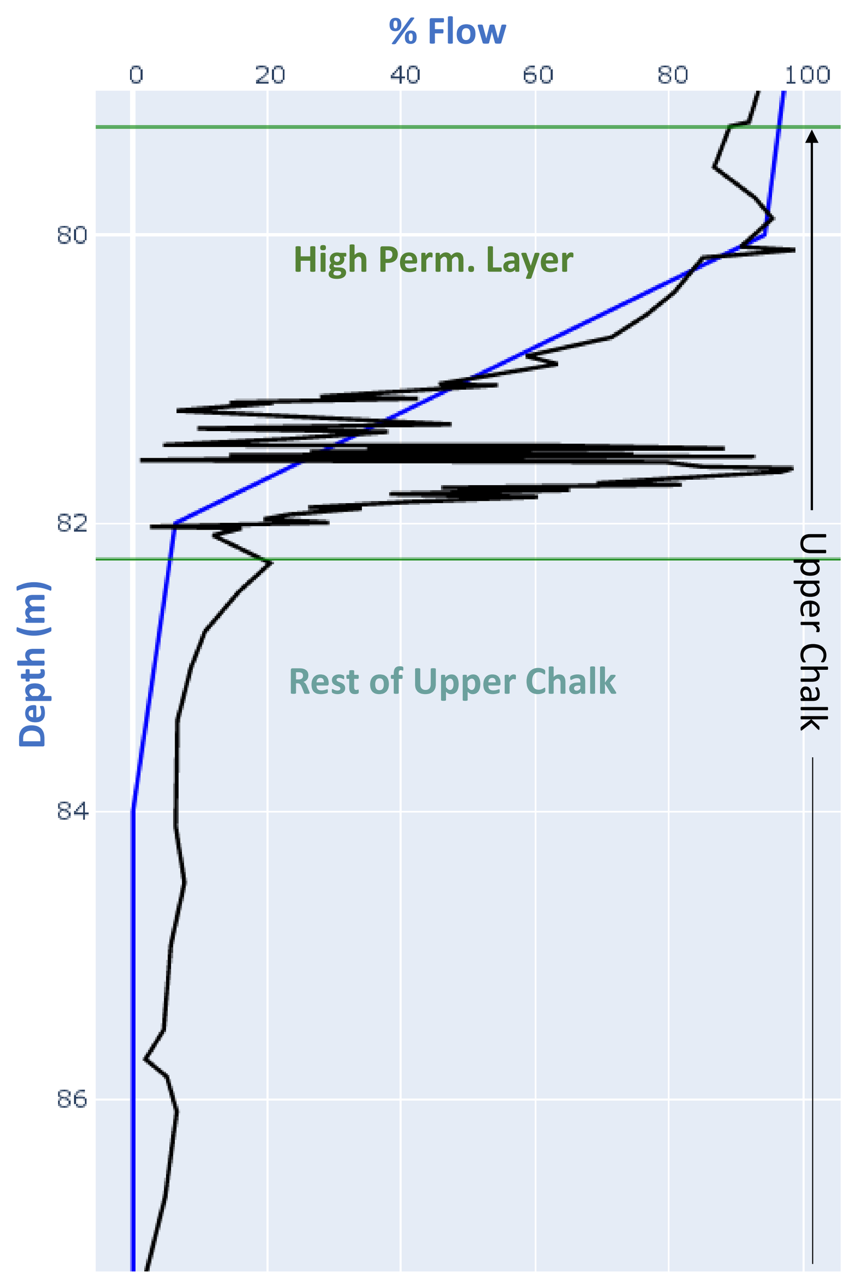


Figure 4: Measured flow profile of WRQ's cold well 3 in black. A simulated flow profile using the model shown in Figure 2 is in blue.

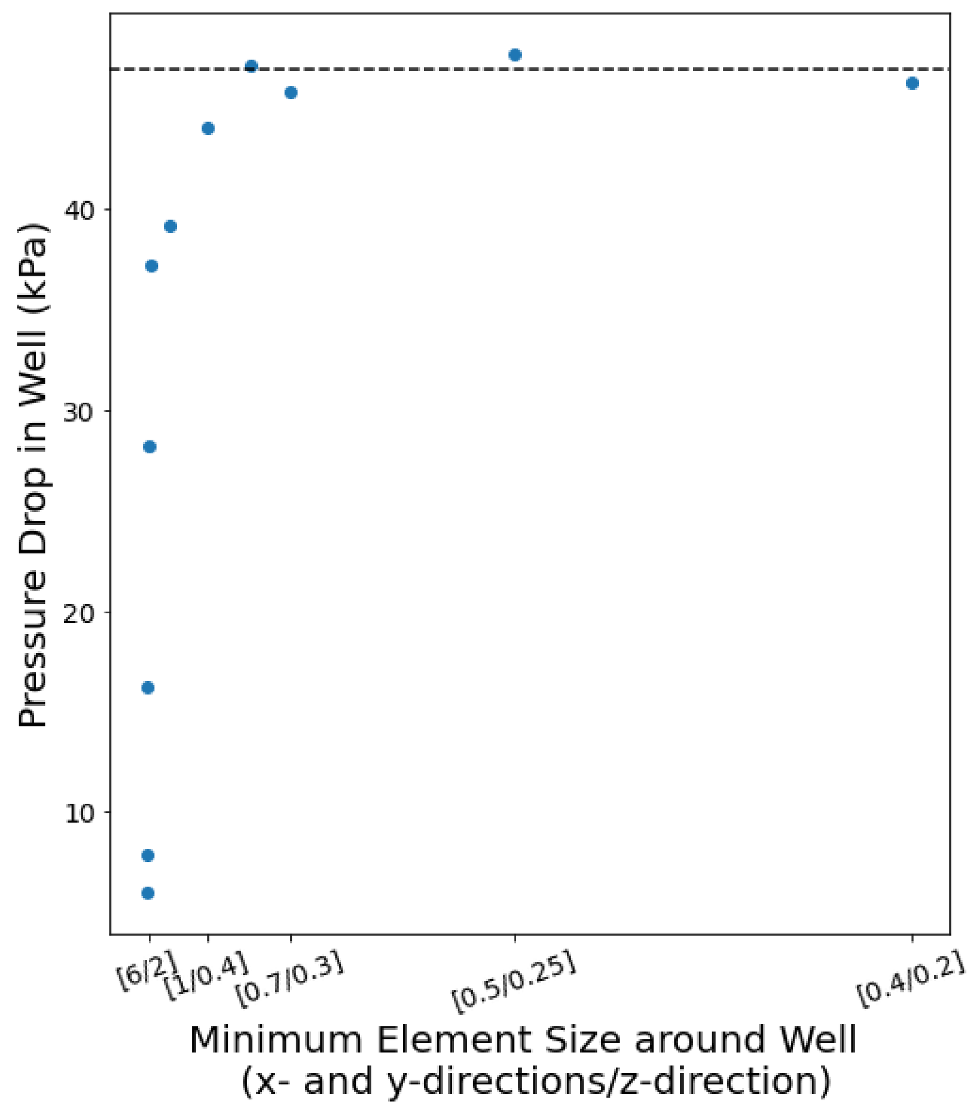


Figure 5: Simulated pressure drop on different fixed meshes for WRQ's cold well 3. x-axis shows element sizes [*x*,*y*,*z*] in meters. The measured pressure drop is shown by the black dashed line.

6. Future Work

- Identify and model additional geological scenarios using observed behaviour, field work, and literature
- Employ a genetic algorithm to history match models to observed data for all 8 wells
- Use the history matched models to make predictions of future behaviour
- Apply learnings to other ATES and shallow geothermal systems operating in the Chalk aquifer

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