Groundwater mapping techniques applied in Africa

Prof Alan MacDonald

IGAD 3rd Water Dialogue Forum

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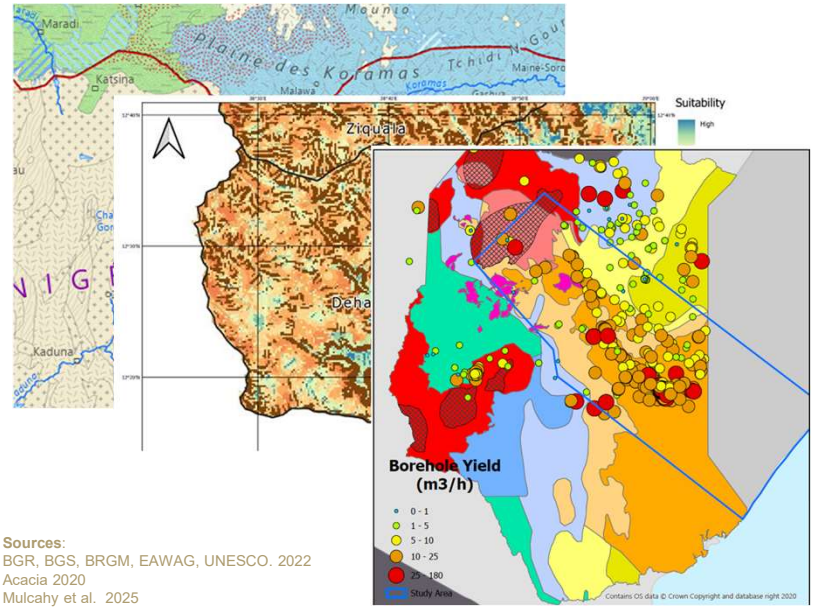
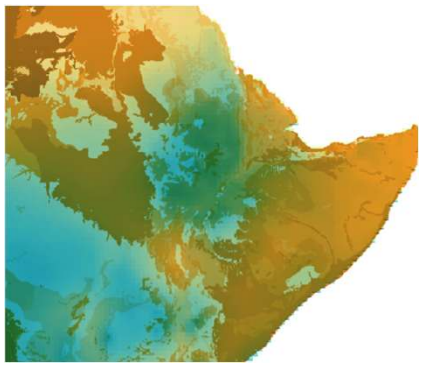
GROUNDWATER MAPPING

What do we mean by a groundwater map?





Sources:
BGR, BGS, BRGM, EAWAG, UNESCO. 2022
Acacia 2020
Mulcahy et al. 2025
MacDonald et al 2021

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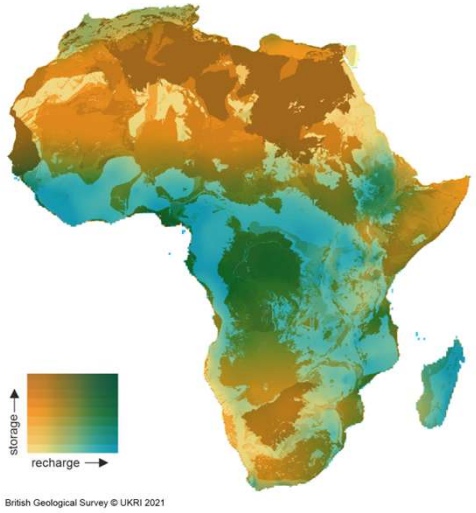
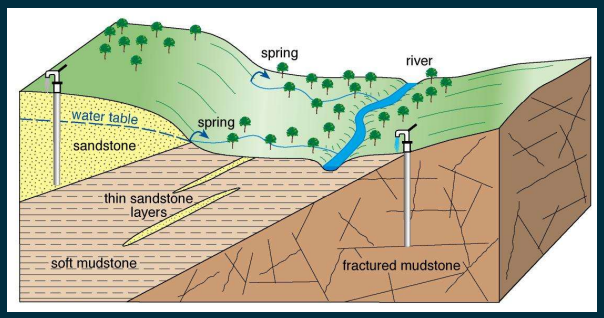
GROUNDWATER MAPPING

Regional/continental

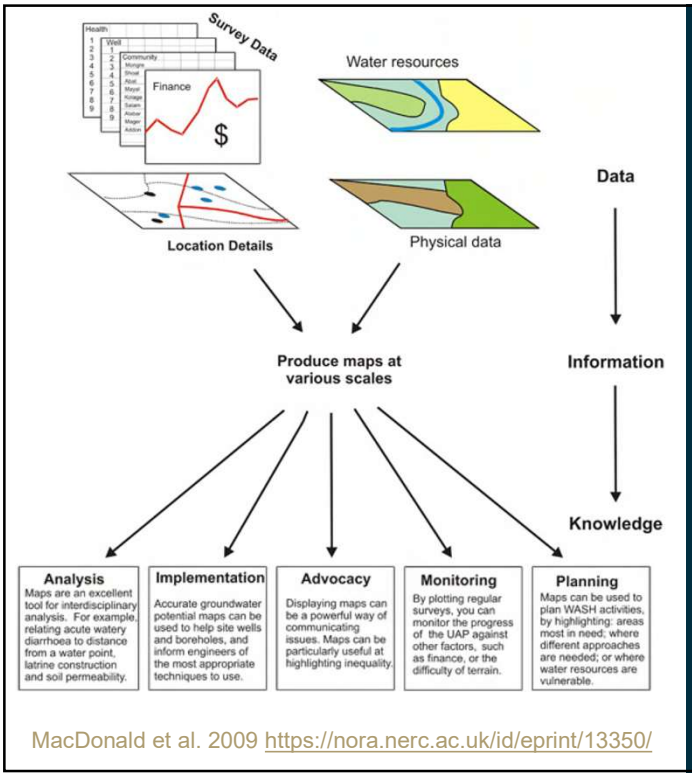


Site specific



GROUNDWATER MAPPING

The type of map depends on what the purpose is – and who will be using it…



MacDonald et al. 2009 https://nora.nerc.ac.uk/id/eprint/13350/

Purpose

1. Advocacy
2. Planning
3. Analysis
4. Monitoring
5. Implementation

Need to design the map to meet the purpose

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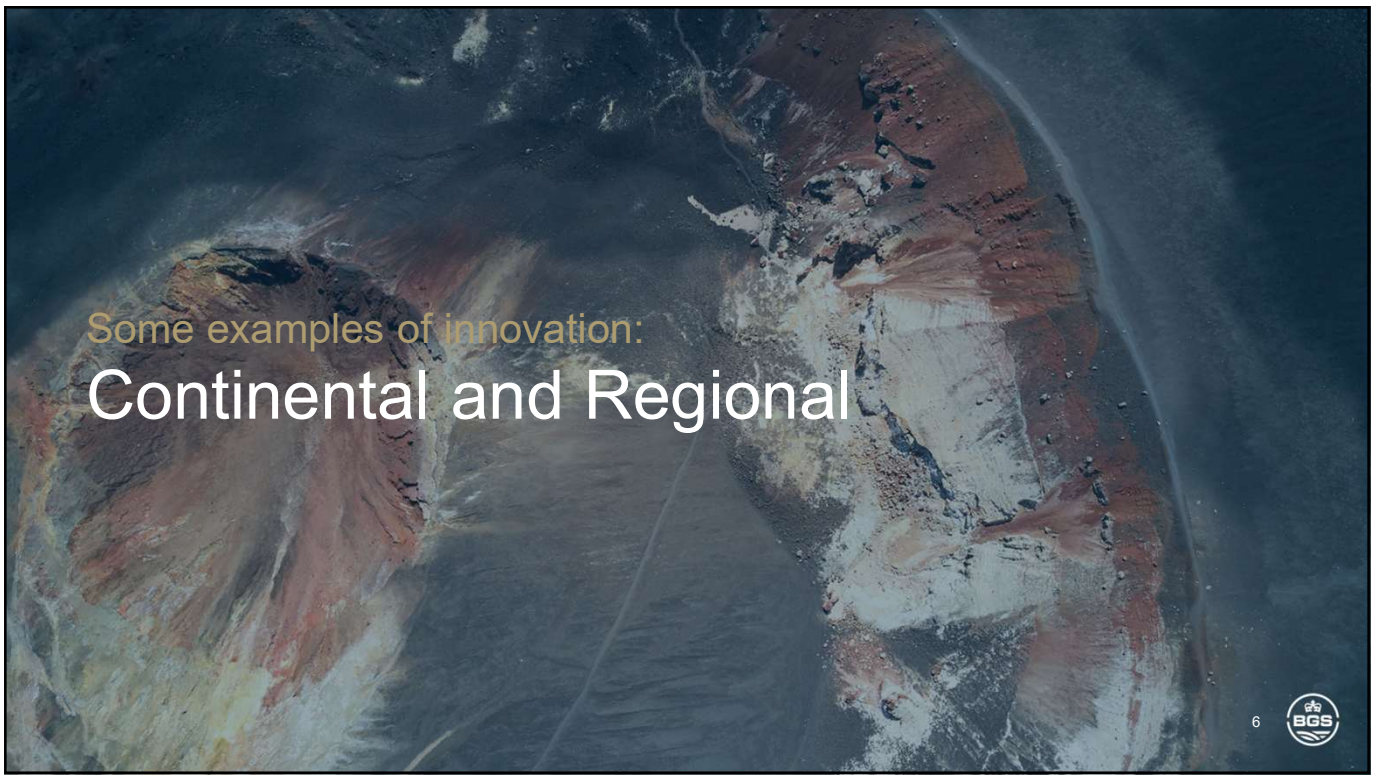

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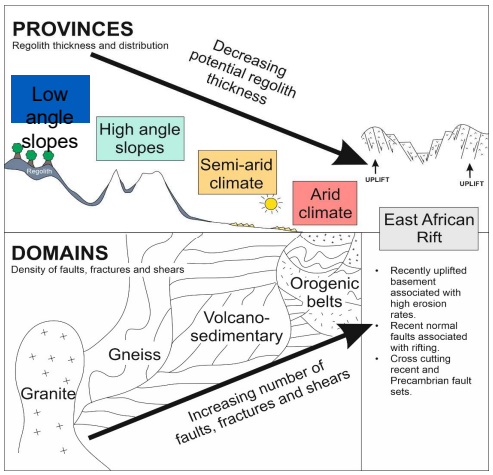
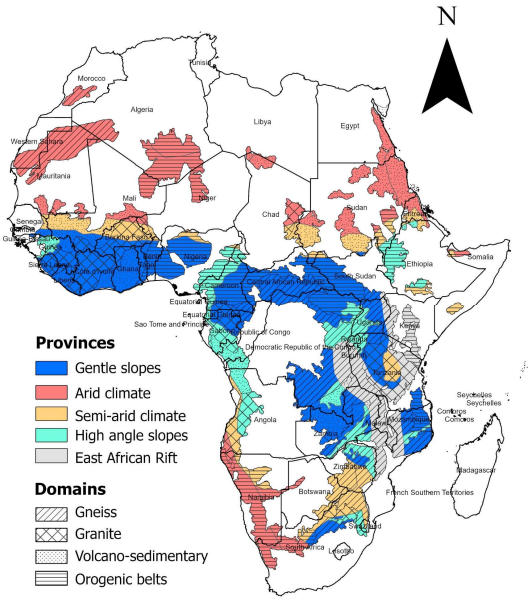
GROUNDWATER MAPPING

Crystalline Basement mapping

Can we better predict basement behaviour across Africa and the factors controlling it?





MacDonald et al. in preparation

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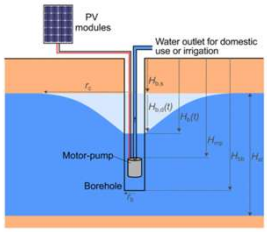
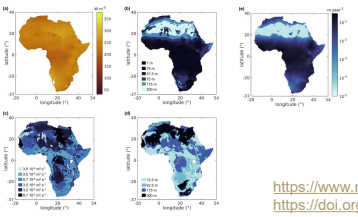
Solar powered pumping

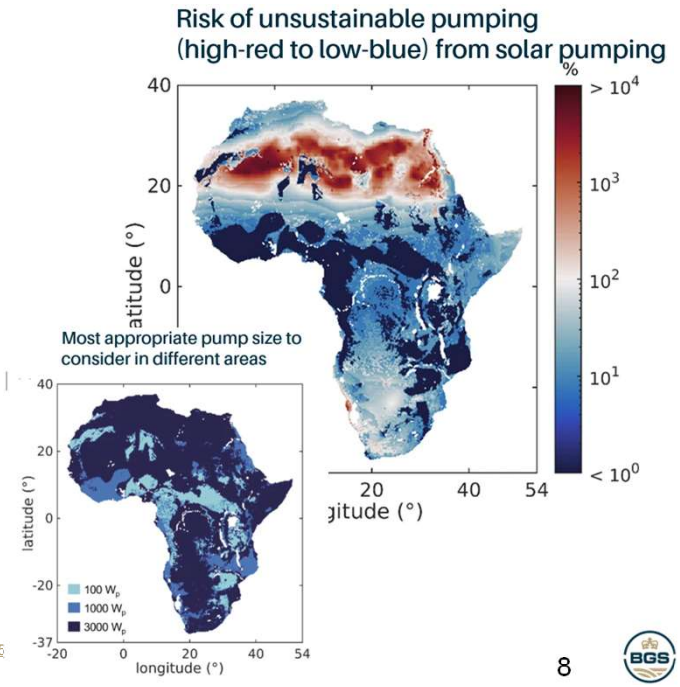
Can we identify regions where solar pumps may be more suitable?



Model modules: atmosphere, PV solar, hydraulic, aquifer, pump



https://www.nature.com/articles/s43247-023-00695
https://doi.org/10.1016/j.scitotenv.2024.177062



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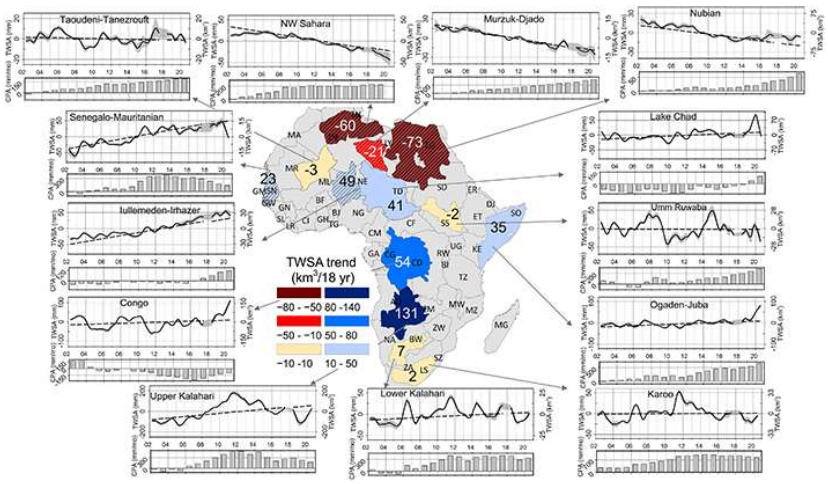
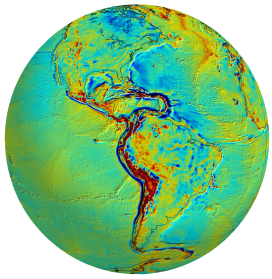
Using GRACE to look at storage changes

Can we see regional storage changes?

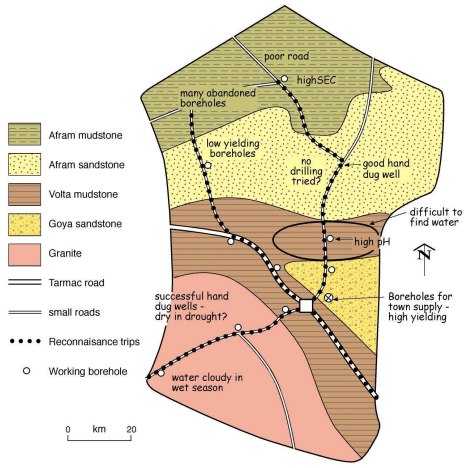


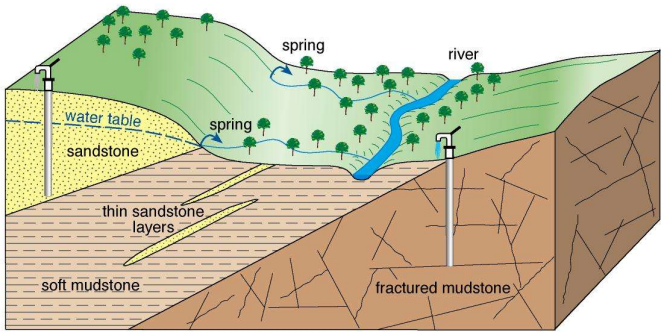
Scanlon et al. 2022. https://iopscience.iop.org/article/10.1088/1748-9326/ac3bfc/meta



- Decline in north Africa
- Rising in Sahel and East Africa
- Climate and telecommunication signals in southern Africa
- *Downscaling, modelling?*

Can we increase the success of developing a productive, sustainable borehole?





MacDonald et al.
2005 http://dx.doi.org/10.3362/9781780441290

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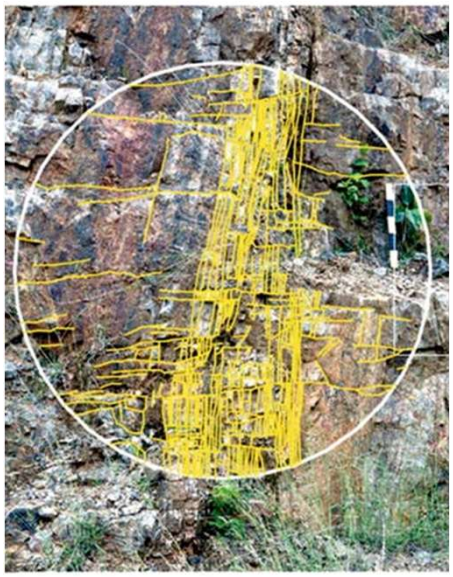
Groundwater potential

Mapping hydrogeologically significant geology and aquifer yield (and chemistry & recharge)



Photos BGS © UKRI 2025

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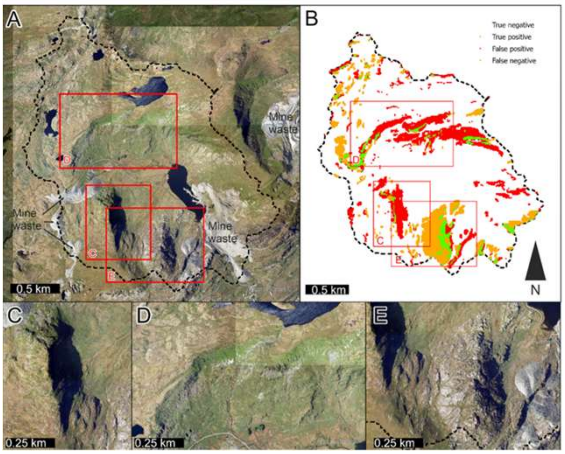
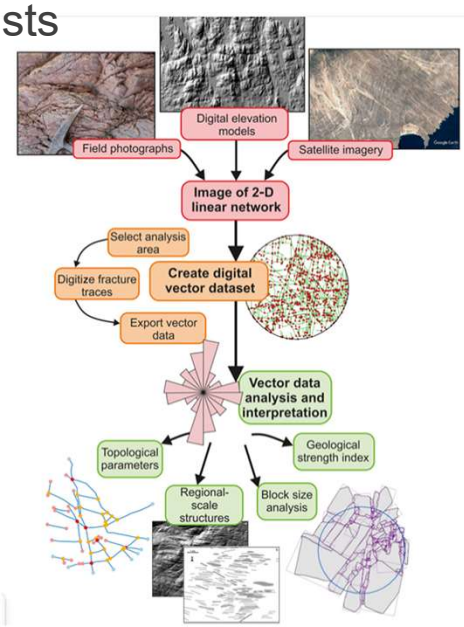
Remote sensing and AI can help geologists



Exposed bedrock

Williams C et al, 2025
https://doi.org/10.1016/j.cageo.2024.105814



Fracture mapping

Palamakumbura, R et al, 2020
https://doi.org/10.5194/se-11-1731-202

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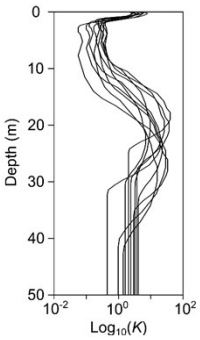
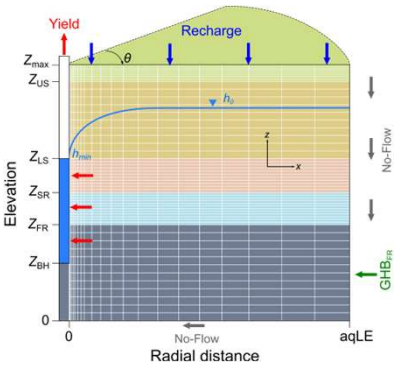
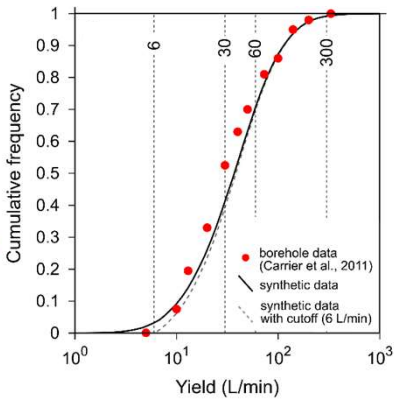
Stochastic modelling of borehole yields – move to probabilities







Bianchi et al 2020 https://doi.org/10.1029/2020WR027746

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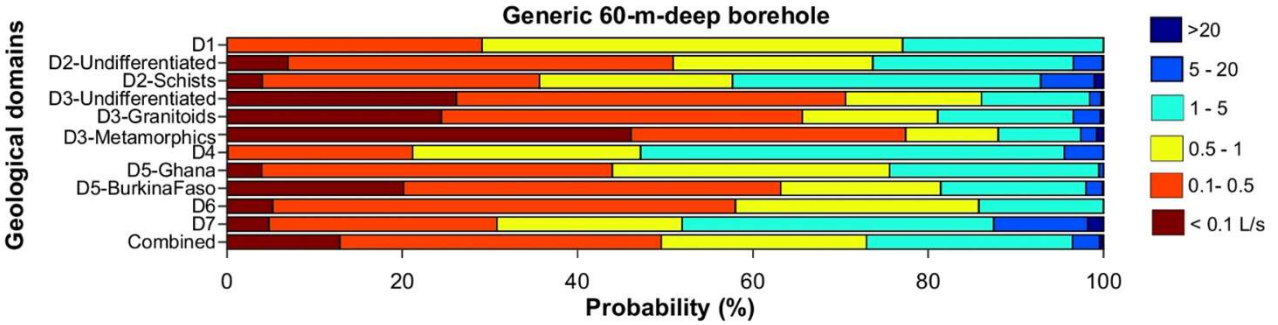
Stochastic modelling of basement borehole yields



Bianchi et al 2023 https://doi.org/10.1007/s10040-023-02594-w

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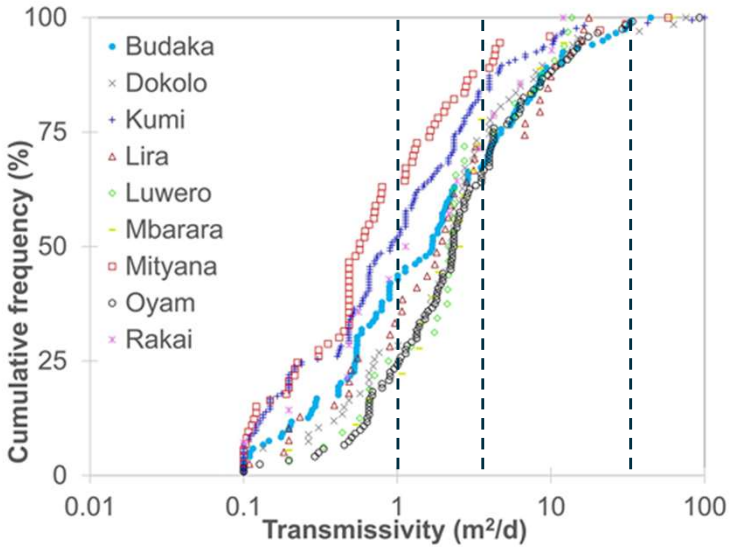
An example from Uganda



Mapping transmissivity by analysing tests done during commissioning

Tells us the probability for different uses

Can help inform the investment needed to site boreholes

Owor et al. 2022
https://nora.nerc.ac.uk/id/eprint/533303/

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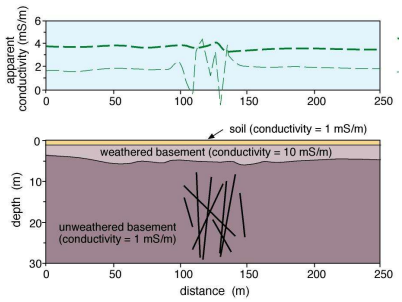
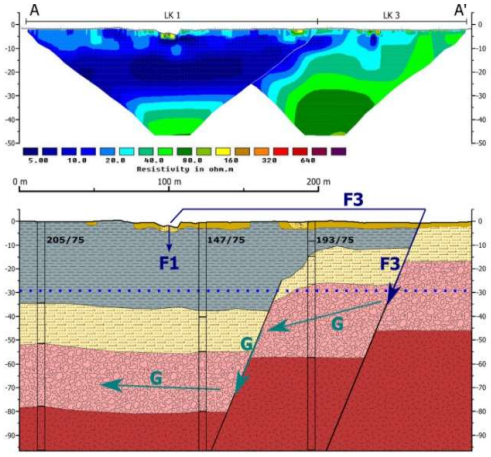
Simple geophysics



Specialised geophysics



https://doi.org/10.1016/j.ejrh.2021.100833

Test drilling

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What is the most important thing for hydro mapping ?

Assess borehole transmissivity & record failed boreholes

GROUNDWATER MAPPING

Key messages

- Maps present complex data
- Be clear about the reason for the map
- Regional/continental –high level planning / advocacy,
- District - project implementation: screen for investigation costs
- Geological mapping + transmissivity
- Limited role for EO and AI
- Good news… maps can make all the difference

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