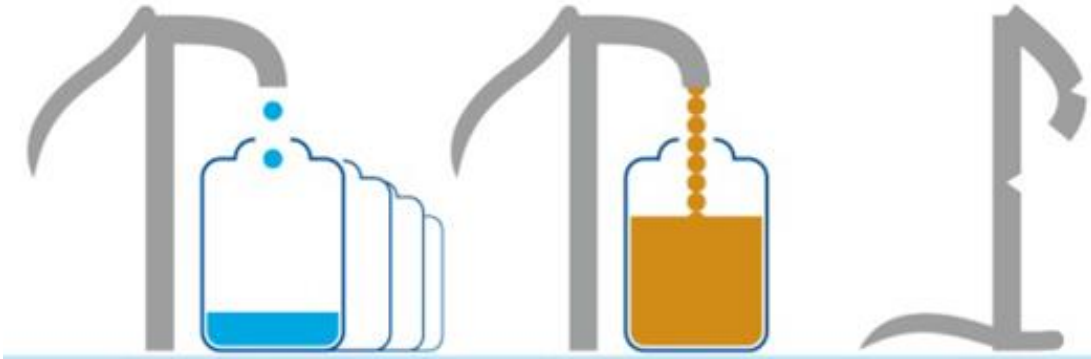
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Gateway to the Earth

Hidden Crisis

Understanding functionality of hand pumped borehole water supply in sub-Saharan Africa



Donald John MacAllister

The University Of Sheffield. · University of Malawi · Addis Ababa University · Flinders University · WaterAid · ODI · University of Cambridge

UPGro Unlocking the Potential of Groundwater for the Poor

Funded by: NERC Science of the Environment · E·S·R·C Economic & Social Research Council · UKaid from the British people

Unlocking the Potential of Groundwater for the Poor

BRAVE
Building understanding of climate variability into planning of groundwater supplies from low storage aquifers in Africa

Gro For GooD
Groundwater Risk Management for Growth and Development

GroFutures
Groundwater Futures in Sub-Saharan Africa

Hidden Crisis
Unravelling current failures for future success in rural groundwater supply

T-GroUP
Experimenting with practical transition groundwater management strategies for the urban poor in Sub-Saharan Africa

NERC SCIENCE OF THE ENVIRONMENT
E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL
UKaid from the British people

BGS international groundwater

50 groundwater scientists

10 active African projects

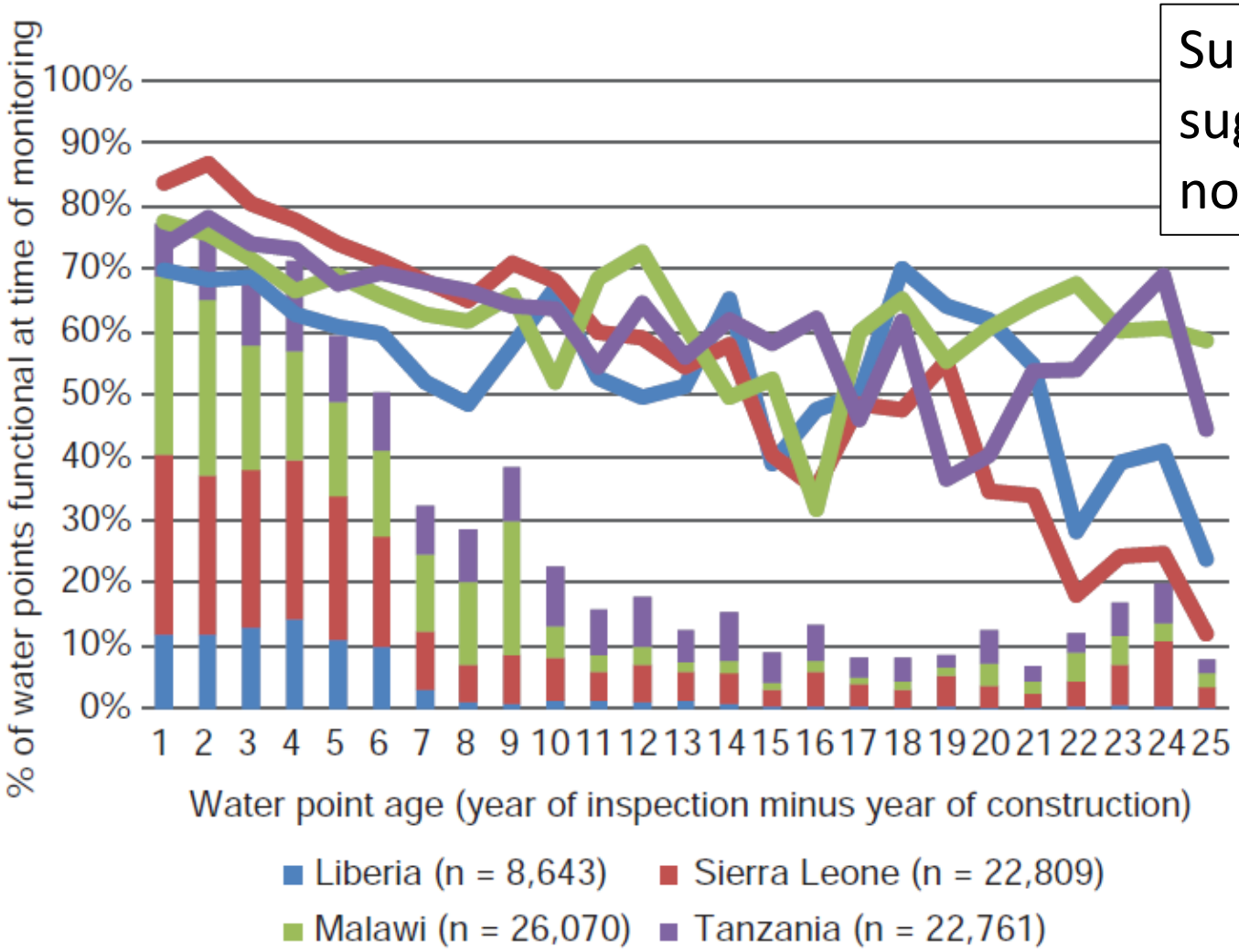
Hidden Crisis

From anecdote to evidence
to understand functionality.

Interdisciplinary. Five objectives:

1. Define functionality of boreholes and water committees
2. Apply to Uganda, Ethiopia and Malawi to explore current status – SURVEY 1
3. Detailed interdisciplinary analysis to answer WHY questions – SURVEY 2
4. Trends and forecasts – longitudinal studies and modelling
5. Interdisciplinary analysis

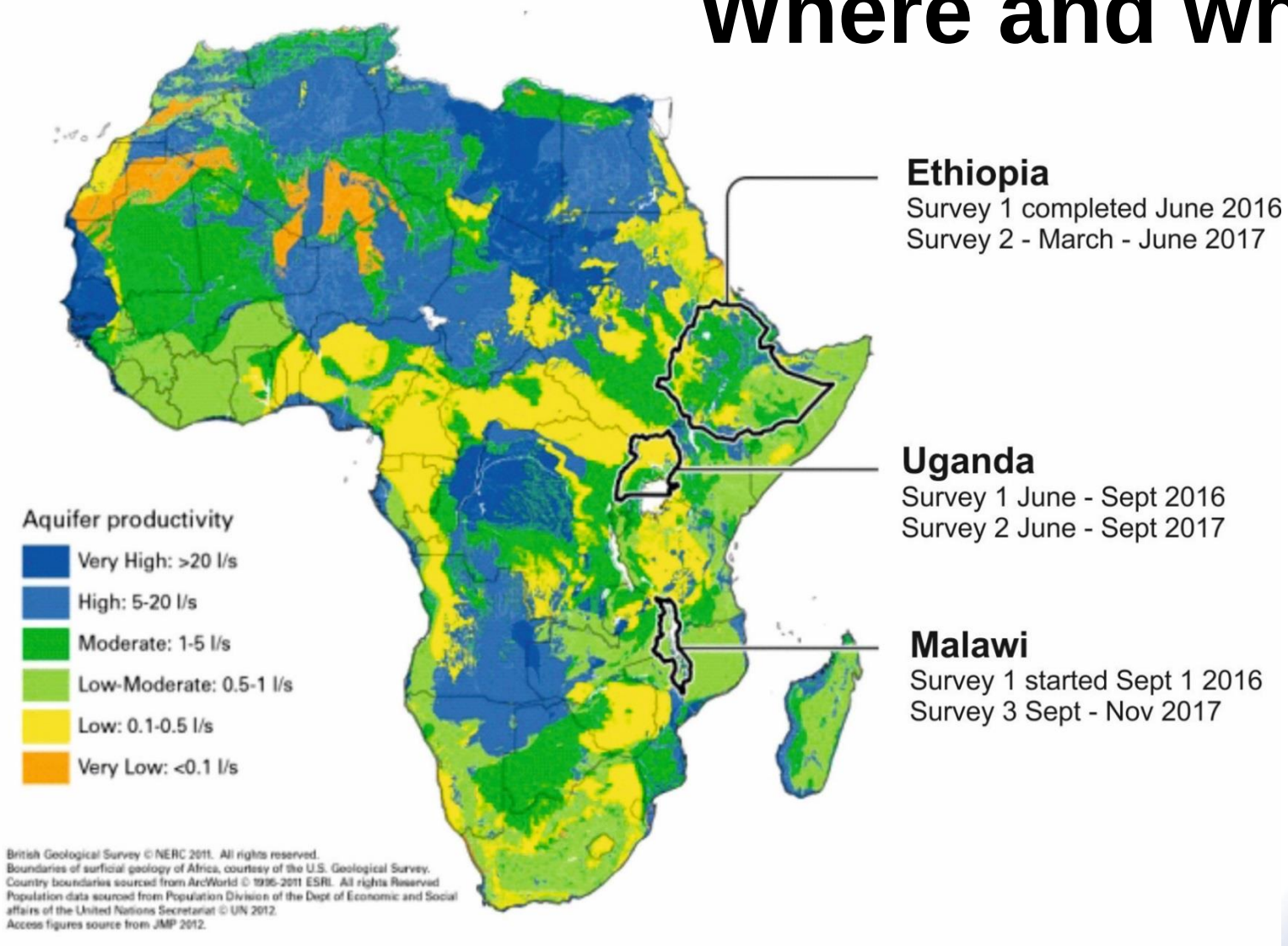
Renewed interest in functionality



Surveys suggest 15-40% non functional

Source: Carter and Ross 2016

Where and when?

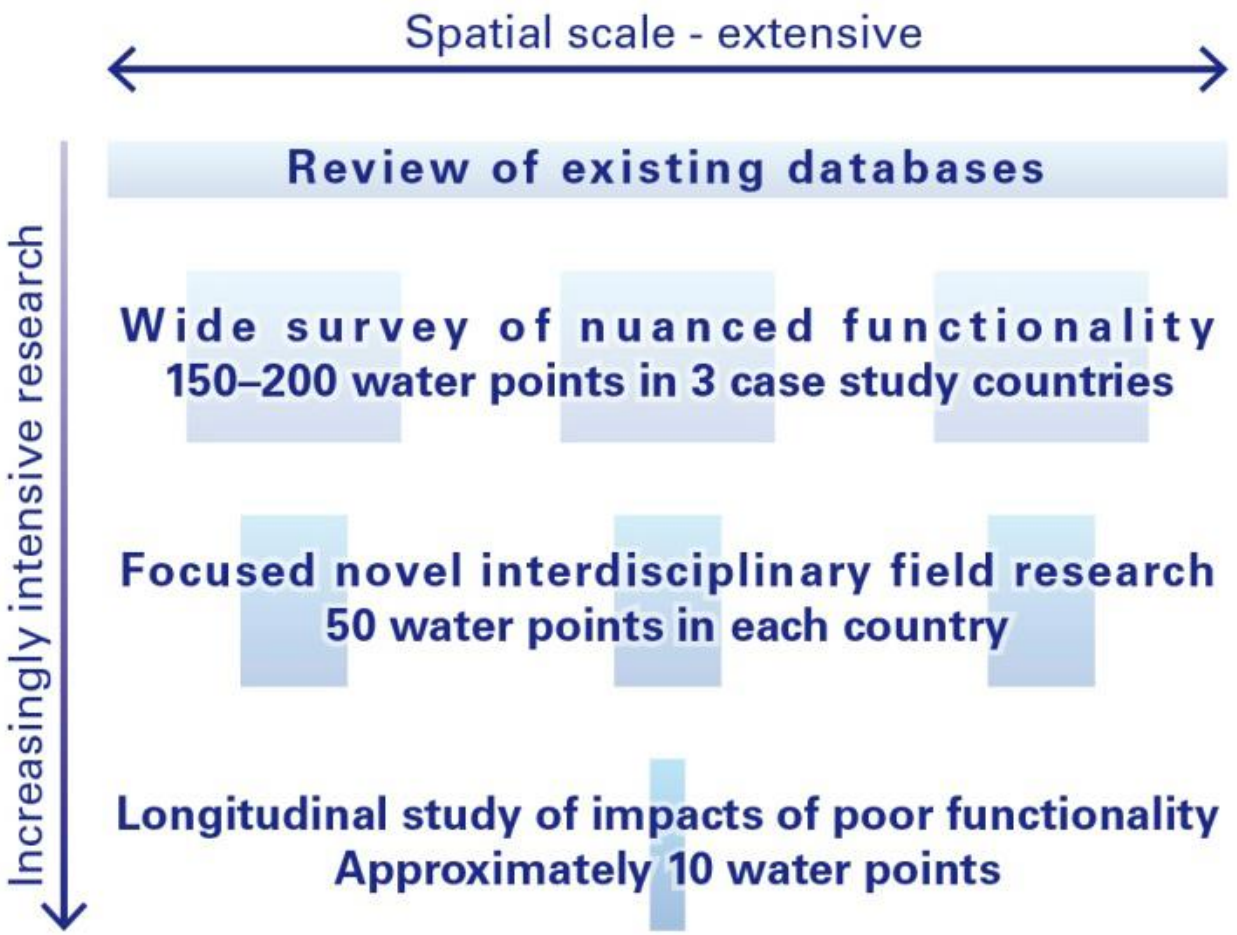


Ethiopia
Survey 1 completed June 2016
Survey 2 - March - June 2017

Uganda
Survey 1 June - Sept 2016
Survey 2 June - Sept 2017

Malawi
Survey 1 started Sept 1 2016
Survey 3 Sept - Nov 2017

Investigating functionality



Year 1 (2015)

Year 1-2 (2016)

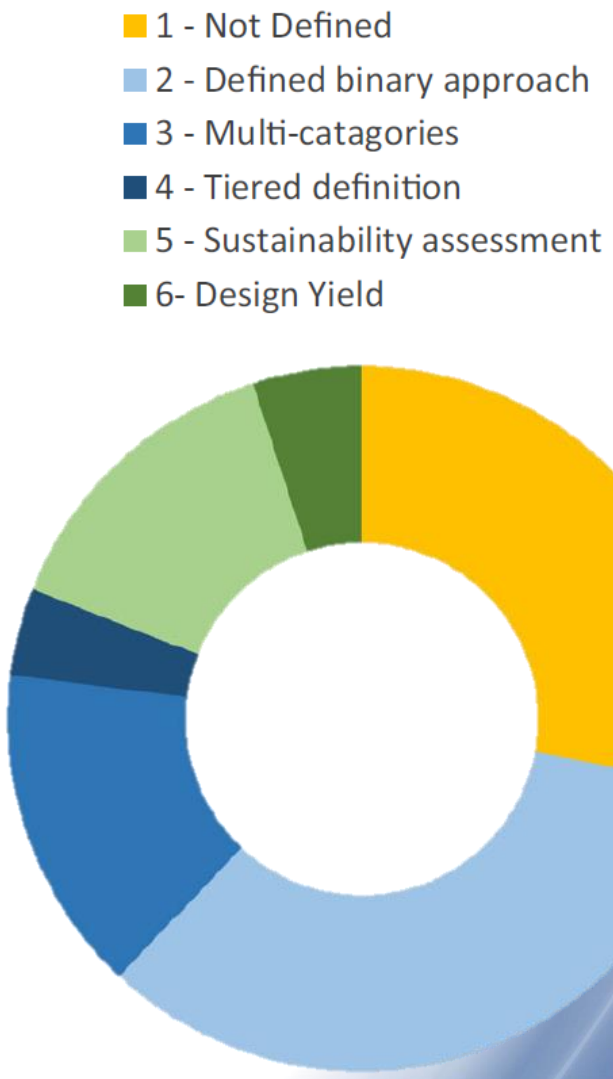
Year 2-3 (2017-18)

Years 2-4

Defining functionality

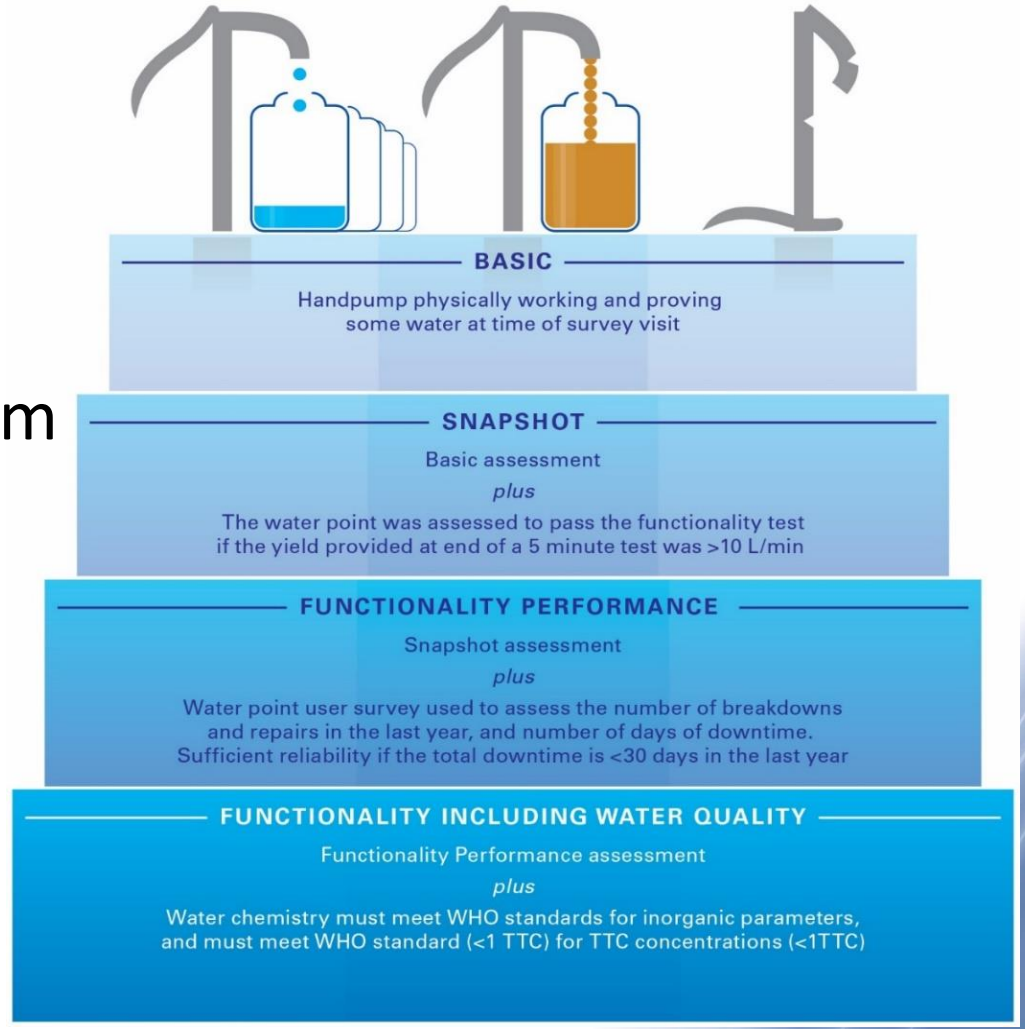
Definitions from the literature

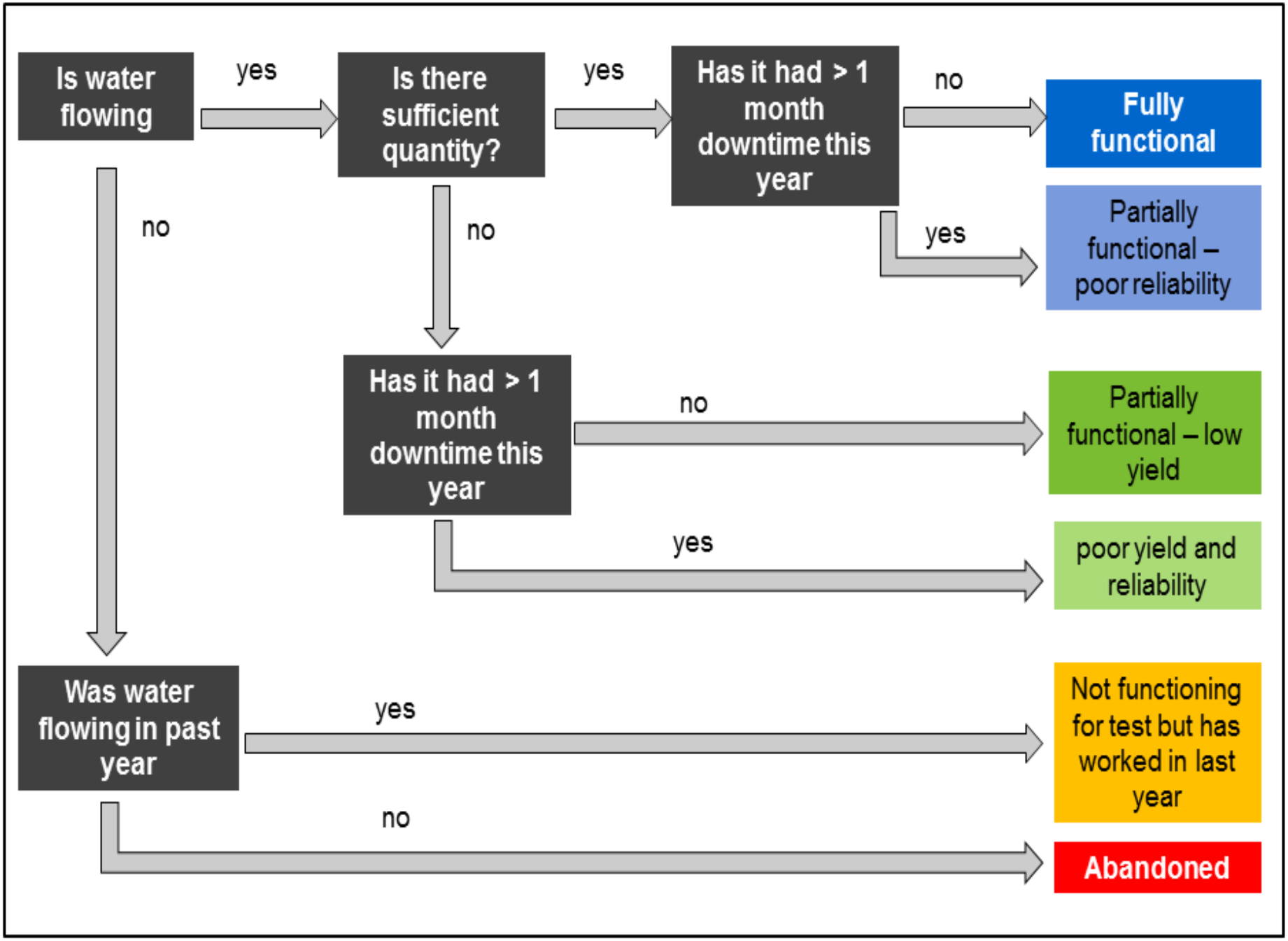
1. No definition
2. Binary: working /not working
3. More complex definitions – e.g. partial working
4. Tiered definitions
5. Broad sustainability assessment
6. Assessed against standard



Defining functionality

- Measure against an explicit standard and population
- Measure separately from the users' experience
- Allow for tiered assessments
- Distinguish between snapshot and temporal





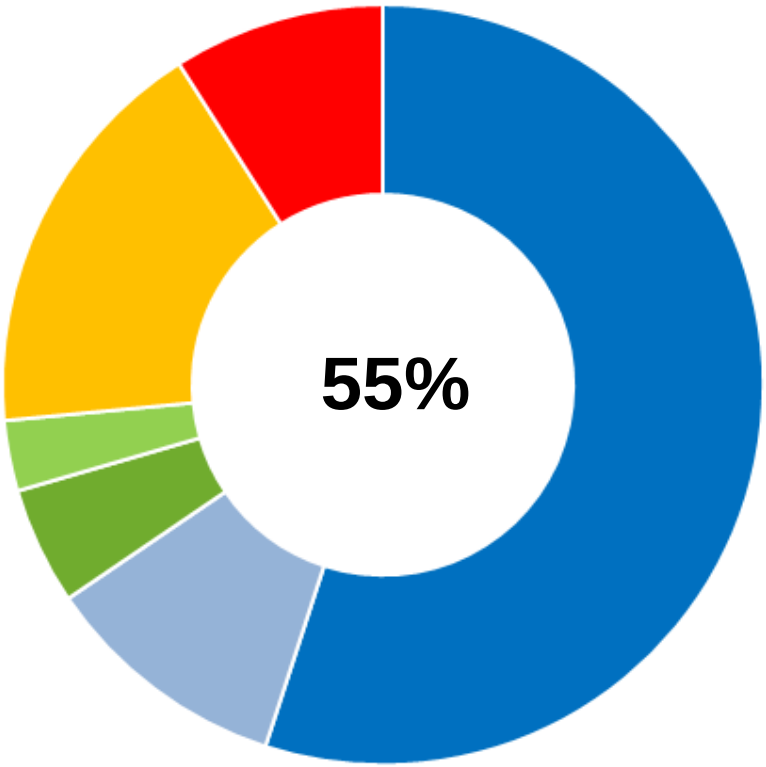
Survey 1 – 600 HPB

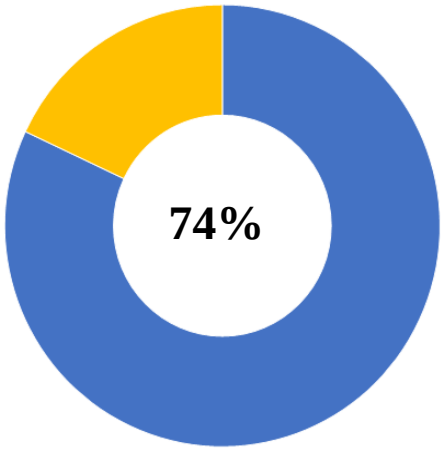
- Two stage randomised stratified sampling.

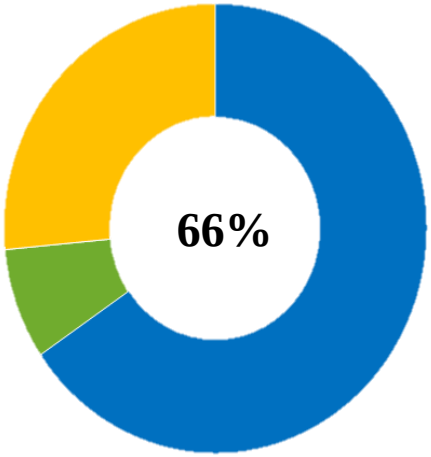
- Physical survey: stroke test, well head observations, water chemistry, TTCs + tryptophan, downtime.

- Social survey: 20 questions - assessing functionality of the water committee, general governance of water point, user perceptions of service level.

Malawi results







Fully functional

Partially functional – poor reliability

Partially functional – low yield

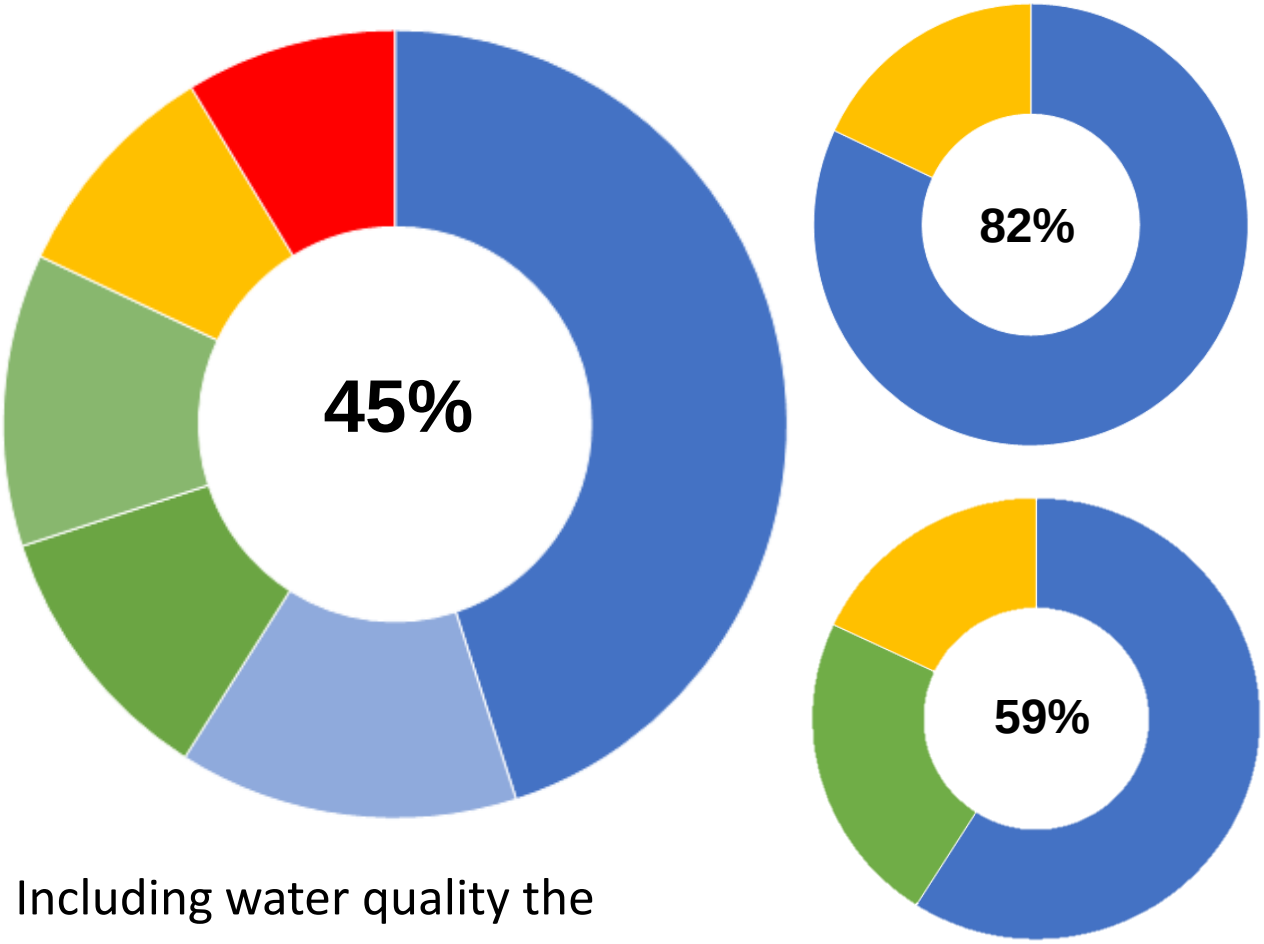
poor yield and reliability

Not functioning for test but has worked in last year

Abandoned

Including water quality the percentage reduces to 43%

Ethiopia Results



Fully functional

Partially functional – poor reliability

Partially functional – low yield

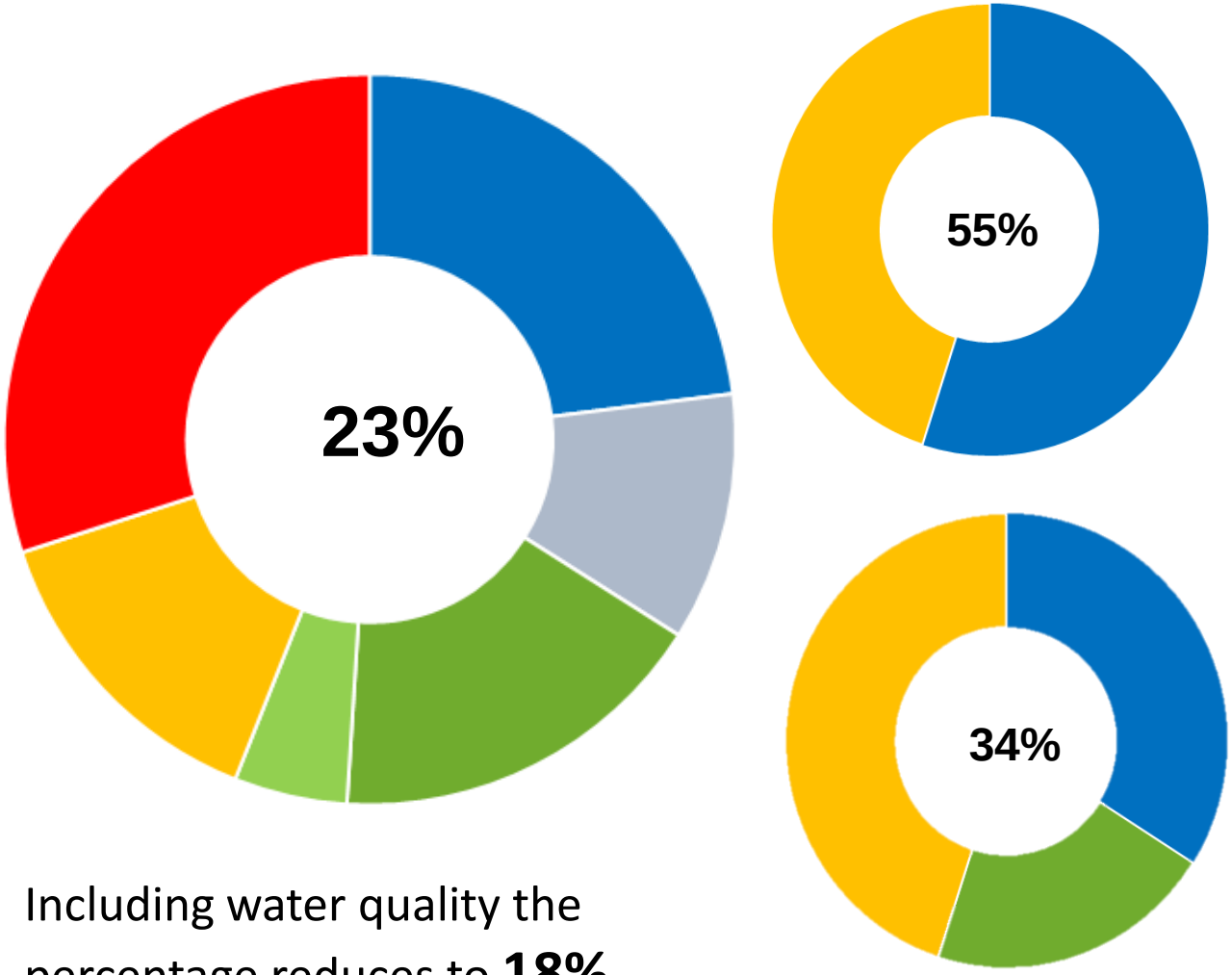
poor yield and reliability

Not functioning for test but has worked in last year

Abandoned

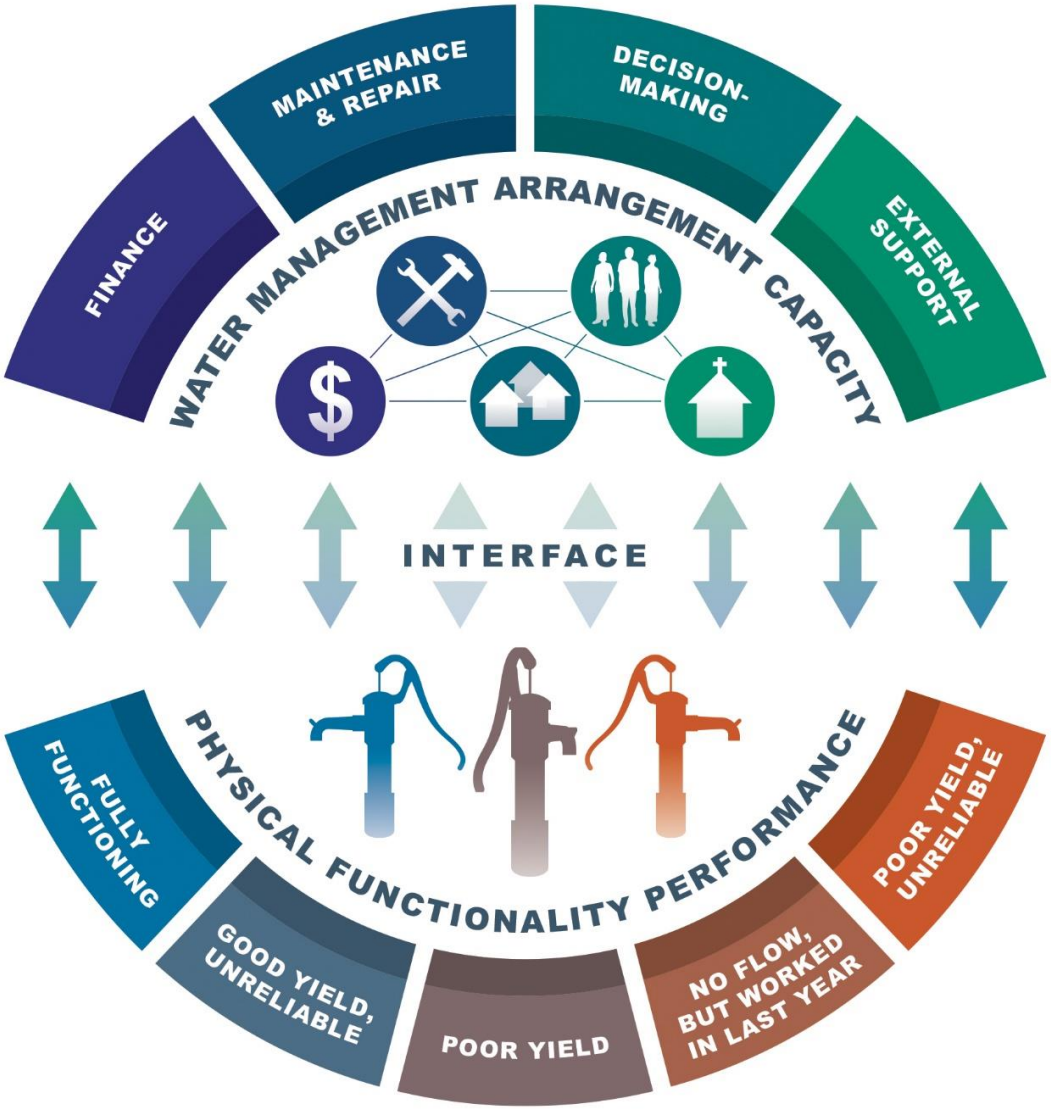
Including water quality the percentage reduces to **28%**

Uganda Results

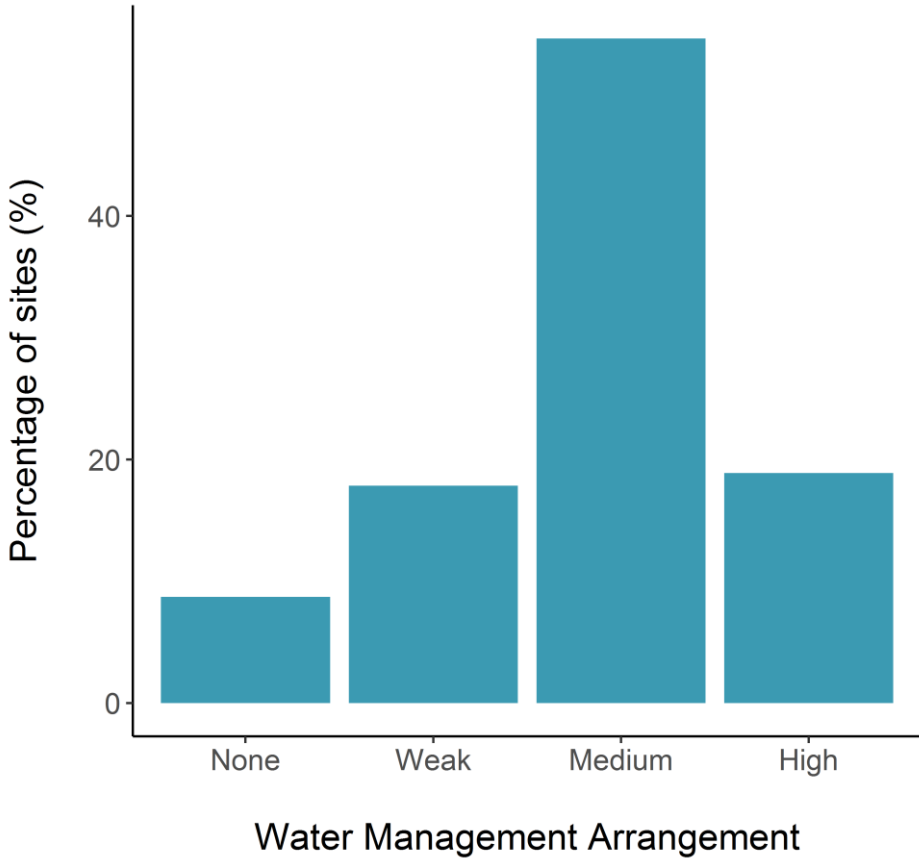


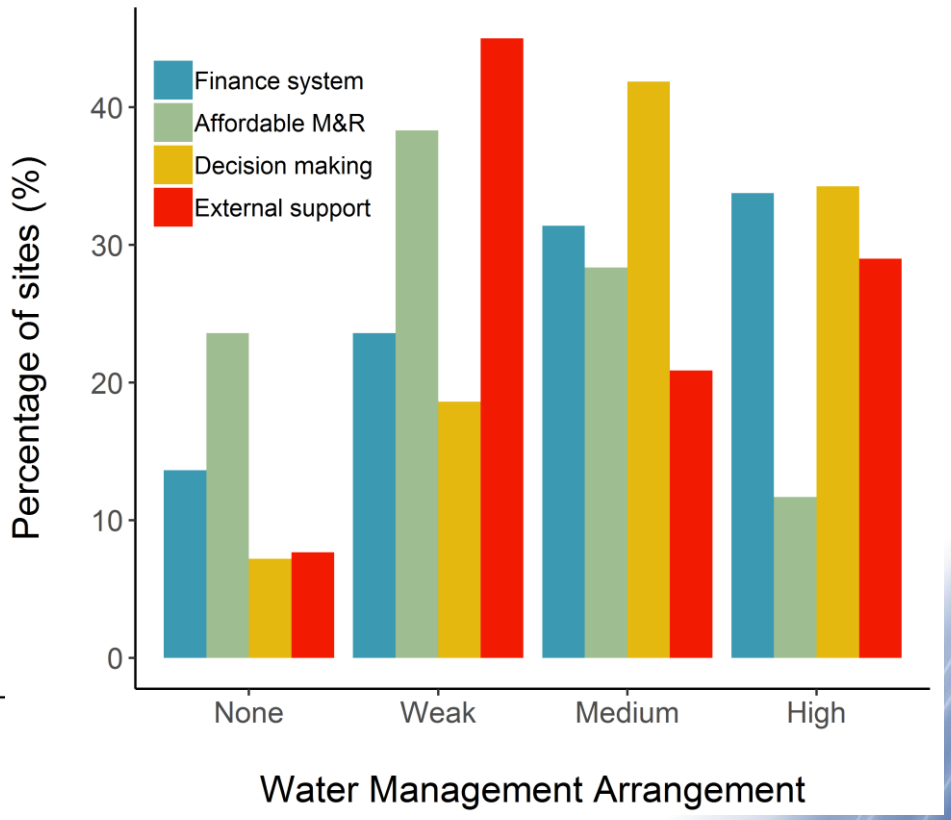
Including water quality the percentage reduces to **18%**

Functionality and management

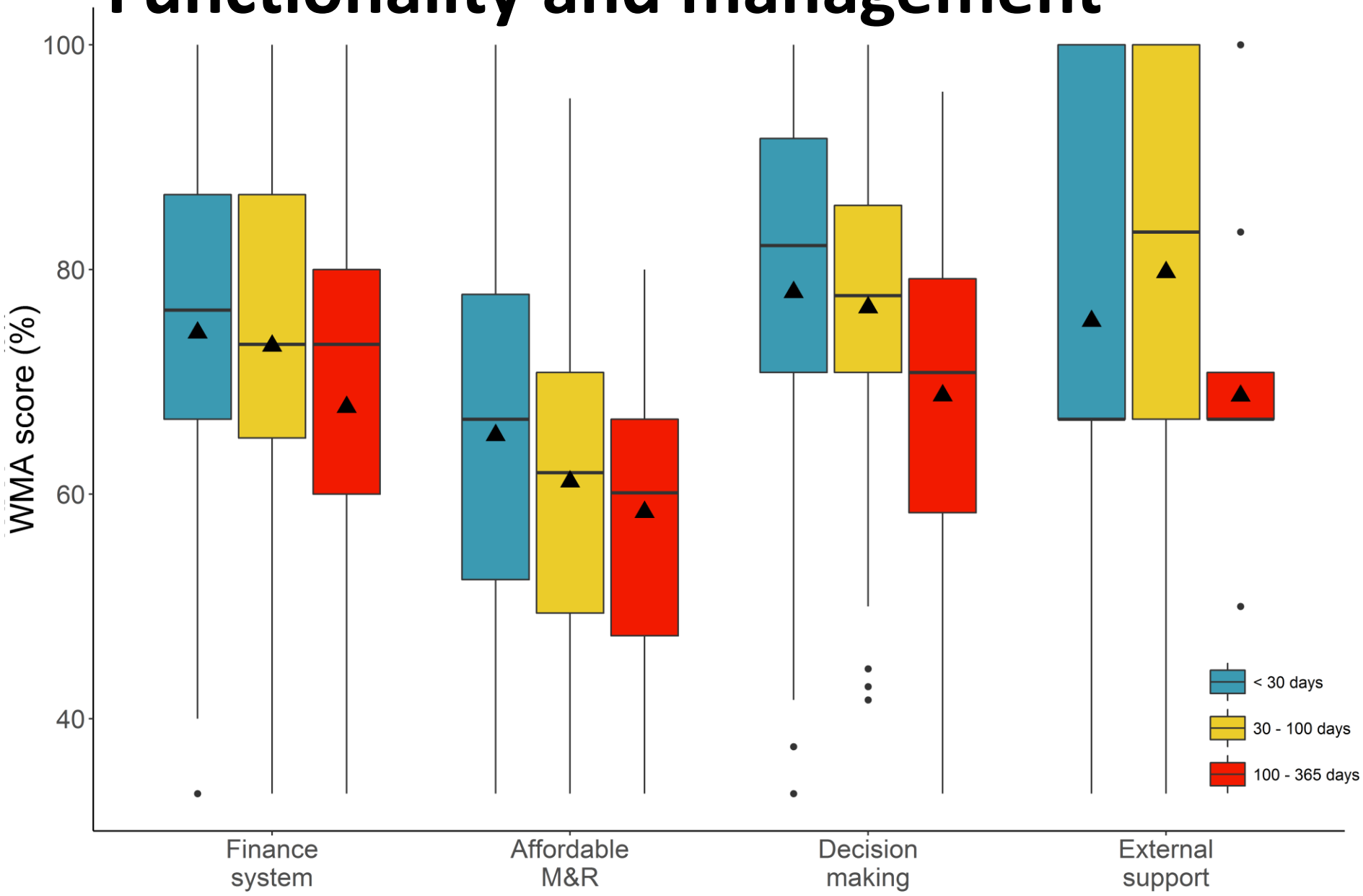


Functionality and management





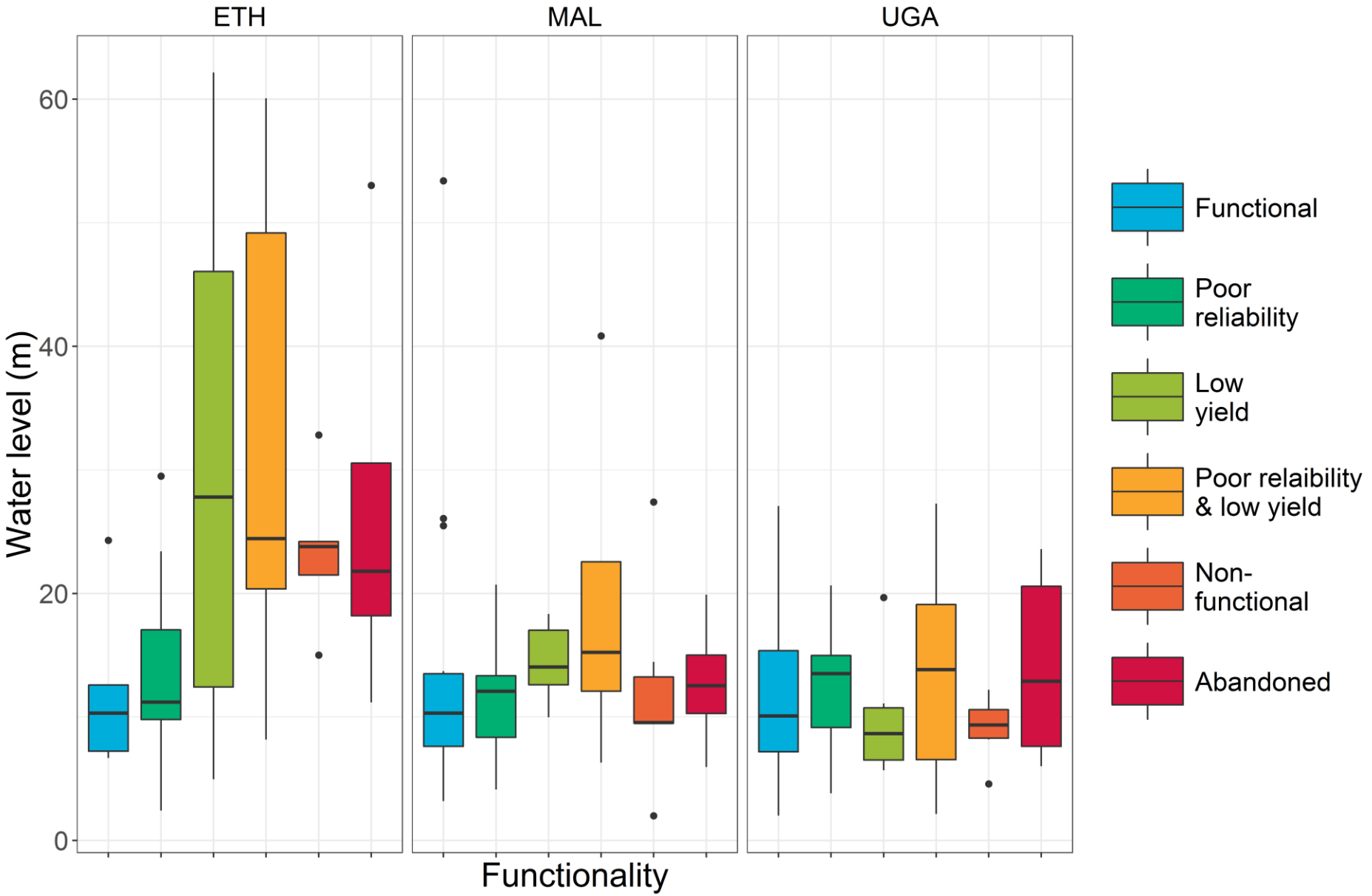
Functionality and management



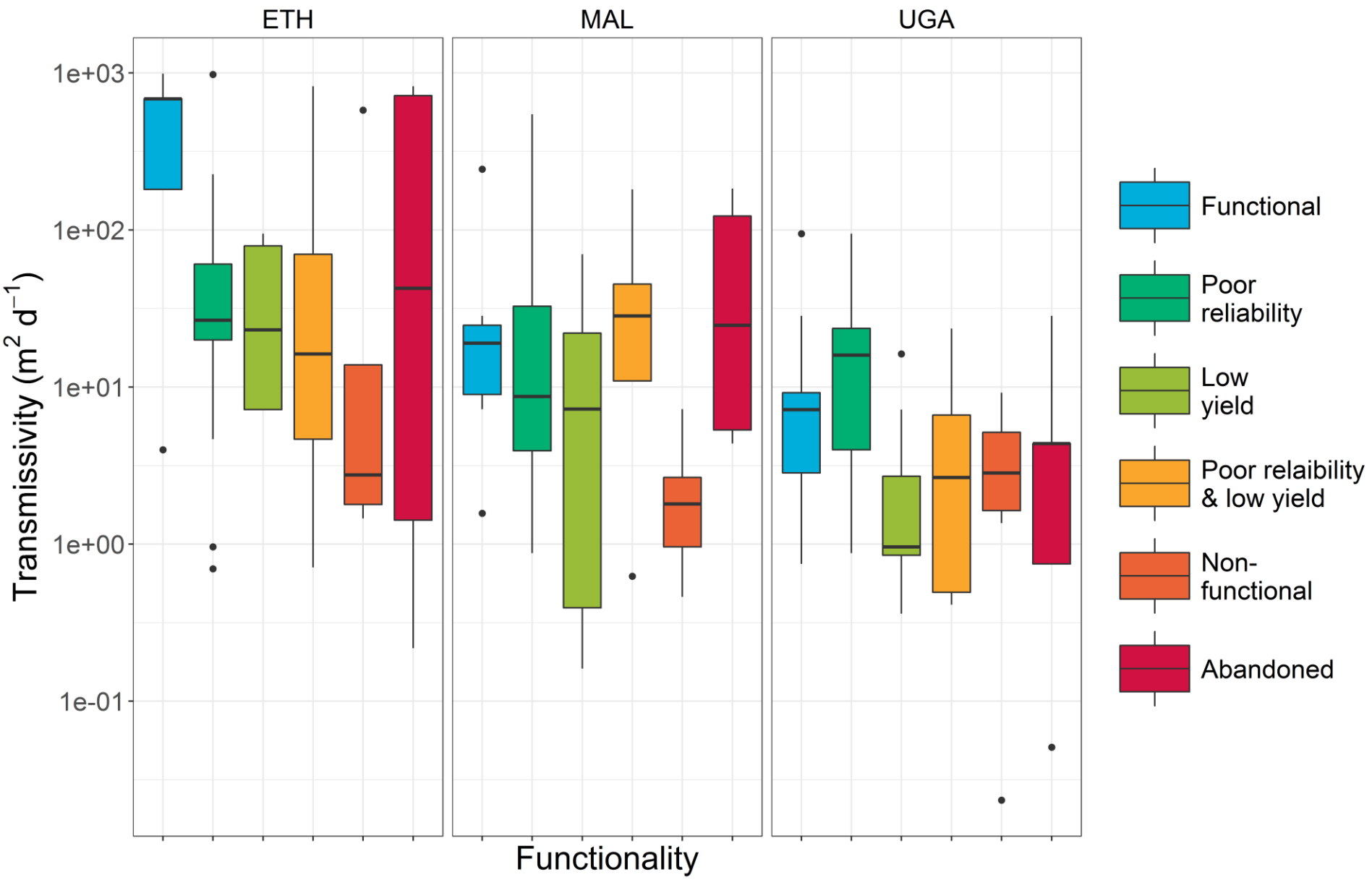
Survey 2 – 150 HPB

- Forensic assessments of Survey 1 sub-sample.
- Social science: focus groups, transect walks.
- Physical survey: sanitary & engineering survey, pumping test, water chemistry, CCTV survey, questionnaires (reliability, downtime, quantity, quality).

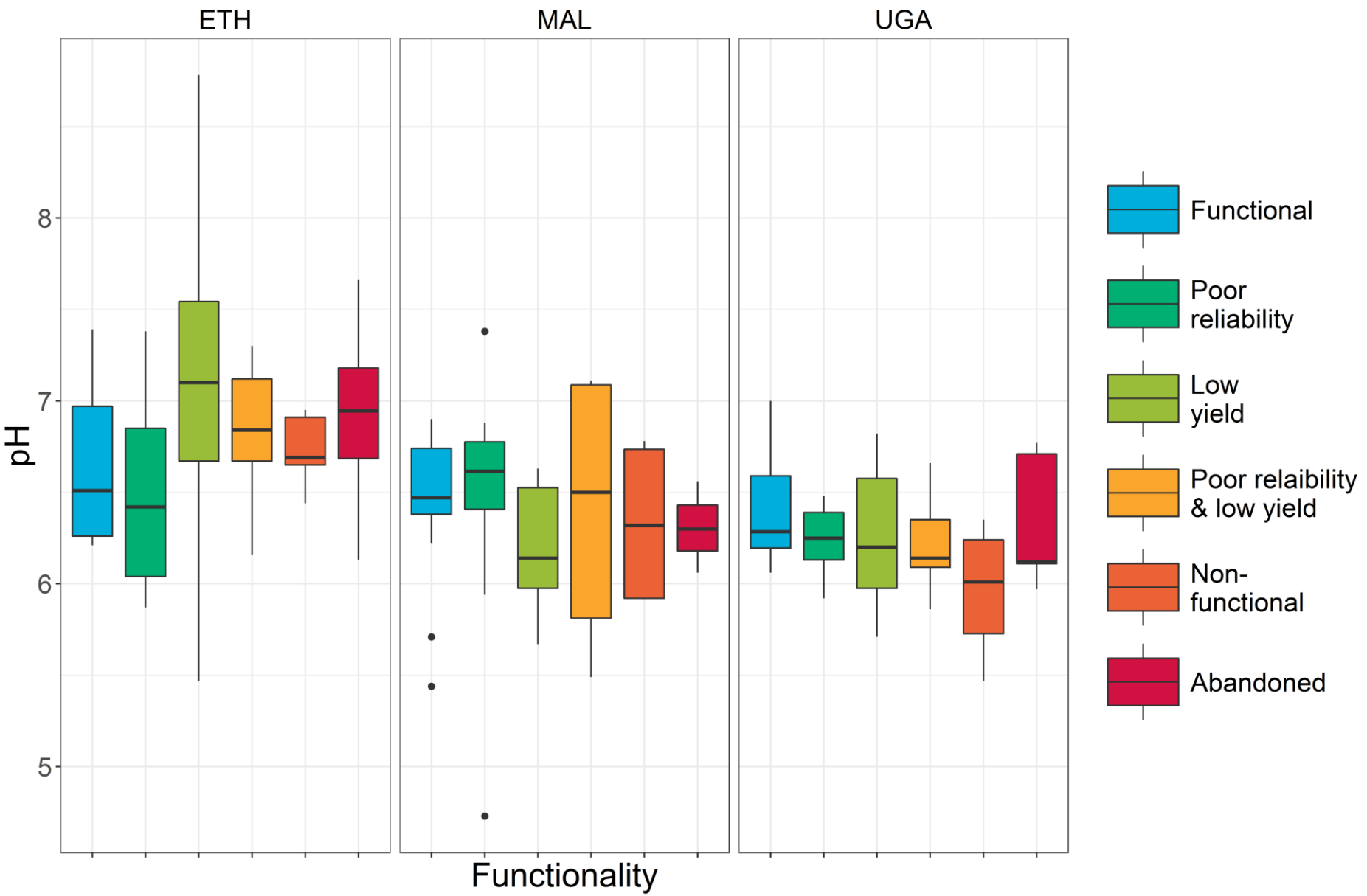
Water Level Depth



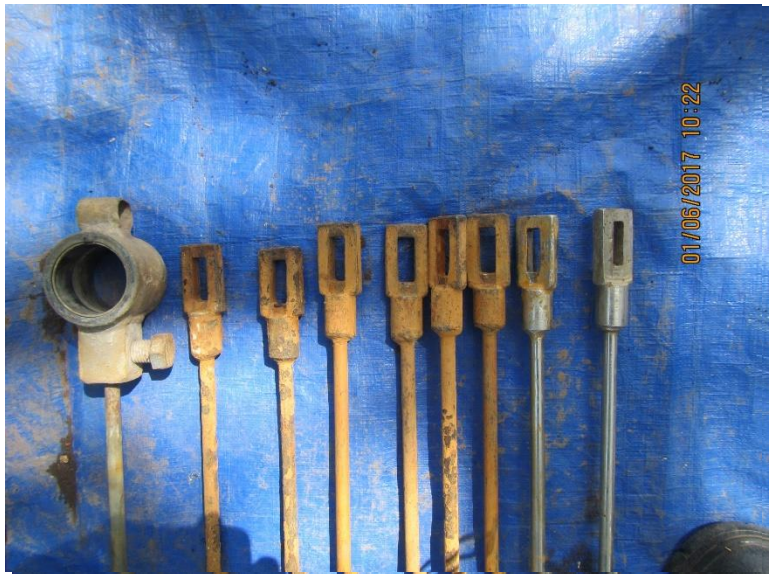
Aquifer yield

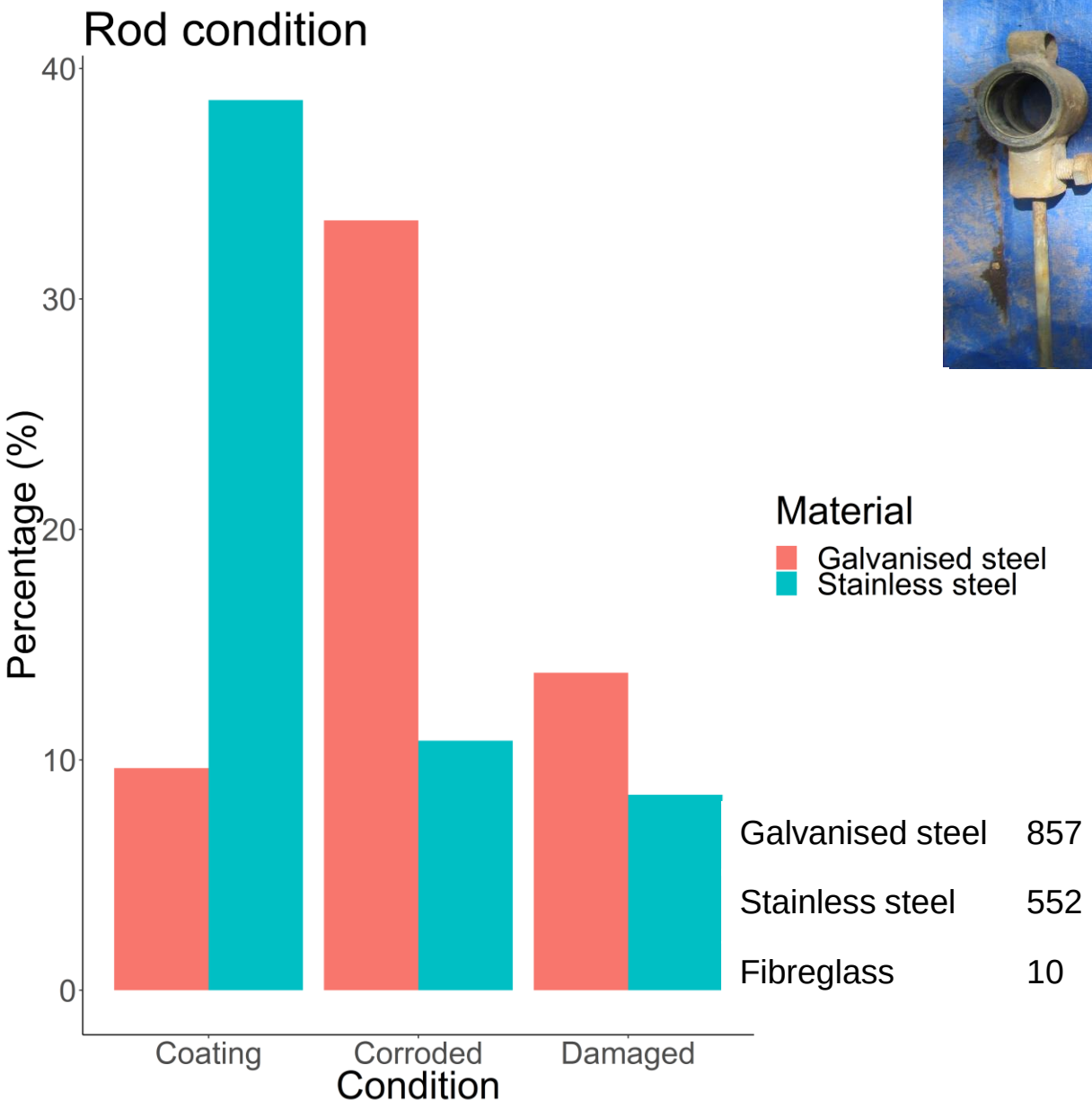


Water chemistry



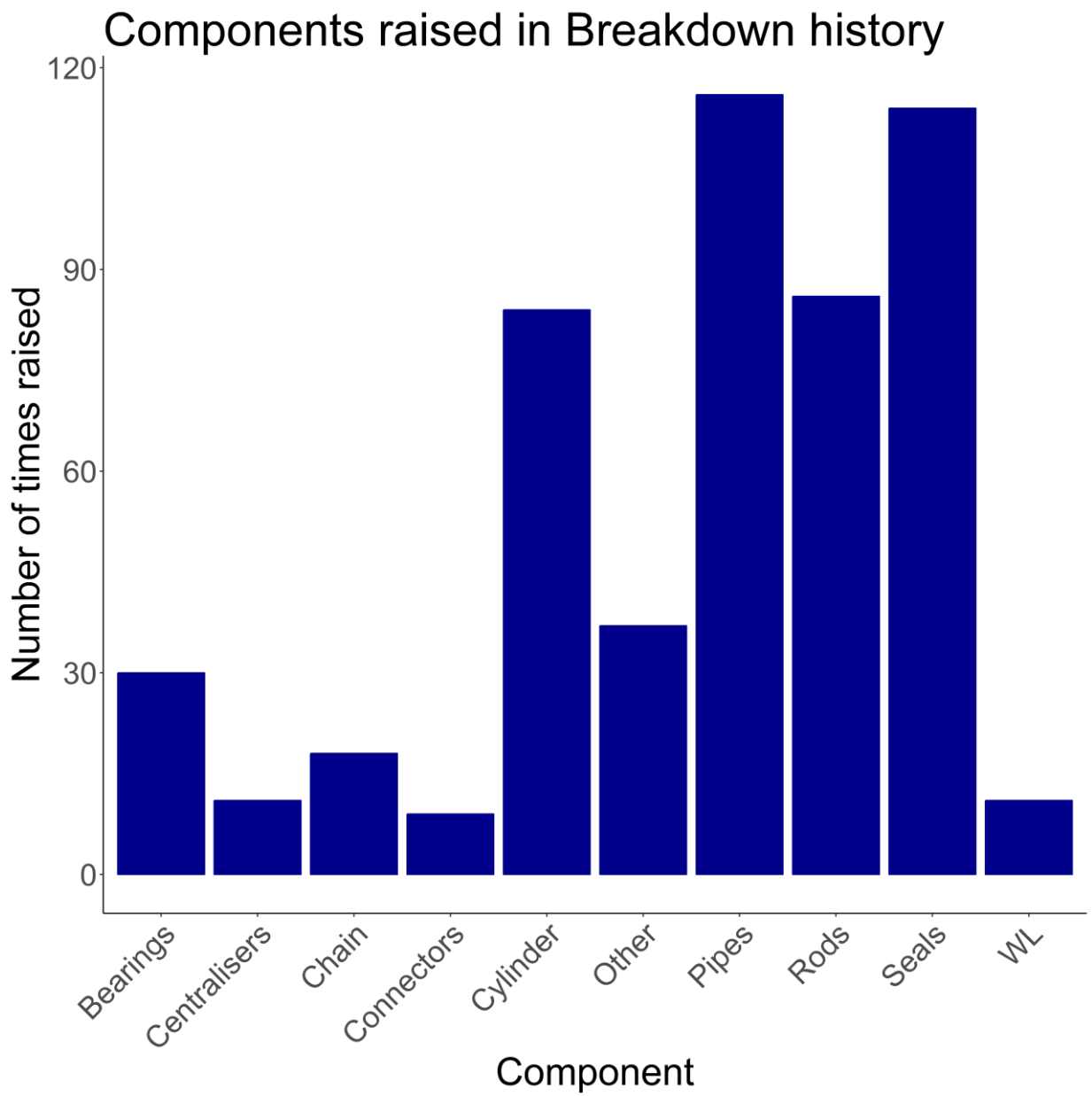
Rising main and Rods



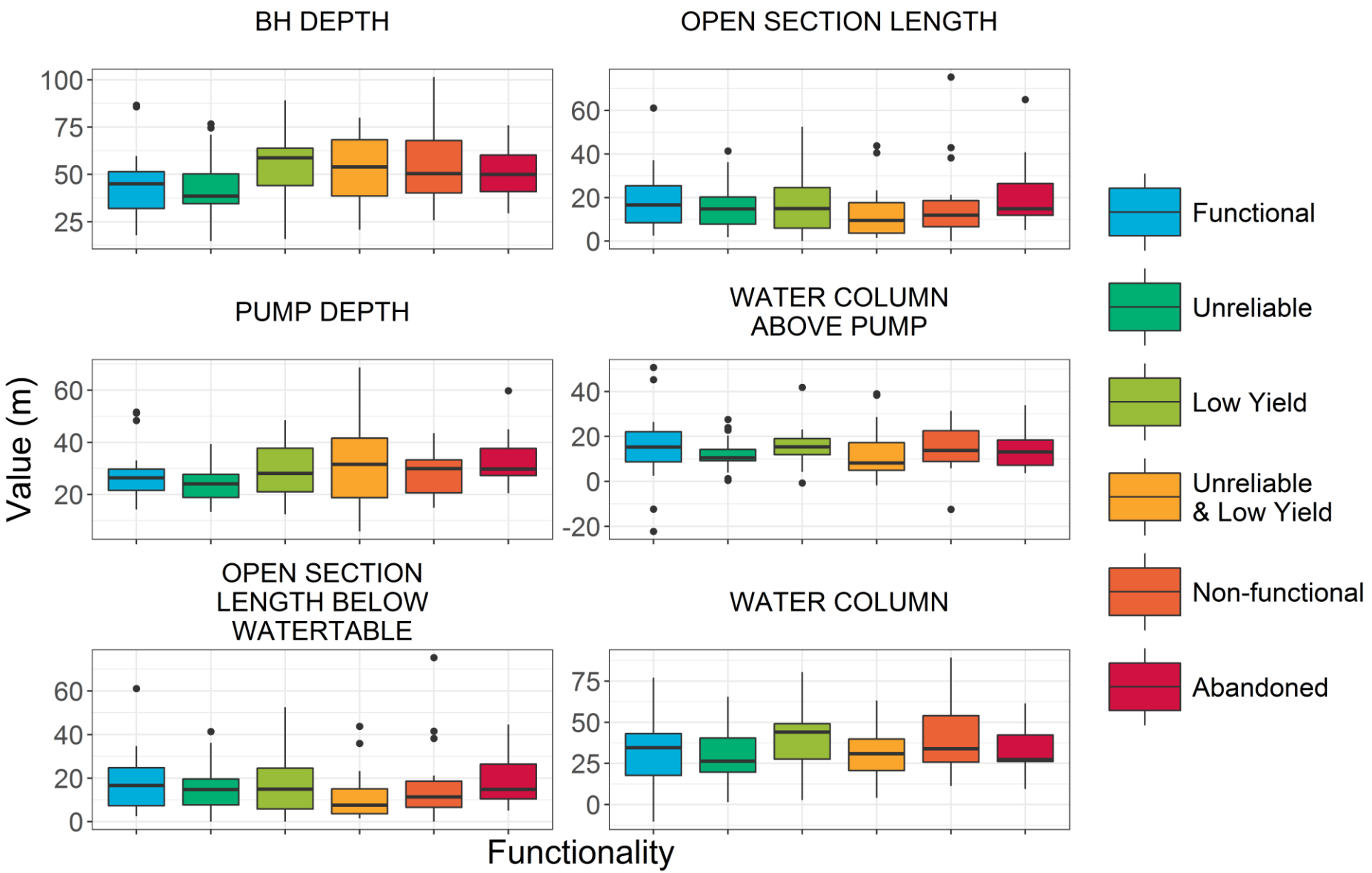


Galvanised steel	857
Stainless steel	552
Fibreglass	10

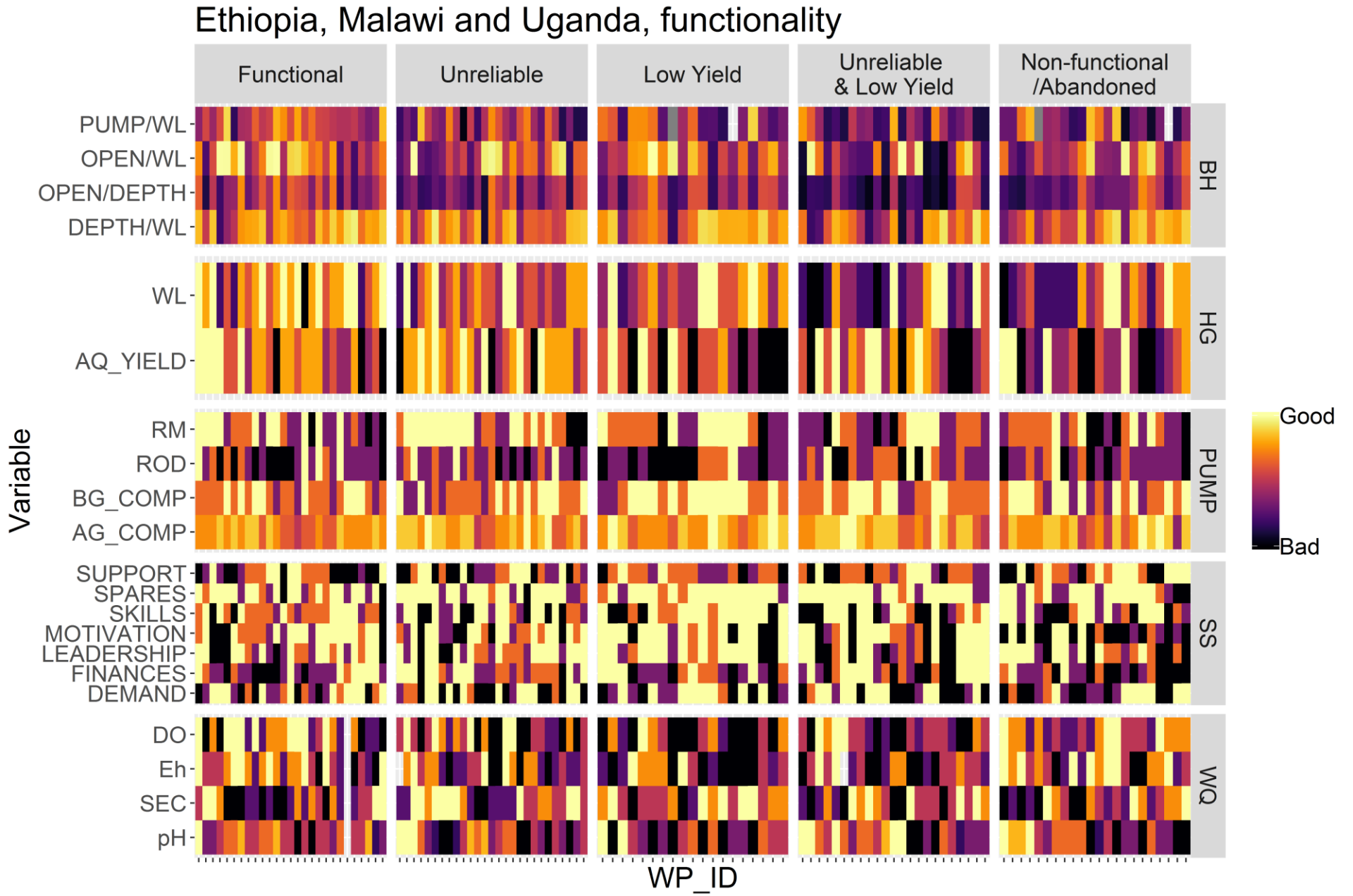
Other pump components



Borehole construction



Integrated analysis



Summary/Conclusions

- Nuanced definition of functionality developed, used as a framework to identify casual factors and explain outcomes.
- Sociotechnical interface is nuanced and complex, thus overly simplistic and reductive approaches are not adequate to fully understand functionality.
- Survey 2 shows:
  - Water level – clear relationship with functionality.
  - Deconstructed hand pump and borehole (Rising main and rods and observations of corrosion) – Rods suffer most corrosion and damage, but any component made of galvanised steel is at risk in any context.
  - Aquifer yield – clear relationship with functionality.
  - Borehole construction – appears to have a bearing on functionality when pump cylinder depth and water level are considered.
- Further analysis required:
  - Seasonality, downtime and re
  - Sanitary condition.
  - Assessment of causal pathwa

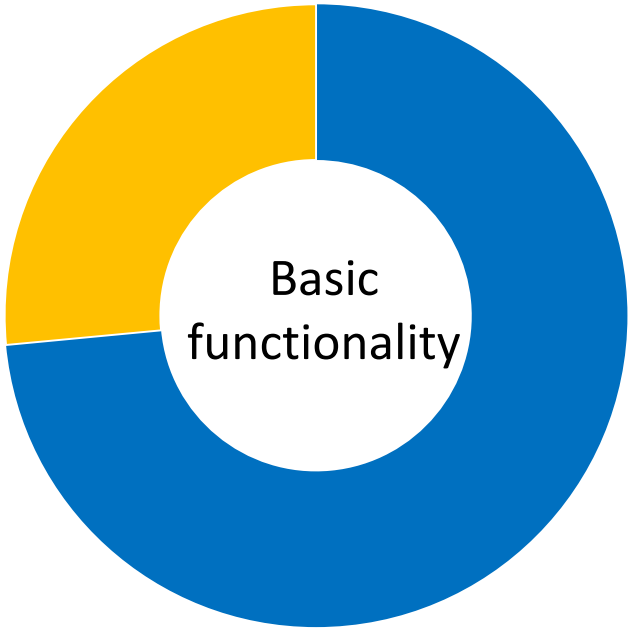
Supporting material

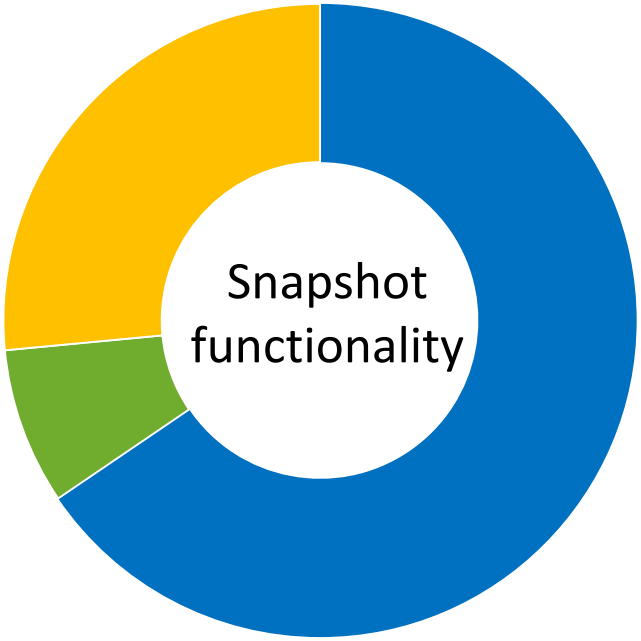
Malawi Results

Fully functional

Partially functional – low yield

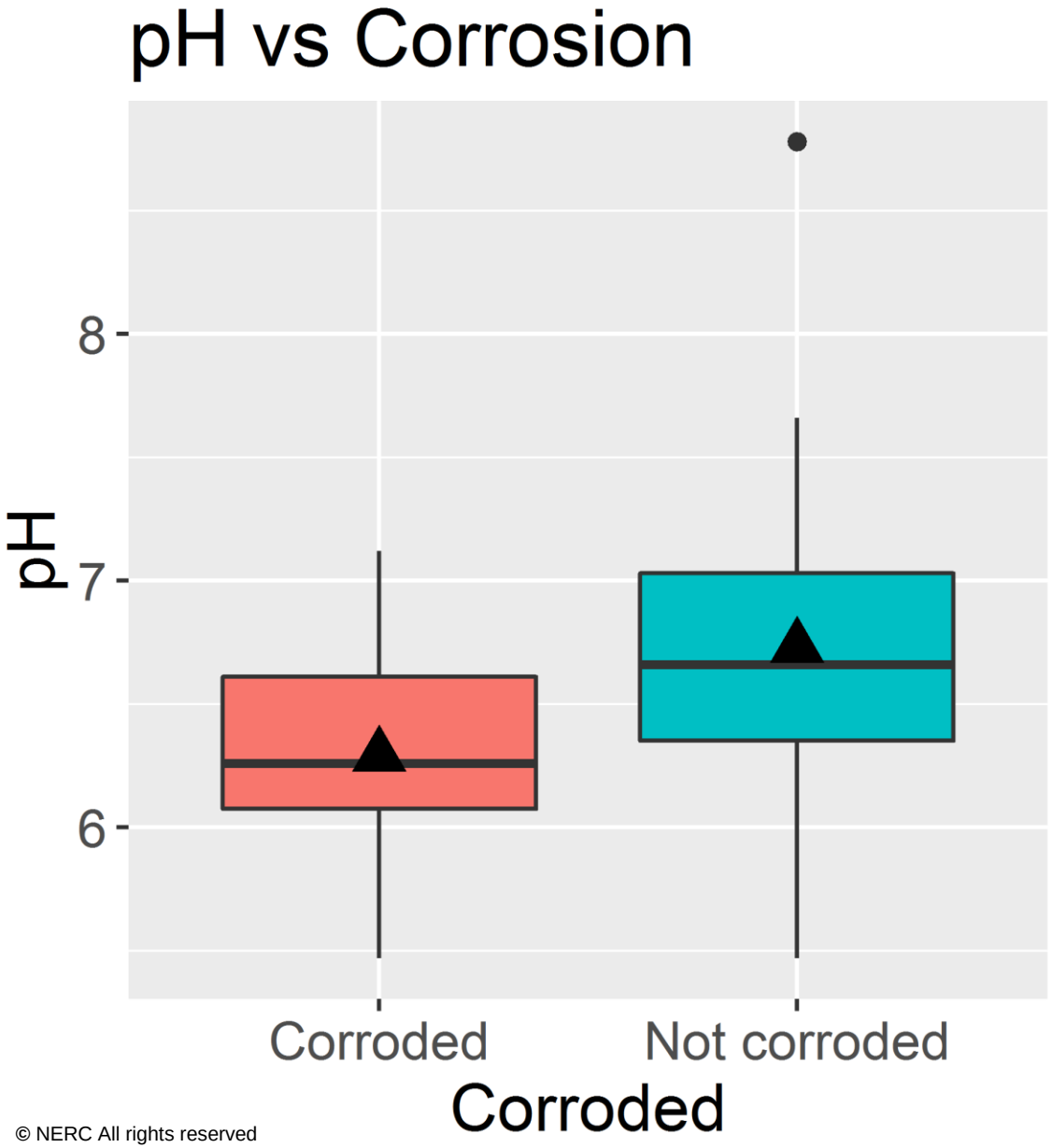
Not functioning for test but has worked in last year





Survey September 2016 – January 2017

Corrosion and water chemistry



GI rising main (RM)

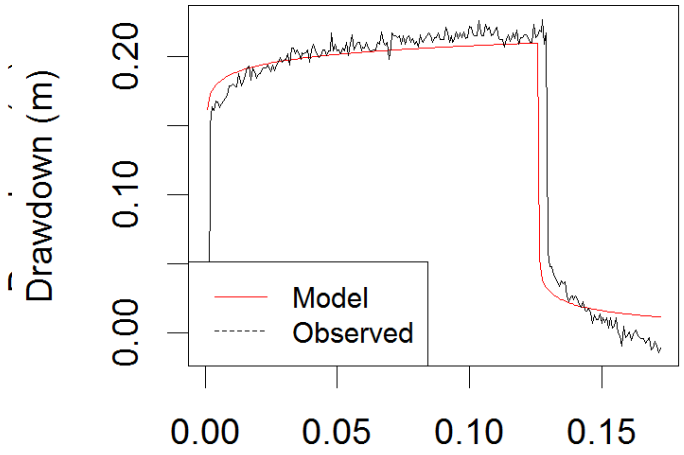
Corroded

Corroded

Not corroded

Low risk > 7
6.5 > Intermediate risk <= 7
6 > High risk <= 6.5
Severe risk <= 6

EEJ10

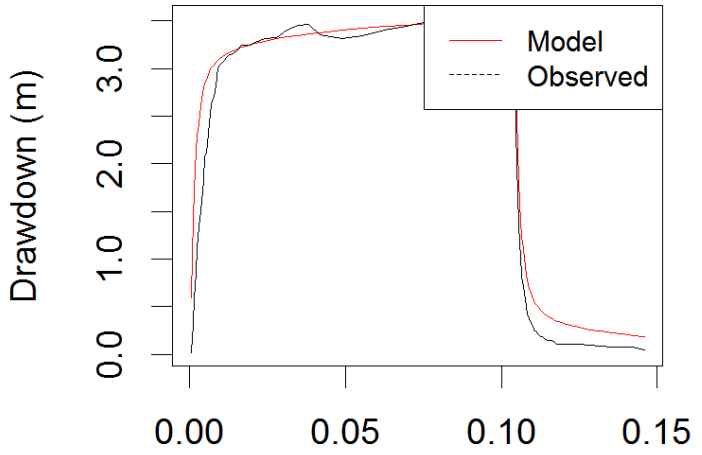


Time (days)

T = 683.7m^2/d

Fully functional

MNK25

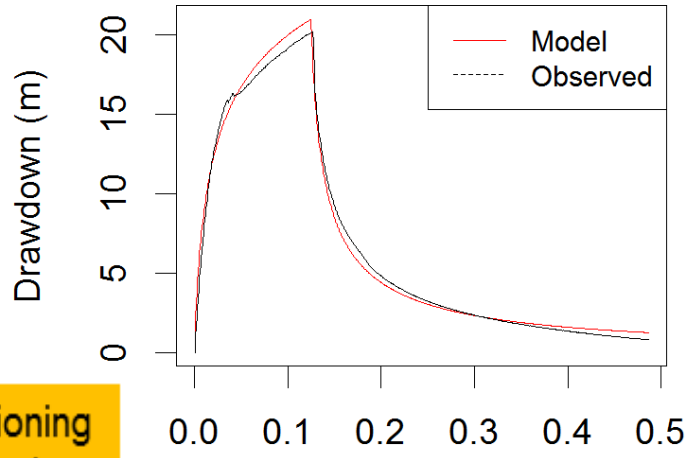


Time (days)

T = 28.42m^2/d

poor yield and reliability

UKU18

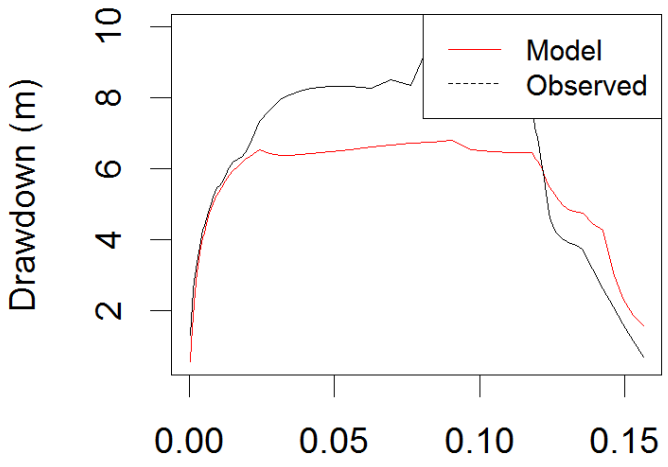


Time (days)

T = 1.3609m^2/d

Not functioning for test but has worked in last year

EAE11

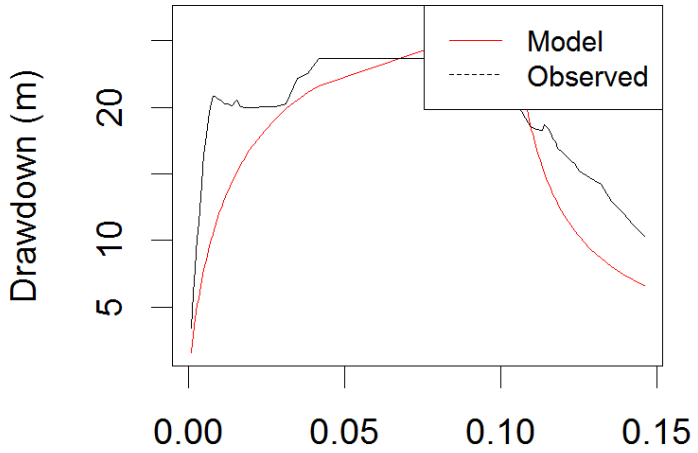


Time (days)

T = 2.6586m^2/d

Abandoned

MMA12

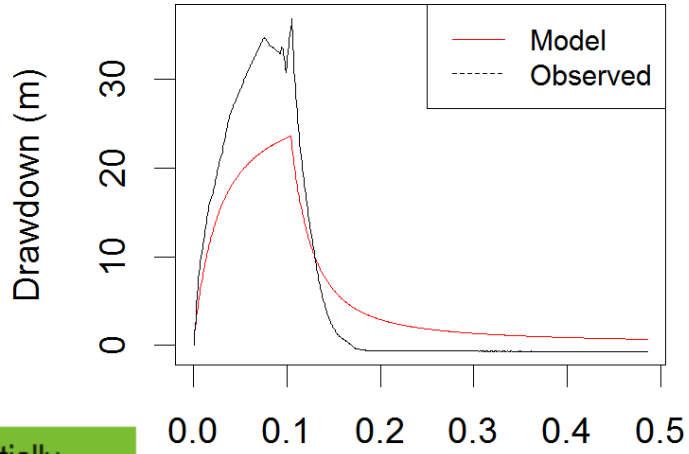


Time (days)

T = 0.62368m^2/d

poor yield and reliability

UBU17

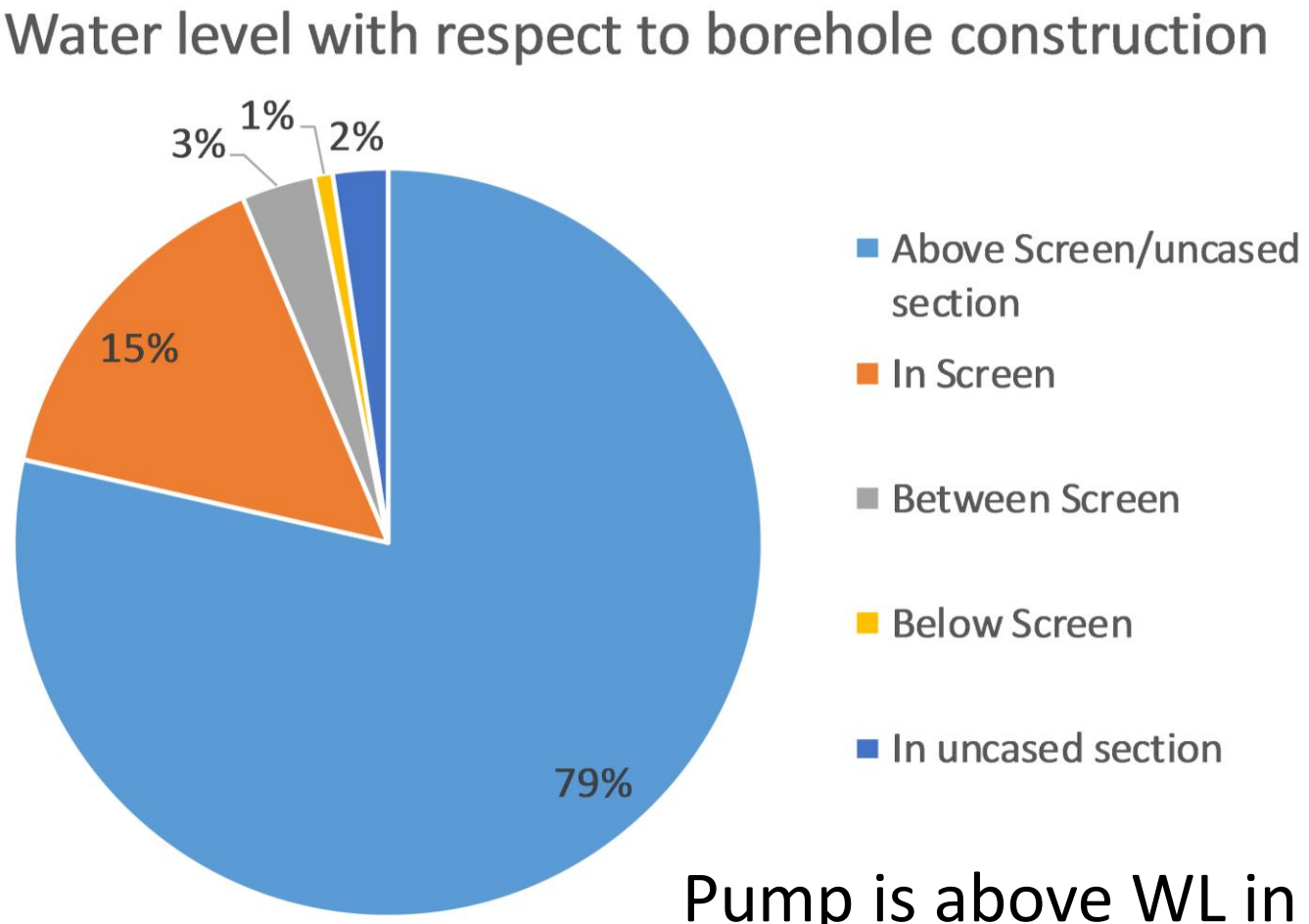


Time (days)

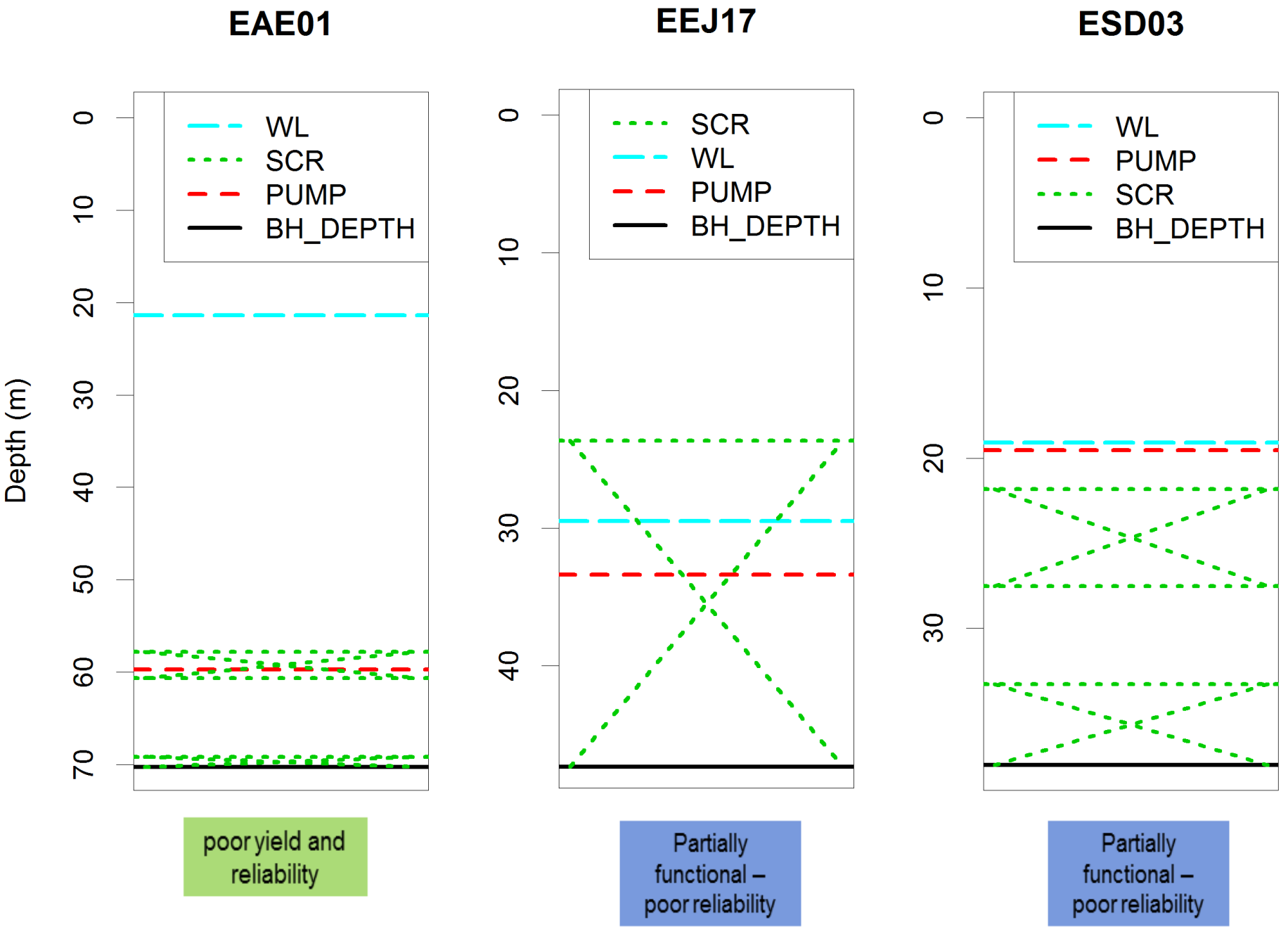
T = 0.74887m^2/d

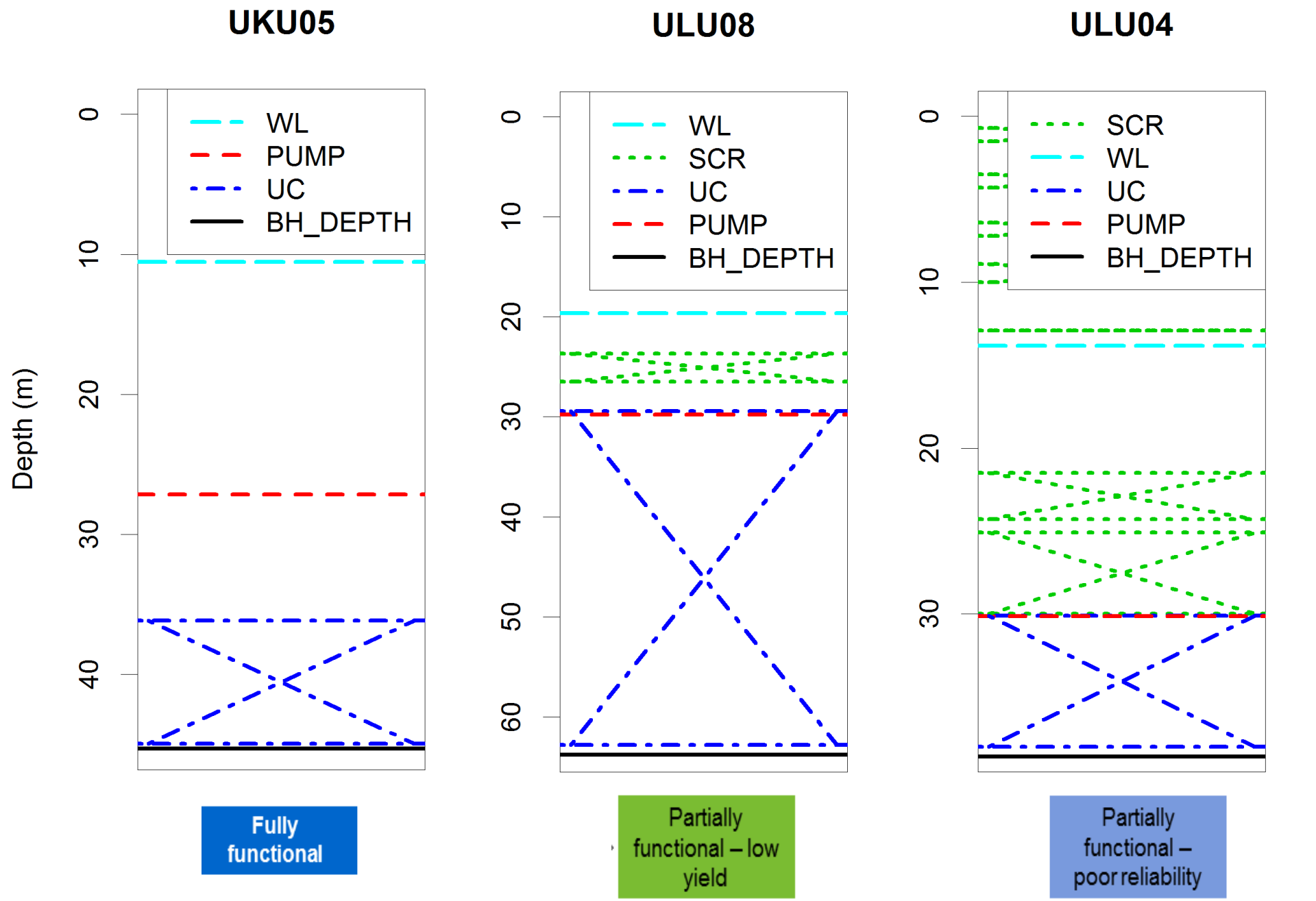
Partially functional – low yield

Borehole construction



Pump is above WL in 4% of boreholes.


EAE01
EEJ17
ESD03
Depth (m)
0
10
20
30
40
50
60
70
WL
SCR
PUMP
BH_DEPTH
poor yield and reliability
Partially functional – poor reliability
Partially functional – poor reliability


UKU05
ULU08
ULU04
Depth (m)
0
10
20
30
40
50
60
WL
PUMP
UC
BH_DEPTH
SCR
Fully functional
Partially functional – low yield
Partially functional – poor reliability

Other aspects

Major project database developed:

All social and physical data