Determining the Hydraulic Behaviour of a Greenschist Metasediment Aquifer, Malaysia

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1) Background

The use of urban aquifers is becoming increasingly more important with growth of population and development. Urban dwellers now outnumber rural populations globally, and urbanisation and industrial growth are particularly rapid in Asia. An example of a new urban area impacting groundwater is Shah Alam, Malaysia.

The aquifer underlying Shah Alam is composed of greenschist facies metasediments with a weathered zone up to 80 m thick. Initial examination of abstraction licence–file data by Roslan (2017) suggested the aquifer to have a fracture flow system, with leakage from the weathered zone or recharge barriers being identified in over 60% of pumping tests available.

Figure 1. Map showing location of study area (Google Earth 2017).

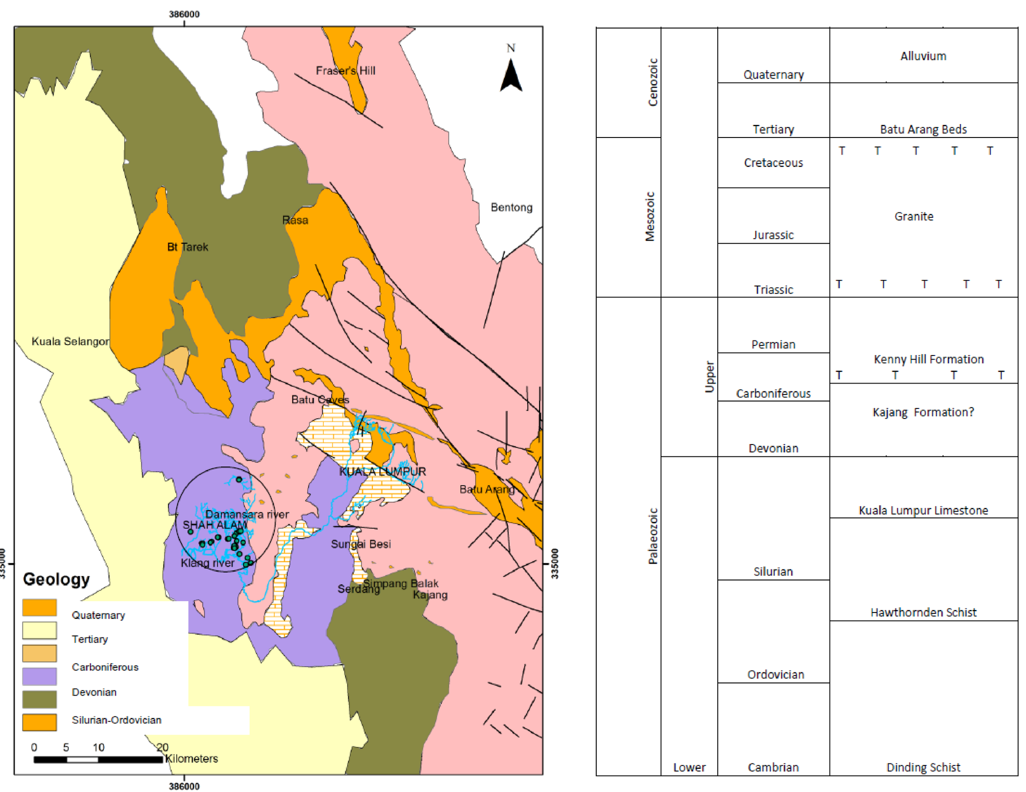


Figure 2. Geological map and stratigraphic column of study area. T represents unconformity (Roslan 2017).

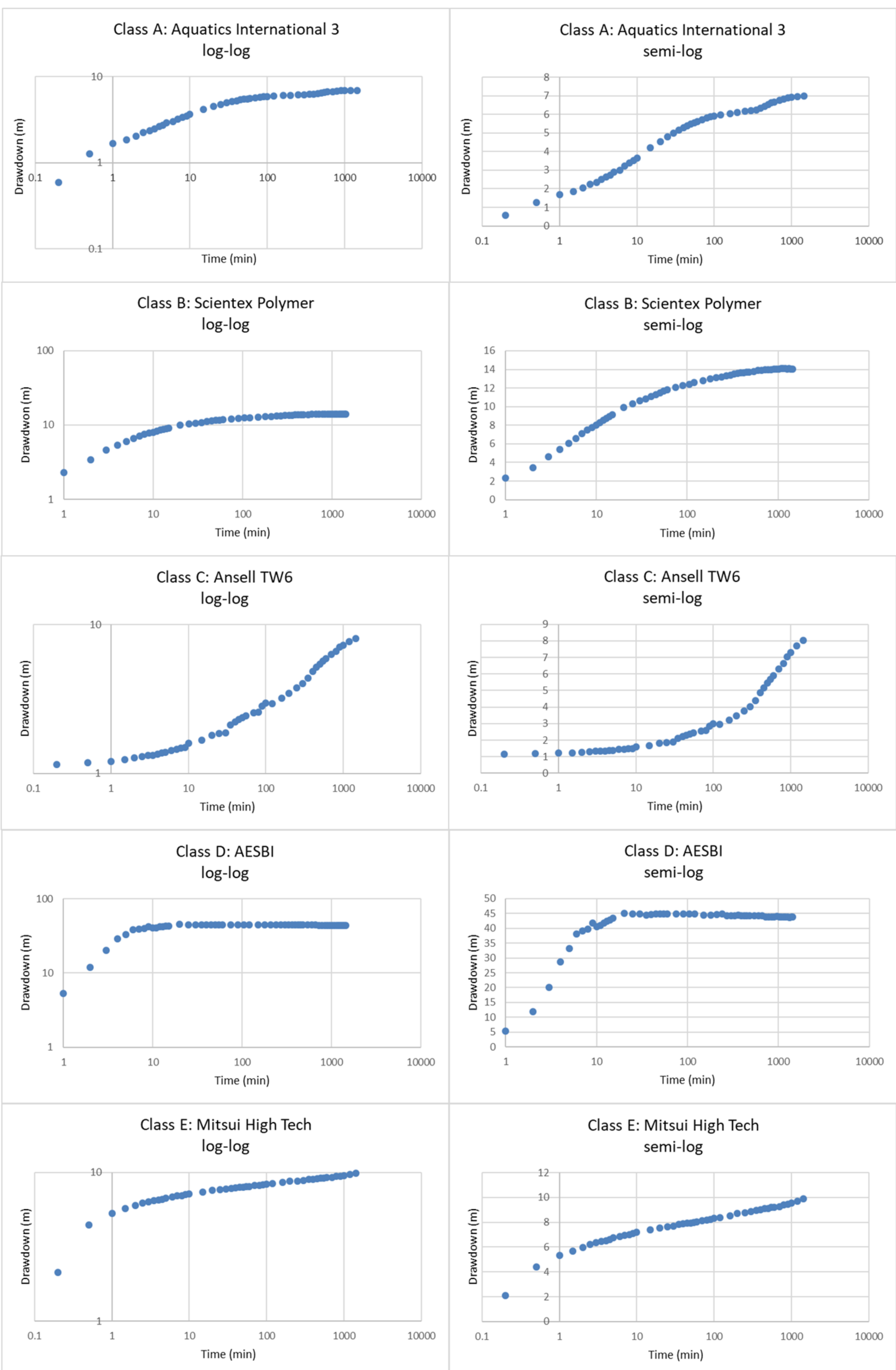
2) Aim

To develop further the understanding of the Shah Alam aquifer by:

1. Re-examining single-well pumping test data collected by the regulator
   - confirming interpretation provided by Roslan (2017)
   - extending interpretation using derivative analysis and numerical modelling.
2. Monitoring pumping wells over several pumping cycles at locations where nearby unpumped wells are also available to act as observation wells, using travel support generously supplied by the IAH John Day Bursary.

3) Re-examination of Single Well Pumping Tests

Re-analysis of data using standard log-log and semi-log type analysis confirmed the 5 classes of aquifer response and T values suggested by Roslan (2017).



Class A:
- an extra, finite source of water becoming available; due to drainage from the unsaturated zone in an unconfined aquifer, or from the matrix in a fractured aquifer.
- 7.5 % of wells
- T values: 51 to 158 m^2/d

Class B:
- possible leaky aquifer response
- 42.5 % wells
- T values: 3.57 to 40.5 m^2/d

Class C:
- barrier effect or patchy aquifer response.
- 5 % of wells
- T values: 37.5 to 49.6 m^2/d

Class D:
- major source of water becoming suddenly available part way through the test, possibly a river.
- 12.5 % of wells
- T values: 5 to 22.9 m^2/d

Class E:
- infinite confined aquifer that is approximately homogeneous.
- 32.5 % of wells
- T values: 1.4 to 47 m^2/d

Figure 3. Characteristic drawdown curves for the five classes of aquifer response.

Further analysis of the data was carried out using derivative analysis and comparison to idealised diagnostic plots by Renard (2009). This confirmed some interpretations (Figure 4a), however, in other cases it suggests that the flow system is more complicated (Figure 4b).

a) shows a close fit to Theis – infinite confined aquifer that is approximately homogeneous

b) a more complicated response, possibly suggesting a change in flow dimension part way through the test.

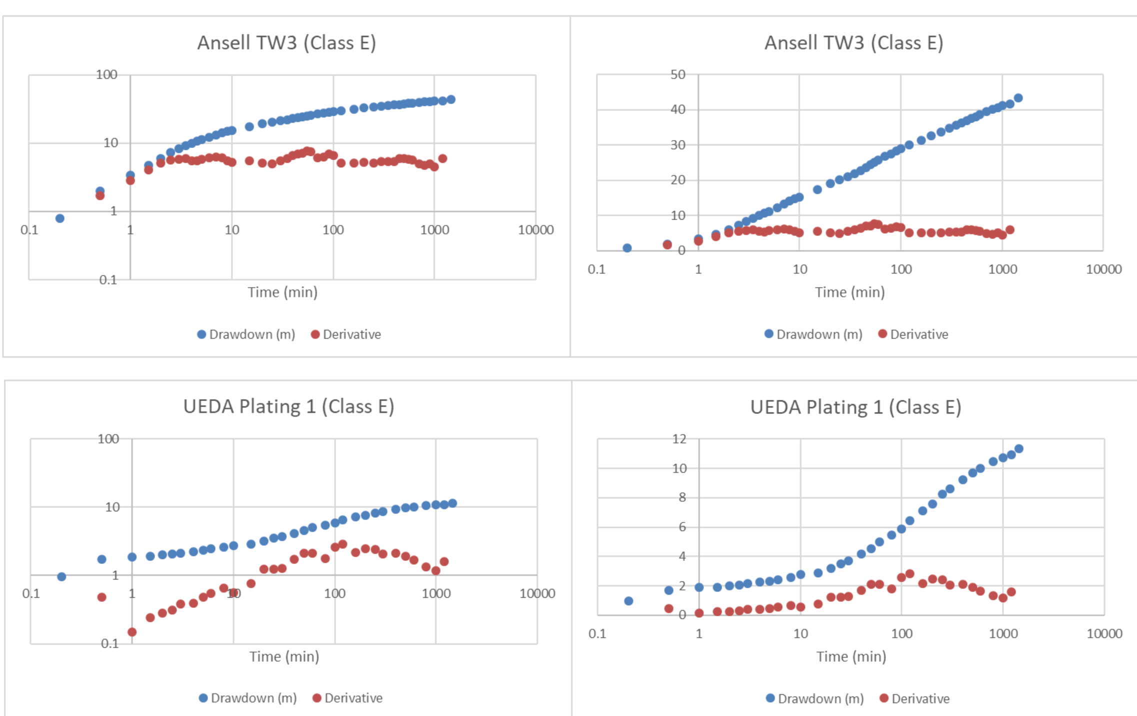


Figure 4: examples of derivative analysis

4) Examination of Monitoring Data Collected in Malaysia

During fieldwork, it proved impossible to get transducers installed in any of the industrial site boreholes available. Instead transducers were installed in boreholes at UKM (National University of Malaysia), which lies in the same geology as Shah Alam; 2 datasets were collected.

- Dataset 1:
  - one well
  - no observation wells
  - constant pumping rate
- Dataset 2:
  - two wells pumping simultaneously (KAB1 & KAB2)
  - no observation wells
  - 5 on/off pumping cycles with partial recovery between each cycle

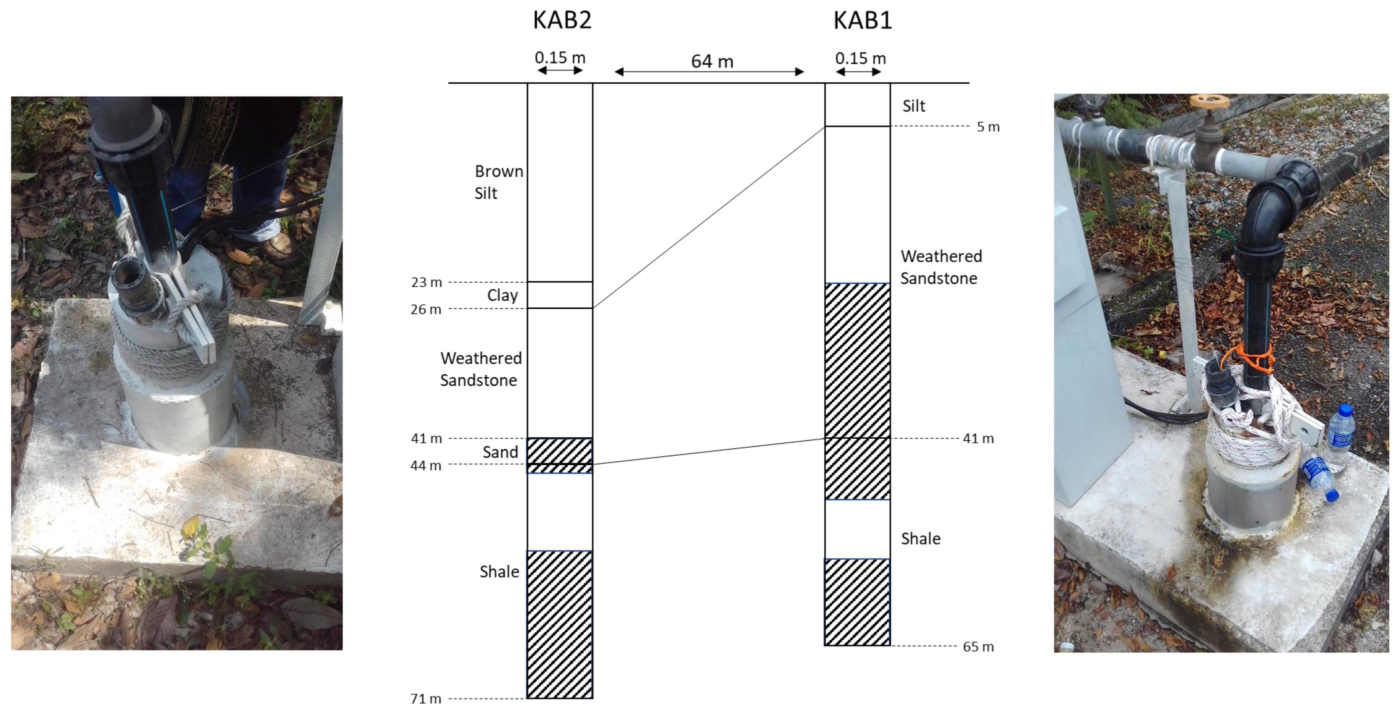


Figure 5. Photos and borehole logs for KAB1 and KAB2.

Analysis of dataset 2 using a range of techniques showed:

- the data could be interpreted to yield static water level estimates
- the possible presence hydraulic barrier between the wells
- broadly similar log-log, semi-log, and derivative diagnostic plots to those found from pumping tests at the same wells from 2015 (Figure 6)
- the well responses fitted most closely to the responses of wells in Class B

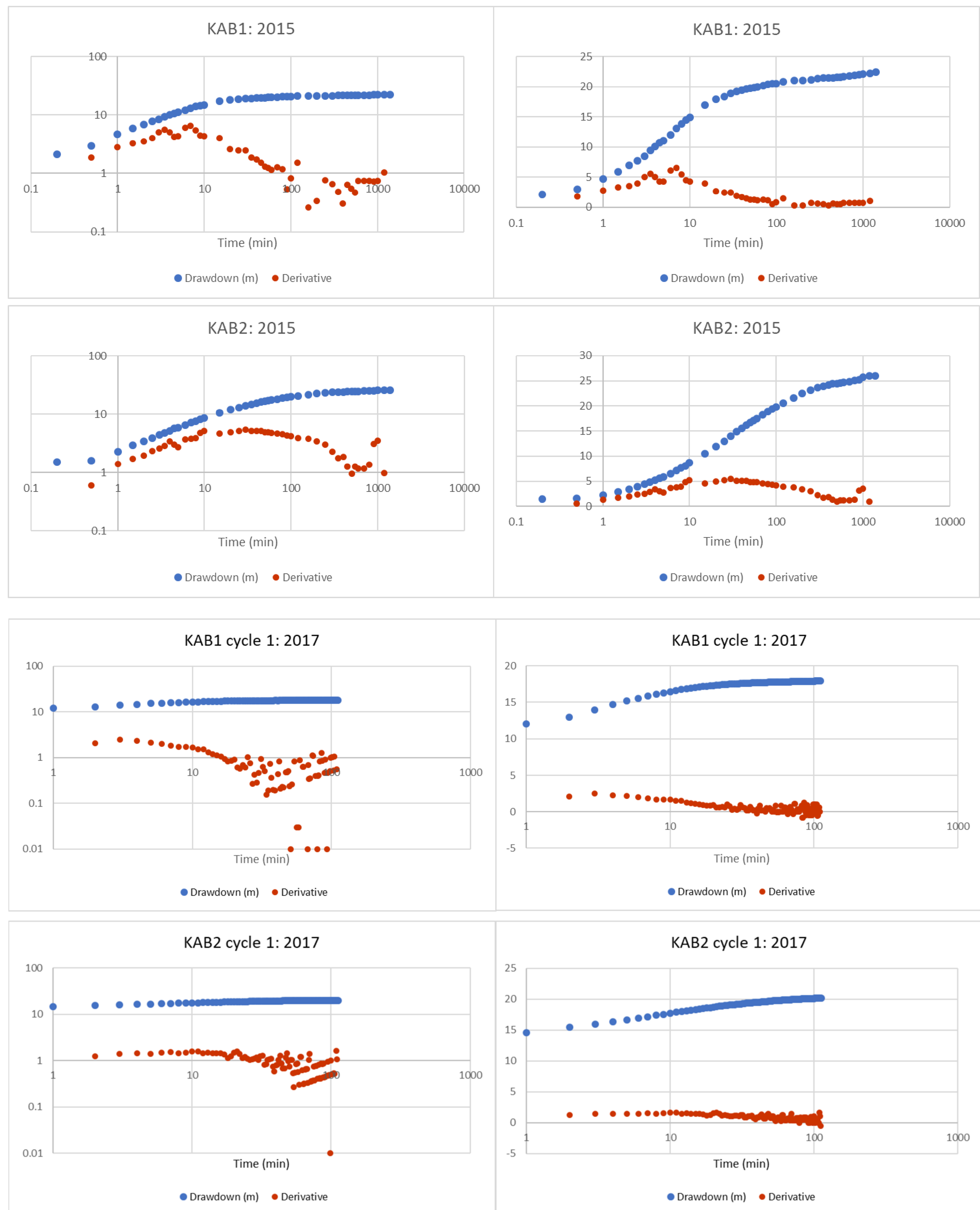


Figure 6. Diagnostic plots for KAB1 and KAB2 data from both 2015 and 2017.

5) Conclusions

- The study confirmed previous analysis of pumping test data, but derivative analysis and modelling have challenged some of the interpretations by possibly suggesting that fewer wells (minimum estimate of 35 %) are affected by recharge sources than previously thought (60 %). This has potential implications for the development of the aquifer.
- It also confirmed that monitoring of water levels in pumping wells can provide data comparable to the short-term pumping tests required by the regulators; this method could be a practicable way to supplement the limited amount of data otherwise available.

References

Renard, P., Glenz, D. & Mejias, M., 2009. Understanding diagnostic plots for well-test interpretation. *Hydrogeology Journal*, 17(3), pp.589–600.

Roslan, N., 2017. *The urban hard rock aquifer in Malaysia: susceptibility approaches.* Unpublished PhD thesis, University of Birmingham.