

OR/19/052 Appendix 3a - Array 1 Borehole descriptions

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Kingdon, A, Fellgett, M W, and Spence, M J. 2019. UKGEOS Cheshire Energy Research Field Site - Science infrastructure. *British Geological Survey Internal Report*, OR/19/052. *Contributors*: Midgley, J, Elsome, J W, Dearden, R A, Chapman, C, Burke, S P, Hough, E, Luckett, R R, and Bianchi, M.

Table 6 Array 1 Summary borehole metadata and planned sampling.

Array 1: Sampling	Details
Scientific Objective:	Long-term baseline groundwater testing and sensor installation
No of Sites and boreholes per site	9 Sites each with both 1 x 100 m and 1 x 50 m borehole
Expected Lithostratigraphy at TD	50 m boreholes TD in Quaternary, 100 m TD in Sherwood Sandstone Group (Triassic)
Boreholes per site	1 x 100 m, 1 x 50 m boreholes
Likely borehole diameter	13½ nominal diameter
Casing Installed: 50 m boreholes	10¾" permanent steel casing (6-22 mbGL), 150 mm PVC screened between 43 to 49 mbGL
Casing Installed: 100 m boreholes	11¾" permeant steel casing (6-22 mbGL), 150 mm PVC screened between 90 to 99 mbGL
Expected end use	Boreholes remain open for future sampling
Samples available during drilling	Drill cutting collected sporadically
Cored Boreholes	5 X 100 m cored to sample superficial & Permo-Trias geology
Geophysical logs	5 x 100 m boreholes, Gamma-Ray — Caliper (Borehole diameter)
Geomicrobiology sampling	Standard geomicrobiology sampling protocol: 1 sample per 10 m of core in cored boreholes
Gas testing during drilling	Equipment
Fluid testing during drilling	None planned
Fluid Testing Post Drilling	None planned
Pump Testing	Long-term Pump testing
Permanently installed equipment	Automated & telemetered data logging in 6 boreholes

The array will provide environmental baseline data of the groundwater, ground motion and air quality across the study area. The purpose of the proposed groundwater array is to create a new groundwater monitoring network which will allow researchers to get an improved understanding of the groundwater processes within the Cheshire Energy Field Research Site (CERFS) area. These data will form the natural baseline against which future research activity will be compared.

Borehole components of array 1

The array consists of 18 boreholes at 9 separate locations in the broad vicinity of the village of Elton in Cheshire. This allows the sampling of the regional groundwater in the vicinity of the CERFS research site and also allows the stratigraphy and variability of the Permo-Triassic geology to be more completely understood.

Following completion of the drilling phase a series of pump tests will be undertaken at each borehole location. In addition these boreholes will also be instrumented with continuously recording sensor to allow the borehole steady-state conditions to be monitored remotely over an extended time interval. Combined with outputs from analytical groundwater geochemistry this will produce a laterally and temporally extensive baseline data set.

Above-ground data acquisition in array 1

Interferometric synthetic-aperture radar (InSAR) ground motion equipment will also be installed across selected sites at the CERFS area. Equipment will be installed at the surface to continuously monitor deformation or shifts in rock mass in the subsurface. Air quality monitoring installations are included as part of the environmental baseline study for the CERFS area. These are designed by (and will be controlled by) Manchester/York Universities and NCAS1. These installations will include a range of sensors and instruments to monitor atmospheric gases.

Subsurface data acquisition in array 1

The groundwater monitoring wells within this array allow an environmental baseline for groundwater quality to be produced. The baseline will detail various chemical and physical parameters and general groundwater quality through the collection of groundwater samples and continuous automated monitoring, using data loggers and groundwater quality sondes, over an extended period. The sondes will be purchased, installed and maintained by the UK Geoenergy Observatories capital funding.

The array is also designed to allow pumping tests to be undertaken during the operational phase of the wells. This will help to characterise how the groundwater flows and behaves across the region.

Table 7 Array 1 List of borehole codes and site locations (Cored boreholes in Bold).

Location	100 m BH	Cored	50 m BH
SITE A	TH0407		TH0420
SITE B	TH0101	TH0101	TH0102
SITE C	TH0107	TH0107	TH0108
SITE D	TH0116	TH0116	TH0117
SITE E	TH0122	TH0122	TH0123
SITE F	TH0125	TH0125	TH0126
SITE G	TH0128		TH0129
SITE K	TH0110		TH0111
SITE N	TH0104	TH0104	TH0105

Table 8 Array 1 planned hydrogeochemical sampling: summary of intended sample types.

Sample Type	Treatment	Sample Container	Analysis Possible
FA 30 ml	Filtered acidified with HNO ₃ to 1%	30 ml LDPE	ICP AES, Na, K, Ca, Mg, SO ₄ , Si, Al, B, Ba, Be, Cd, Co, Cr, Cu, Fetotal, La, Li, Mn, Ni, Mo, Pb, Ptotal, Sc, Sr, V, Y, Zn, Zr, As, Se, ICP MS suite

FUA 60 ml		60ml LDPE	Cl, F, Br, I, NO ₂ , NO ₃ , TON, NH ₄ (SO ₄ , PO ₄)
FUA 30 ml NH ₄	Filtered, unacidified		Ammonium
FUA 30 ml As		30 ml LDPE	Arsenic
NPOC	Silver filtered, unacidified	14 ml foil capped glass vial	Dissolved Organic Carbon
δ ¹⁸ O/δ ² H	Filtered, unacidified	60 ml HDPE	Oxygen and Deuterium
δ ¹³ C		100 ml HDPE	Carbon Isotopes
Dissolved gases		Gas Sampling Bomb	Dissolved gases
CFCs		Small Amber Bottle	CFCs
SF ₆		Clear Glass Bottle	SF ₆
SVOCs		1 x Green Bottle 2 x Glass Vials	SVOCs
NORM	Unfiltered, unacidified	1L Glass Amber Bottle	NORMS
Tritium		1L Glass Amber Bottle	Tritium (³ He)
S Isotopes		250 ml Nalgene	Sulphur Isotopes
Radon Daughters		Nalgene pots	Radon Daughters
Radon		60 ml HDPE	Radon (Rn)(Triathler)
Organic micropollutants		2 x 1 L PTFE Lined Bottles	GCMS/LCMS
PAHs		1 x 1 L PTFE Lined Bottles	PAHs
VOCs		1 x 250 ml plastic bottle	Chlorinated hydrocarbons, BTEX

Table 9 Array 1 Non-geochemical sampling (Groundwater Baseline).

Type	Data Collection	Data Produced/Possible	Status
Pumping Tests	Step Drawdown	Well efficiency, critical pumping rate, optimum pumping rate	Operational details to be confirmed
	Constant Rate	Transmissivity (hence hydraulic conductivity), storage coefficient, aquifer response	
	Constant Head	Transmissivity (hence hydraulic conductivity)	
InSAR	Ground level monitoring	Baseline of ground level stability	Confirmed

Special sample handling procedures that will be adopted:

- One sample will be acidified in the field
- The majority of samples will be filtered
- Samples will be refrigerated in the field using ice packs/ice and kept in cold stores over the weekend before shipping to labs
- There is scope to keep some samples in the cold store for testing at a later date
- Further parameters need to be further examined including long-term storage requirements

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