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Cheshire Energy Research Facility Site (CERFS): A new experimental observatory location for geoscience energy research.

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Addressing future energy challenges and new zero carbon targets will require increasing use of the subsurface. Utilising the subsurface with public consent requires impartial, independent and open data to adequately evaluate potential risks. De-risking of the subsurface is dependent on new standardised data, highly characterised locations and readily available subsurface experimental facilities to deliver the innovation needed.

To address this NERC and UKRI have provided funding to BGS to construct geoscience observatories at two UK locations to deliver new long-term research. Such observatories require the geology to be characterised in detail, to provide a database to baseline new hypothesis-led experimental science.

The observatories will benefit from a pre-existing database of high quality geoscience data to increase over the operational lifetime. Characterisation of each facility site has involved the integration of baseline monitoring, regional borehole data and where available 2D and 3D seismic which are beyond the limits of research budgets. Once completed each observatory site will comprise a wide range of publicly available data including: fully-cored and characterised boreholes, facilities to baseline the regional groundwater environment, a set of new downhole sensors for time-series monitoring of geophysical and geological parameters served in real-time via the internet to anyone.

The construction phase of the UK Geoenergy Observatories (UKGEOs) Cheshire Energy Research Facility Site will begin construction in summer 2020. The site has been chosen at an accessible location in a sequence of scientifically and significant Triassic to Carboniferous strata. This sequence is typical of the sediments under much of northern England, included areas which have been explored for oil hydrocarbons. Up to 50 boreholes between 50–1200m depth will be drilled, with a combined length of up to 8000m, including 3000m of core and geophysical logging, including resistivity borehole imaging.

The boreholes will be split in arrays to characterise the region including: baseline groundwater, quantify the baseline seismicity down to near globally unique resolution of -0.6 to -1.0 M and characterising a volume of rock so it can then be dynamically parameterised with properties. This will become a default locations for synthesis and testing of new solutions to energy by becoming

the basis for an experimental faculty where natural and anthropogenic perturbations can be undertaken and monitored.

UKGEOs will create a long-term experimental facility open for all scientists for experiments and testing of new subsurface technology. All materials recovered will be available for sampling with derived data and published research made available to create an ever-growing archive of data to facilitate future understanding.

An immediate priority research question is the capacity for faults to act as conduits or barriers to subsurface fluid flow. This is a major concern to the public around hydrocarbon developments but is of critical relevance to any development of deep geothermal heat, subsurface storage of energy and gas or Carbon Capture and Storage. CERFS will provide the facilities to deliver such research and new insights.

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CERFS science objectives

- to reduce subsurface uncertainty to encourage new low-carbon energy technologies including CO_2 storage, shallow geothermal and aquifer storage of heat and compressed air
- investigate the effects of subsurface heterogeneity on fluid flow
- Investigate controls on connectivity of sandstone aquifers at different scales
  - Faults & fractures
  - pore filling cements,
  - changes in depositional facies
- Online realtime monitoring of
- seismicity, ground resistivity, and groundwater

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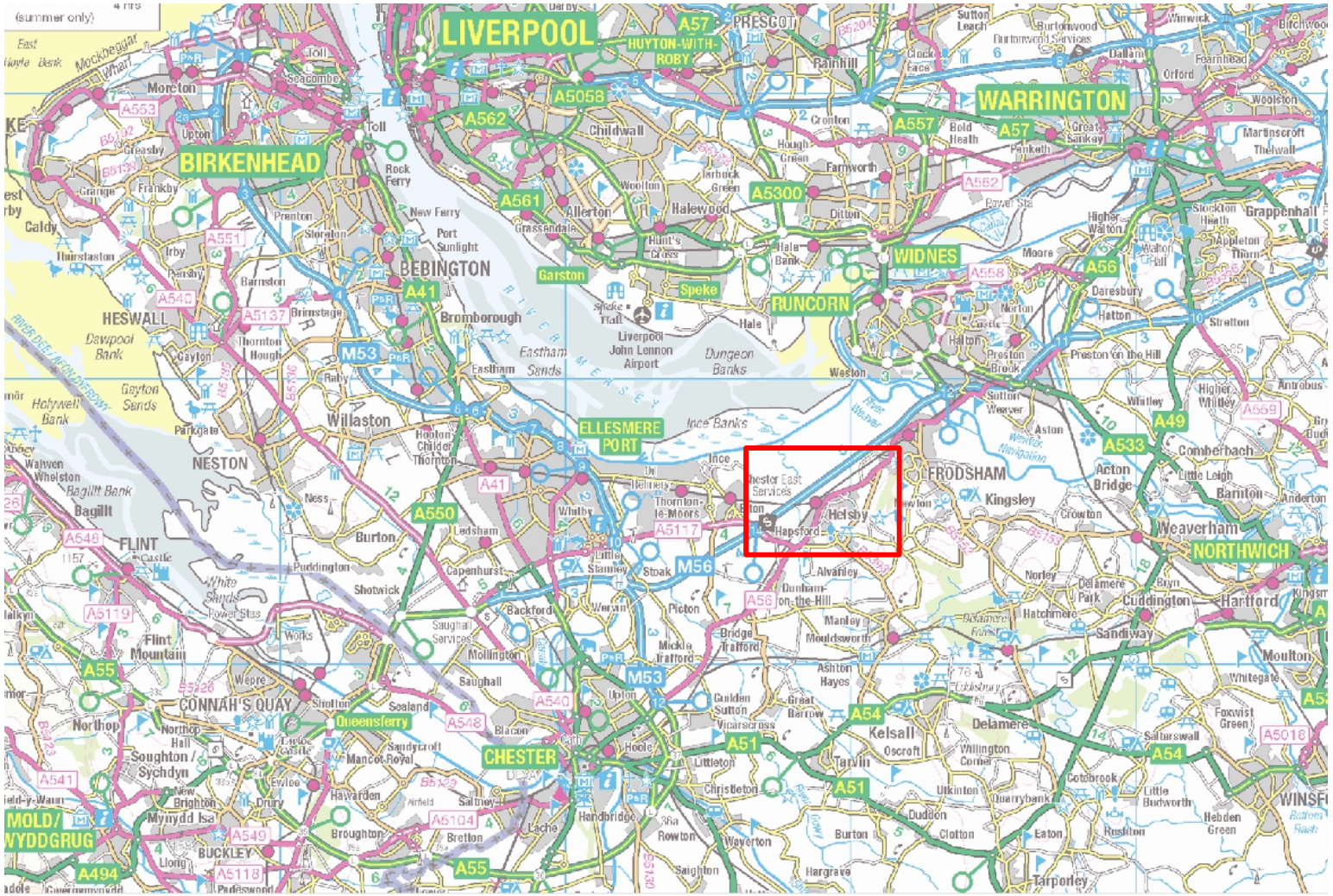
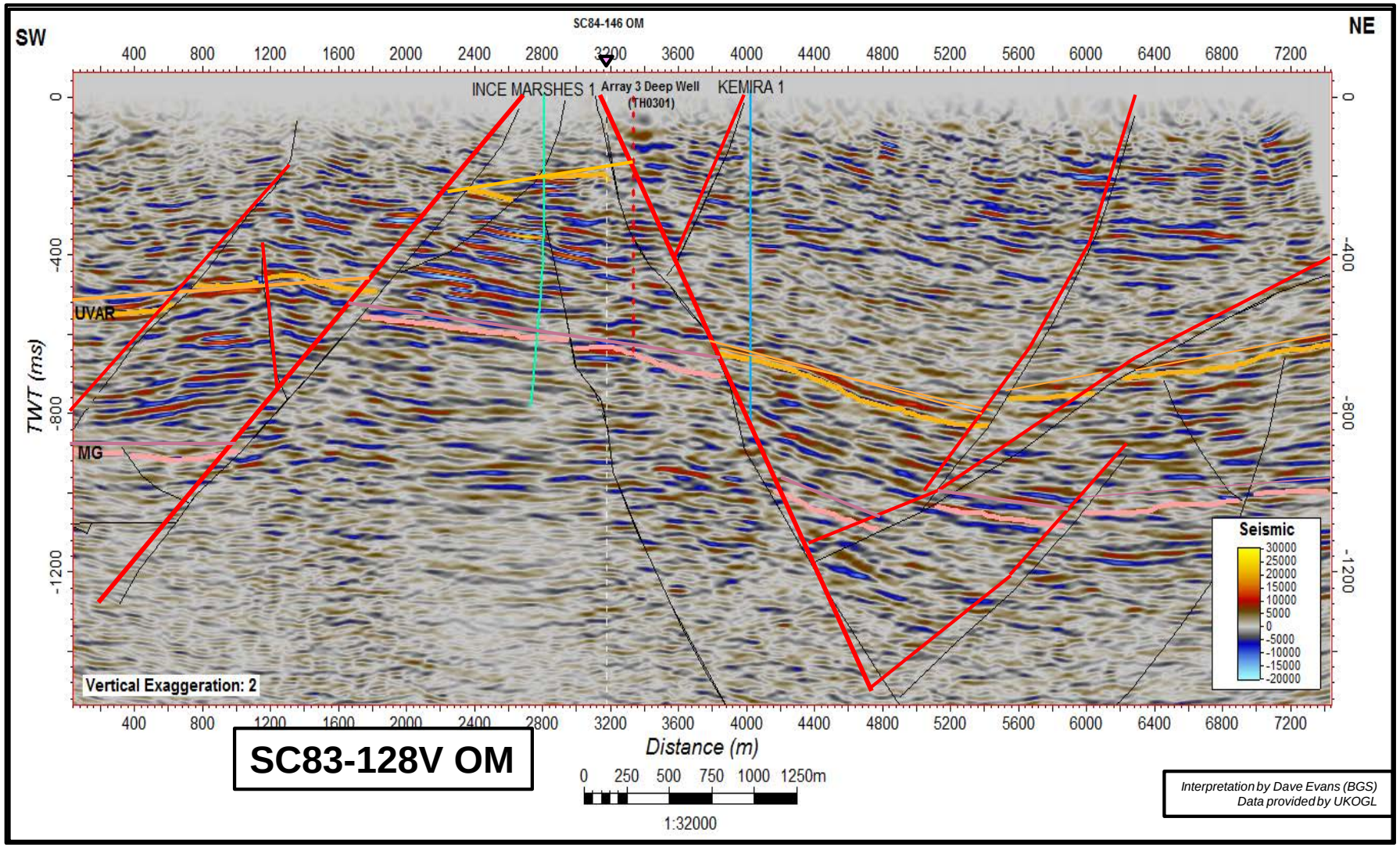
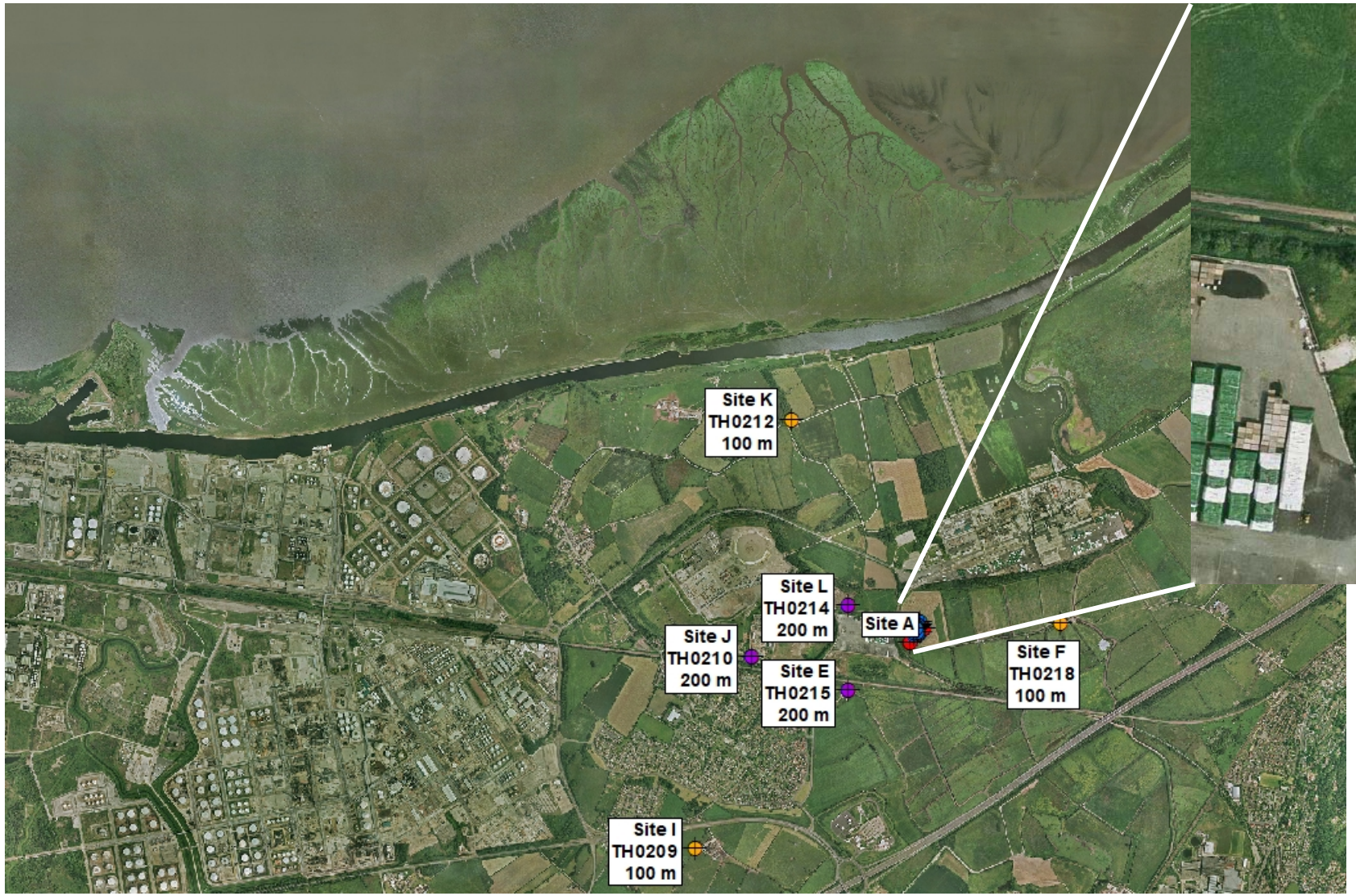
Cheshire Energy Research Facility Site



Structural & stratigraphic model



CERFS Borehole Locations



UK GEOENERGY OBSERVATORIES

Seismic array : Real-time measurements of ground motions

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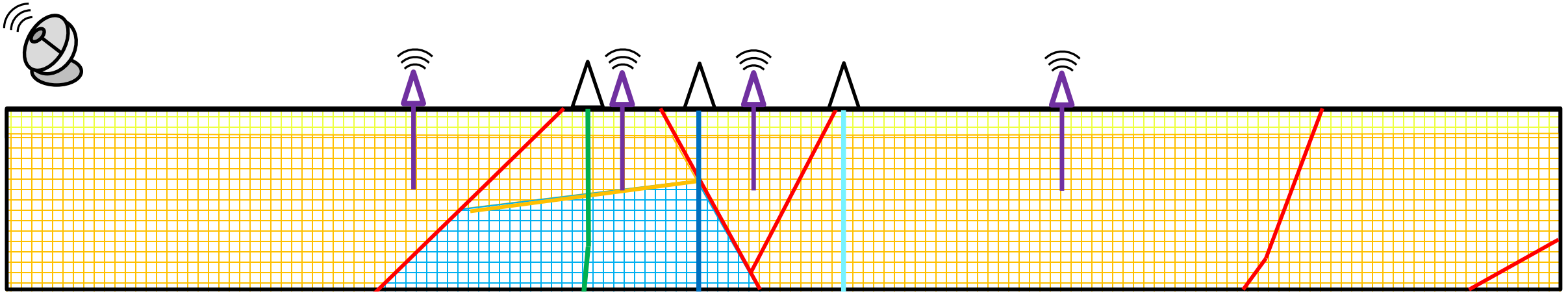
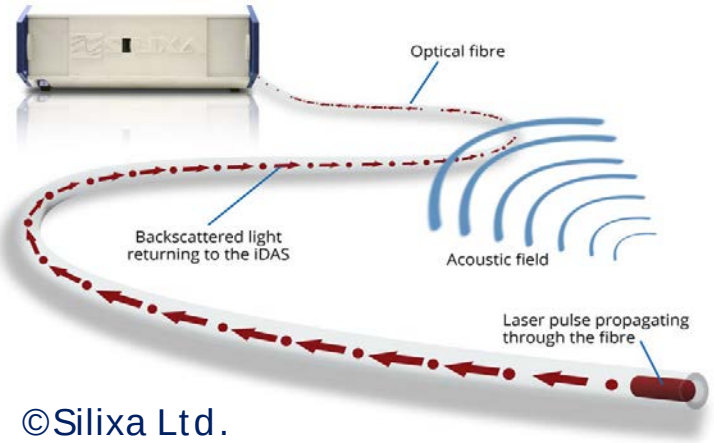


- The aim of the array is deliver seismicity baseline data
  - provide a seismic monitoring network to understanding of seismic activity around CERFS
  - Baseline data against which future seismic activity will be compared
  - One of the highest resolution seismic monitoring arrays in the world.
  - Aims to detect earthquakes of -0.6 to -1.0 magnitude - this type of quake is 1000 times smaller than a quake someone is likely to feel.
  - Measuring seismicity across all parts of the horst block and graben systems
  - Well placed to monitor seismicity on and offshore UK

Description of Seismic monitoring array

- 10 seismometers installed in boreholes
  - 3 at 300 m deep
  - 7 at 200 m deep
- Guralp Radian borehole seismometers
- 3–component (orientation measured by internal magnetometer).
- Automatically corrects for even large tilts.
- Broadband (120 seconds to > 200Hz).
- Acceleration output improves performance at high frequencies.
- 140 dB dynamic range.
- Integral digitiser sampling at 500 Hz

New monitoring Technology



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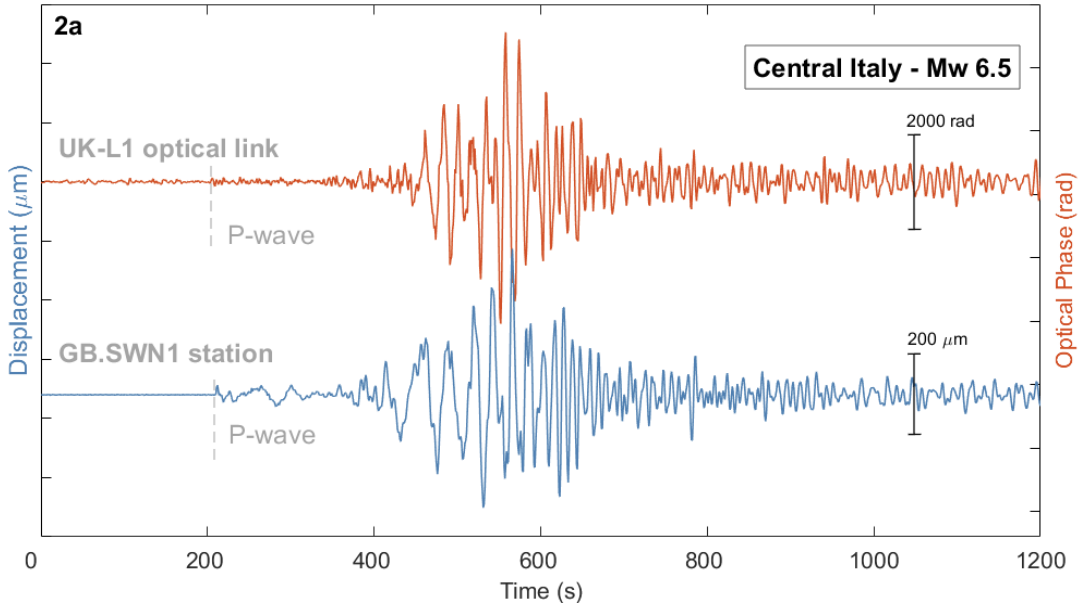
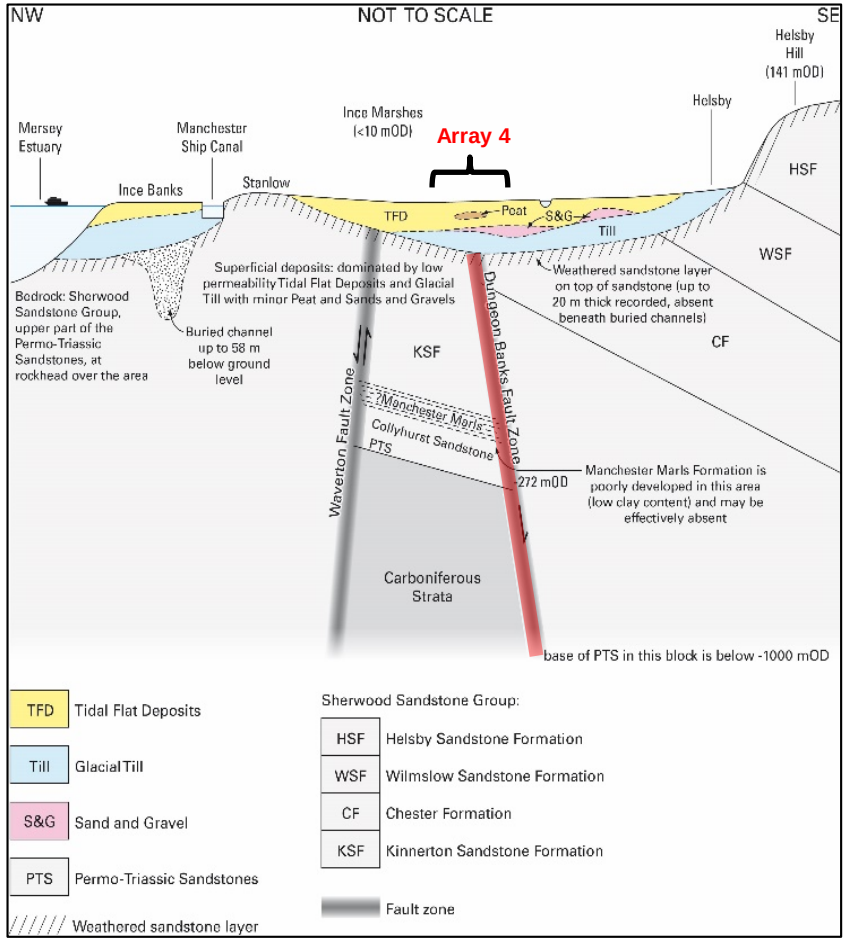
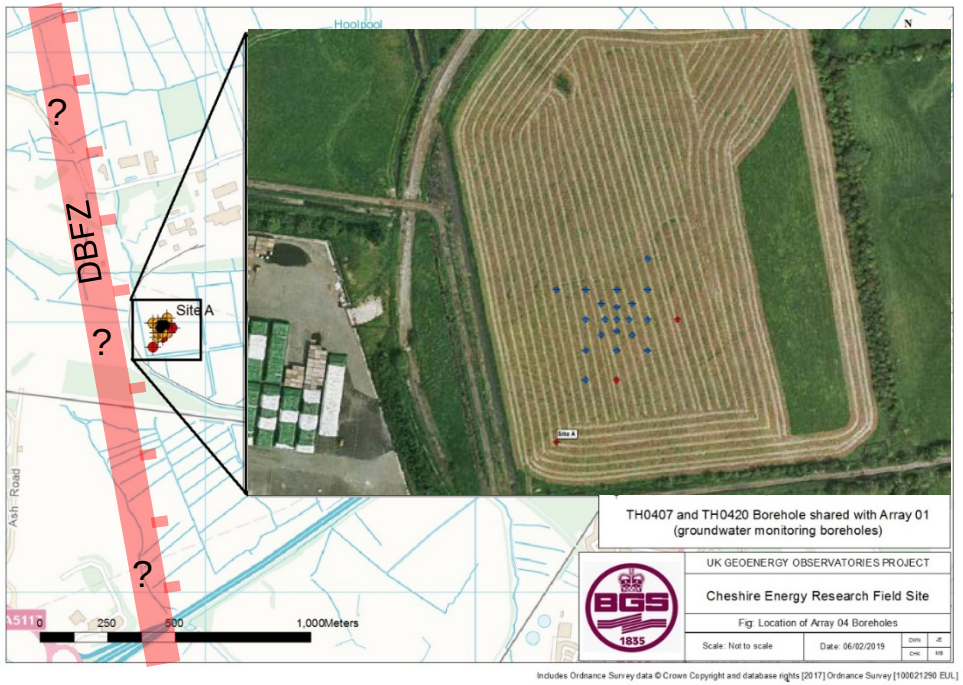


- Several seismic boreholes will have optical fibre installed behind the casing.
- **When connected to a suitable sensor can perform as a string of geophones.**
- A laser sends short pulses, which return with a phase shift proportional to the change in strain.
- **Technology is currently generating much interest with several important questions unanswered.**

Multi-scale array through the Permo-Triassic succession and into the underlying faulted contact with the Carboniferous

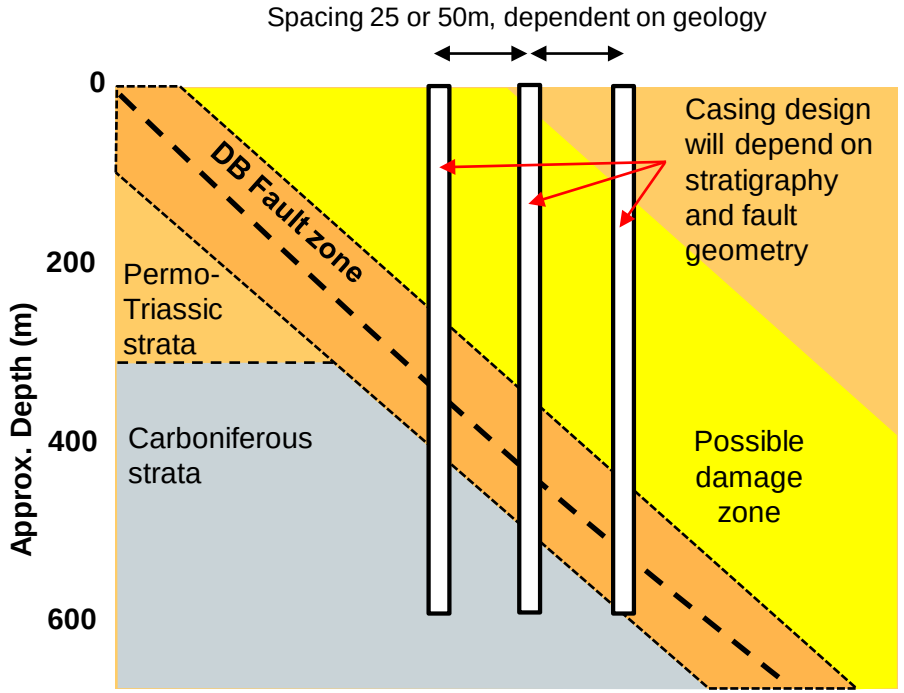


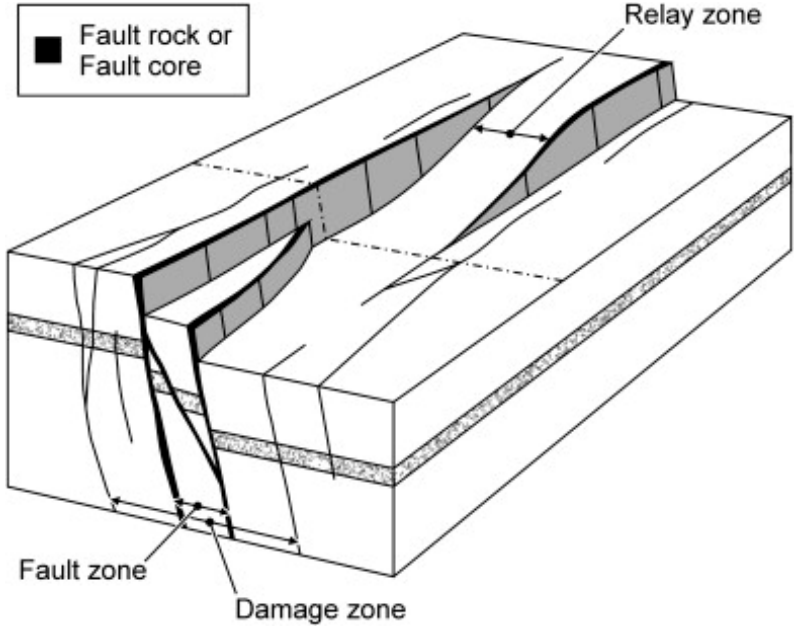


Dungeon Banks Fault Array

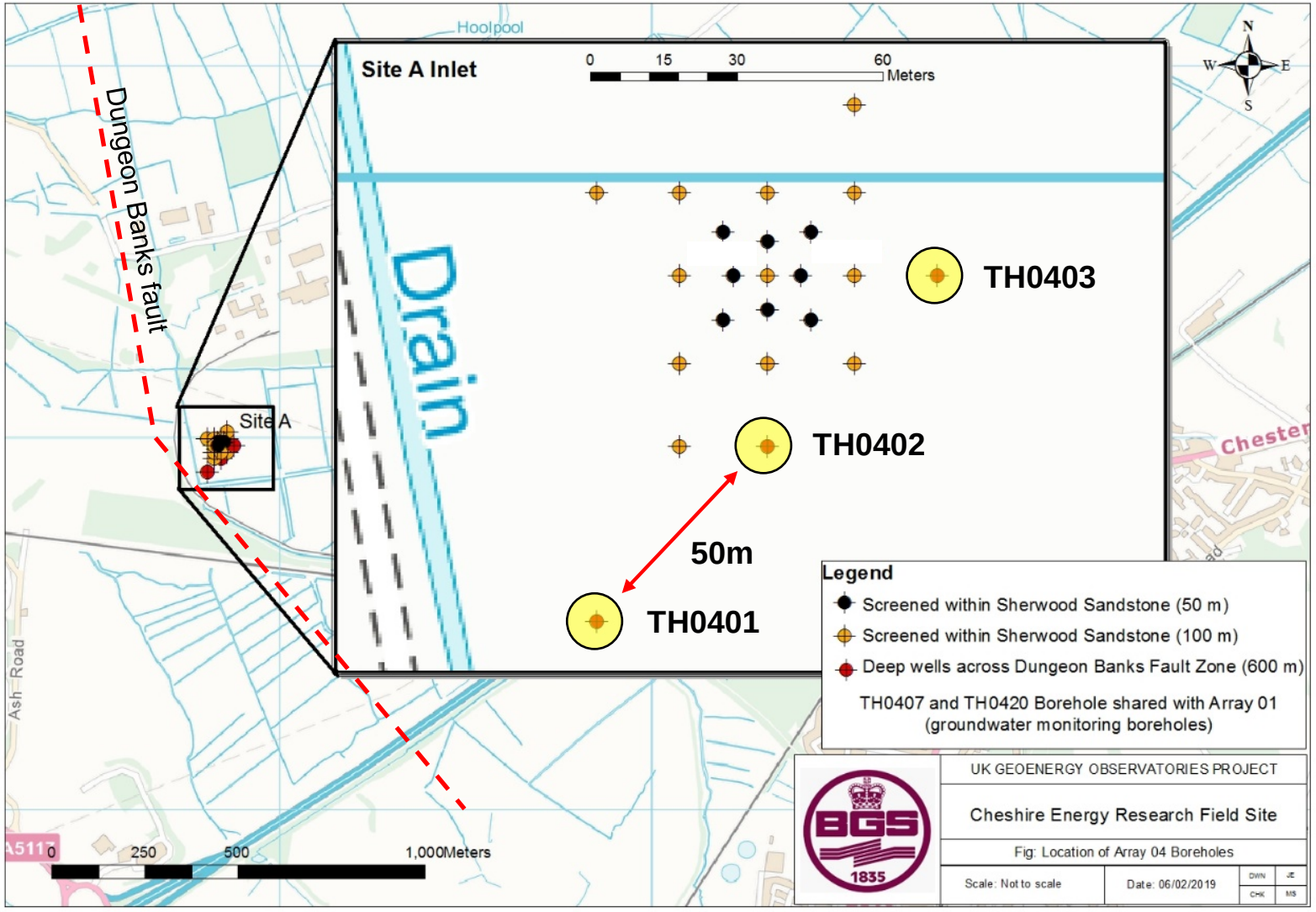
Science Objectives:

- ❑ Variation in fault characteristics with depth
- ❑ Role of faults as a barriers/ pathways to fluid migration
- ❑ Potential for movement on fault structures in response to subsurface activities

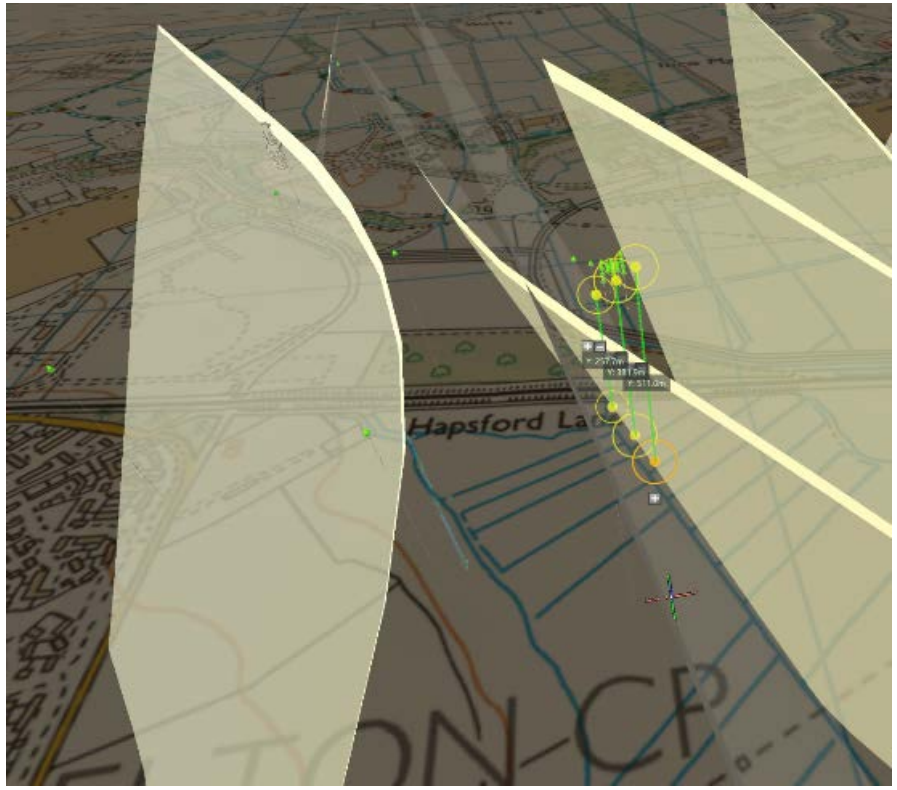




Design of Dungeon Banks Array (3 x 600m BH across DB fault at 50m or 25m spacing) structures



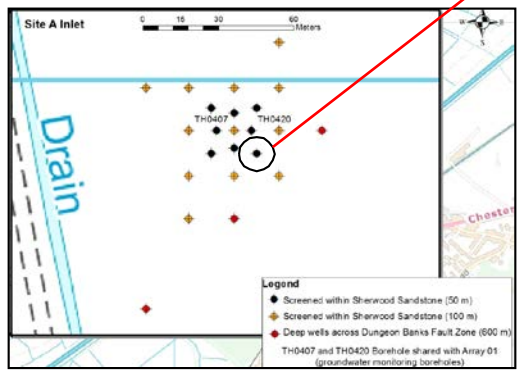
The 600m boreholes are designed, based on the North Dee 3D seismic interpretation, to intersect the DB fault from 250-550m depth, to support investigation of controls on fluid flow in the vicinity of the fault

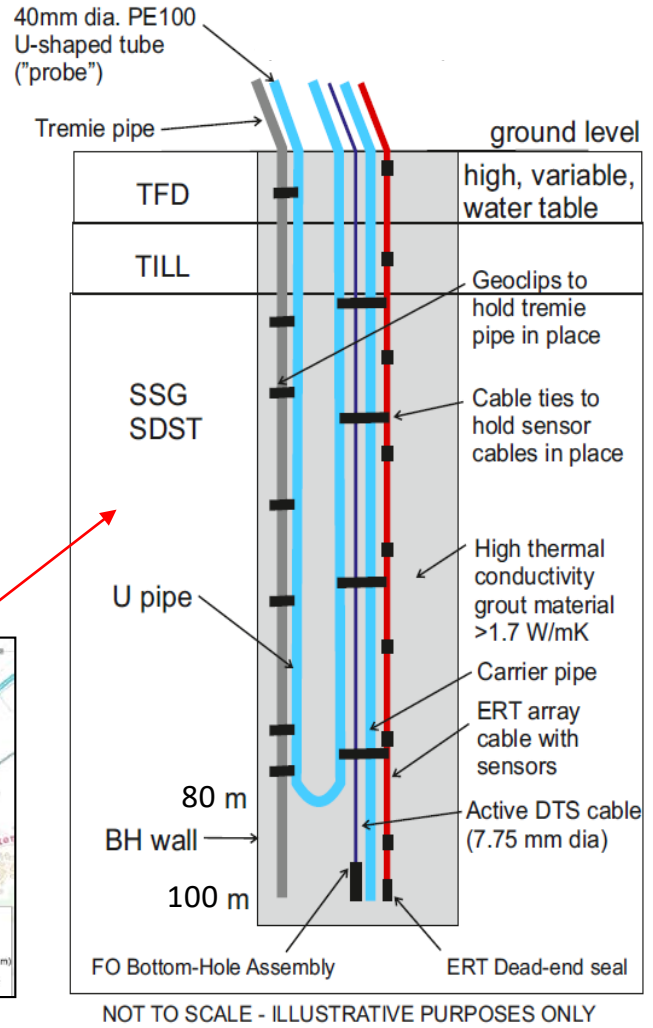


Thermal/ Tomography Array

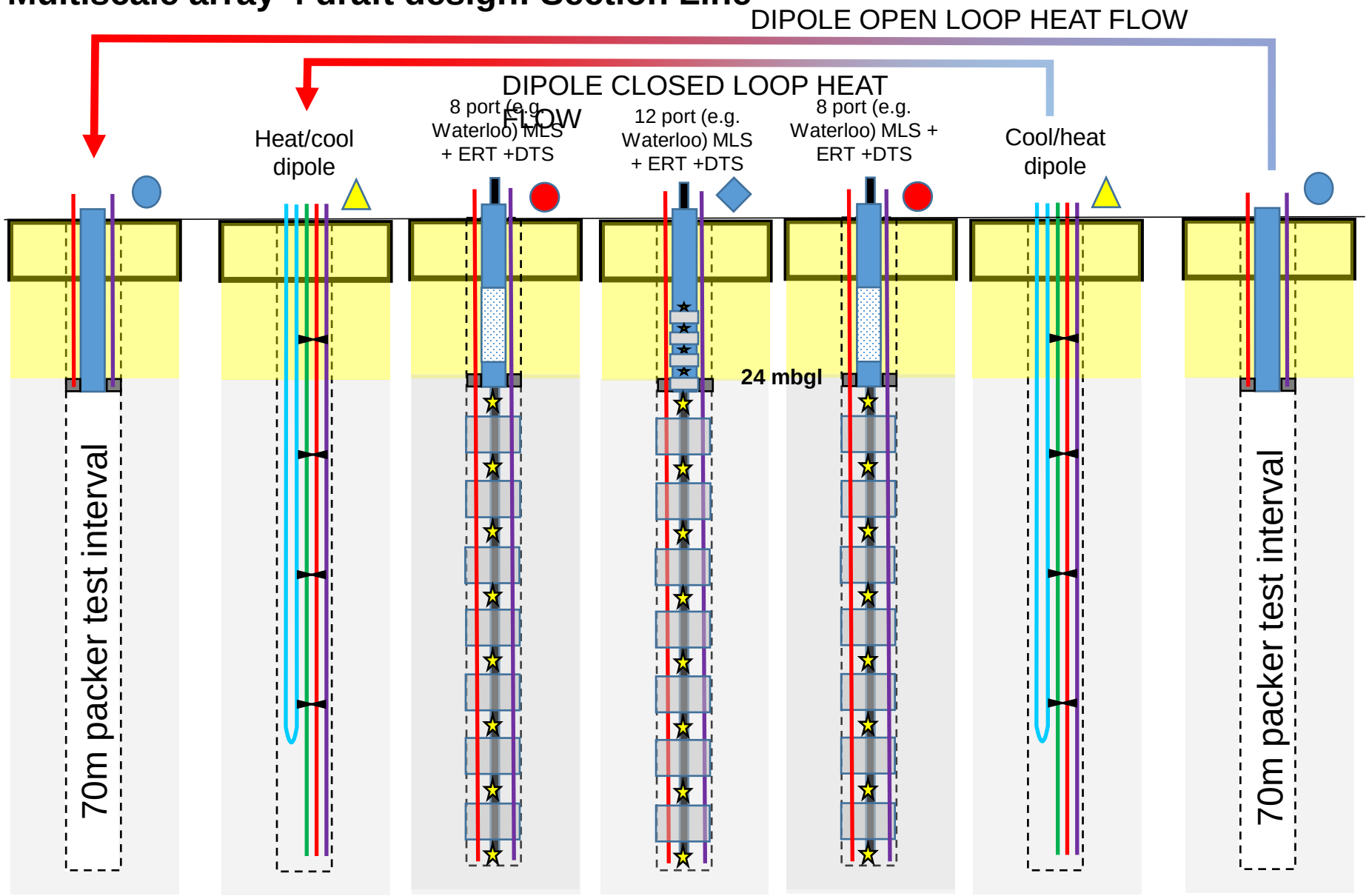
Science Objectives:

- Cross-borehole and surface-borehole 2D and 3D geoelectrical imaging
- Advanced hydraulic experimentation with 4D hydrogeophysical monitoring.
- Time-lapse imaging of natural and induced fluid processes in the near surface
- Effect of heat addition and removal on subsurface environment-thermal response test well (illustrated)

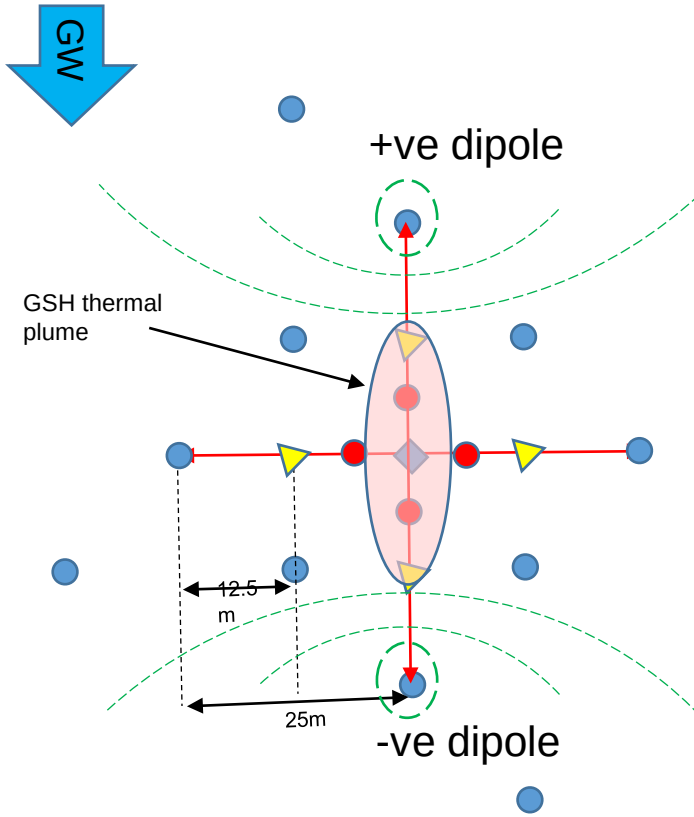




Multiscale array 4 draft design: Section Line



	KEY	
●	100m dipole pumping wells with well screen in superficials	ERT sensors + DTS cables
●	100m deep 8 port multilevel well for sampling & level logging	
△	Ground source heat research (TRT) well	
■	100m deep 12 port multilevel well for GW sampling only	
↔	Lines of cross section	



Phase 1: Use uncased BH to characterise aquifer properties

Phase 2: Install open loop GSH well screens and additional DTS/ERT monitoring systems

1 Aim :Static parameterised 3D model