Vertical, Horizontal Array or Mine Water Source for Heat Pumps: Wales Case Studies

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ERDF
Llywodraeth Cymru
Welsh Government
Ewrop & Chymru: Buddsoddi yn eich dyfodol
Cronfa Datblygu Rhanbarthol Ewrop
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Seren
Sustainable Earth Energy

Heat from the Ground – Seren Activities

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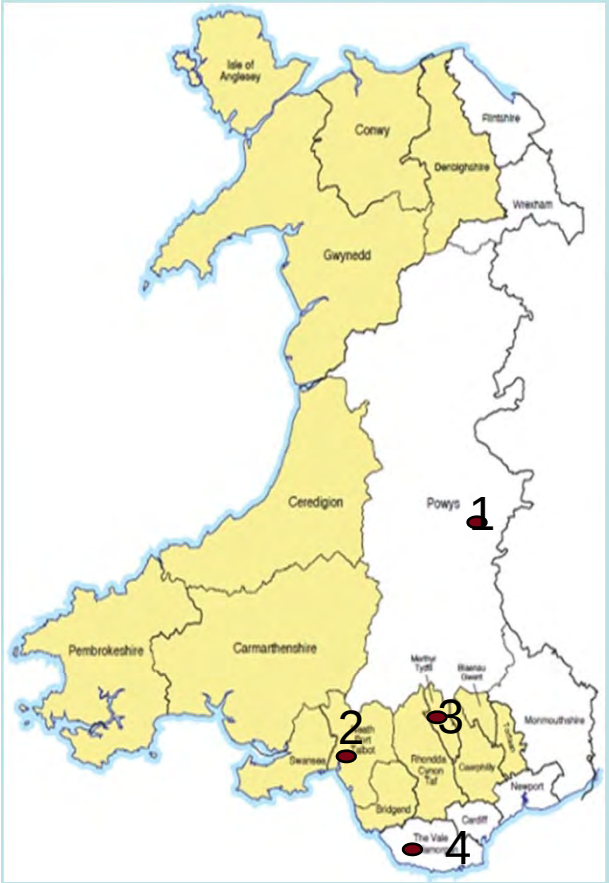
Extensive research and development through

- Development of demonstration sites and long term monitoring of Ground/Water Sourced heat pump systems
- Development of analytical and computational tools to understand ground behaviour

Close Collaboration to facilitate the uptake of technologies

- SMEs, local authorities, regulatory bodies and related associations

Seren GSHP System Case Studies



Symbols	System	Heat Provided
1	Horizontal Ground loop system	16kW; domestic house; heating and hot water
2	Mine water heating system	40kW; domestic house; heating and hot water
3	4 Boreholes Vertical system	28kW; domestic house; heating and hot water
4	1 Borehole Vertical system	3kW; Social housing; heating and hot water

Rational for the demonstration

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Ground Behaviour	Spatial resolution of ground temperature data to better understand heat extraction
Sustainability	Answer to the question of sustainability of GSHPs
Contribution	Complied data-set for the scientific community

Horizontal Ground loop system: Site Details

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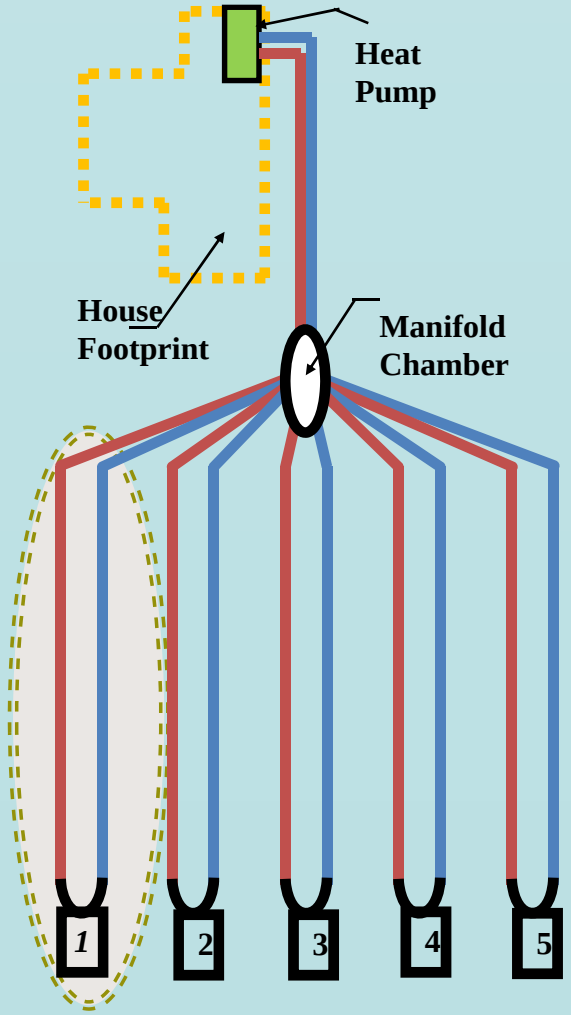
Location	Lower Pentre Farm located in Ffynnon Gynydd, Powys
Building and Fuel Type	Refurbished old cottage; Oil and Electric
GSHP system	Provides building space heating and hot water need 16kW
Horizontal ground Loop	5 Nos. of 75 m long trenches
Flow rate	30 l/s
Monitored since	June 2012; 112 thermistors buried in the ground




Detailed cross-section


Silicon-cell pryranometer


Tipping bucket rain gauge


Intermediate cross-section

Horizontal Ground loop system Data

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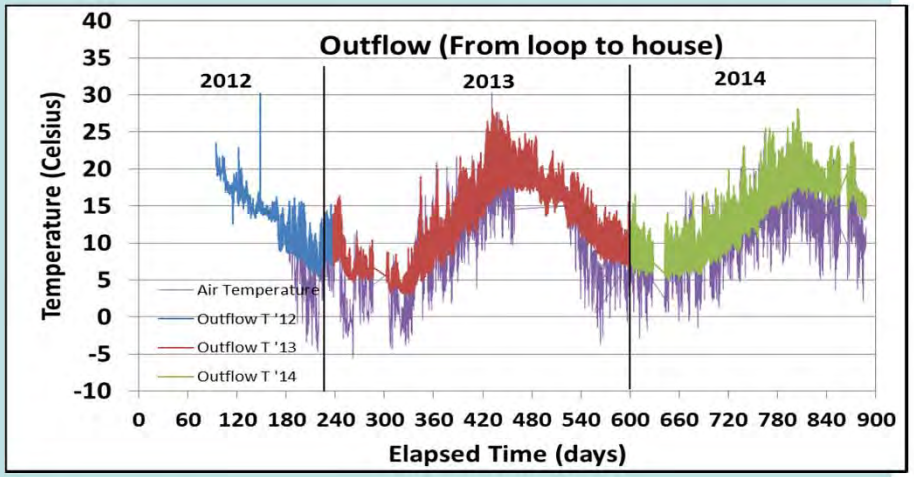
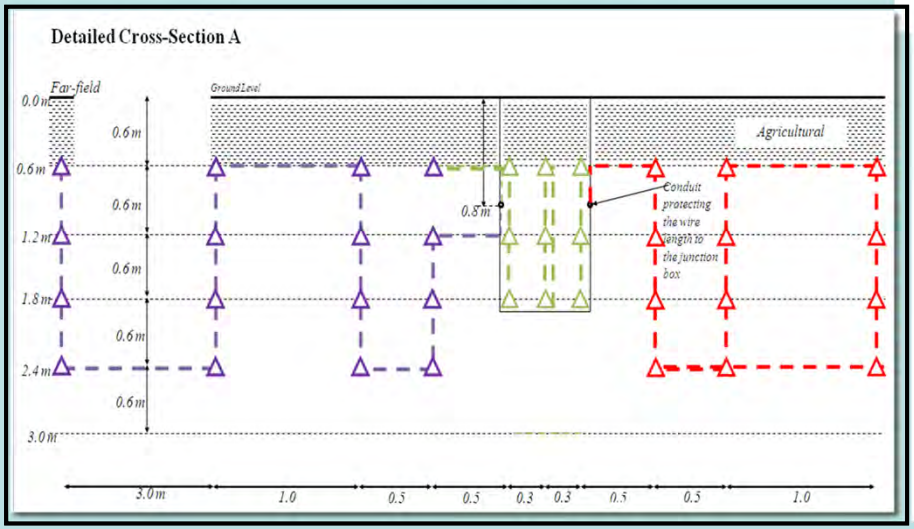
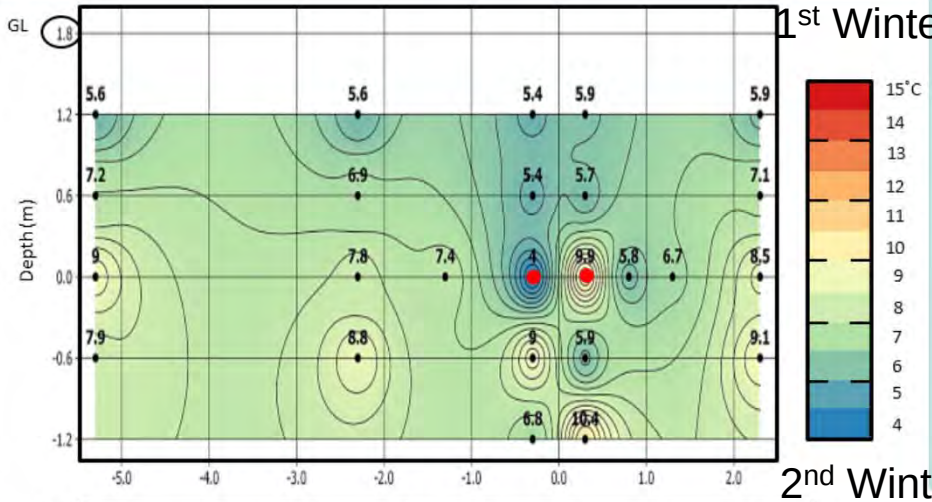
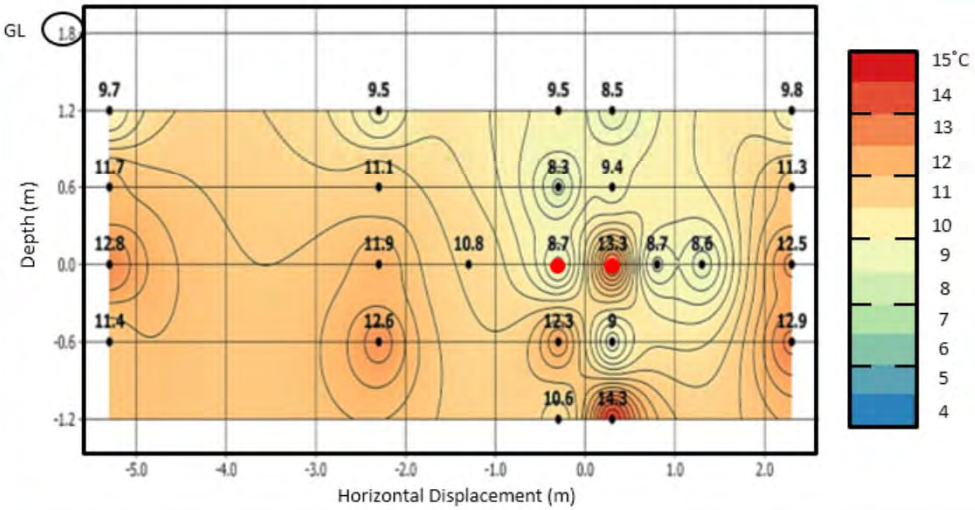




1st Winter



2nd Winter



Coldest day contour

Vertical Borehole system: Site Details

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External insulation on the building

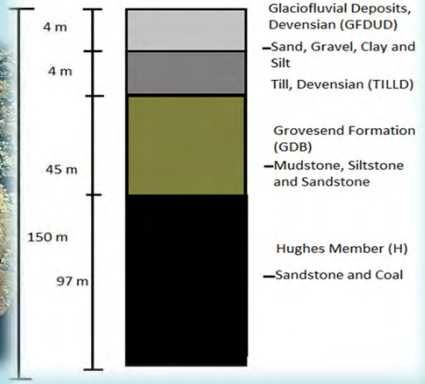
Location	House near Bedlinog, Taff Merthyr
Building and Fuel Type	Refurbished Cottage with 10cm external insulation; Oil and Electric
GSHP system	Space heating and hot water; 28kW
Vertical borehole	4 Nos. 120m Deep Borehole
Monitored since	October 2014

View from Plant Room

Drilling in progress

Thermistor string

Typical vertical borehole



Stratigraphy of Taff Merthyr

Borehole GSHP system Data

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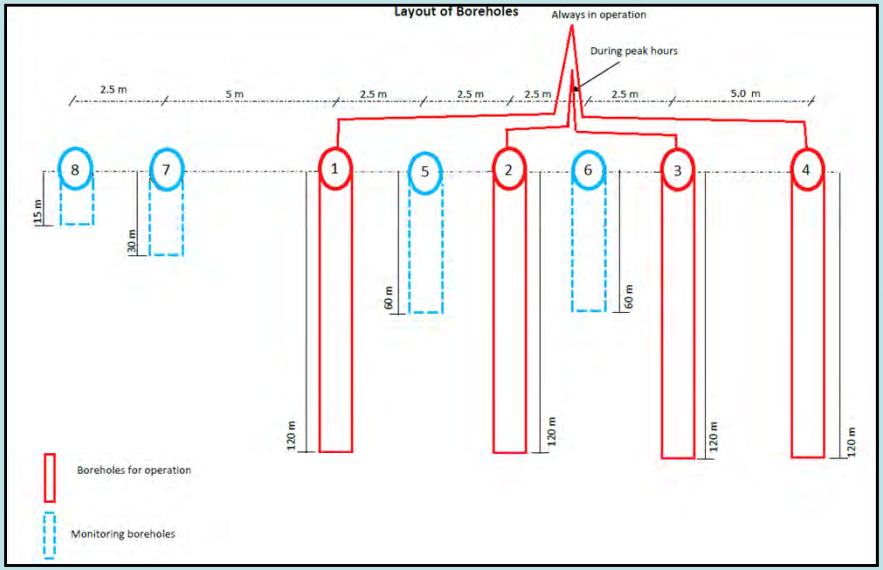
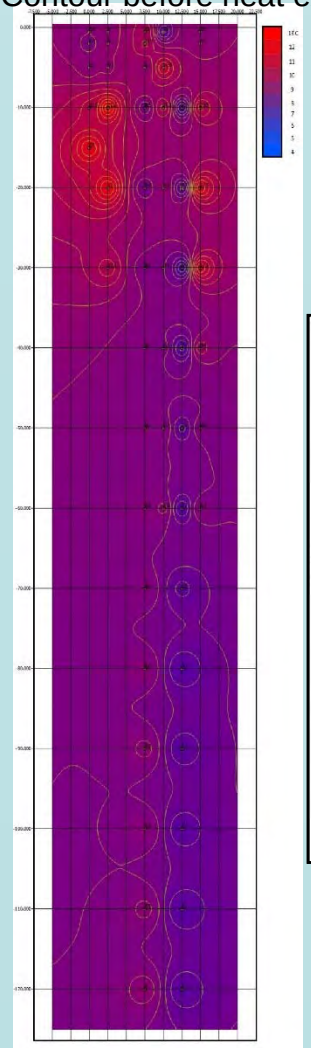
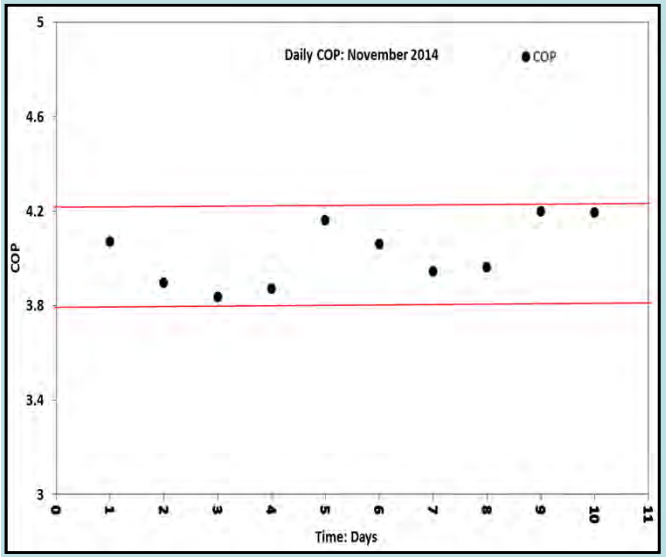
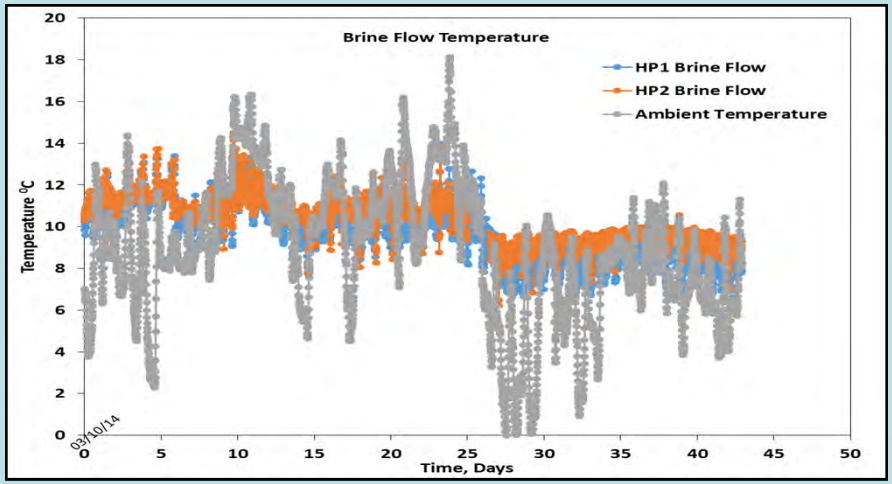


Contour before heat extraction







1st Demonstration site in Wales -Crynant

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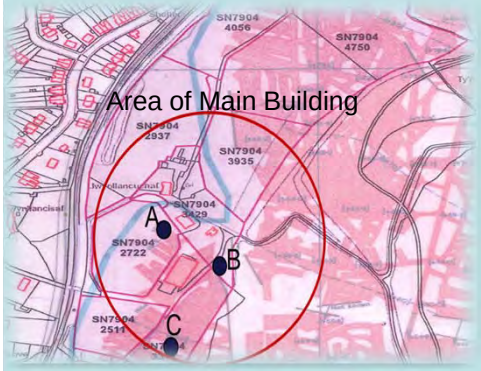

Mine Workings near the building

Location	Crynant in the Dulais valley
Building and fuel Type	A large farmhouse, workshops and adjoining physiotherapy business; Oil and Electric
GSHP system	Space heating and hot water; 40kW
Vertical borehole	2 Nos. 64m Deep borehole
Flow rate	7 m^3/hr
Monitored since	April 2014

Heat pump with data collection and logger system

Drilling in action

Abstraction and Discharge borehole

System data acquisition at site

Potential of Abandoned Coal mines in Wales

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- 90km from west to east
- Approx.30km from north to south.

Large area

Most of these are now abandoned

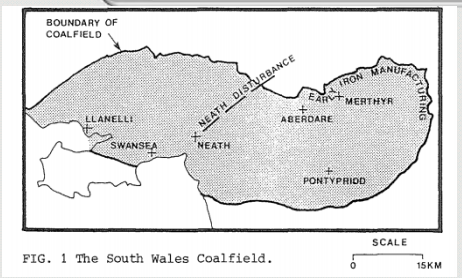

FIG. 1 The South Wales Coalfield.

- 63 MW of thermal energy from South Wales coalfield
- Approx. 13000 houses could be heated

Available thermal energy

Burrell et al. 2007

Drive for the Demonstration

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Sustainable Regeneration	• Low carbon and renewable energy resource that can deliver energy for societies facing fuel poverty and social deprivation
Practical experience	• Communities, Industries and Policy makers
Market penetration	• Supporting the use of heat pump technology in former mining communities
Asset	• Converting an environmental liability into an environmental and economic asset.

Offset greenhouse gas emissions as a consequence of previous mining

Project development

Desk Study	Borehole locations based on mine records
Heat Recovery Access Agreement	Discussions with Coal Authority
Abstraction license and Discharge permits	Discussions with NRW Exploratory drilling, Test Pumping and Water Quality Analysis

Long Term Monitoring at Crynant

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Continuous monitoring of Water Level, Water Temperature & Electrical Conductivity using CTD Divers in:

- Abstraction Borehole
- Discharge Borehole
- Monitoring Borehole

Periodic Water sampling from:

- Abstraction Borehole
- Discharge Borehole
- Monitoring Borehole

Continuous monitoring of:

- In flow and outflow Temperatures
- Heat Produced
- Electricity consumed

Data Analysis

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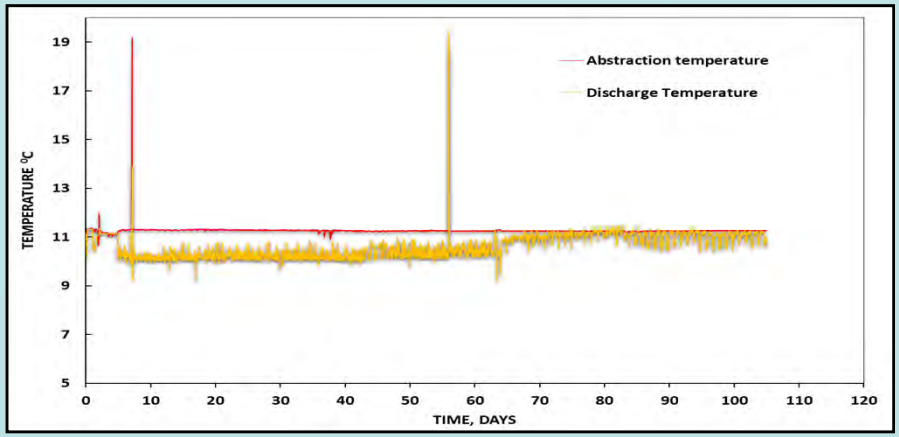

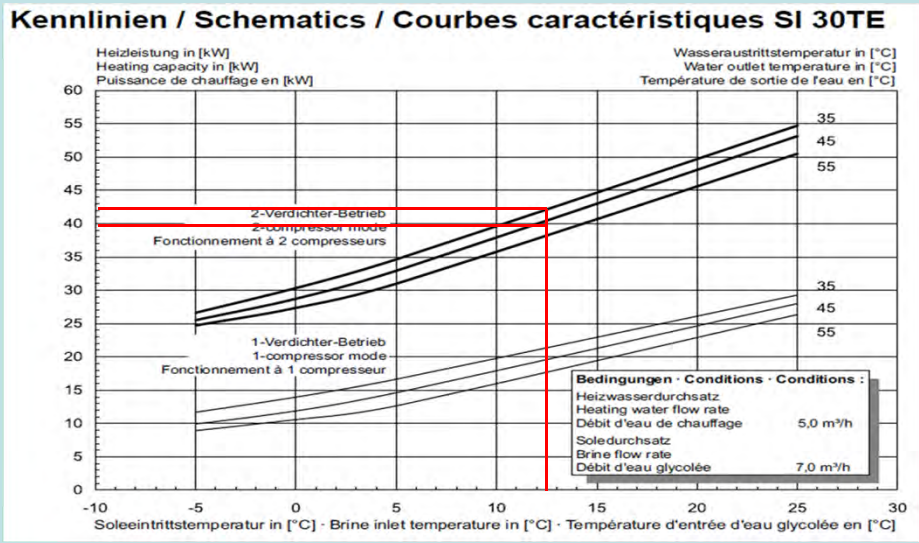

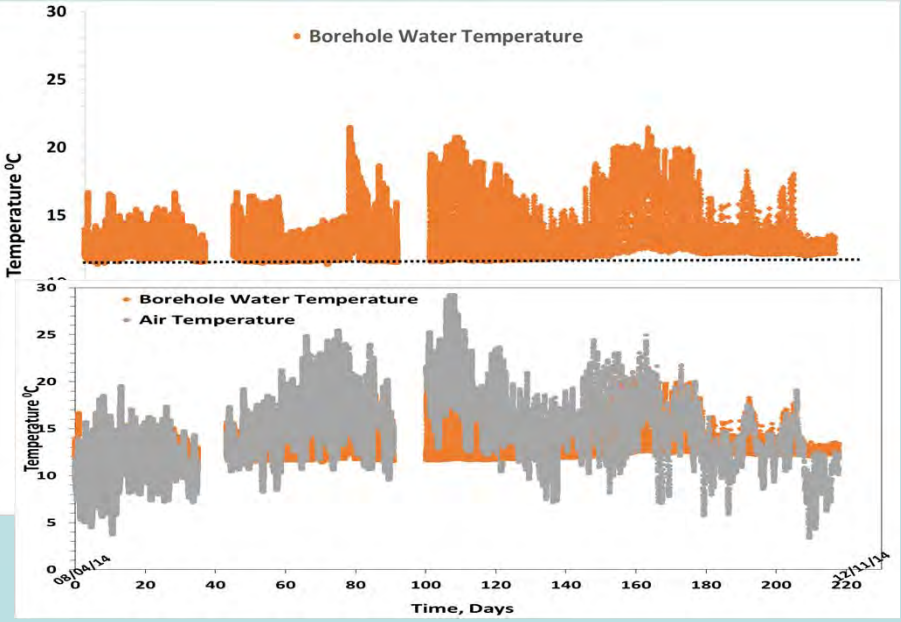

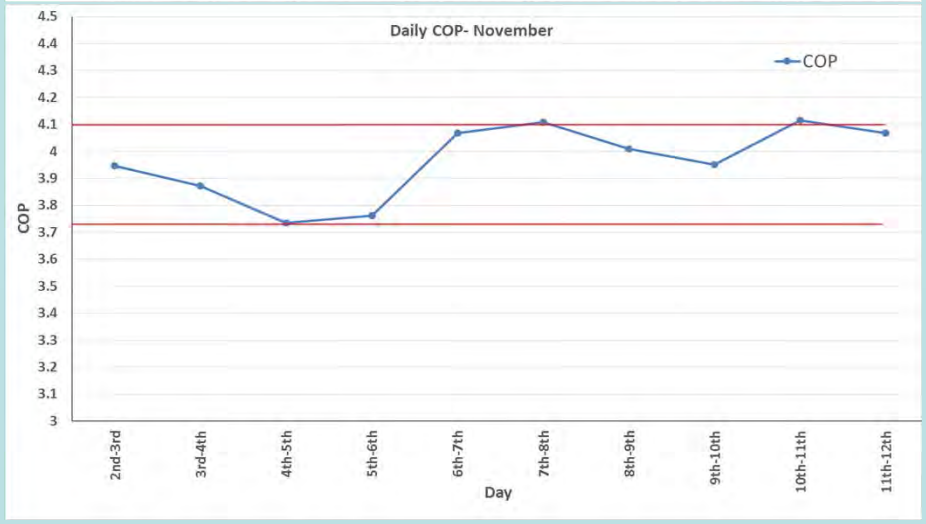

Aqueous Chemistry of Manganese and Iron

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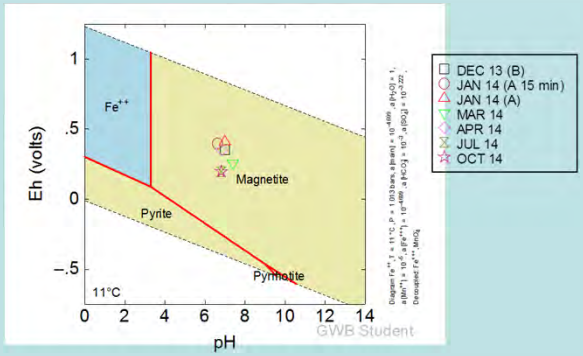

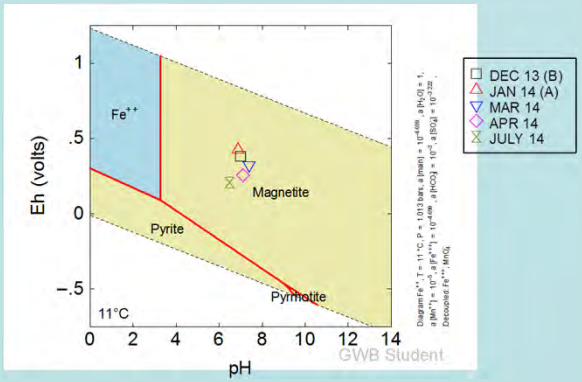

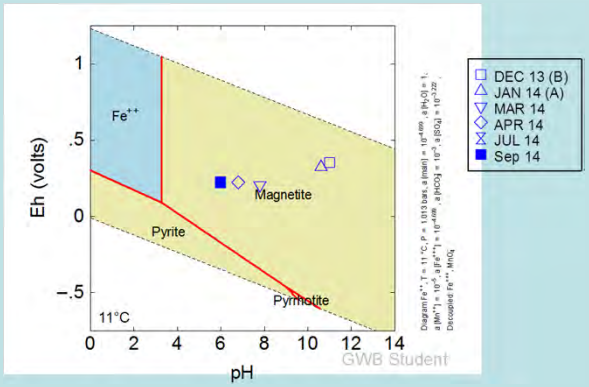

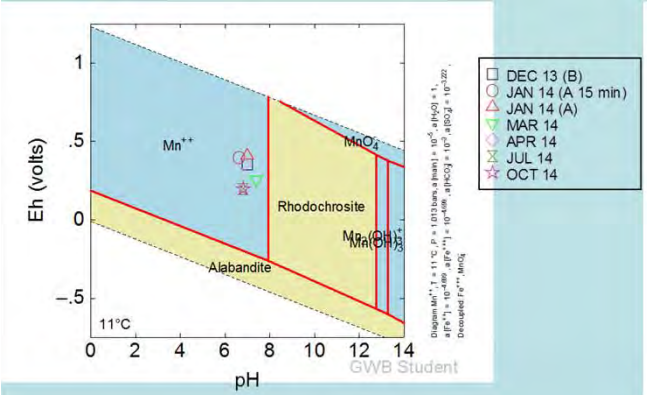

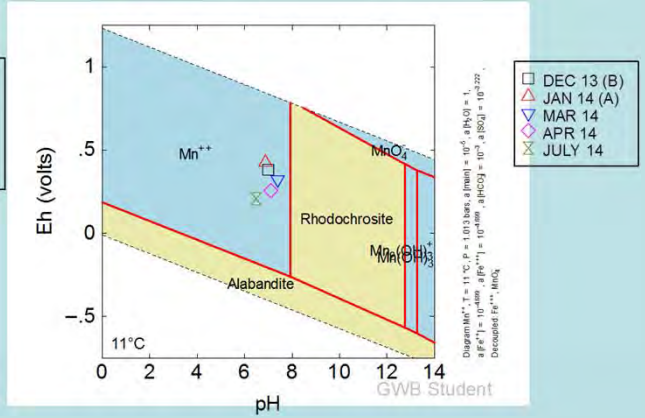

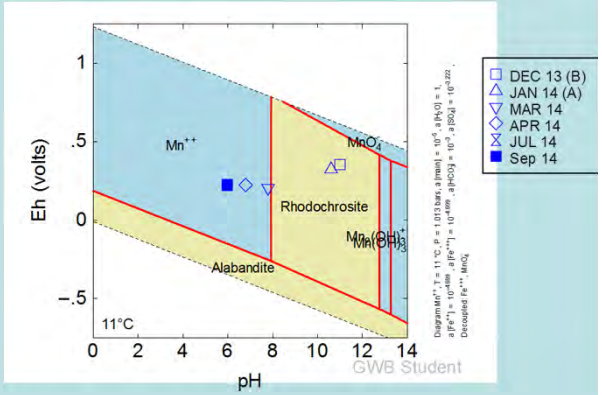

Eh-pH diagram for iron and manganese of Abstraction water samples

Eh-pH diagram for iron and manganese of Discharge water samples

Eh-pH diagram for iron and manganese of Monitoring water samples

Hydro-Geochemistry of Water

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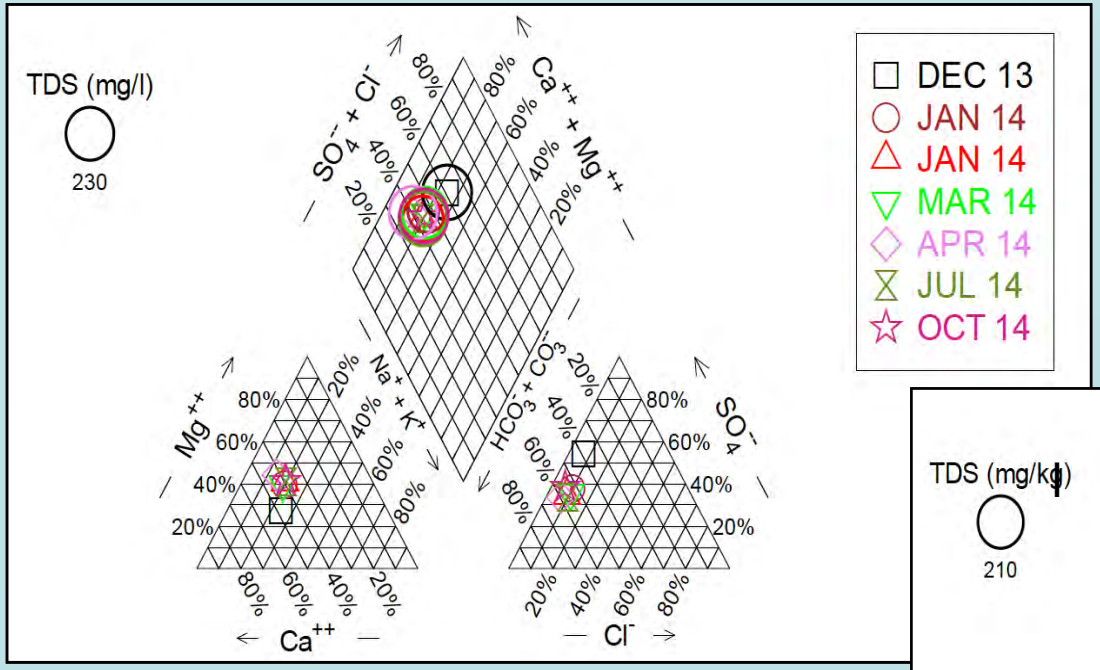
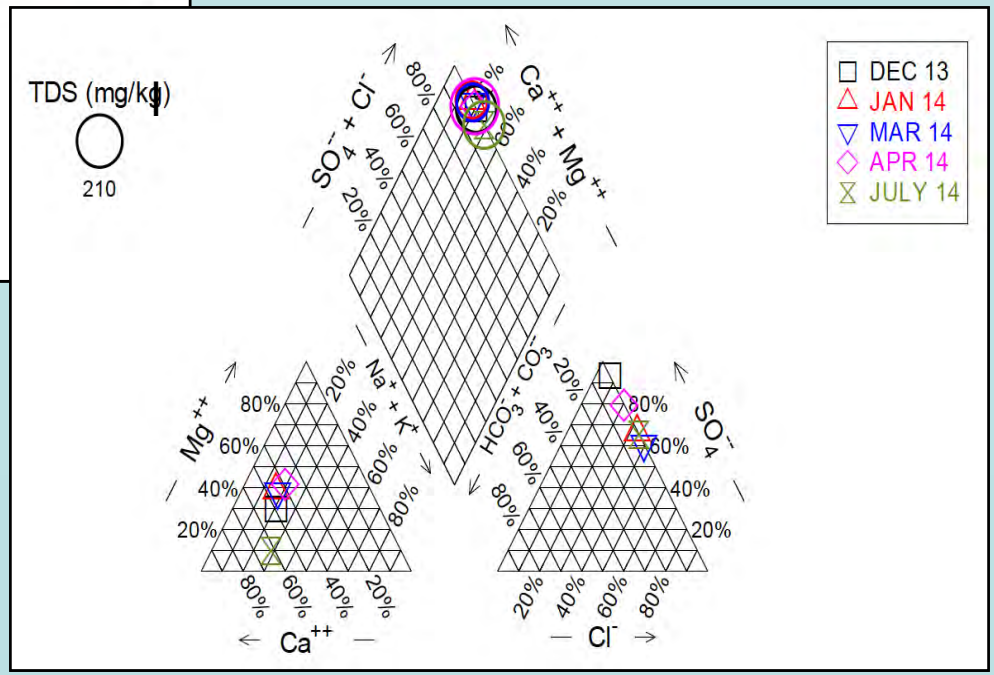


Piper diagram for Abstraction Borehole



Piper diagram for Discharge Borehole

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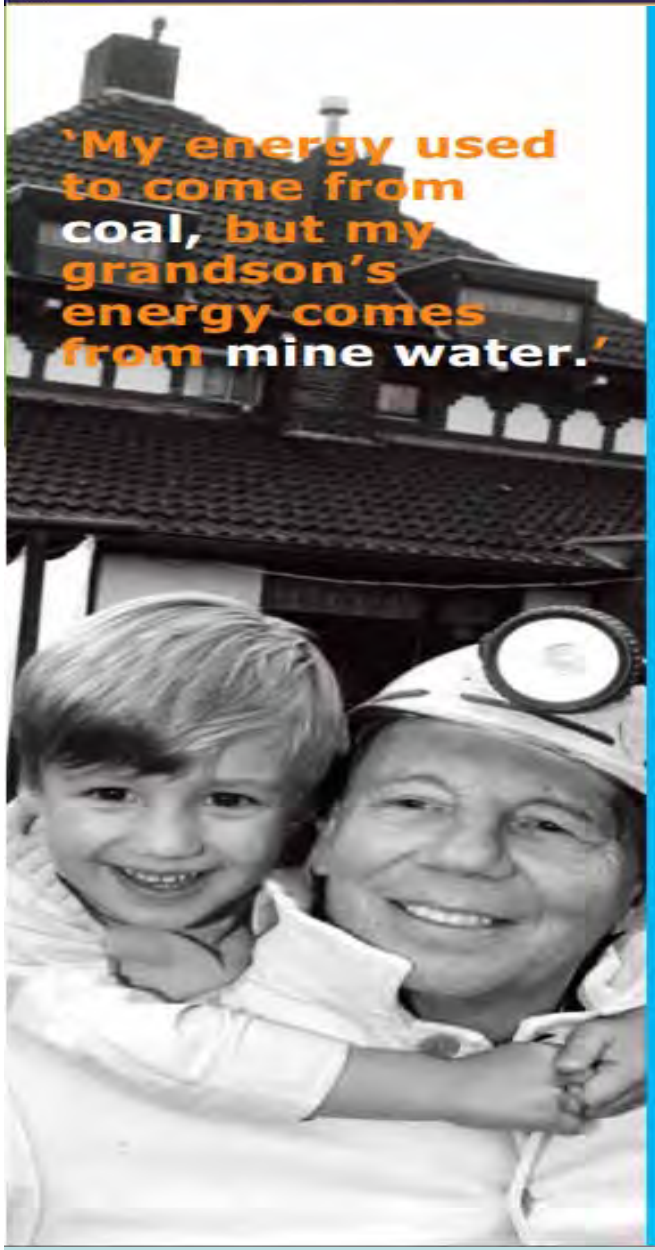

Mine water Energy

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Thank You