WSP ENVIRONMENT & ENERGY

PROVIDING SOLUTIONS FOR SUSTAINABLE DEVELOPMENT

Stansted Airport SG2 Ground Source Heat Pump Trial – Results and Interpretation

Geothermal Live - 1st May 2008

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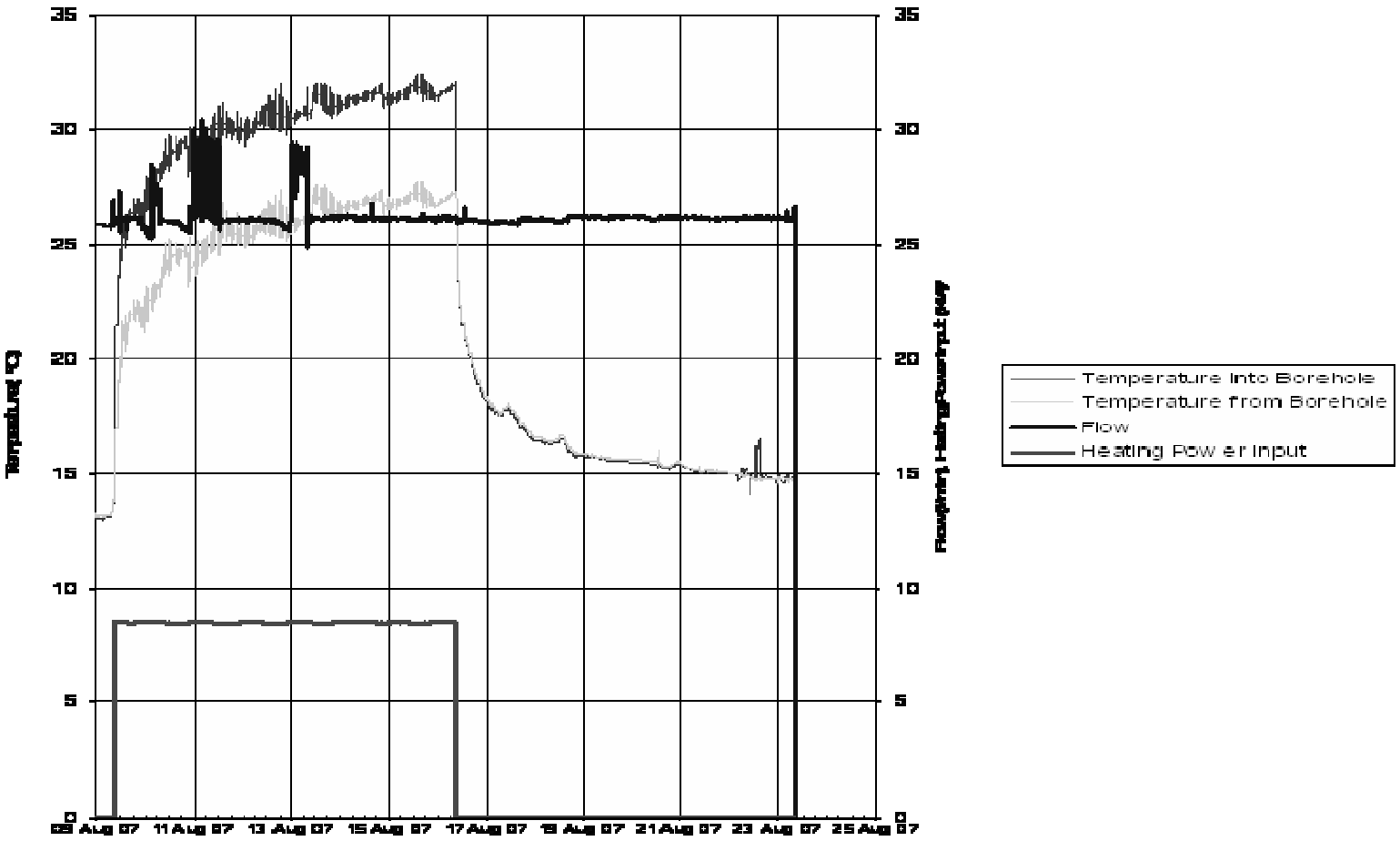
WSP

Acknowledgements

- Nigel Raven, Senior Design Manager, SG2 Project
- Gary Holmes, WJ Groundwater
- Ian Willis

Thermal Response Test Results

Figure 2: Thermal Response Test Data



Heating and cooling phases

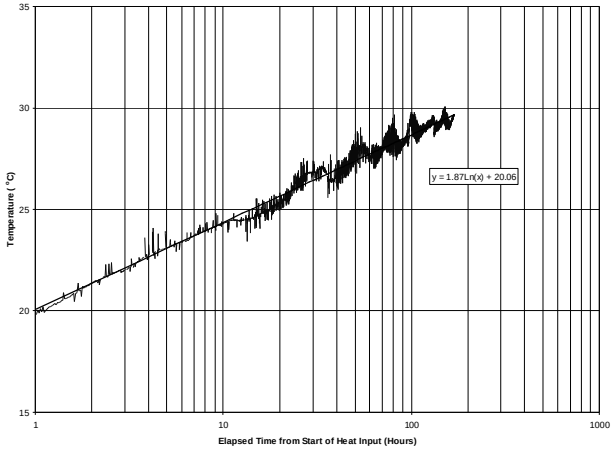
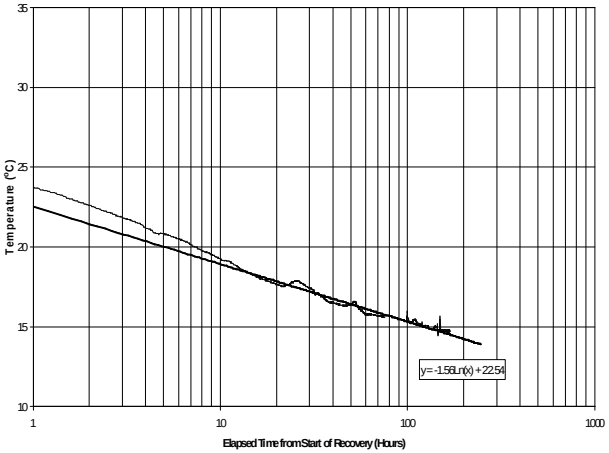
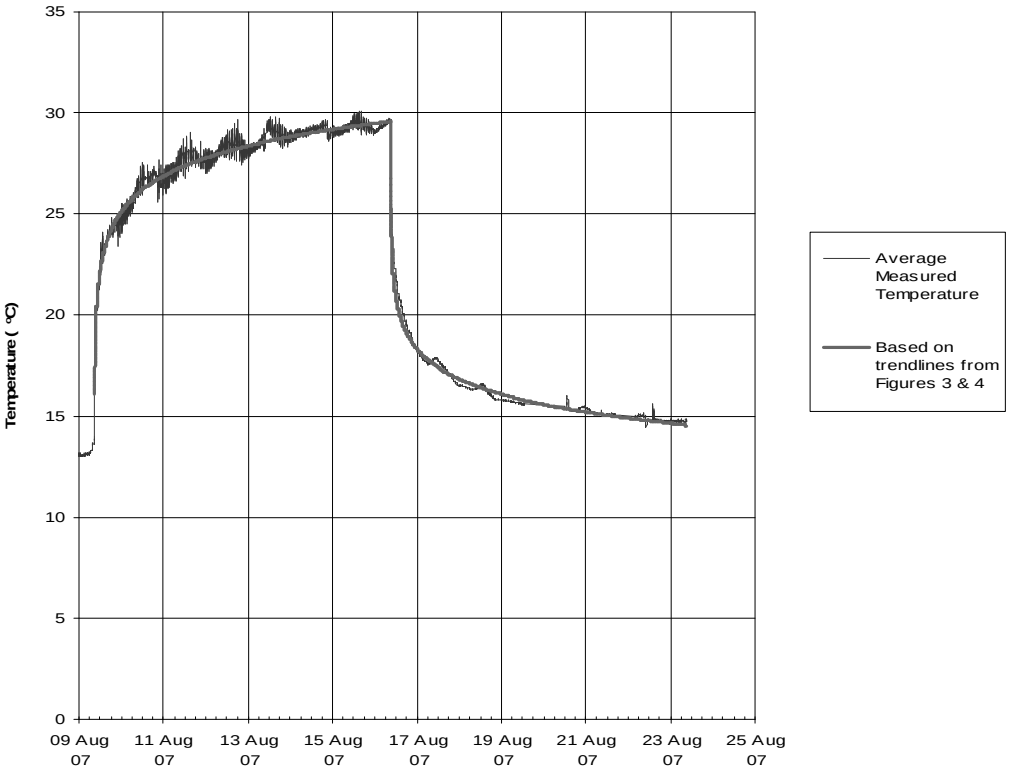


Figure 4: Semi-Log Average Temperature Plot, Recovery Phase





Thermal Conductivity Results

In situ Measurement of Ground Thermal Properties			
Heating			
	[Enter Value]		
k	1.87	Inclination of temperature v log time (-)	
Q	8.5	Heat injection / extraction (kW)	
H	200	Length of borehole heat exchanger (m)	
λ_{eff}	1.81	Effective thermal conductivity (W/m.K)	$\lambda_{eff} = Q / 4 \pi H k$
Cooling			
	[Enter Value]		
k	1.56	Inclination of temperature v log time (-)	
Q	8.5	Heat injection / extraction (kW)	
H	200	Length of borehole heat exchanger (m)	
λ_{eff}	2.17	Effective thermal conductivity (W/m.K)	$\lambda_{eff} = Q / 4 \pi H k$
Average	**1.99**	**W/m.K**	

Thermal Resistance Results

	[Enter Value]		
Q	8.5	Heat injection / extraction (kW)	8500 W
H	200	Length of borehole heat exchanger (m)	
λ_{eff}	1.81	Effective thermal conductivity of rock (W/m.K)	
S_{vc}	2.75E+06	Specific heat capacity by mass of the ground ($J/m^3/K$)	
r_b	0.0775	Borehole radius (m)	
t	86400	Time (s)	
T_0	286.1	Undisturbed average ground temperature over length of borehole (K)	
T_b	299.3285	Average temperature of collector fluid in borehole at time t (K)	
γ	0.5772	Euler's constant 0.5772	
α	6.58E-07	Thermal diffusivity	
R_b	1.77E-01	Borehole thermal resistance (K.m / W)	

Important - convert Celcius to Kelvin

Celcius	Kelvin
13.1	286.1

Time (days)	Time (secs)	Av Temp (K)	Rb (K.m/W)
1	86400	26.3285	1.77E-01
2	172800	27.599	1.76E-01
3	259200	28.3165	1.75E-01
4	345600	28.2665	1.62E-01
5	432000	29.0335	1.70E-01
6	518400	29.2635	1.67E-01
7	604800	29.559	1.67E-01
			1.71E-01

Observations from Trial

- Pump power must be factored into the calculations
- Ambient air temperature must be measured and taken into account and sensor cables must be well insulated
- Upper section of borehole would benefit from thermal grout
- Access to the site of installation was not feasible but the results are considered representative for closed system – importance of geo/hydro analysis
- Temperature changes in the fluid were rapid – purpose is to obtain thermal parameters only and is not representative of operational mode. THEREFORE…

- The test was successful in obtaining the thermal parameters but the results should never be used in isolation to determine feasibility. Modelling is required to ensure the optimum configuration is achieved.

Basic Modelling

- **Earth Energy Designer (EED)** used for initial analysis
  - Models ground feasibility but not any impact of plant
- Originally planned 1500 energy piles. EED loads calculated on 100 piles – EED system limitation
- Model assumptions:
  - 100% cooling uses ground and 100% heating from heat pumps. CoP = 4.
  - No additional free or conventional cooling was used in the calculations. These will be used in practice.
- Results demonstrate
  - Borehole spacing is critical to the system operation
  - EED is too simple for analysis of such a complex system but further analysis using GSHP in combination with conventional methods led to no significant fluctuation from ambient ground temperature over time
  - In conjunction with supplementary systems - Use of GSHP at SG2 is feasible and sustainable

Conclusions

- Thermal conductivity across the **whole** borehole was averaged as being 1.99W/m.K
- Thermal resistance across the **whole** borehole was averaged as being 0.17 K.m/W
- On large schemes small variations in thermal properties can be economically significant and justifies in-depth testing

- Feasibility of using GSHP for heating and cooling in conjunction with supplementary systems was confirmed BUT…
- Additional modelling is required on completion of the final building mix to optimise system

THANK YOU

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