Winning the NIBE Project of the Year Award

Ground Source Live 2011

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NIBE Project Award Criteria

- Includes NIBE Ground Source Heat Pump
- Demonstrates Innovation
- Overcoming Difficulties
- Sustainable Renewable Energy Resource
- Must provide Energy/Cost Savings.

The Project

- 55 Bedroom Care Home for the Elderly
- Royal Masonic Benevolent Institution
- Scarbrough Court, Cramlington, Northumberland, North East England
- 180 kW Peak Heating (UFH System)
- 100 kW Peak DHW (65^{o}C – Hot Water).

Space Heating

- 80kW GSHP’s for UF space heating
- 2 No. x 40kW NIBE Fighter 1330
- Common Buffer Tank
- Docked with conventional gas boiler
- NIBE “Degree Minute Control”.


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Pre-Heating of DHW

- 40kW GSHP's for DHW heating
- 1 No. x 40kW NIBE Fighter 1330
- Single Pre-heat Buffer Tank (55^{o}C)
- Pre-heat water pumped to indirect coil within Solar Panel Calorifier
- Calorifier used as pre-heat water
- Boiler increases temperature to 65^{o}C.

Ground Energy Resource

- High heat demand for space heating
- GSHPs active for 5000 Full Load hours/a
- GSHPs providing 400MWh/a to building
- Large cumulative demand from ground
- Required innovation in Ground Energy.

Innovation by Overcoming Difficulties

- High annual heat demand from ground
- Restricted site area and depth
- Restricted depth due to mine workings
- No water table due to drained mines...

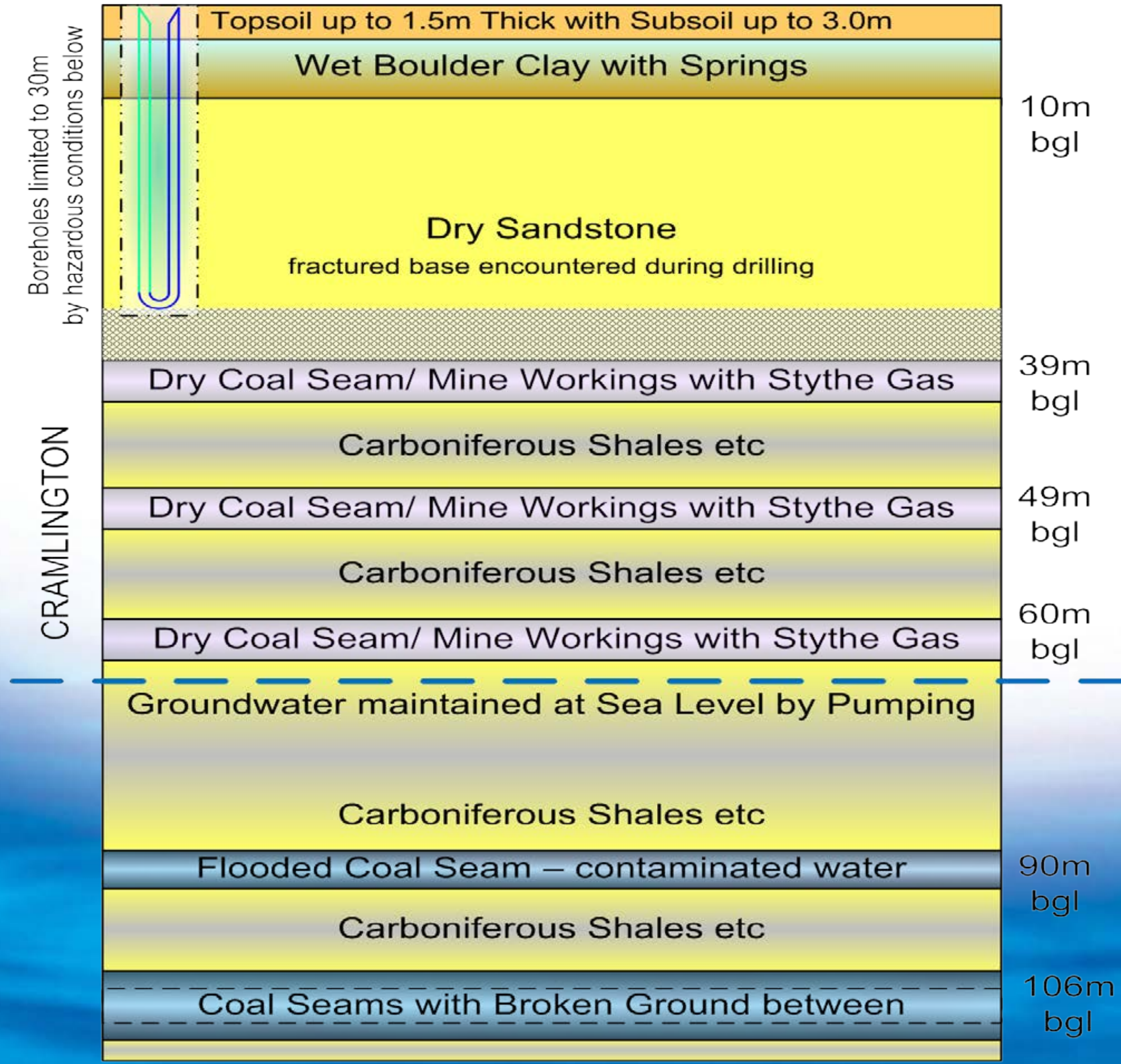
Innovation by Overcoming Difficulties

- Accurate mathematical modelling
- Multi-borehole testing to establish two key thermal properties of the ground
- Thermal recharge to the boreholes.

Mine Workings

- Numerous mineworkings
- Shallowest at 39m below ground level
- Mine fractured ground up to 32m bgl
- Boreholes limited to 30m bgl


Dewley
Doxford Pl
Doddington Dr
Alexandra Way
A1171
Westmorland Way
Hareside



Topsoil up to 1.5m Thick with Subsoil up to 3.0m
Wet Boulder Clay with Springs
Dry Sandstone
fractured base encountered during drilling
Boreholes limited to 30m by hazardous conditions below
10m bgl
Dry Coal Seam/ Mine Workings with Stythe Gas
39m bgl
Carboniferous Shales etc
Dry Coal Seam/ Mine Workings with Stythe Gas
49m bgl
Carboniferous Shales etc
Dry Coal Seam/ Mine Workings with Stythe Gas
60m bgl
CRAMLINGTON
Groundwater maintained at Sea Level by Pumping
Carboniferous Shales etc
Flooded Coal Seam – contaminated water
90m bgl
Carboniferous Shales etc
Coal Seams with Broken Ground between
106m bgl

Mathematical Modelling

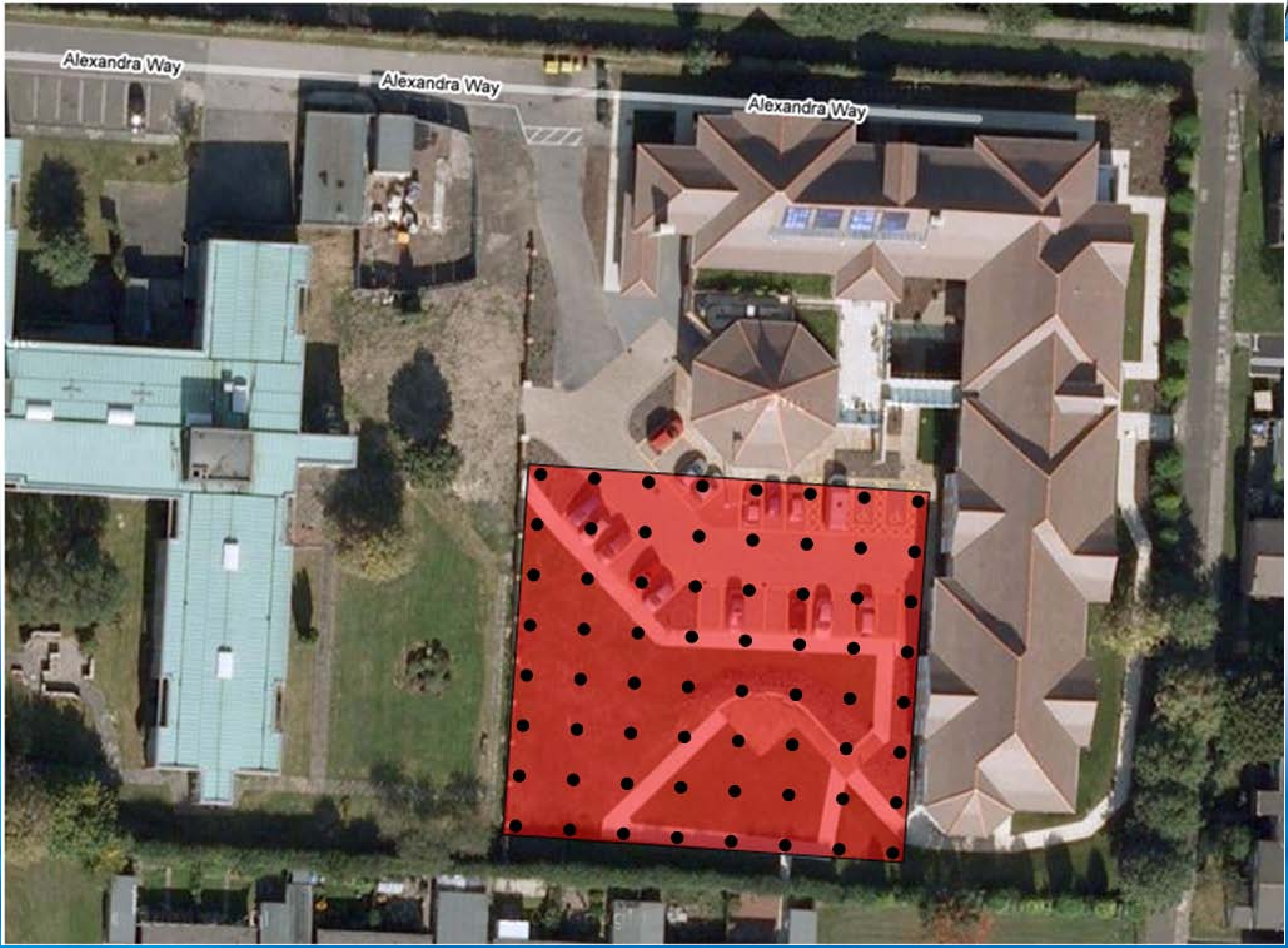
- In-house mathematical modelling
- Optimising heat abstraction from ground
- Economic design of borehole field
- Maximise abstraction from each borehole.

Collector Field Modelling

- Requirement to maximise heat abstraction
- Modelling various permutation of collectors.

$$\frac{\partial}{\partial x_i} k_{ij} \frac{\partial T}{\partial x_j} = \rho c \frac{\partial T}{\partial t}$$

T	= temperature
k_{ij}	= thermal conductivity
ρc	= volumetric heat capacity
$x_{i,j}$	= space
t	= time


Alexandra Way
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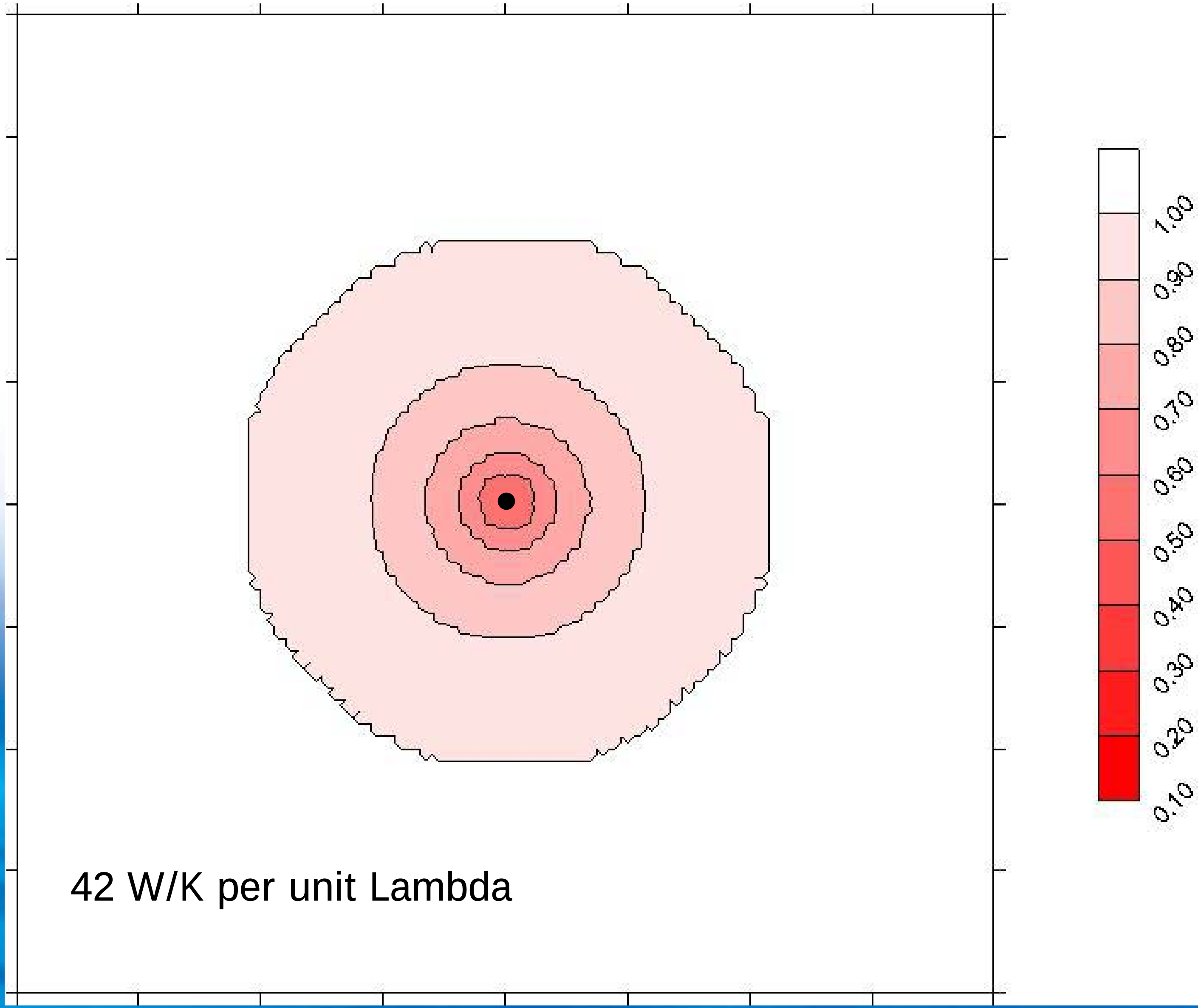
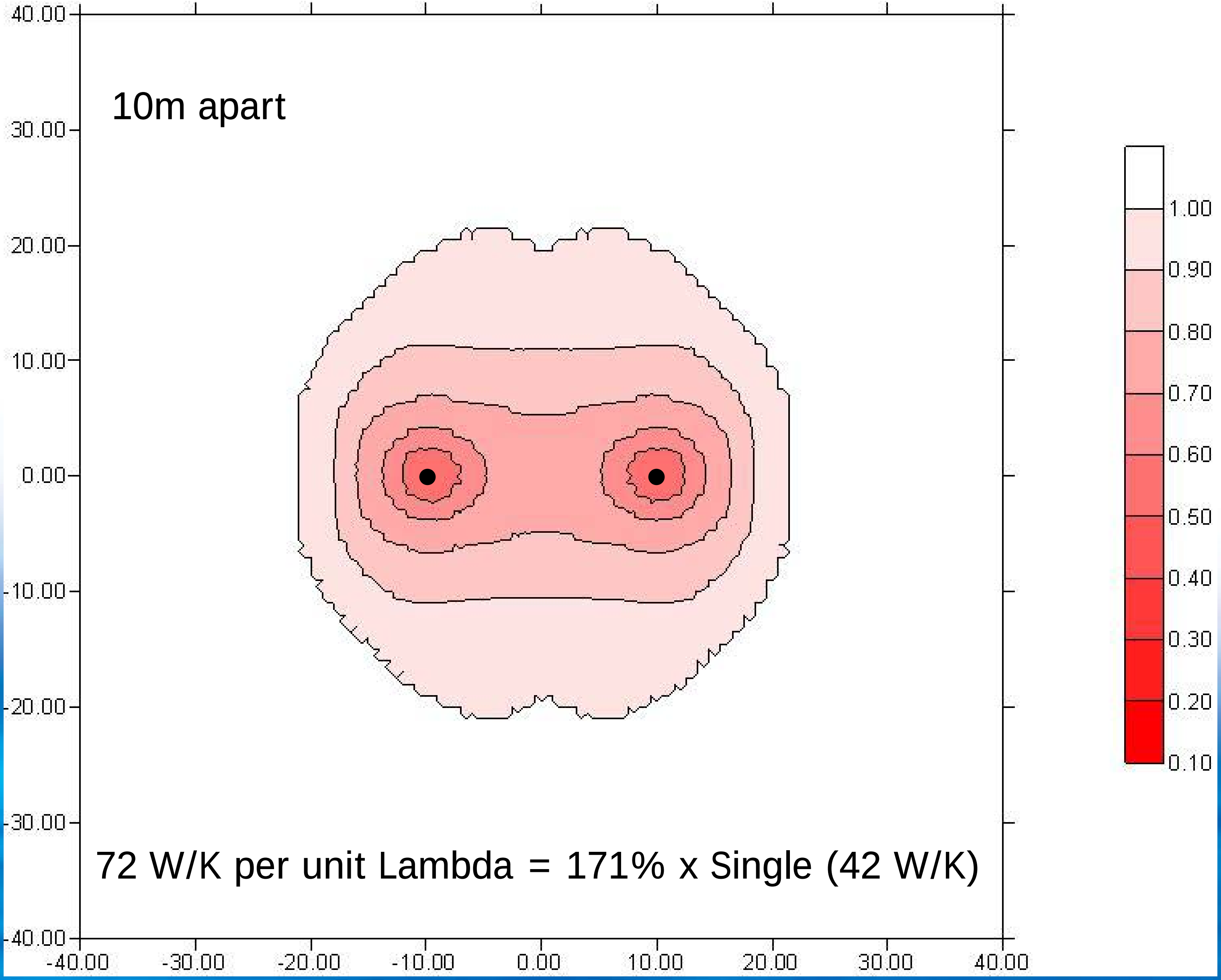
Alexandra Way

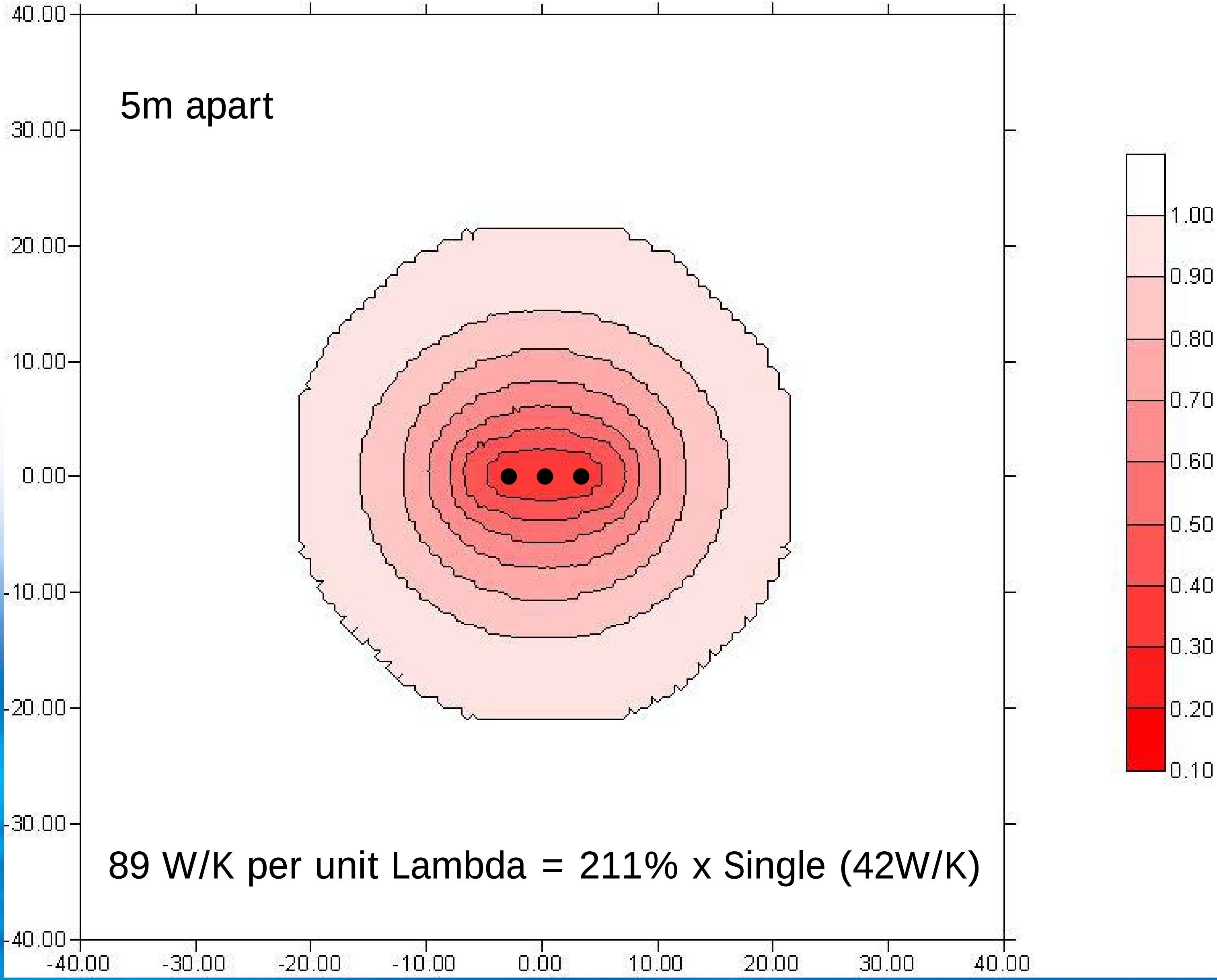
Single 30m Borehole

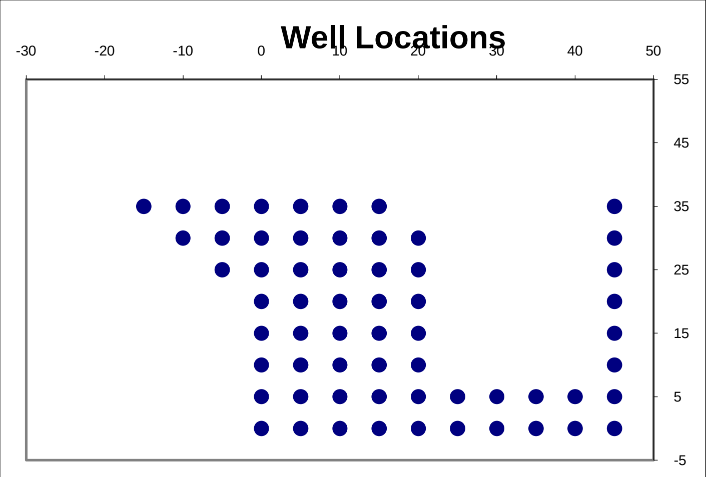


Two separated Boreholes

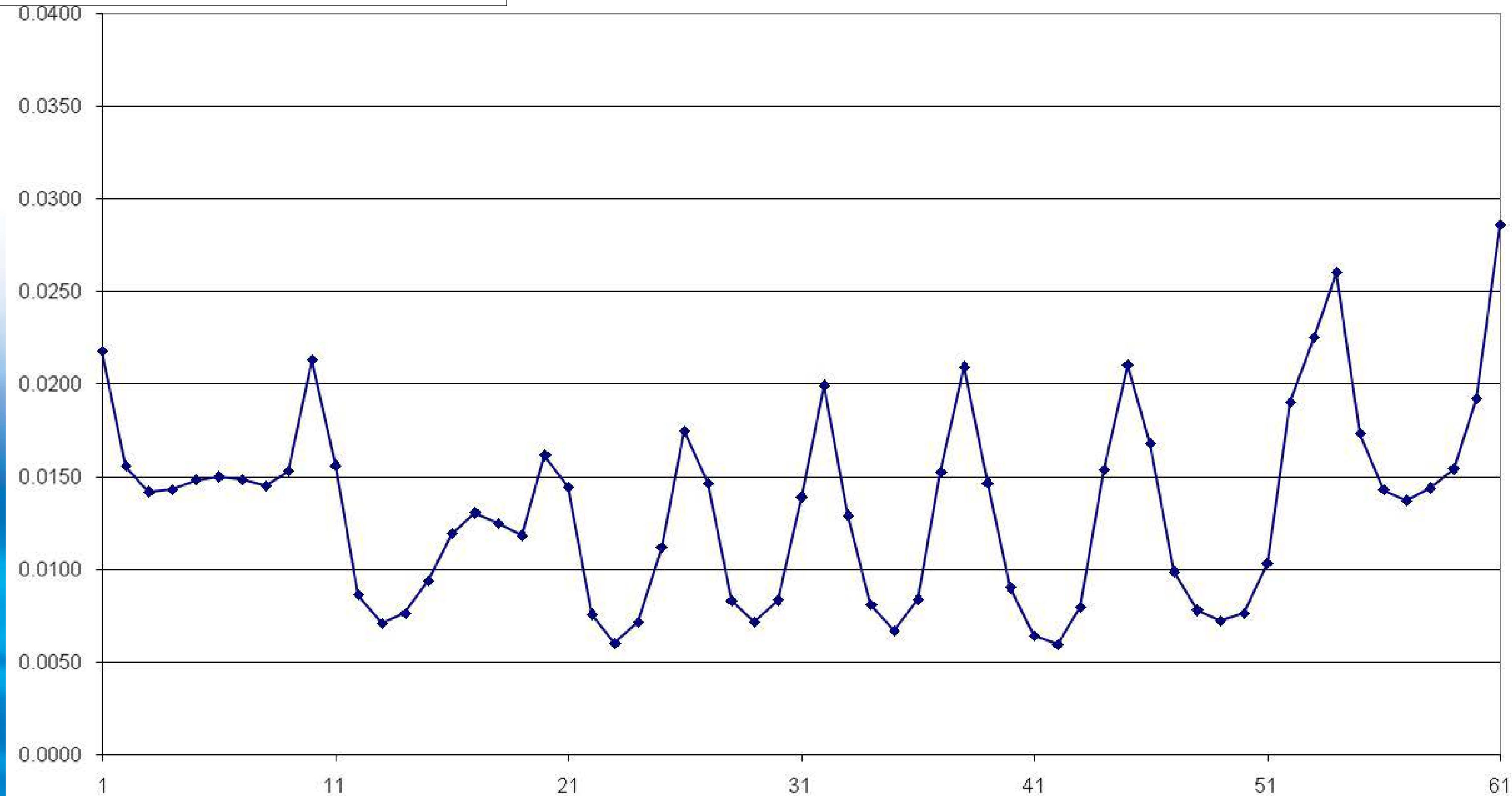


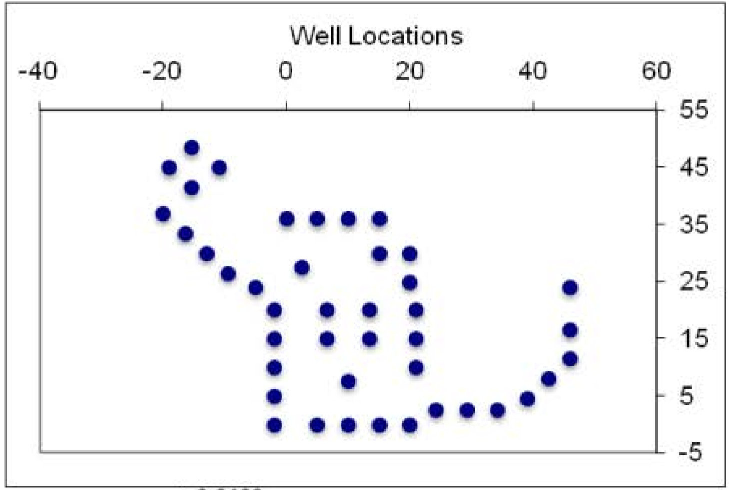
Three Close Boreholes



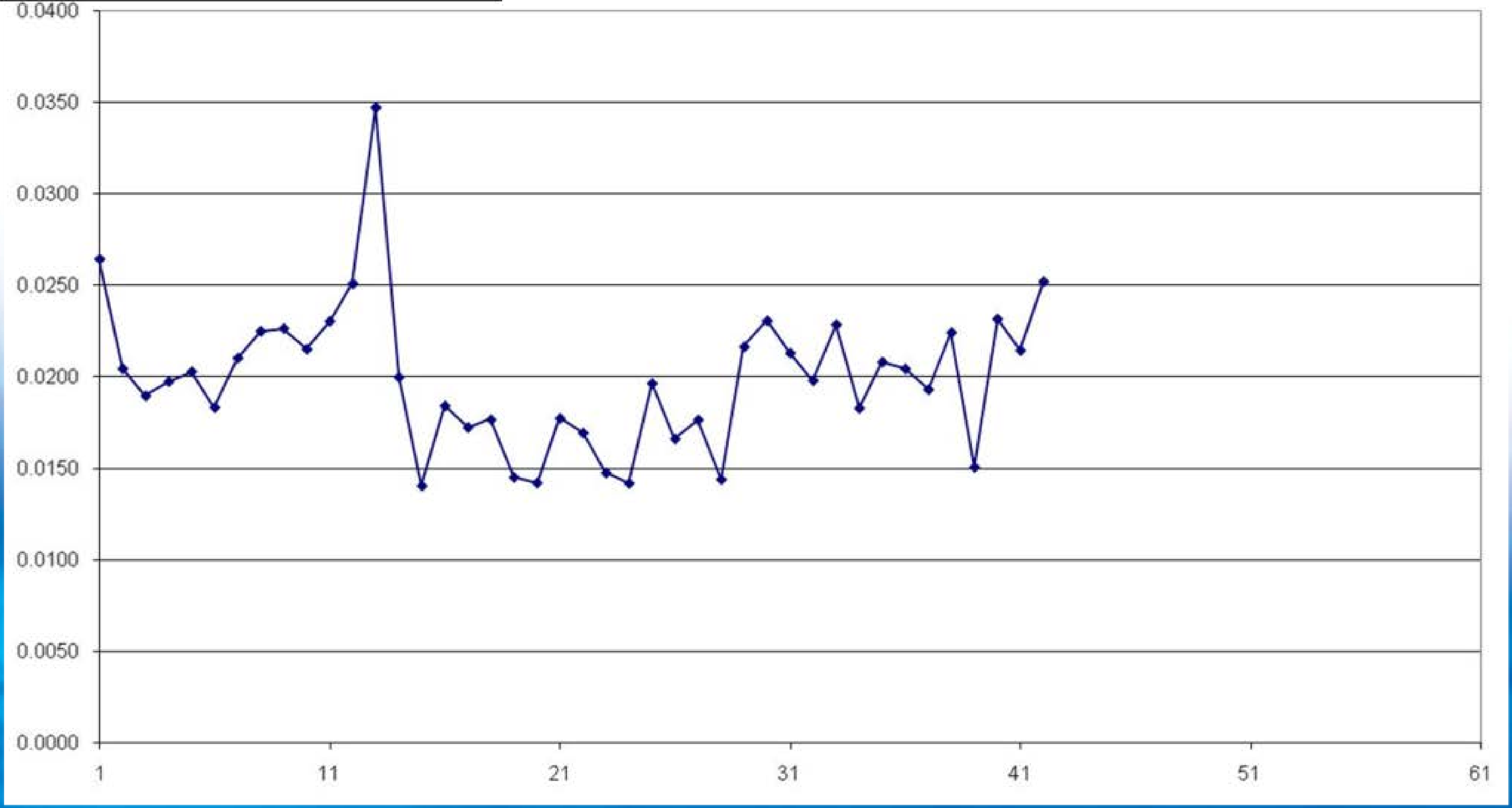


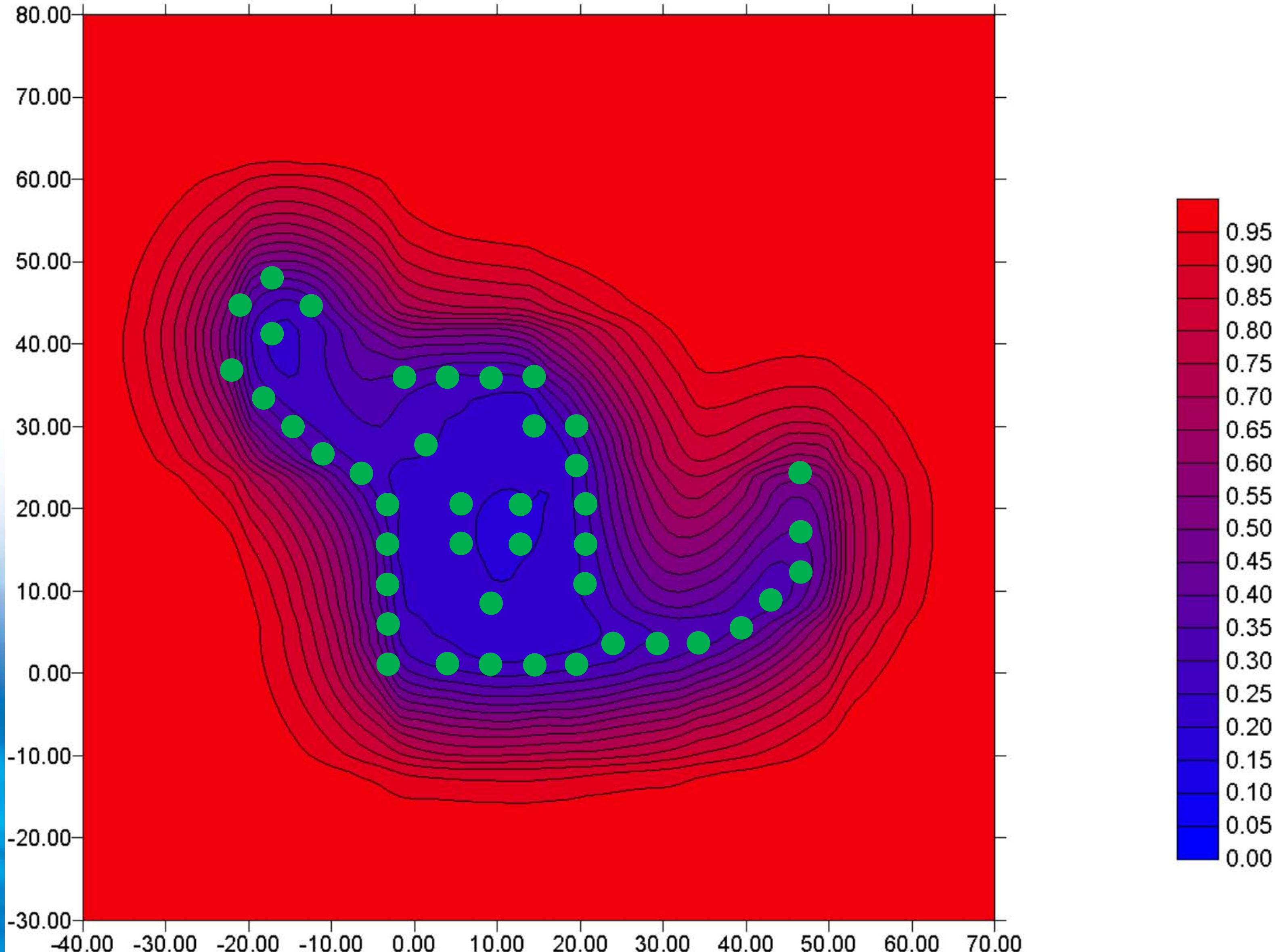
Individual Borehole Yield - 61 Boreholes
1 °C Temperature Difference
Heat Abstraction Rate: 816 W

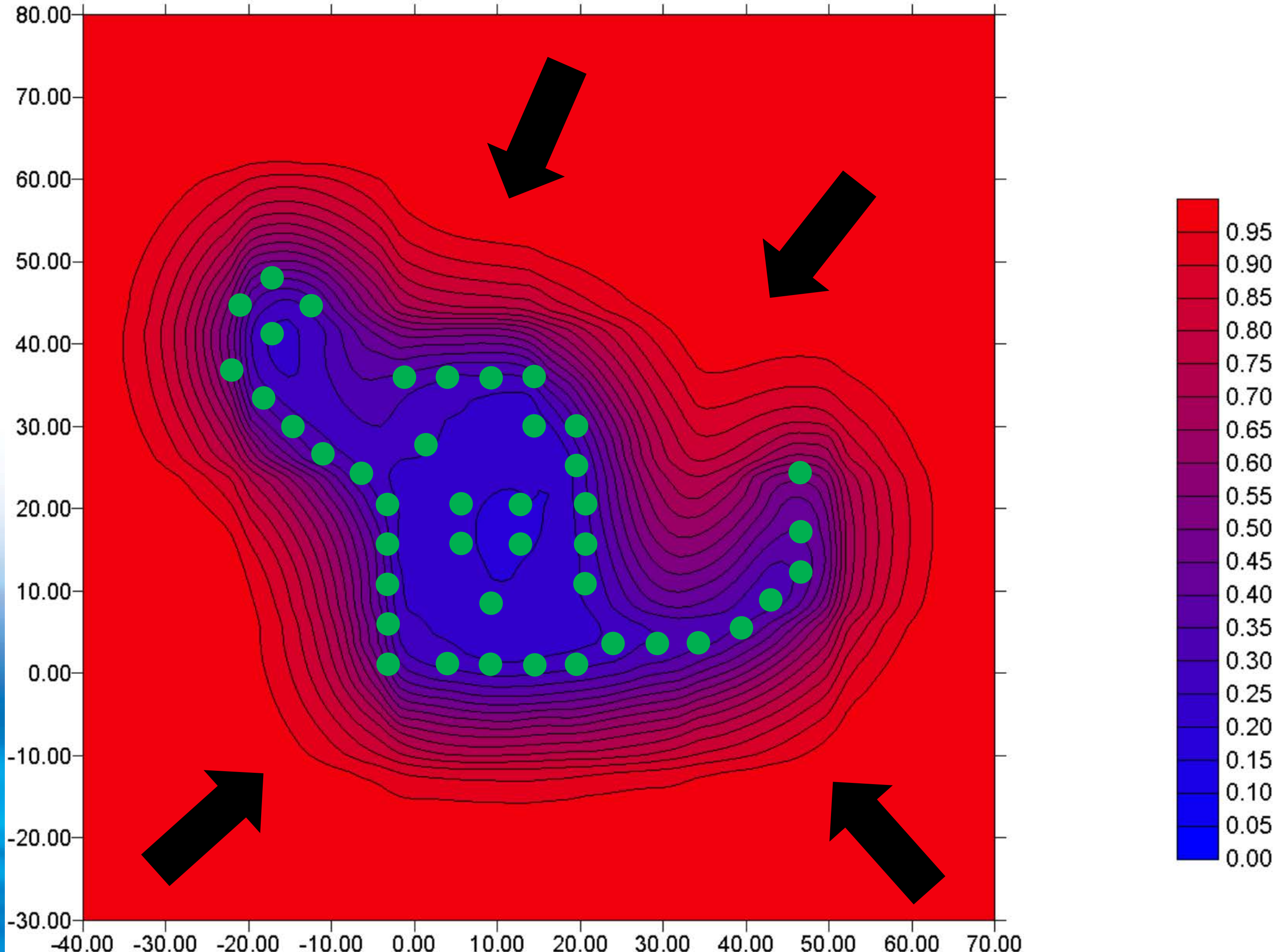




Individual Borehole Yield - 42 Boreholes
1 °C Temperature Difference
Total Heat Abstraction Rate: 837 W




80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
-40.00
-30.00
-20.00
-10.00
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00



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70.00
60.00
50.00
40.00
30.00
20.00
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0.00
-10.00
-20.00
-30.00
-40.00
-30.00
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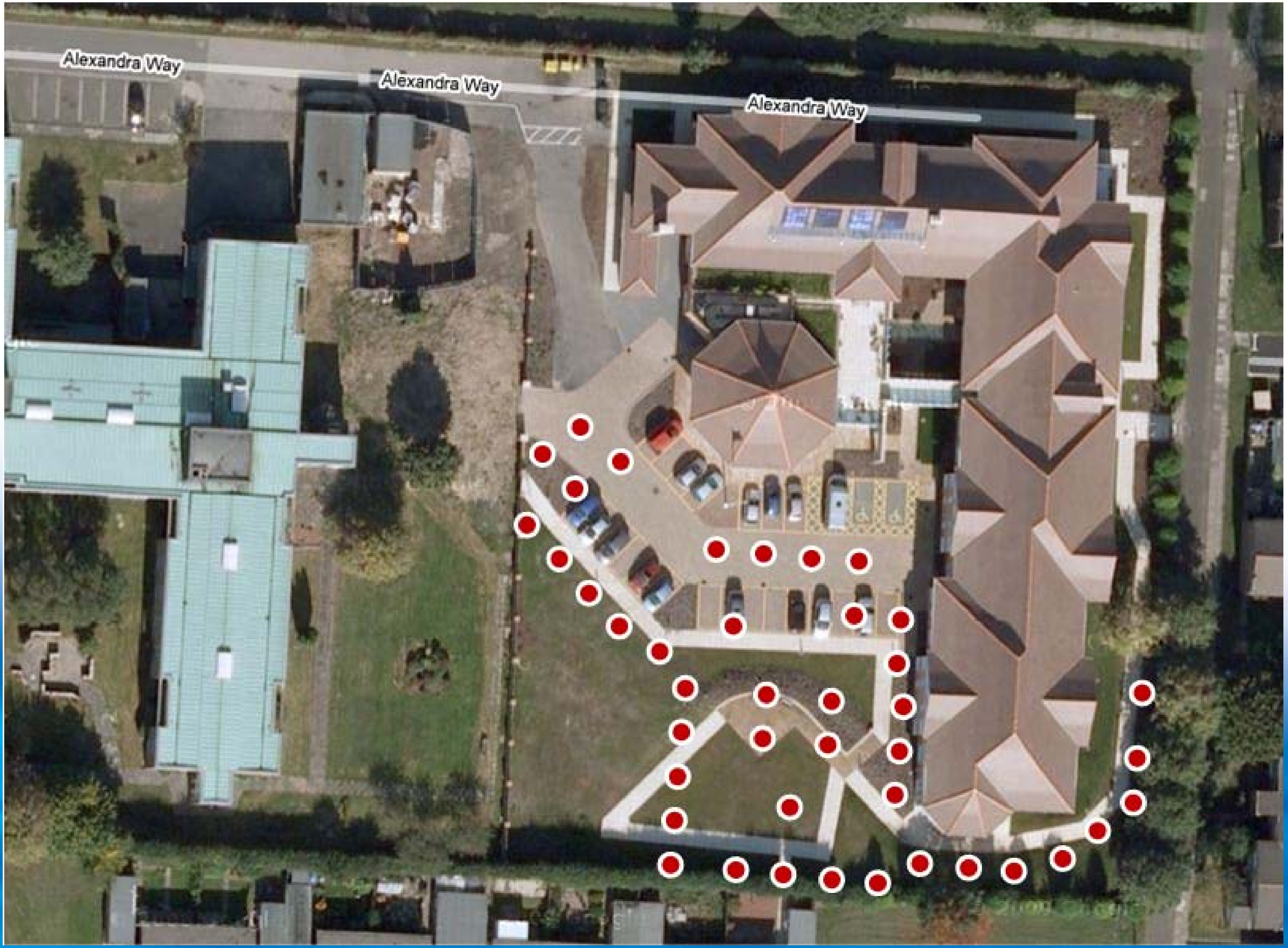
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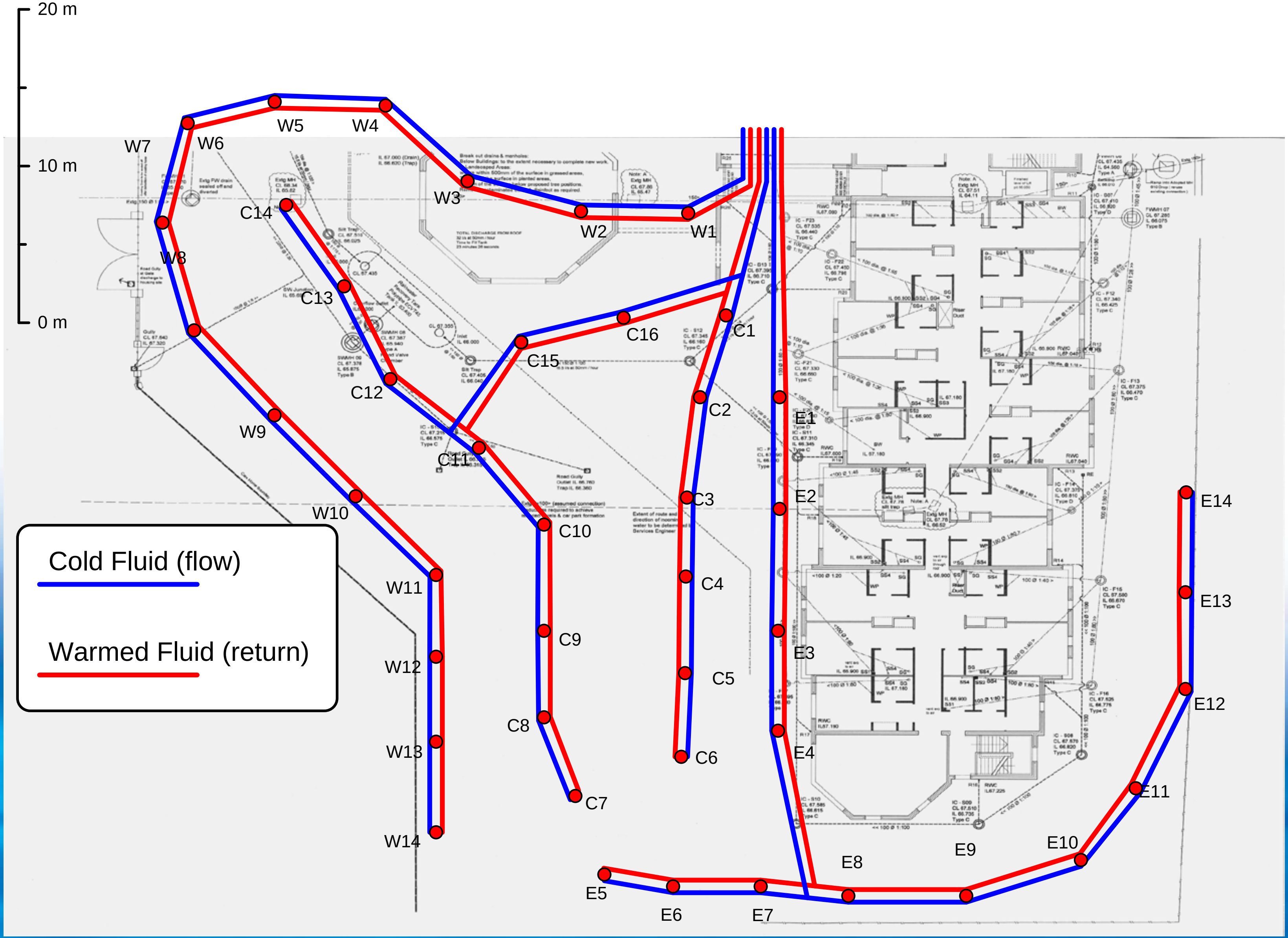
20 m
10 m
0 m
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
W14
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
E1
E2
E3
E4
E5
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E7
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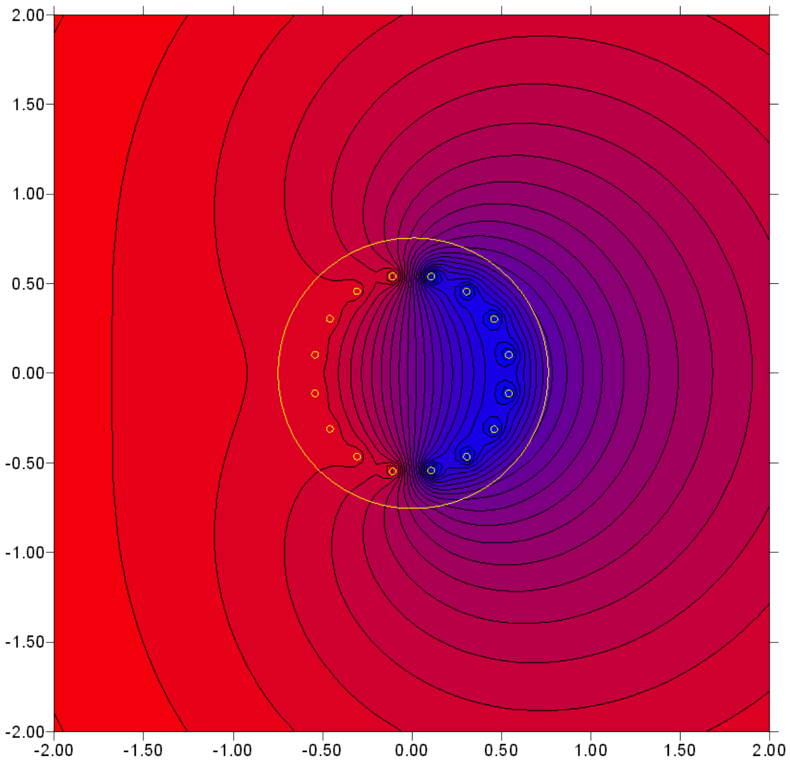
E14
Cold Fluid (flow)
Warmed Fluid (return)

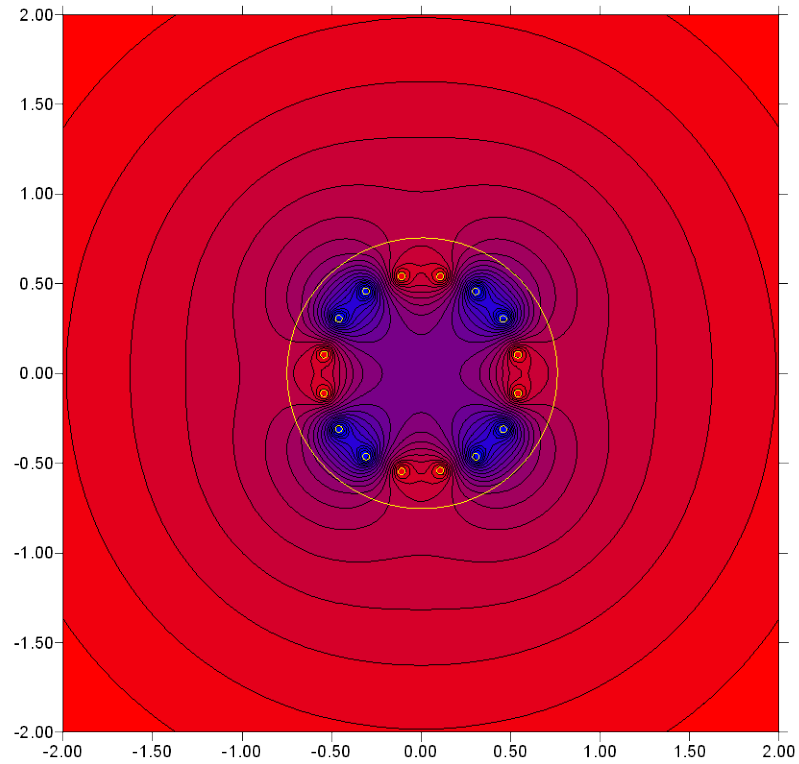
Borehole Modelling

- Requirement to maximise heat abstraction
- Modelling single loop versus double loop.



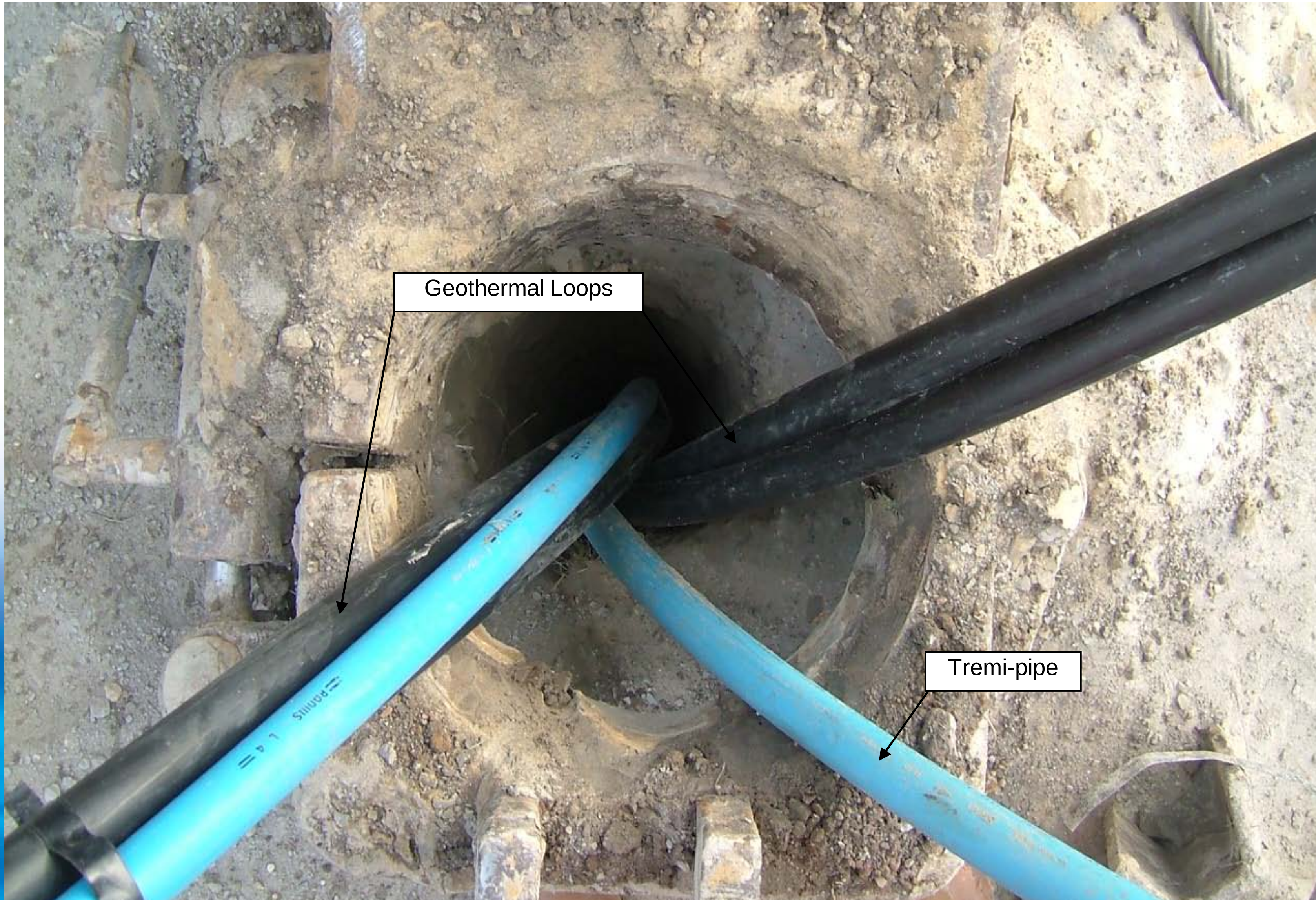
Scale: None
Drawing based on: Seftrans 006S

OGI Groundwater Specialists	Project: Energy Piles	Drawing: Figure 1 (IP/005/002D)	
	Client: Internal Project	Description: Heat Contour	
	Date: May 2007	Drawn by: JG	Checked by: ST

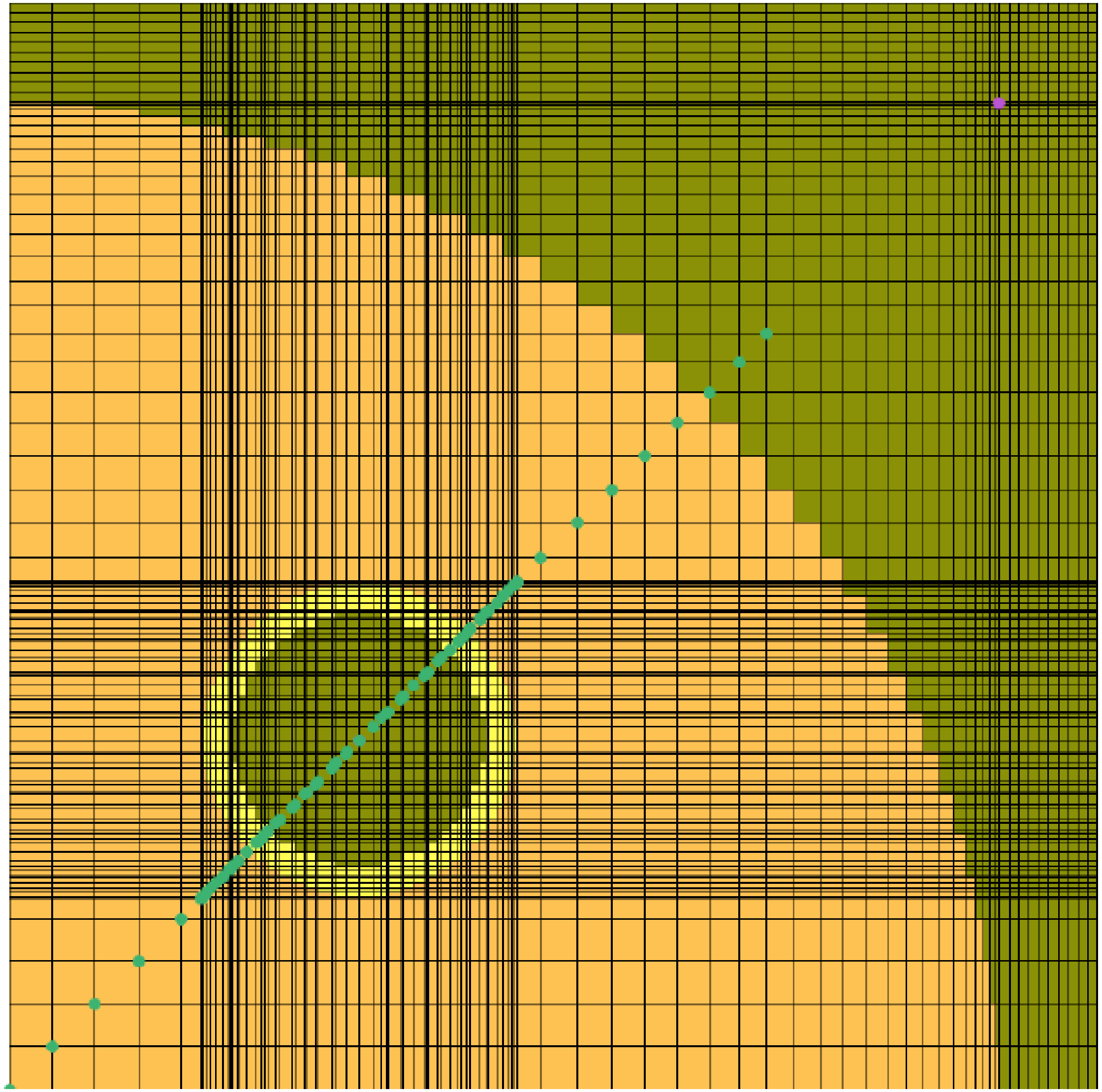


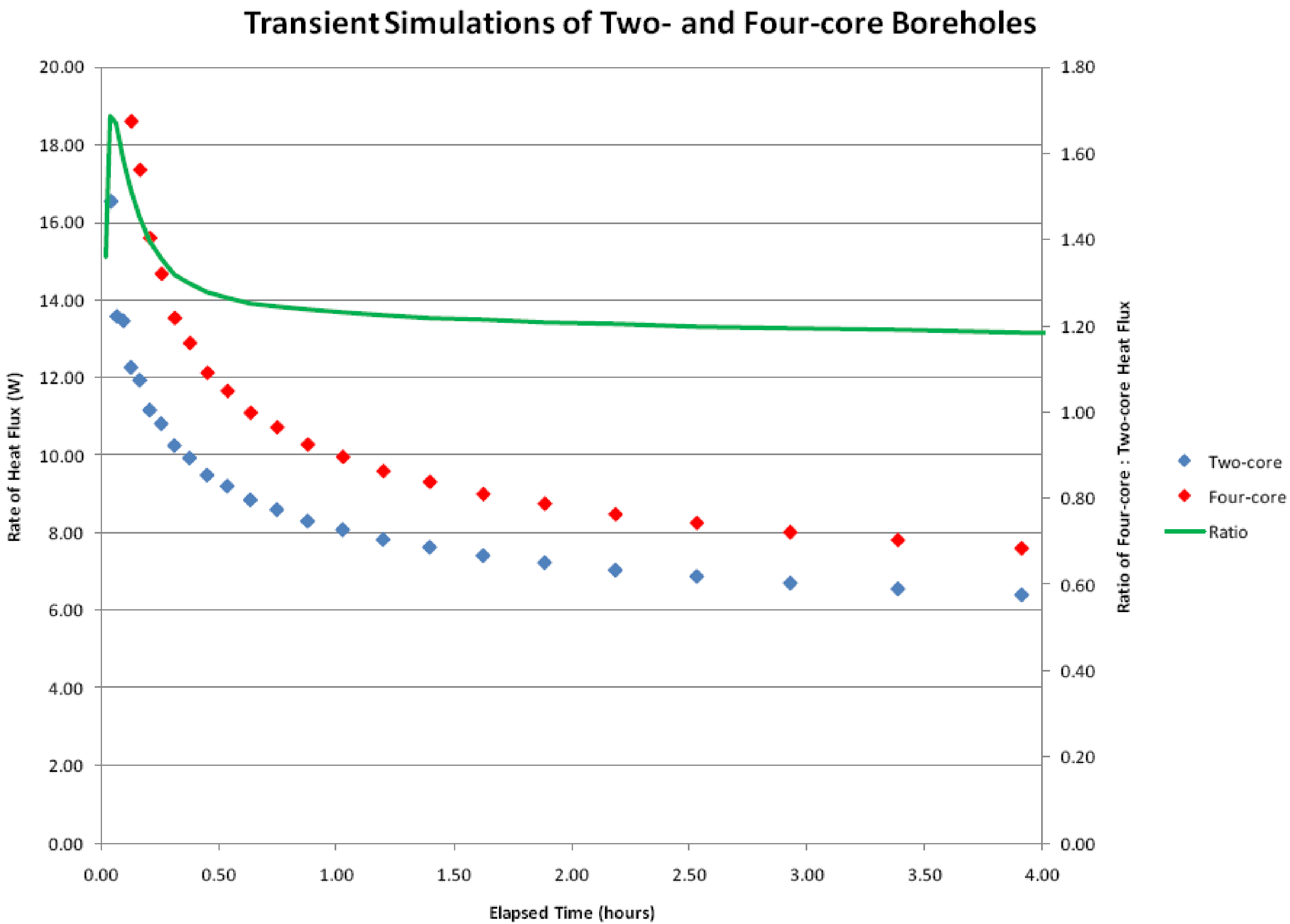
Scale: None
Drawing based on: Seftrans 007S

OGI Groundwater Specialists	Project: Energy Piles	Drawing: Figure 2 (IP/005/003D)	
	Client: Internal Project	Description: Heat Contour	
	Date: May 2007	Drawn by: JG	Checked by: ST

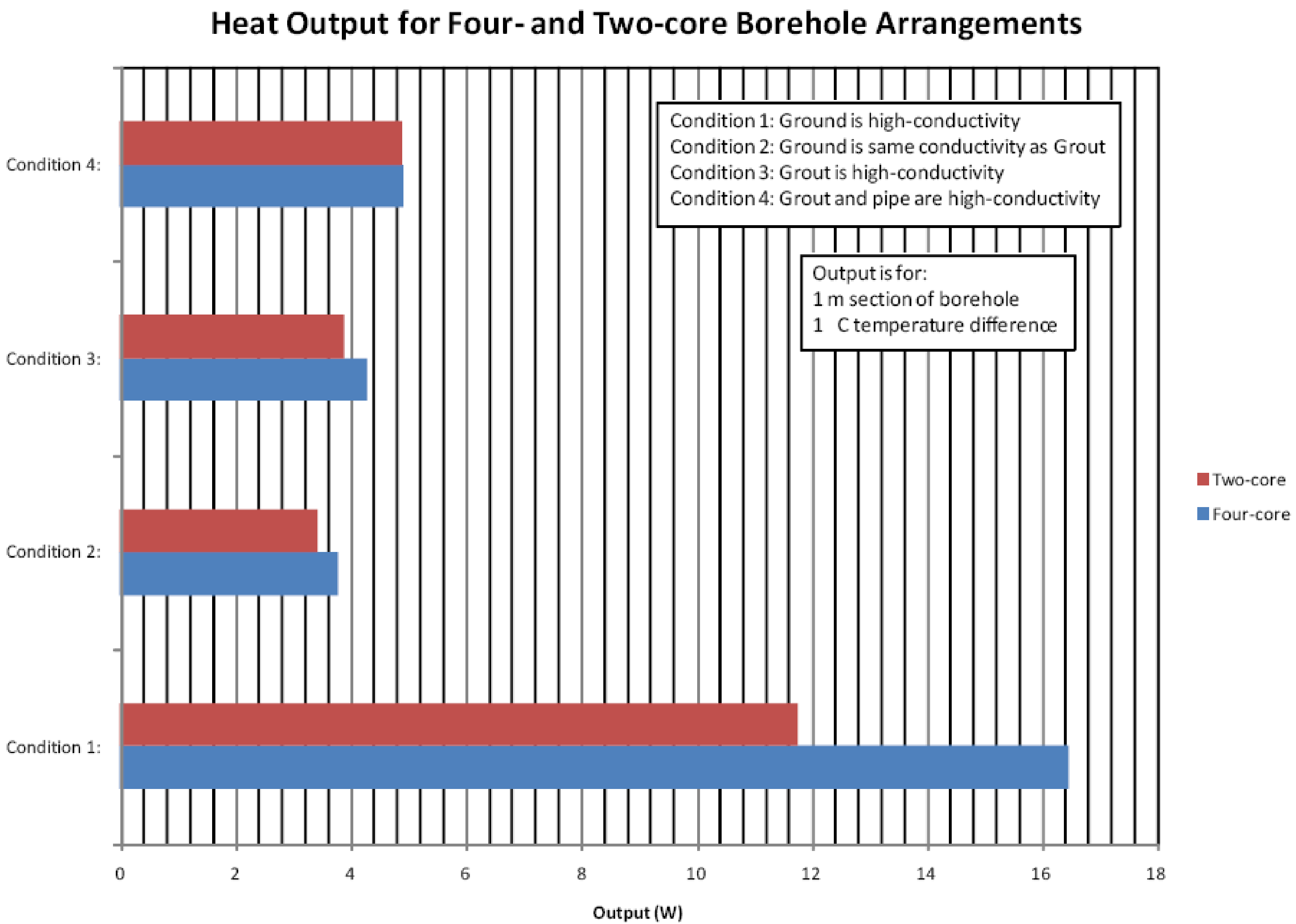

Geothermal Loops
Tremi-pipe

Multi-Core Borehole Efficiency





Transient Simulations of Two- and Four-core Boreholes
Rate of Heat Flux (W)
Ratio of Four-core : Two-core Heat Flux
Elapsed Time (hours)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Two-core
Four-core
Ratio


Heat Output for Four- and Two-core Borehole Arrangements
Condition 4:
Condition 3:
Condition 2:
Condition 1:
Condition 1: Ground is high-conductivity
Condition 2: Ground is same conductivity as Grout
Condition 3: Grout is high-conductivity
Condition 4: Grout and pipe are high-conductivity
Output is for:
1 m section of borehole
1 C temperature difference
Two-core
Four-core
0
2
4
6
8
10
12
14
16
18
Output (W)

Thermal Testing

- Heat resource dependent on ground
- Thermal conductivity governs sustainable annual heat resource
- Volumetric heat capacity governs the heat storage of summer recharged heat
- Thermal test using **three** boreholes
- Observing temperature change at **three** locations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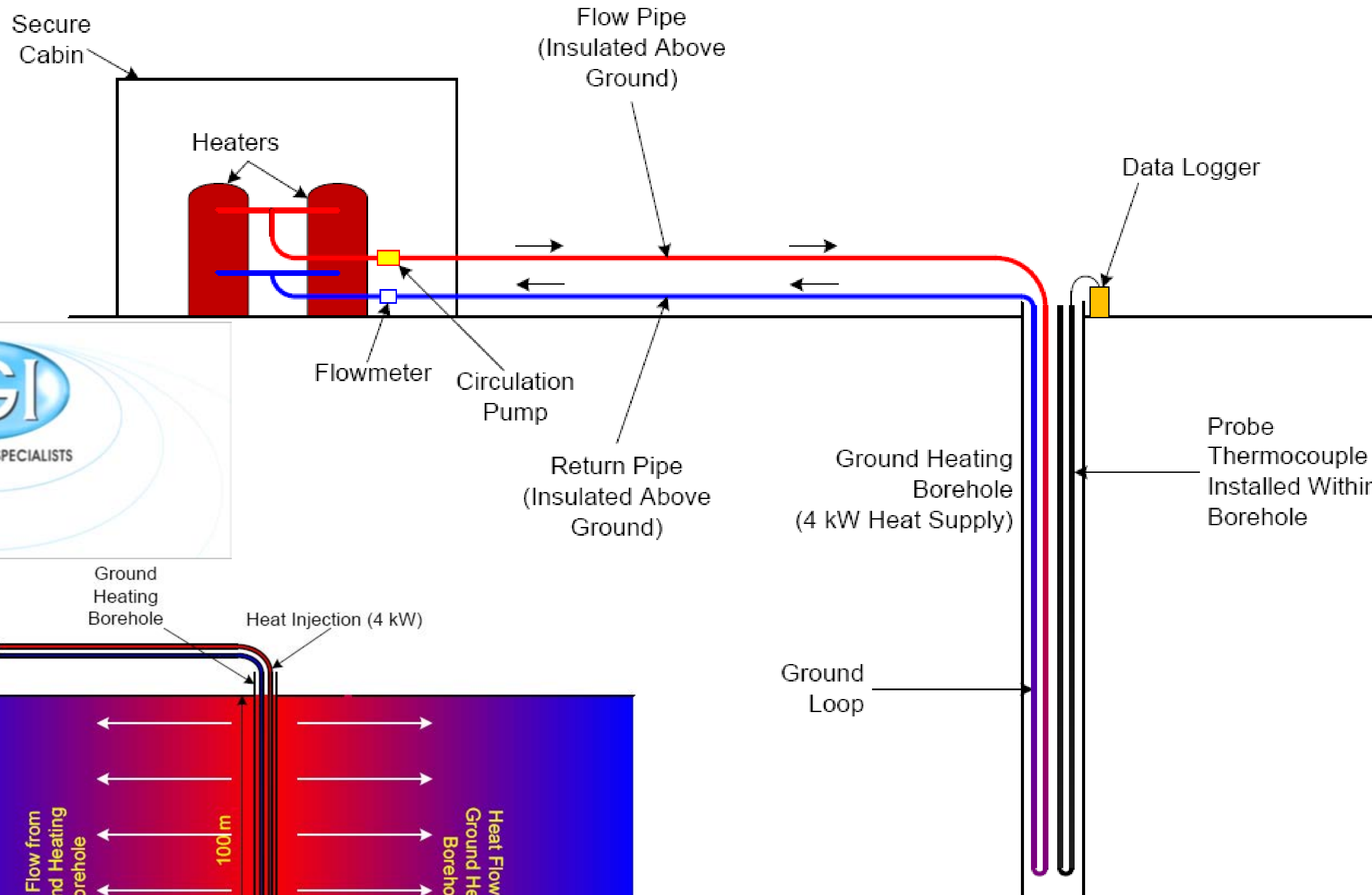
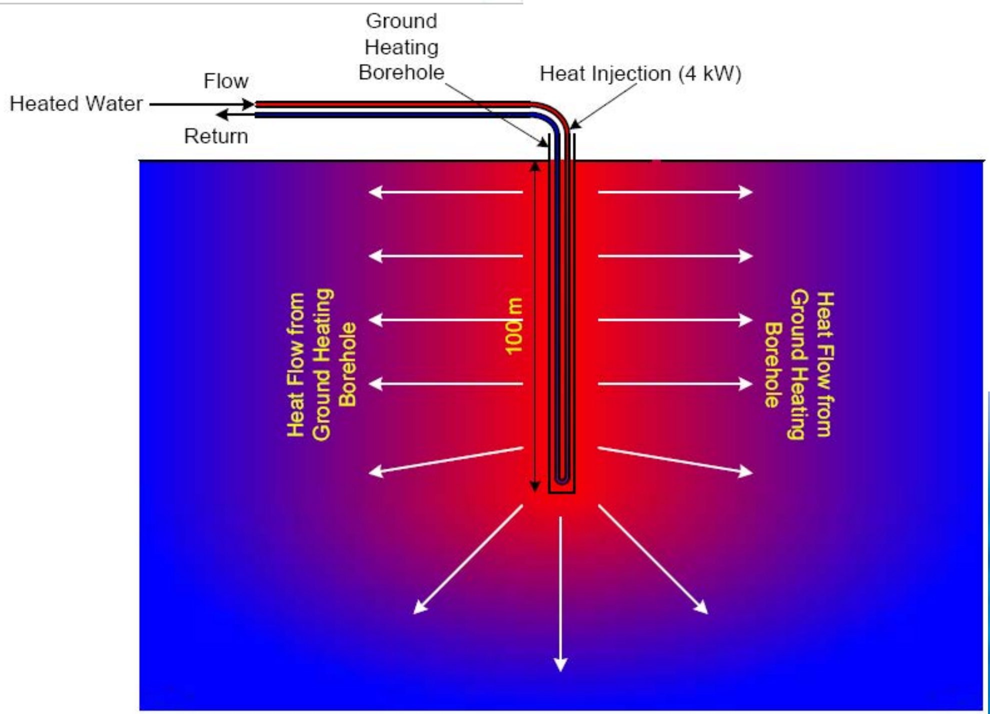
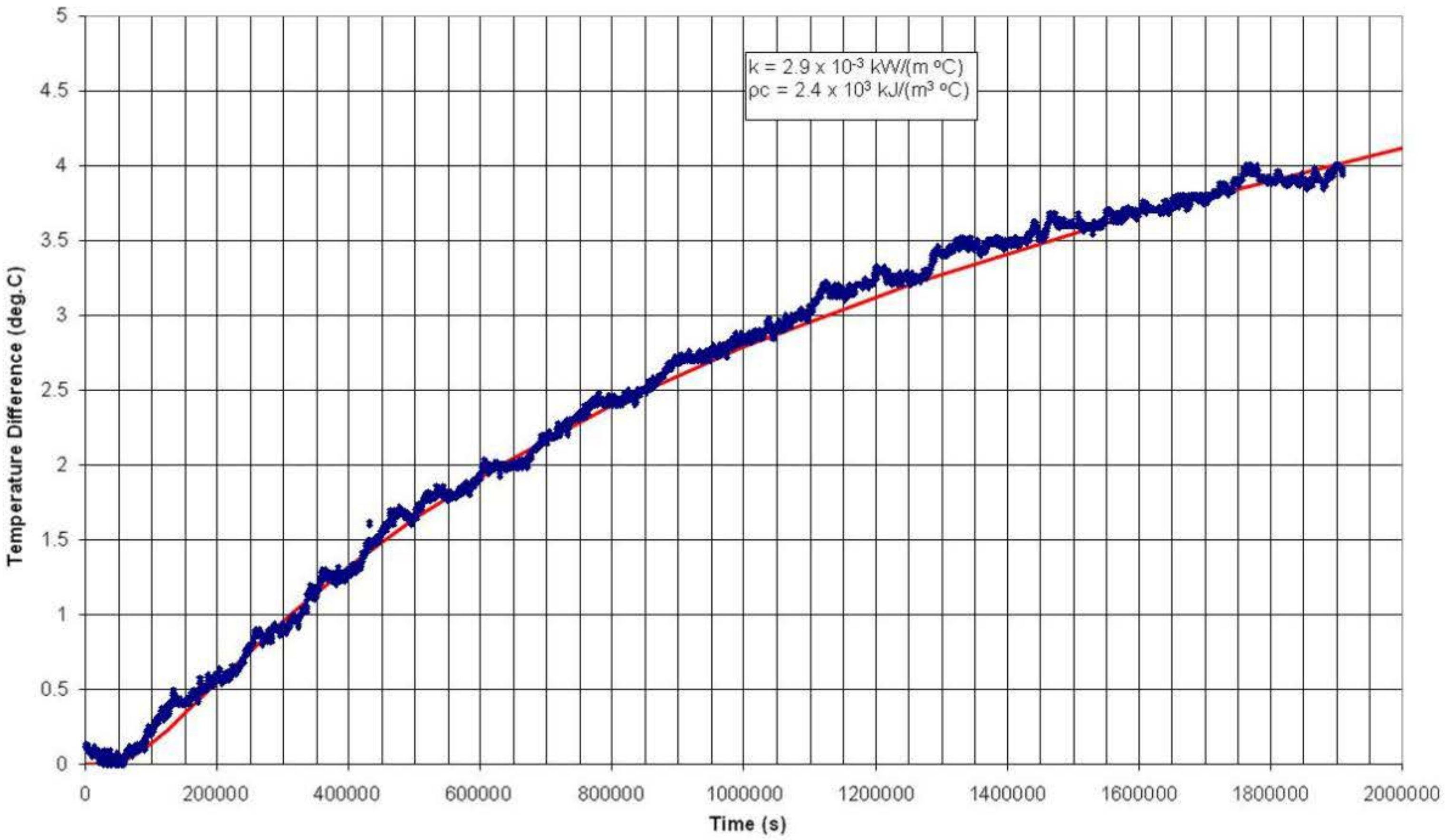


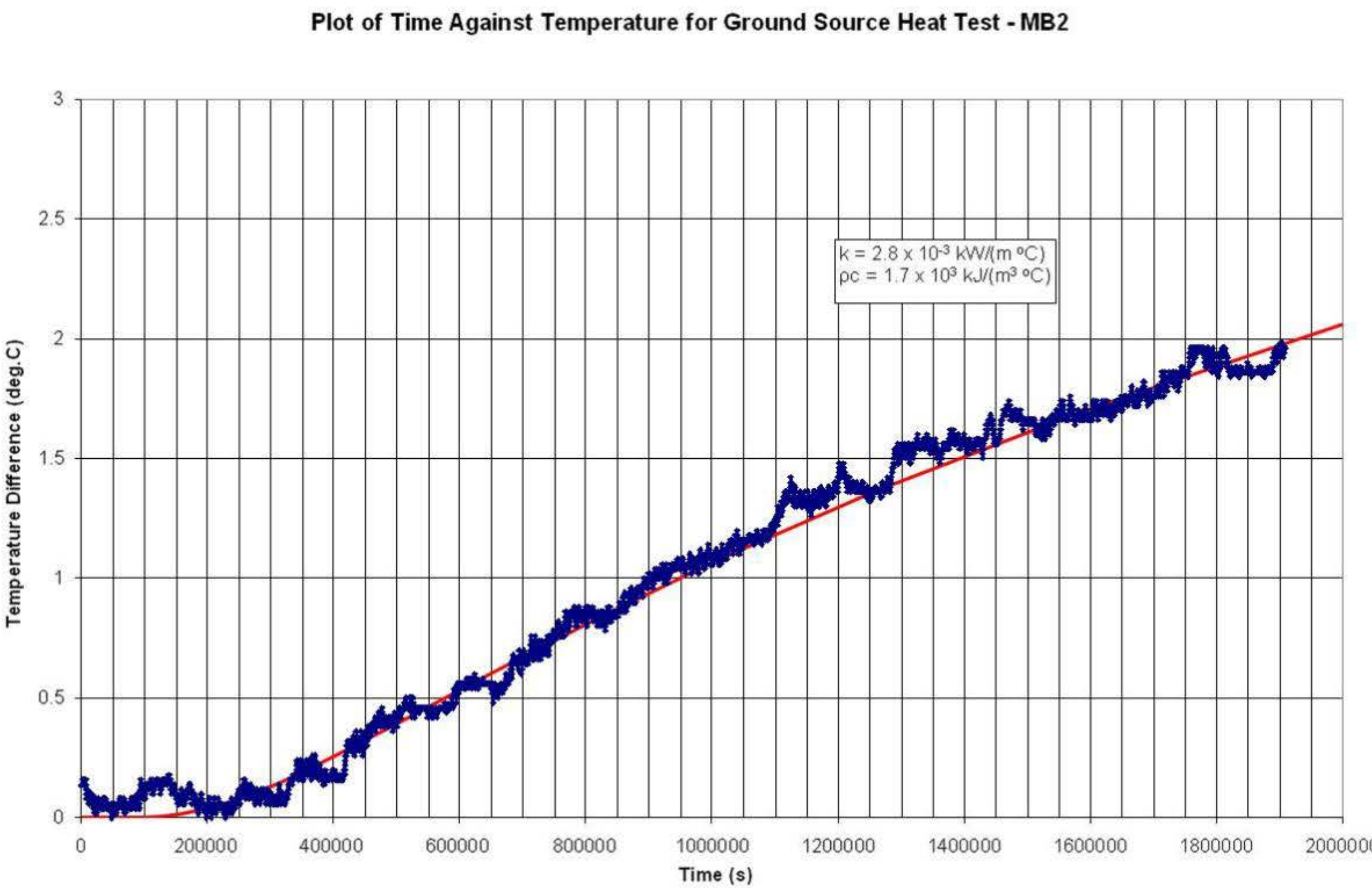


Work on Site starts with a Ground Conductivity Test. This tells us how fast the Heat will flow into our collector pipes.

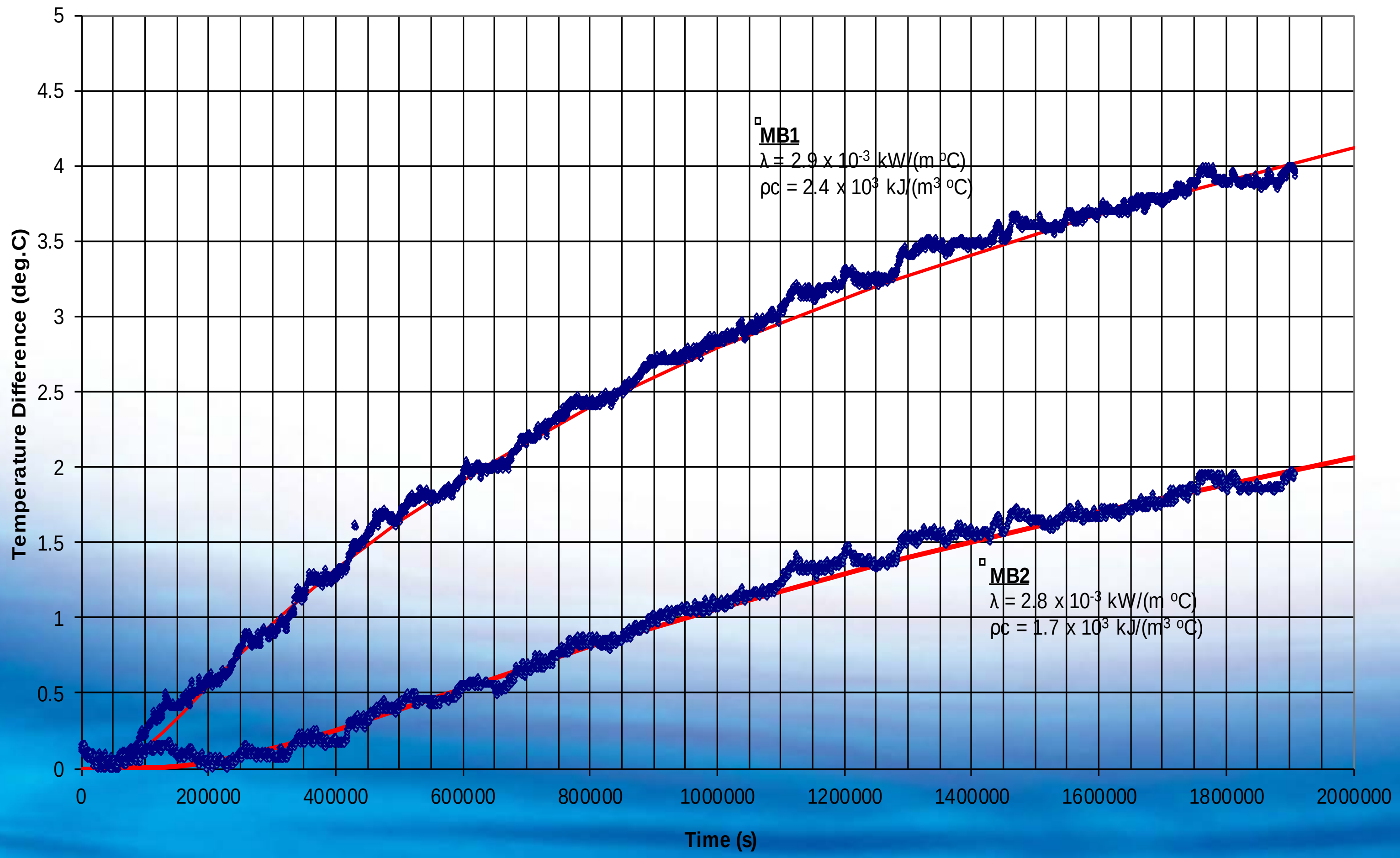
For the Test we put Heat into the Ground and work out how long it takes to dissipate.

Plot of Time Against Temperature for Ground Source Heat Test - MB1



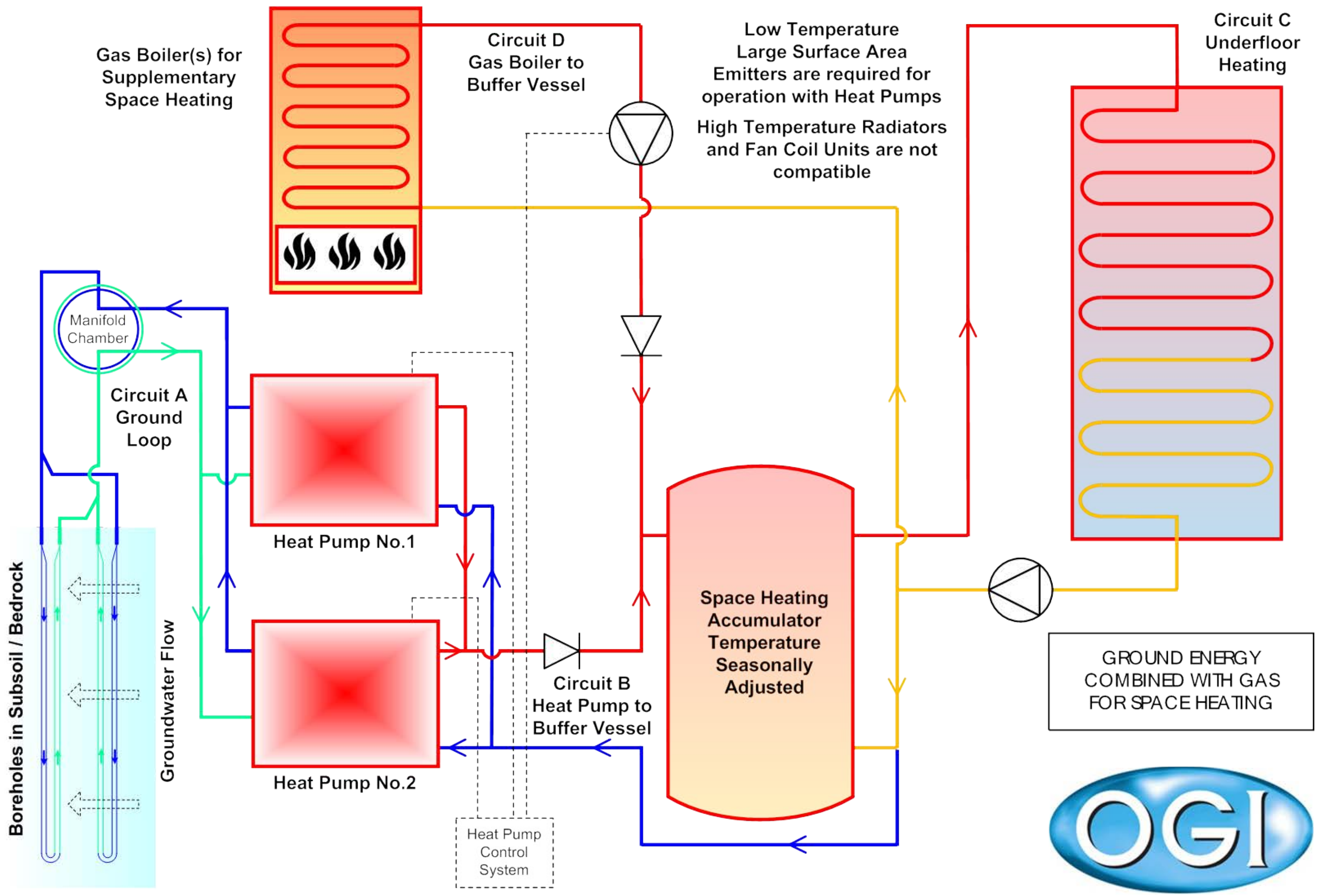

Plot of Time Against Temperature for Ground Source Heat Test - MB2
k = 2.8 x 10-3 kW/(m ºC)
ρc = 1.7 x 10³ kJ/(m³ ºC)
Temperature Difference (deg.C)
Time (s)
0
0.5
1
1.5
2
2.5
3
200000
400000
600000
800000
1000000
1200000
1400000
1600000
1800000
2000000

Plot of Time Against Temperature for Ground Source Heat Test



Integration with Gas Boiler

- GSHP Primary Heat Supply
- Supplemented by 100kW Gas Boiler
- Controlled by NIBE Degree Minute System.

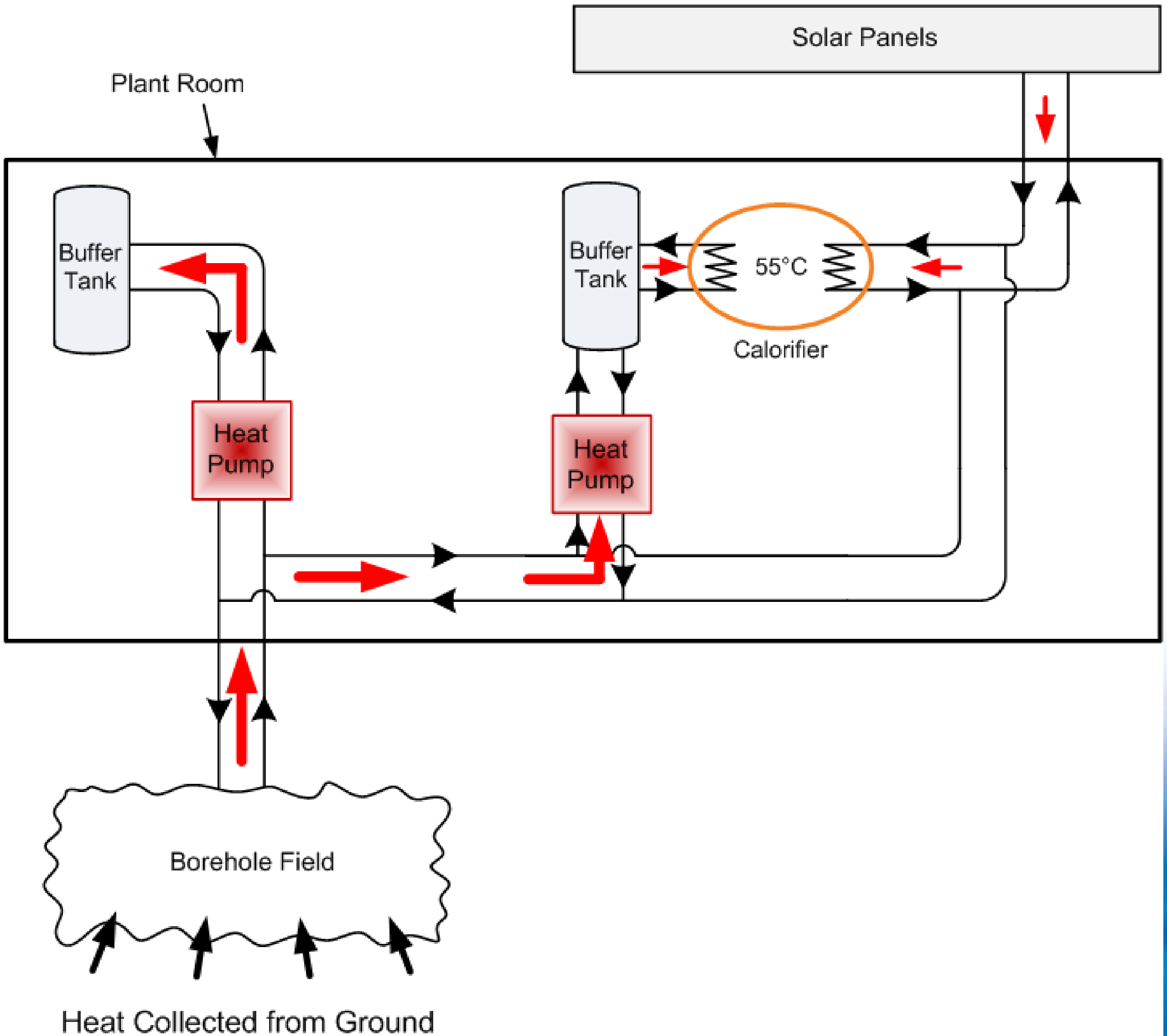


Ground Energy

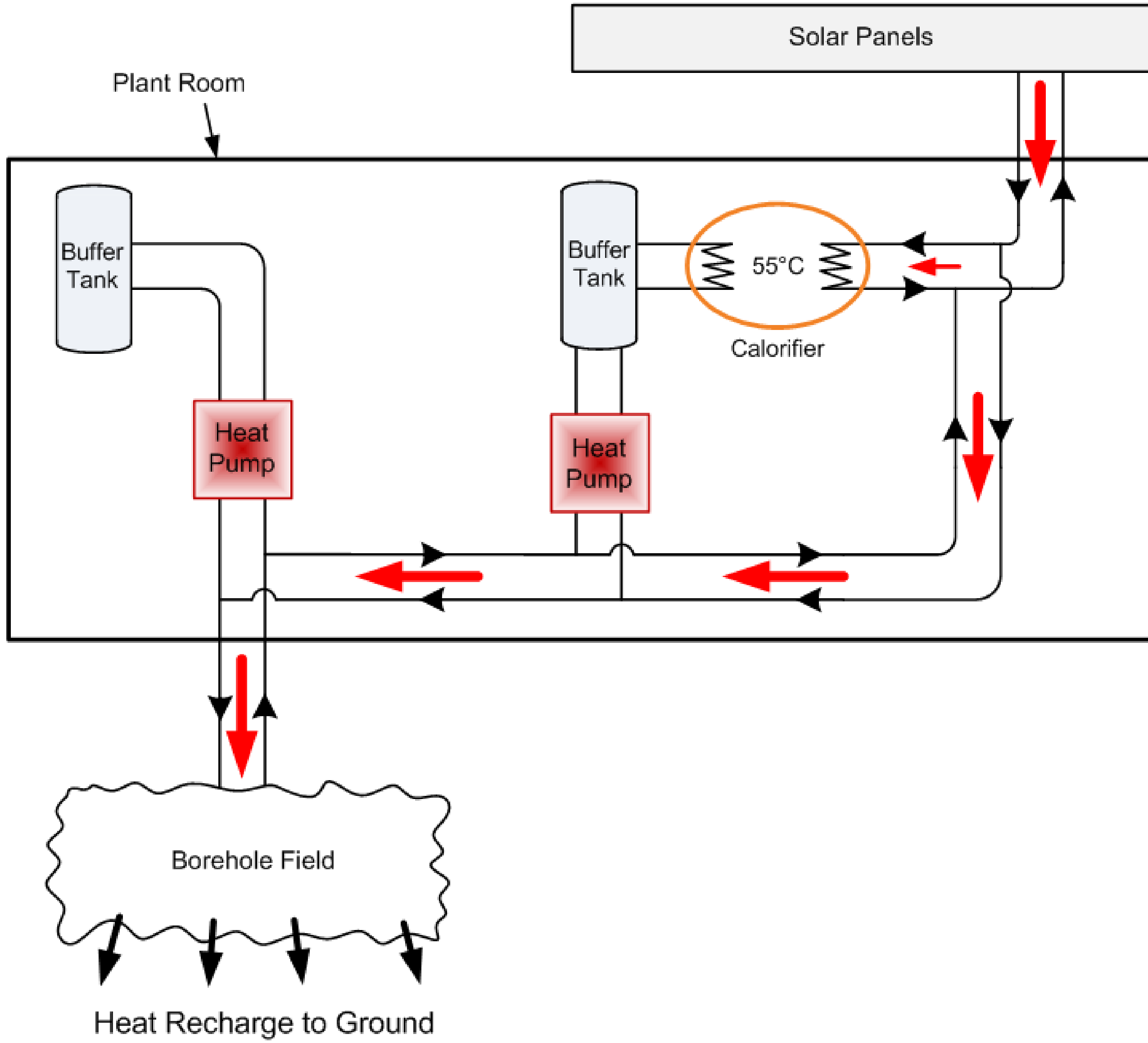
Integration with Solar Panel

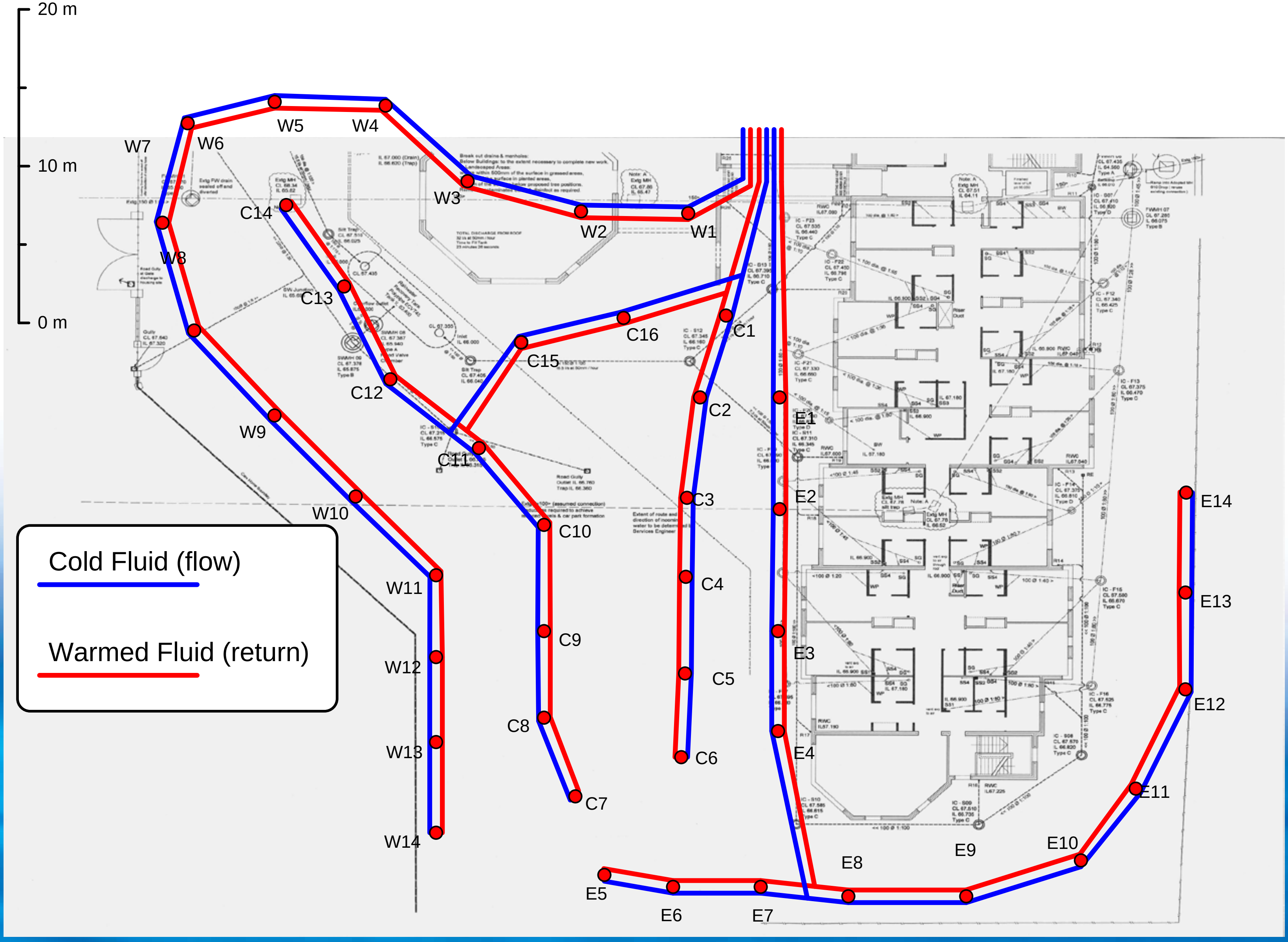
- Solar Panel providing Primary Heat Supply (Riomay Solar Panels)
- GSHP Providing Secondary Heat Supply
- Gas boiler providing Tertiary Heat Supply.

Heat Extraction from Ground in Winter



Heat Recharge to Ground in Summer





20 m
10 m
0 m
Cold Fluid (flow)
Warmed Fluid (return)
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
W14
C1
C2
C3
C4
C5
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C11
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C14
C15
C16
E1
E2
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E9
E10
E11
E12
E13
E14

Cost Savings

- GSHP approximately 8 x Gas system to install.
- Running costs approximately 50% of Gas
- Running costs approximately 30% of Oil
- 25 year life on Heat Pumps
- Low maintenance costs
- No deliveries - only electrical supply
- Ideally linked to mortgage to reduce CAPEX investment
- Adds asset value to building balance sheet