Session 4

- Grouting & backfilling
- Flow and pressure testing
- Recording of the installation

Grouting & Backfilling

What is grout what is backfill.

Definition of Backfill

Material used for refilling an excavation

Definition of Grout

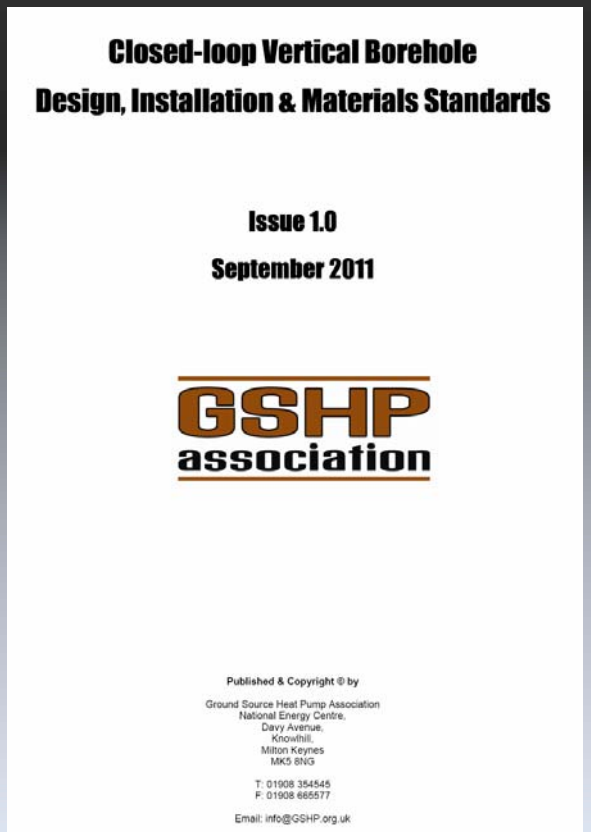
a thin, coarse mortar poured into various narrow cavities, as masonry joints or rock fissures, to fill them and consolidate the adjoining objects into a solid mass.

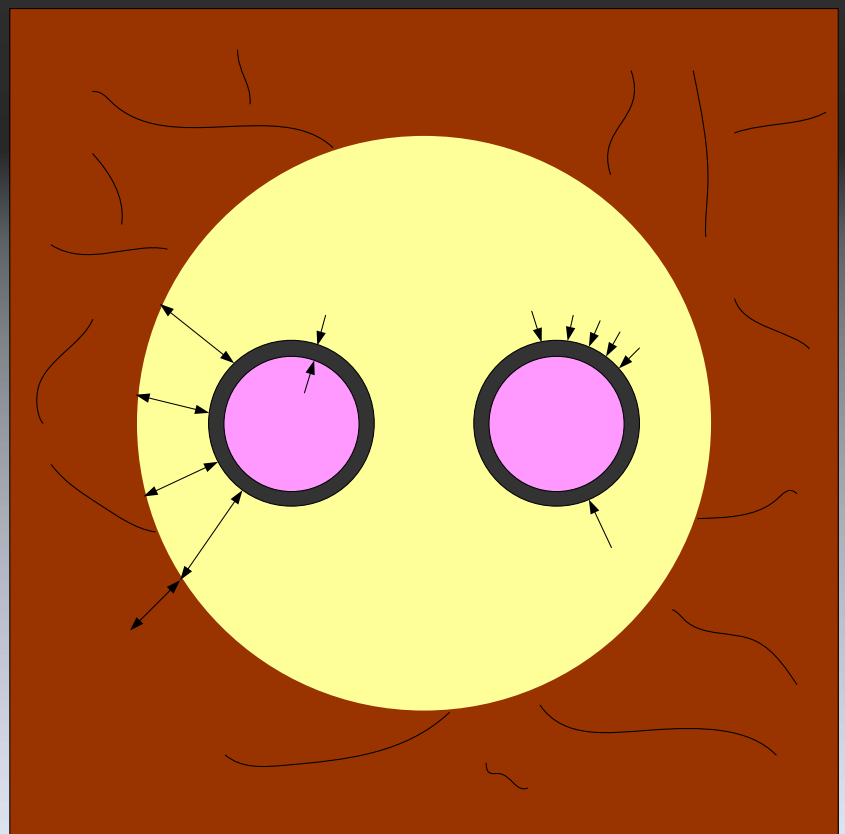
Grouting & Backfilling

What is required of a geothermal grout.

GSHPA VBS – Section 8 is all about grouts. Outlining the sealing requirements and levels of acceptable permeability and conductivity,

Thermal Grout is an engineered component of the closed loop system installation. It is part of the design





Grouting & Backfilling

Different Types of Grout & Impact on Loops

- Cement & Water only
- Cement, Bentonite & Water
- Bentonite, Cement, Sand & Water
- Bentonite & Water only
- Bentonite, Silica Sand & Water

Grouting & Backfilling

Bentonite Mixing

A Geo-loop grouter was purpose built to mix thermally enhanced bentonite grouts.

A 100 m hole can be grouted in under an hour

Is the colloidal mixer suitable?

Answer – Nope !

Other paddle mixer pumps are fine and many contractors may already have paddle mixer and positive displacement pumps to get started in the geothermal field without immediate outlay for new pumps

Grouting & Backfilling

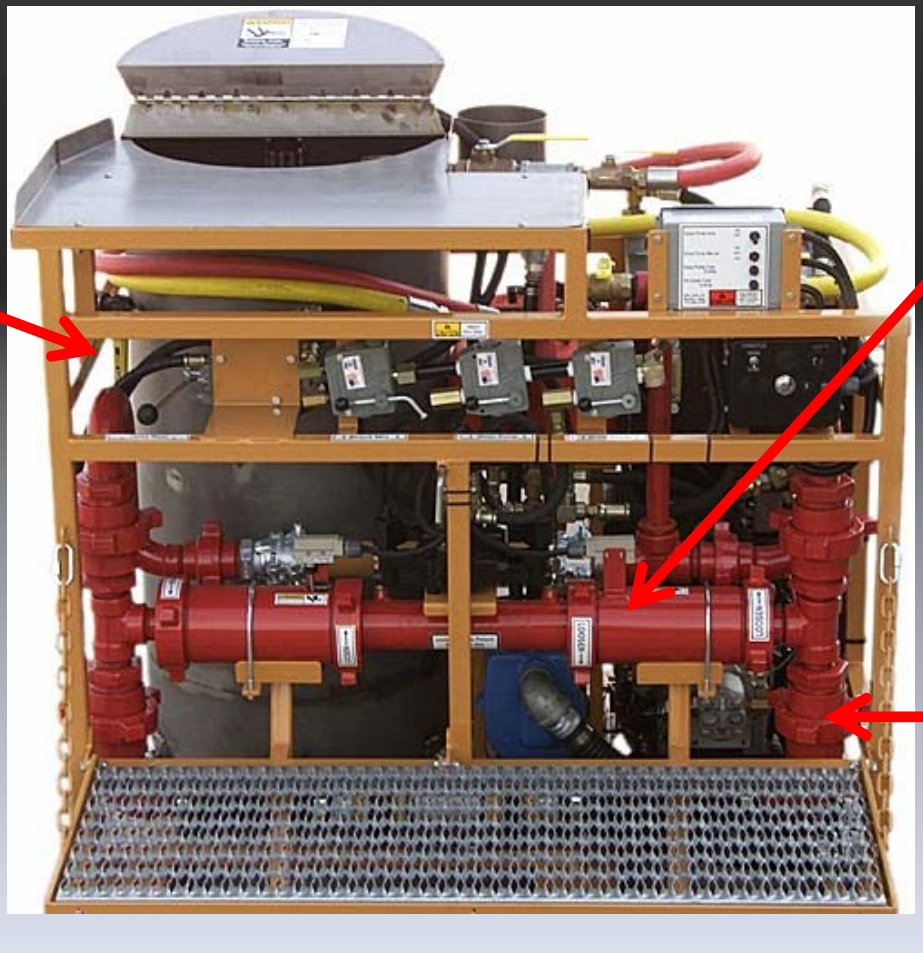
Bentonite Mixing

Simple Paddle Mixer

Grouting & Backfilling

Bentonite Pumping

It even comes with its own hammer !!



The Geo-loop pumps have a very hard chrome liner system to take the sand of thermally enhanced grouts

All pump and valve are removed by hammer fixings so is extremely quick t dismantle in the fie if required

Grouting & Backfilling

Bentonite Pumping

Crucially however the Geo-Loop system comes with powered sand loaders, loop reels and tremmie reels all operated from the same grout unit to arrive at a total grouting unit that can be operated by one man once its in the field.

Grouting & Backfilling

Tremmie Pipes and Their Importance

This is not a tremmie pipe

Grout must be placed from bottom of the hole to the top of the hole

Grout must be placed until thick consistent grout appears at the surface and not just creamy water.

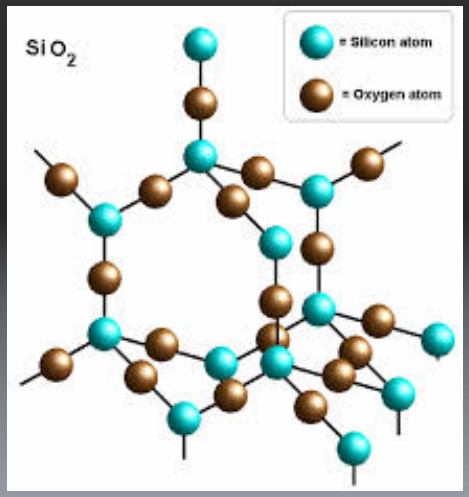
Grouting & Backfilling

Thermal Enhancement using Silica Sand

Not all Silica Sands are made equal

This may have the least appealing packaging but it has been selected and tested by the supplier to ensure it is suited to thermally enhanced grouts

Silica Dioxide is the magic ingredient



The difference between 95% and 99.7% is in fact quite large and may result in using 175 Kg per batch as opposed to 125 Kg

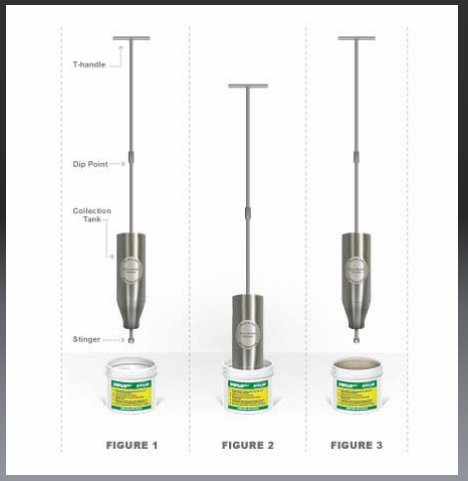
Grouting & Backfilling

Water Quality & Grout Samples

Water makes up a large percentage of the mixture.

Ensure water available on site is suitable quality with a water test kit.

Some grout suppliers provide sampling as free service.



Grout sampling is an important element of the quality control and reporting, in particular if the quality of sand is unknown,

Grouting & Backfilling

Loops Being Displaced From the Hole !

You may have worked out how much weight you need on the loop to get it through the mud when you put it in but when you start grouting, how much weight would it need to stop the grout shoving it back out ??

Number of loops per bore	2	nr
Loop Diameter	32	mm
Hole Depth	135	m
Rest Water level	0	m
Bore Fluid Density	1700	kg/m3
Water in loop density	1000	kg/m3
PE100 Density	955	kg/m3

Volume of fluid displaced	0.434	m^3
Weight of fluid displaced	738.3	Kg
Weight of water in loop	290.7	Kg
Weight of loop pipe	137.1	Kg
Weight differential	-310.5	Kg
Total amount of loop weight to be added to overcome buoyancy by 50%	466	Kg

The loop tails must be secured to prevent the loop being displaced. Even though in theory it needs 500 Kg, in reality it only needs to be secured because it has to over come the viscosity of the grout now.

However, beware… if it starts, it can be hard to stop !!

Grouting & Backfilling

Examples of securing a loop to the surface

Once Bitten Use Sleepers !

Alternative uses Heras fencing clips and tied it to casing

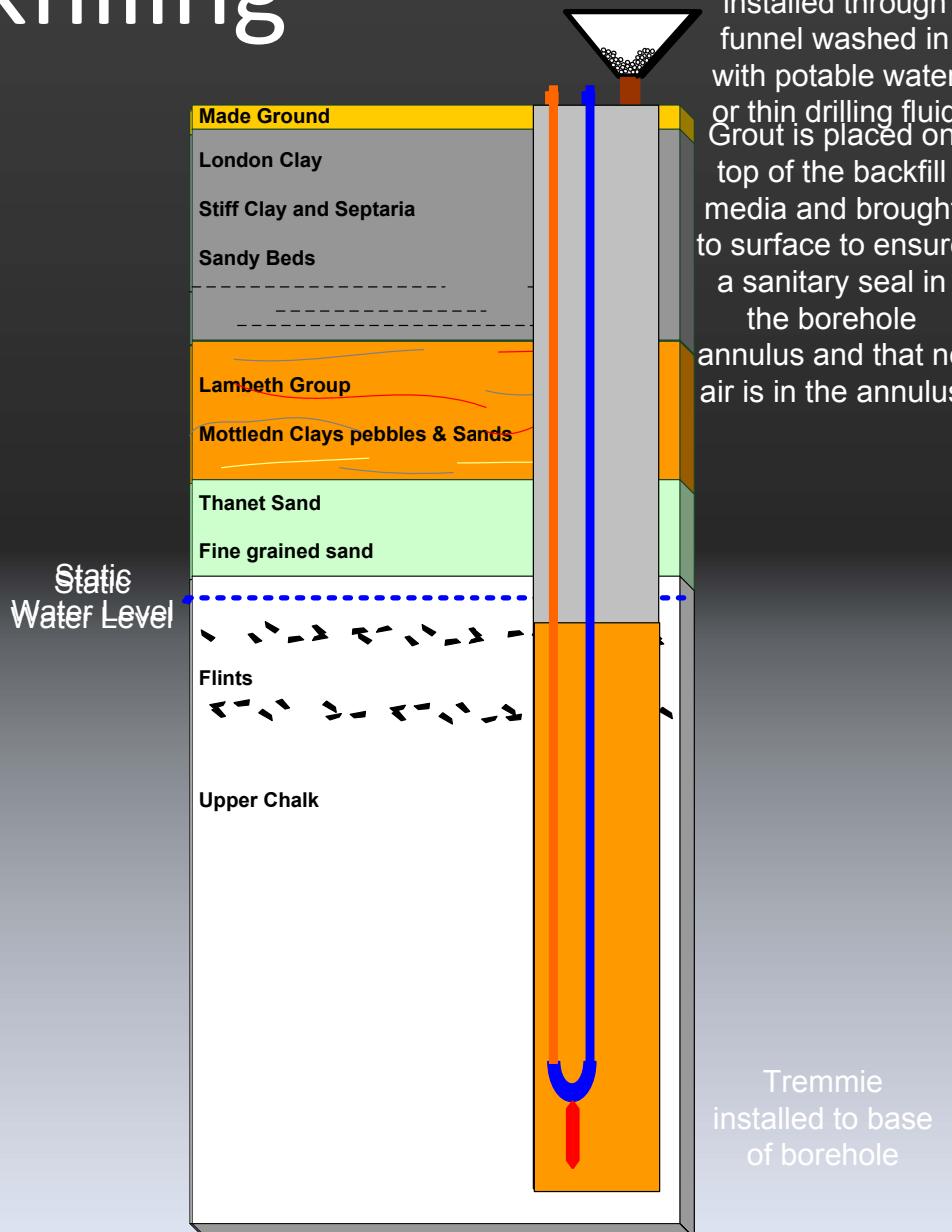
Grouting & Backfilling

Backfilling with granular fill requires skill and experience

A Tremmie pipe should be used to ensure the backfill is placed in the correct area

The Tremmie pipe is raised as the level of backfill rises but the backfill should not be able to fall more than 3 m in the annulus

Once the fill is at the correct level, grout should always still be used to seal the hole to avoid creation of a pathway and receptor

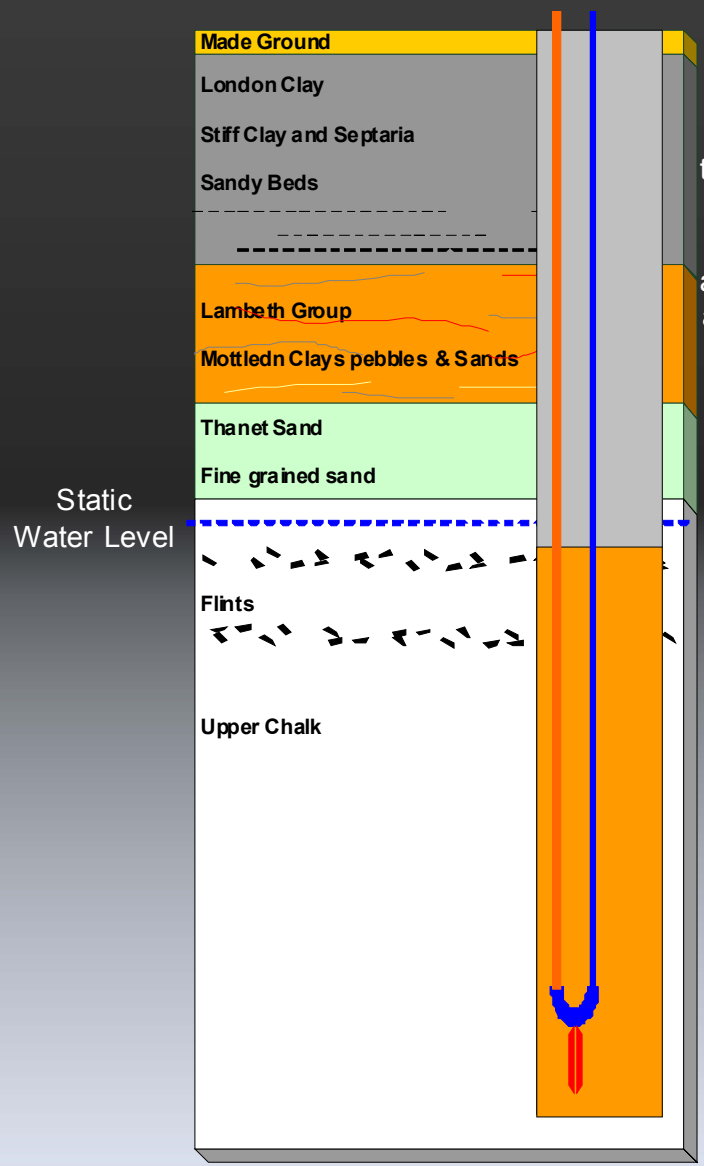


Grouting & Backfilling

The granular backfill material should be well rounded and not have sharps within it or be angular.

Angular gravels can place point loads onto the pipe material which may lead to an increase in slow crack propagation, reducing the lifespan of the material

Backfill is used mainly in very deep boreholes and also to bridge areas where grout loss cannot be stopped.



Grouting & Backfilling

This is not the way to place backfill materials !!

Flow & Pressure Testing

These are the tests that once carried out, recorded and accepted by the client complete the installation.

These are the money tests so its worth getting these right !!!

Flow & Pressure Testing

Flow testing should always be done first

This borehole failed its flow test but it did flow. That means it would have passed its pressure test. The loop could be 99% blocked but still pass a pressure test.

This is the borehole that had a bucket full of gravel in it !!

Flow & Pressure Testing

What must be measured during a flow test?

The flow rate in the loop

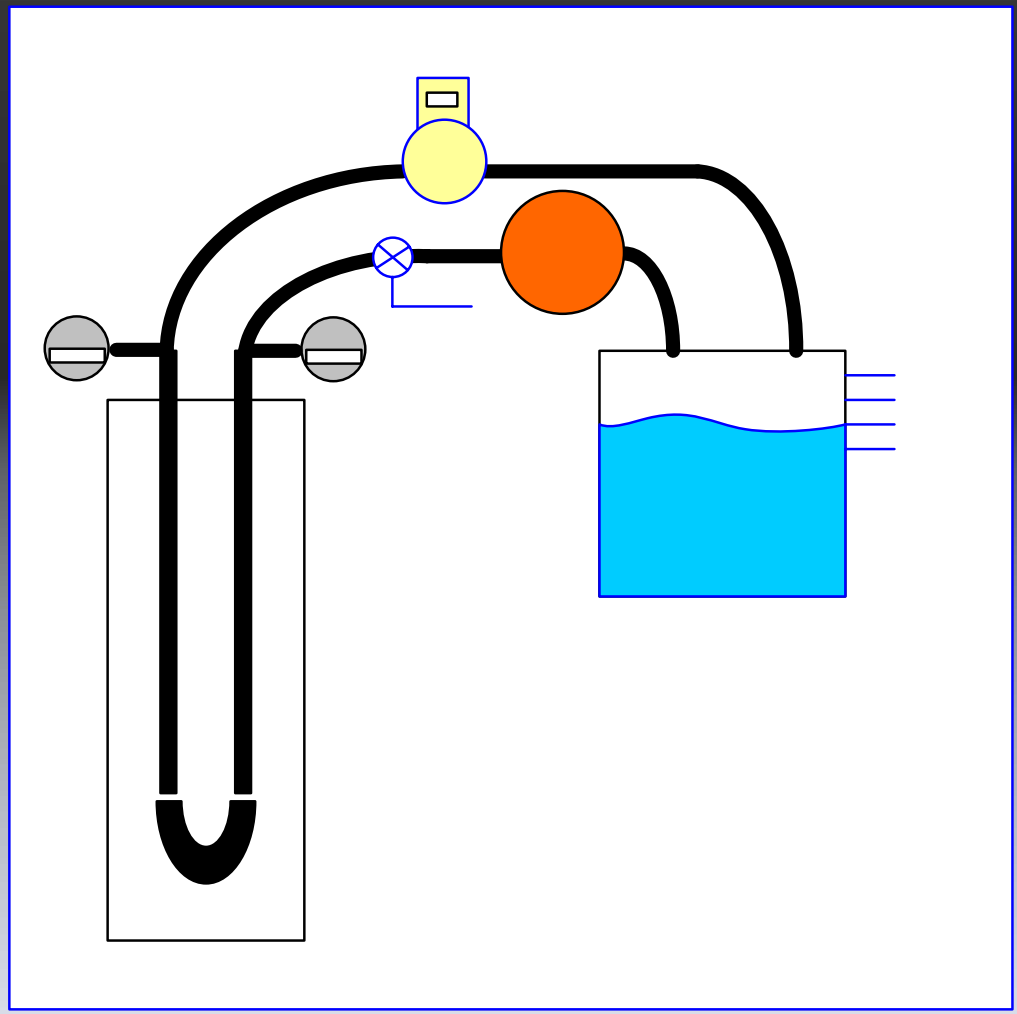
Anything else?

The Pressure developed in the loop

Flow & Pressure Testing

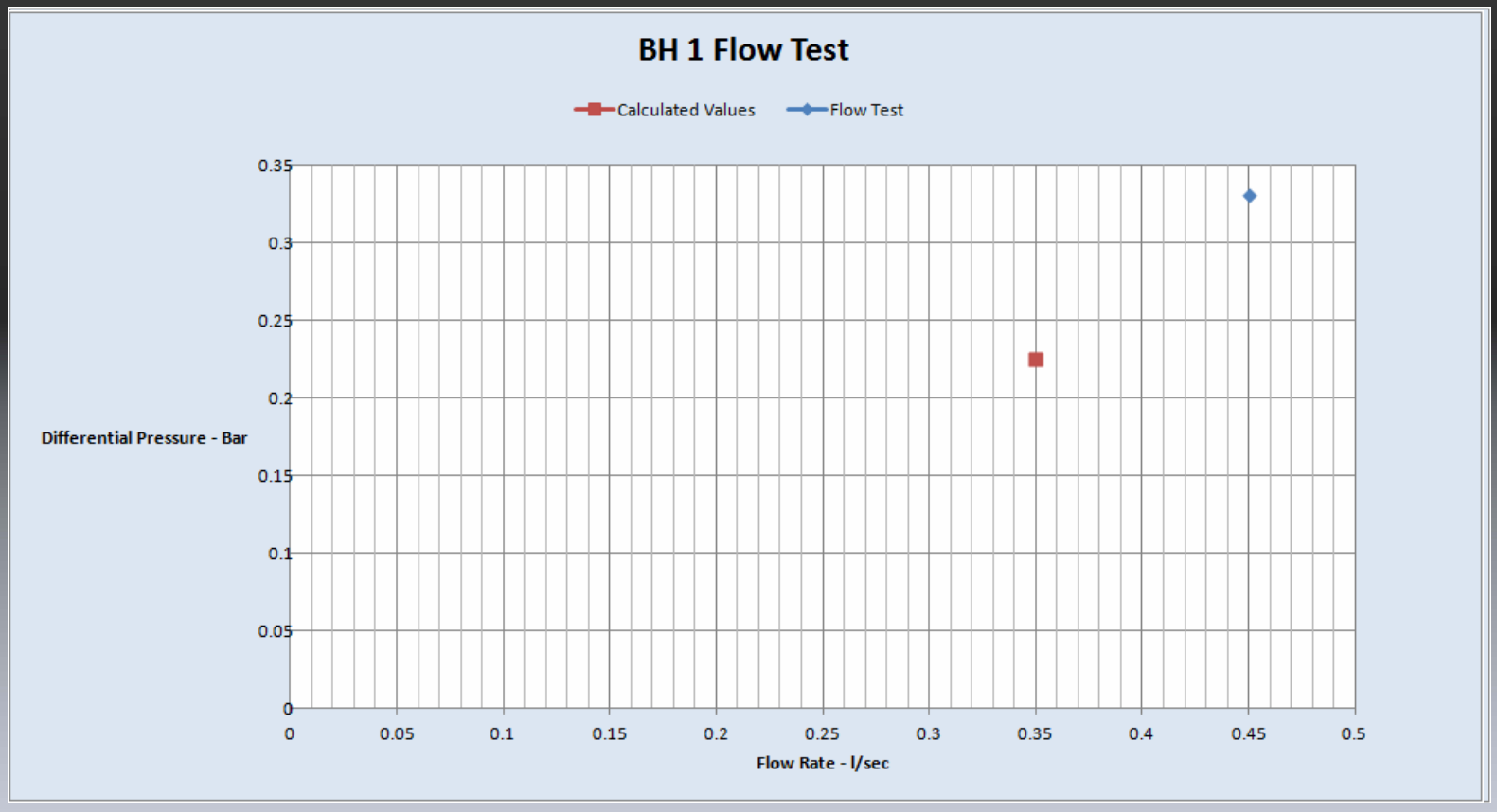
Schematic of a flow test.

- Gauges as close to the loop tails as possible
- Smooth Pump
- Flow restricting valve to achieve different flow rates
- Water meter and / or bucket with known volume
- Stop watch



Flow & Pressure Testing

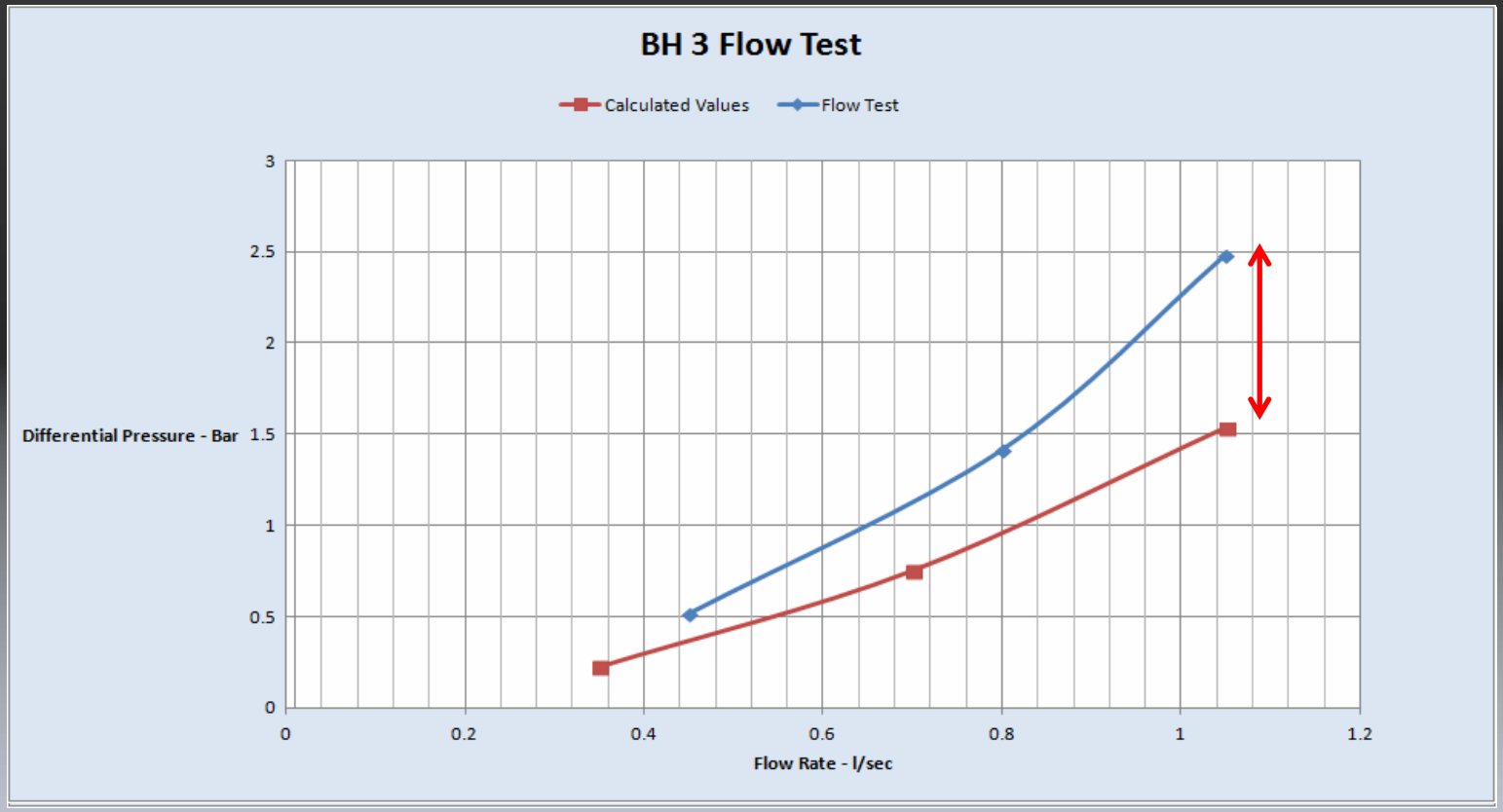
What about this one?



One is partially blocked but which one?

Flow & Pressure Testing

A flow test must have more than one test value and preferably at least 3 different flow rates and corresponding pressures.



Borehole 3 has failed the test
Pressure diverges from the calculated values

Flow & Pressure Testing

Flow testing is not as easy as it sounds

- A Smooth pump is needed. Piston pumps pulse and it is hard to accurately read the pressure gauges
- Accurate pressure gauges are required preferably digital but avoid ones without Glycerine in as the needle can bounce all over the place.
- The test needs to be done with the gauges as close to the loop flow and return as possible
- The flow meter needs to be accurate and in many ways, measuring into a bucket or a known volume test is by far the easiest and usually the most accurate

Flow & Pressure Testing

The contractor on site couldn't get the flow test values to even remotely tally with the calculated values

Spot the reasons why?

25 mm valves on a 40 mm loop seriously restricting flow

30 m of 1" pipe between the test kit and the borehole

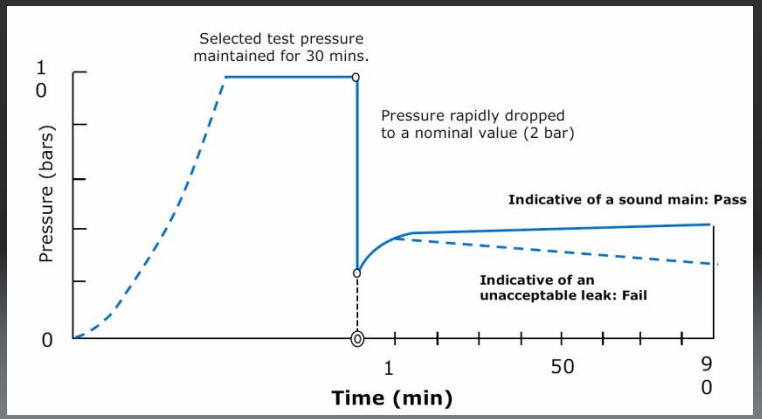
The flow restrictions and extra pipe meant that the contractor was not testing the loop but was testing the loop, the 1" pipe and the 25 mm small bore valves.

Flow & Pressure Testing

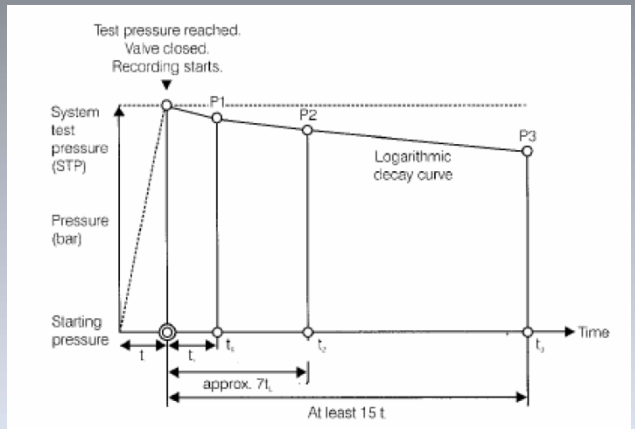
Pressure test is to be done to BS EN 805

PE pipes will expand under pressure and the test may go on and on to get to stable pressure

BS EN 805 Simple Test



WRc Decay Test



Flow & Pressure Testing

Does weather alter the results of a pressure tests?

There may only be a few metres of pipe work for loop tails but if the sun comes out and shines onto a black pipe it gets hot.

If this happens during a test, the pipe will expand and become softer and the results may be impacted.

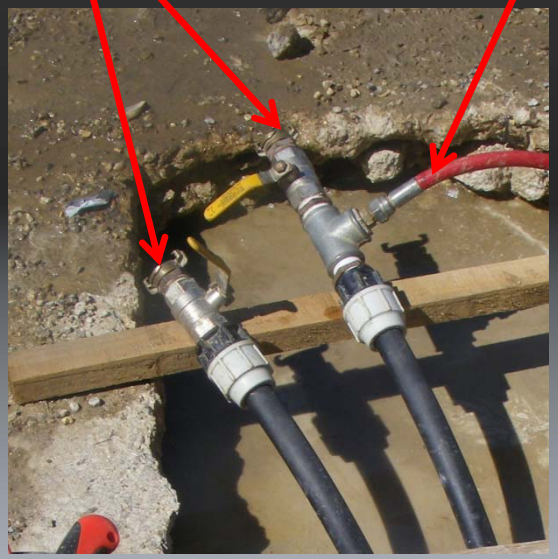
This is worse in the summer when the sun is far stronger of course

Flow & Pressure Testing

Typical simple pressure test set up

Bleed/isolation Valves

Pressure pump connection



Pressure pump

A stop watch, pencil and paper !

Flow & Pressure Testing

Selecting the test pressure

Test Pressure 8 Bar plus test pressure 4 bar. Total 12 Bar

Pressures Converge

8 Bar Req to overcome grout Pressure

Borehole Depth 100 m

Flow & Pressure Testing

The Test…

Borehole No.	1	Name of Contractor	Perfect Geo Ltd
Loop No.	GSL - 134614	Name of Installer	James Wilkes
Installed Loop Length	135 m	Name of Tester	Les Morrice
Date of Loop Insertion	10th June 2014	Date of Test	12th June 2014
Header Set No.	N/A	Pass or Failed Test	Pass
Date of Grouting 10th June 2014		Signature of Tester	
No. of Grout mixes 14		Signature of Engineer	
Notes:			

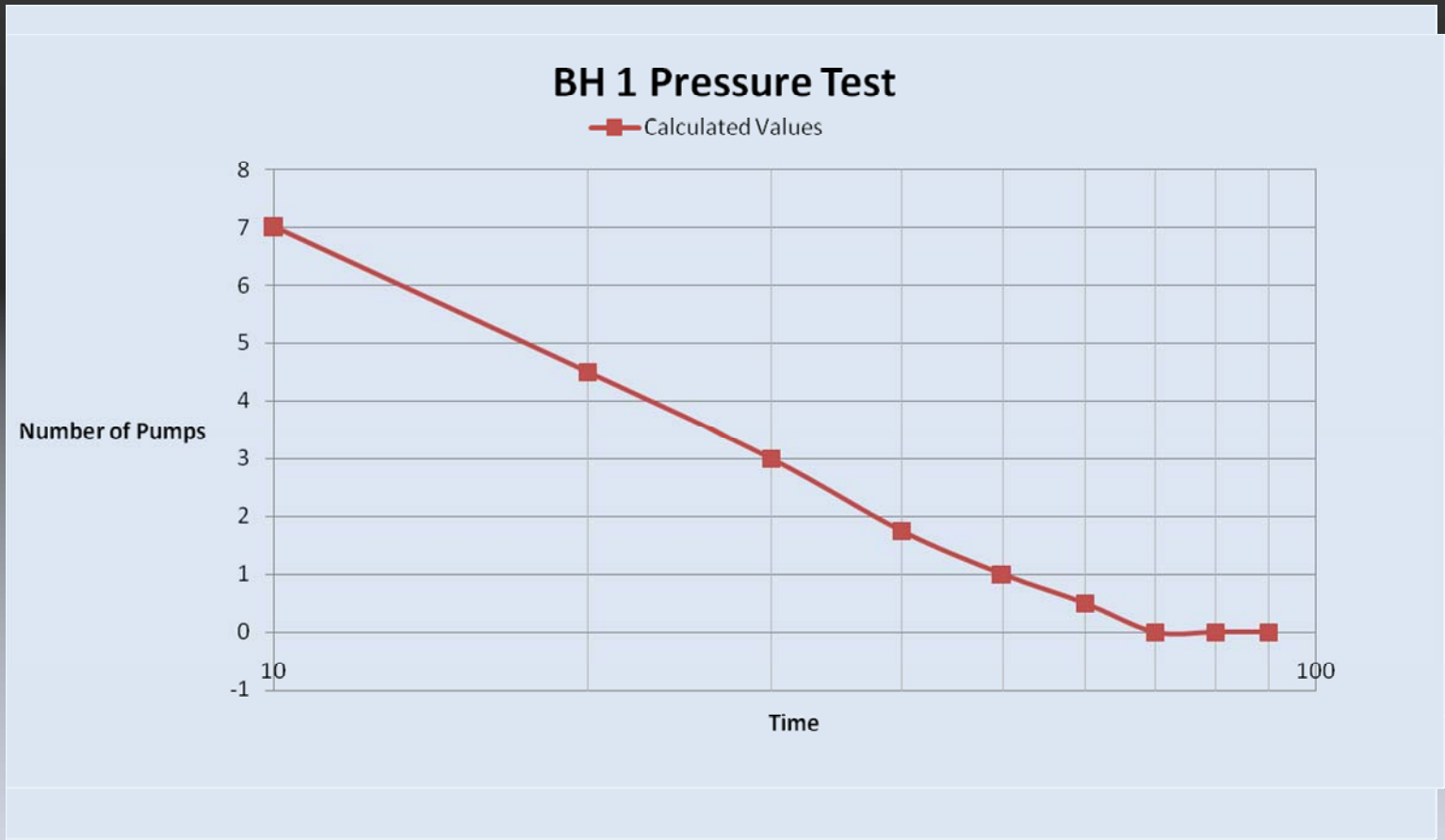
Pressure Test Results

Elapsed time mins.	Pressure (Bar) (Theory)	Pressure (Bar) (Actual)	No. of pumps to re-establish Test Pressure (Theory)	No. of pumps to re-establish Test Pressure (Actual)
0		12		
10		11.9		7
20		12.1		4.5
30		12		3
40		12		1.75
50		12.1		1
60		12		0.5
70		12		0
80		12		0

Flow & Pressure Testing

The Results…

Reasonably straight line
Steady Curve
until pumping stops



Flow & Pressure Testing

Recording of the Installation

Why record the install?

"Where is the loop?"

"There is a car park and building where we drilled when it was a field"

Recording of the Installation

Borehole Drill Log & Completion Record for the Installation of the Loop

Client:	Ground Source Consult	**Rig No.**	4	**Driller:**	Les Morrice	**Date Started:**	9th June 2014
Site:	Integer	**Rig Type:**	COM405P	**Assistant Driller:**	James Wilkes	**Date Completed:**	9th June 2014
Location:	London	**Flush Medium:**	Fluid	**Assistant Driller:**		**Weather:**	Drizzle / Warm
Borehole No.	1 (test bore)					**Rest Water/Fluid Level**	At surface

Expert Geothermal Drilling Ltd

Drilling Details

Depth From	Thickness	Bore Depth	Bit Size and Method	Casing Installed	Geology	Returns	Peteration Rates (m/min)	Notes	Mud Weight	Mud Viscosity
GL	1.2	1.2	Auger		Top Soil bricks and backfill	100%	0.3		N/A	N/A
1.2	4	5.2	Auger		Saturated sand and gravel	100%	0.1		N/A	N/A
5.2	1	6.2	Auger	6.2 m 150 NB	Brown weathered London Clay	100%	0.1		N/A	N/A
6.2	23.5	29.7	143 mm 3 wing TC Drag and fluid flush		Grey stiff London Clay with hard limestones bands at 21.5 m	100%	0.8	Start Fluid Flush / Polymer added	1002 Kg/m3	35 Sec
29.7	8.5	38.2	143 mm 3 wing TC Drag and fluid flush		Mottled red grey and brown clay	100%	0.8		1010 Kg/m3	38 Sec
38.2	7.8	46	143 mm 3 wing TC Drag and fluid flush		Grey / green clays with pebbles	100%	0.8		1008 Kg/m3	45 Sec
46	6.9	52.9	143 mm 3 wing TC Drag and fluid flush		Very fine green silty sand	100%	1		1009 Kg/m3	52 Sec
52.9	0.9	53.8	143 mm 3 wing TC Drag and fluid flush		Black flint pebbles and chalk fragments	10%	0.3	Fluid loss prevention	1021 Kg/m3	48 Sec
53.8	1.8	55.6	143 mm 3 wing TC Drag and fluid flush		Soft yellow putty chalk and flints	60%	0.7	Bit changed from drag bit to roller bit	1045 Kg/m3	55 Sec
55.6	58	113.6	143 mm Rock Roller and Fluid Flush		white chalk with many flints	80%	0.7	Fluid thinned	1025 Kg/m3	41 Sec
113.6	68	181.6	143 mm Rock Roller and Fluid Flush		White chalk with few flints	70%	0.9		1026 Kg/m3	40 Sec
181.6	5	186.6	143 mm Rock Roller and Fluid Flush		Grey marly chalk with few flints	100%	0.8		1031 Kg/m3	42 Sec

Loop Installation Details

Loop Depth:	182 m
Tremmie Depth:	182 m
Loop Diameter:	40 mm
No. Loops per Hole:	2 nr
Fluid Level at loop install:	Surface
Fluid Weight at Hole TD:	1031 Kg/m3
Weights added to loops:	63 Kg Under Loop
Loop Serial No.	GSL- 134614

Grouting Details

Grout Start Depth:	GL
Grout Bottom Depth:	60
Granular Fill Start Depth:	60
Granular Fill Bottom Depth:	186.6
Type of Grout Used:	GSL-Connect
Grout Mix Ratio to Sand:	1 : 5
No. Bags/Kg Sand Used:	30
No. Bags/Kg Grout Used:	6

Drillers Notes:

Stopped to re-pack swivel at 10.00 am to 10.15 am. Site Visit from clients representative

Recording of the Installation

Summary Record of Installation details

Client:	Kensa Group
Site:	Whaplode Drove
Location:	Spalding

Date Project Started:	9th June 2014
Date Project Completed:	20th June 2014

Expert Geothermal Drilling Ltd

Summary Installation Details

Property Address	Borehole ID	Drilled Depth	Loop Serial No.	Loop depth	Loop Dia mm	Double or Single Loop	Grout Depth	Installation Date	Driller	Rig No.	Marked on site plan
2, Farrow Rd	1	123.5	GSL - 134616	120	40	Double	123.5	9th June 2014	Les Morrice	4	yes
4, Farrow Rd	2	121.5	GSL - 134614	120	40	Single	121.5	10th June 2014	Les Morrice	4	yes
6, Farrow Rd	3	120.0	GSL - 134615	119	40	Single	120.0	11th June 2014	Les Morrice	4	yes
6, Farrow Rd	4	122.5	GSL - 134617	120	40	Single	122.5	12th June 2014	Les Morrice	4	yes
10, Farrow Rd	5	122.5	GSL - 134618	120	40	Single	122.5	13th June 2014	Les Morrice	4	yes
12, Farrow Rd	6	122.5	GSL - 134623	120	40	Single	122.5	16th June 2014	Les Morrice	4	yes
1, Coppers Close	7	123.0	GSL - 134624	118.5	40	Single	123.0	17th June 2014	Les Morrice	4	yes
2, Coppers Close	8	123.0	GSL - 134625	118.5	40	Single	123.0	18th June 2014	Les Morrice	4	yes
3, Coppers Close	9	121.0	GSL - 134619	118.5	40	Single	121.0	19th June 2014	Les Morrice	4	yes
4, Coppers Close	10	121.0	GSL - 134620	118.5	40	Single	121.0	20th June 2014	Les Morrice	4	yes
1, Greenbank	11	84.0	GSL - 134621	80.5	32	Single	84.0	10th June 2014	Steve Goulding	7	yes
2, Greenbank	12	83.0	GSL - 134622	80.5	32	Double	83.0	11th June 2014	Steve Goulding	7	yes
3, Greenbank	13	85.0	GSL - 134626	80.5	32	Double	85.0	12th June 2014	Steve Goulding	7	yes
4, Greenbank	14	85.0	GSL - 134627	80.5	32	Single	85.0	13th June 2014	Steve Goulding	7	yes
1, Chapel Gate	15	87.0	GSL - 134628	84.5	32	Single	87.0	16th June 2014	Steve Goulding	7	yes
3, Chapel Gate	16	88.0	GSL - 134629	84.5	32	Single	88.0	17th June 2014	Steve Goulding	7	yes

Recording of the Installation

Summary report flow and pressure test

Client:	Kensa Group
Site:	Whaplode Drove
Location:	Spalding

Date Project Started:	9th June 2014
Date Project Completed:	24th June 2014

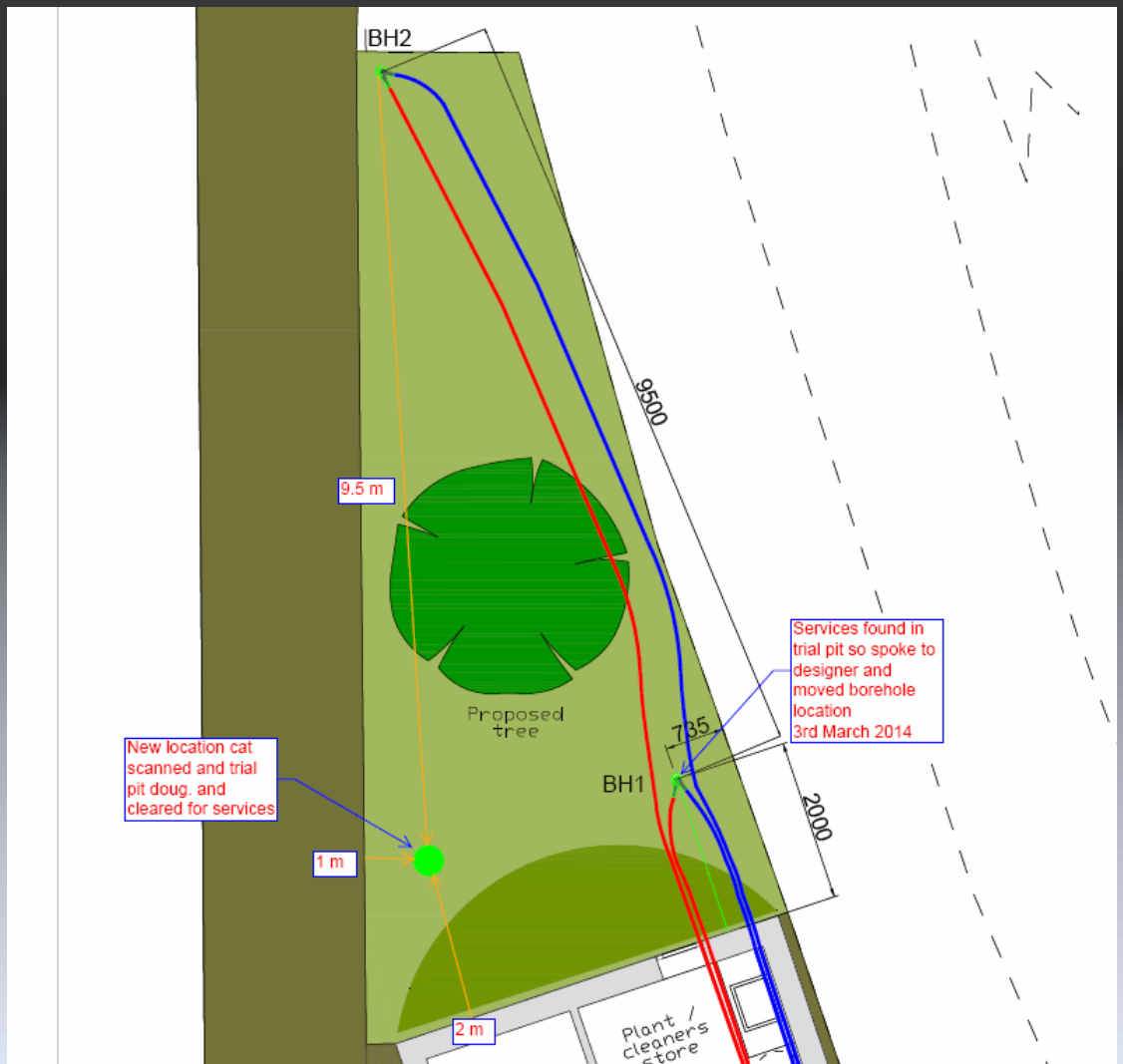
Expert Geothermal Drilling Ltd

Summary Installation Details

Property Address	Borehole ID	Drilled Depth	Loop Serial No.	Loop depth	Loop Dia mm	Double or Single Loop	Grout Depth	Pressure Test Date	Test Passed	Flow Test Date	Test Passed	Tester
2, Farrow Rd	1	123.5	GSL - 134616	120	40	Double	123.5	11th June 2014	yes	11th June 2014	yes	Les Morrice
4, Farrow Rd	2	121.5	GSL - 134614	120	40	Single	121.5	11th June 2014	yes	11th June 2014	yes	Les Morrice
6, Farrow Rd	3	120.0	GSL - 134615	119	40	Single	120.0	14th June 2014	yes	14th June 2014	yes	Les Morrice
6, Farrow Rd	4	122.5	GSL - 134617	120	40	Single	122.5	14th June 2014	yes	14th June 2014	yes	Les Morrice
10, Farrow Rd	5	122.5	GSL - 134618	120	40	Single	122.5	18th June 2014	yes	18th June 2014	yes	Les Morrice
12, Farrow Rd	6	122.5	GSL - 134623	120	40	Single	122.5	19th June 2014	yes	19th June 2014	yes	Les Morrice
1, Coppers Close	7	123.0	GSL - 134624	118.5	40	Single	123.0	20th June 2014	yes	20th June 2014	yes	Les Morrice
2, Coppers Close	8	123.0	GSL - 134625	118.5	40	Single	123.0	20th June 2014	yes	20th June 2014	yes	Les Morrice
3, Coppers Close	9	121.0	GSL - 134619	118.5	40	Single	121.0	23rd June 2014	yes	23rd June 2014	yes	Les Morrice
4, Coppers Close	10	121.0	GSL - 134620	118.5	40	Single	121.0	23rd June 2014	yes	23rd June 2014	yes	Les Morrice
1, Greenbank	11	84.0	GSL - 134621	80.5	32	Single	84.0	23rd June 2014	yes	23rd June 2014	yes	Les Morrice
2, Greenbank	12	83.0	GSL - 134622	80.5	32	Double	83.0	23rd June 2014	yes	23rd June 2014	yes	Les Morrice
3, Greenbank	13	85.0	GSL - 134626	80.5	32	Double	85.0	24th June 2014	yes	24th June 2014	yes	Les Morrice
4, Greenbank	14	85.0	GSL - 134627	80.5	32	Single	85.0	24th June 2014	yes	24th June 2014	yes	Les Morrice
1, Chapel Gate	15	87.0	GSL - 134628	84.5	32	Single	87.0	24th June 2014	yes	24th June 2014	yes	Les Morrice
3, Chapel Gate	16	88.0	GSL - 134629	84.5	32	Single	88.0	24th June 2014	yes	24th June 2014	yes	Les Morrice

Recording of the Installation

Mark up of borehole layout drawing



Q & A on session 4

Any questions….

Any slides you want to go back to?