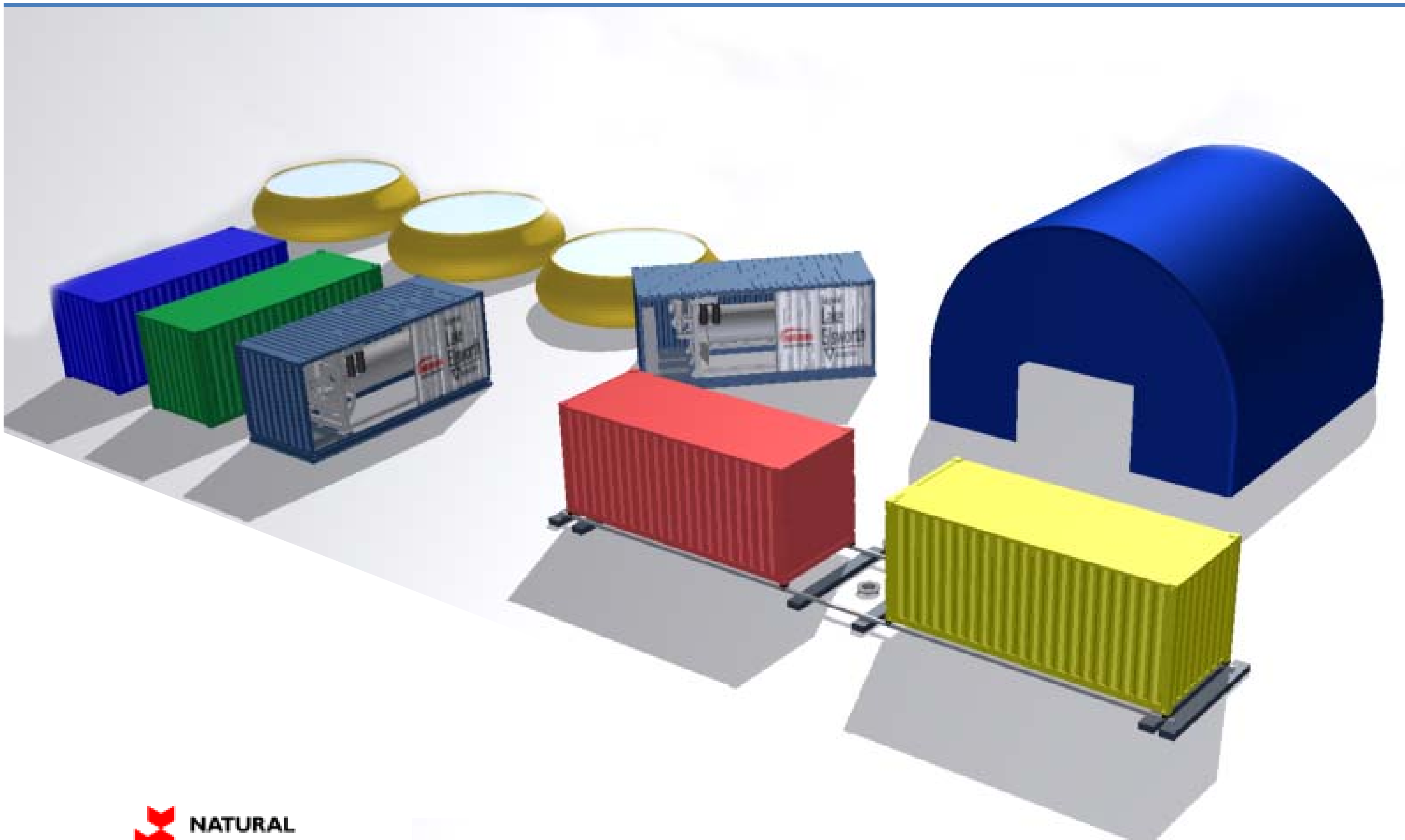
Subglacial Lake Ellsworth

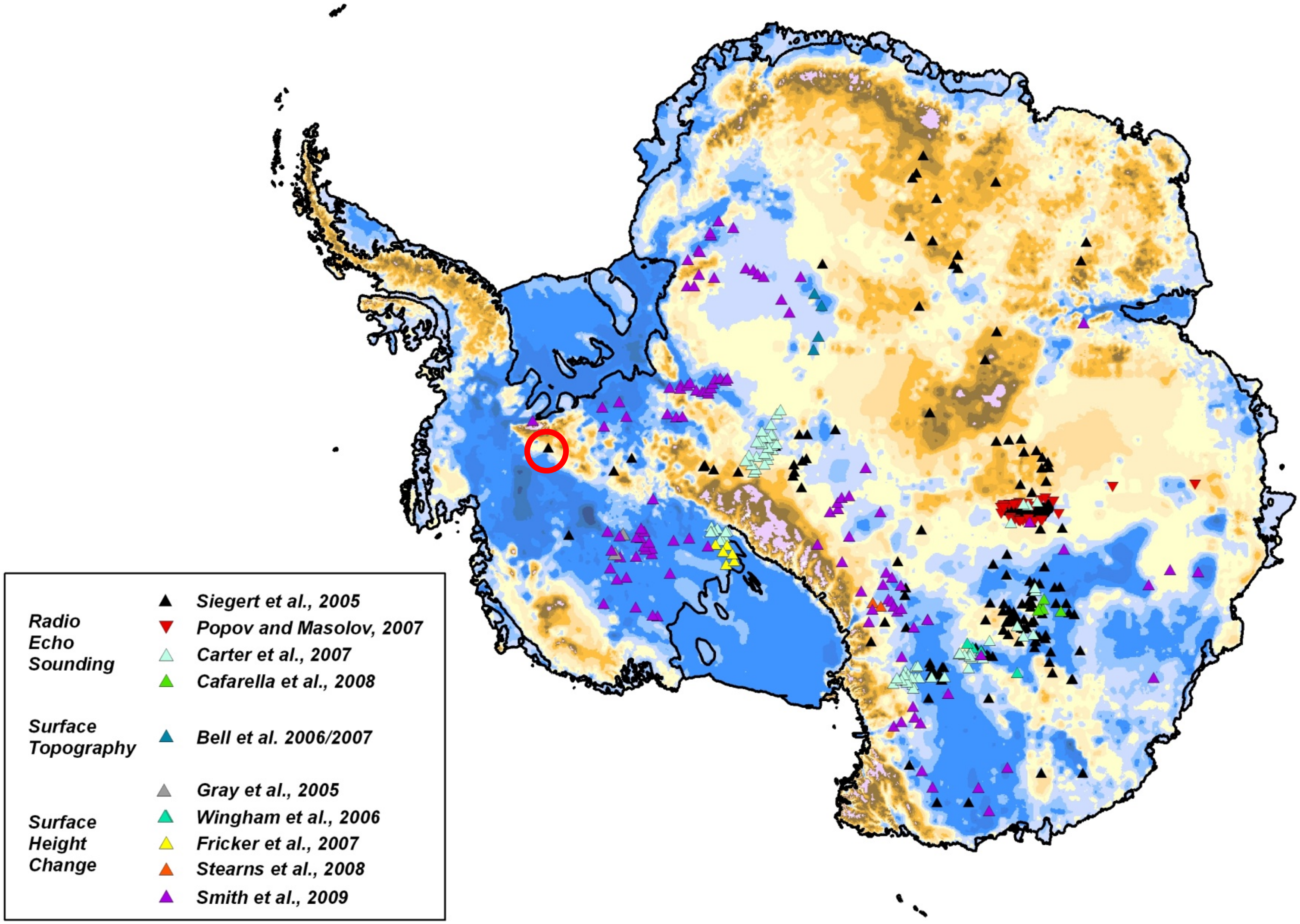
A review of the Programme



NATURAL ENVIRONMENT RESEARCH COUNCIL

Subglacial Lake Ellsworth Antarctica

Subglacial lakes in Antarctica



Wright and Siegert, 2011

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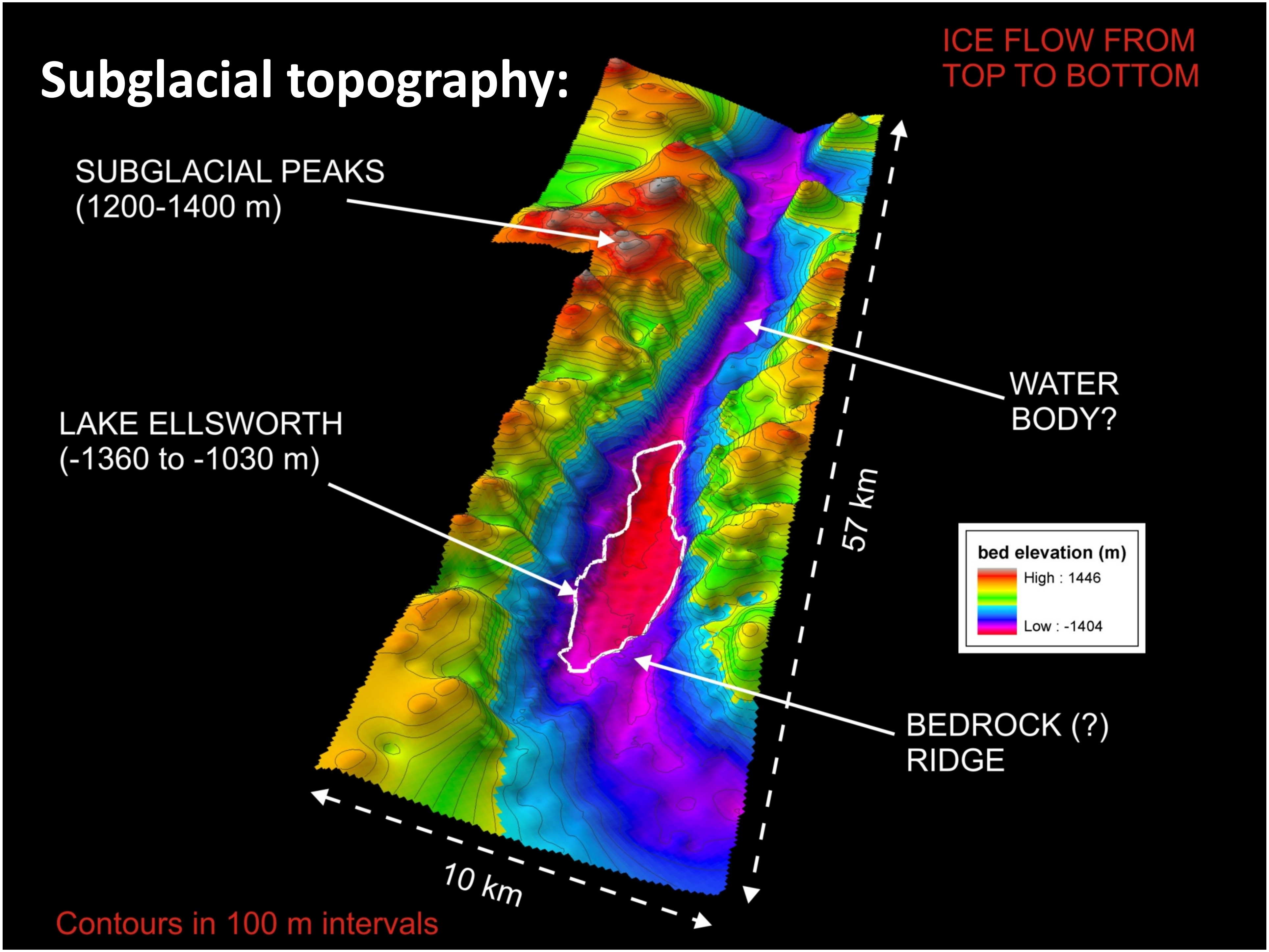
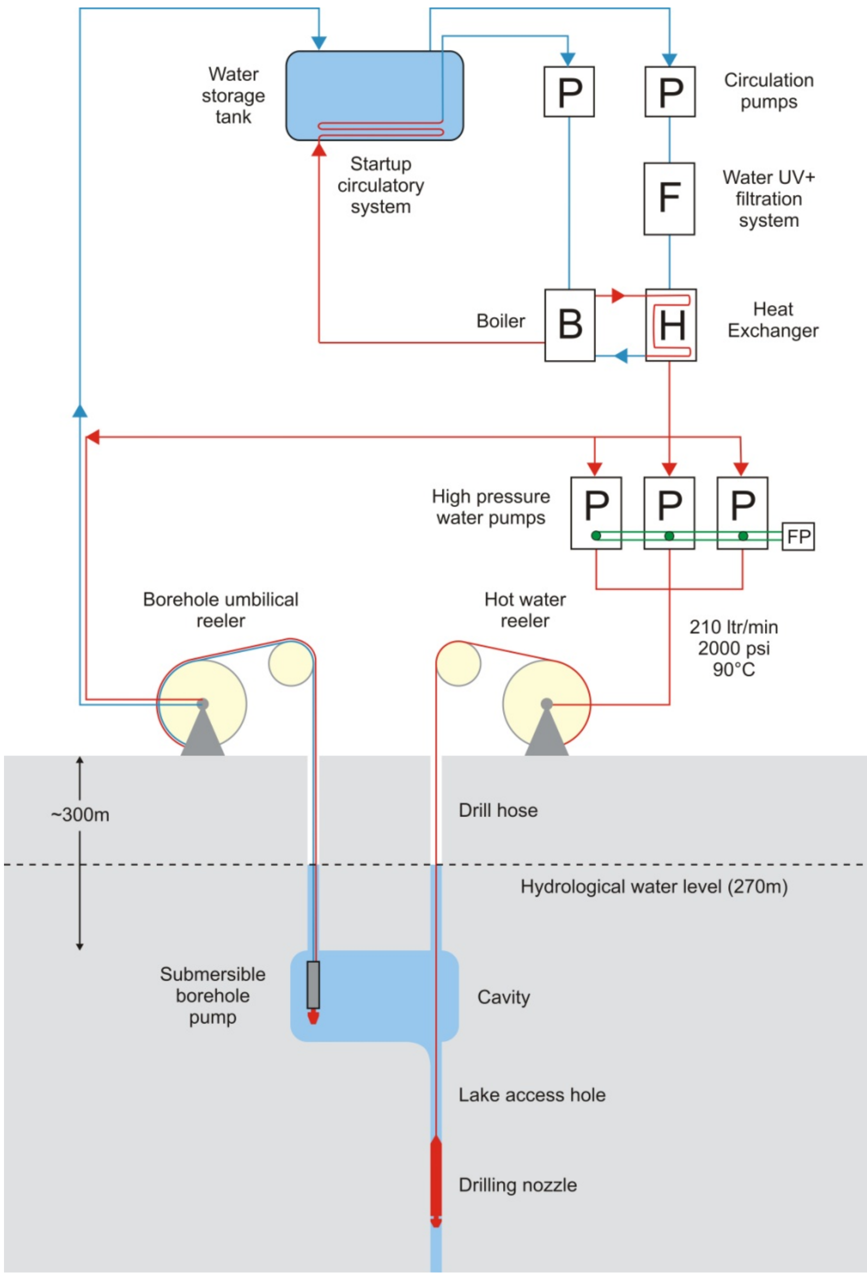
Subglacial topography:





HOT WATER DRILL

Equipment specifications

- ~90 m^3 water storage
- Absolute filtration to 0.1 micron + UV
- Heating capacity ~1.5 MW
- Pumping capacity ~240 litres/min@ 2000 psi
- Electrical capacity 300 kW
- Water recovery ~260 litres/min from 300 m

- Bespoke single piece hose 3.4 km long, 1.25” bore and self supporting in air filled hole
- Hose transports between 180-226 litres/minutes @2000 psi and 90-100°C

- 30-100 % spare capacity (filtering, pumping, heating and electrical) to provide flexibility
- All standard commercial equipment with minor modifications to meet environmental conditions

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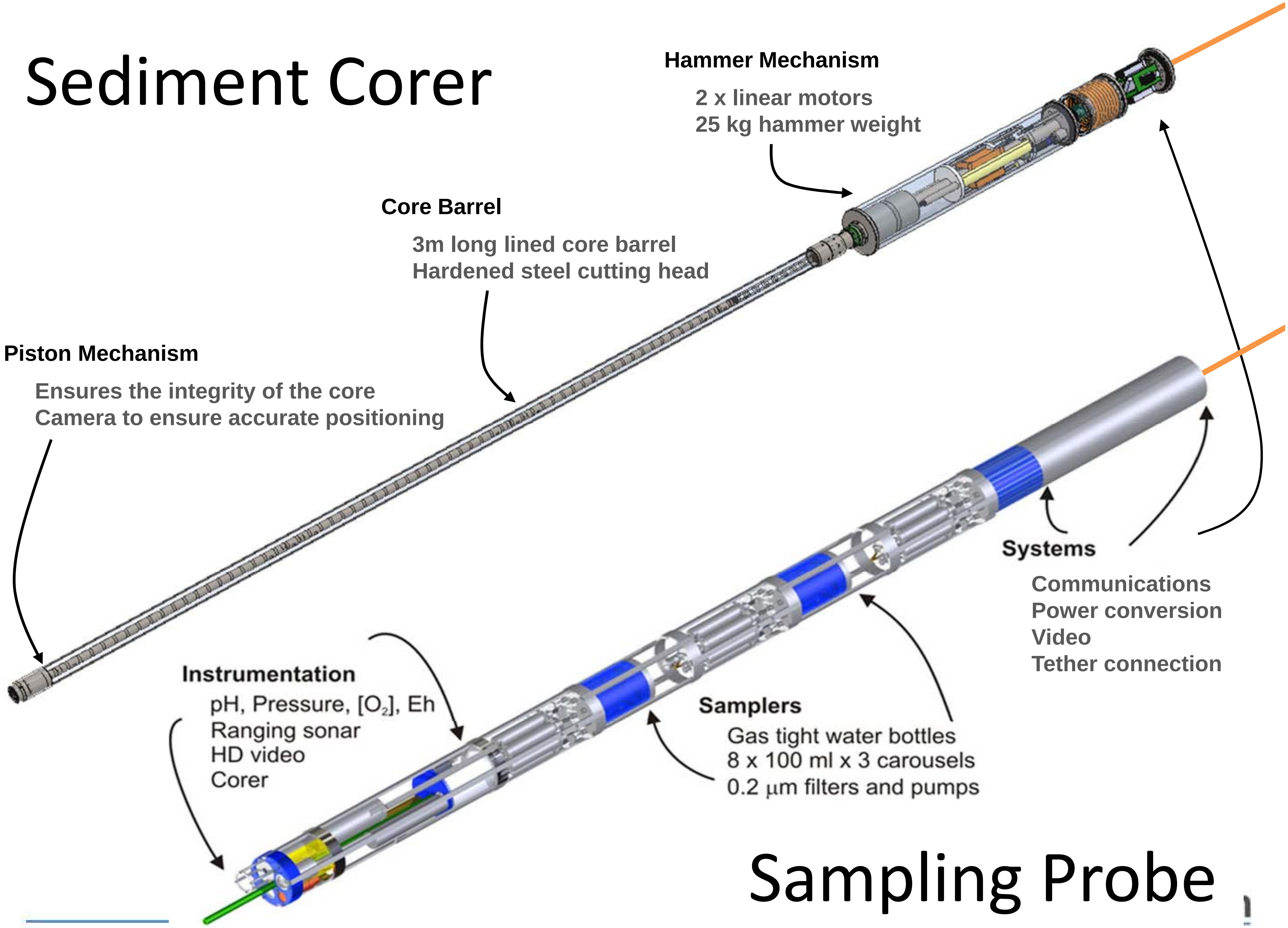
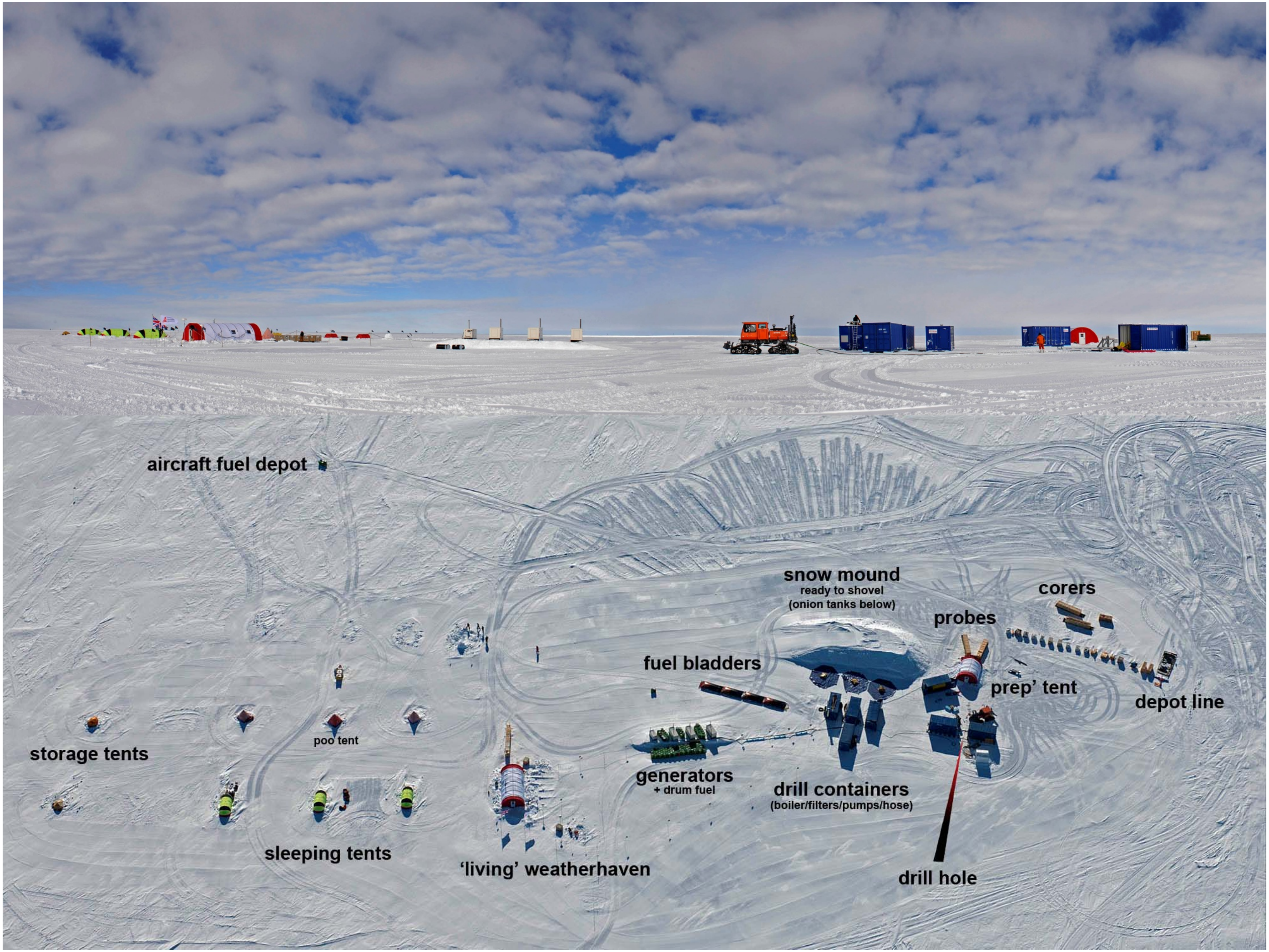
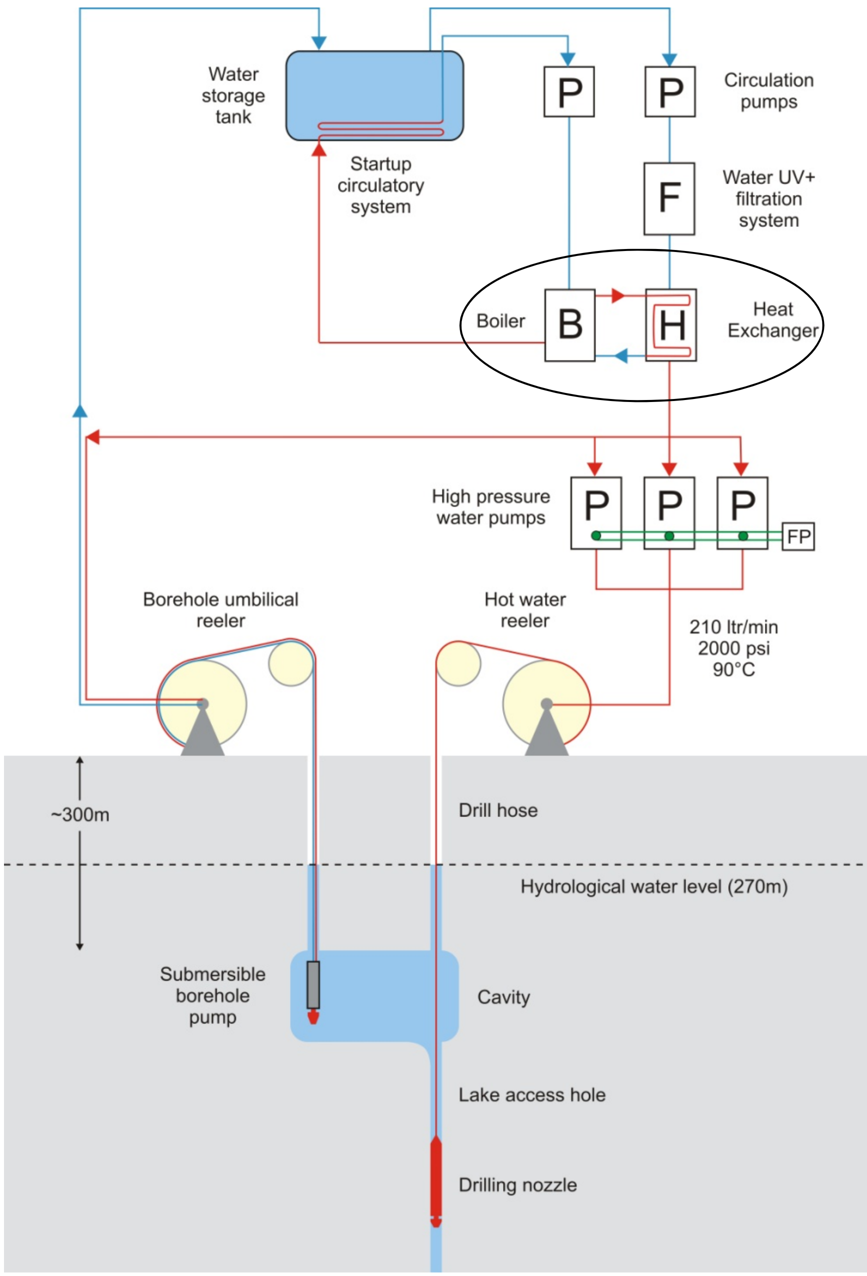
Sediment Corer

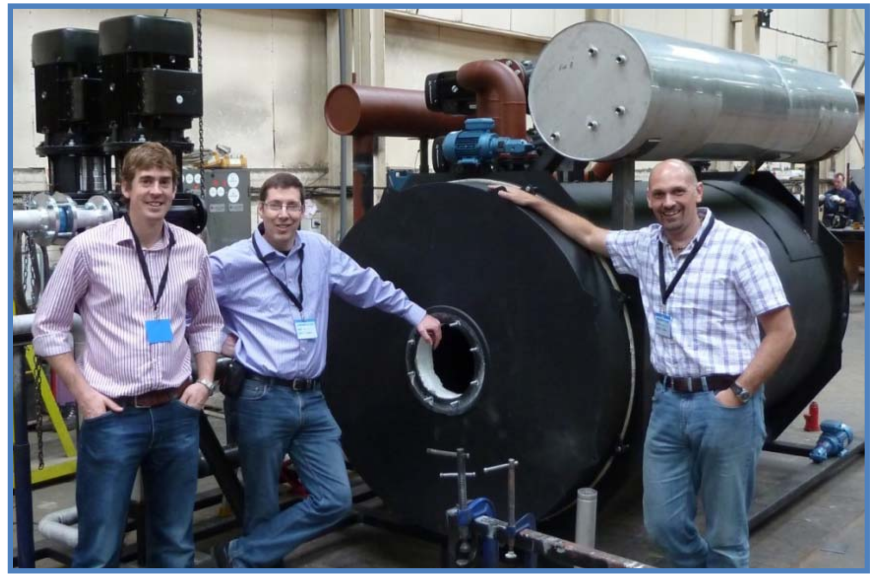


Sampling Probe


aircraft fuel depot
snow mound
ready to shovel
(onion tanks below)
corers
probes
fuel bladders
prep' tent
depot line
storage tents
poo tent
generators
+ drum fuel
drill containers
(boiler/filters/pumps/hose)
sleeping tents
'living' weatherhaven
drill hole



BOILER SYSTEM



- Bespoke containerised boiler system with isolated stainless steel heat exchanger
- Gross weight 8.5 tonnes
- 1.5 MW oil fired boiler
- Burns 250 litres/hr of Jet A1 fuel
- Auxiliary 108 kW electric heater

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DUNPHY


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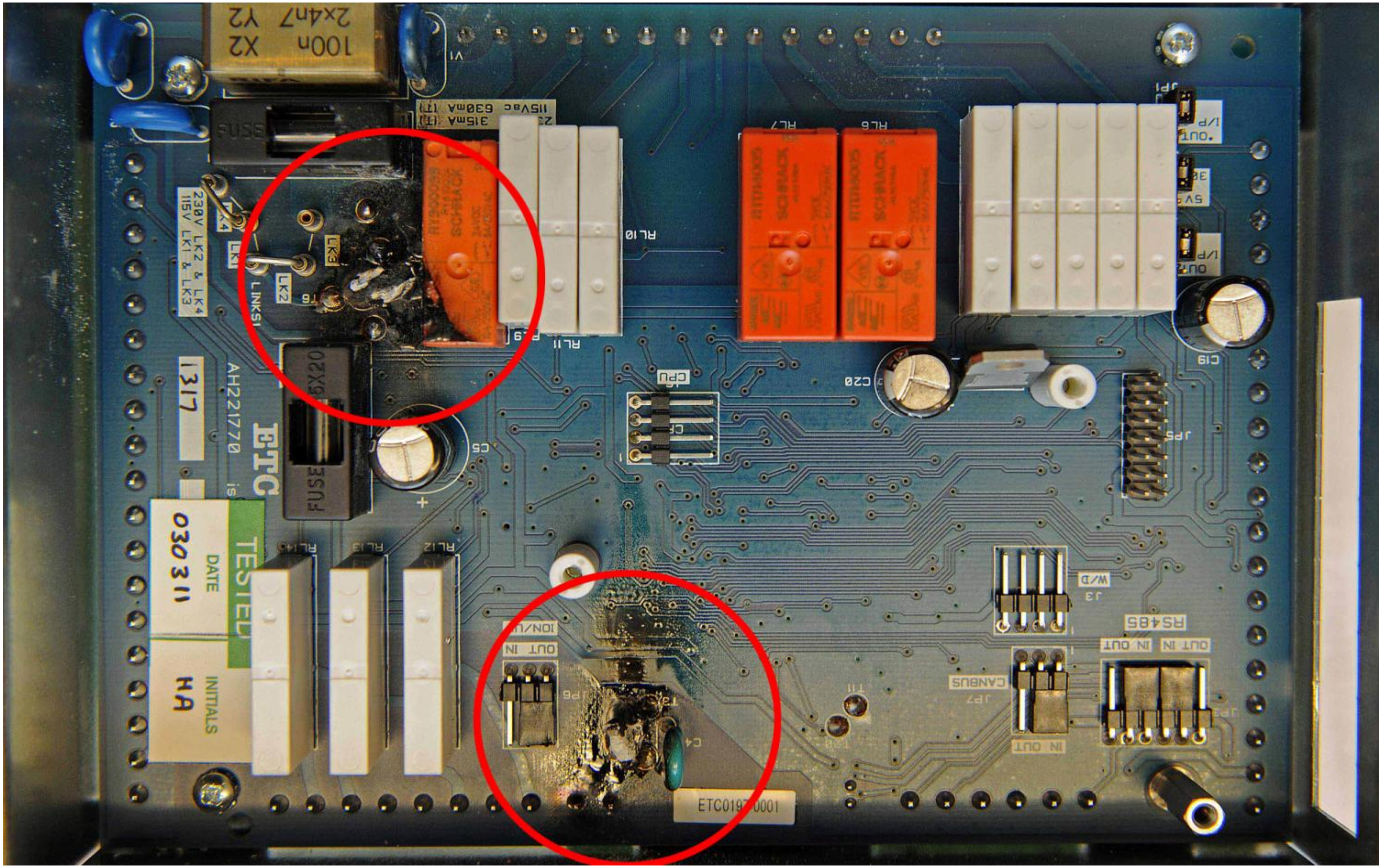
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STATE OF PLAY

- Air / fuel mix difficult to balance resulting in smoke and reduced heat output
- Two controller boards failed – third flown in and programmed via satellite
- A number of fittings failed due to cold and needed to be replaced
- Boiler working (sort of). In contact with the suppier
- Ready to melt snow

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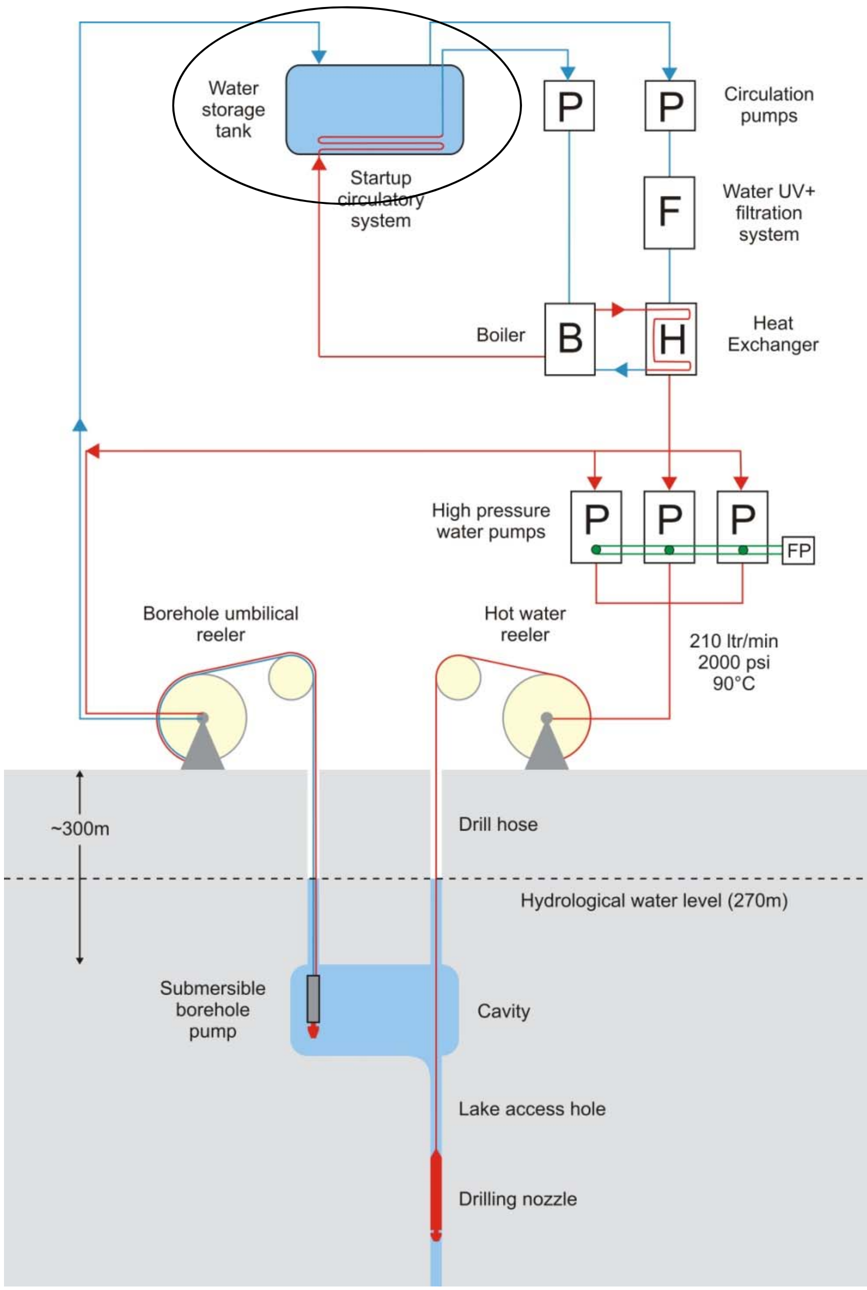

WATER STORAGE TANKS

- 3 interconnected flexible storage tanks
- Each capable of holding 30,000 litres of water
- Size 5.5 m x 1.5 m
- The central tank contained a heating coil fed from the primary circuit of the boiler

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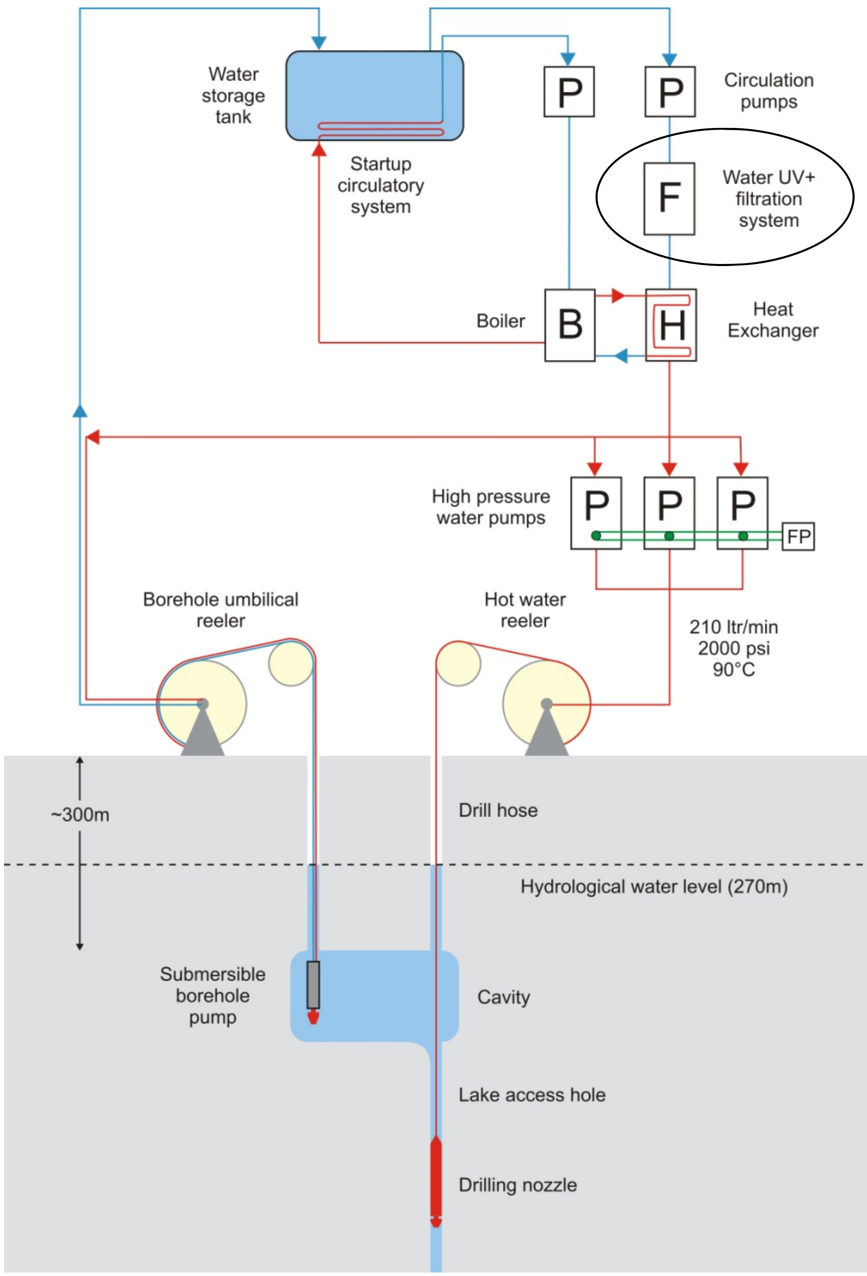
WATER UV & FILTRATION SYSTEM



- Four stage filtration system - 20 µm, 5 µm, 1 µm, 0.1 µm
- Each stage houses 7 polypropylene filters
- Two UV units connected in parallel
- Dual redundancy of filters and UV units

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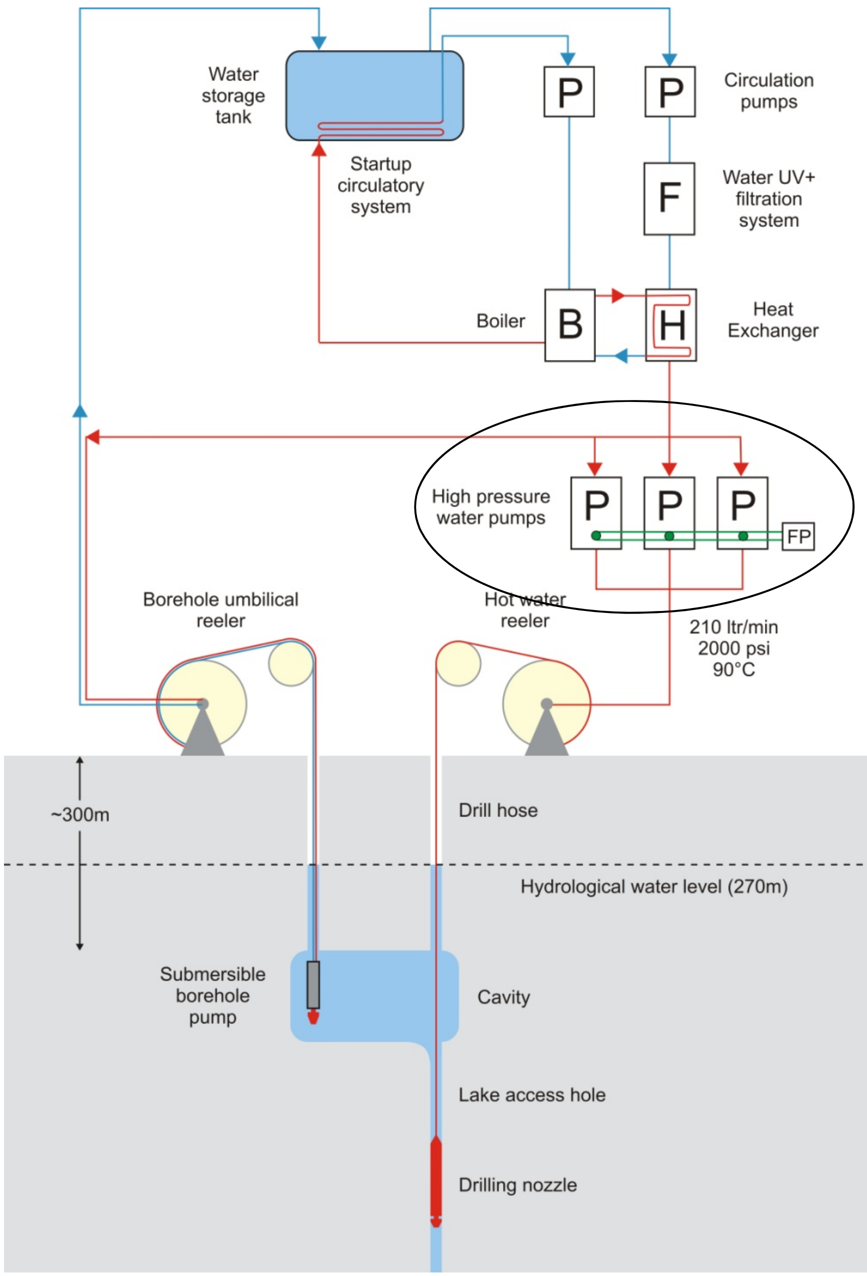
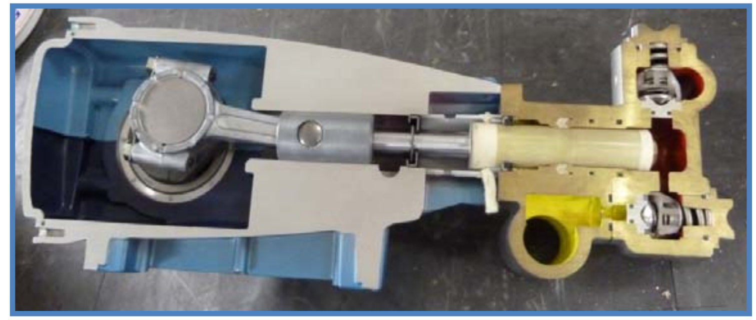


HIGH PRESSURE PUMPS



- Cat Pumps – field proven
- Bank of 4 pumps in parallel, any 3 could be used to reach the required pressure
- A flush pump was used to cool the pumps using an ethanol based coolant to keep the drill water sterile

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STATE OF PLAY

- Water tanks were satisfactory but filling them manually was hard work and the uneven surface meant they lilted to one side obstructing some of the valves
- Filter system worked very well and removed all the soot emissions from the boiler
- Cat pumps worked very well
- Ready to start drilling the borehole

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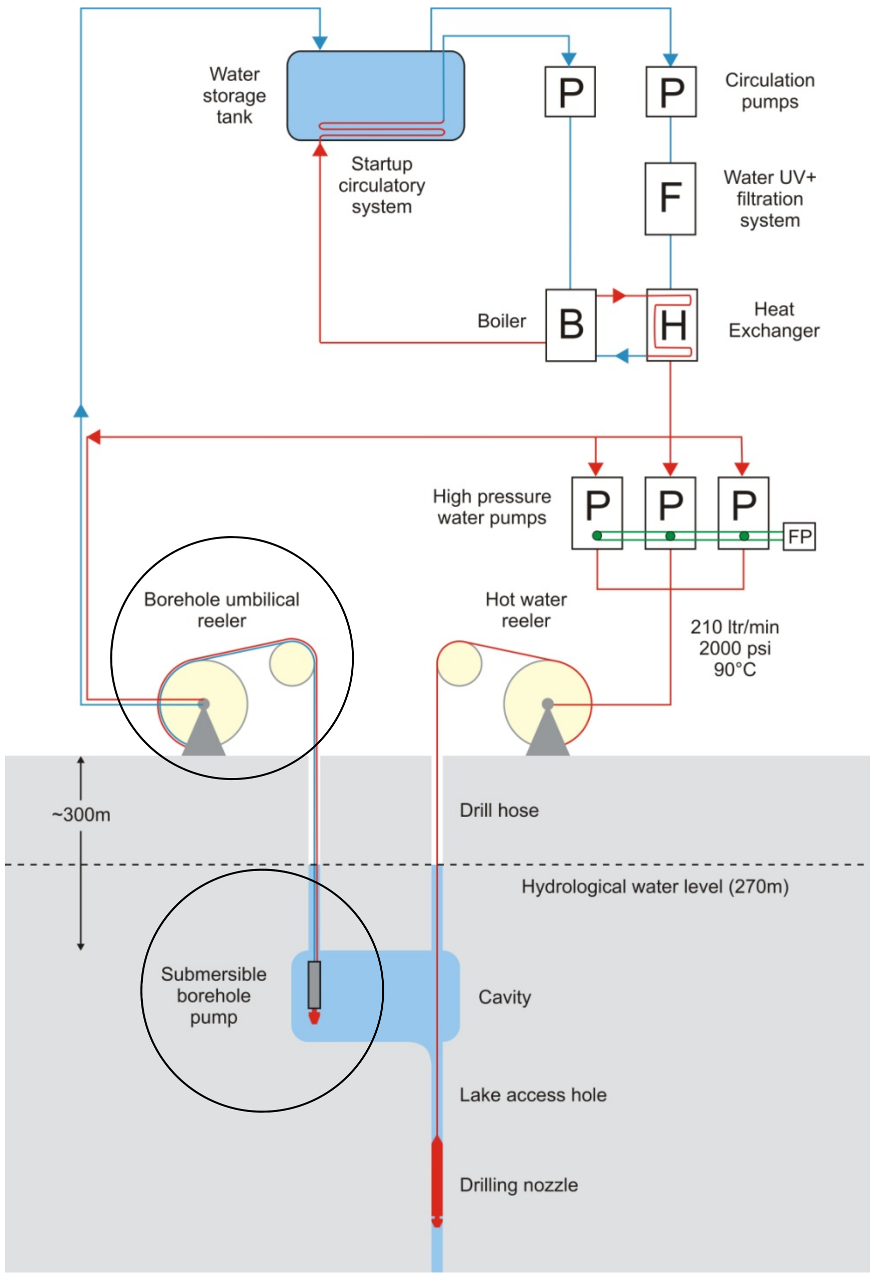
BOREHOLE UMBILICAL REELER & SUBMERSIBLE PUMP



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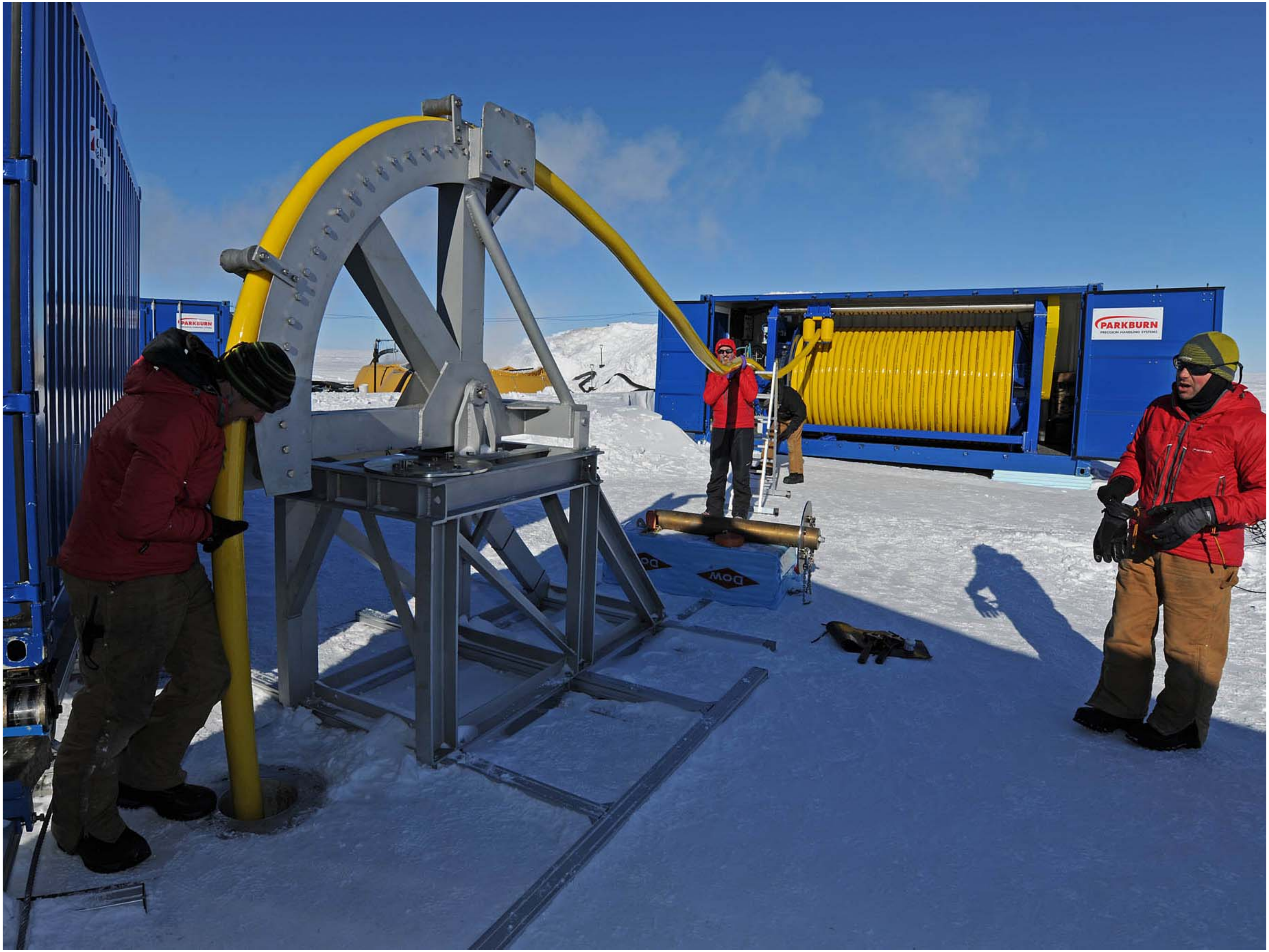
PARKBURN
PRECISION HANDLING SYSTEMS
PARKBURN
Dow
Dow

STATE OF PLAY

- Lack of good winch speed control at slower drilling speeds (hydraulic drive limitations)
- Severe electrical noise and damaged winch load cells made it difficult to “see” the drilling process
- The above resulted in the drill nozzle extension below the submersible pump being bent .... **twice**!
- Nozzle removed!

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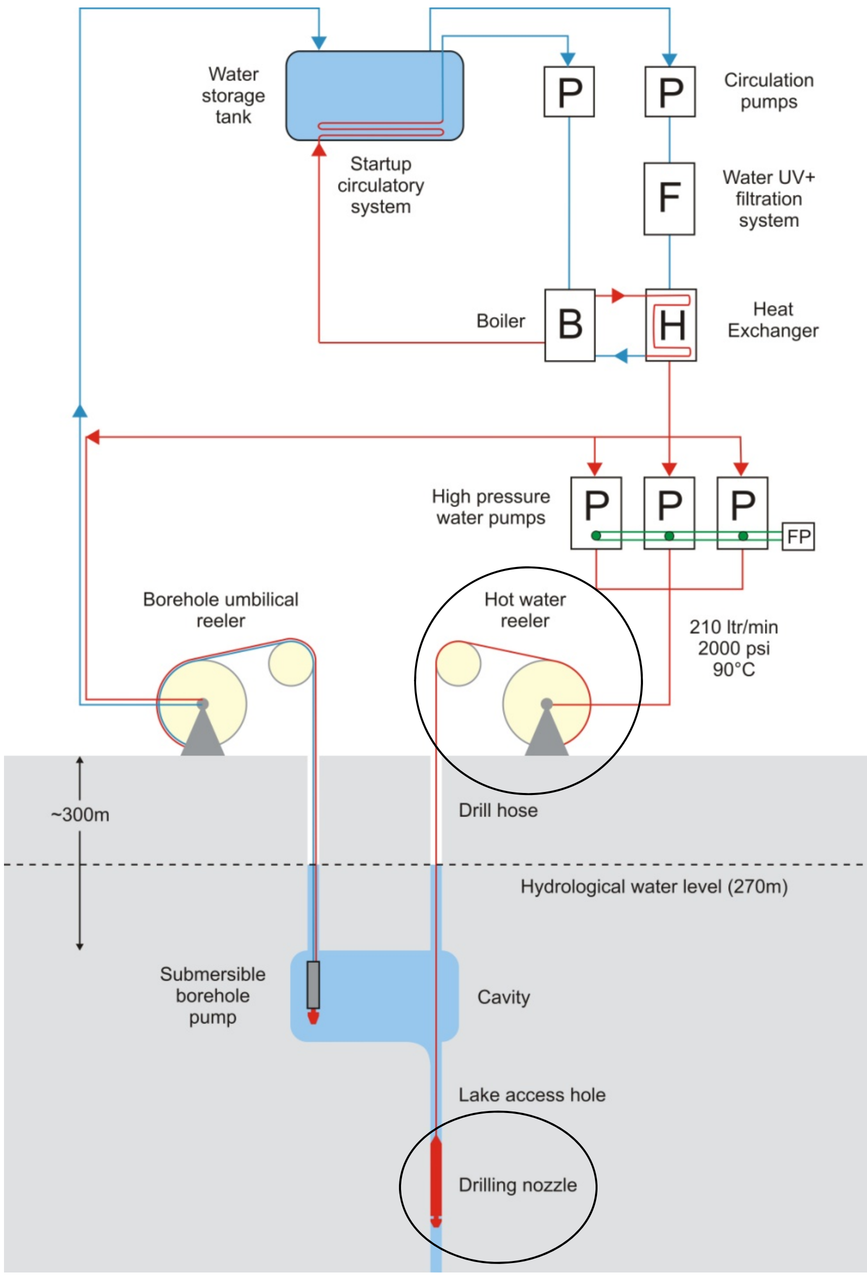
DRILL HOSE REELER & NOZZLE



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Lake Ellsworth
ANDY TAIT
MONTANE
DOW
DOW

STATE OF PLAY

- Borehole cavity volume at 300 m depth estimated to be >100 m^3 after ~ 40 hours in situ
- Main hole cavity volume at 300 m depth estimated to be >70 m^3 after ~ 20 hours in situ
- Failure to link holes at 300 m
- 90,000 litres water used
- Finite supply of fuel
- Limited ability to generate water at surface at the rate required

GAME OVER!

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So what happened?

Drill cavity at 300 m depth

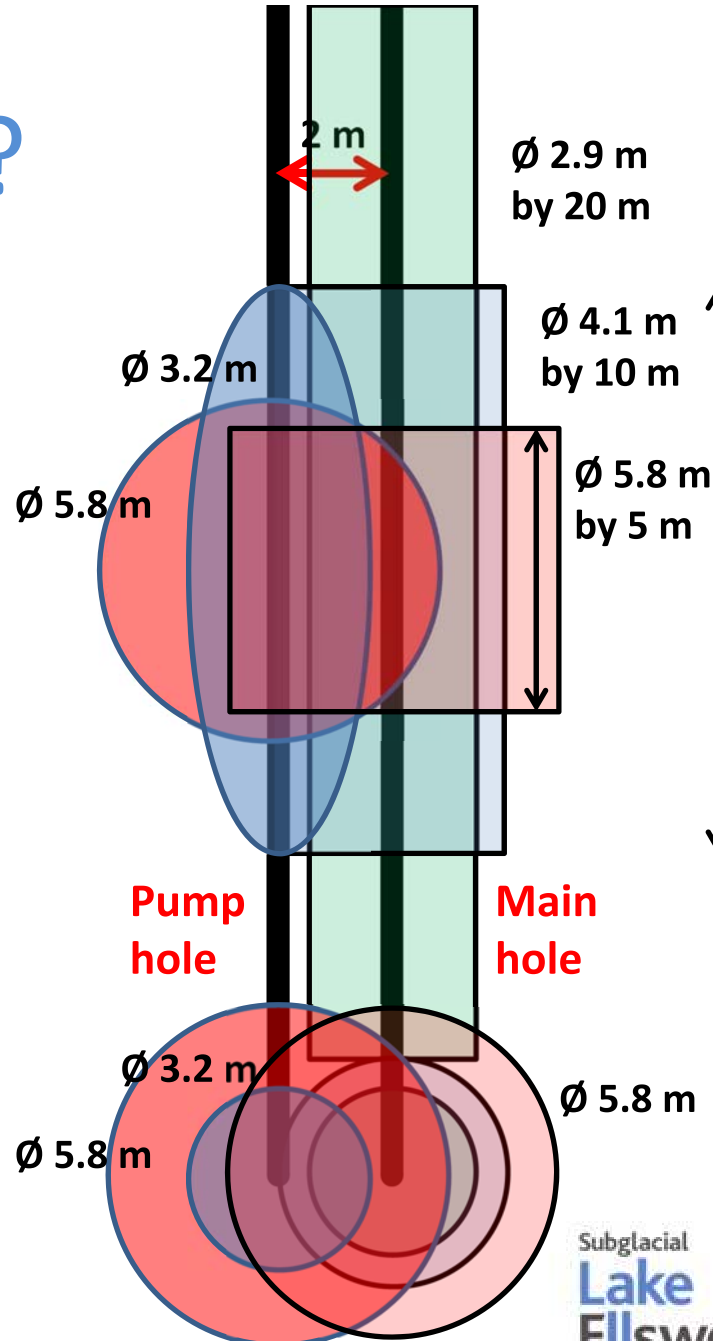
0.52 MW over 20 hrs, melted 102 m^3 of ice in pump hole cavity.
(Sphere Ø 5.8 m, Ellipsoid 10x3.2x3.2 m)

Over 20 hours at >70°C melted 135 m^3 of ice in main hole cavity.
(Cylinder 20x2.9x2.9m or 10x4.1x4.1 or 5x5.8x5.8)

Vertical positioning accurate to 0.5 m.

Conclusion

One or both holes were not vertical as a result of the problems encountered with the winch controls and drill sensors



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Lessons Learned

- Better understanding of the cavity creating process and the max distances between holes
- Instrumentation to determine hole verticality
- Better control of slower winch speeds (switch to electric?)
- Working load cells are essential to determine max drill speed
- Boiler system needs a rethink – there were several minor and one major issue with it
- The data acquisition system needs to be screened from the noise
- The ability to make water quickly needs to be addressed
- The number and skill set of the field team should be reviewed

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Questions?
UP-17601
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