Coastal Geothermal Energy Initiative

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Digging Deeper 2011

Queensland Government

Presentation outline

- Project overview
  - Status
  - Work program
  - Project timeline
- Preliminary results
  - Millungera Basin
  - Maryborough Basin

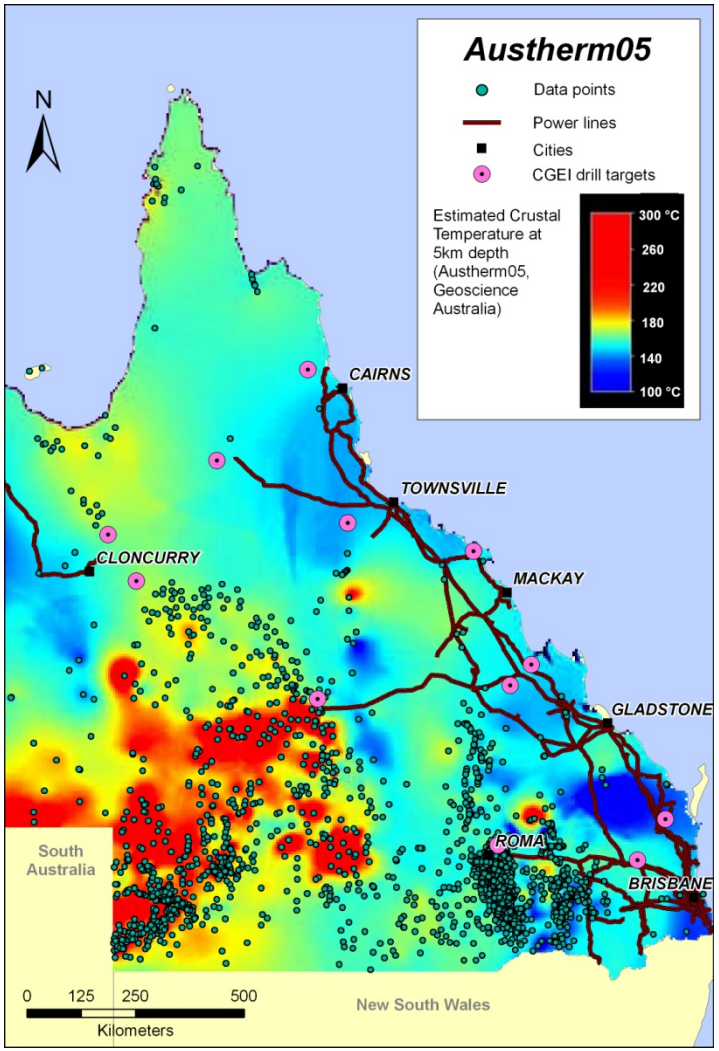
- Drilling program
  - Hole design
  - Hole completion

Coastal Geothermal Energy Initiative

- ***Project aim:***

  Investigate sites with geothermal potential close to existing electricity markets through a regionally spaced drilling program

- Collaboration between Geological Survey of Queensland (GSQ) and Office of Clean Energy (OCE)



Status (as of the 10th November 2011)

Drilling:

- 11 sites drilled
  - 1 site abandoned
- 1 site not to be drilled

Thermal conductivity analysis:

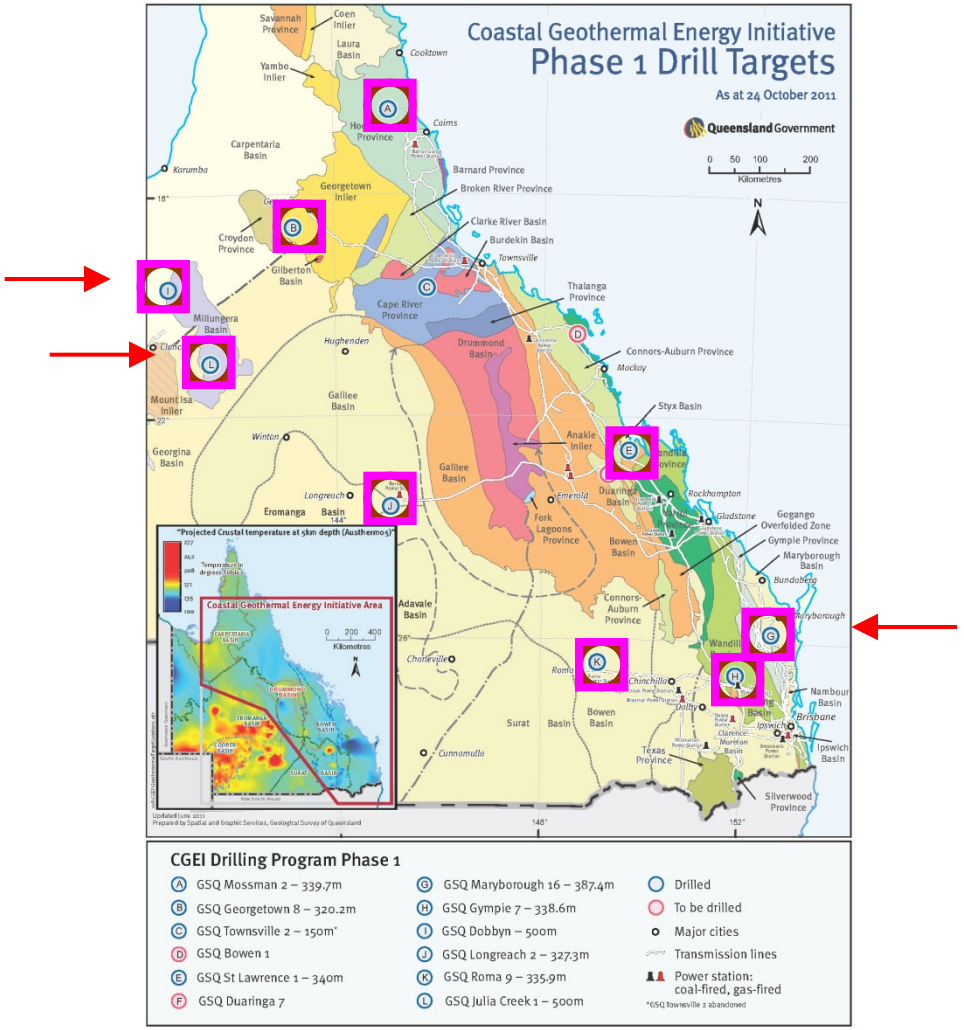
- 9 sites

Temperature logging:

- 9 sites

Heat flow modelling:

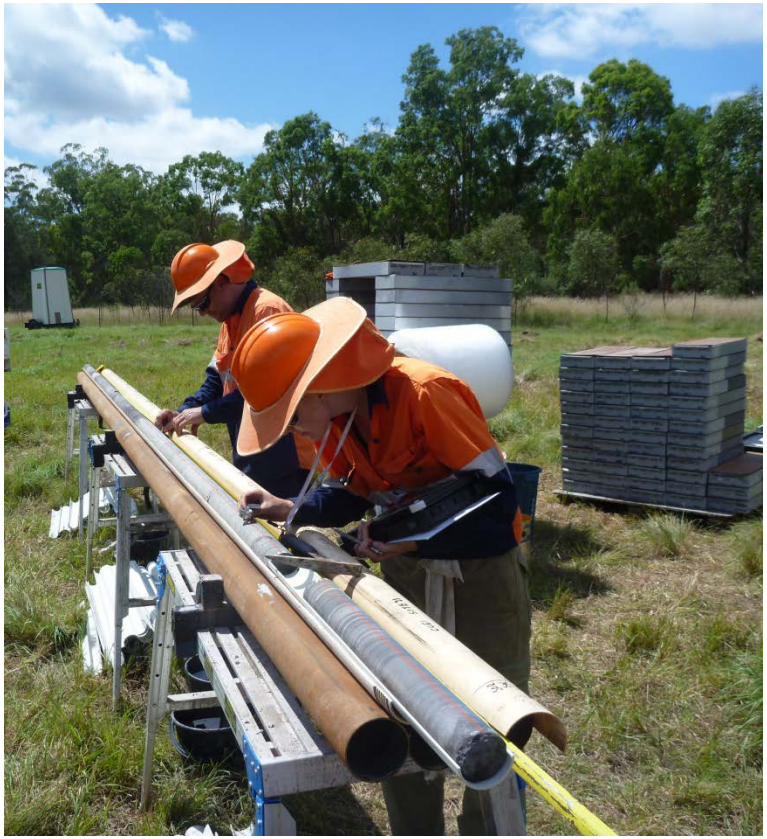
- 3 sites



CGEI work program

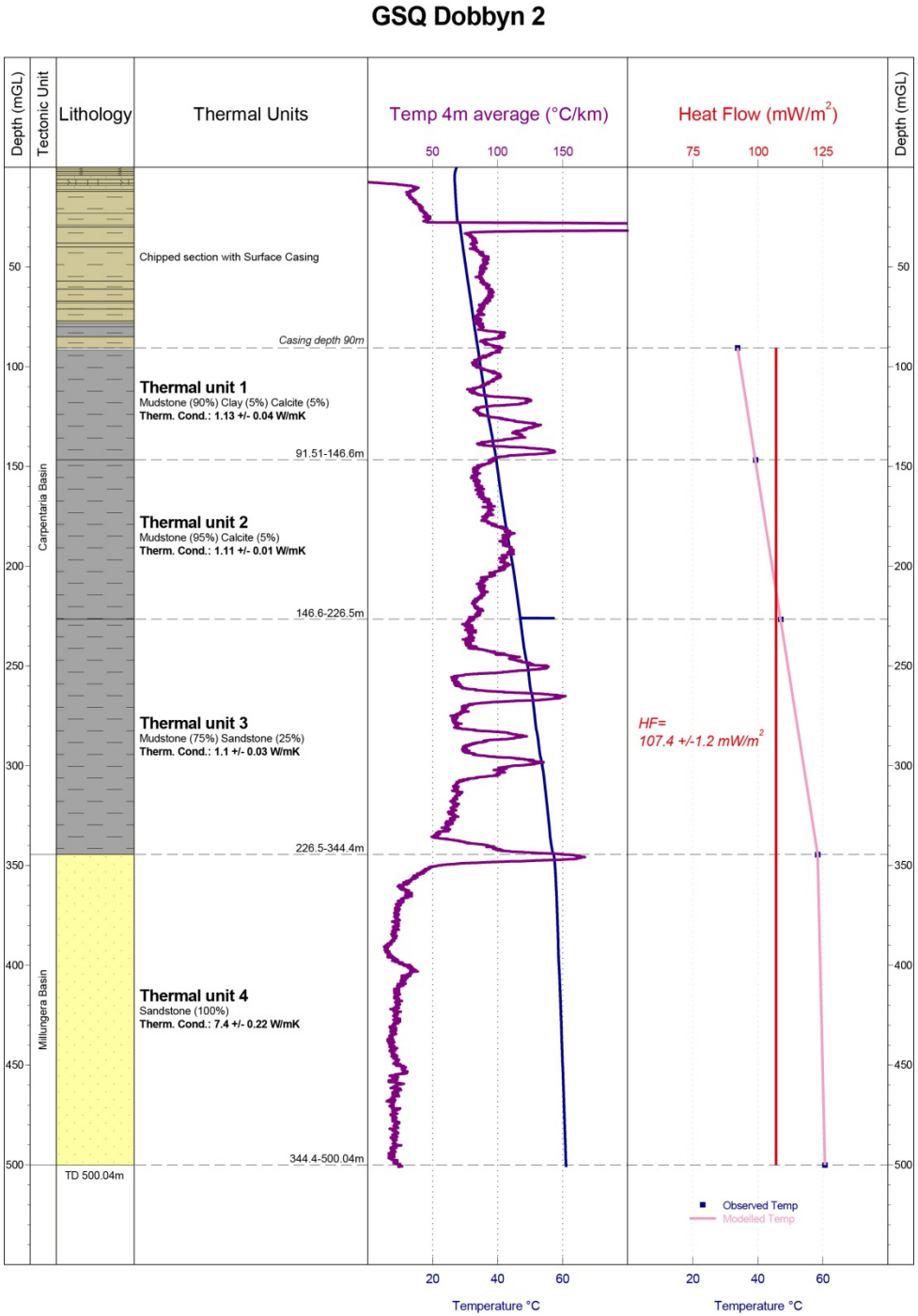
1. **Target assessment**
   - 32 targets
2. **Phase 1 Drilling**
   - 10-12 highest ranking sites
3. **Thermal data collection**
   - Thermal conductivity analysis
   - Temperature logging
   - Hot Dry Rocks and Geoscience Australia
4. **Heat flow modelling**
   - 1D inversion technique

$$q = k.{dT}/{dz}$$



Project timeline

Data collection and analysis:	
•Phase 1 drilling	Nov 2010 - Nov 2011
•Phase 1 work over	Dec 2011 - Jan 2012
•Thermal data collection/analysis	Nov 2011 - Apr 2012
Reporting:	
•Well Completion Reports	Jan 2012 - June 2012
•Final Report: Geothermal potential of Queensland	Dec 2012



Heat flow modelling results

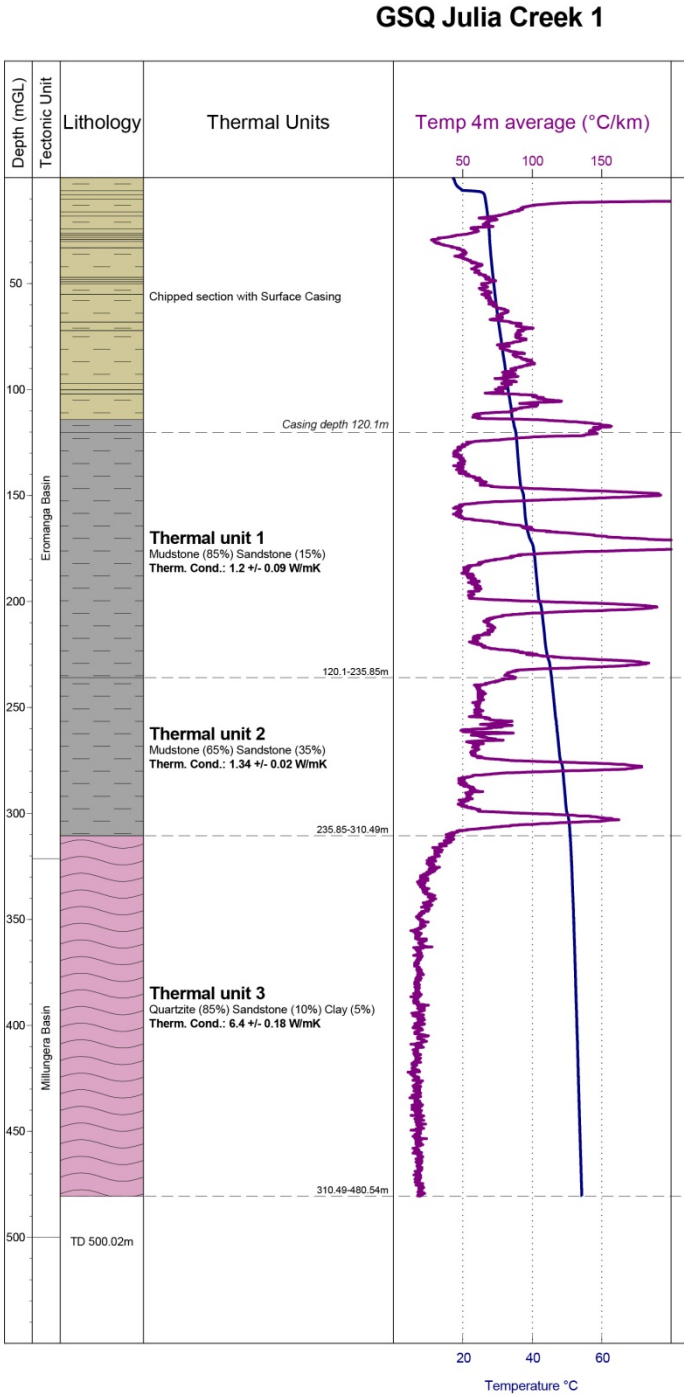
GSQ Dobbyn 2

- BHT 61.1 °C @ 500m
- 4 thermal units

Modelled heat flow:

107.4 ± 1.2 mW/m²

>> 60 mW/m² (average)



Heat flow modelling results

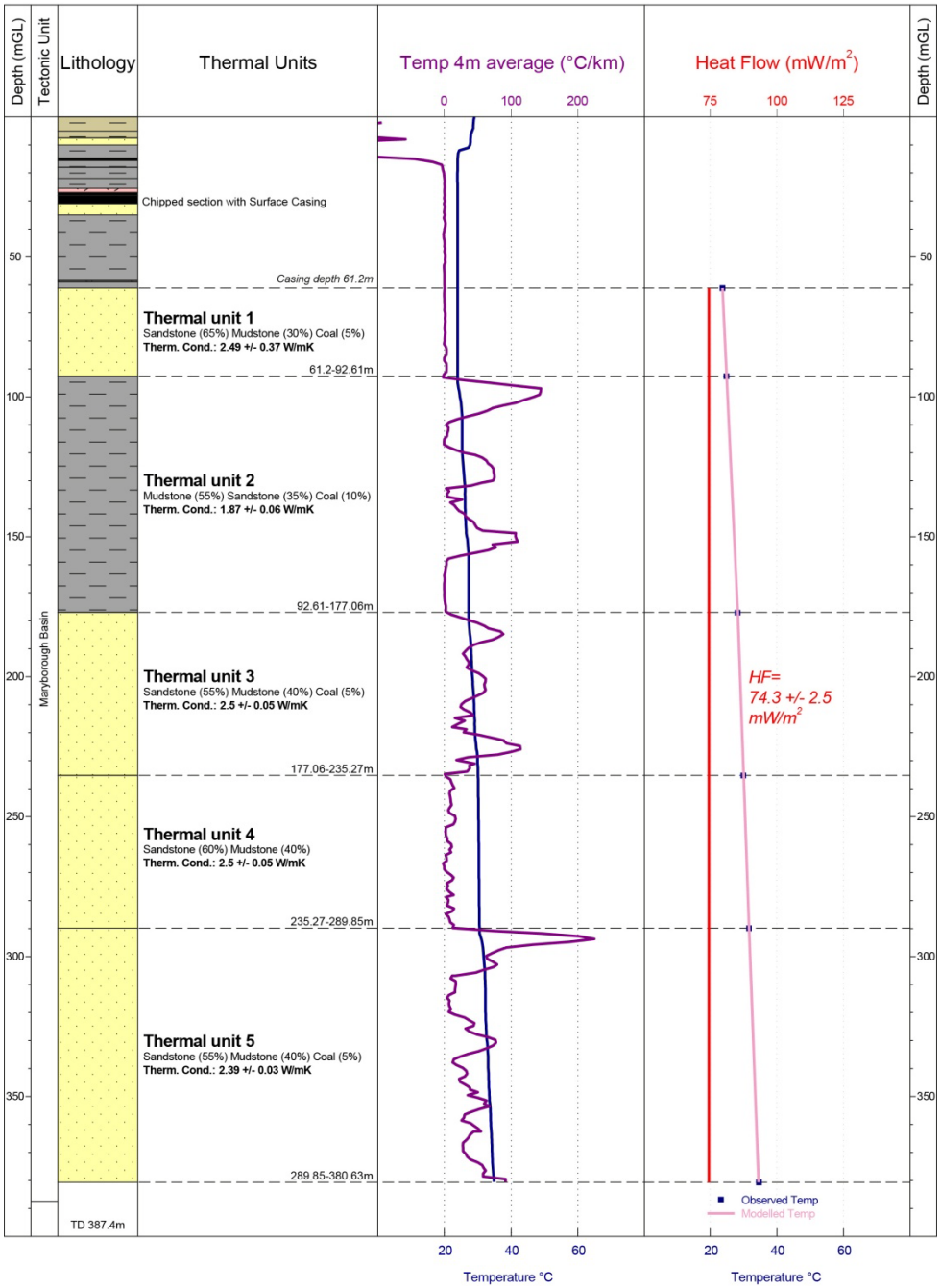
GSQ Julia Creek 1

- BHT 54.3 °C @ 480.5m
- 3 thermal units

Modelled heat flow:

103.3 ± 4.2 mW/m^2

>> 60 mW/m^2 (average)



Heat flow modelling results

GSQ Maryborough 16

- BHT 34.9°C @ 380.6m
- 5 thermal units

Modelled heat flow:

74.3 ± 2.5 mW/m²

> 60 mW/m² (average)

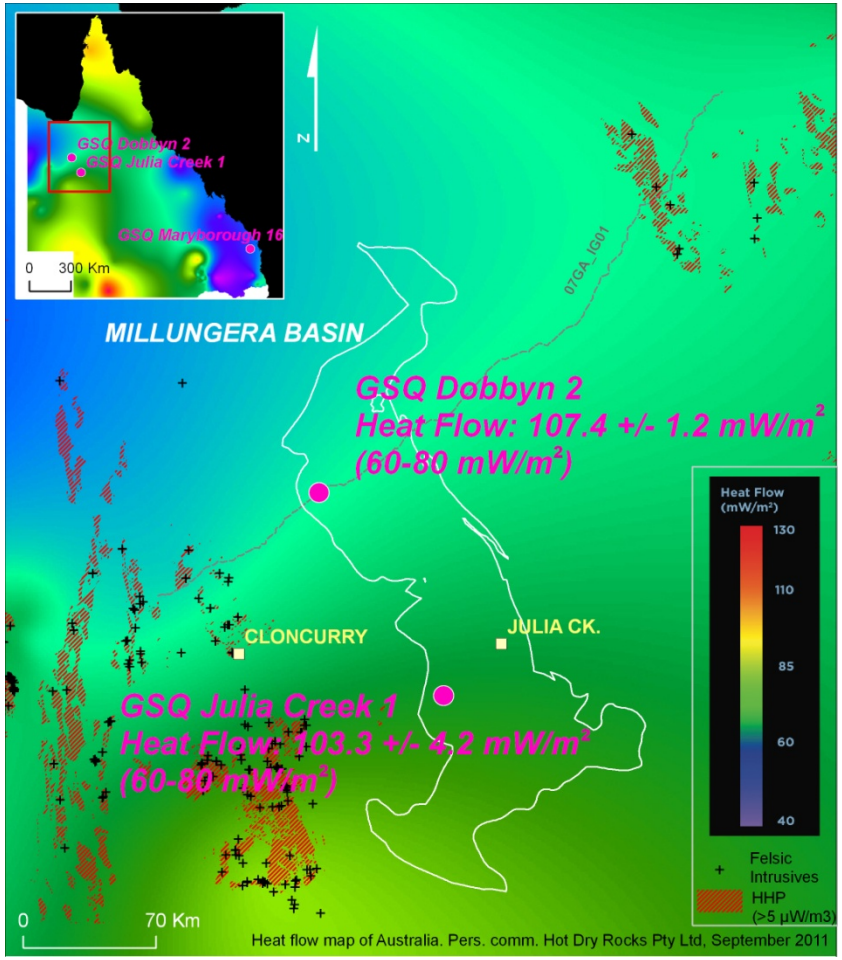
Millungera Basin geothermal potential

Current heat flow estimate:

60-80mW/m² (HDR, 2011)

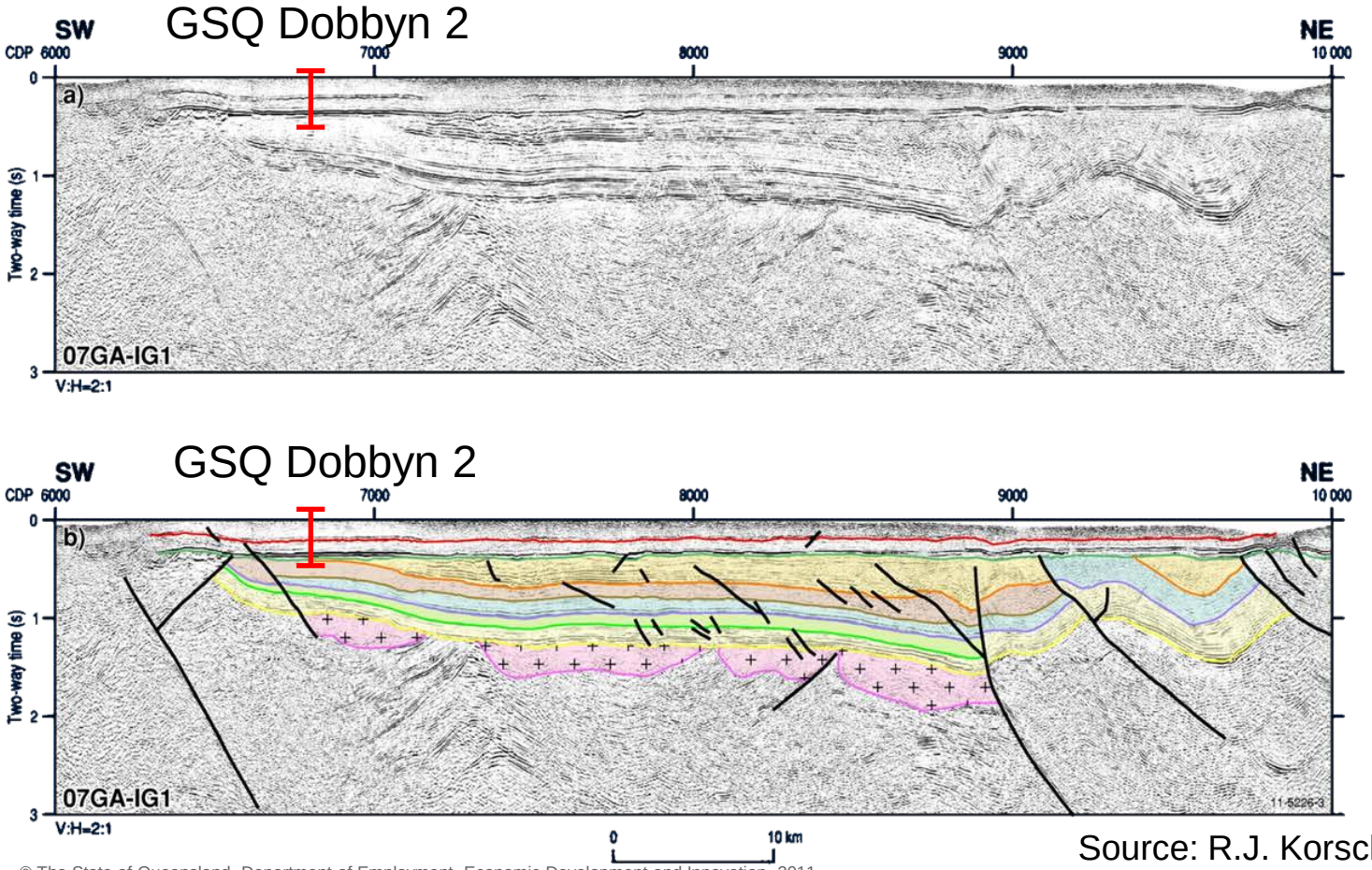
HEAT SOURCE

- High heat producing (HHP) Proterozoic intrusives to the west (Mount Isa Inlier) and east (Georgetown Inlier)



Millungera Basin geothermal potential

INSULATION



07GA-IG1

- Granite
- Fault
- Base Toolebuc Formation
- Base Carpentaria Basin

Millungera Basin

- Base Sequence 3
- Mid Sequence 2
- Base Sequence 2
- Mid Sequence 1
- Base Sequence 1

Source: R.J. Korsch and others, 2011.

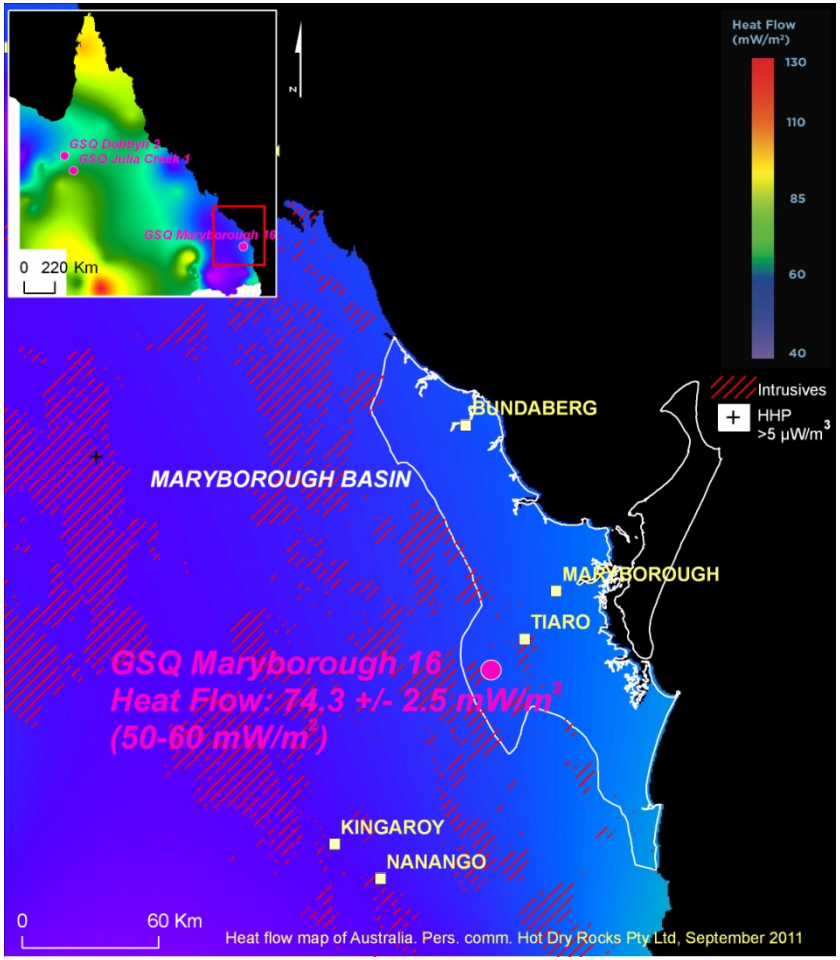
Maryborough Basin geothermal potential

Current heat flow estimate:

50-60mW/m² (HDR, 2011)

HEAT SOURCE

- Late Triassic, Late Jurassic-Cretaceous intrusives
- No heat production values available

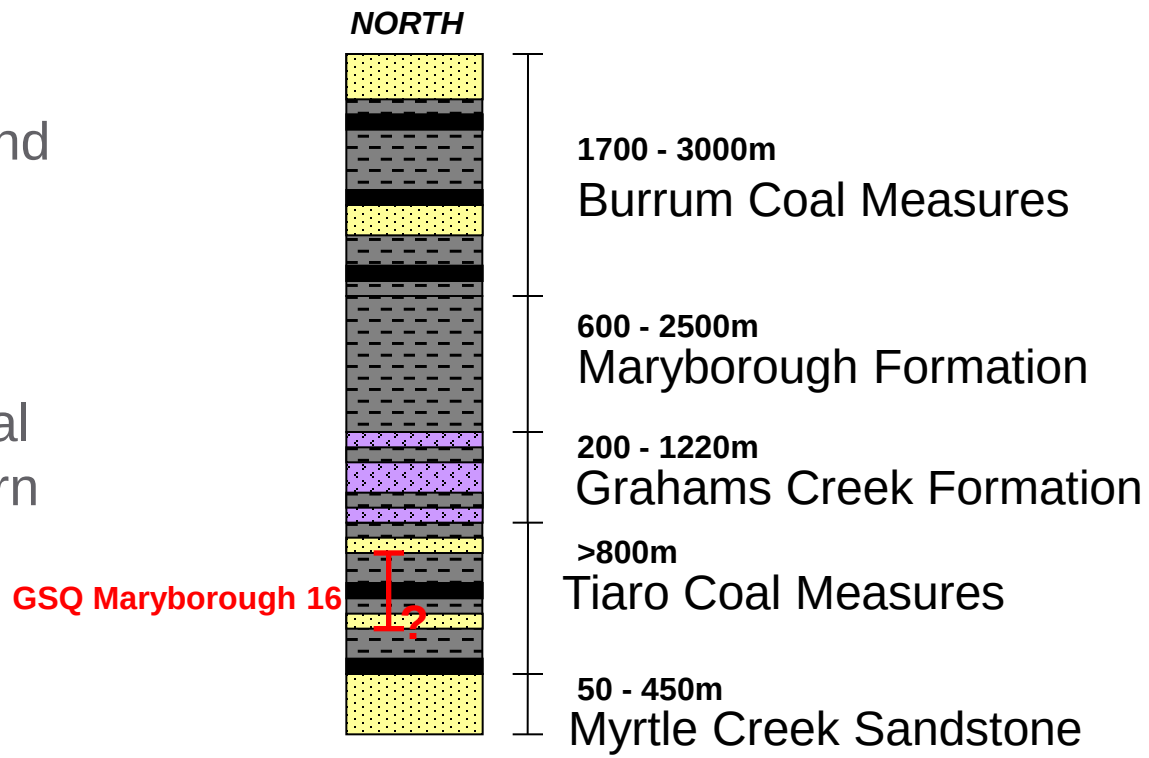


Geothermal potential in Queensland: Maryborough Basin

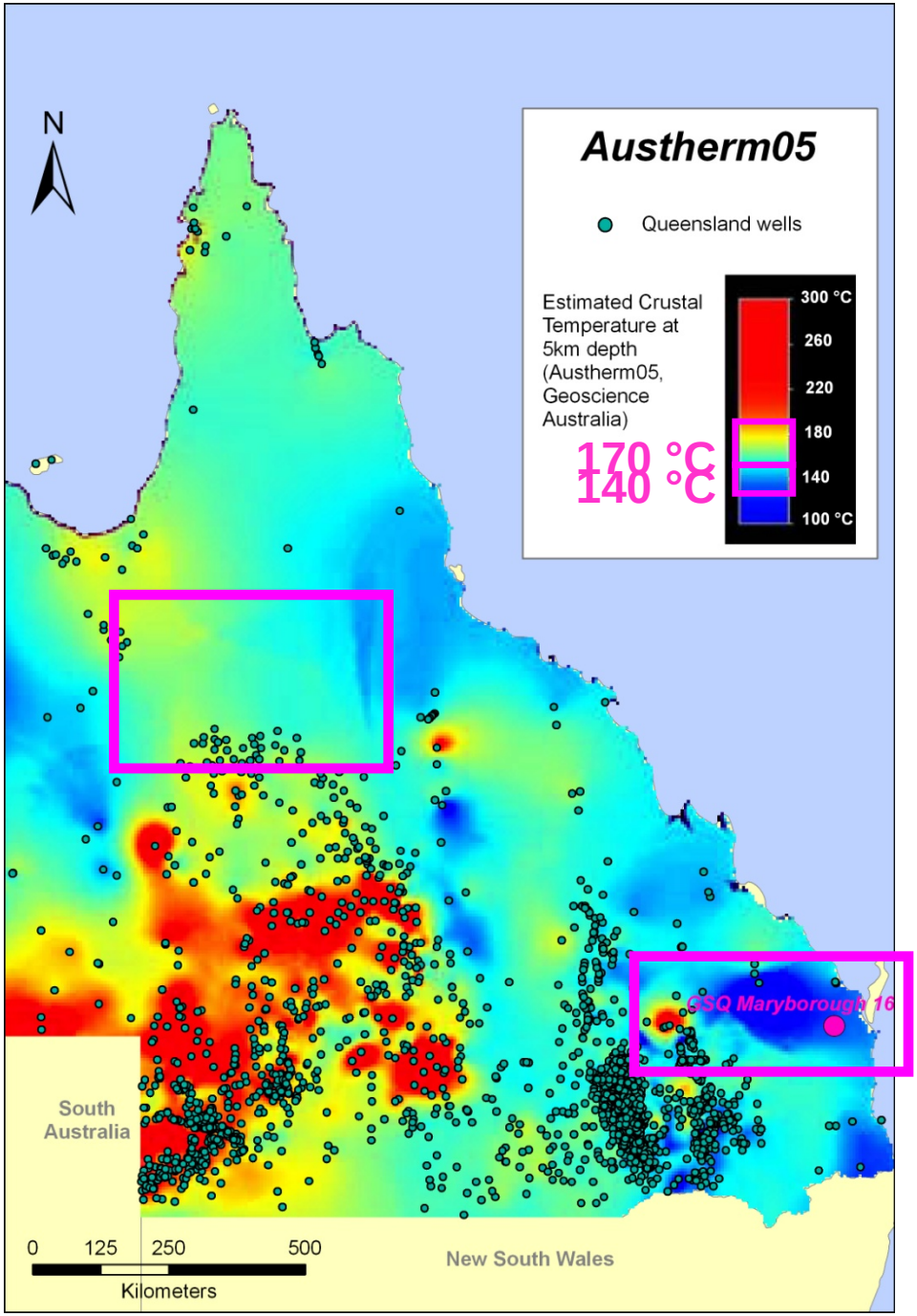
INSULATION

- Interbedded mudstones, siltstones, sandstones and coal provides excellent insulation

- Up to 3000m of additional coal measures in northern basin



Source: Day and others, 1983.

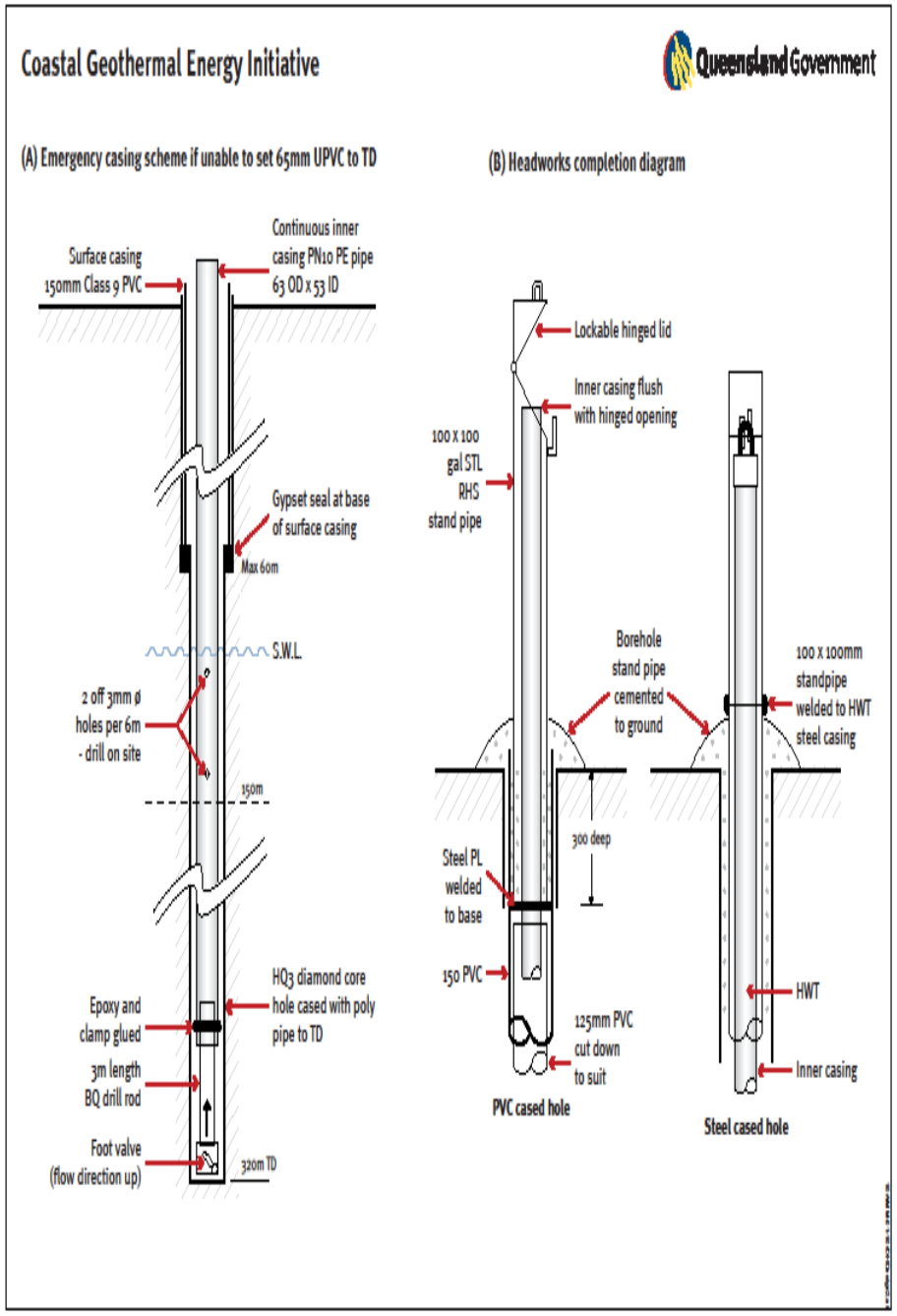


Temperature extrapolation to 5 km

- MILLUNGERA BASIN
  - GSQ Dobbyn 2
    234 ± 15 °C
  - GSQ Julia Creek 1
    223 ± 15 °C
- MARYBOROUGH BASIN
  - GSQ Maryborough 16
    202 ± 15 °C

Drilling program

- Initial considerations
- Drilling complexities
- Changes to hole design and completion
- What we have learnt
- Future considerations

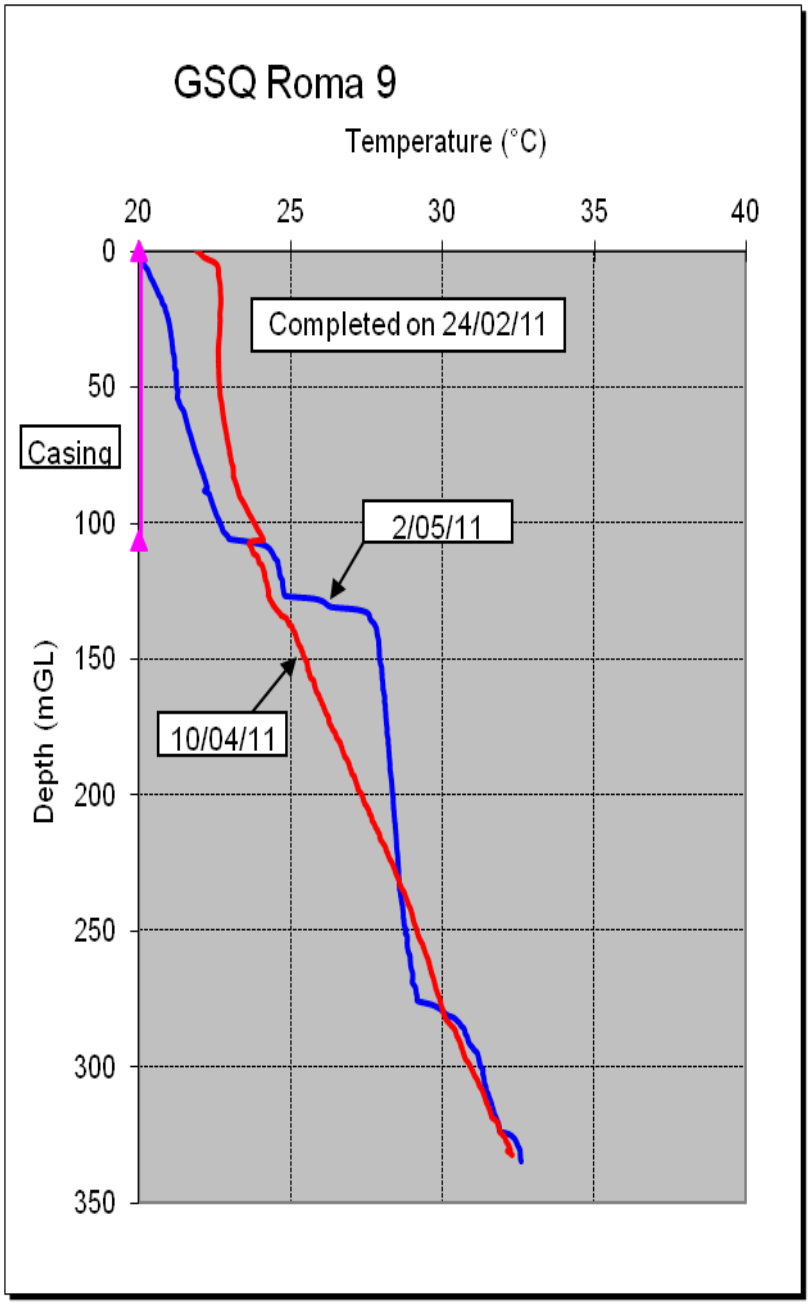


Initial considerations

- Previous shallow hole geothermal drilling programs
- Costs vs number of holes
- Thermal stabilization – period and methods
- Acts and Regulations
- Hole design

Drilling complexities

- Aquifer detection and cementing
- Achieving thermal stabilization

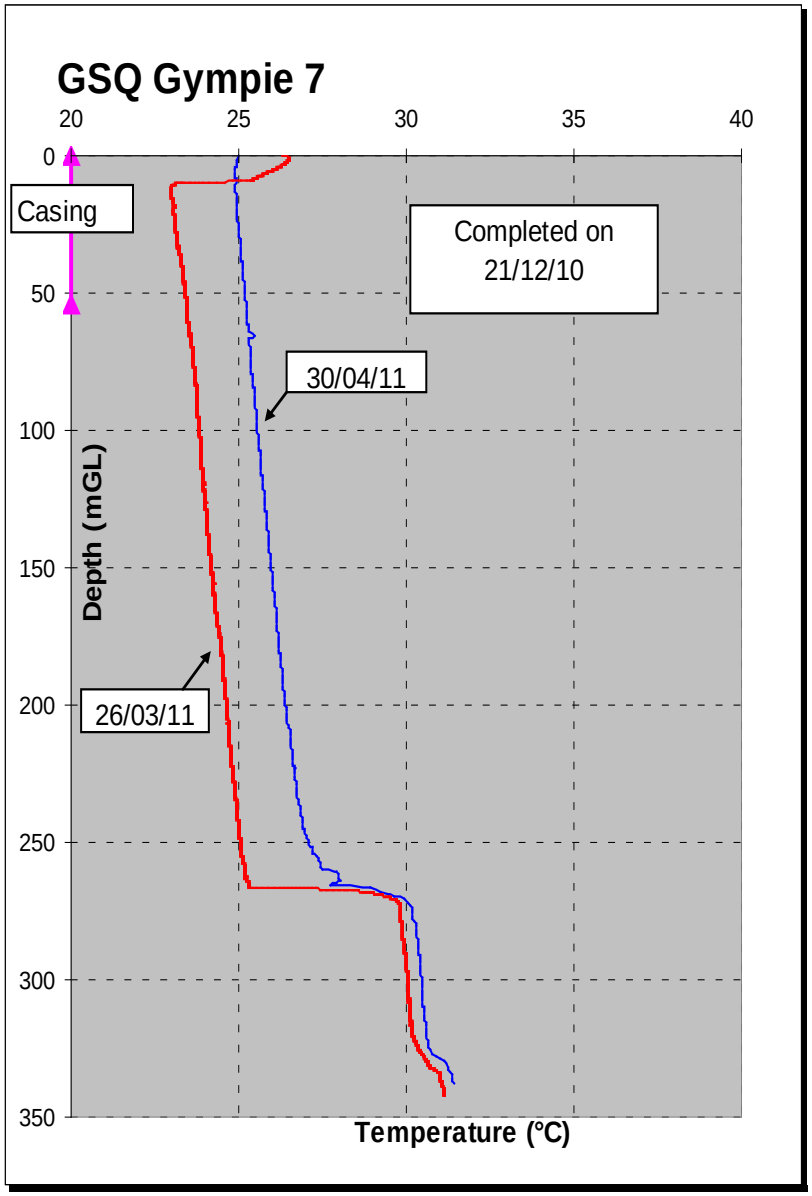


Aquifer detection and cementing

- Known aquifers and unknown ‘aquifers’
- Detection Methods
  - drillers
  - logging
- Adequate pumping pressure to penetrate the formation
- Aquifer flow and type of cement

Achieving thermal stabilization

- Measuring thermal stabilization period?
- Impact of undetected aquifers/porous formations

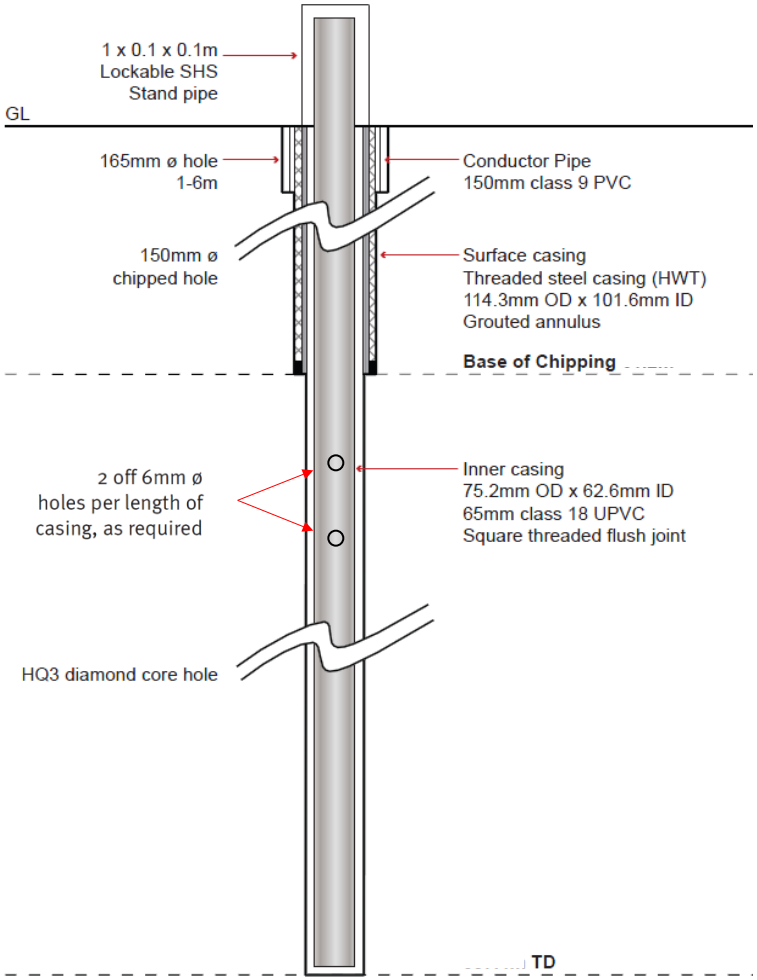


Casing

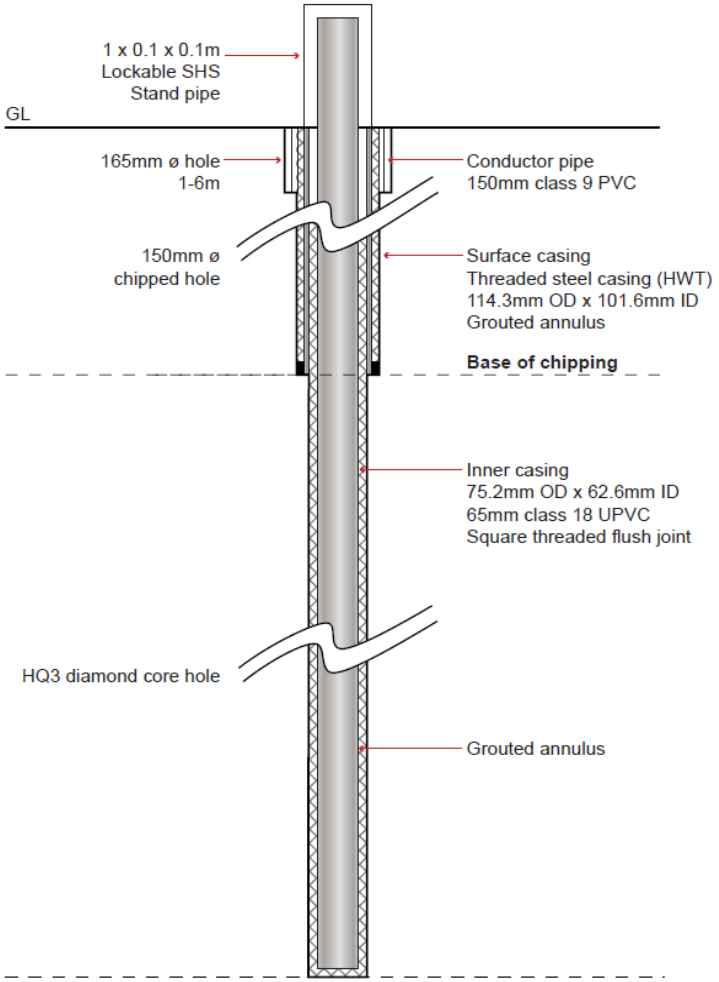
- Surface casing
- Previous projects have used poly pipe to TD
- We used Class 18 PVC to keep the hole open

Changes to hole design

Initial design



Final design



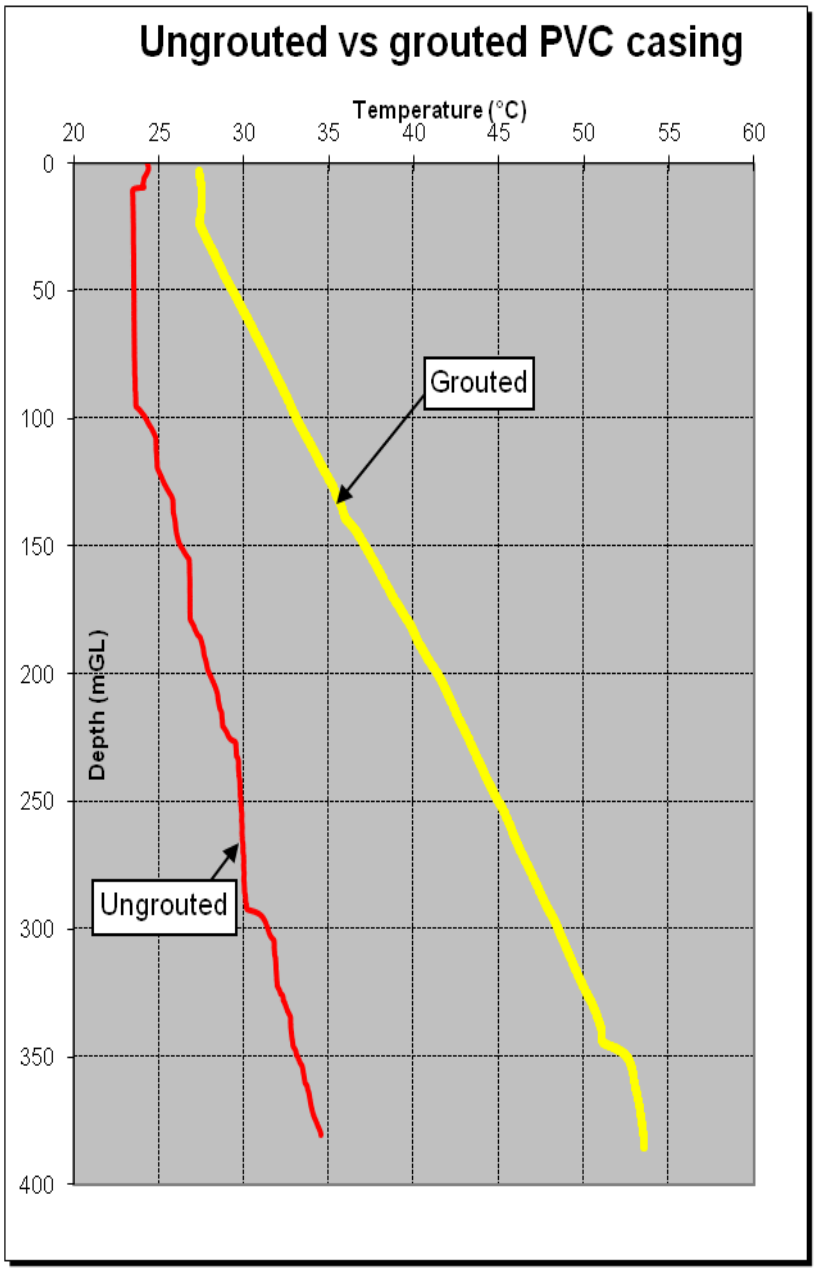
Changes to hole completion

- First 5 sites

  - uncemented TD casing, pressure equalization relief
  - holes open to TD but open to circulations issues

- Remaining holes

  - cemented in TD casing
  - open to cementing issues



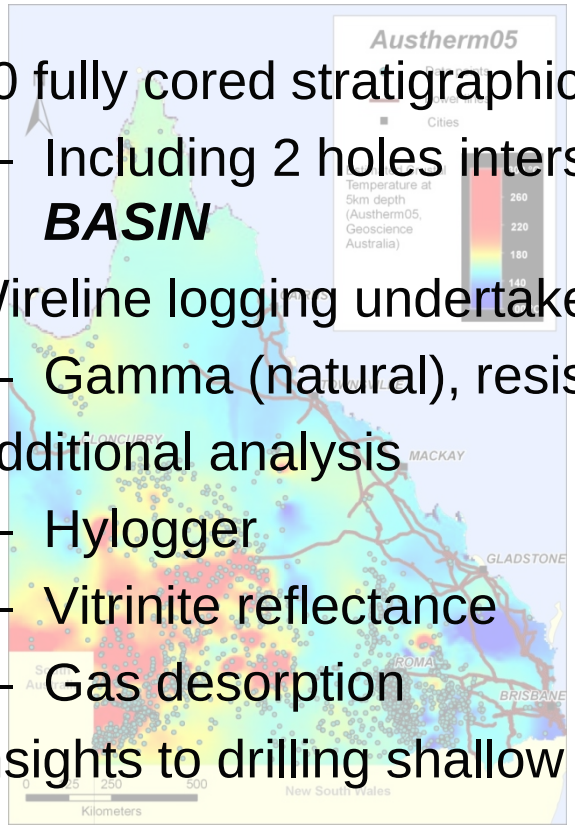
Learning and recommendations for the future

Picture courtesy of AMC Equipment Division Pamphlet 2010

- Better mud logging
- Site by site hole specifications
- Open hole geophysical logging
- TD casing and cementing

Benefits to Queensland's explorers

Detailed temperature datasets to enhance Queensland's geothermal exploration



- 10 fully cored stratigraphic holes between 320-500m
  - Including 2 holes intersected newly discovered ***MILLUNGERA BASIN***
- Wireline logging undertaken where possible
  - Gamma (natural), resistivity (LON, SPR, SHN), sp, sonic
- Additional analysis
  - Hylogger
  - Vitrinite reflectance
  - Gas desorption
- Insights to drilling shallow holes for temperature and heat flow data

Collaborations

- Geoscience Australia

  Thermal conductivity analysis and temperature logging

- Hot Dry Rocks

  Thermal conductivity analysis and temperature logging

- Queensland Geothermal Energy Centre of Excellence

APPENDIX

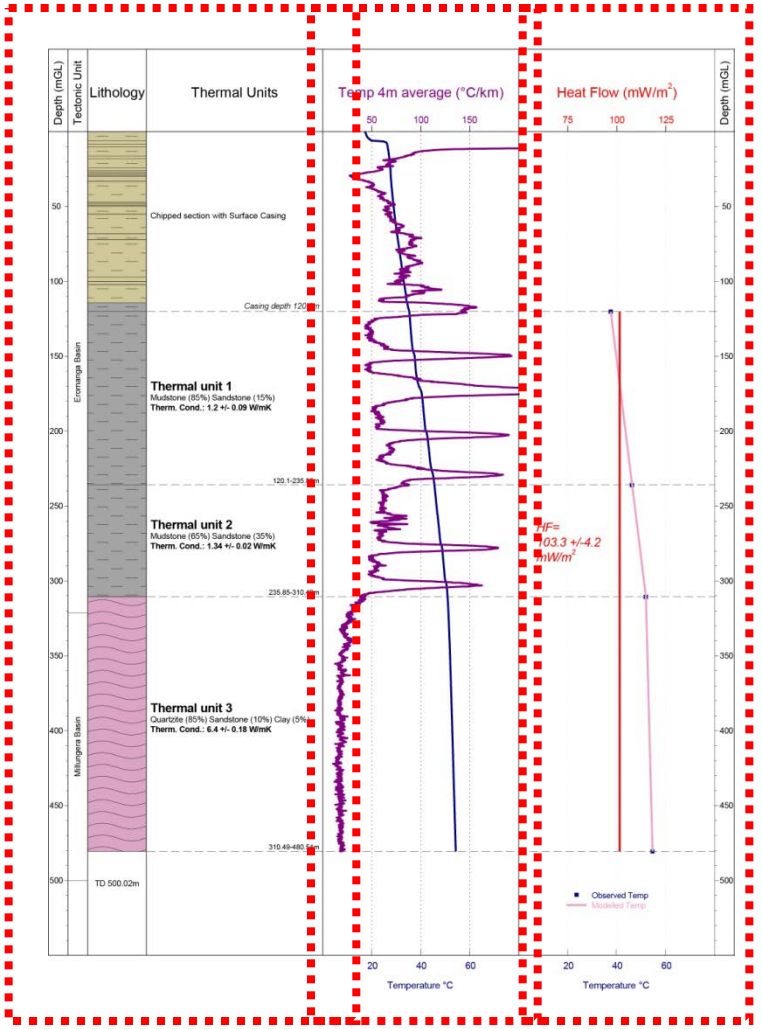
CGEI project workflow: Heat flow modelling

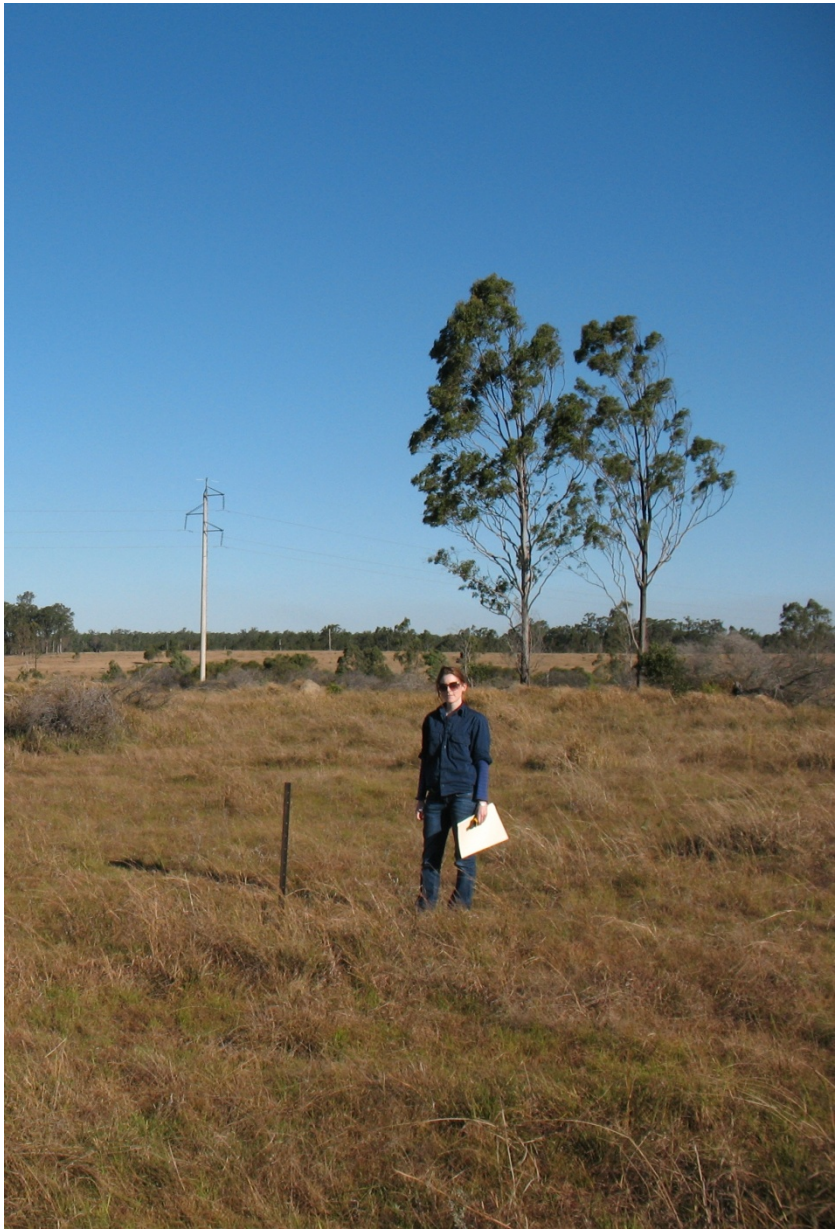
- Thermal units selected from temperature gradient
- Representative thermal conductivity sample was selected to represent the bulk rock type for each thermal unit
- Heat flow modelling over thermally stable interval

$$q = k.\frac{dT}{dz}$$

Where q = heat flow (mW/m^2), *k* = rock thermal conductivity (W/mK); *dT/dz* = vertical temperature gradient (degrees Kelvin per metre, K/m).

- ***Comparison to crustal heat flow global average 60 mW/m^2 (Cull, 1982)***





Site 19 Maryborough South GSQ Maryborough 16

- Drilled 18/11/10 to 29/11/10 – 12 days
- 387 m TD; PVC not cemented but perforated each section
- 61.2 m grouted in TST
- Approx cost = $223,000
- Tiaro JV and Geodiscovery

Site 21 – Tarong Basin
GSQ Gympie 7

- Drilled 12/12/10 to 21/12/10 – 10 days
- 338.6 m TD; PVC not cemented but each length perforated
- 54.1 m grouted in TST casing
- Open hole logging – gamma, SP and resistivity
- Approximate cost = $163,000
- Open hole logged – gamma, SP and resistivity
- Tarong Energy and JB Mining

Site 35 Barcaldine GSQ Longreach 2

- Drilled 9/1/11 to 3/2/11 – 18 days
- 327.3 m TD; PVC not cemented but perforated each section
- 83.3 m grouted in TST
- Open hole logged x 3
- Ronlow aquifer cemented 290 to 320 m – 2 attempts
- Approx cost = $283,000
- TMR road easement

Site 36 – Roma
GSQ Roma 9

- Drilled 6/2/11 to 24/2/11 – 11 days
- 335.9 m TD; PVC not cemented; each length perforated
- 106.2 m grouted in TST casing
- Open hole logging – verticality only
- Approximate cost = $178,000
- Gubberamunda aquifer cemented but leakage indicated
- Workover failed when casing broken
- Santos Ltd

Site 14 Styx
GSQ St Lawrence 1

- Drilled 28/2/11 to 17/3/11 – 10 days
- 340 m TD; PVC not cemented but perforated each section
- 90.3 m grouted in TST
- Open hole logged – gamma, SP and resistivity
- Approx cost = $163,000
- On ‘Oakdean’ near Ogmore

Site 38 – Millungera South GSQ Julia Creek 1

- Drilled 23/4/11 to 8/6/11 – 31 days
- 500 m TD; PVC annular cemented
- 120 m grouted in TST casing
- Open hole logging – gamma, SP, resistivity, sonic and verticality
- Approximate cost = $744,000
- Hooray aquifer 310 to 320 m
- Extremely hard siliceous metasandstone, quartzites
- Gas samples from Toolebuc

Site 29 – Millungera North GSQ Dobbyn 2

- Drilled 10/6/11 to 20/7/11 – 23 days
- 500 m TD; PVC annular cemented
- 90.5 m grouted in TST
- Open hole logged – gamma, SP, resistivity, sonic and verticality
- Approx cost = $552,000
- On ‘Clonagh’, NW of Cloncurry
- Gas samples from Toolebuc

Site 3 – Candlow Formation
GSQ Georgetown 8

- Drilled 23/7/11 to 27/8/11 – 14 days
- 320 m TD; PVC annular cemented
- 43 m grouted in TST casing
- No open hole logging – ground too broken
- Approximate cost = $214,000
- Difficult drilling
- Hole deviated and plugged

Site 2 – Hodgkinson Province
GSQ Mossman 2

- Drilled 29/8/11 to 22/9/11 – 17 days
- 340 m TD; PVC annular cemented
- 61 m grouted in TST
- 3 attempts at getting the hole straight
- No open hole log – broken ground and no loggers available
- Approx cost = $277,000
- Australian Wildlife Conservatory property

Site 6 – Burdekin Basin
GSQ Townsville 2

- Drilled 25/9/11 to 18/10/11 – 16 days
- 4 attempts at drilling hole
- Core barrel and 39 m rods stuck in first attempt
- No open hole logging – faulted ground
- No consolidated formation found above our limit of 150 m
- Approximate cost = $289,000
- Basalt, sands and clays
- TMR road easement

Site 13 – Hillsborough Basin
GSQ Bowen 1

- Drilled 27/10/11 to 9/11/11 – 14 days
- 321 m TD; PVC unable to be cemented due to hole collapse and PVC casing pressure limits
- 89 m grouted in TST
- No open hole log – hole collapsing
- Approx cost = $214,000
- Arrow Energy