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Heat flow modelling of selected wells in SEL26/2005, Tasmania

Prepared for KUTh Energy Ltd (KEN)

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Executive summary

Five (5) shallow wells in SEL26/2005 (Tasmania) were measured by Hot Dry Rocks Pty Ltd (HDRPL) for equilibrated downhole temperature. Core from the same wells was sampled and measured for rock thermal conductivity. Temperature and conductivity data have been combined using HDRPLs 1D Heat Flow Modelling Software to determine vertical heat flow within each well.

The resulting surface heat flows for each well are summarised in the table below:-

Well	Westbury 1	Perth 1	Nunamara 1	Frankford 1	Charlton 2
Modelled Heat Flow (mW/m^2)	72 ± 1.3 (60 ± 1.3 at surface)	75 ± 1.1	75 ± 1.1	72 ± 2.2	105.3 ±1.9 (71 ±1.3 at surface)
Relative confidence	Mod - High	High	High	High	Mod - High

All five wells have elevated surface heat flow (ranging from 72 – 75 mW/m^2), with Charlton and Westbury exhibiting possible advective influence at depth resulting in higher basal heat flow of 105 mW/m^2, and 72 mW/m^2 respectively.

Surface heat flow values for these locations, all fall within the upper 40% of heat flow values recorded for Australia in the *Global Heat Flow Database*.

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1.0 Introduction

Hot Dry Rocks Pty Ltd (HDRPL) was commissioned by KUTh Energy Ltd (KEN) to undertake heat flow modelling of selected wells in their tenement (SEL26/2005).

SEL26/2005 is located in eastern Tasmania and extends from George Town in the north of the state to Hobart in the south. As part of its work program, KEN is undertaking a shallow drilling program to define heat flow variation within its tenement. This report provides modelled heat flow values for the following shallow wells:-

- Westbury -1
- Perth -1
- Nunamarra - 1
- Frankford -1
- Charlton - 2

Heat flow models described in this report incorporate rock thermal conductivity measurements and calibrated precision temperature logs recently undertaken by HDRPL for the same wells.

2.0 Introduction to heat flow

Heat flow is a power unit expressed at surface (mW/m^2) and is a function of heat generated within the crust plus heat conducted from the mantle.

The principle aim of geothermal exploration is to locate anomalously high temperatures at an economically and technically viable drilling depth. The thermal state of a region is usually expressed at the surface in the form of heat flow units (mW/m^2) and it is generally assumed that heat is transported to the surface by conductive means.

In a conductive heat regime the temperature **T**, at depth **z** is equal to the surface temperature $\mathbf{T_0}$ plus the product of heat flow **Q** and thermal resistance **R**, such that:

$\mathbf{T=T_0+QR}$, where **R**=**z**/(average thermal conductivity between the surface and **z**).

Consequently the most highly prospective regions for geothermal exploration are those that have geological units of sufficiently low conductivity (high thermal resistance) in the cover sequence combined with high heat flow.

Heat flow is a product of temperature gradient and rock thermal conductivity and is therefore not directly measured. The measurement of heat flow is a precision skill that requires a detailed understanding of physical conditions in the bore and the physical properties of the rocks; including potential advective processes that may influence bore temperature (such as ground water flow) and the temperature dependence of conductivity.

HDRPL utilises its own 1D Heat Flow Modelling Software to determine heat flow from measured values. Forward modelled temperature distribution with depth, incorporating advective influences and temperature dependence of thermal conductivity, is compared against the observed temperature profile within a bore. The precise vertical heat flow value is determined that best fits the observed profile. The results of 1D heat flow modelling should be treated with caution when extrapolating over lateral distances, because heat refraction can lead to significant variation in vertical heat flow over relatively short lateral distances. Detailed 2D or 3D modelling is recommended if such effects are suspected.

3.0 Results of heat flow models

3.1 Summary of modelled surface heat flows

A summary of modelled surface heat flow results is shown in Table 1. Sections below describe each model in detail.

Table 1. Summary of modelled surface heat flows for shallow wells in SEL26/2005 in this study

Well	Westbury 1	Perth 1	Nunamara 1	Frankford 1	Charlton 2
Modelled Heat Flow (mW/m^2)	72 ± 1.3 (60 ± 1.3 at surface)	75 ± 1.1	75 ± 1.1	72 ± 2.2	105.3 ±1.9 (71 ±1.3 at surface)
Relative confidence	Mod - High	High	High	High	Mod - High

3.2 Westbury 1

The heat flow model for Westbury 1 (Fig. 1) illustrates a good fit between the observed and predicted temperature profiles. The well shows possible advective influence at around 140 m depth, reducing the heat flow at surface to 60 ± 1.3 mW/m². The conductive basal heat flow is **72 ± 1.3 mW/m²** over the conductivity-constrained interval (approximately 100 m – 252 m).

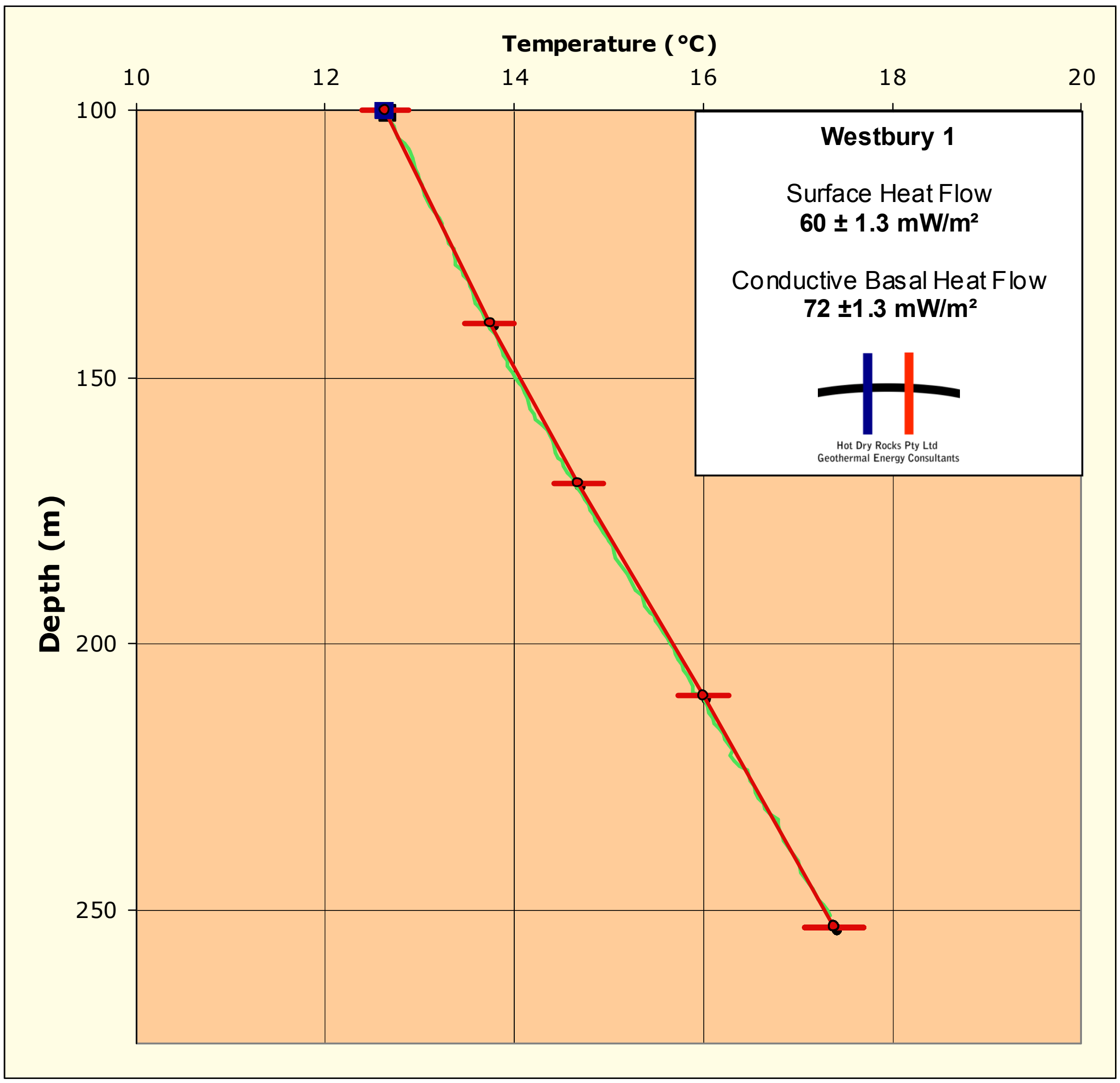

Figure 1. Westbury 1 – conductive heat flow modelled from rock thermal conductivity data and precision temperature log (green line). Red line is the modelled temperature profile for the stated heat flow.

3.3 Perth 1

The heat flow model for Perth 1 (Fig.2) illustrates a good fit between the observed and predicted temperature profiles. The well only intersected Jurassic dolerite with thermal conductivities ranging from 2.07 – 2.41 W/mK. The modelled surface heat flow is **75.0 ± 1.1 mW/m²** calculated from the conductivity-constrained interval (approximately 120 m – 253 m).

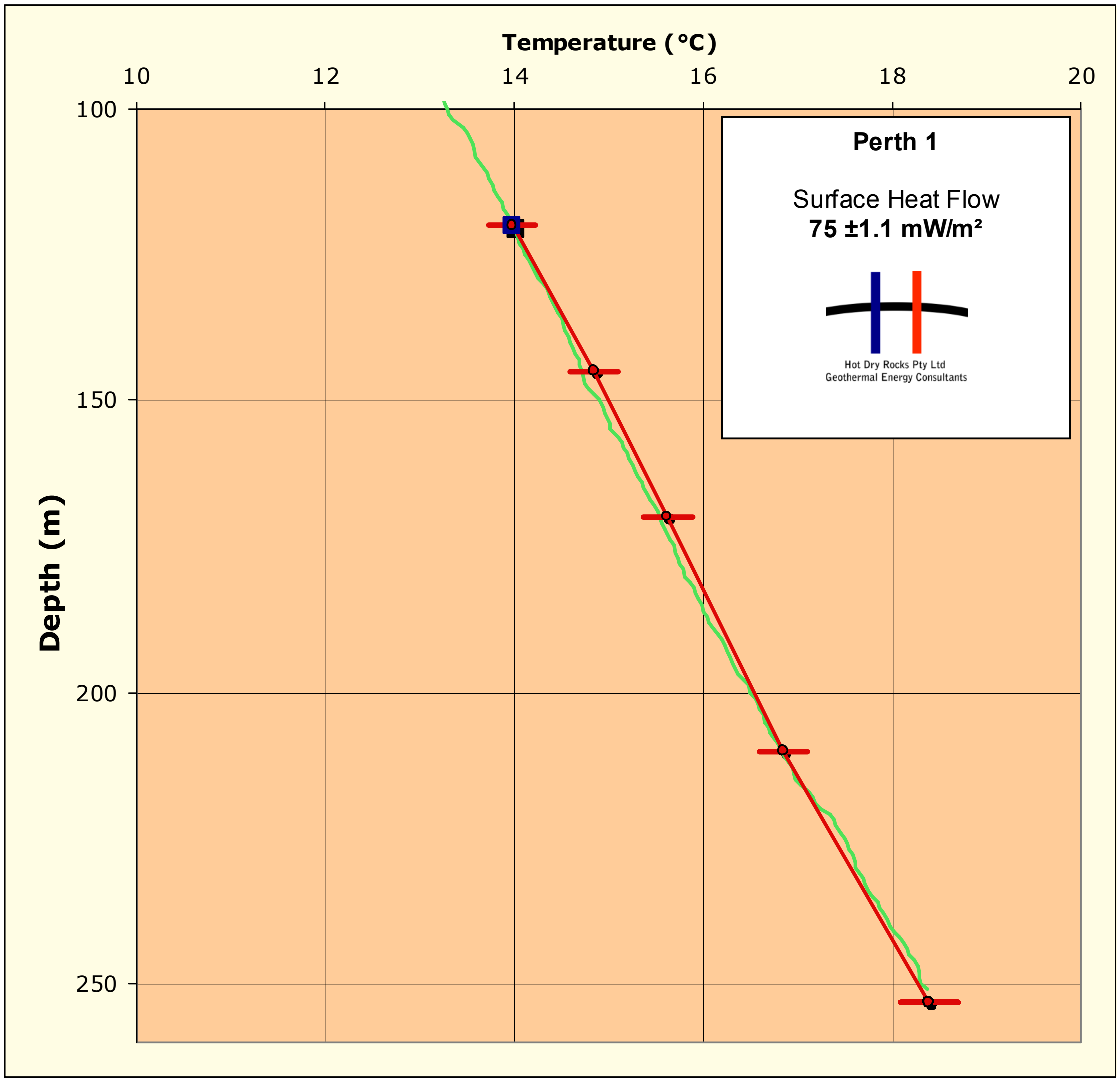

Figure 2. Perth 1 – surface heat flow modelled from rock thermal conductivity data and precision temperature log (green line). Red line is the modelled temperature profile for the stated heat flow.

3.4 Nunamara 1

The heat flow model for Nunamara 1 (Fig.3) illustrates a good fit between the observed and predicted temperature profiles. The well initially intersected Jurassic dolerite and is thought to have passed into silty sandstones of the Permian Parmeener Super Group rocks at approximately 223 m with thermal conductivities ranging from 2.17 – 2.23 W/mK. The modelled surface heat flow is **75 ± 1.1mW/m^2** calculated from the conductivity-constrained interval (approximately 70 m – 253 m).

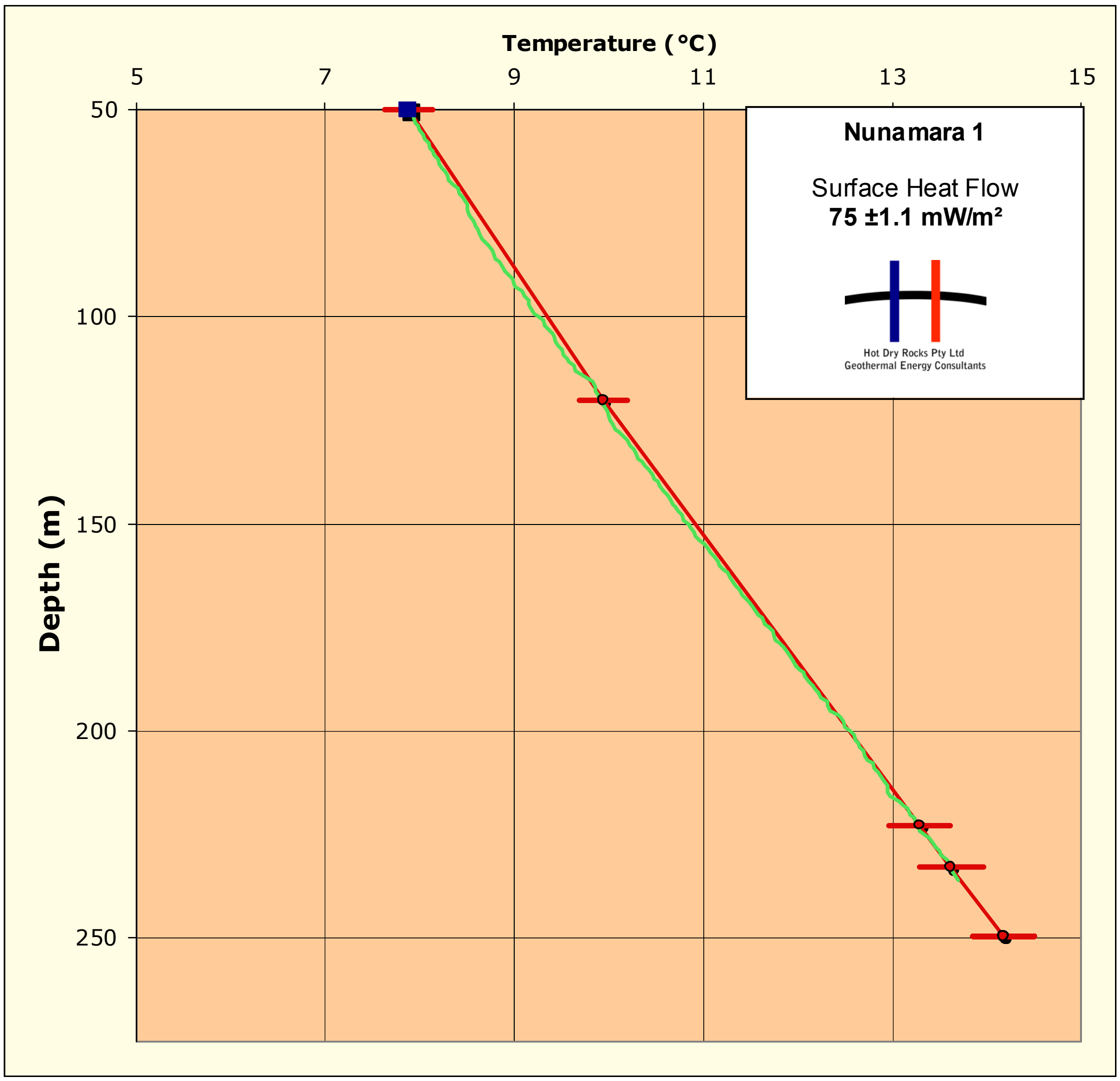

Figure 3. Nunamara 1 – surface heat flow modelled from rock thermal conductivity data and precision temperature log (green line). Red line is the modelled temperature profile for the stated heat flow.

3.5 Frankford 1

The heat flow model for Frankford 1 (Fig.4) illustrates a good fit between the observed and predicted temperature profiles. The well commenced in Jurassic dolerite rocks with thermal conductivities ranging from 2.17–2.35 W/mK, and is thought to have passed into silty sandstones of the Permian Parmeener Super Group rocks at approximately 195 m with thermal conductivities ranging from 3.00 – 3.26 W/mK. The modelled surface heat flow is **72 ± 2.2 mW/m^2** calculated from the conductivity-constrained interval (approximately 116 m – 249 m).

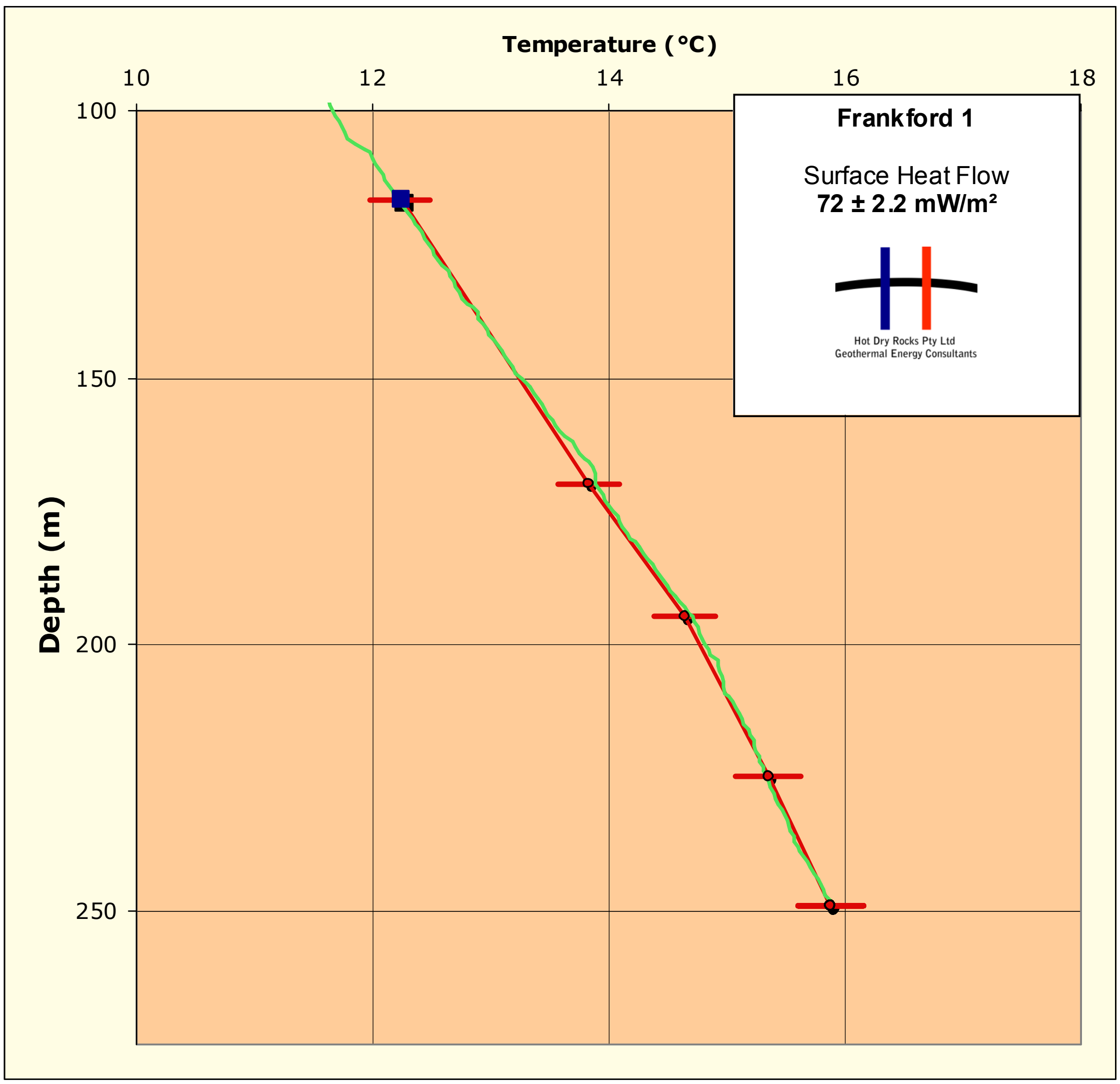

Figure 4. Frankford 1 – conductive heat flow modelled from rock thermal conductivity data and precision temperature log (green line). Red line is the modelled temperature profile for the stated heat flow. Divergence in the temperature profile in the deeper section of the bore is due to contrasting conductivities.

3.5 Charlton 2

The heat flow model for Charlton 2 (Fig.5) illustrates a good fit between the observed and predicted temperature profiles, when a possible advective influence is included between 100 and 160 m. The well only intersected Jurassic dolerite with thermal conductivities ranging from 2.23 – 2.28 W/mK. The modelled conductive basal heat flow is **105.3 ± 1.9 mW/m²** below 200 m, which is reduced to 71.3 ± 1.3 mW/m² at surface due to possible advection.

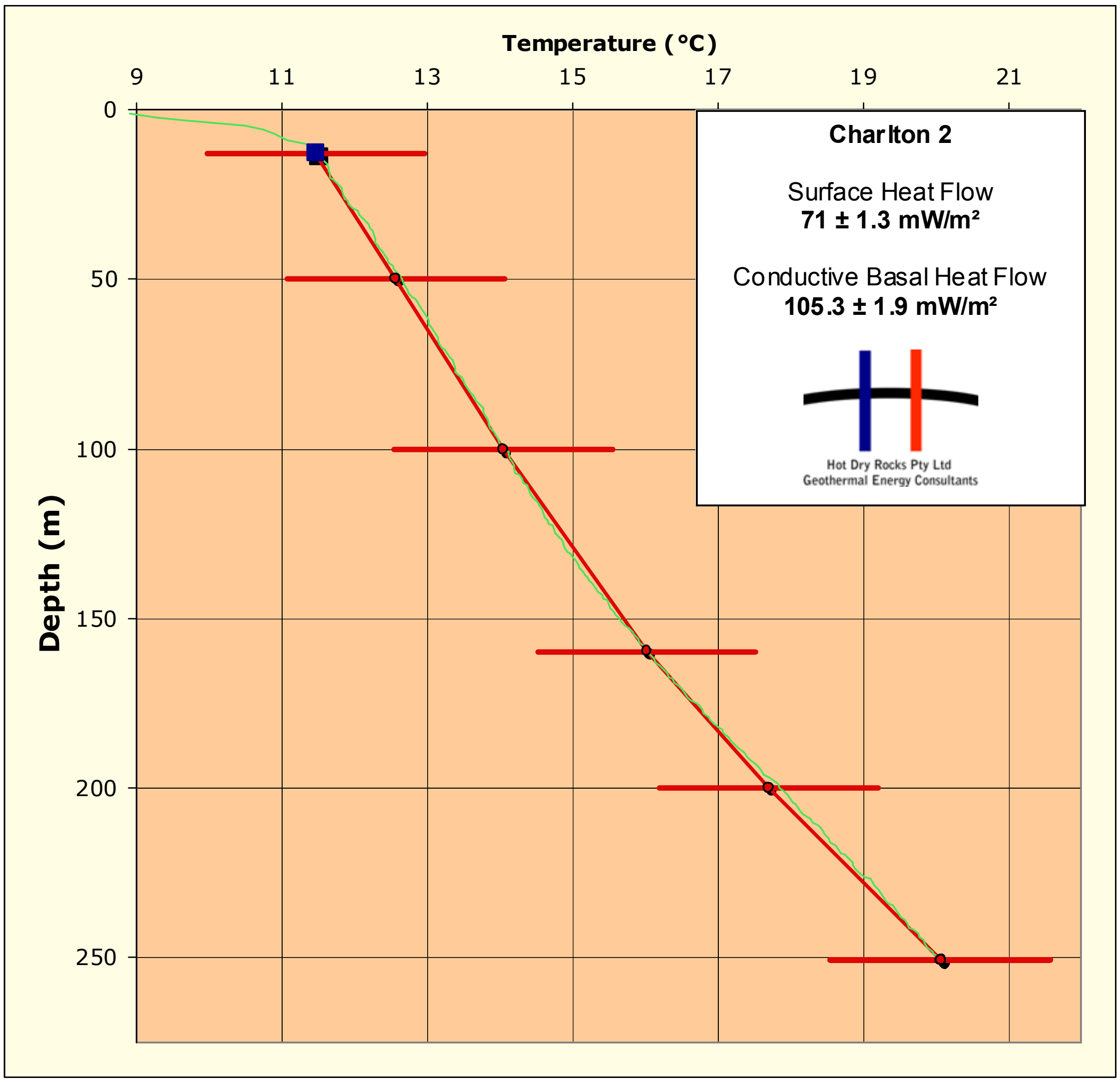

Figure 5. Charlton 2 – conductive heat flow modelled from rock thermal conductivity data and precision temperature log (green line). Red line is the modelled temperature profile for the stated heat flow. Divergence in the temperature profile in the deeper section of the bore is due to advection between 100 and 160 m.

4.0 Comparative interpretation of heat flow data

Modelled surface heat flow values for the five selected wells in SEL26/2005 range from 60 to 75 mW/m^2. When possible advective influences are taken into account the modelled conductive vertical heat flow values range from 72 - 105 mW/m². Figure 6 illustrates the distribution of heat flow data modelled in this report with respect to those values presently available for all of Australia within the *Global Heat Flow Database*. All five wells modelled in this report have surface heat flow values that are within the top 40% of heat flow values for Australia in the *Global Heat Flow Database*, however the Charlton 2 well shows a conductive basal heat flow of greater than 100 mW/m^2, representative of values in the upper 11% of heat flow values for Australia in the *Global Heat Flow Database.*

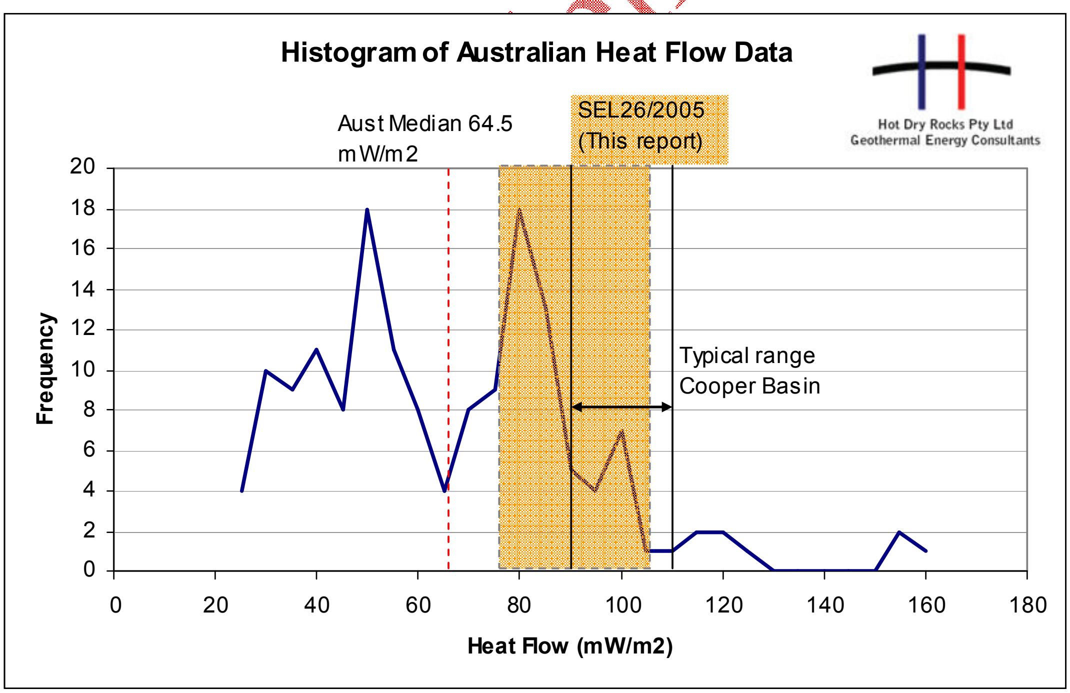

Figure 6. Distribution of Australian heat flow data from the Global Heat Flow Database showing relative position of values commonly reported for the Cooper Basin (South Australia) and values modelled for all five wells in this study.

5.0 Conclusions and recommendations

Modelled conductive vertical heat flow values for the five selected shallow wells in SEL26/2005 in this report range between 72 and 105 mW/m^2. The results are regionally consistent with previous heat flow data calculated for the tenement.

The following recommendations are presented for KEN's consideration:-

- Continue thermal conductivity measurement, precision temperature logging and heat flow modelling for other parts of SEL26/2005 to increase the spatial density of available quality heat flow data.
- Model deep 1D heat flow projections of selected areas based on data presented in this and earlier reports and using stratigraphy derived from regional reflection seismic data and/or geological cross-sections and maps. This modelling should also consider thermal resistance risks associated with anisotropy. This process would provide preliminary projections of temperature at depth.
- Consider 3D heat flow modelling as more regional conductivity data become available.