Hot Dry Rocks Pty Ltd
Geothermal Energy Consultants

HEAD OFFICE
PO Box 251
South Yarra, Vic 3141
Australia
T +61 3 9867 4078
F +61 3 9279 3955
E info@hotdryrocks.com
W www.hotdryrocks.com

ABN: 12 114 617 622

SERVICES
Exploration
Rock Property Measurements
Project Development
Portfolio Management
Grant Applications

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

Prepared for KUTh Energy Ltd (KEN)

Date 07 August 2008 Final

Gareth Cooper & Ben Waining

Executive summary

Four (4) 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	Woodsdale-1	Kingston-1	Tiberias-1	Fingal-1
Modelled Heat Flow (mW/m^2)	81.0 ± 3.2	86.0 ± 3.1	73.0 ± 3.9 Apparent average conductive heat flow	97.0 ± 2.9 (base) 70.0 ± 2.1 (top)
Relative confidence	High	High	Low	Mod

Two of the wells have elevated surface heat flow (ranging from 81–86 mW/m^2). Both Tiberias-1 and Fingal-1 show evidence of probable heat removal which appears to impact on the temperature log for the upper portion of each well, thereby reducing the confidence level in heat flow calculation for both wells. Fingal-1 appears to have a loss of about 27 mW/m^2 in the upper portion of the well. This is interpreted to represent the possible movement of water down the bore, cooling the upper rocks by conduction. This may be a function of a water movement behind the PVC collar from an aquifer located in the upper 200m of the section.

Surface heat flow values for Woodsdale and Kingston fall within the upper 36% of heat flow values recorded for Australia in the *Global Heat Flow Database*.

Disclaimer
The information and opinions in this report have been generated to the best ability of the author, and Hot Dry Rocks Pty Ltd hope they may be of assistance to you. However, neither the author nor any other employee of Hot Dry Rocks Pty Ltd guarantees that the report is without flaw or is wholly appropriate for your particular purposes, and therefore we disclaim all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Table of Contents

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:-

- Woodsdale-1
- Kingston-1
- Tiberias-1
- Fingal-1

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. Consequently, 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	Woodsdale-1	Kingston-1	Tiberias-1	Fingal-1
Modelled Heat Flow (mW/m^2)	81.0 ± 3.2	86.0 ± 3.1	73.0 ± 3.9 Apparent average conductive heat flow	97.0 ± 2.9 (base) 70.0 ± 2.1 (top)
Relative confidence	High	High	Low	Mod

3.2 Woodsdale 1

The heat flow model for Woodsdale-1 (Fig. 1) illustrates a very good fit between the observed and predicted temperature data. The well intersected Permian Parmeener SuperGroup rocks (conductivities ranging from 2.25–4.54 W/mK) before intersecting a Jurassic dolerite sill at the base (conductivities ranging from 2.28–2.49 W/mK). The conductive vertical heat flow is **81.0 ± 3.2 mW/m^2** over the conductivity-constrained interval (approximately 105 m – 212 m).

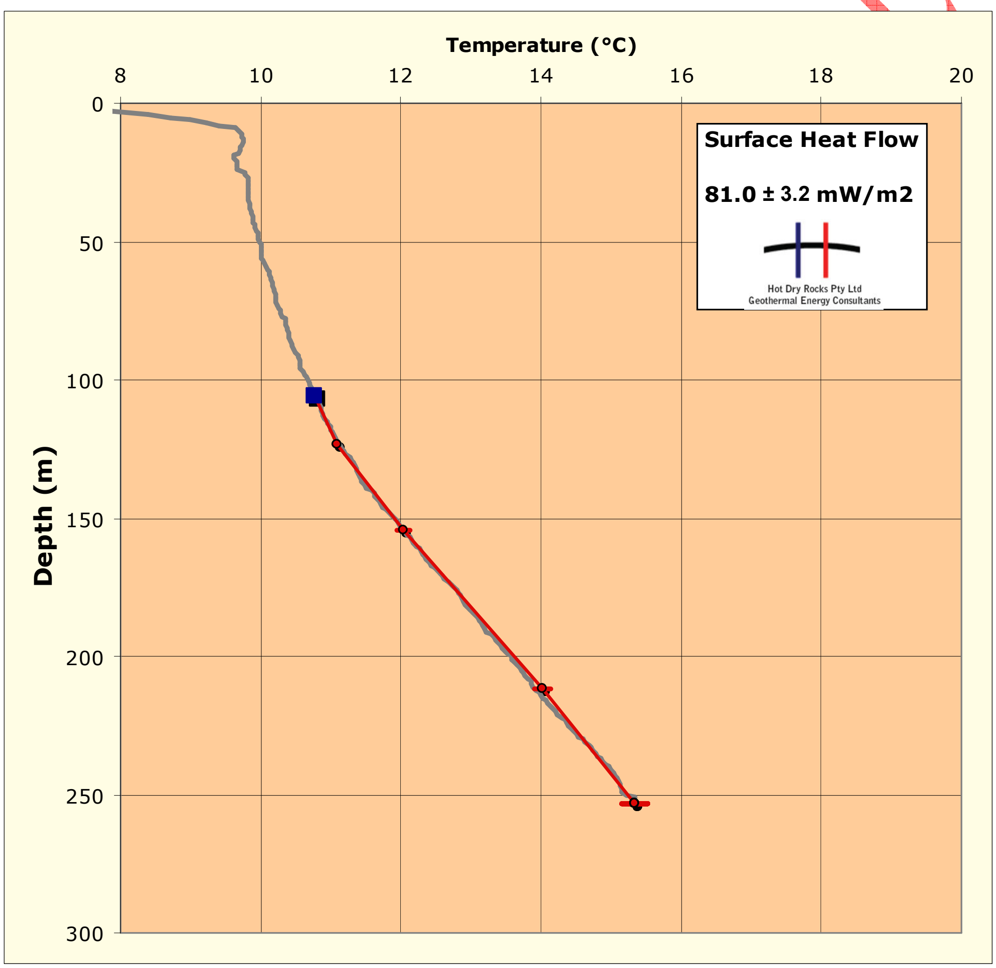

Figure 1. Woodsdale 1 – conductive heat flow modelled from rock thermal conductivity data and precision temperature log (grey line). Red line is the modelled temperature profile for the stated heat flow. Divergence in the temperature profile in the shallow section of the bore is due to air and cooled water at the top of the bore.

3.3 Kingston 1

The heat flow model for Kingston-1 (Fig.2) illustrates an excellent fit between the observed and predicted temperature data. The well only intersected Jurassic dolerite rocks with rock thermal conductivities ranging from 1.88–1.97 W/mK. The modelled conductive vertical heat flow is **86.0 ± 3.1 mW/m^2** over the conductivity-constrained interval (approximately 99 m – 202 m).

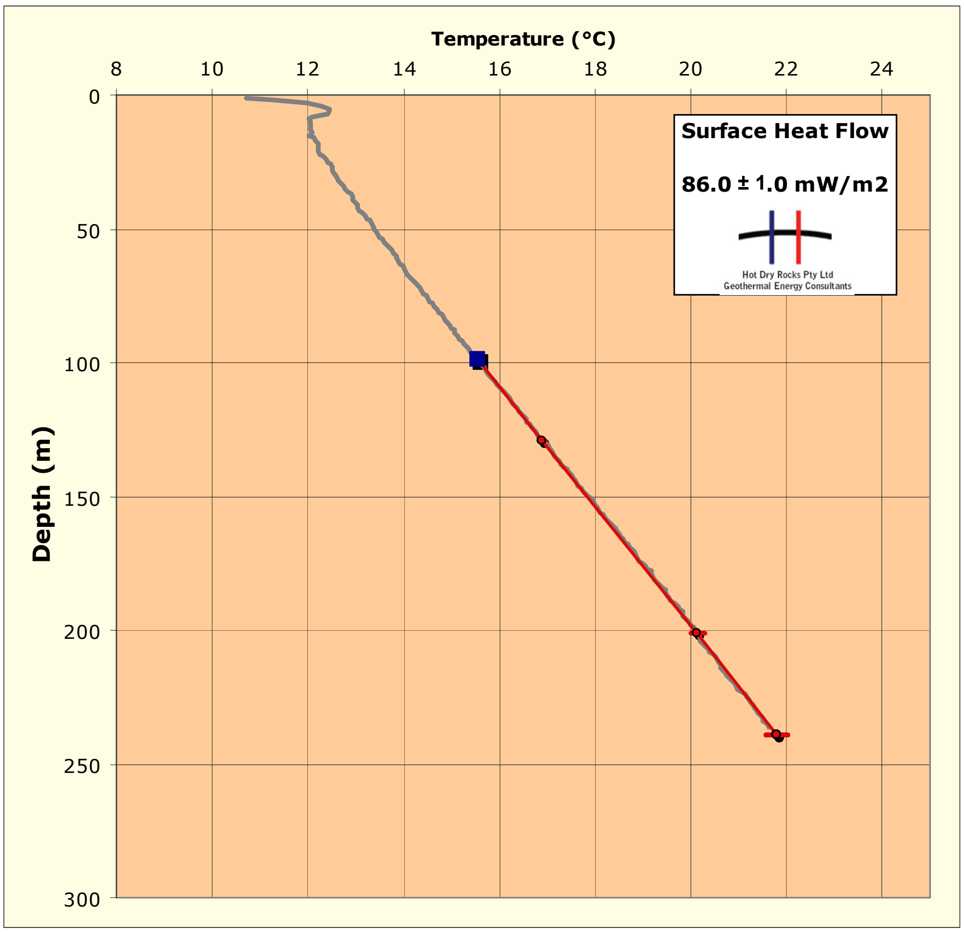

Figure 2. Kingston-1 – conductive heat flow modelled from rock thermal conductivity data and precision temperature log (grey line). Red line is the modelled temperature profile for the stated heat flow. Divergence in the temperature profile in the shallow section of the bore is due to air and cooled water at the top of the bore.

3.4 Tiberias 1

The heat flow model for Tiberias-1 (Fig.3) illustrates a poor fit between the observed and predicted temperature data. The well only intersected Upper Parmeener SuperGroup rocks with thermal conductivities ranging from 1.70–4.50 W/mK. It is not possible to model the well in accordance with the temperature log, which has a relatively low gradient for the upper section and a marked curved geometry at about 233 m. This suggests that relatively cool water may be moving down the upper section of the bore. This may be due to an aquifer in the upper part of the bore causing the movement of water behind the PVC collar.

HDRPL has attempted to model the well using a surface intercept temperature and a basal temperature (BHT), assuming that both values may be relatively accurate. This suggests that the surface heat flow of the well is about **73.0 ± 3.9 mW/m^2**, however this should be regarded as an apparent average conductive heat flow, given the poor fit between measured and actual data. The confidence level of the modelled heat flow value is considered to be low.

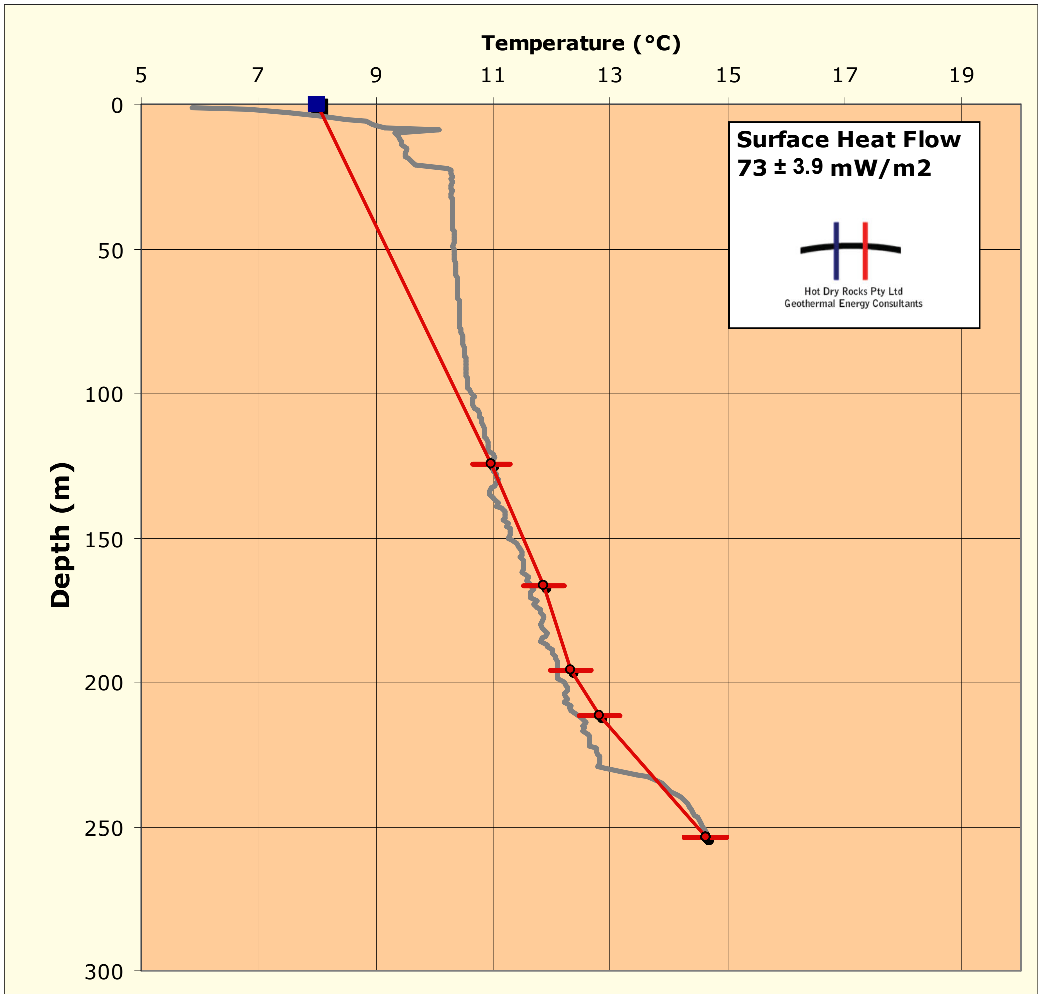

Figure 3. Tiberias-1 – conductive heat flow modelled from rock thermal conductivity data and precision temperature log (grey line). Red line is the modelled temperature profile for the stated heat flow. This model represents an apparent average conductive heat flow due to the poor fit of the data.

3.5 Fingal 1

The heat flow model for Fingal-1 (Fig.4) illustrates a reasonable fit between the observed and predicted temperature data. Some assumptions have been made about the likely thickness of coal bands within the well based on the temperature log. The well intersected Jurassic Dolerite (thermal conductivity of 2.07 W/mK) before entering Upper Parmeener SuperGroup rocks with (thermal conductivities ranging from 0.68–2.54 W/mK).

The Parmeener SuperGroup is dominantly carbonaceous in this well and minor coal bands are common. Sample KEN057 is a highly fractured coaly-siltstone with a thermal conductivity of 0.68 W/mK. Low conductivity results were also obtained for sample KEN058 which was mounted in a hollow cell for conductivity measurement.

Fingal-1 cannot be precisely modelled in accordance with the temperature log without removing heat (~27 mW/m^2) from the upper ~150 m. Such an effect could be due to ground water flow across the top of a coal seam around 140 m. Modelling suggests that the surface heat flow of the well is about **70.0 ± 2.1 mW/m^2**, although heat flow in the deeper section may be in the order of **97.0 ± 2.9 mW/m^2**. The value for the deeper portion of the bore is more likely to represent the background heat flow at that location, and is similar to other regional values. The confidence level of the modelled heat flow value is considered to be moderate.

.

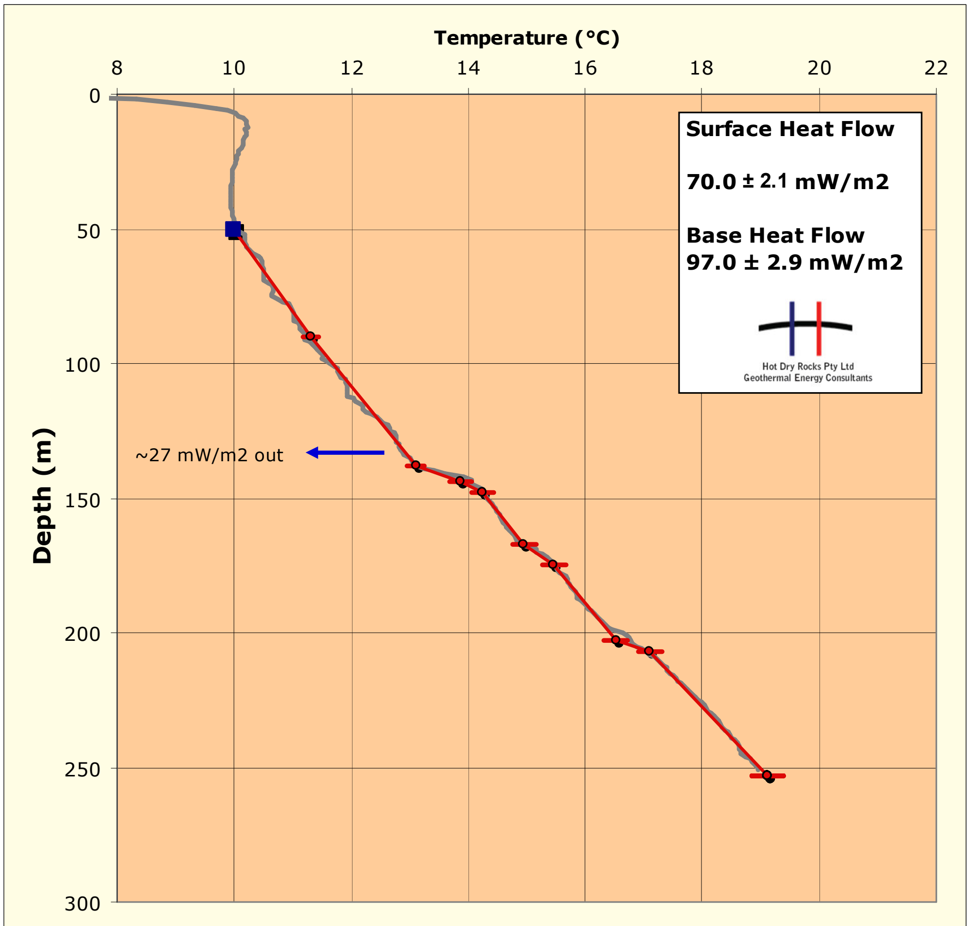

Figure 4. Fingal-1 – conductive heat flow modelled from rock thermal conductivity data and precision temperature log (grey line). Red line is the modelled temperature profile for the stated heat flow. Divergence in the temperature profile in the shallow section of the bore is due to air and cooled water at the top of the bore.

4.0 Comparative interpretation of heat flow data

Modelled surface heat flow values for the four selected wells in SEL26/2005 range from 70 to 86 mW/m^2, although the lowest surface heat flow values are probably the result of cooling from the flow of water down the Tiberias and Fingal bores.

Figure 5 illustrates the distribution of heat flow data modelled in this report (excluding Tiberias-1 and Fingal-1) with respect to those values presently available for all of Australia within the *Global Heat Flow Database*. Values modelled in this report for the two selected wells SEL26/2005 are within the top 36% of heat flow values for Australia in the *Global Heat Flow Database*.

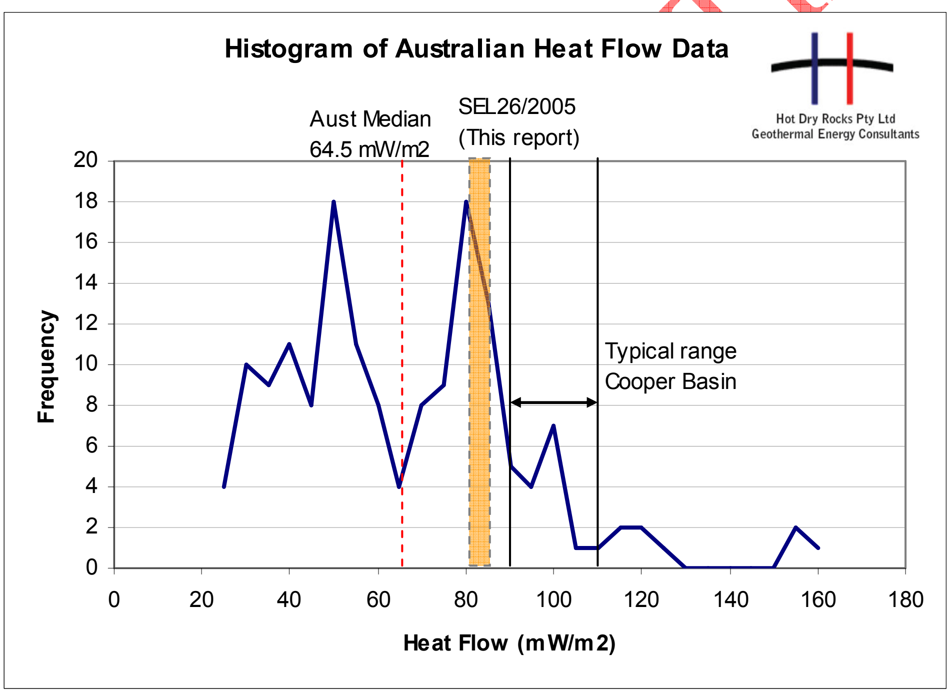

Figure 5. Distribution of Australian heat flow data from the Global Heat Flow Database showing relative position of values commonly reported for the Cooper Basin (South Australia) and values modelled for the two selected wells in SEL26/2005 (Tasmania) in this study (orange polygon), excluding Tiberias-1 and Fingal-1.

5.0 Conclusions and recommendations

Modelled surface heat flow values for the four selected shallow wells in SEL26/2005 in this report range between 70 and 86 mW/m^2. It is possible that the surface lower heat flow values for Tiberias-1 and Fingal-1 are influenced by the movement of water down the bore or through aquifers. Consequently, the estimated basal heat flow of 97.0± 2.9 mW/m^2 for Fingal may be more representative of the thermal regime at depth for that well. The Tiberias heat flow model has a low confidence level due to the probable influence of water movement in the bore and the modelled heat flow value of 73.0± 3.9 mW/m^2 is regarded as an apparent average conductive heat flow.

The following recommendations are presented for the client's consideration:-

- Continue 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 stratigraphy derived from regional reflection seismic data and/or geological cross-sections and maps. This would provide preliminary projections of temperature at depth.
- Consider 3D heat flow modelling as more regional conductivity data become available.