September 16th 2013 IAH

Groundwater flow modeling solutions based on different degrees of geological complexity:

A case study from the north Perth Basin, Western Australia (working progress)

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BUILDING A BETTER WORLD

Presentation outline

Location & geological setting

Model construction & calibration

Degrees of model complexity

Results

Conclusions

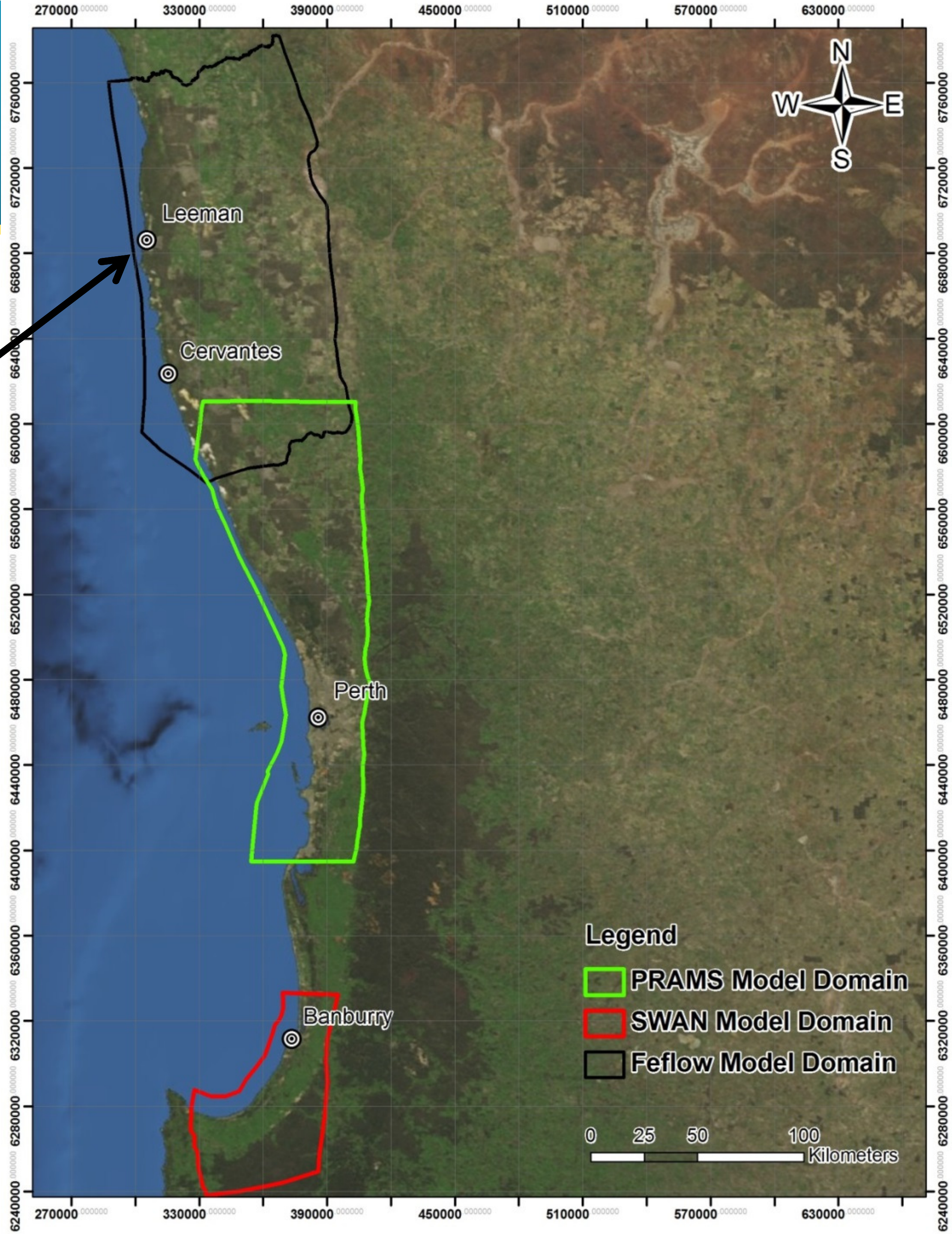
Previous modeling projects in the Perth region

Location:

current *FEFLOW* model

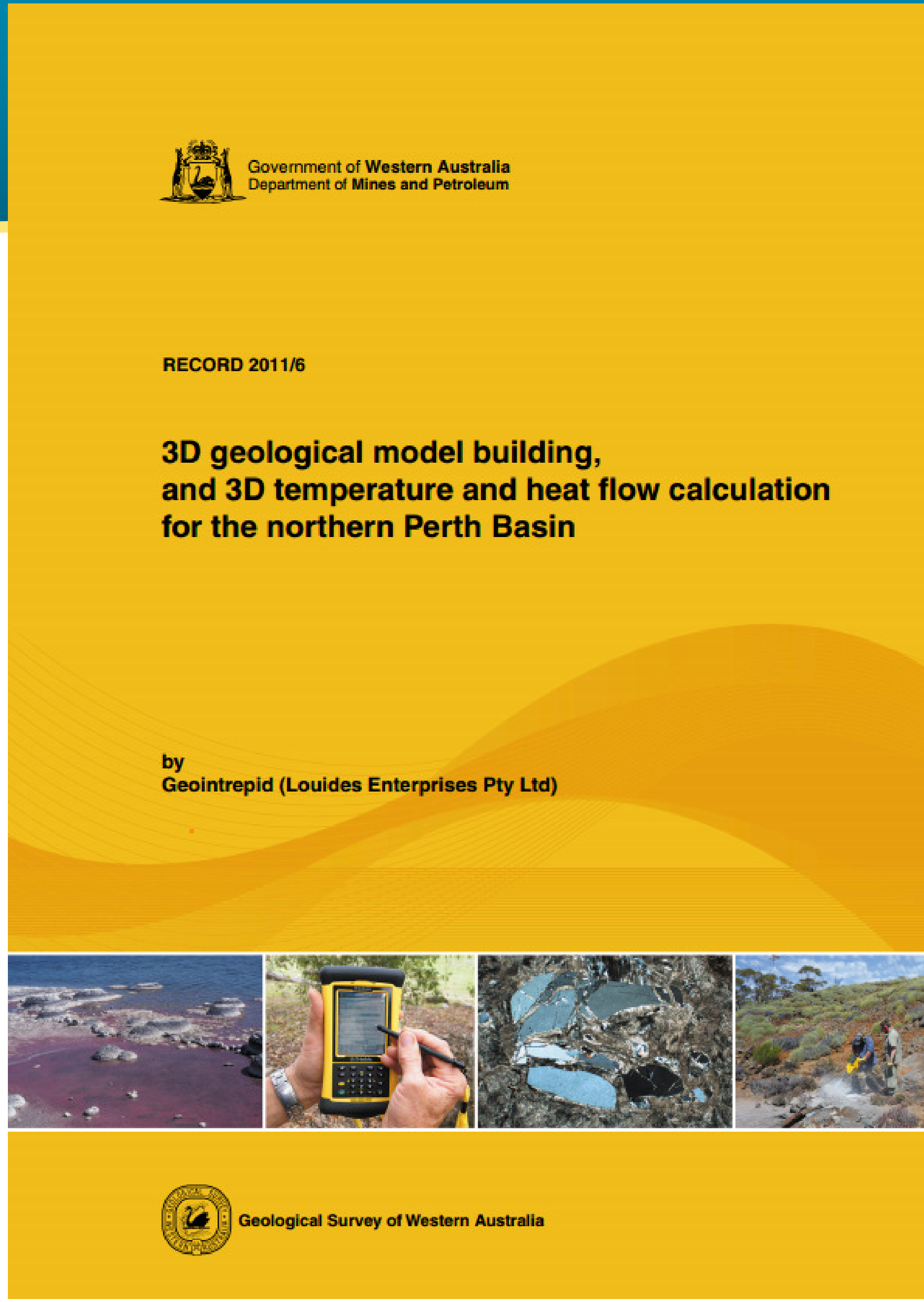
Perth **R**egional **A**quifer **M**odelling **S**ystem – **PRAMS** (Department of Water, WA)

SWAN Coastal Plain GW modelling (SKM)



Original model:
For geothermal
resource assessment

WA DMP Record 2011/6


Government of Western Australia
Department of Mines and Petroleum

RECORD 2011/6

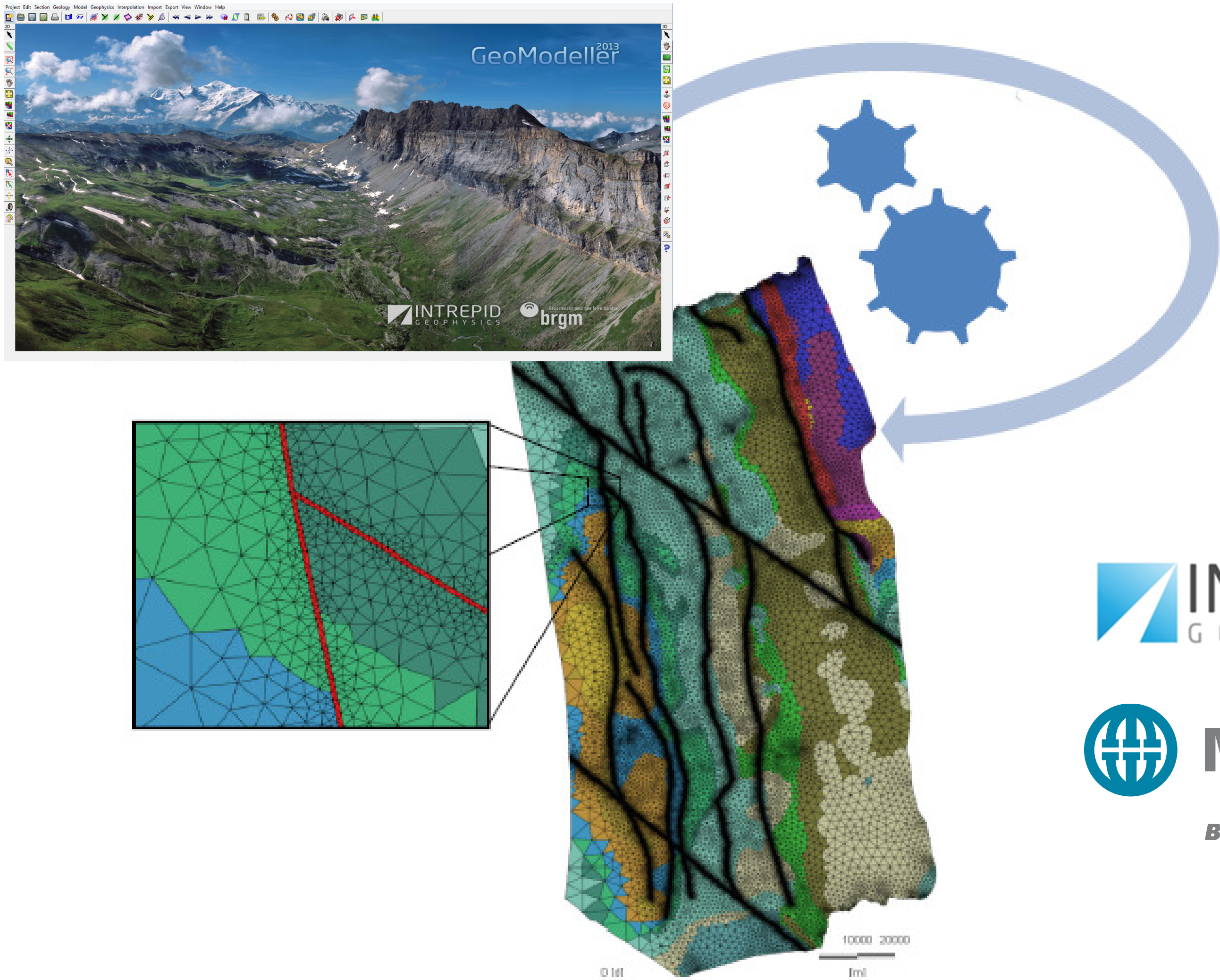
3D geological model building,
and 3D temperature and heat flow calculation
for the northern Perth Basin

by
Geointrepid (Louides Enterprises Pty Ltd)

Geological Survey of Western Australia

Software link *GeoModeller* and *FEFLOW*

Represents collaborative work: a demonstration case study



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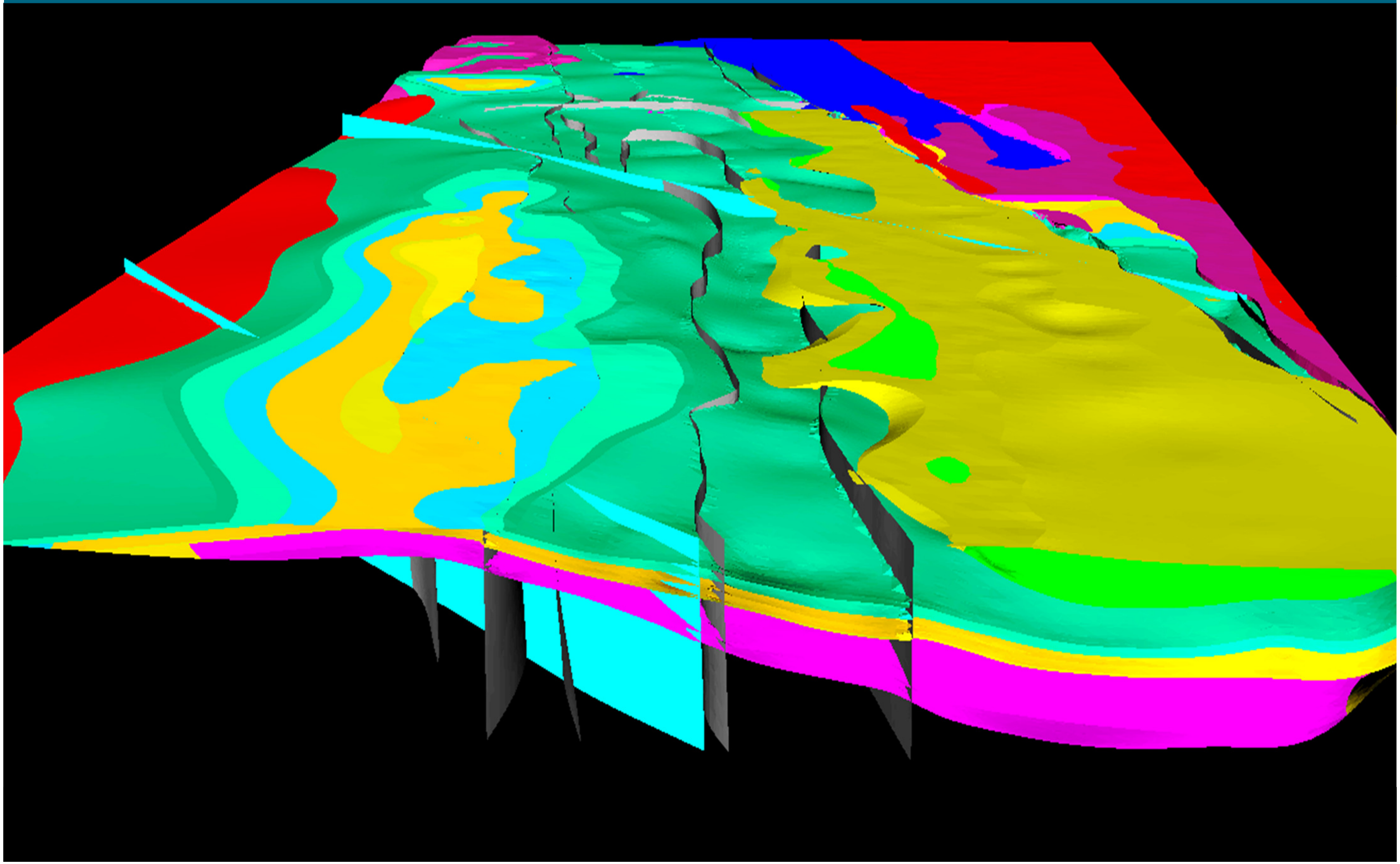
GeoModeller Model

- 96 wells
- Surface mapping
- 7 interpreted cross-sections (seismic)
- Depth to basement structure map



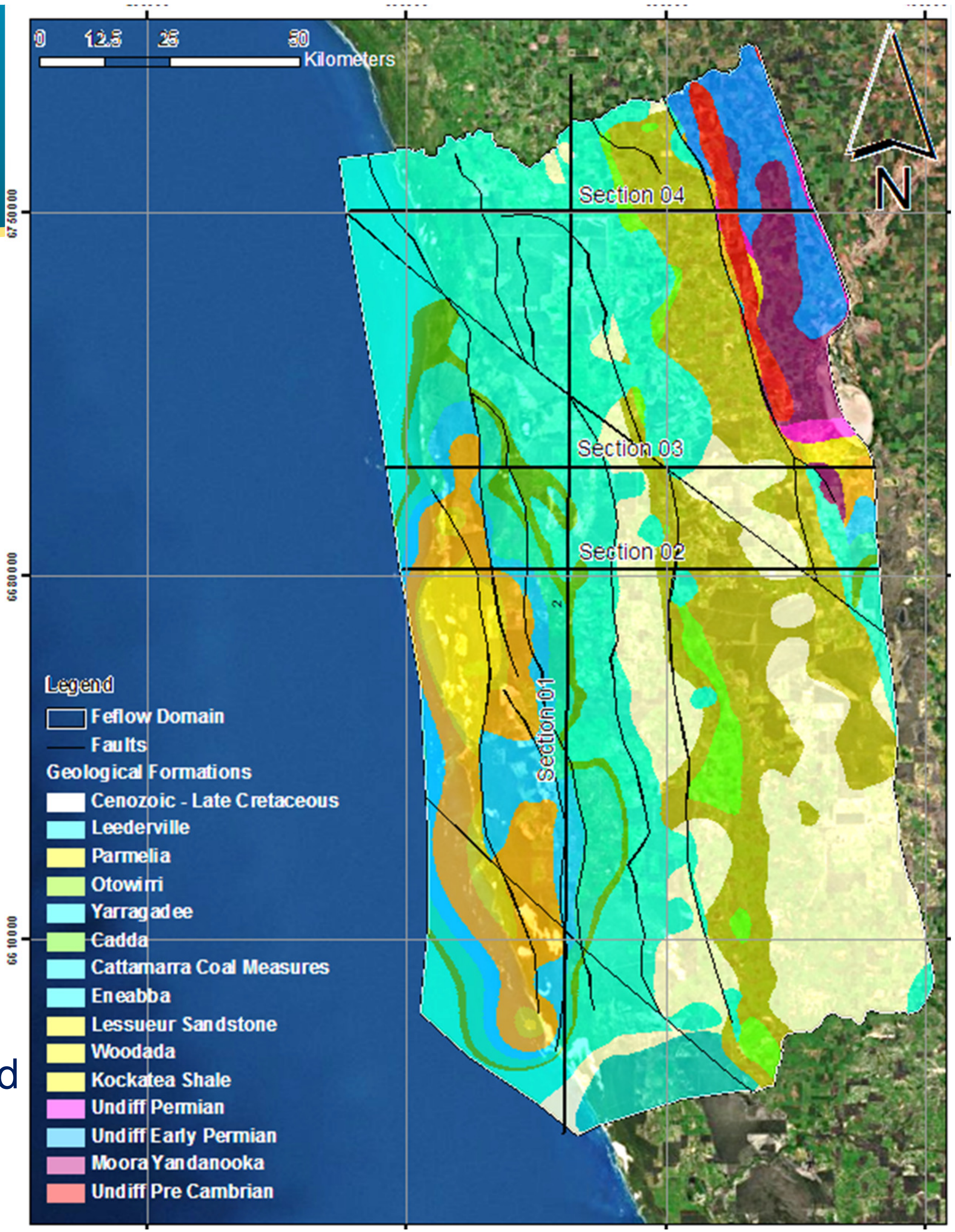
Model Domain

Regional Stratigraphy

- Mory & Iasky 1996

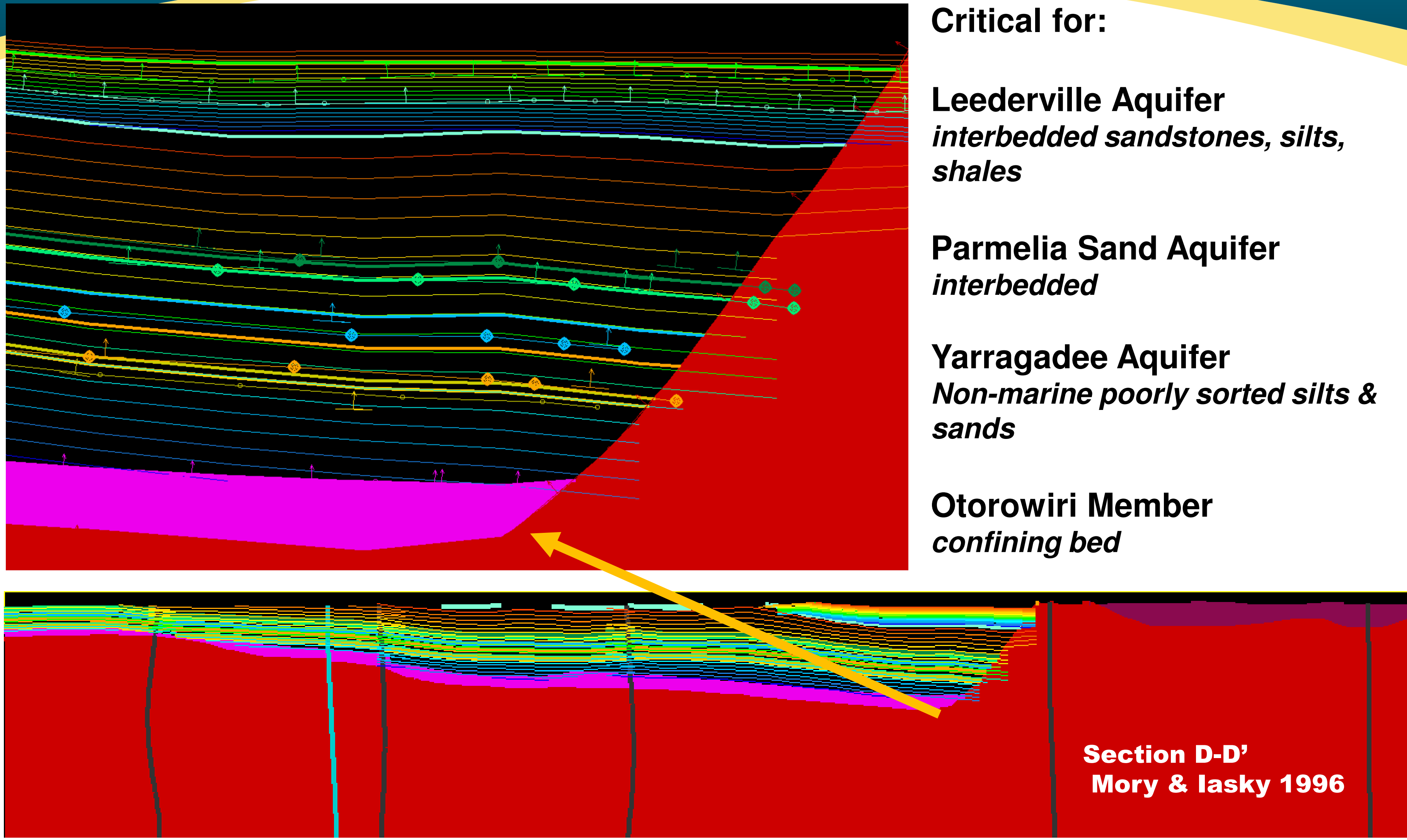
Structural/geological setting

- Pinjarra Orogen basement
- Elongate rift basin: formed in Permian to Early Cretaceous
- Wrench system, re-activated
- Dandaragan Trough 12km thick
- Late-E Cret – Cainozoic: Transgressive marine, undeformed



GeoModeller: potential field method for building implicit surfaces from contacts & dips

Re-use trend lines of bedding ►anisotropy angle



Critical for:

Leederville Aquifer
interbedded sandstones, silts, shales

Parmelia Sand Aquifer
interbedded

Yarragadee Aquifer
Non-marine poorly sorted silts & sands

Otorowiri Member
confining bed

Complex geological settings:
1. Strong vertical gradient

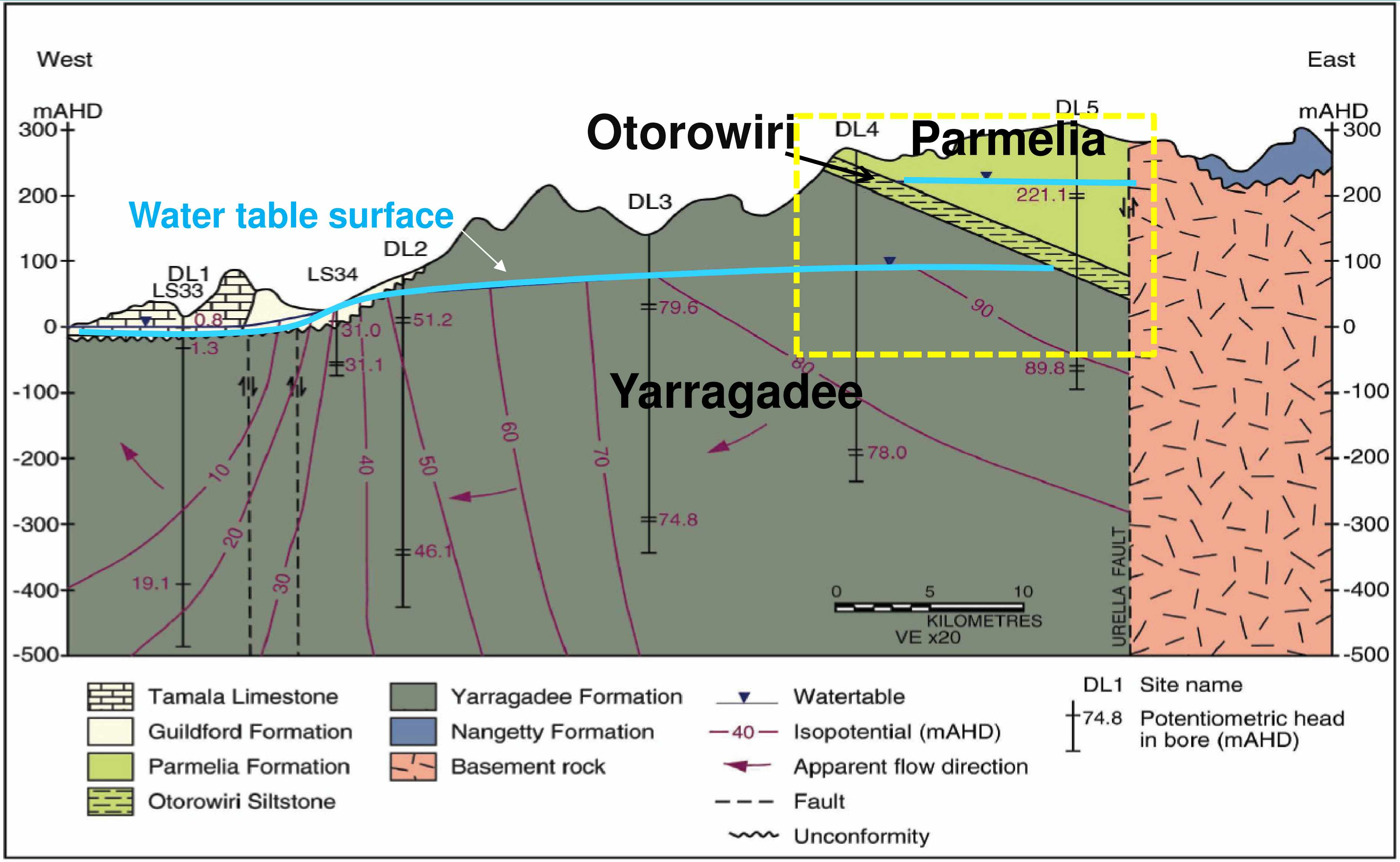


Figure 5. Isopotentials and apparent groundwater flow

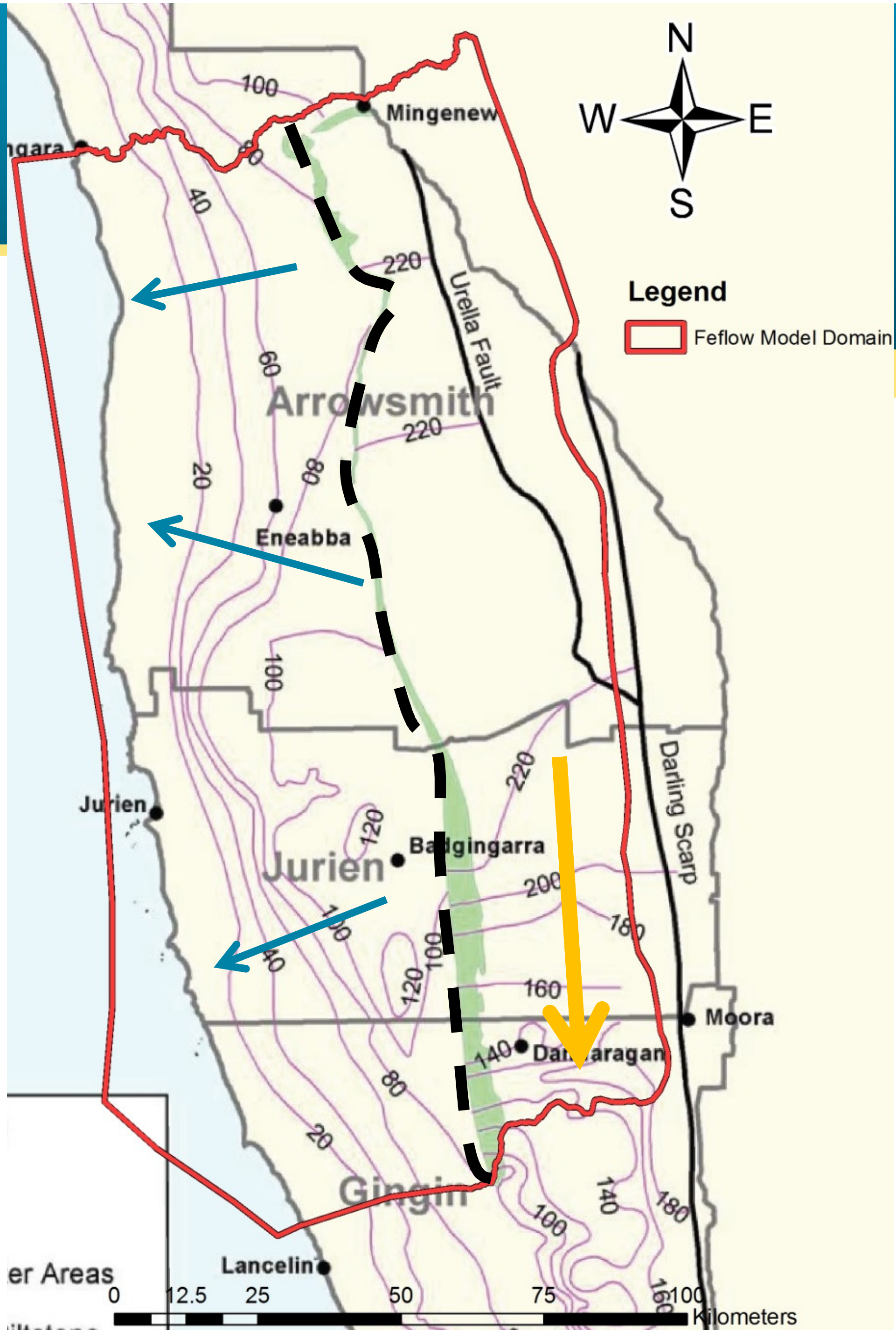
Complex geological settings: 2. Duality of two aquifers systems

Two principal flow directions:

North-South

&

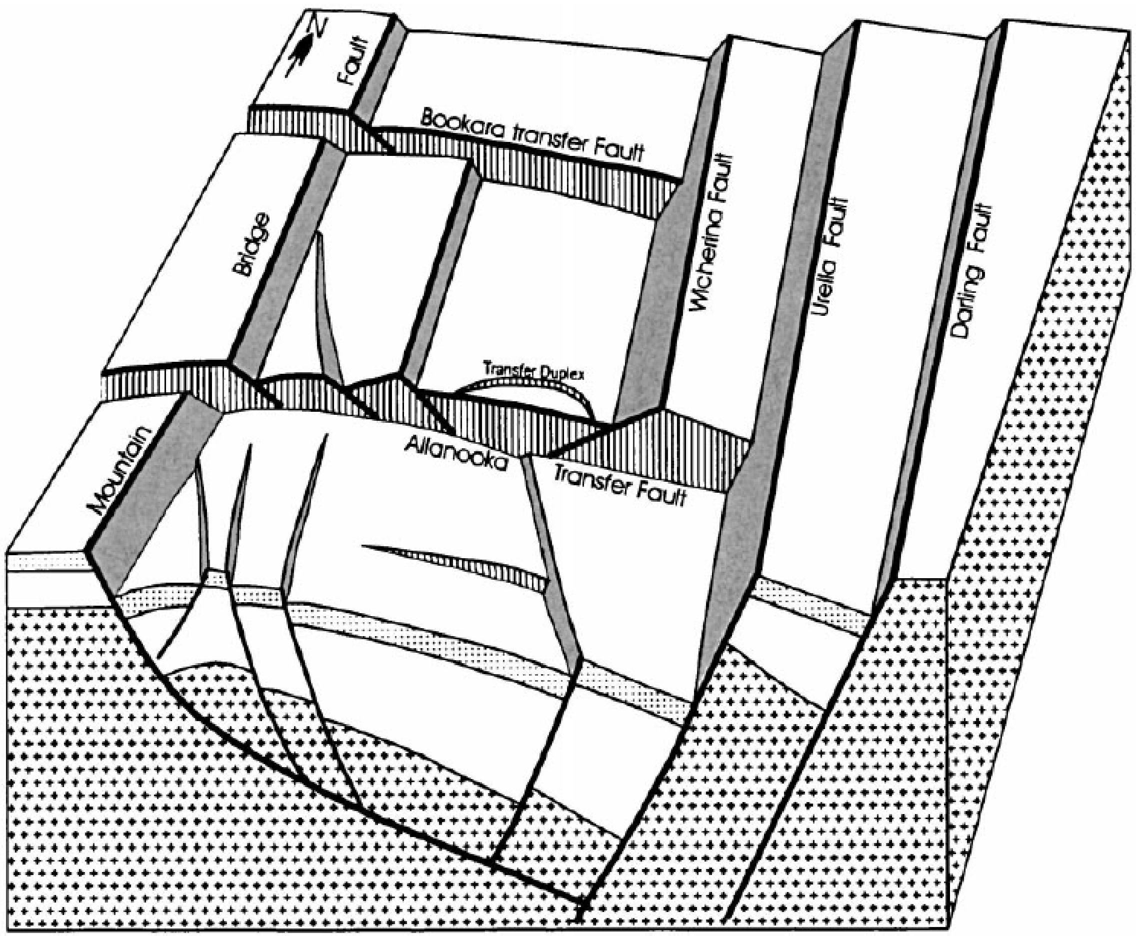
East-West



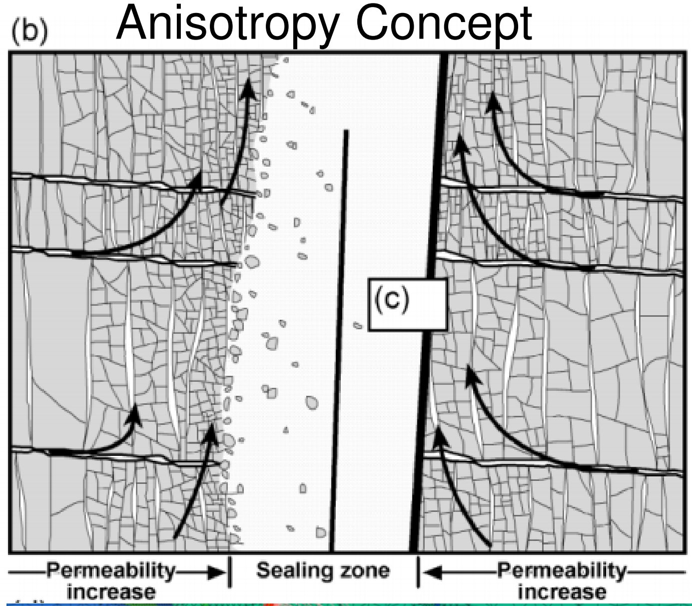
Source: Rutherford (2005)

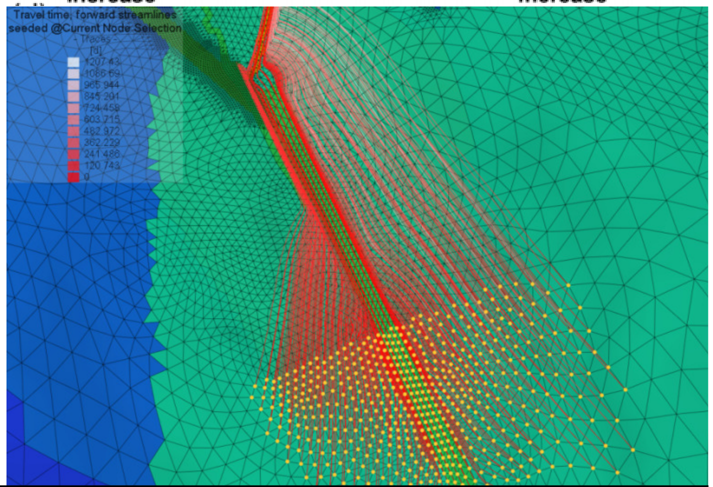
Complex geological settings:
3. Compartmental effects related to faults and structures

T. Song, P.A. Cawood / Tectonophysics 317 (2000) 55–72



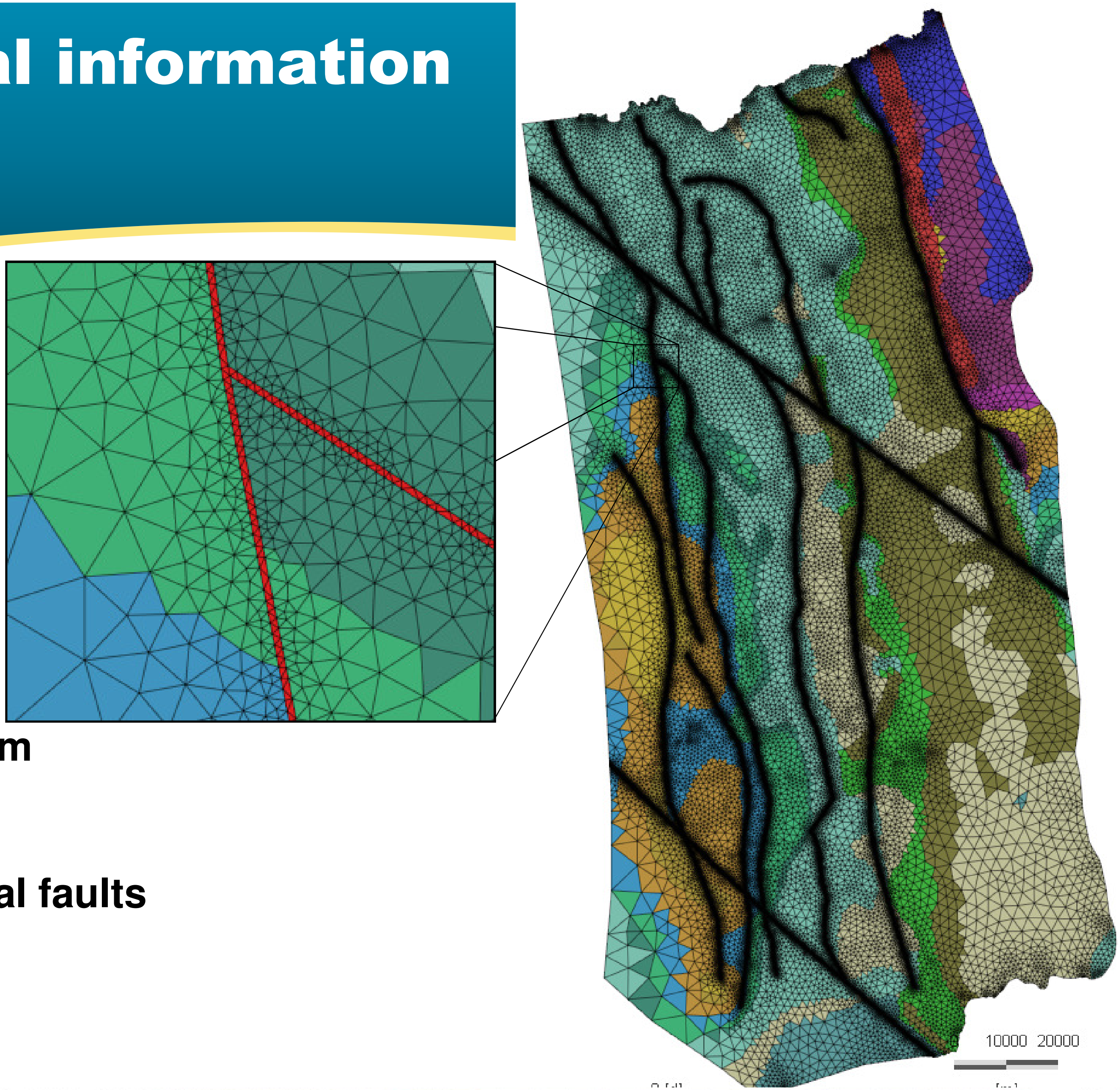
Anisotropy Concept





Fault within FEFLOW

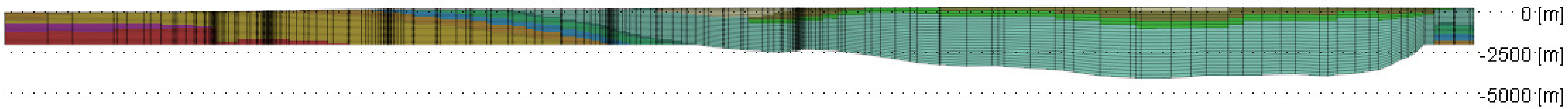
Model general information and meshing



Selected code:

FEFLOW and GeoModeller

- **Steady state**
- **Unsaturated**
- **100km * 200 km * ~ 2km**
- **21 layers**
- **5.5 million elements**
- **Refinement of principal faults**
- **Regional model**
- **Bottom at -2000m SL**

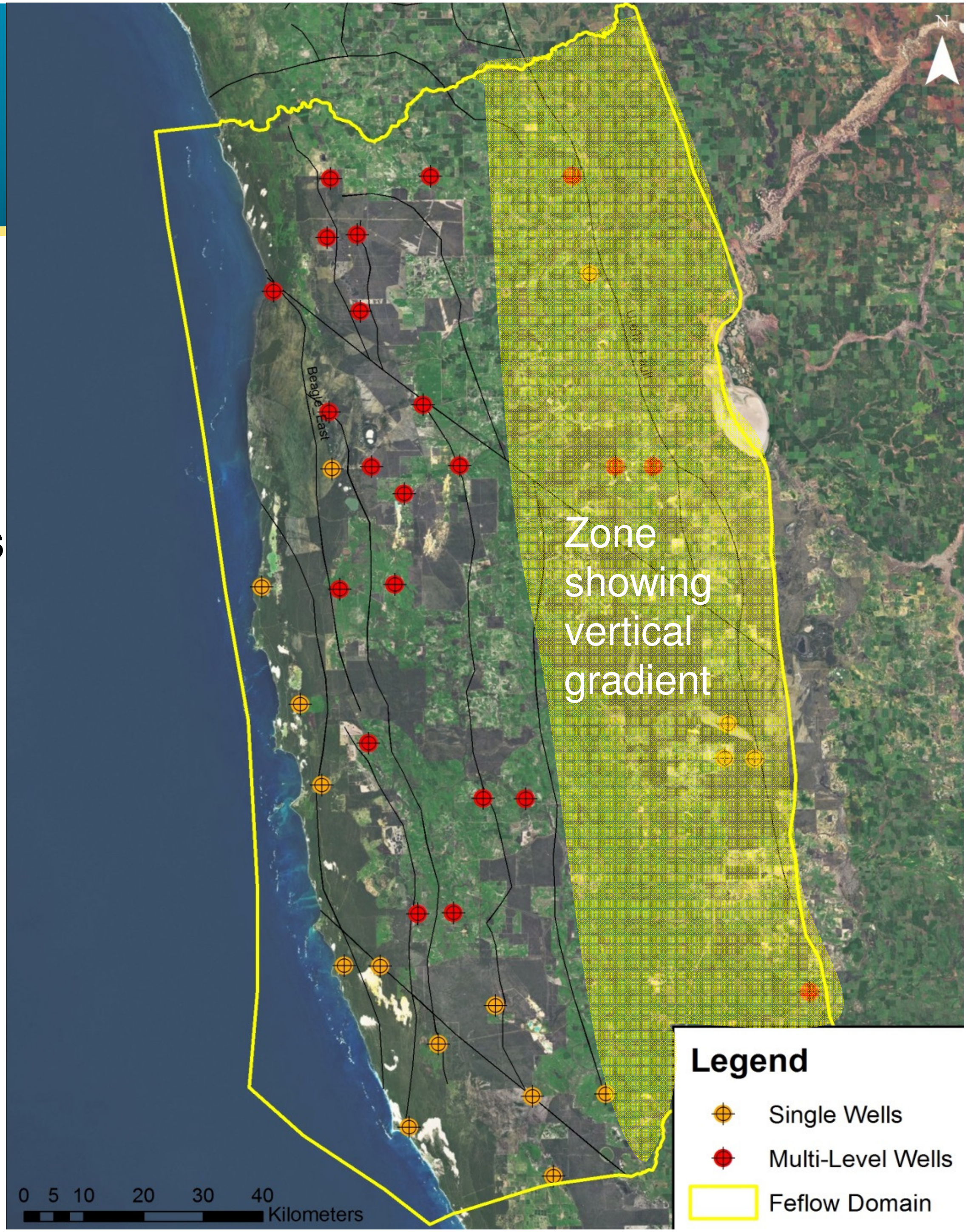


Calibration Data

- **63 calibration points**
- **22 multi level piezometers**
- **16 simple piezometers**

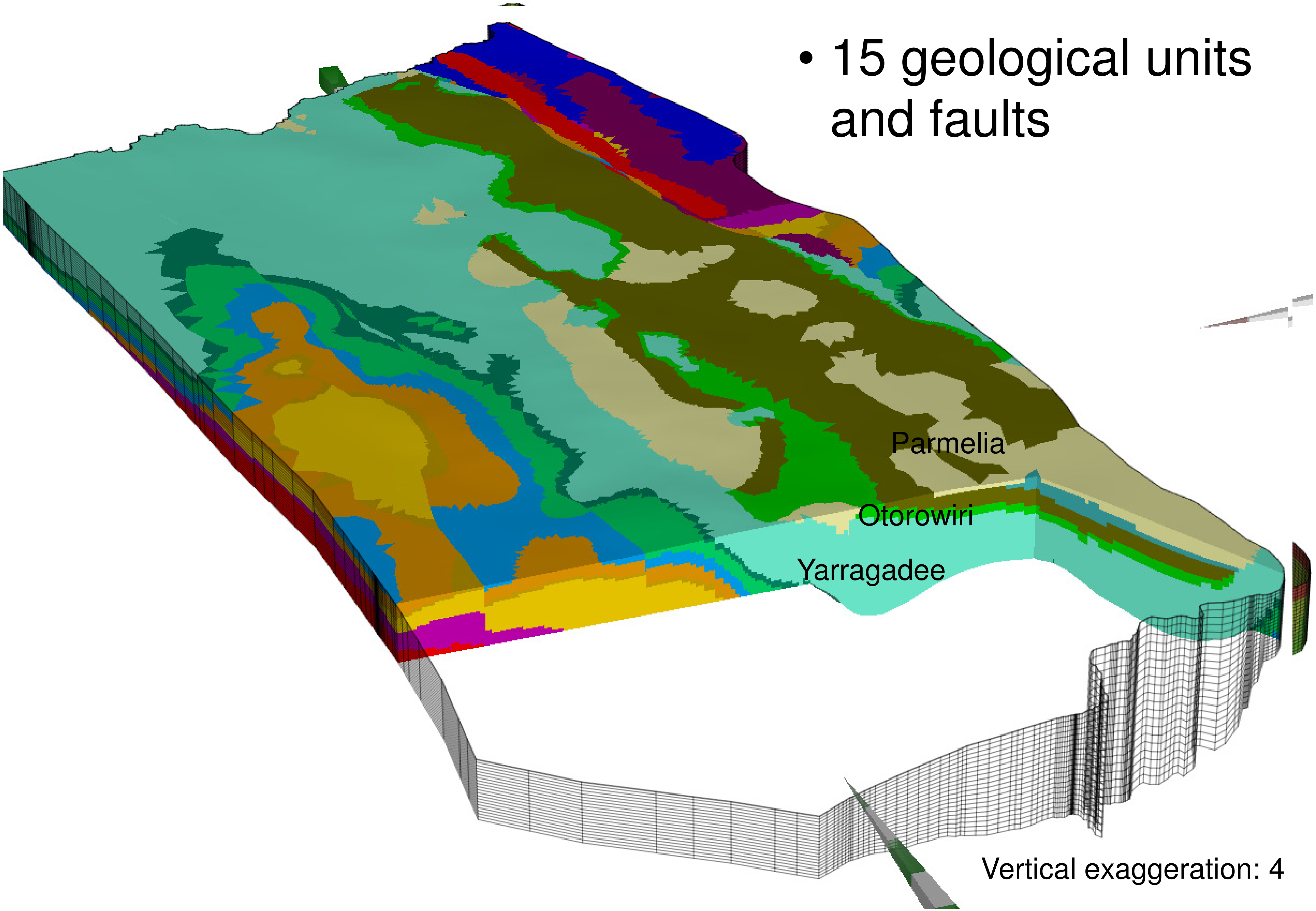
>100m difference in head between:
Parmelia Aquifer & Yarragadee Aquifer
separated by the Otorowiri Member (yellow area)

Source: water.wa.gov.au



Insertion of the GeoModeller model into FEFLOW

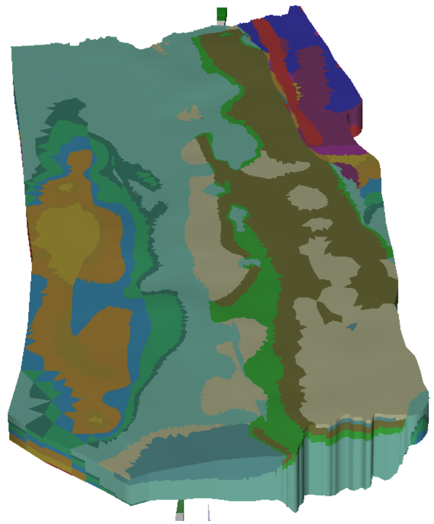
- 15 geological units and faults



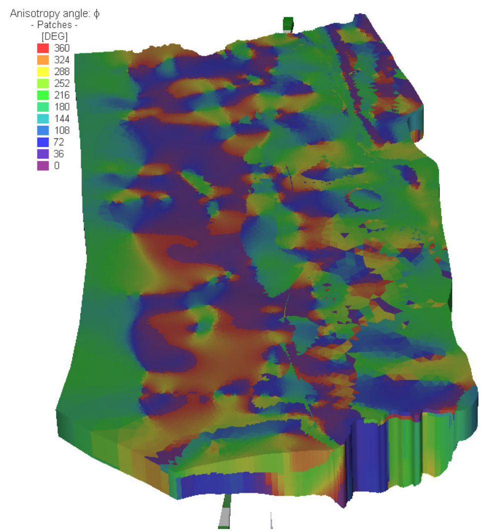
4 models: different degrees of complexity

No Geology No Anisotropy No Fault	Geology No Anisotropy No Fault	Geology Anisotropy Angle No Fault	Geology Anisotropy Angle Fault

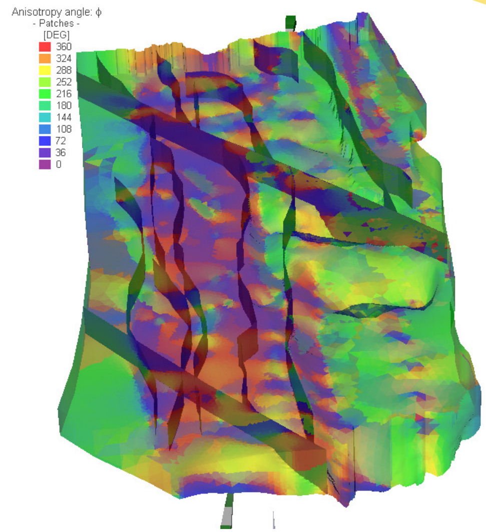
1 Unit



8 Units



8 Units
Anisotropy angle
Ratio: 100



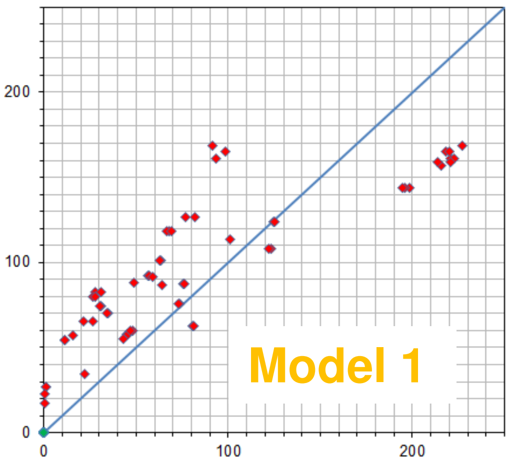
8 Units + 4 Faults
Groups
Anisotropy angle
Ratio: 100

All models are calibrated with PEST (Parameters ESTimation)

Conductivities are calibrated for all units or faults (Anisotropy ratio in unit and fault is fixed)

Comparison of models calibration and complexity using PEST

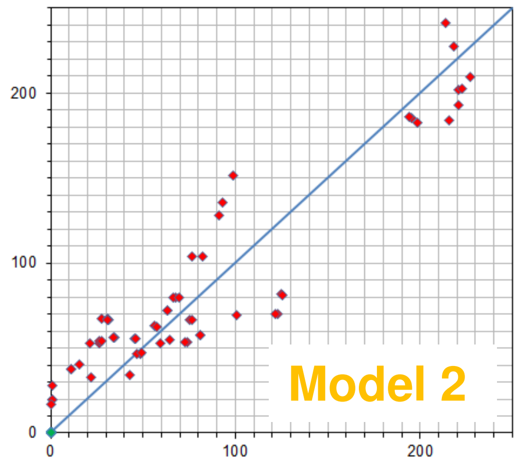
No Geology + No Anisotropy + No Fault
NRMS: **18%**



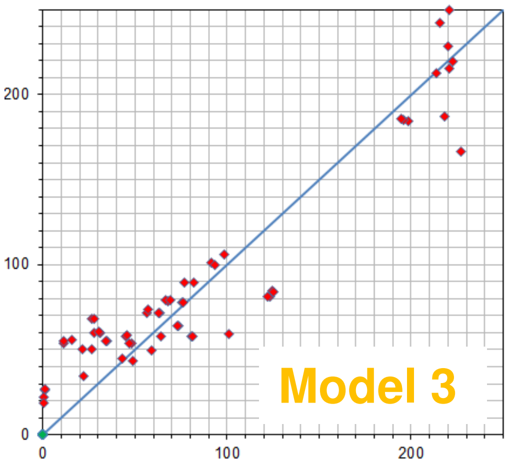
Calculated Head

Measured Head

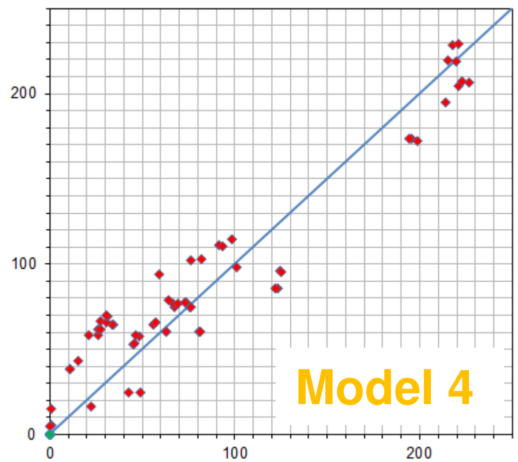
No Fault + No Anisotropy
NRMS: **11.2%**



No Fault + Anisotropy
NRMS:**10.6%**

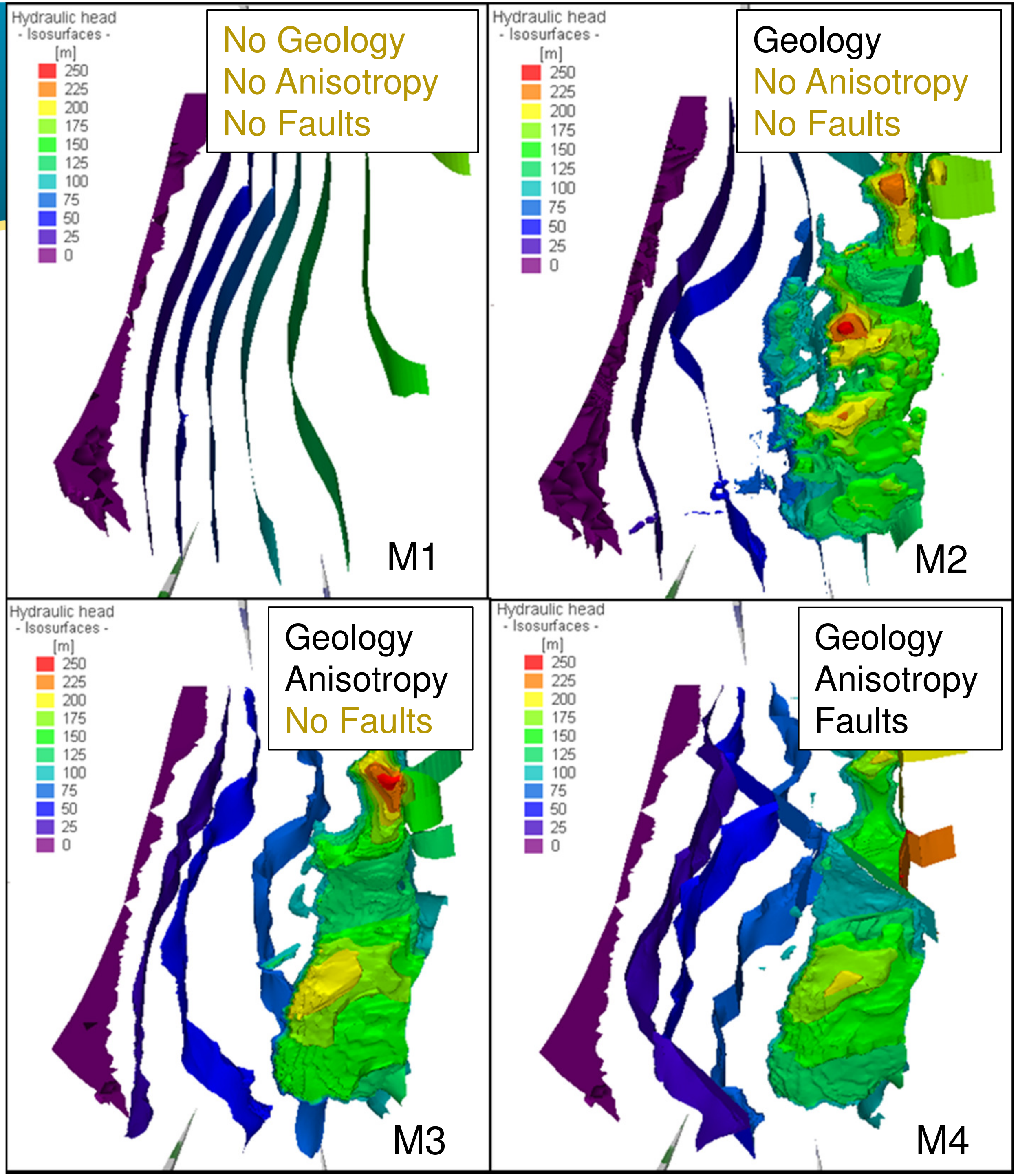


Geology + Anisotropy + Fault
NRMS: **9.5%**



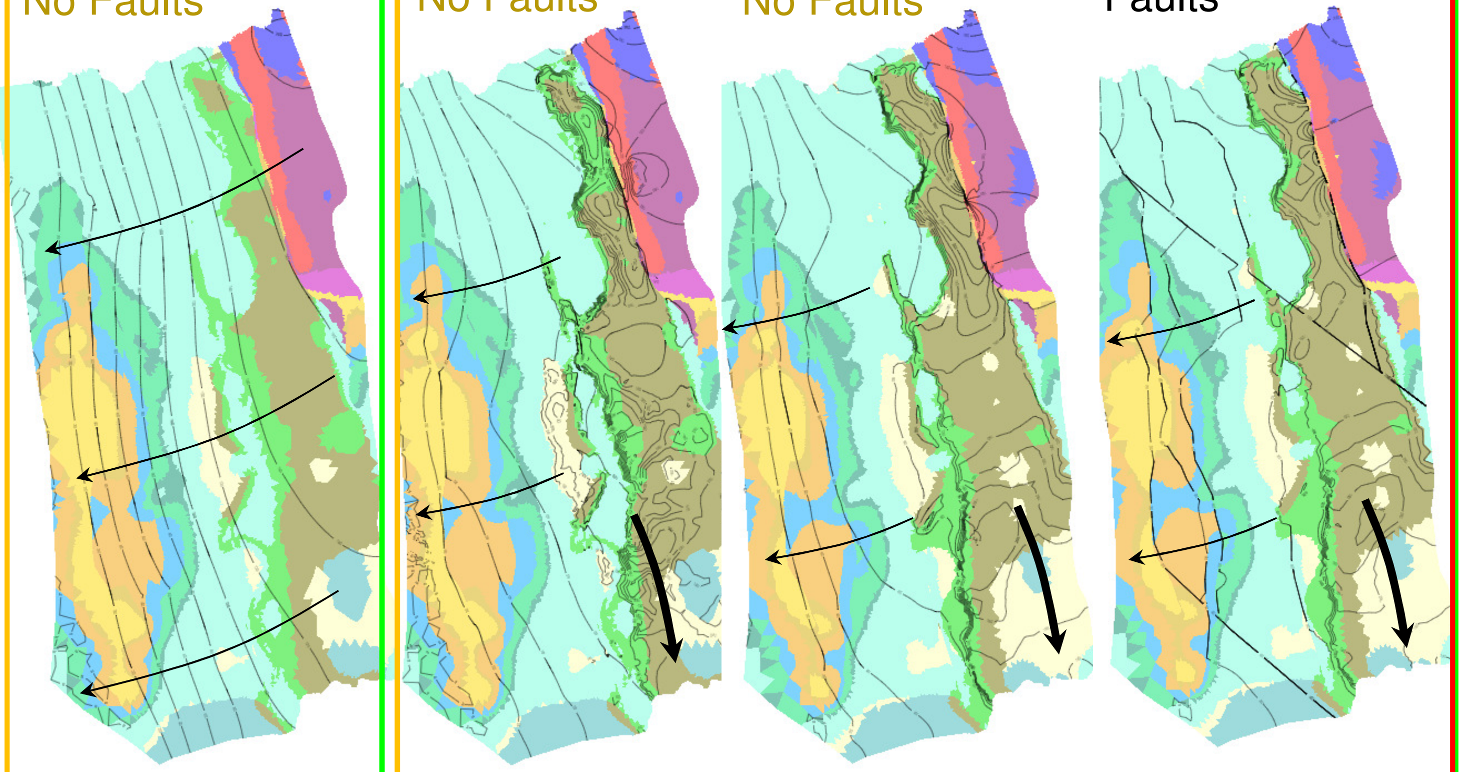
Isosurfaces of head for the 4 models:

Horizontal isohead surfaces => Vertical gradient

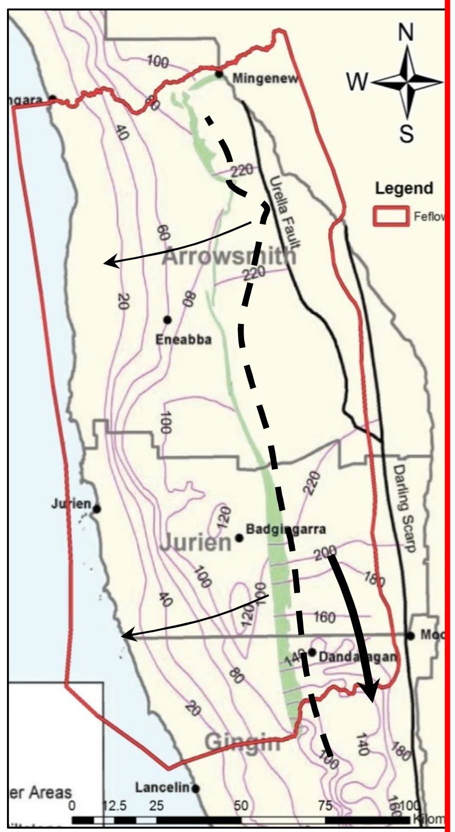


Results:
Head contour using 4 different flow Models

M1	M2	M3	M4
No Geology No Anisotropy No Faults	Geology No Anisotropy No Faults	Geology Anisotropy No Faults	Geology Anisotropy Faults



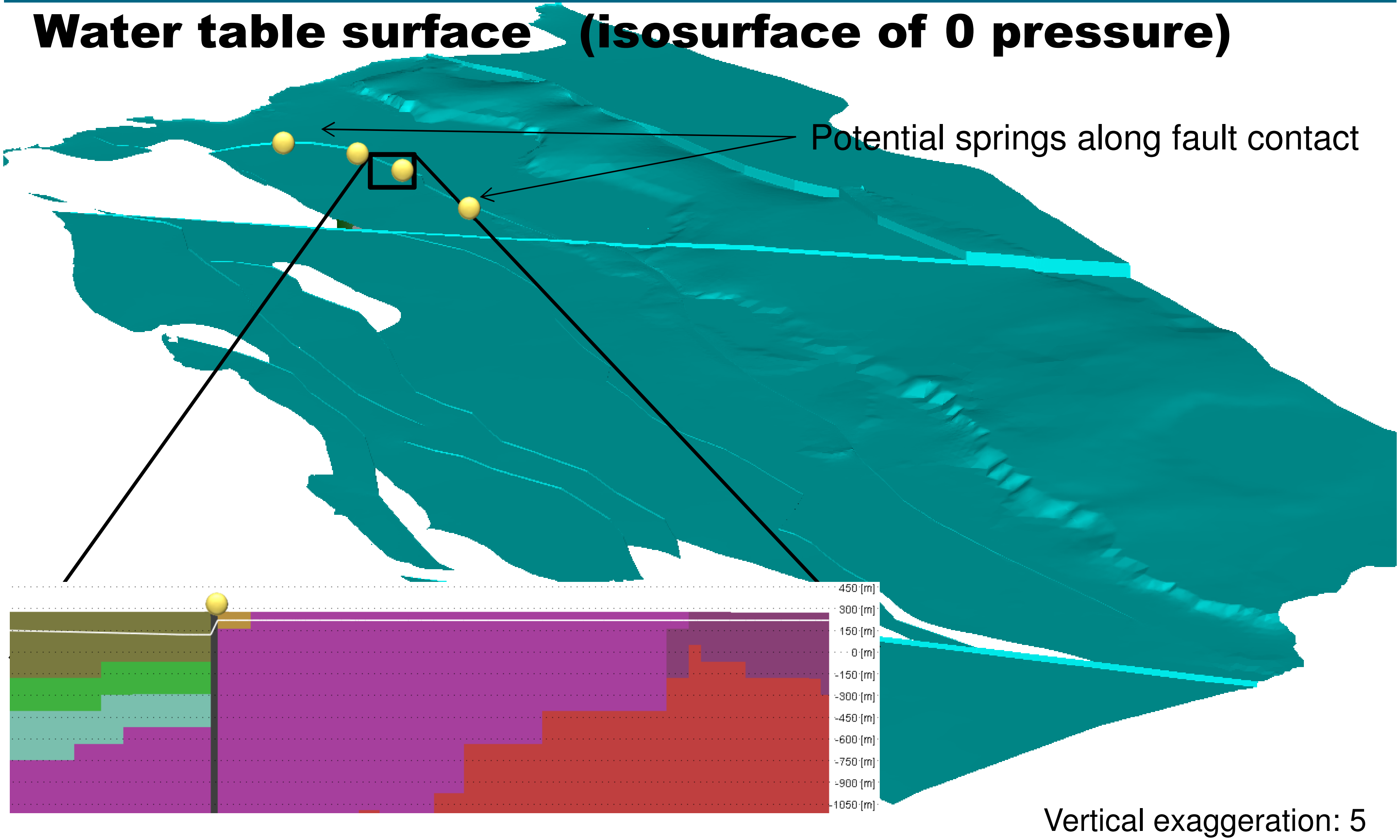
Conceptual Model



Source: Rutherford

Effect on potential springs and WT due to fault compartmentalisation (Model 4)

Water table surface (isosurface of 0 pressure)



Conclusions

- Inserting the *GeoModeller* model units into *FEFLOW* helps **improve calibration by 50%.**
- The North-South direction flow component in the Parmelia aquifer can **only** be represented with the insertion of the geological model
- It is possible to model **strong vertical gradients** in Otorowiri Fm (evident in several boreholes) by applying a **low K value** to this Fm.
- **Faults potentially contribute to the locations of springs**. Adding them to the model creates hydrogeological compartments, improves calibration and generates a more **realistic model**.
- Preliminary evidence that adding **anisotropy angles** also improves calibration and model reliability (as seen in other studies)

Thanks