An overview of how a Geothermal Scientist interacts to link field data to help protect geothermal resources

The Geothermal Institute
University of Auckland

Bridget Lynne

Santiago de Chile, 26-29 May 2014

GEOTHERMAL INSTITUTE

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau


Link field data to protect these features

The purpose of the Resource Management Act (RMA) is summed up as:

The protection of outstanding geothermal features from inappropriate use and development is a matter of national importance (refer section 6(b) of the Act).

Complex consenting processes for geothermal development

Prior to consent for development many demands must be met

The following list is from an Environmental Court Hearing prior to consent for a geothermal development in New Zealand ~ 2010 (by Chris Bromley)

15 items of evidence presented by one geothermal specialist

Note:

For the same case there were other specialists who presented lists of evidence.

For example, Prof Mike O'Sullivan, UoA, Dept of Engineering Science, presented 10 different reservoir models based on different scenarios of extraction and reinjection to show the time required to achieve a pre-exploitation natural field state

The court uses the evidence presented to show cause and effect of development.

1. Geophysical techniques for identifying geothermal system characteristics

2. Description of changes in surface geothermal activity

3. Description of shallow groundwater aquifers

4. Characteristics of shallow hydrothermal regime

5. Effects of development on thermal features

6. Changes in shallow aquifers post development

7. Strategies for management of the productive potential of the resource

8. Strategies for management of thermal features

9. Infield and outfield injection strategy

10. Proposed outfield injection areas

11. Effects of targeted injection on subsidence

12. Subsidence mechanisms

13. Hydrothermal eruptions

14. Mitigation of hydrothermal eruptions through injection

15. Peer review management mechanisms

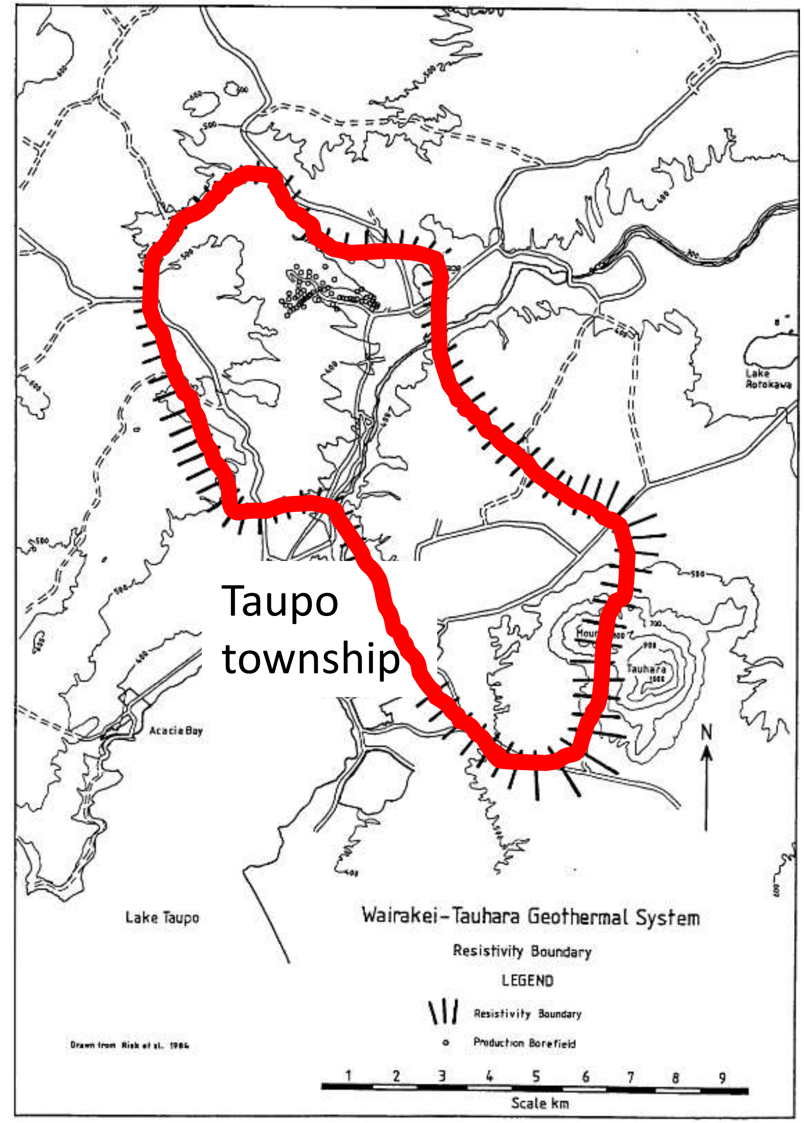
This is only 1 geothermal specialist's input

1. Geophysical techniques for identifying geothermal system characteristics

Resistivity Boundaries indicate the approximate extent of the geothermal system

Maps land within your study area

Geophysics defines location of heat source



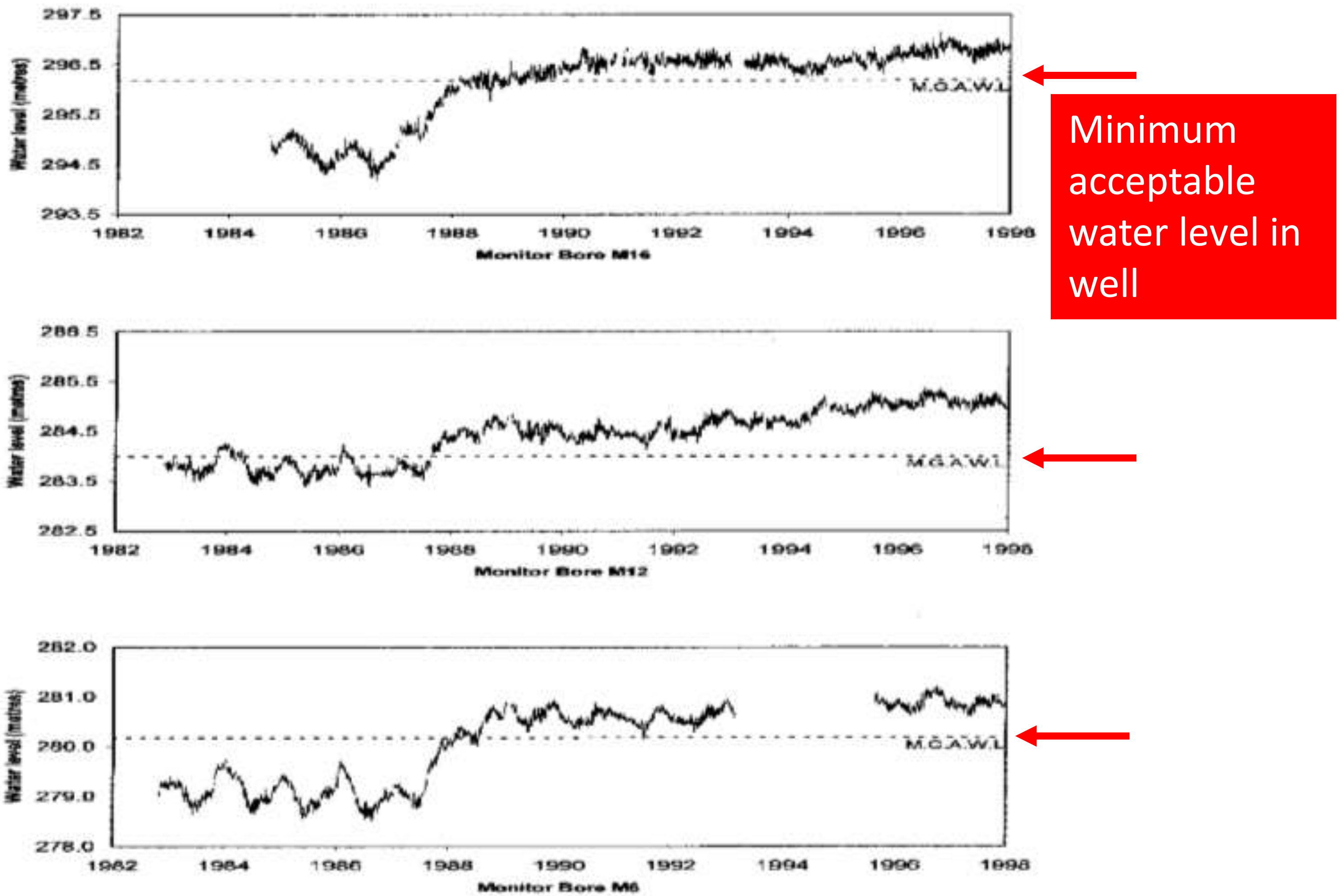
2. Description of changes in surface geothermal activity

Repeat site visits and document observations

Mud Geyser 2009

Mud Geyser 2010

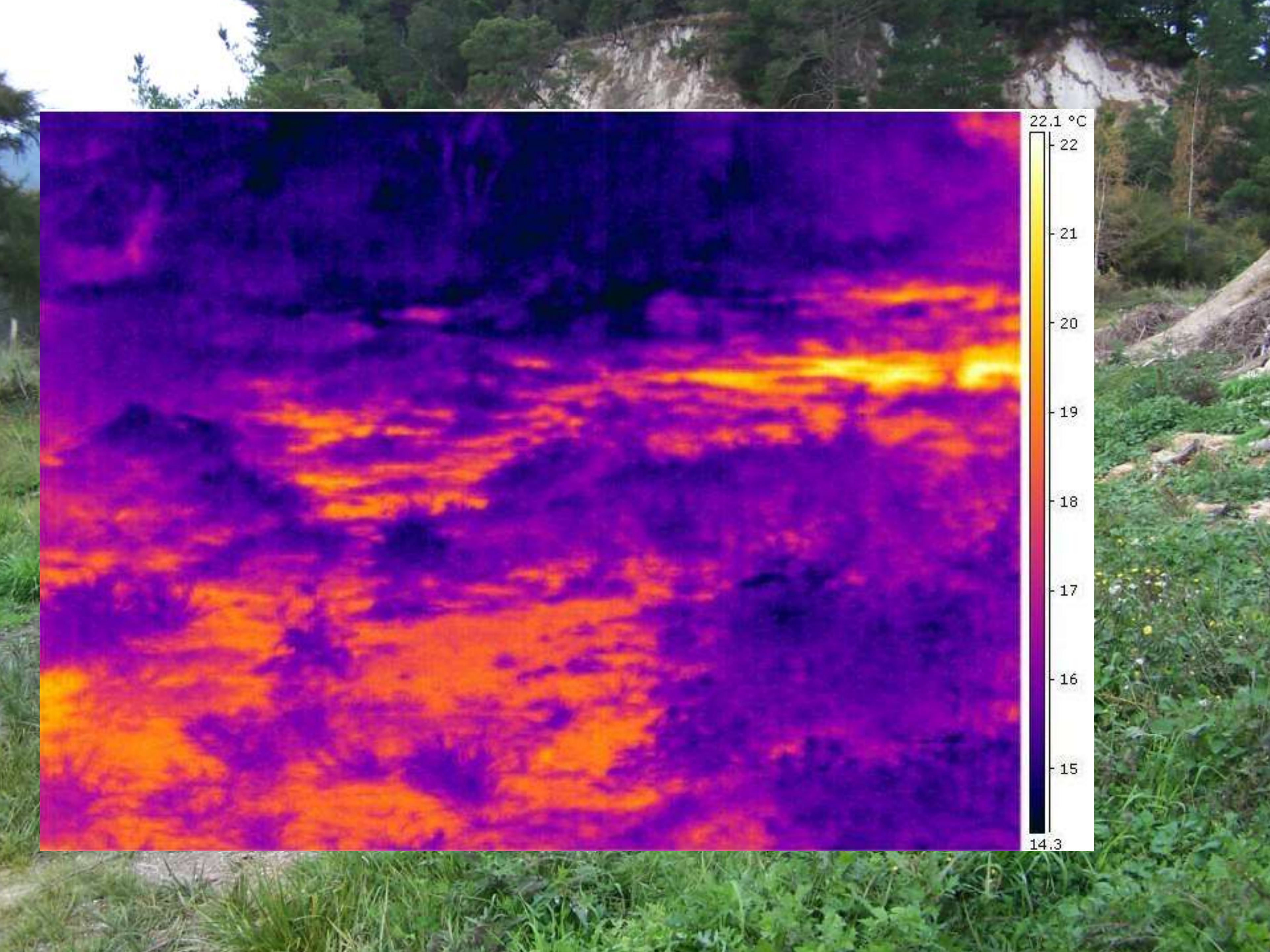
3. Description/Monitoring of shallow groundwater aquifers (include water chemistry) Use monitoring wells.



4. Characteristics of shallow hydrothermal regime

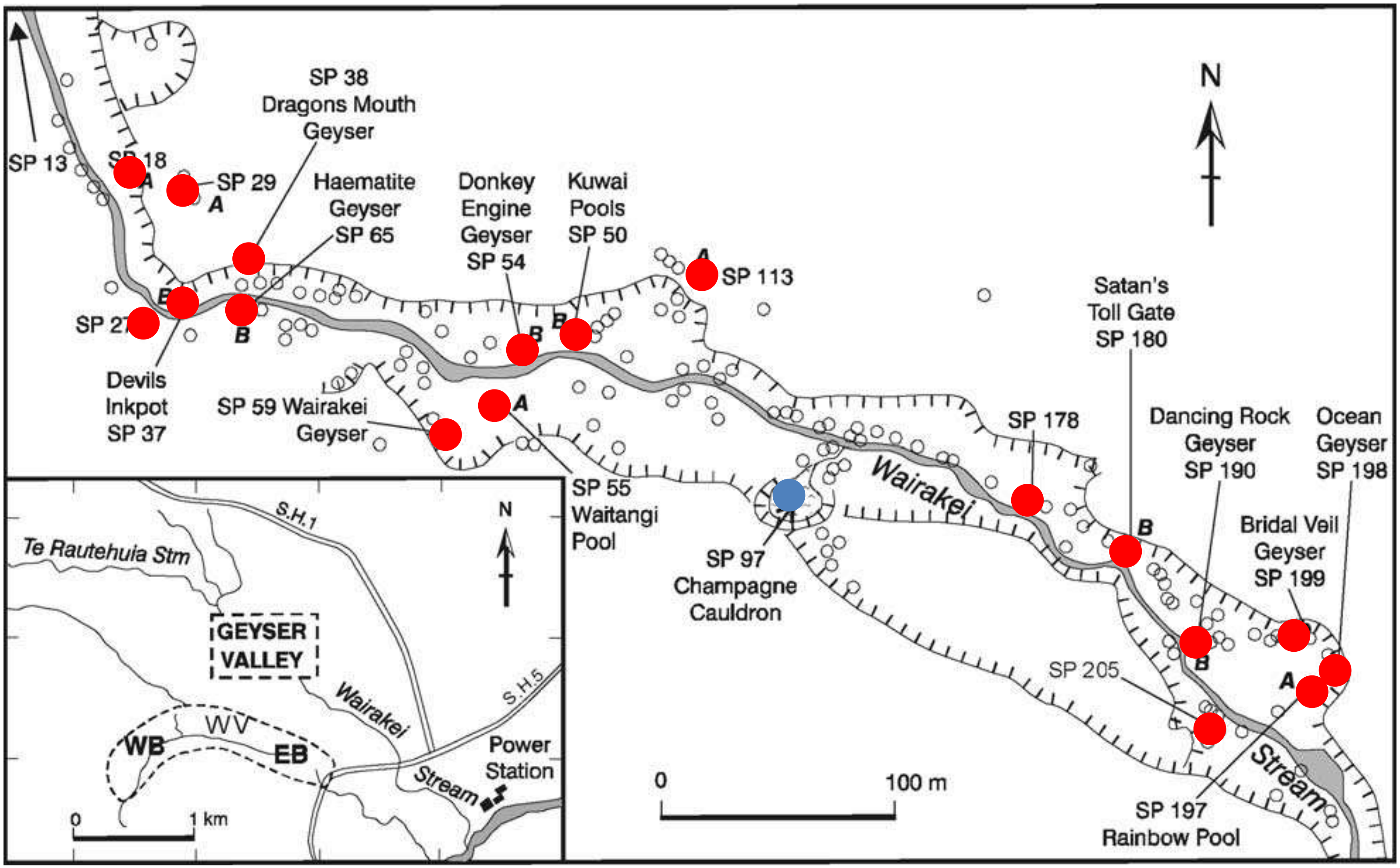

Sites of modern activity


Historic thermal activity


22.1 °C
22
21
20
19
18
17
16
15
14.3

5. Effects of development on thermal features

Post development = only 1 remaining feature



6. Changes in shallow aquifers post development

7. Strategies for management of the productive potential of the resource

8. Strategies for management of thermal features

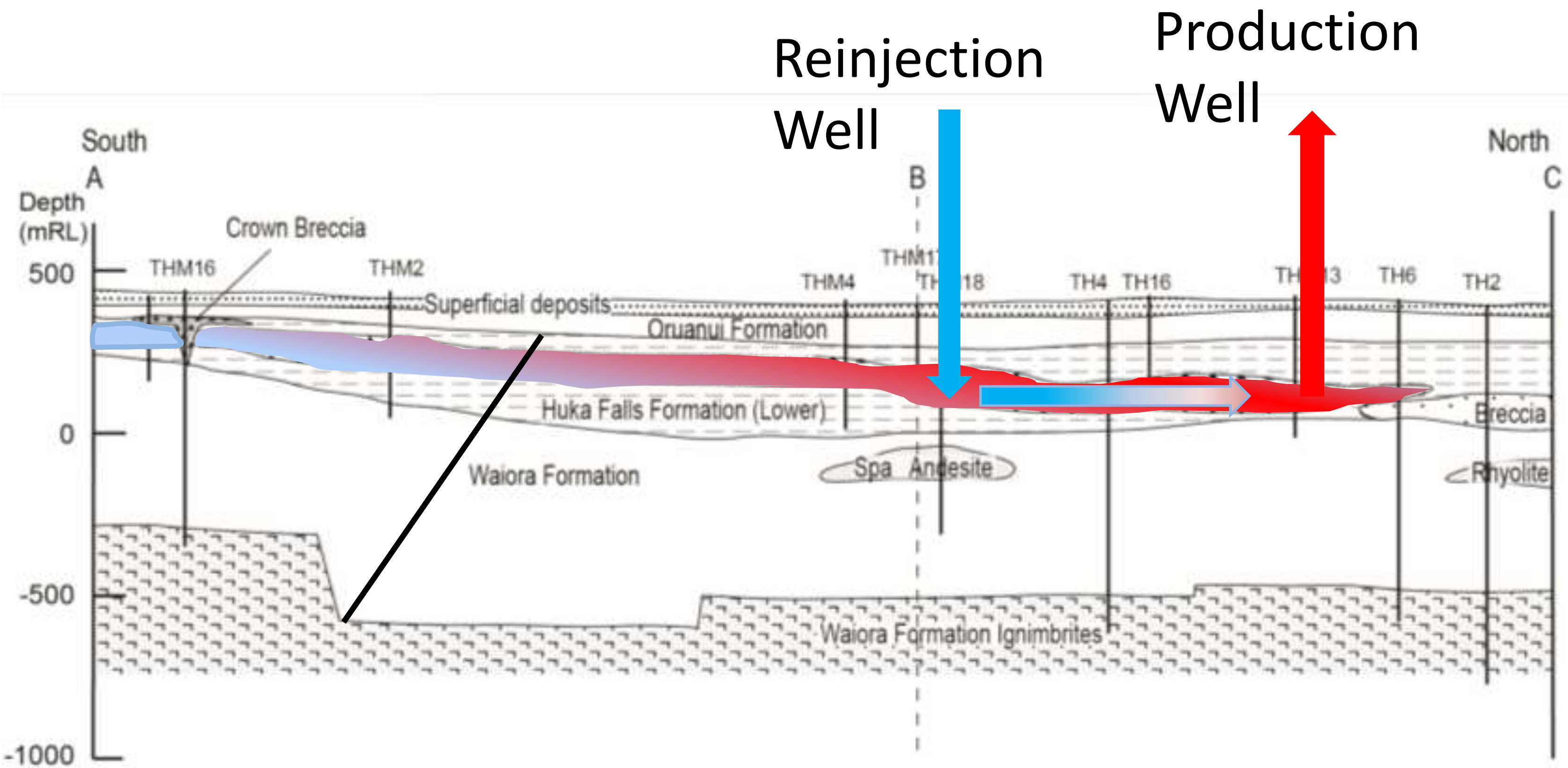
Team of specialised staff working together

9. Infield and outfield injection strategy

10. Proposed outfield injection areas

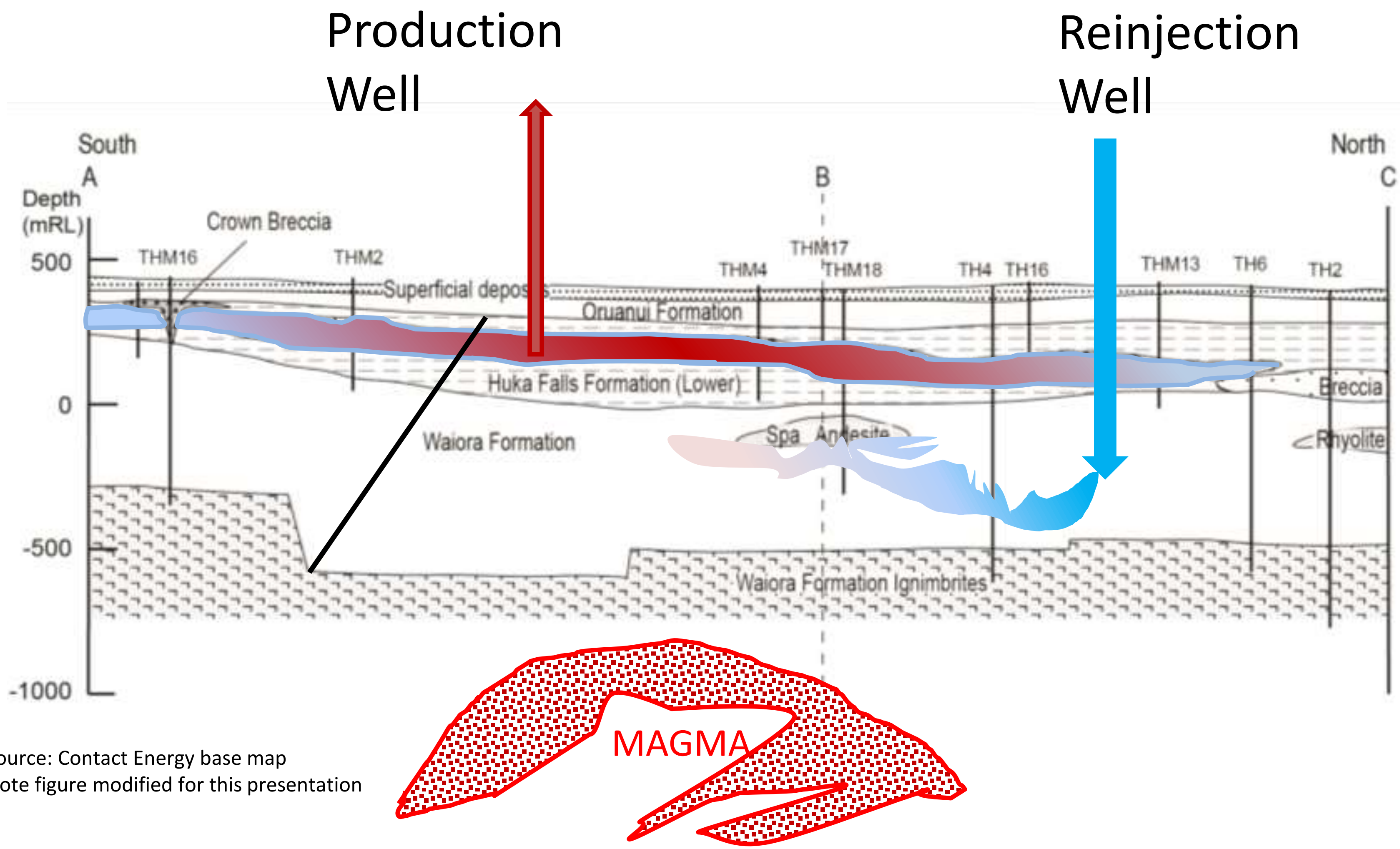
Example of thermal break through

Both above ground and below ground scientists and engineers working together to find best location and depth for injection



Source: Contact Energy base map
Note figure modified for this presentation

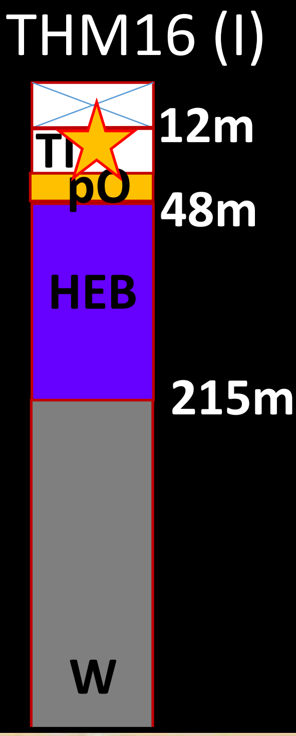
11. Effects of targeted injection on subsidence



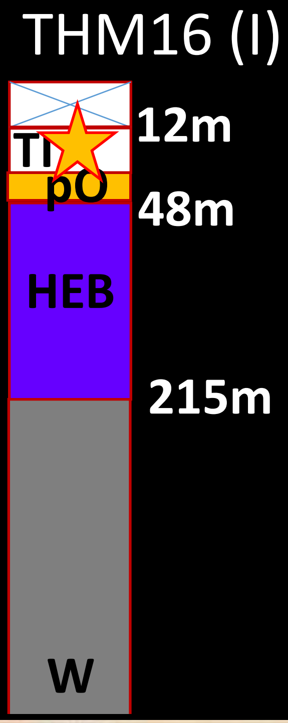
Source: Contact Energy base map
Note figure modified for this presentation

12. Subsidence mechanisms

22m



30m



Taupo Ignimbrite

Pumice-rich

Taupo Ignimbrite Pumice horizon

22 m

CV = 294 MPa

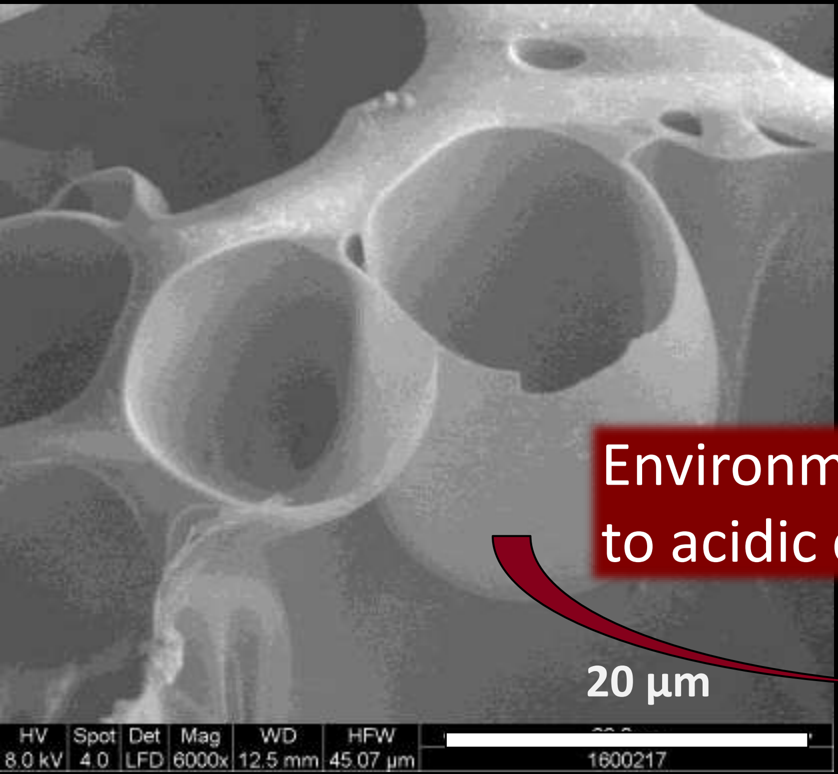
30 m

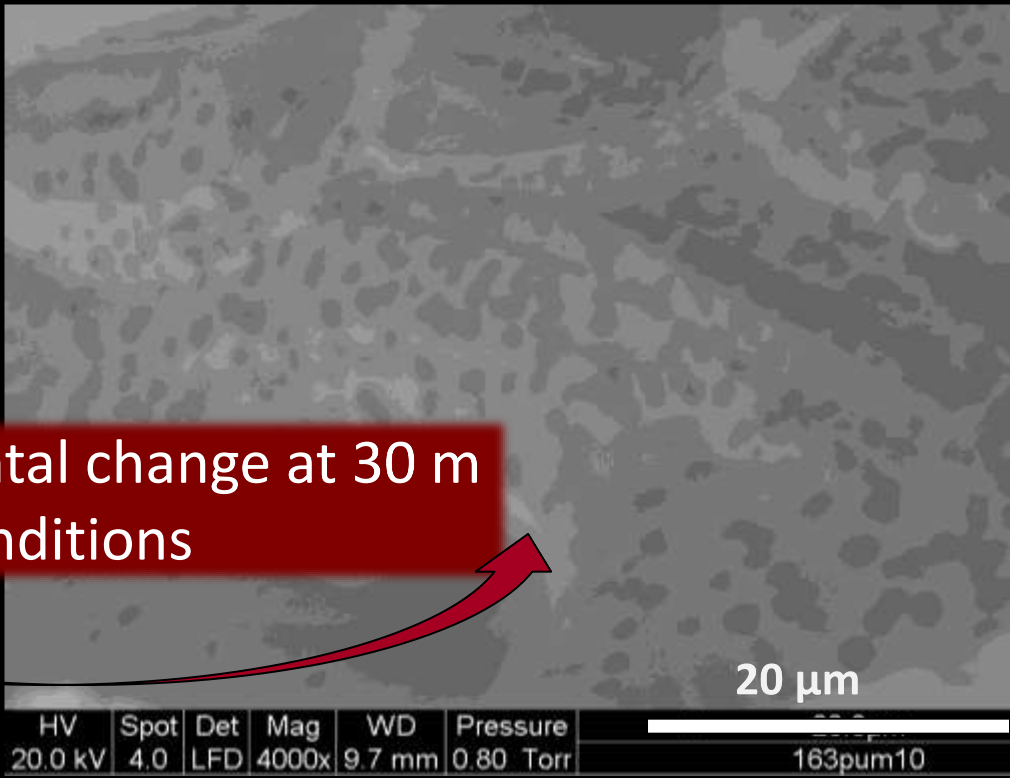
CV = 108 MPa

?? Process ??

Unaltered

Dissolution





Environmental change at 30 m to acidic conditions

Steam condensate alteration over **9800 years old** at Wairakei

13. Hydrothermal eruptions

14. Mitigation of hydrothermal eruptions through injection

Ngatamariki 2005

15. Peer review management mechanisms

Peer-Review Panels established once a development is underway

Consist of a range of independent technical expertise

Panels meet regularly (annually or more often if required)…

…to review resource data compiled in an
annual monitoring report

Regional councils require
3 monthly monitoring reports on thermal surface activity

Annual reports

Build up data base of landowner details.
In NZ, as council enforce RMA they have the automatic right to access features anytime.

What to monitor and how?

Geothermal activity and features such as

geysers
fumaroles
mud pools
hot springs

can only exist if the field pressure is maintained at a level that enables a healthy natural outflow.

It is necessary to be able to recognise the different geothermal features as some features are more susceptible to subtle changes than others

For example

A **hot spring** is a spring that is produced by the emergence of geothermally heated groundwater from the Earth's crust.

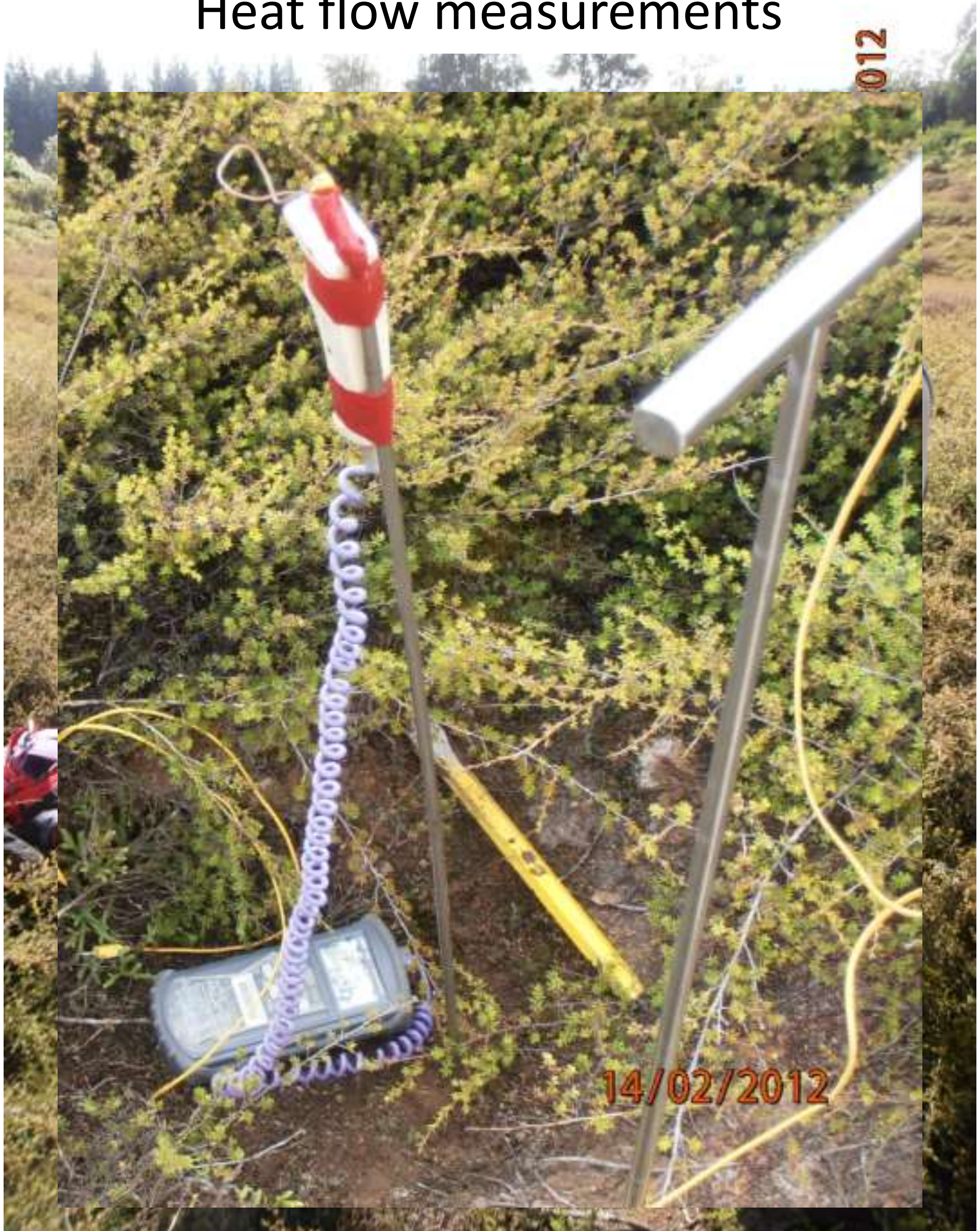
Spouter: … a pressurised hydraulic head of thermal fluid, continuously discharging through a restricted outlet. This creates a distinct “nozzling’ effect

They may react differently to subtle changes in hydrology

What to measure?

- Date of visit
- GPS location
- Pool temperature
- Pool depth and size
- Max height of ebullition
- Discharge rate
- Elevation
- Barometric pressure
- Ambient temperature
- Fluid chemistry

Heat flow measurements



Steam velocity measurements

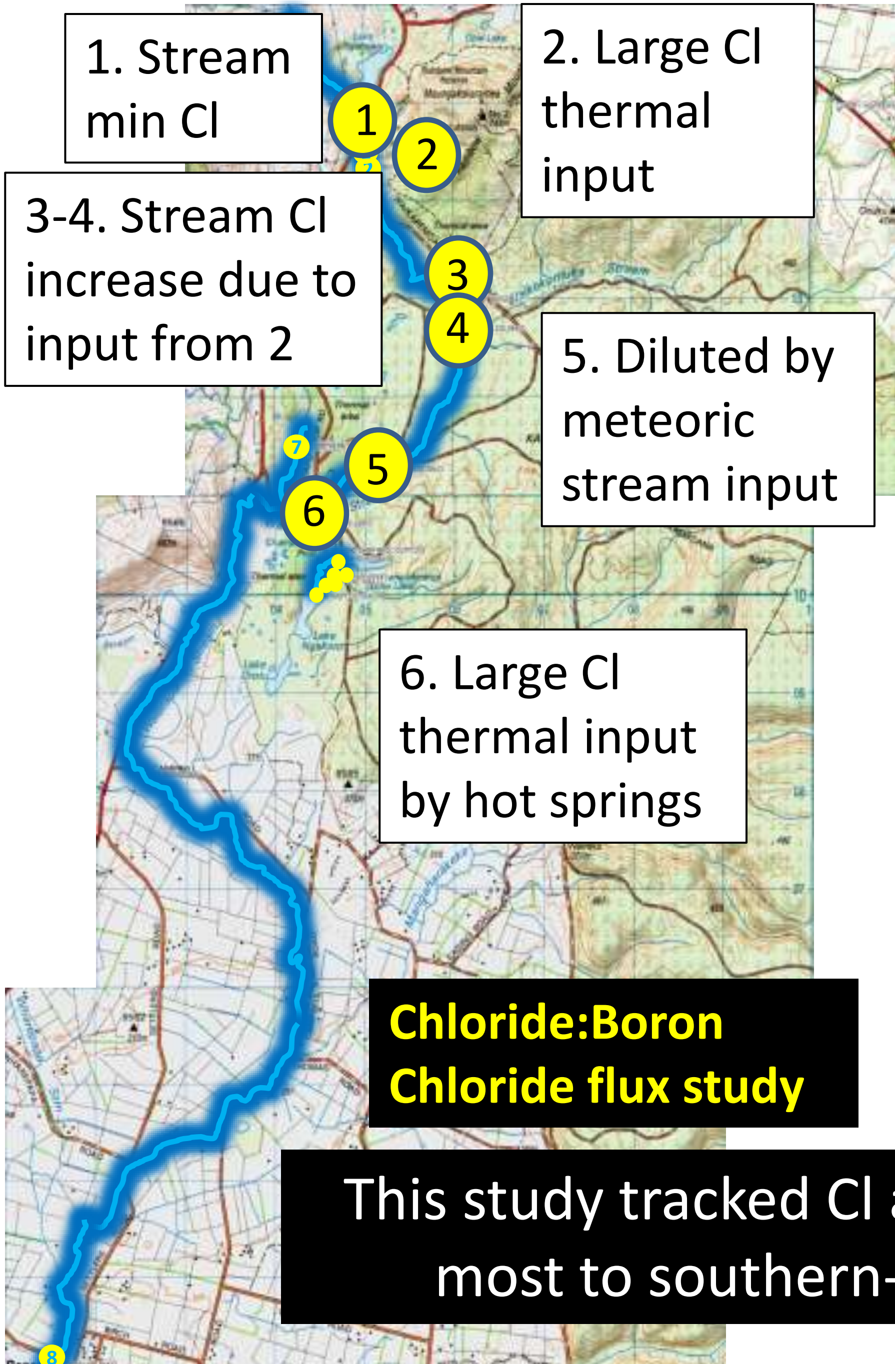
Weather data necessary for heat loss calculations

Flow rate measurements

Water sampler

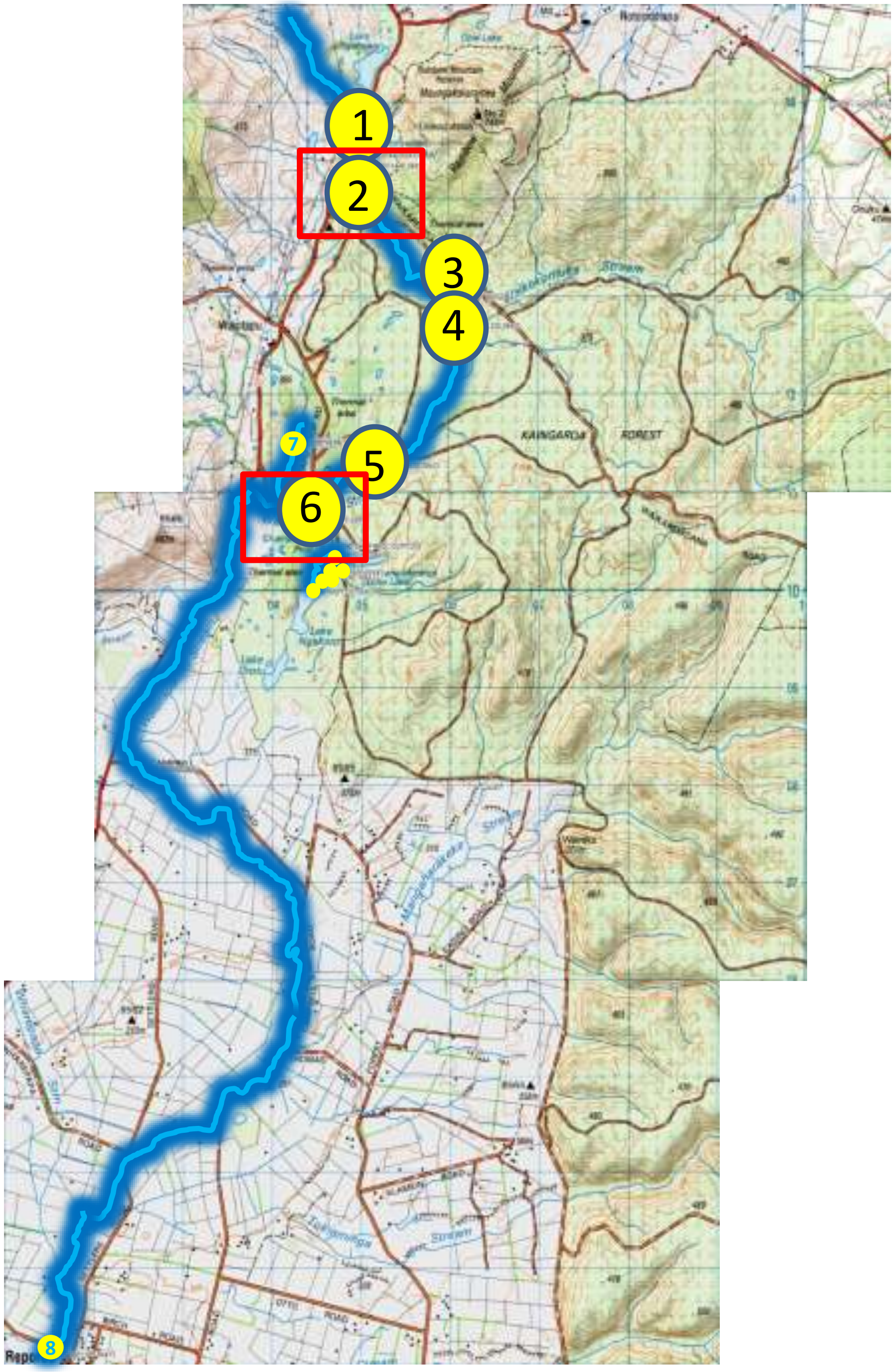
CO_2 collection from water bodies

CO_2 collection from soil



Site	Boron	Chloride	Cl:B
1	0.3	5	17
2	1.7	193	114
3	0.1	88	22
4	0.1	90	26
5	3.9	43	31
6	1.7	127	101

This study tracked Cl and B changes from northern-most to southern-most extent of the system



Cl:B ratios

Site	Boron	Chloride	Cl:B
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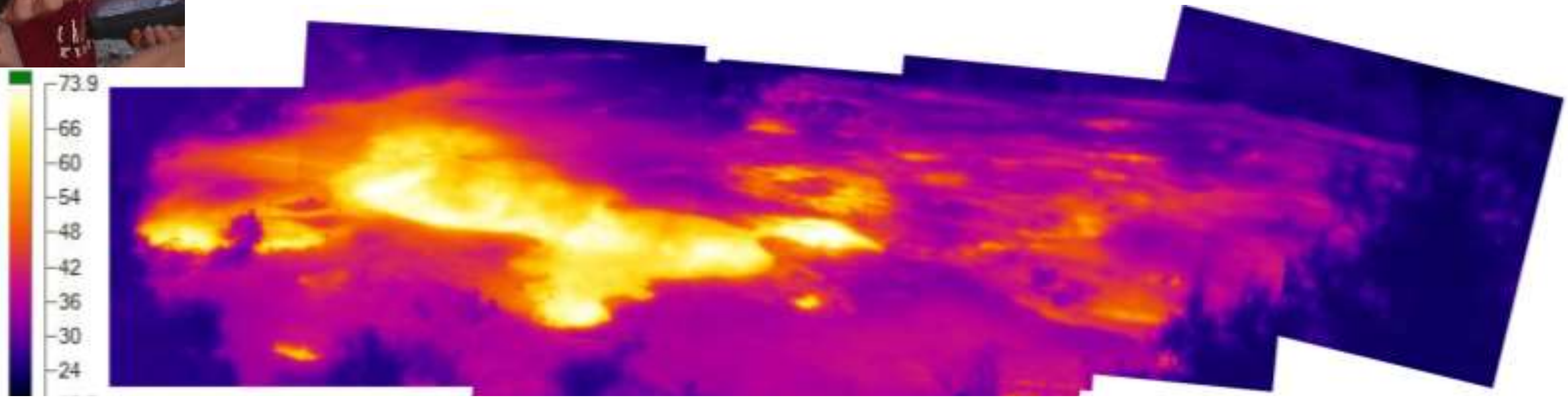
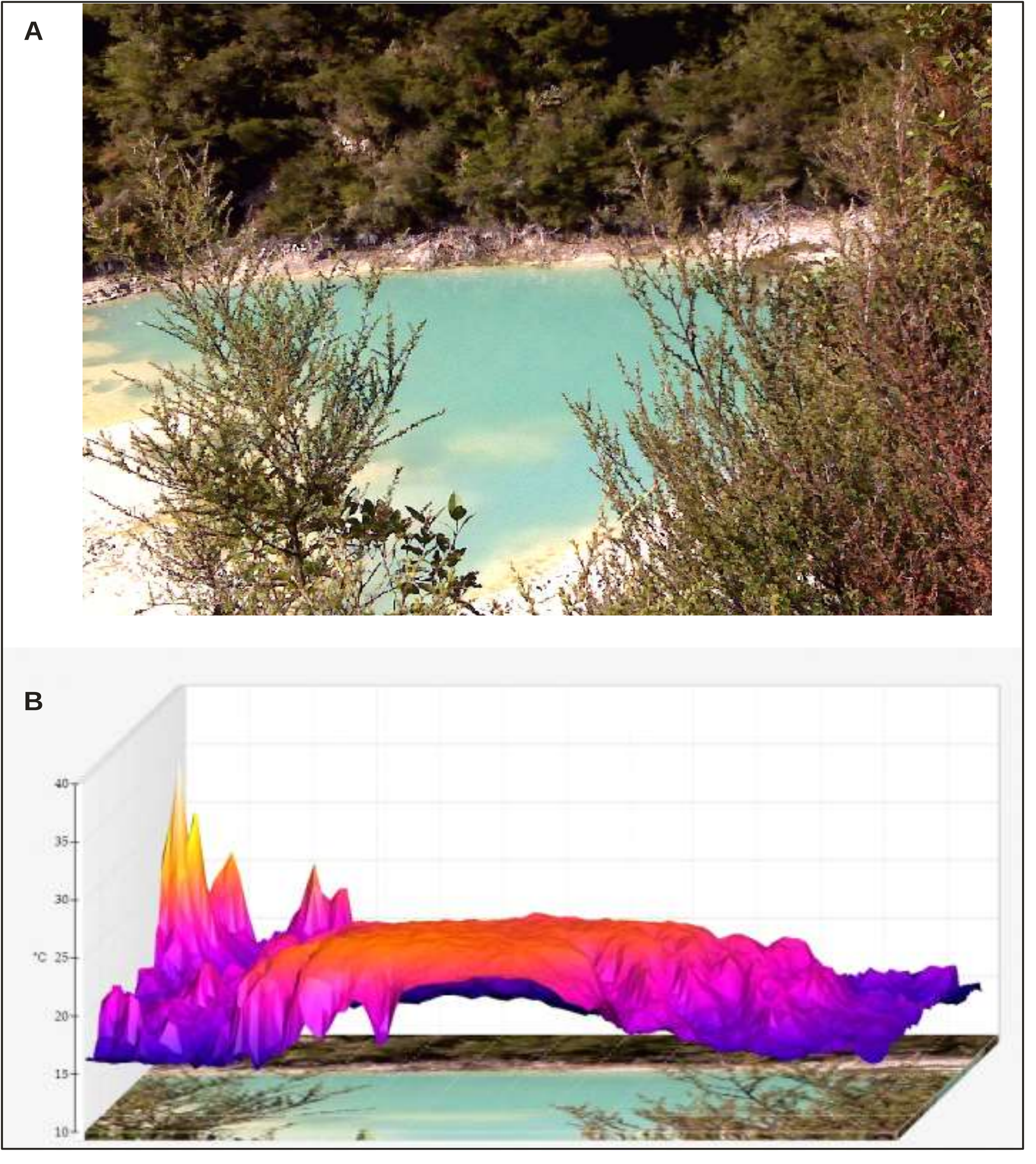
Use the correct method for the job



Ground truth some sites with hand held temperature probe


A
B
40
35
30
°C 25
20
15
10

Restricted to surface temperature only

Radiation effects due to solar radiation can heat up the water surface

Beaware hand held IR temperature probe is not the most accurate but better than no temperatures

Could be elevated by several °C

Basic Field Observation

Feature type

Feature temperature (˚C)

Feature steaming Yes/No

Any microbial mats Yes/No

Colour of microbial mats

Location of microbial mats

Feature pH

Feature colour Clear Opaque (what colour)

Boiling Yes/No

Gas discharge rare moderate abundant

Gas odour minor moderate abundant

Height of bubbling

Feature has discharge channel Yes /No

Flow rate in discharge channel (m/s)

(count the seconds it takes for a leaf to flow 1 m)

Surrounded by hot spring rocks Sinter or Travertine

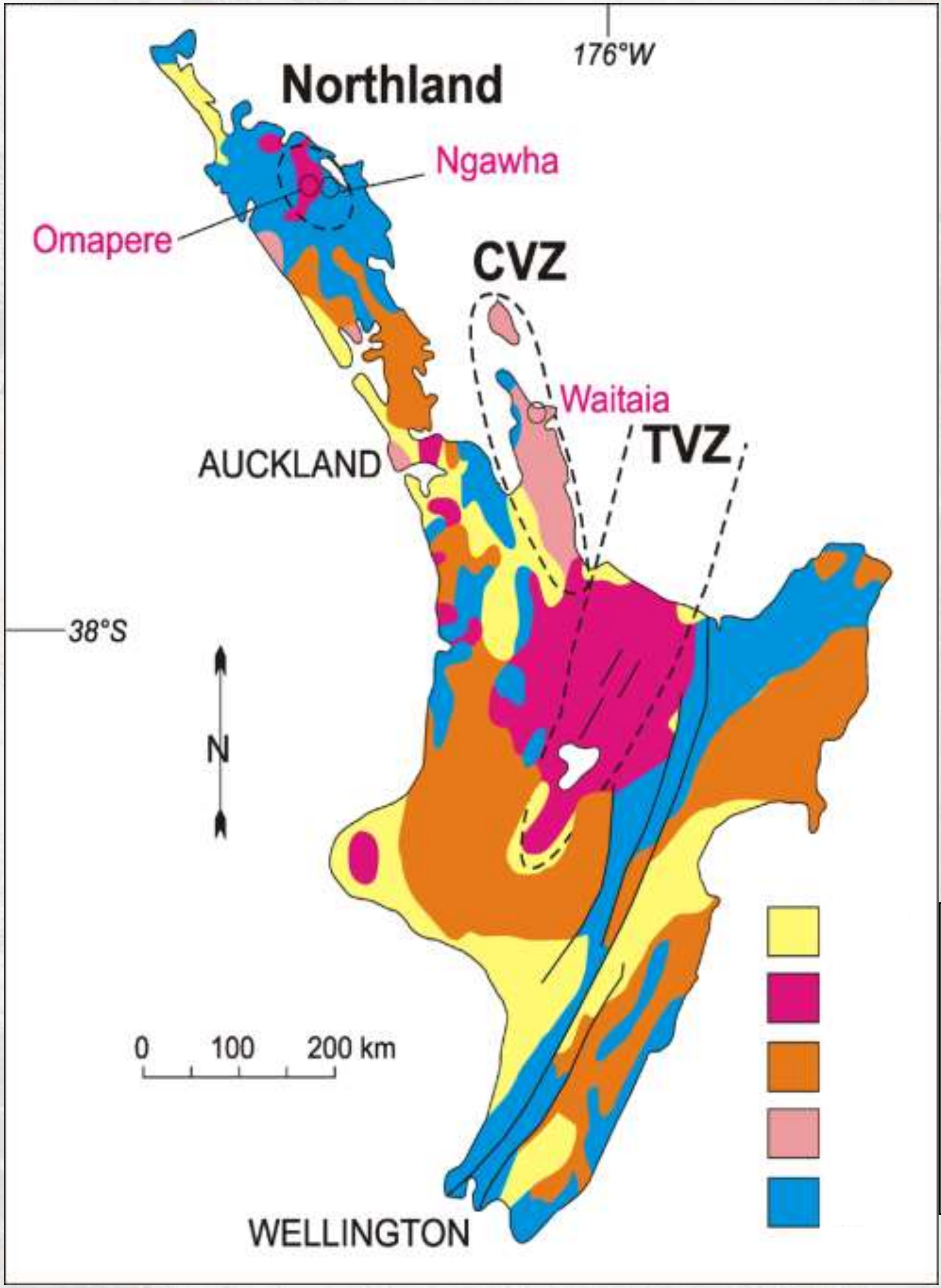
Any clay alteration surrounding feature Yes/No

Distinguishing features

Sketch in field note book

- Pool shape and dimensions
- Zones up upwelling gas
- Zones of vigorous bubbling
- Location of discharge channel
- Location of microbial mats
- Location and type of hot spring rocks
- Alignment of bubbles e.g., North-South etc

Epithermal Gold and silver deposits



Geothermal activity moved from CVZ to TVZ

Gold deposits left behind in CVZ from ancient hot fluids moving through rocks

Youngest rocks

Oldest rocks

Golden Cross gold mine, CVZ, NZ


dreamstime.com


©davidwallphoto.com

Black areas consist of electrum.

Electrum is:

60% gold + 40% silver

Active gold deposition at Champagne Pool, Waiotapu, NZ

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Summary

- Good geothermal practice involves a team of specialised scientists and engineers
- Multi-discipline approach provides good understanding of geothermal system
- Exploration, Exploitation and Development takes many years and on-going
- Continually modifying your conceptual model as new data comes to hand
- Team Approach

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Research works *wonders*