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Executive summary

The Resource Management Act 1991 (RMA) requires that regional councils sustainably manage geothermal resources. Geothermal surface features are an important part of the geothermal resource and in some cases are outstanding natural features to be protected from inappropriate use and development (RMA s6(b)). Throughout the region, most geothermal features and ecosystems are adversely affected to a greater or lesser degree by geothermal resource use or uses of land and water. Section 35(1) and (2a) of the RMA require the regional council to gather information and undertake or commission research to monitor the state of the environment as necessary to carry out its functions. Waikato Regional Council monitors the natural state of the geothermal resource and assesses what changes of state have occurred or are occurring.

This report describes the results of the quarterly monitoring schedule for the 2013 to 2014 year on the state of geothermal features throughout the region.

Uses of the quarterly and annual monitoring reports include:

- Providing Waikato Regional Council and other researchers with long-term information on the natural range of heat and mass outputs of geothermal features
- Identifying significant changes in the behaviour of features that could be precursors to extreme events such as hydrothermal eruptions
- Identifying departures from the baseline trend of feature activity so that the cause can be investigated
- Identifying unintended human-induced adverse effects on springs (e.g. litter blowing into them, road runoff, pines falling in) that can then be remediated
- Similarly, identifying threats to the features that can mitigated before they happen
- Identifying activities that may require enforcement action, such as discharge of contaminants to geothermal pools
- Counting the number of visitors to springs, to aid in quantification of the economic value of the geothermal resource to the Waikato Region.

There was a significant increase in temperature of the North and South Pool at Orakei Korako in January 2014. There also appears to be increased activity next to the Diamond Geyser, with a new geyser possibly formed.

Remediation work has been carried out at Tahunaatapu pool, Whangairorohea.

Some changes have been made to the pool at Horohoro, with a new outlet being inserted.

No major hydrothermal eruptions or other major changes of either natural or human-induced origin were observed in the months April 2013 to January 2014.

1 Introduction

1.1 Background

Monitoring of the geothermal features in the Waikato Region was implemented in 1995. The aim of the monitoring is to observe the natural state of geothermal surface features. Assessments are made on changes that are occurring over time, as well as reporting on any threats or damage to the features. This will allow us to make more informed decisions to protect and enhance the geothermal resources and ecosystems.

1.2 Report Content

Geothermal monitoring is conducted quarterly, with a more extensive range of sites monitored annually. This report covers the monitoring period from April 2013 to January 2014. The specific sites monitored for this report are as follows:

- Atiamuri
- Golden Springs
- Horohoro
- Ngatamariki
- Orakei Korako
- Reporoa
- Rotokawa
- Tauhara
- Te Kopia
- Waikite
- Waiotapu
- Whangairorohea

1.3 Method

Water temperature was measured using a Fluke IR gun along with a 6 m long thermocouple.

GPS co-ordinates gathered during previous site visits have been converted from NZMG to NZTM. Where co-ordinates have not been available, a Garmin GPSmap 60CSx has been used to record locations, with an accuracy of ± 5 m. Each GPS reading was taken in the same spot as the photograph.

pH indicator paper was used to determine pH, Samples were cooled before being tested, to comply with the paper's temperate range.

Where possible, water flow was estimated. The liquid flow or discharge was estimated when assessed to be realistic, i.e. that the entire flow can be seen and seepage or flow diversion is not occurring on a large scale.

The water level was recorded for some features; subject to choosing an easily identified and physically long-lived benchmark in the vicinity, or relative to the overflow level. 'Ebullience' and gas discharge are recorded, also water clarity and colour, and the general condition of the sinter is noted.

For many features, photos in both the visible and infrared spectra are shown. Composite photos of both spectra are used to give a better indication of the location of the hot areas in a feature. The photos were taken using a Mikron Thermal Imaging Camera (Model M7816), which has a temperature range of -40 °C to 500 °C.

2 Atiamuri

2.1 Matapan Road

E1869089 N5740458; Located number 72.3005 (Geothermal Spring)

There are two springs at this location; the one on the left is geothermal and the one on the right is cool. Measurements are also taken downstream of the springs to get a combined reading. Vegetation surrounding the cool stream has grown further since the previous visit in January 2013, making visibility difficult. There were no visible changes to the geothermal stream; there is still green algal growth on the rocks. The temperature of the geothermal stream was 6.3 degrees cooler than was in the previous visit in January 2013 and the flow has decreased.

Table 1: Data from the Matapan Road Spring at Atiamuri

	Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
Geothermal Spring	24 Jan 2013	69.0	7-8	~ 5	-	-	Clear
Geothermal Spring	05 Feb 2014	62.7	6-7	2-3	-	-	Clear
Cool Spring	24 Jan 2013	16.6	5	seep	-	-	Clear
Cool Spring	05 Feb 2014	17.9	5	seep	-	-	Clear
Combined Stream	24 Jan 2013	42.7	7	~ 5	-	-	Clear
Combined Stream	05 Feb 2014	41.2	5-6	2-3	-	-	Clear

Figure 1: Matapan Road geothermal spring at Atiamuri taken in Feb 2014

Figure 2: Matapan Road geothermal spring at Atiamuri taken in Jan 2013 (A) and Feb 2014 (B)

2.2 Whangapoa Pools

- **Northern Pool**
  E1866461 N5749568 ±3 m; Located number 72.3004

  The geothermal pool itself cannot be accessed easily; therefore the measurements are taken from near the outflow.

  The pool did not appear to be surging in February 2014. The colour has changed from being a cloudy green-blue in January 2013 to a cloudy green in February 2014. The temperature has also decreased by 2.3 °C.

Table 2: Data from the Northern Pool at Whangapoa Pools, Atiamuri

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
24 Jan 2013	66	7	0.5	Overflowing	Upwelling near outlet	Cloudy, blue-green
05 Feb 2014	63.7	7	<0.5	Overflowing	Upwelling near outlet	Cloudy, green

Figure 3: Northern Whangapoa Pool in Jan 2013 (A), Feb 2014(B), Atiamuri

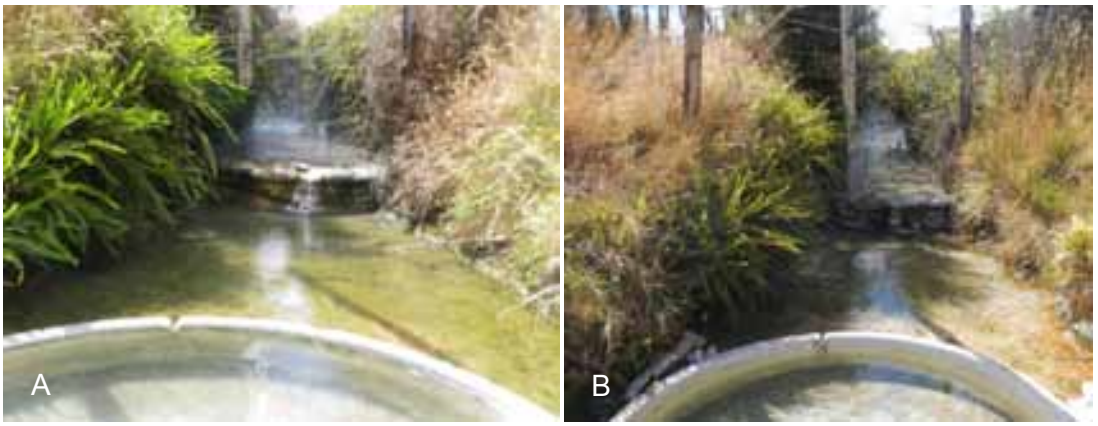


Figure 4: Northern Whangapoa Pool outlet, Jan 2013 (A), Feb 2014 (B), Atiamuri

The infrared photo shows that the heat is centralised in the pool. The cooler areas in the foreground depict the vegetation in the photo.

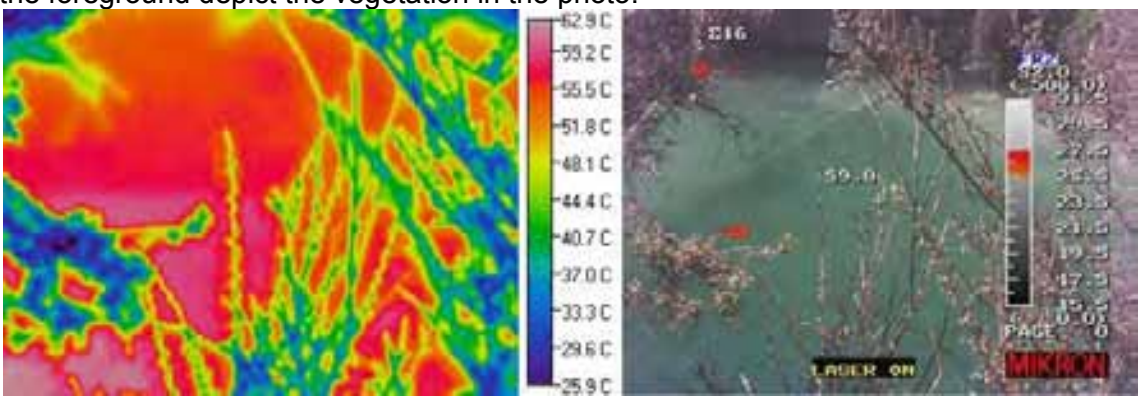


Figure 5: Infrared photo of Northern Whangapoa Pool Atiamuri

- **Southern Pool**
  E1866476 N5749517 ±7 m; Located number 72.4387

  The pool is fenced. Historically, a channel has been cut from the pool as an outlet to the apron. This appears to be healing over as the sinter is growing. It has a sinter apron extending about 40 m from the pool outlet.

  The flow has decreased from <1 l/s to <0.5 l/s since the previous monitoring visit in January 2013, and the temperature has also decreased by 1.9 °C. The pool was not flowing out of the side channel. The overflow was blocked and the water was flowing around the blockage.

Table 3: Data from the Southern Pool, Whangapoa Pools, Atiamuri

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
24 Jan 2013	65.7	8	<1	Overflowing	Constant upwelling in centre	Clear, blue-green
05 Feb 2014	63.8	7-8	<0.5	Overflowing	Upwelling in centre	Clear, turquoise

Figure 6: Southern Pool, Whangapoa Pools in Jan 2013 (A), Feb 2014 (B), Atiamuri

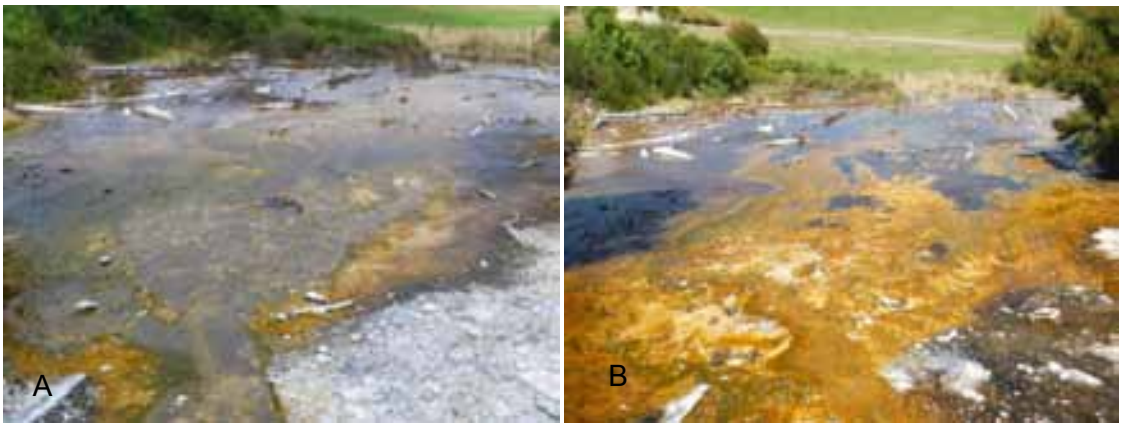


Figure 7: Sinter apron, Southern Whangapoa Pool, Jan 2013 (A), Feb 2013 (B), Atiamuri

Figure 8: Outlet, Southern Whangapoa Pool, Jan 2013 (A), Feb 2014, Atiamuri

The warmest part of the pool appears to be in the centre and foreground. The sinter along the edge under the water is heated.

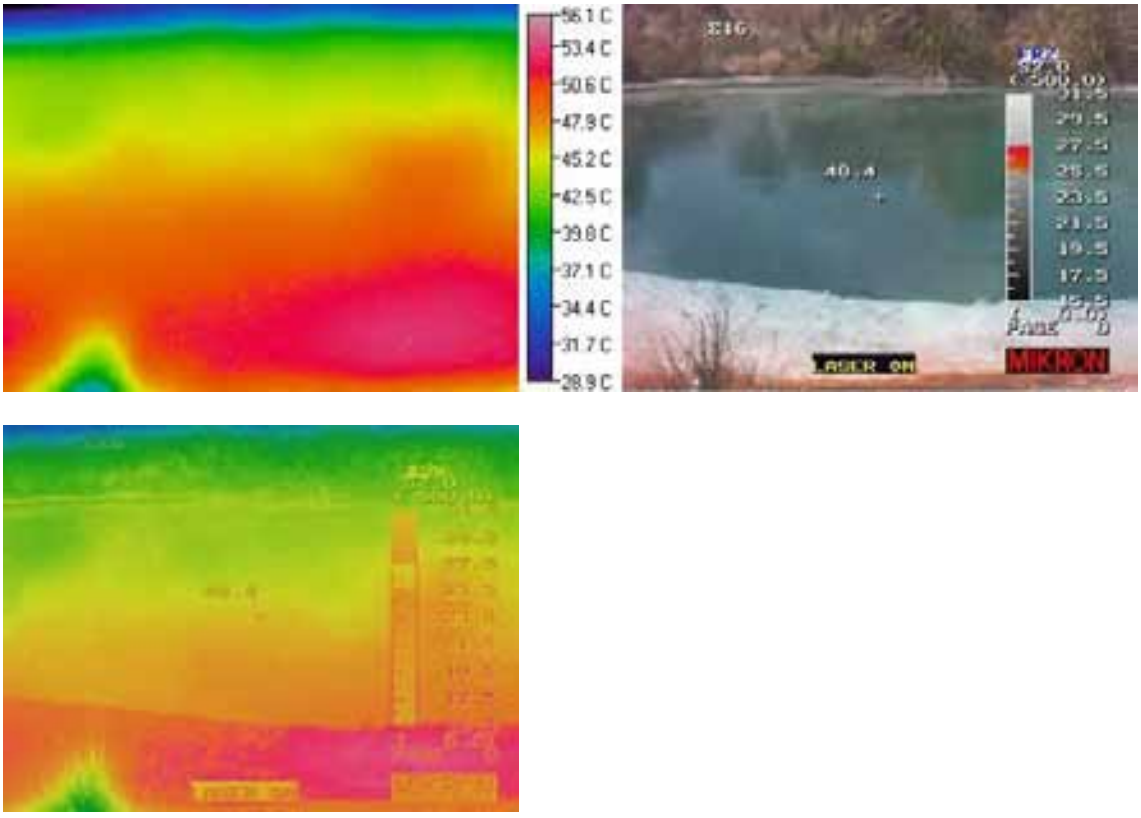


Figure 9: Infrared photos of Southern Whangapoa Pool, Atiamuri

- **Two small mud pools off Ohakuri Road**
  E1866296 N5749797

  These are two small mud pools, which are fenced off. The mud pools could not be seen due to the vegetation growth. There was audible bubbling from the western pool; nothing could be heard from the eastern pool. The temperature reading was taken using the IR gun, which may have resulted in a lower temperature being recorded due to the vegetation covering the pools.

Table 4: Data from the two small mud pools off Ohakuri Road, Atiamuri

Date	Pool	T(°C)	pH	Flow (l/s)	Water level	Diameter (m)	Depth (m)	Ebullition	Colour
24 Jan 2013	West	97	6	-	0.8 m below ground level	-	nd	Constant gas discharge	Brown
05 Feb 2014	West	44.6	-	-	-	-	-	Audible bubbling	-
24 Jan 2013	East	96	-	-	Dry	-	nd	-	Brown mud
05 Feb 2014	East	32.9	-	-	-	-	-	-	-

Figure 10: Mud pools off Ohakuri Rd, Jan 2013 (A); Feb 2014 (B), Atiamuri

- **Berg's Crater**
  E1866162 N5749496

This feature has been filled with logs. During the January 2013 visit, it was noted that the feature was warm. It reached a temperature of 50 °C in the centre of the crater. During the February 2014 visit, the temperature was reading 27 °C in the centre of the crater. The ground outside of the fence appears to be subsiding, and the crater may be sinking.

Figure 11: Berg's Crater, Jan 2013 (A); Feb 2014 (B), Atiamuri

3 Golden Springs

3.1 Pools in stream through the Golden Springs Motel

- **North Pool**
  E1888743 N5736981

There were no evident changes and no bathers at 15:25.

Table 5: Data from the North Pool, Golden Springs Motel

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	40.2	7-8	~20	Overflowing	-	Green/grey, cloudy
04 Feb 2014	40.2	7-8	~20	Overflowing	-	Green, cloudy

Figure 12: North Pool, Golden Springs Motel in Jan 2013 (A), Feb 2014 (B)

The infrared photos show that the hottest part of the pool appears to be where it flows over the weir. This could be due to the infrared camera only showing the surface temperature, which is cooler than within the pool due to its exposure to air. The water going over the waterfall includes the deeper warmer water mixed with the cooler surface water, so it appears hotter than the surface water above and below the waterfall.

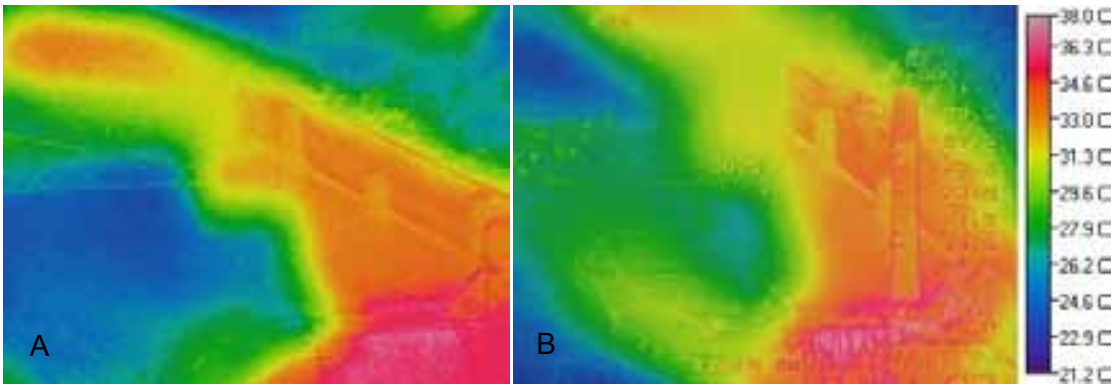


Figure 13 Infrared photos of North Pool in Jan 2013 (A) and Feb 2014 (B), Golden Springs Motel

- **South Pool**
  E1888678 N5736842

There were no bathers at 15:20 and no discernible changes.

Table 6: Data from the South Pool, Golden Springs Motel

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	37.5	7	30	Overflowing	-	Green/grey, cloudy
04 Feb 2014	38.0	7-8	30-40	Overflowing	-	Green, cloudy

Figure 14: South Pool, Golden Springs Motel in Jan 2013(A), Feb 2014 (B)

The infrared photo shows that the hottest area of the pool is in the vicinity of the waterfall. This reason for this is the same as for the North Pool.

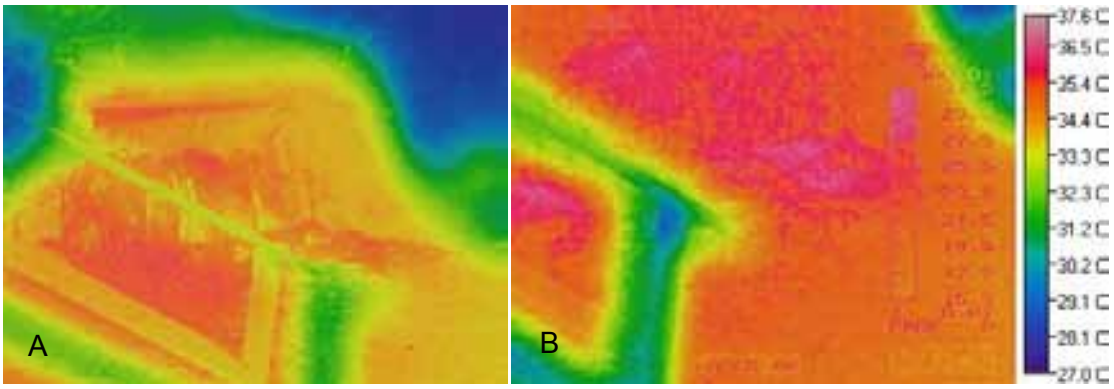


Figure 15: Infrared photos of South Pool in Jan 2013 (A) and Feb 2014 (B), Golden Springs Motel

3.2 Pools across the road from the Golden Springs Motel

- **Feature 3**
  E1888846 N5737375

There ph has dropped from pH 7 to pH 6. There are algal mats around the edges of the pool. The colour has changed slightly.

Table 7: Data from Feature 3, Golden Springs

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	42.6	7	nd	nd	Effervescing	Murky, green
04 Feb 2014	41.8	6	nd	nd	Effervescing	Cloudy, green

Figure 16: Feature 3, Golden Springs in Jan 2013 (A), Feb 2014 (B)

The infrared image below shows that the temperature of the pool is reasonably consistent, cooling down as it nears the edge. This is show in both January 2013 and February 2014; however the former is distorted slightly by the vegetation in front of it.

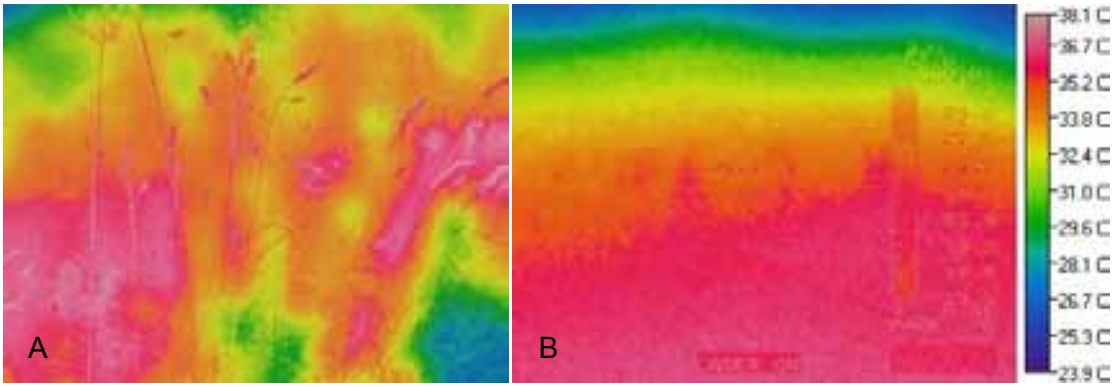


Figure 17: Infrared photo of Feature 3, Golden Springs in Jan 2013 (A) and Feb 2014 (B)

- **Feature 4**
  E1888827 N5737465

The feature was covered in algal mats and the colour of the water has changed from a light grey in January 2013 to green/grey in January 2014.

Table 8: Data from Feature 4, Golden Springs

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	39.1	7	nd	nd	Calm	Clear, light grey
04 Feb 2014	41.0	6-7	Seep, just flowing	nd	Calm	Murky, green/grey

Figure 18: Feature 4, Golden Springs in Jan 2012 (A), Feb 2014 (B)

4 Horohoro

4.1 Waipupumahana Pool

1878253E 5761598N; Located number 72.3006

The flow has increased since the previous visit in January 2013. A new outflow has been created, lowering the pool water level. The original outflow has been blocked off. Orange algae grow on the pool bed.

Table 9: Data from Waipupumahana Pool, Horohoro

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
24 Jan 2013	50.4	7-8	± 0.5	Overflowing	Upwelling	Clear, green
05 Feb 2014	51.7	7-8	0.5 – 1	Overflowing	Upwelling	Clear, green

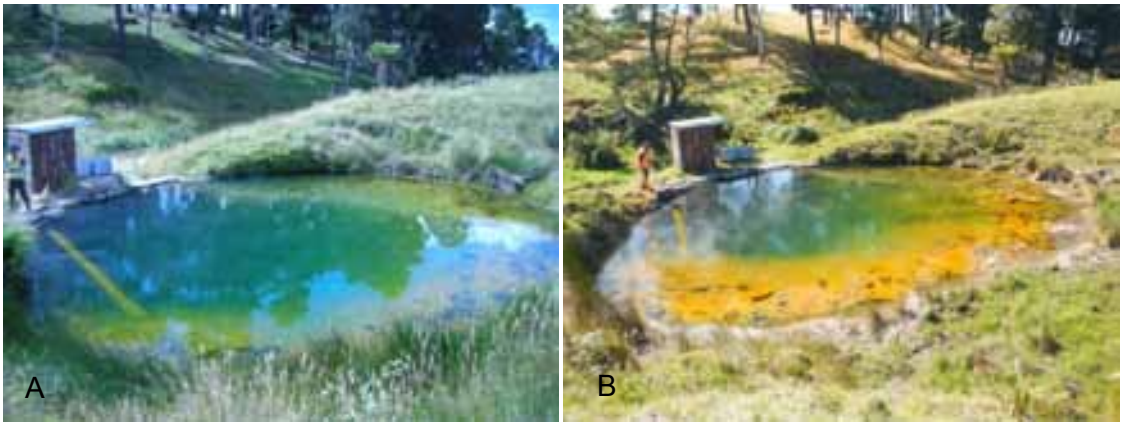


Figure 19: Waipupumahana Pool, Horohoro in Jan 2013 (A), Jan 2014 (B)

Figure 20: Old (A&B) and New (C&D) outlets, Waipupumahana Pool, Horohoro

The pool appears to be warmer in the foreground, this was apparent from both visits in January 2013 and February 2014.

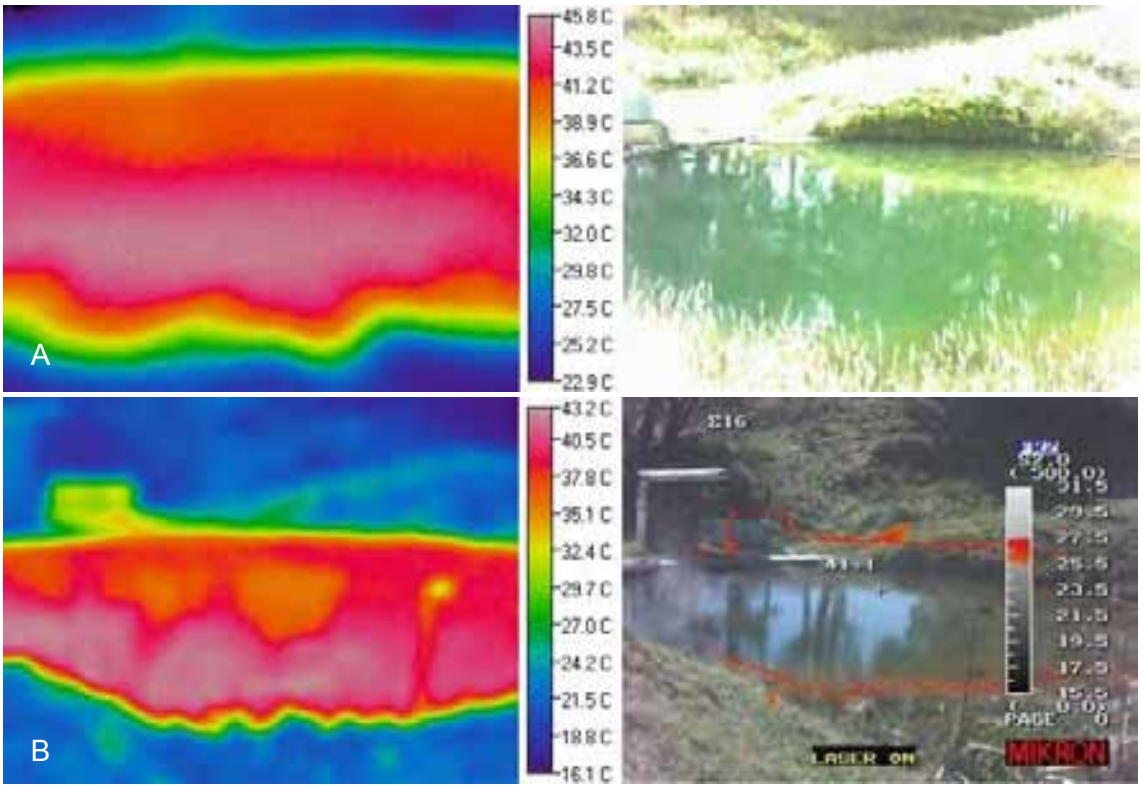


Figure 21: Infrared photos, Waipupumahana Pool, Horohoro in Jan 2013 (A) and Feb 2014 (B)

5 Ngatamariki

5.1 Hydrothermal Eruption Crater

- **Large pool occupying the crater**
  E1876505 N5730230; Located number 72.2098

There was an eruption at this location in April 2005, with a large amount of sediment deposited in the area. There is a large pool within the hydrothermal eruption crater, with a small mud pool alongside it. There is a lot of steam coming from the far side of the pool. The extent of the yellow/green algae growing around the edges has been consistent at each visit throughout the year. The temperature remains relatively consistent, with the greatest difference of temperature being 4 °C. The level of the pool has fluctuated, with an initial ESG reading of 0.105 m in April 2013, to 0.102 m in January 2014. It was lower in June and September. The colour and clarity of the pool has been reasonably consistent throughout the year (see Table 10 for details). The vegetation on the sediment mound surrounding the crater is starting to grow. The January 2014 photos have been taken with the IR camera due to technical issues with the visual-range camera.

Table 10: Data from Ngatamariki Hydrothermal Eruption Crater Pool

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	49.8	6-7	2-3	Overflowing, ESG 0.105 m	Effervescing with a gas odour	Cloudy, pale green
26 June 2013	47.8	8	4-5	Overflowing, ESG 0.098 m	Constant small bubbles upwelling all over the pool	Green, cloudy. Visibility 0.5-1 m
26 Sept 2013	45.8	6	2-3	Overflowing, ESG 0.085 m	Intermittent in centre	Murky, green
28 Jan 2014	46.9	6	2-3	Overflowing, 0.102 m	Constant, small bubbles	Murky, green

Figure 22: Large Pool: Overview, Apr 2013 (A), June 2013 (B), Sept 2013 (C)

Figure 23: Large pool gas discharge, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

Figure 24: Steam at large pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

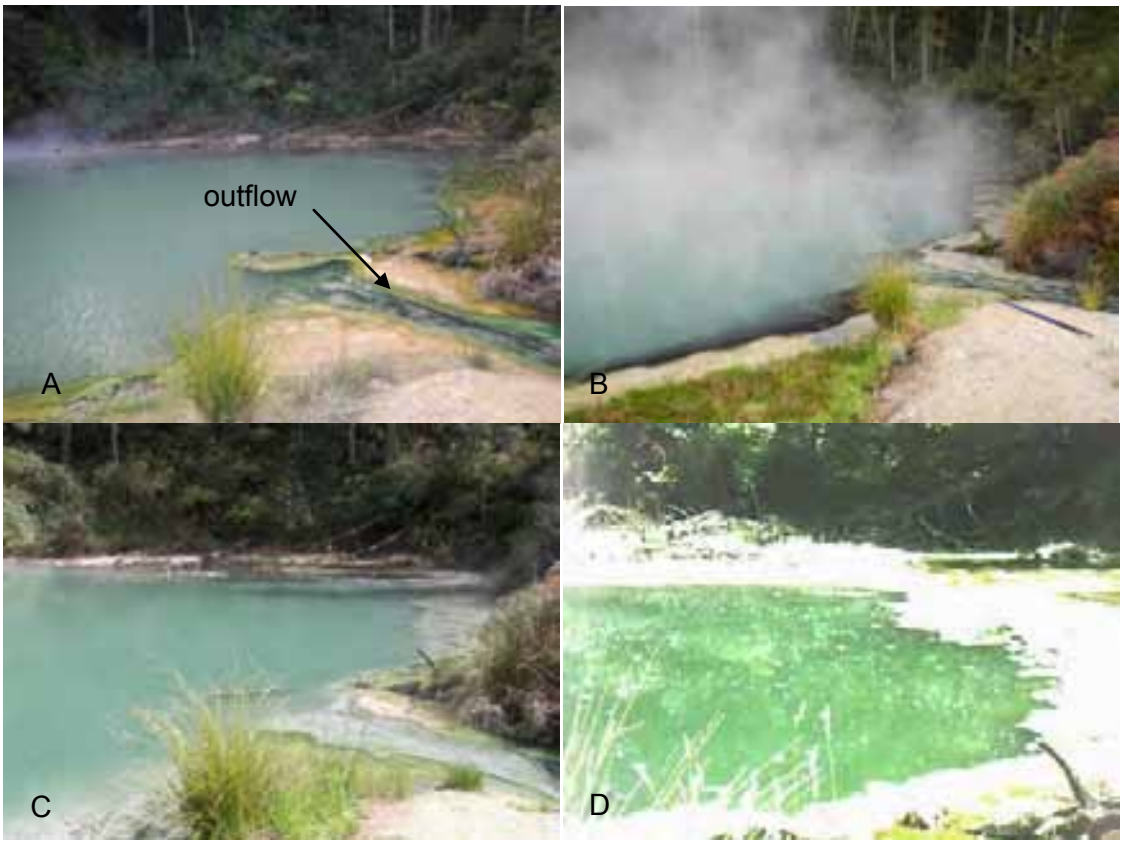


Figure 25: Large Pool outflow in Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos below show the heat concentrated in the steaming area at the back of the pool.

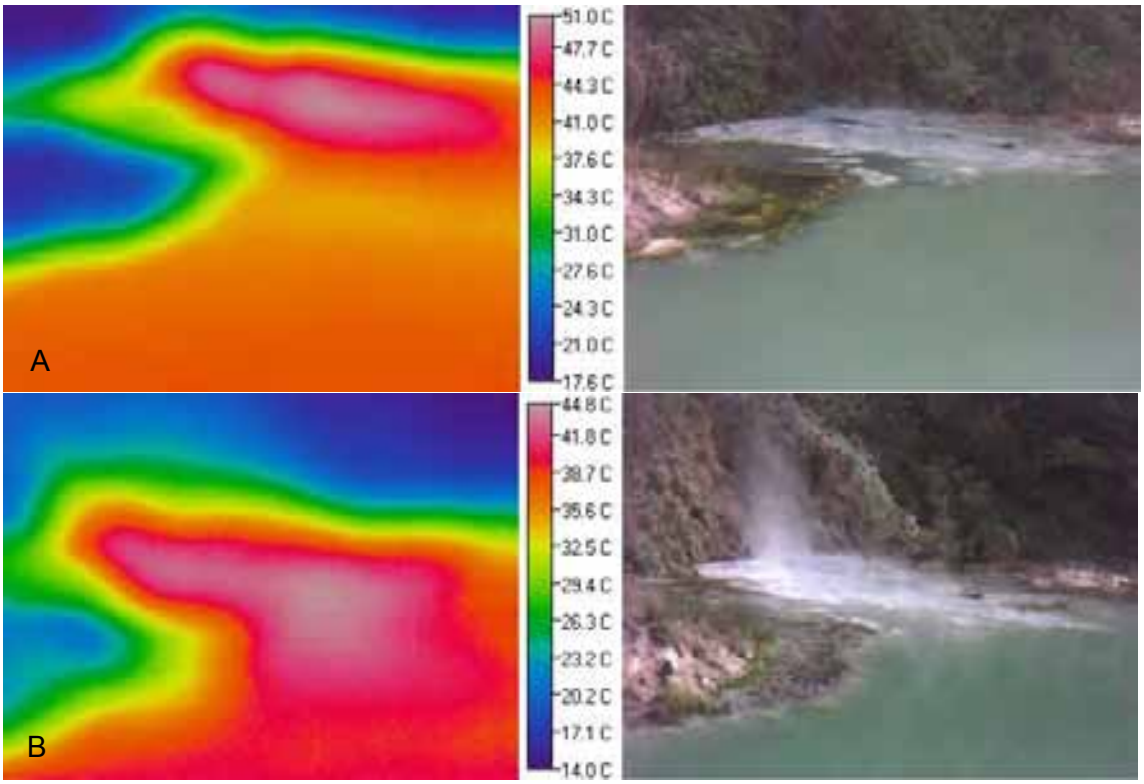


Figure 26: Infrared photos, Ngatamariki Hydrothermal Eruption Crater in Apr 2013 (A), Sept 2013 (B)

- **Mud pool beside large pool**

There is a log in the pool, which has been there for some time. Although the log is discoloured, there is no visual evidence of it rotting or being dissolved. The pool level has fluctuated over the year, and the temperature appears to be decreasing, from 57.3 °C in April 2013 to 40.6 °C in January 2014. The January 2014 photos have been taken with the IR camera due to technical issues.

Table 11: Data from Mud pool beside Ngatamariki Hydrothermal Eruption Crater Pool

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	57.3	3	nd	0.55 m below outflow	Effervescing	Murky blue/grey mud
26 June 2013	53.6	3	nd	0.75 m below outflow	Constant discharge	Grey mud and water
26 Sept 2013	38.7	3-4	nd	0.3 m below outflow	Constant discharge	Grey mud and water
28 Jan 2014	40.6	3	nd	0.75 m below outflow	Constant small discharge	Grey mud

Figure 27: Mud Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos show that the pool is hottest in the areas where ebullition is occurring.

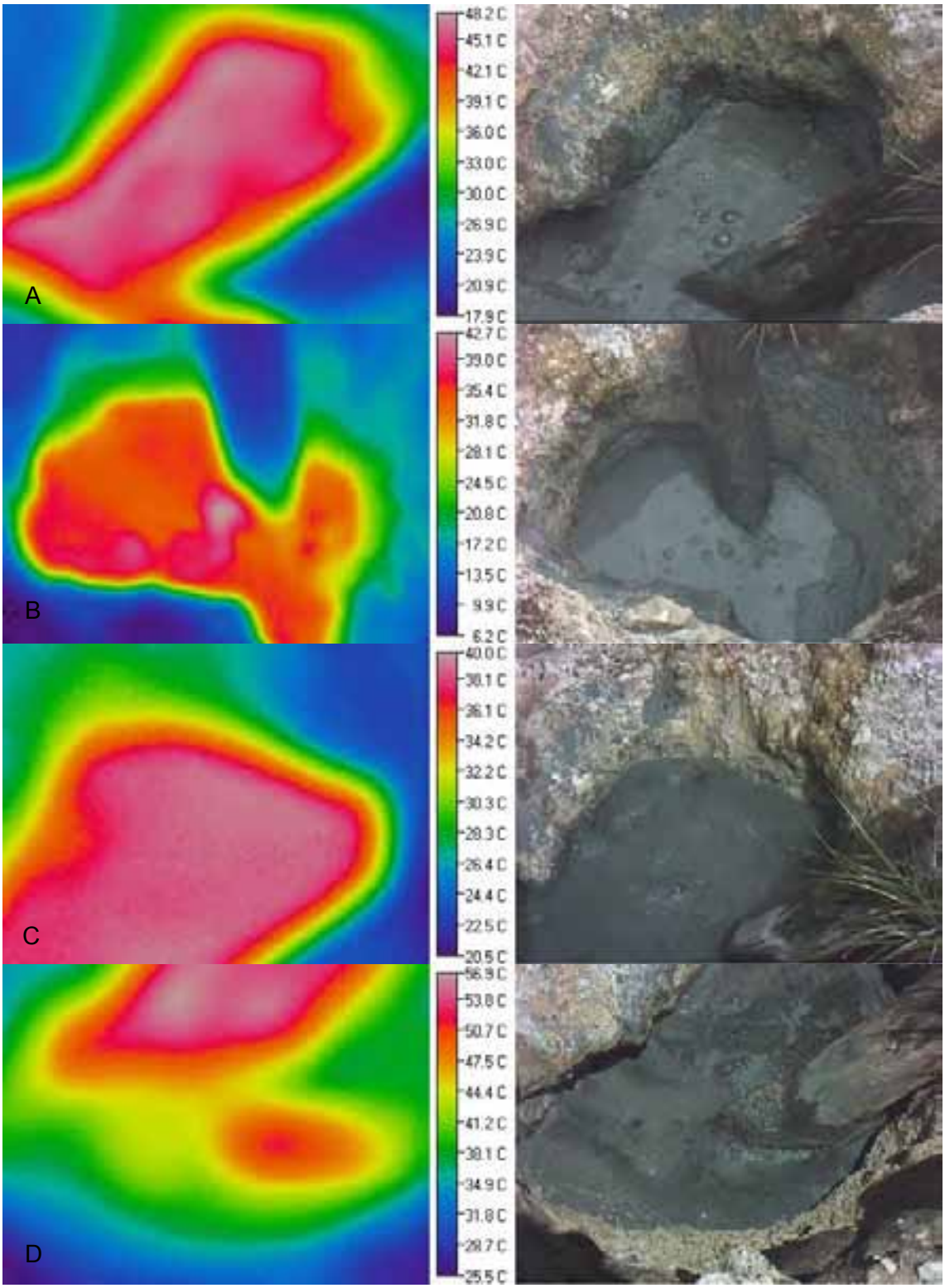


Figure 28: Infrared photos showing the mud pool, Ngatamariki in April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Northwest Pool**

This pool was not visited during the monitoring period.

- **Biodiversity Pool**

This pool is located amongst the trees to the right of the track leading to the hydrothermal eruption crater, just before the clearing. There were yellow algal mats on the pool at the time of the visits. The level of cover and colour fluctuated throughout the year. The temperature of the pool fluctuates, with a maximum difference of 9.7 °C over the four monitoring visits. The pH changes at each visit, with the lowest being pH 7-8 and the highest pH, 9. The January 2014 photos have been taken with the IR camera due to technical issues.

Table 12: Data from Biodiversity Pool, Ngatamariki

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	66.0	8	nd	nd	Constant discharge all over pool	Clear
26 June 2013	61.5	9	nd	nd	Constant discharge all over pool	Clear
26 Sept 2013	56.3	8-9	nd	nd	Constant discharge all over pool	Clear
28 Jan 2014	60.1	7-8	nd	nd	Constant	Clear

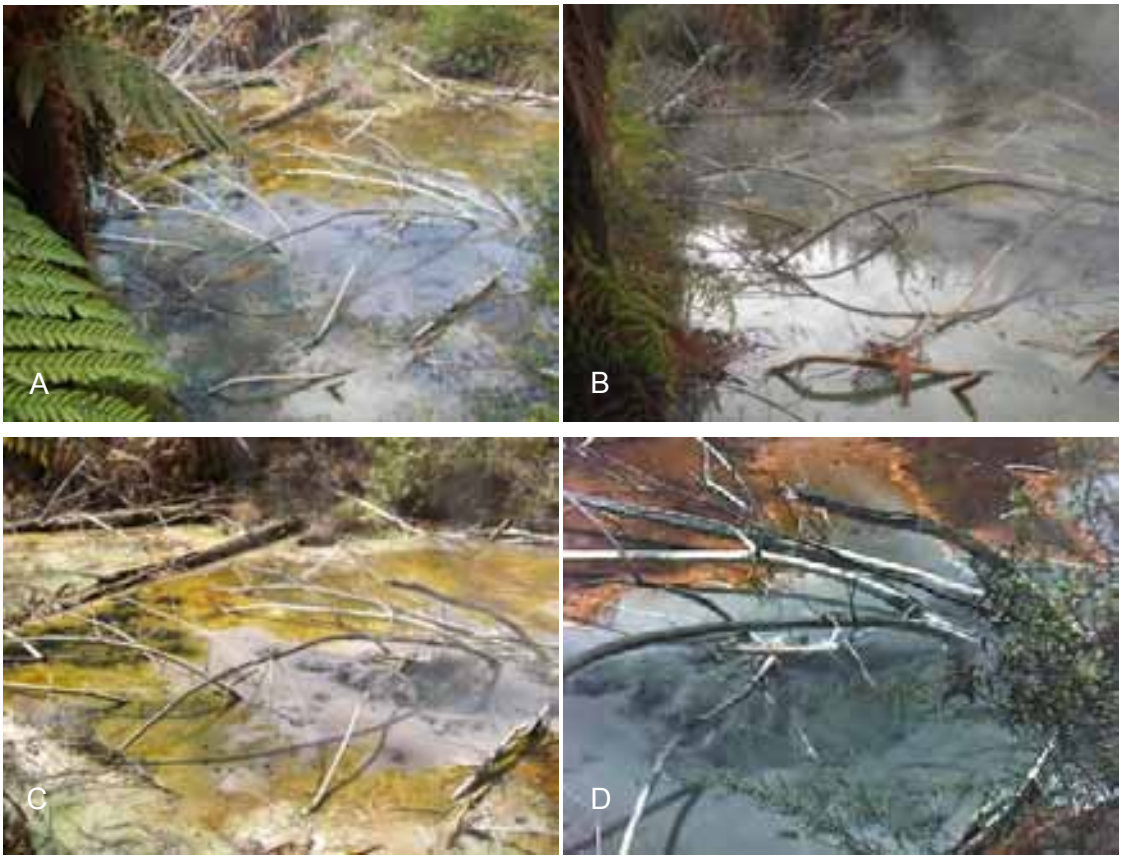


Figure 29: Biodiversity Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

The Infrared photos below show the area of heat emanating from the deeper zone of the pool where most of the ebullition is occurring.

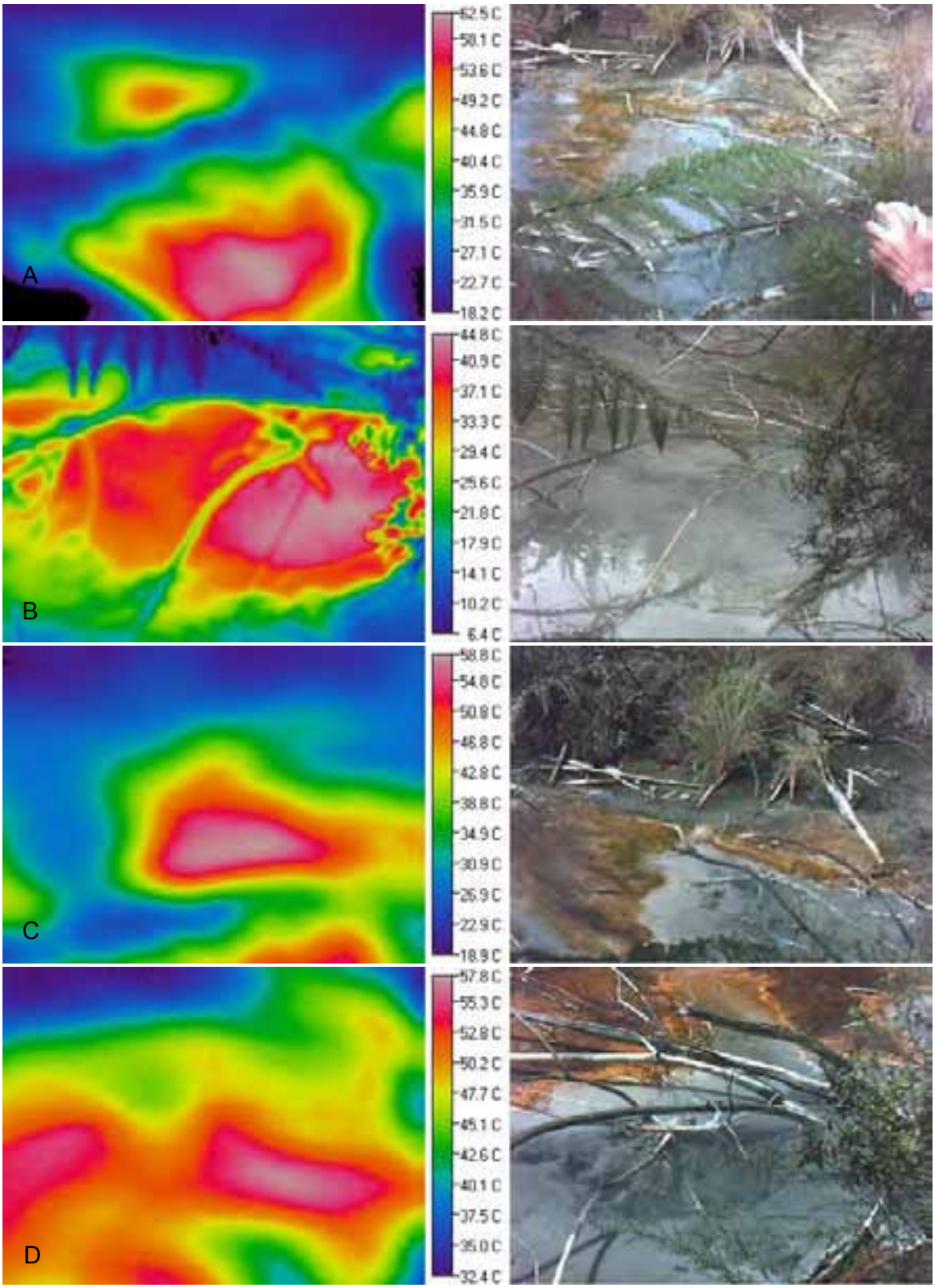


Figure 30: Infrared photos of the Biodiverity Pool, Ngatamariki in April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

6 Orakei Korako

6.1 Orakei Korako Springs

Located number 72.2107

- **Diamond Geyser**
  E1874515 N573694

Figure 31: Diamond Geyser, Apr 2013 (A), June 2013 (B), Sept 2013 (C)

The temperature has been consistent throughout the visits. The pH fluctuated between pH 6 and pH 7. The flow had increased from a seep in January 2014. The January 2014 photos have been taken with the IR camera due to technical issues.

Table 13: Data from the Diamond Geyser, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	87.4	6	Seep	Overflowing	Constant upwelling on far side of pool near outlet	Clear, blue
26 June 2013	87.4	7	Seep	Overflowing	Constant upwelling on far side of pool near the outlet	Clear, blue/grey
27 Sept 2013	86.8	7	Seep	Overflowing	Constant upwelling	Clear, blue
28 Jan 2014	87.1	6	<0.5	Overflowing	Constant upwelling near outlet	Clear, blue/grey

Figure 32: Diamond Geyser, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos below appear to show that the areas where the sinter is growing are quite hot compared to the surrounding surfaces. The warmest areas are near the outlet and along the Eastern side of the pool.

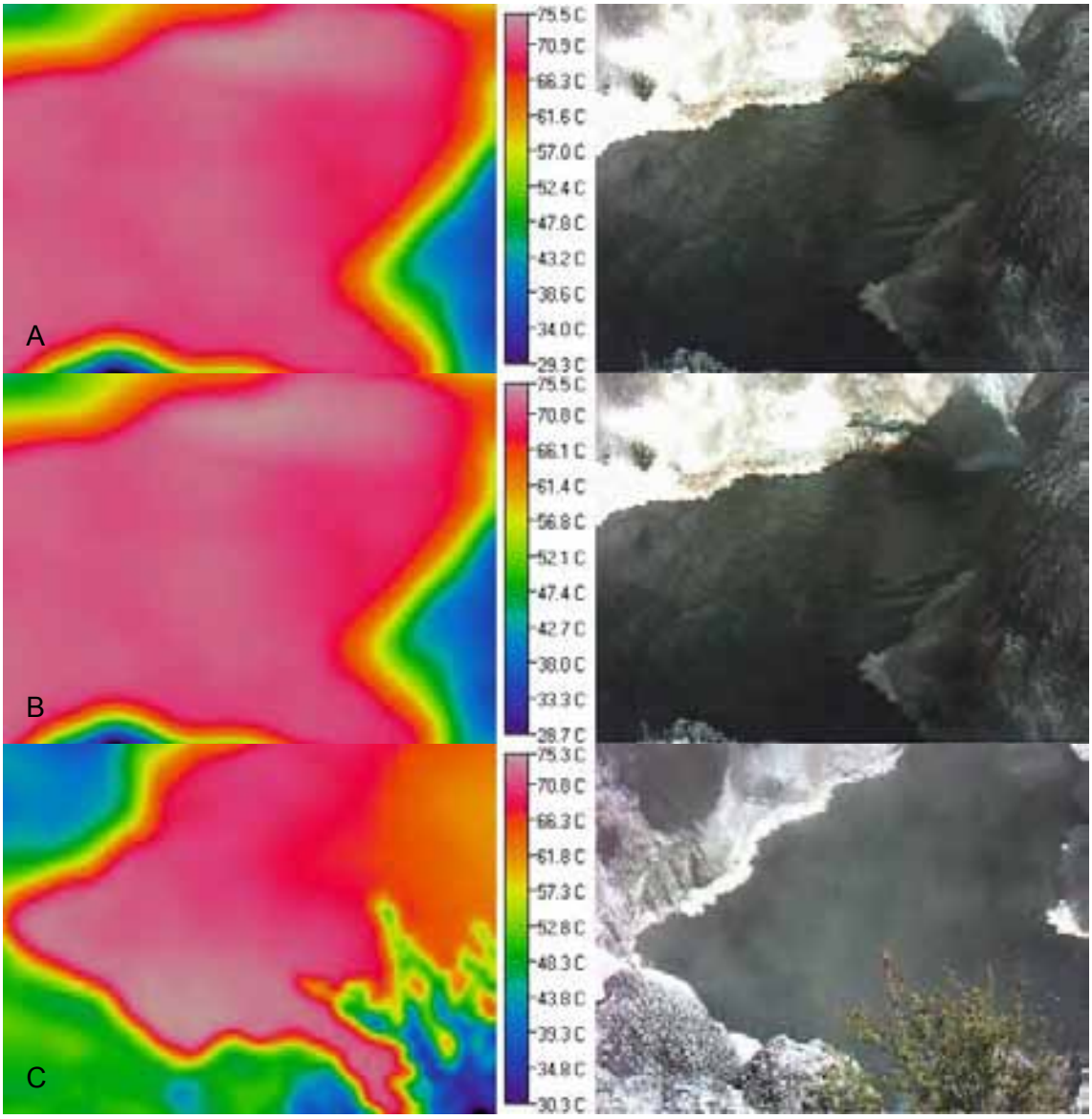


Figure 33: Infrared photos of the Diamond Geyser, Orakei Korako, Apr 2013 (A), Sept 2013 (B) and Jan 2014 (C)

A temperature data logger was placed on the side of the pool near the outlet of the Diamond Geyser to capture any temperature increases corresponding to an increased flow of an eruption. The data on the July 2013 show that there is an increase in activity

from approximately 10 am. The pool may have been surging this time. The data from September 2013 show a reasonably consistent temperature range; therefore it is assumed that there is less activity during this period.

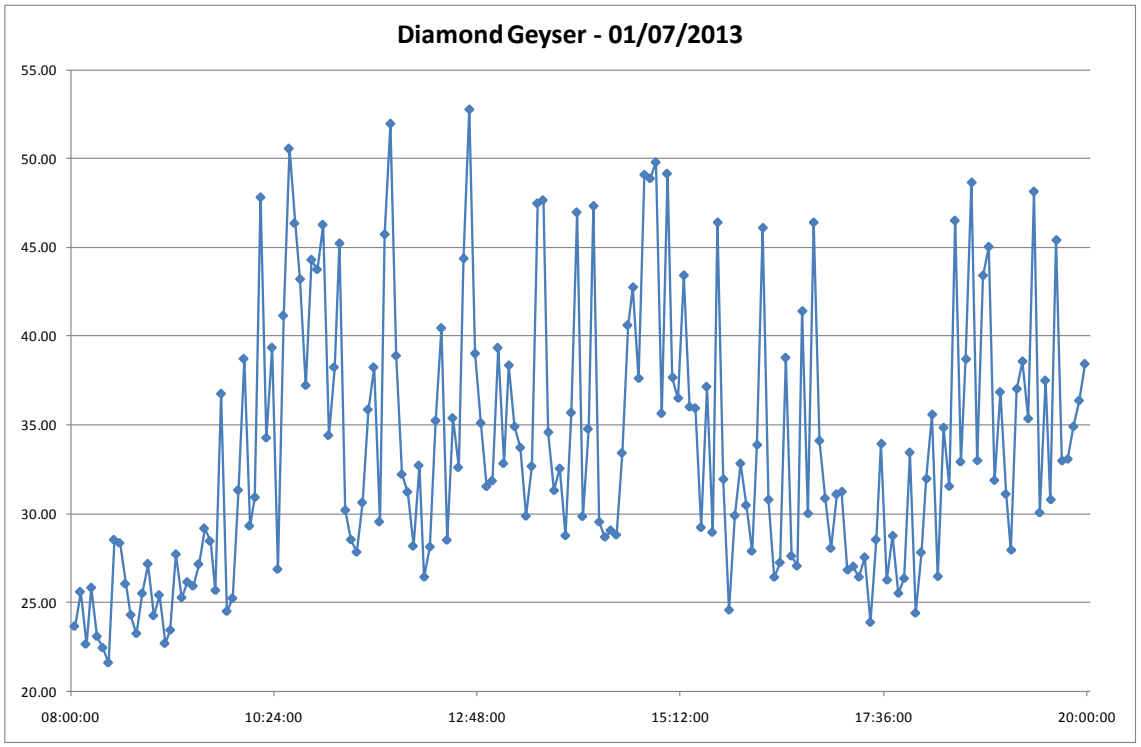


Figure 34: Temperature logger data from Diamond Geyser, 01 July 2013

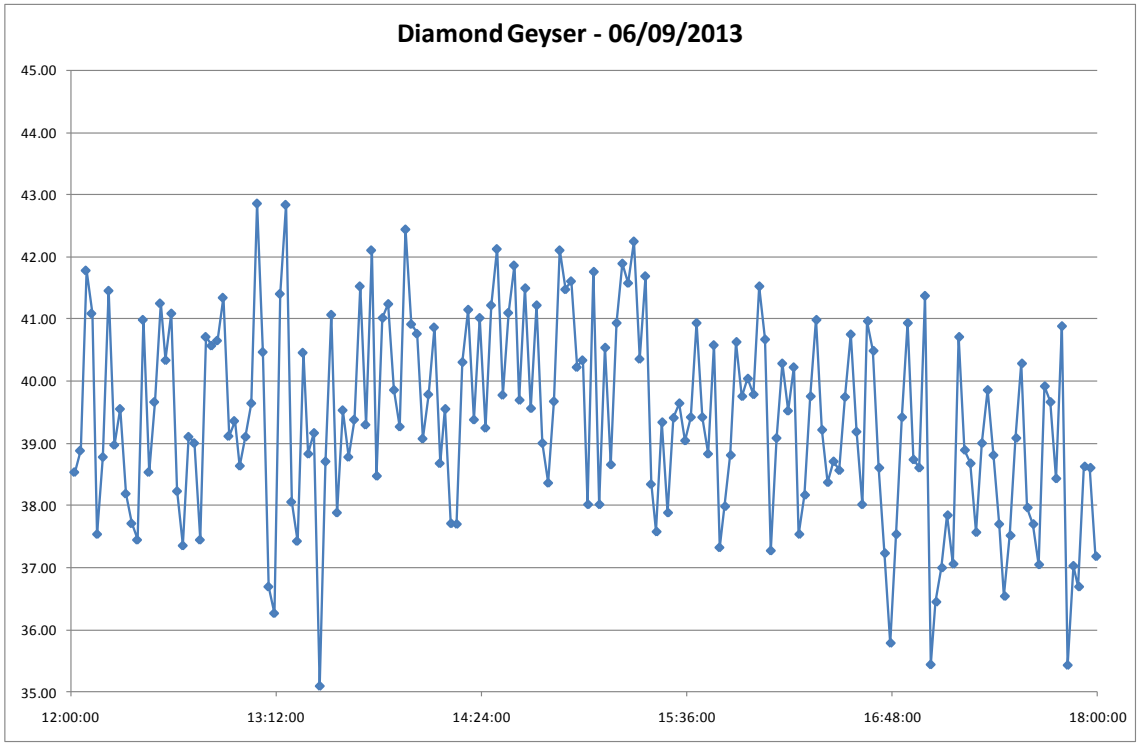


Figure 35: Temperature logger data from Diamond Geyser, 06 Sept 2013

- **Pool beside Diamond Geyser**

The temperature dropped slightly (1.4 °C) between April 2013 and January 2014. There were fluctuations in the colour and clarity of the water.

Table 14: Data from the pool beside the Diamond Geyser, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	84.5	5	Seep	Overflowing	Constant small discharge	Grey
26 June 2013	84.5	4	Seep	Overflowing	Constant upwelling	Murky, blue
27 Sept 2013	84.9	5	Seep	Overflowing	Constant upwelling	Cloudy, grey
28 Jan 2014	83.1	5	Seep	Overflowing	Constant small discharge	Murky, blue/grey

Figure 36: Pool beside Diamond, Apr 2013 (A), June 2013 (B), Sept 2013 (C) Jan 2014 (D)

The infrared photos in Figure 37 show that the hottest area of the pool appears to be at the front towards the outlet, although it heated throughout the pool. In Jan 2014 the hottest area is to the top left of the pool.

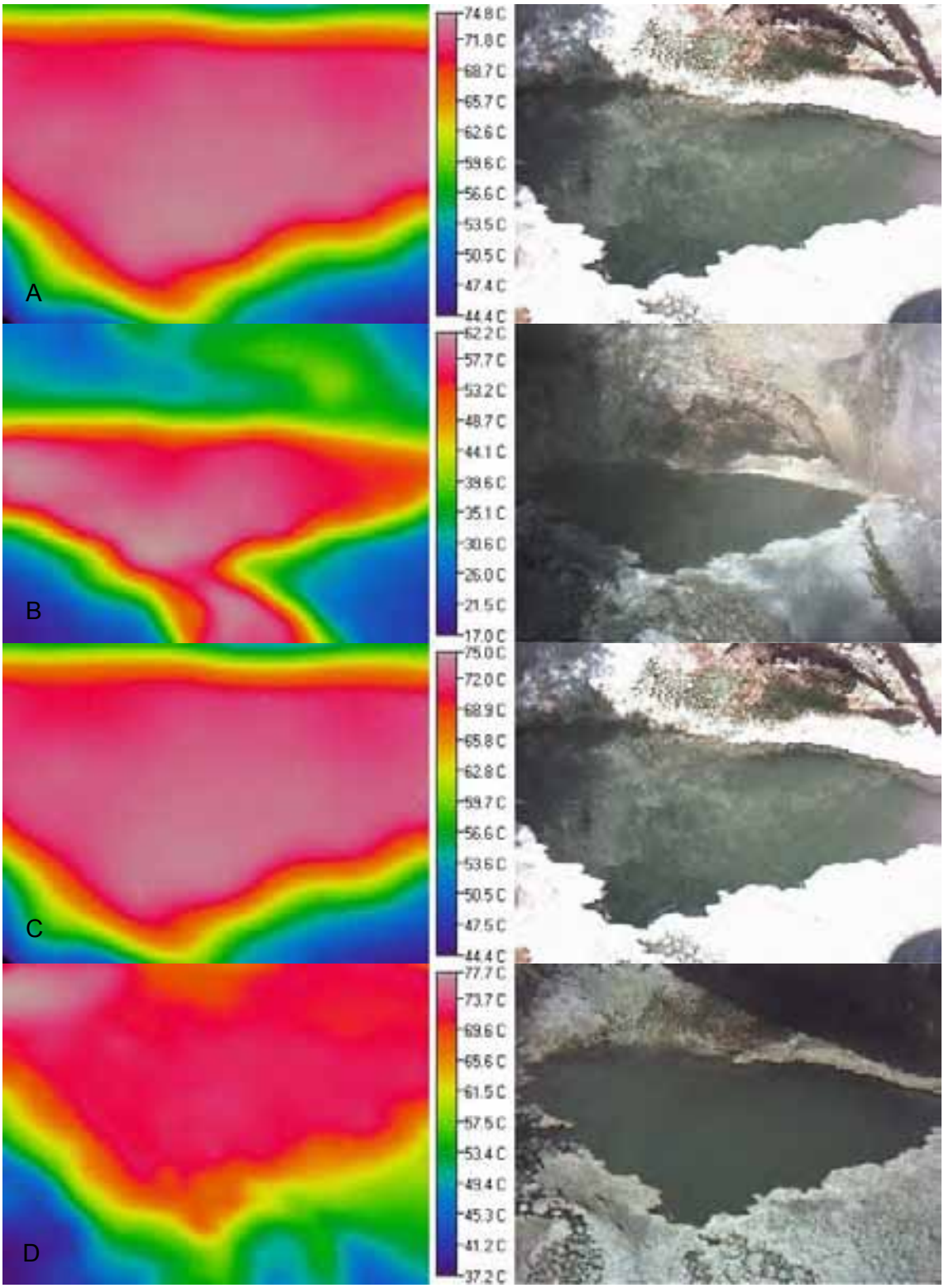


Figure 37: Infrared photos of the pool beside the Diamond Geyser, Orakei Korako in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

The small pool to the left of the diamond geyser appears to be increasing in size. In April 2013, the temperature reading was 65.4 °C and in June 2013 the temperature was 63.8 °C. There was a reading of pH 6 on both occasions. In January 2014, there was an increase in activity in the area to the left of the diamond geyser. A new geyser may have formed, as there was an abundance of steam and flow periodically pouring down the hill. The soil structure in the area has been degraded by either the flow from above or a new fumarole opening up. The area of increased activity is on the left of the small pool (depicted in Figure 38) and in the bushes. It was not possible to access it.

Figure 38: Small pool beside Diamond Geyser, Orakei Korako, April 2013 (A), June 2013 (B) and Sept 2013 (C)

In the infrared photo it appears that the hottest area of the pool is near the outlet, which is where the ebullition is most apparent.

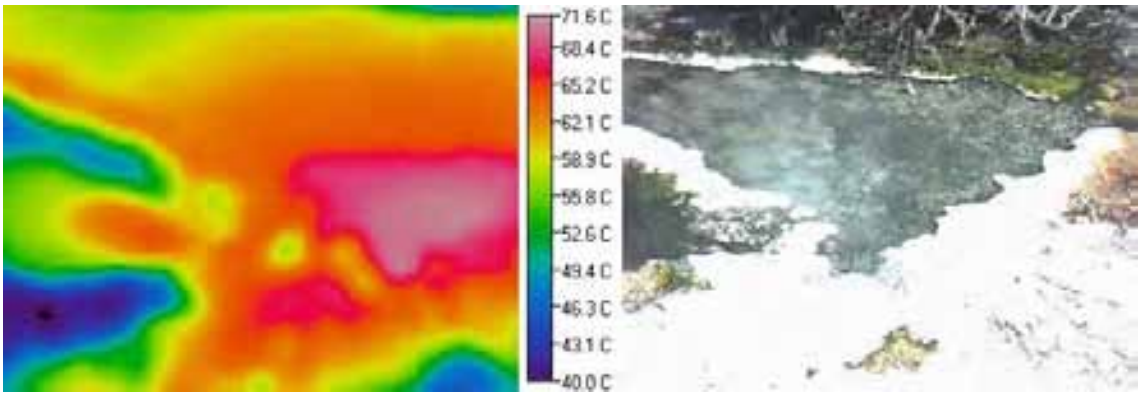


Figure 39: Infrared photo of small pool beside Diamond geyser, Orakei Korako, Jan 2014

- **Bush Geyser**

The January 2014 photos have been taken with the IR camera due to technical issues.

April 2013: A small amount of water was visible ~0.75 m below the surface before and after eruption. The pH was measured after the eruption and the reported temperature (Table 15) is from before the eruption. The temperature after the eruption was 93.6 ^{o}C. Fresh nodules were noted around the edge of the vent. The eruption occurred at 11:55, approximately five minutes after the Cascade Geyser erupted at 11:50.

June 2013: There was no water visible between eruptions; therefore, pH could not be tested. The Bush geyser erupted twice during our visit at 13:12 and 13:34, with intervals of two minutes and five minutes respectively. No changes are evident since the previous visit.

September 2013: The geyser erupted briefly twice at five- minute intervals at 09:28 and 09:33. The water level drops rapidly after an eruption.

January 2014: The geyser was erupting as we arrived at 13:35. The water level was 0.75 m below the rim after the eruption.

Table 15: Data from the Bush Geyser, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	88.8	9	-	Overflowing during eruption	Audible gas discharge before eruption	Clear
26 June 2013	89.8	nd	-	Overflowing during eruption	Geysering	Clear
27 Sept 2013	95.1	9	-	-	Geysering briefly	Clear
28 Jan 2014	98.5	8-9	-	Overflowing during eruption, 0.75 m below surface after eruption	Geysering	Clear

Figure 40: Bush Geyser, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos below were taking during a quiescent stage. The hottest area appears to be the vent on the right side of the geyser.

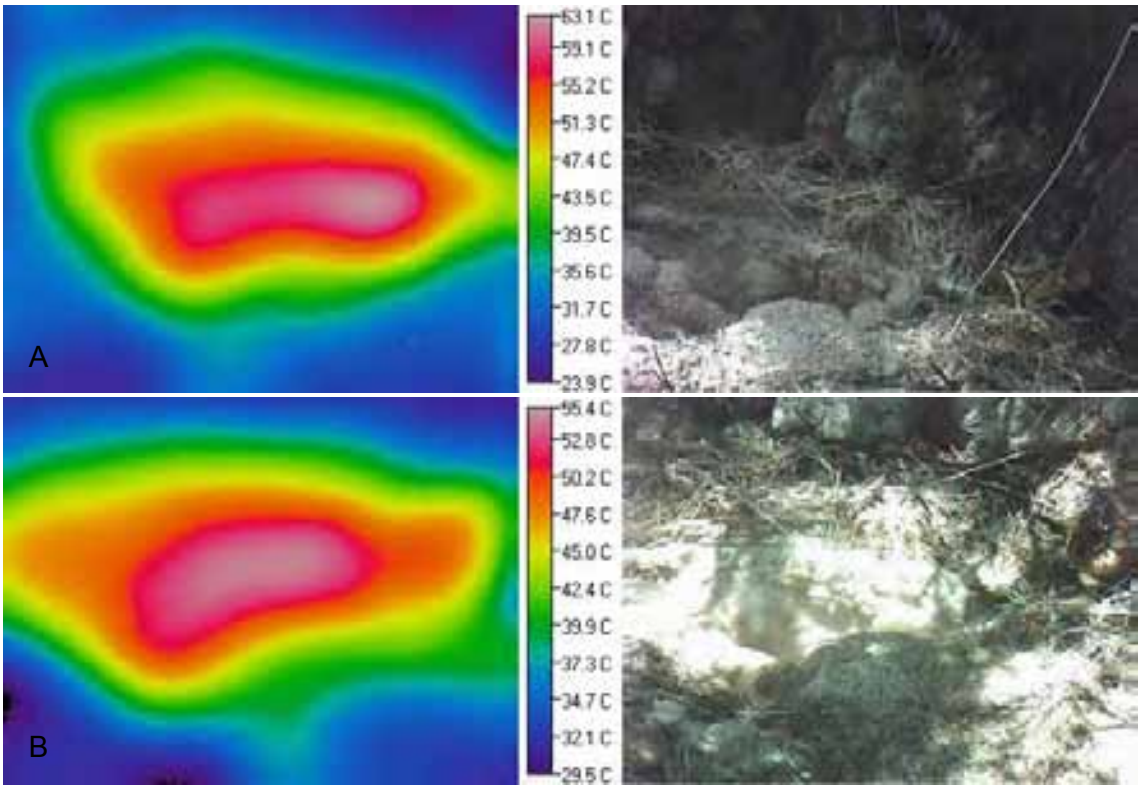


Figure 41: Infrared photos, Bush Geyser, Orakei Korako in Sept 2013 (A) and Jan 2014 (B)

Extracts of data loggers measuring temperature are shown in Figures 42 and 43. The data logger probe for the Bush geyser was inserted the vent, so that it would measure the change in temperature as the geyser erupted and the water level rose. The Cascade geyser probe was placed on the terrace below where the geyser erupts. The temperature increase is due to the water from the geyser flowing over the probe as an eruption occurs.

Both geysers are reasonably consistent with the sequence of eruptions during the six-hour period, however as seen in the graphs below this does change depending on the day.

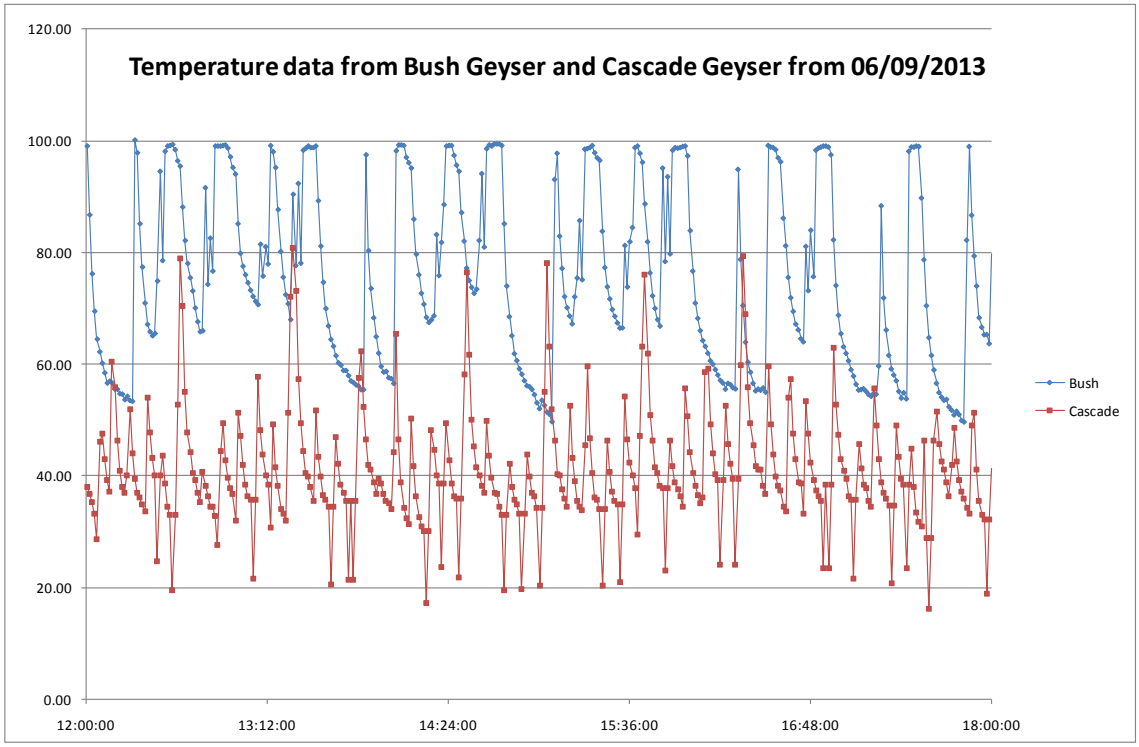


Figure 42: Temperature logger data from Bush and Cascade Geyser from 12:00 to 18:00 on 06 Sept 2013

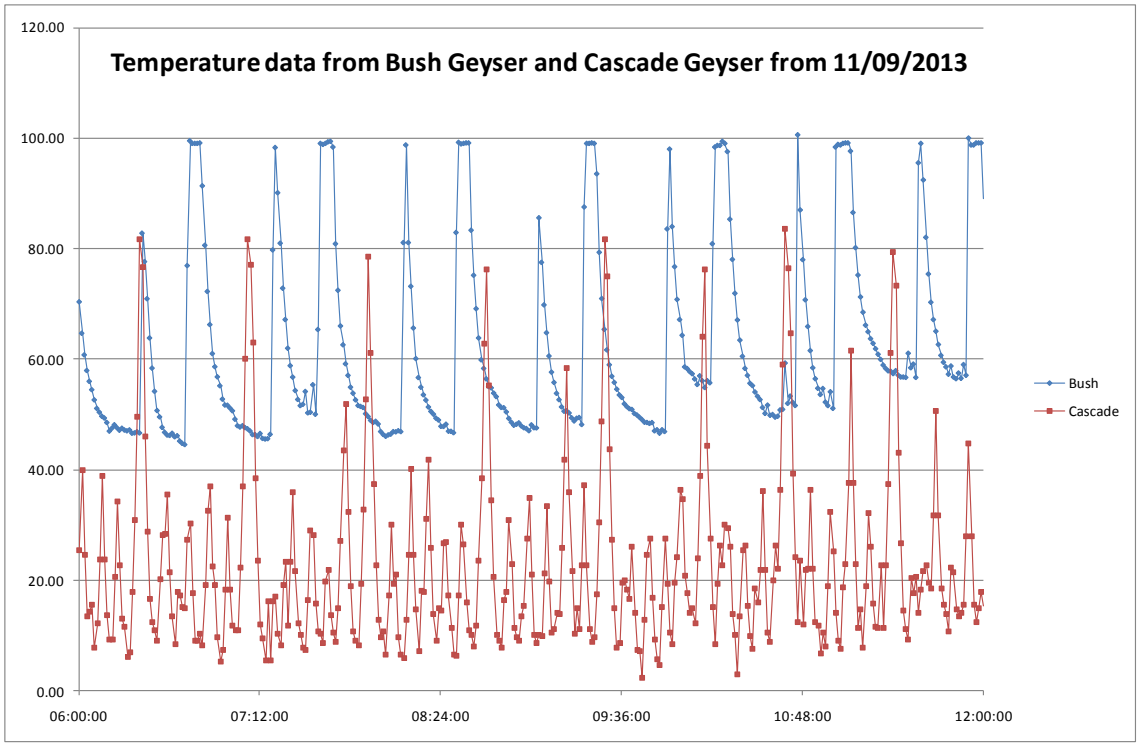


Figure 43: Temperature logger data from Bush and Cascade Geysers from 06:00 to 12:00 on 11 Sept 2013

- **Cascade Geyser**

The January 2014 photos have been taken with the IR camera due to technical issues.

April 2013: The geyser was seen to erupt three times during our visit (the 11:50 eruption noted in 3.1.2 was heard not seen), with an eruption length of one minute. Eruptions were notes at 11:59, 12:04 and 12:09. Eruption height was approximately 0.5 m.

June 2013: The Cascade Geyser erupted five times during our visit (with the first eruption at 13:09), with durations from fifty seconds through to three and a half minutes.

September 2013: Erupted once at 09:30 for three minutes.

Jan 2014: Erupted at 13:46 and 13:50 for one minute each.

Figure 44: Cascade Geyser, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos in Figure 45 were taken during an eruption, and show the flow path of the water during an eruption. There are also a couple of hot spots to the right of the geyser.

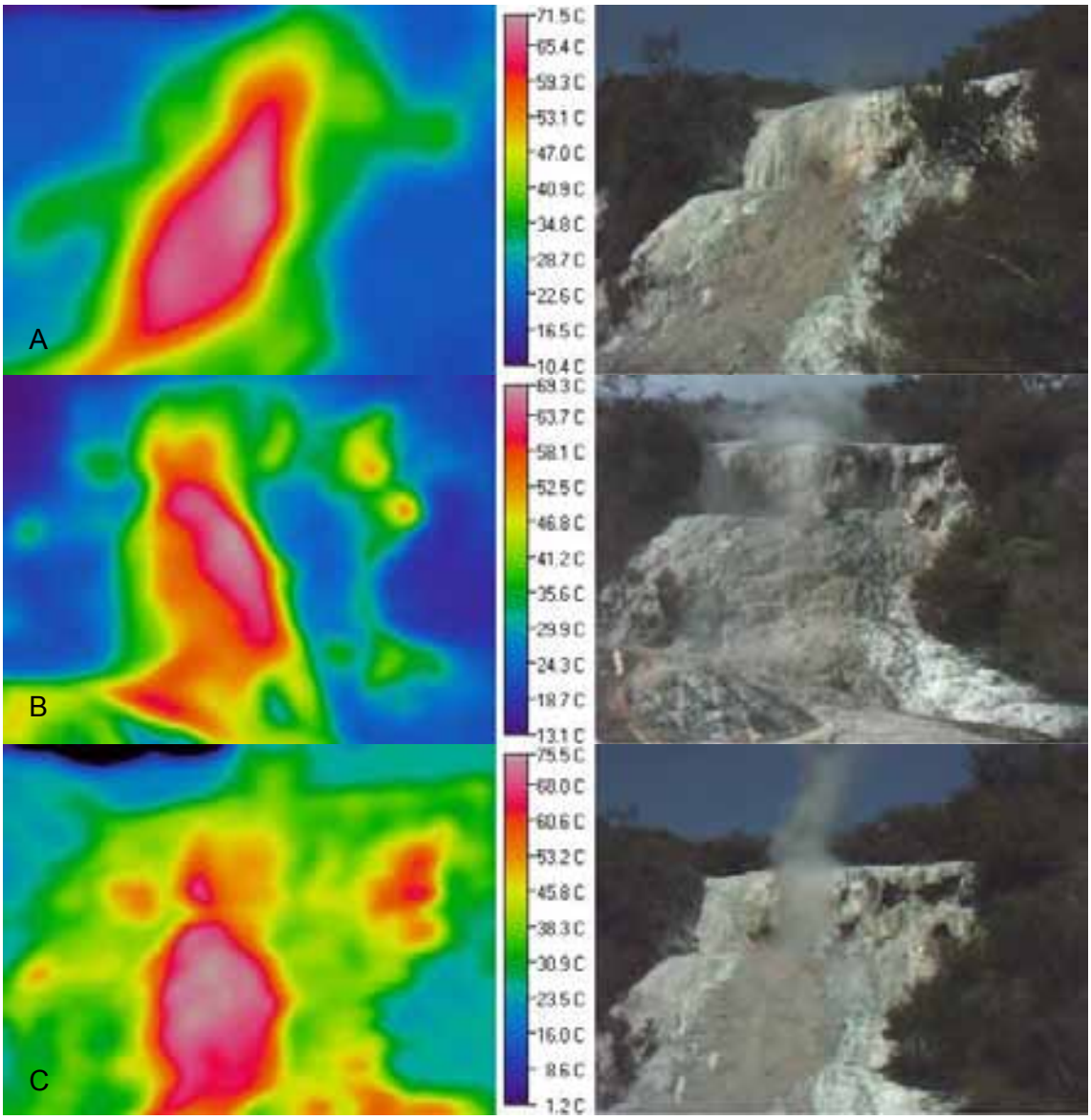


Figure 45: Infrered photos, Cascade Geyser at Orakei Korako during an eruption, April 2013 (A), Sept 2013 (B) and Jan 2014 (C)

- **Sapphire Geyser**

The January 2014 photos have been taken with the IR camera due to technical issues.

April 2013: The geyser erupted at 12:02, but only steam was visible from the viewing platform.

June 2013: Erupted at 13:09 for 50 seconds, followed by four more eruptions ranging from 50 seconds to 3½ minutes.

September 2013: Erupted at 09:30 for 1 minute.

January 2014: Erupted at 13:44, 13:49, 13:54 and 13:58 for approximately 1 minute.

Figure 46: Sapphire Geyser, Orakei Korako in Sept 2013 (A) and Jan 2014 (B)

The heat from the sapphire geyser can be seen to the left of the Cascade geyser in the Infrared photo.

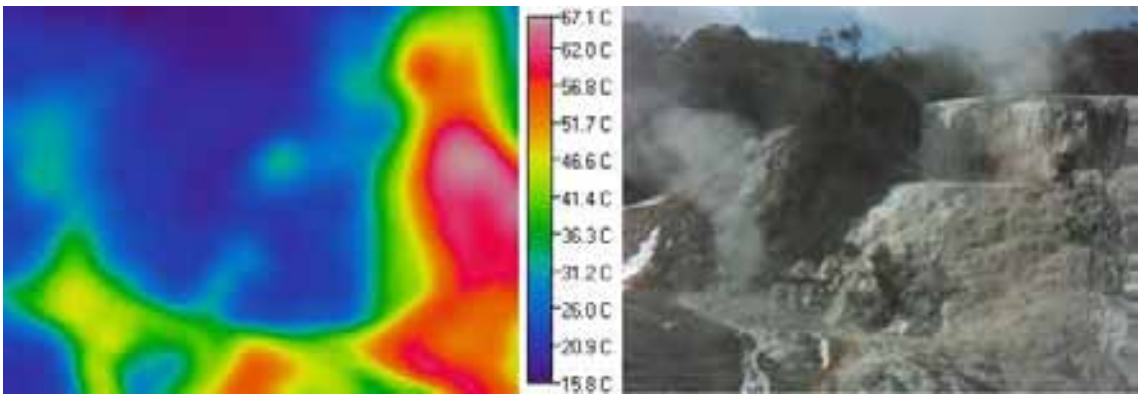


Figure 47: Infrared photo of Sapphire Geyser, Orakei Korako, Sept 2013

The temperature data logger was inserted inside the lip of the geyser vent, in order to catch the heat of the water as it erupts and splashes onto the probe. There does not appear to be a pattern or frequency to the events.

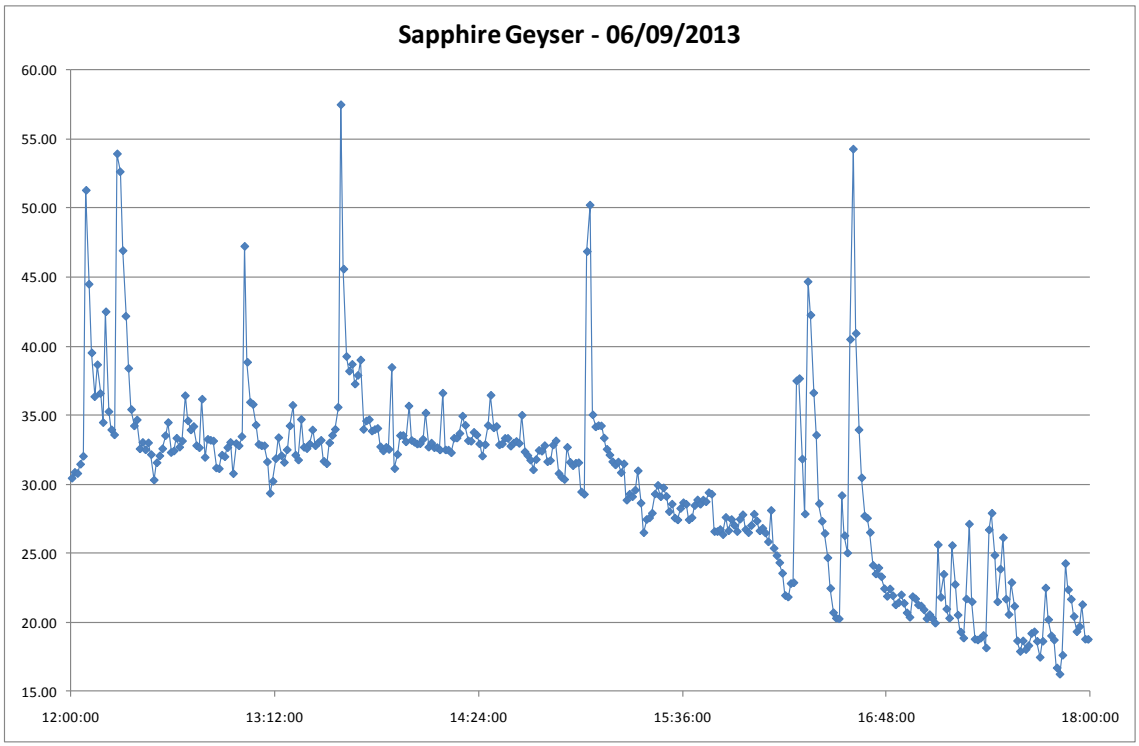


Figure 48: Temperature logger data from Sapphire Geyser on 06 Sept 2013

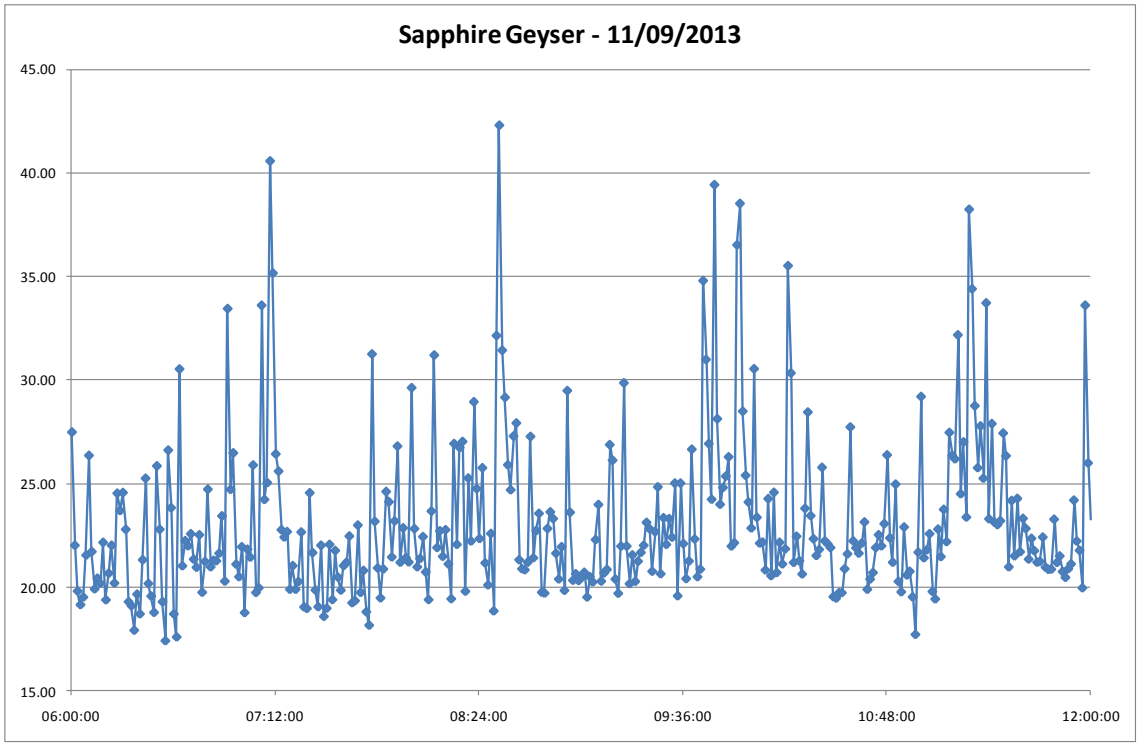


Figure 49: Temperature logger data from Sapphire Geysers on 11 Sept 2013

- **Map of Africa**
  E1874578 N5736954

The January 2014 photos have been taken with the IR camera due to technical issues.

Various coloured algal mats were observed on the water surface during all of the monitoring visits. The area that the mats cover tends to vary at each visit. There was a slight amount of bubbling noticeable during the September 2013 visit compared to the calm surface of the other visits. The pH seems to vary from pH 7 to pH 8. The pool could not be reached to obtain a pH result on the April 2013 visit. The temperature seems to vary between monitoring periods, with the lowest being 33.1 °C during the June 2013 visit and highest of 45 °C during the April 2013 visit.

Table 16: Data from the Map of Africa Pool, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	35-45	-	0.5	nd	Calm	Blue/green
26 June 2013	33.1	8	Seep	Overflowing	Calm	Clear
27 Sept 2013	41.5	7	Seep	Overflowing	Calm with some small bubbles	Clear, dark green
28 Jan 2014	43.2	8	Seep	Overflowing	Calm	Clear, green

The Map of Africa has a relatively low temperature; however, there is an area of increased temperature originating at the base of the cliffs next to the Map of Africa. This can be seen in the Infrared photos in Figure 51.

Figure 50: Map of Africa, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

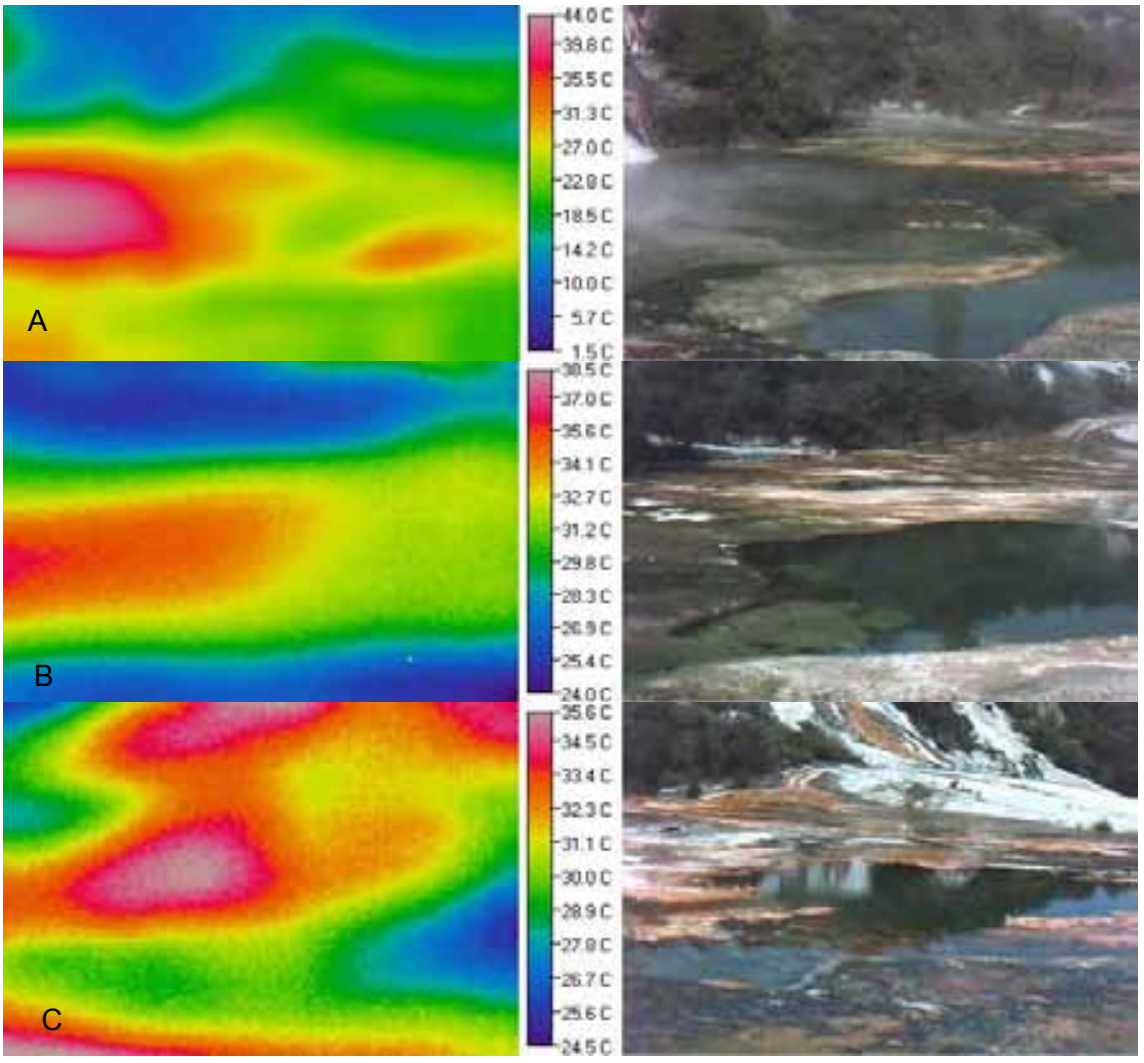


Figure 51: Infrared photos, Map of Africa, Apr 2013 (A), Sept 2013 (B) and Jan 2014 (C)

- **Devil's Throat**
  E1874599 N5736996

The vent appeared to be surging with constant bubbling during the all of the monitoring visits. The bubbling becomes more vigorous as it surges, with the flow changing from <0.5 l/s up to 1 l/s when surging. The pH seems to vary from pH 6-7 to pH 8. The temperature had minor fluctuations.

September 2013: over 0.5 l/s when surging

Jan 2014: flow 0.2-0.5 before surging, 0.5-0.75 while surging

Table 17: Data from the Devil's Throat, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	97.4	7	~0.5	Overflowing	Surging	Clear
26 June 2013	97.4	8	~0.5	Overflowing	Surging	Clear
27 Sept 2013	96.5	6-7	<0.5	Overflowing	Surging	Clear
28 Jan 2014	97.6	6-7	<0.5	Overflowing	Surging	Clear

Figure 52: Devil's Throat, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

As can be seen from the infrared photo below, the hottest areas appear to be from the main surging vent, a small vent to the left the photo and the throat.

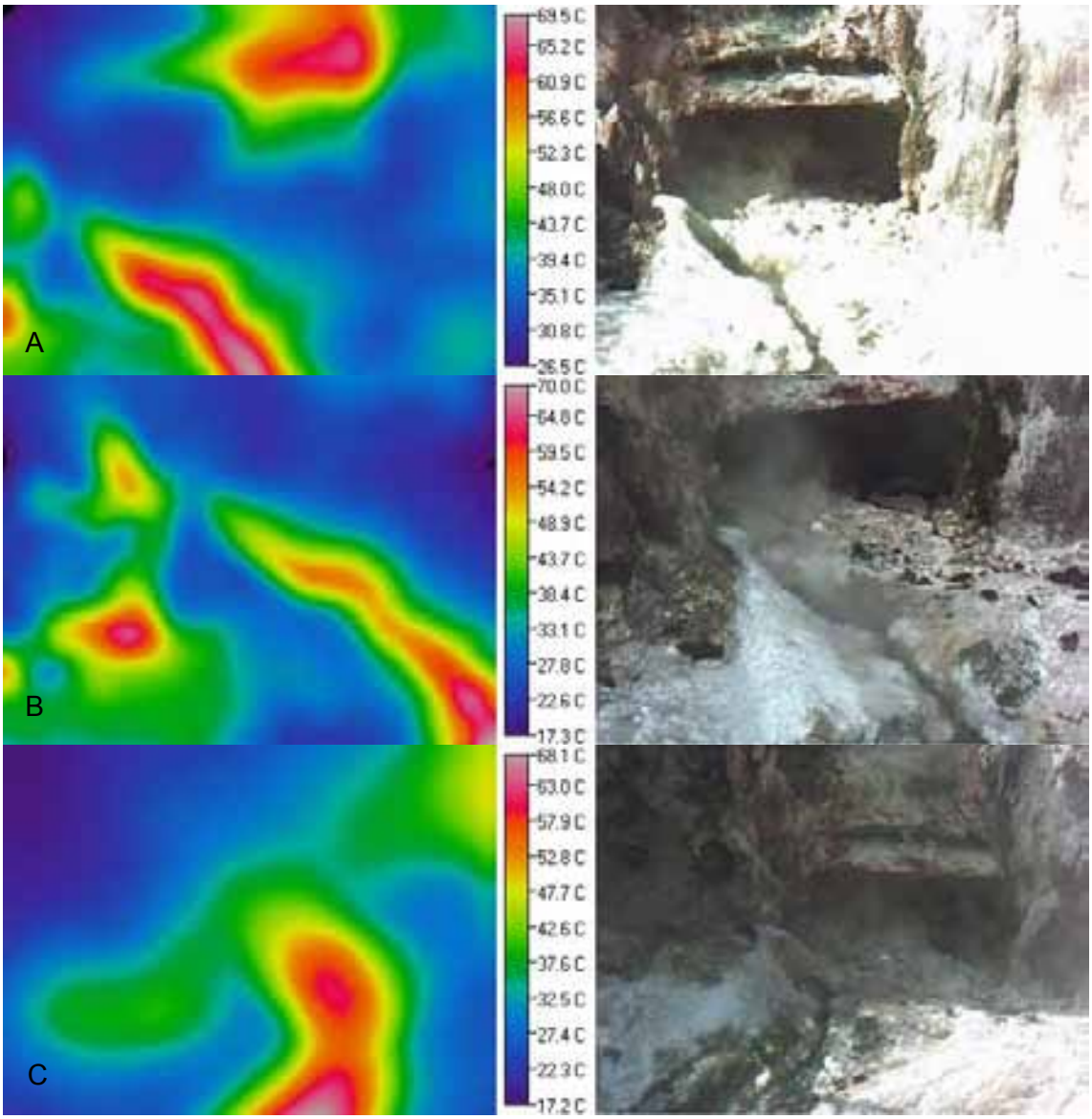


Figure 53: Infrared photos of Devils Throat, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C)

- **Fred and Maggie's Pool**
  E1874648 N5736981

The temperature fluctuated throughout the period, with the lowest temperature recorded in April and June (93.2 °C) and a high of 97.5 °C in September 2013.

Table 18: Data from Fred and Maggie's Pool, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	93.2	8	<0.5	Overflowing	Boiling near outflow	Clear, grey-blue
26 June 2013	93.2	7	<0.5	Overflowing	Constant upwelling near outflow	Clear, blue
27 Sept 2013	97.5	8	<0.5	Overflowing	Boiling near outflow	Clear, grey
28 Jan 2014	95.0	5-6	<0.5	Overflowing	Constant upwelling/boiling near outflow	Clear, grey

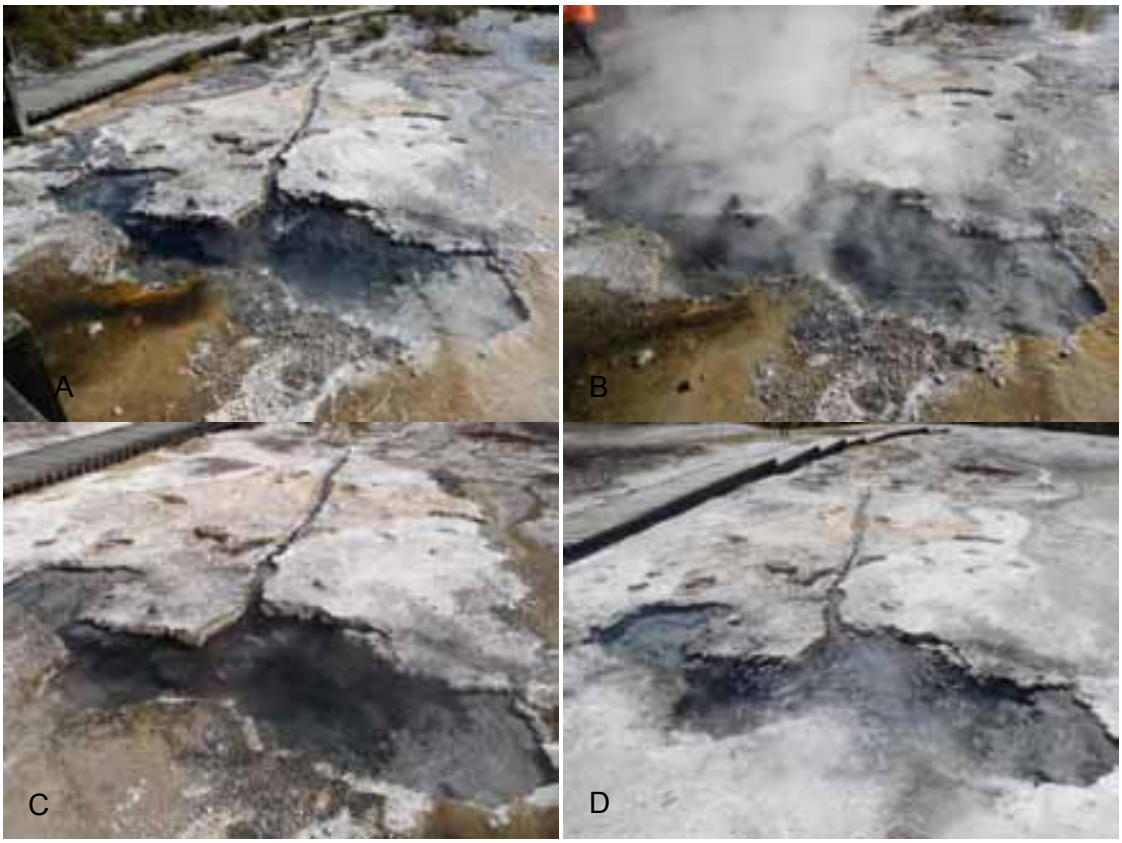


Figure 54: Fred and Maggie, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

In April and September 2013, the heat appears to originate from the area of upwelling and disperses from there. In June 2013, the Infrared photos below it show that the warmest area is on the western side of the pool. However, the steam can cause fluctuations in temperature across the pool as it cools quickly.

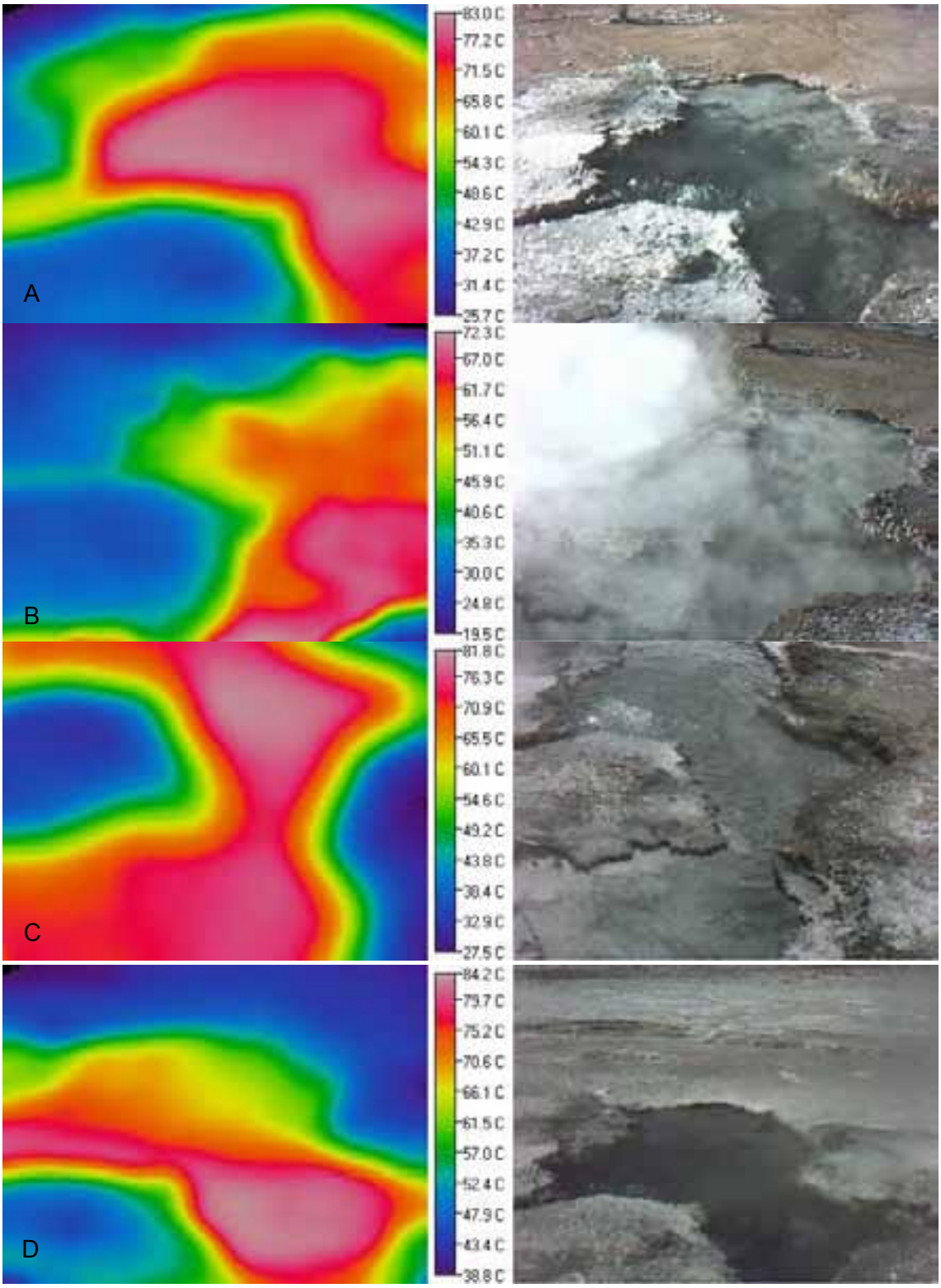


Figure 55: Infrared photos of Fred and Maggie's Pool, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Wairiri Geyser**
  E1874643 N5736951

It was noted that the sides of the geyser appeared to have collapsed into the pool during the April 2013 visit. The only water within the geyser is from atmospheric inflow and a temperature was 20.3 °C. During the June 2013 visit there was a small amount of water seeping into the pool; however the geyser is dry and cold. The ground is subsiding to the left of the pool. By the September 2013 visit, water was returning to the pool, and the temperature was 67.4 °C. This had increased to 70.5 °C by January 2014.

Table 19: Data from the Wairiri Geyser, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	20.3	-	nd	-	-	-
26 June 2014	cold	-	nd	dry	nd	-
27 Sept 2013	67.4	7-8	nd	1.6 m below outflow	Calm	Clear, brown base
28 Jan 2014	70.5	6-7	nd	1.7 m below outflow	Calm	Clear

Figure 56: Wairiri Geyser at Orakei Korako in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (C)

The geyser appears to be cold, however the infrared images below show that there was a slightly warmer area (up to about 15 °C) near the back of the geyser in June 2013. The pool has water and has heated up again by September 2013.

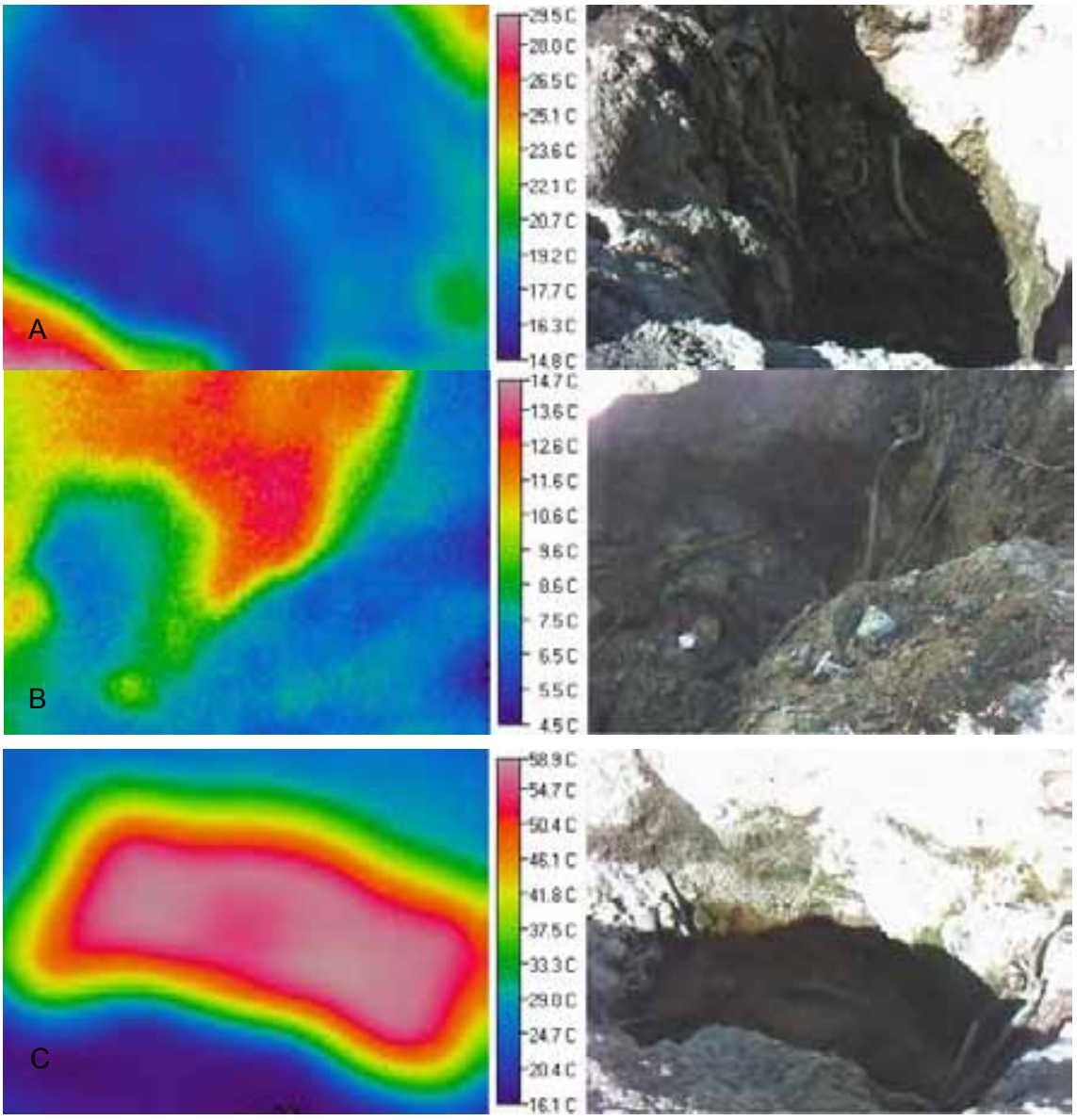


Figure 57: Infrared photos, Wairiri Geyser, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C)

- **Steaming ground on the Western edge of Artists Palette.**
  E1874661 N5736910

In April and June 2013 the area was flooded.

Table 20: Data from steaming ground, Western edge, Artists Palette, Orakei Korako

B Date	T(°C)
29 April 2013	20-40
26 June 2013	17-40
27 Sept 2013	20-71.5
28 Jan 2014	27.7-67.7

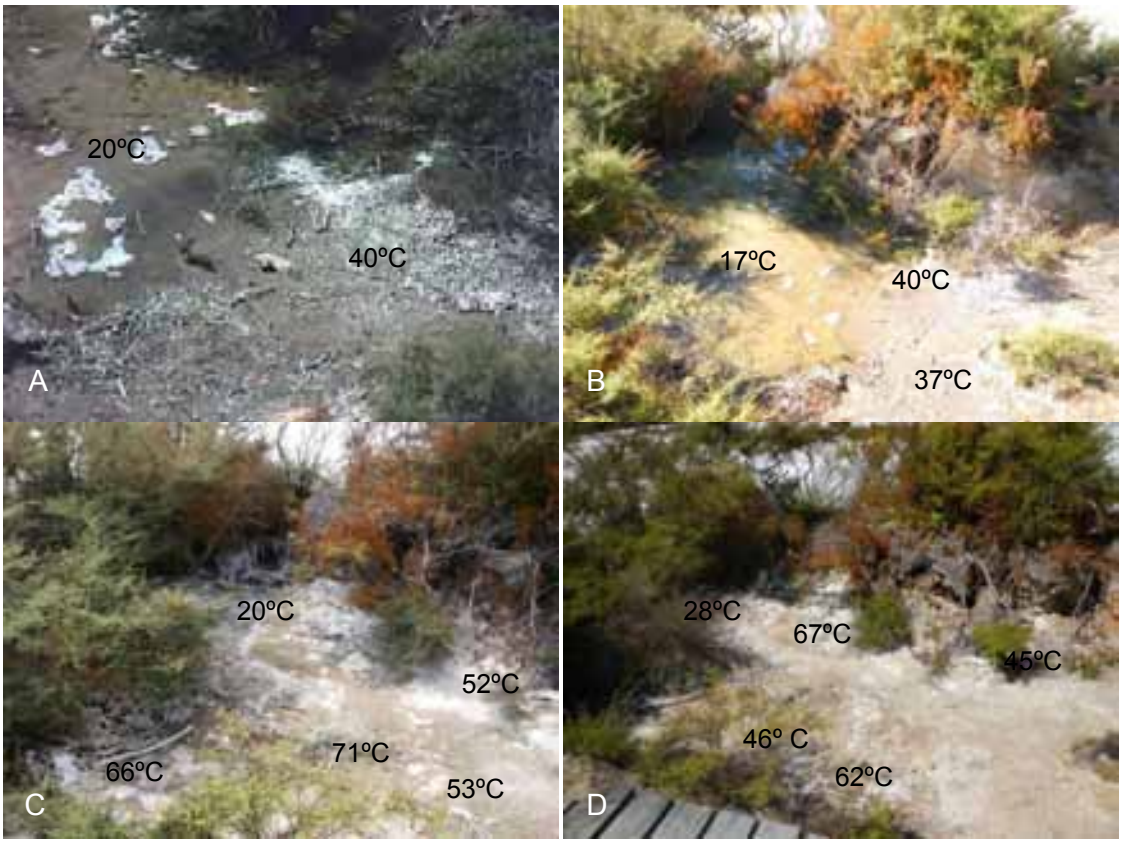
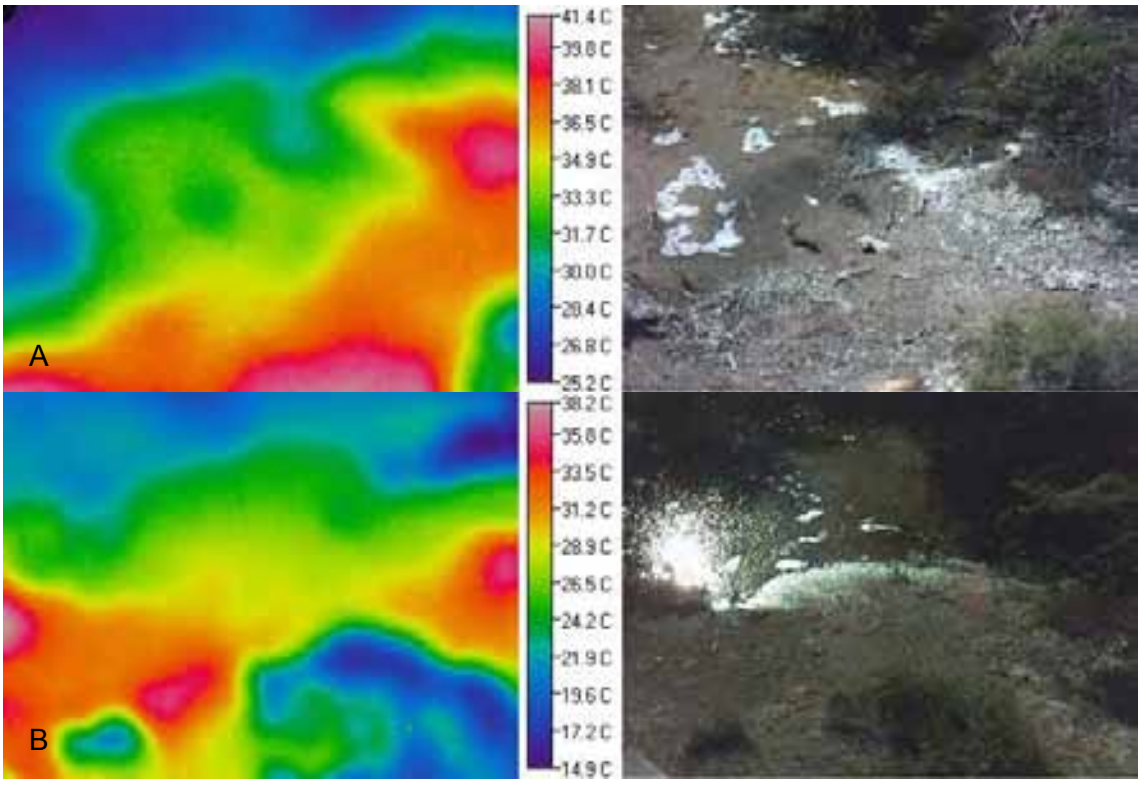


Figure 58: Steaming ground in April 2013 (A), June 2013 (A), Sept 2013 (B), Jan 2014 (D)

April and June 2013: There are various areas of warm ground; the water dissipates any heat, which may be produced under the wet area. The ground was dry in September 2013 and January 2013.



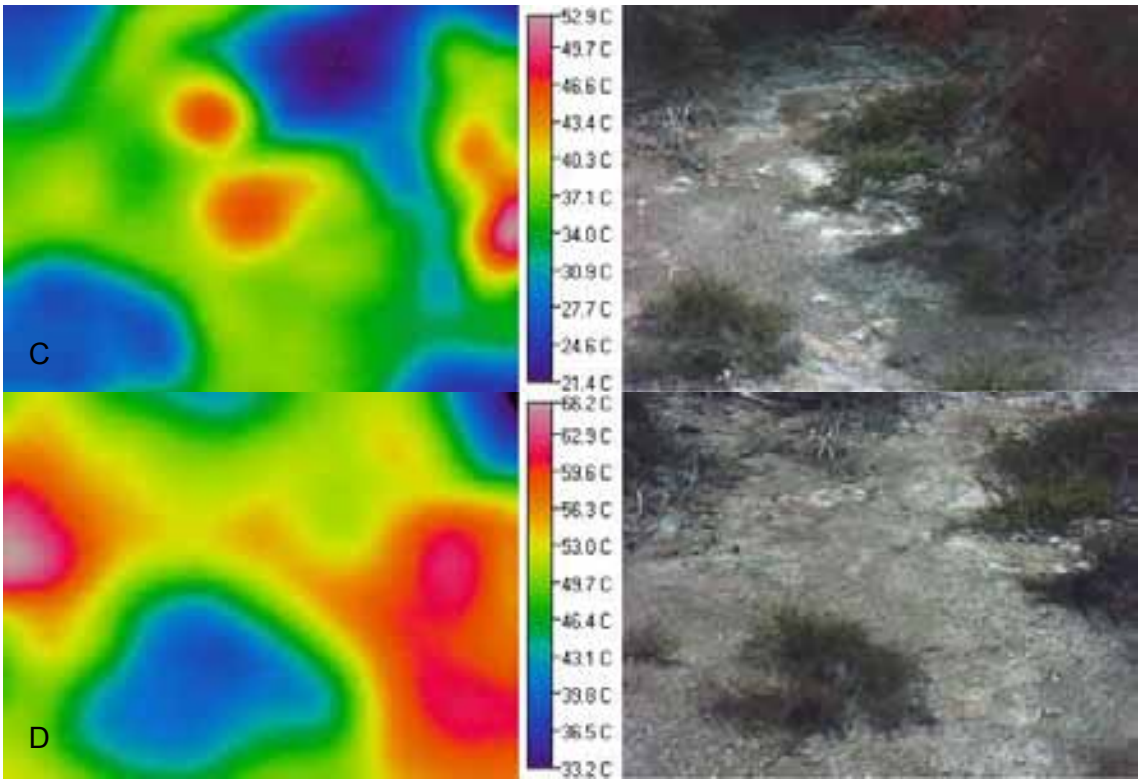


Figure 59: Steaming ground, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Fumarole to left of boardwalk**
  E1874662 N5736878

The fumarole was dry during all visits. It has an average depth of 0.6 m and a diameter of ~0.75 x 1 m. There are temperature fluctuations in the fumarole over the monitoring period, ranging from 40 °C to 46 °C.

January 2014: There has been a fresh cave-in on the side.

Table 21: Data for the Fumarole to the left of the boardwalk, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Ebullition	Diameter (m)	Depth (m)
29 April 2013	40	-	Dry	Steam	1.0 x 0.75	~0.6
26 June 2013	41	-	Dry	Steam	1.0 x 0.7	~0.6
27 Sept 2013	41.4	-	Dry	Steam	1.2 x 0.8	~0.7
28 Jan 2014	56.0	-	Dry	Steam	-	-

Figure 60: Fumarole, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos in Figure 61 show that the main area of heat is towards the rear of the fumarole.

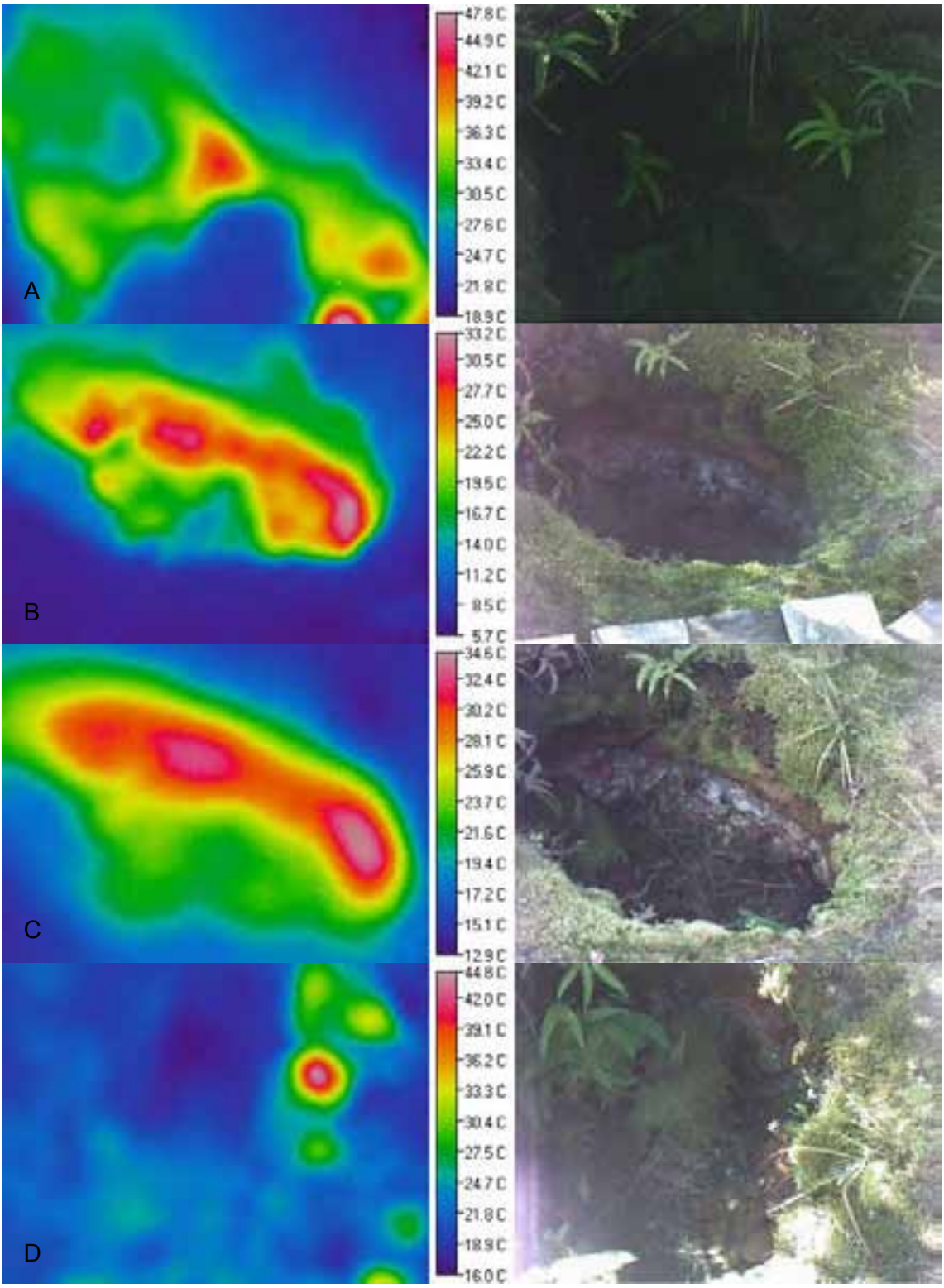


Figure 61: Infrared photos, Fumarole to the left of the boardwalk, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Two pools by the boardwalk**
  E1874670 N5736770

The water temperature at the South Pool fluctuates throughout the year, increasing significantly between September and January with a 25.6 °C increase. The water level has dropped from 0.7 m to 3 m below the surface over the monitoring period. The colour has altered from grey/green in April to brown/black in January.

Table 22: Data from the South Pool by the boardwalk, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	58.8	5	nd	0.7 m below surface	Constant large upwelling	Murky, grey/green
26 June 2013	52.5	5	nd	1 m below surface	Constant	Murky, grey
27 Sept 2013	56.1	5	nd	1.7 m below surface	Intermittent small bubbles	Murky, brown
28 Jan 2014	81.7	5-6	nd	3 m below surface	Constant, small bubbles	Murky, brown/black

Figure 62: South Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The warmest area appears to be in the centre of the pool.

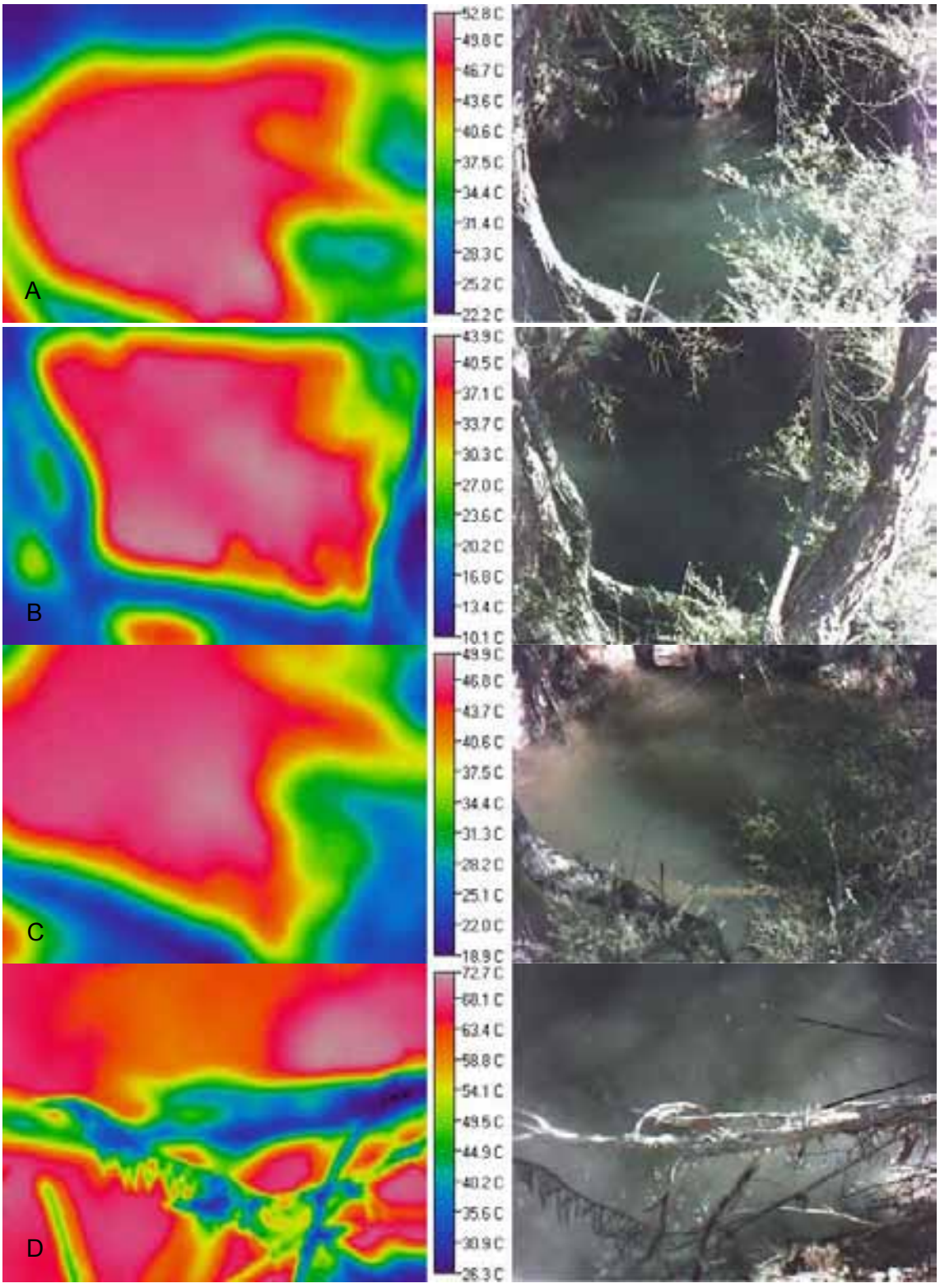


Figure 63: Infrared photos, South Pool by the boardwalk, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

The water temperature at the North Pool has increased markedly (41.7 °C) from 56.8 °C in Apr 2013 to 98.5 °C in January 2014. The pH has fluctuated between pH 6 and pH 7-8. The water level has dropped.

Table 23: Data from the North Pool by the boardwalk, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	56.8	6	Seep inflow from Artists Palette	0.8 m below outflow	Upwelling in centre	Grey/Green
26 June 2013	62.9	7	nd	1.3 m below outflow	Constant	Murky, grey
27 Sept 2013	72.8	6	nd	1.5 m below outflow	Constant upwelling	Murky, grey
28 Jan 2014	98.5	7-8	nd	2.5 m below outflow	Constant small upwelling	Clear

Figure 64: North Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The temperature of the pool appears to be consistent throughout the pool, with a slight drop in an area of steam.

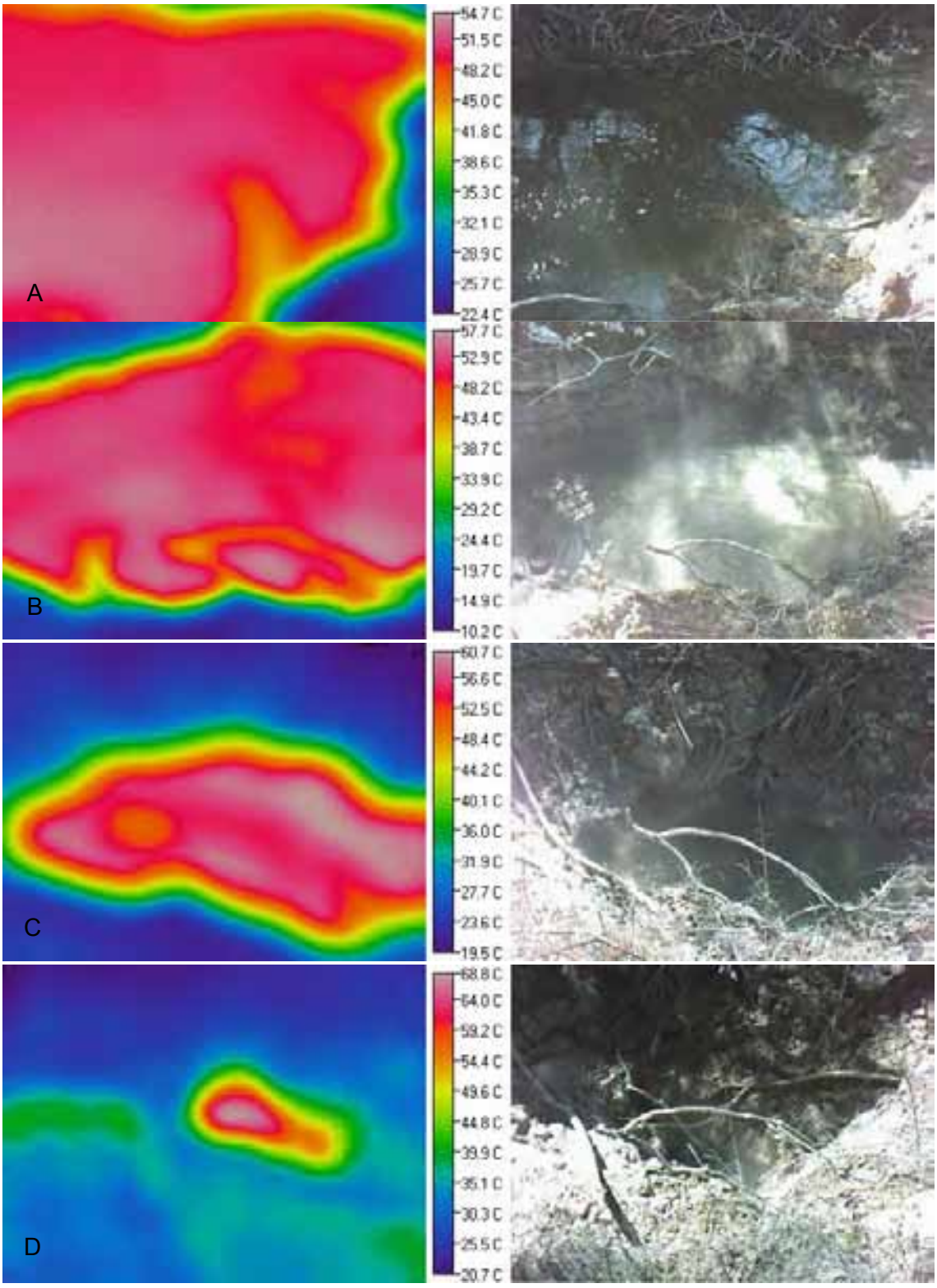


Figure 65: Infrared photos, North Pool by the boardwalk, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Artist's Palette and Pyramid of Geysers**

Figure 66: Artist's Palette, with the Pyramid of Geysers in the background in Jan 2014

April 2013: The majority of the pools appeared to be dry and steaming from the viewing platform. The large pool to the left of the platform was overflowing, with constant ebullition. A small pool to the left of the geyser was surging.

June 2013: The large pool to the left was overflowing. The rest of the pools were steaming.

September 2013: The majority of the pools appeared to be dry. The large pool to the left was overflowing at a seep. It was clear and blue, as was the small pool to the southwest of it. The small pool to the northwest of the Geyser was discharging vigorously.

January 2014: The majority of the pools appeared to be dry, apart from one pool to the left of the geyser.

Figure 67: Composite photo, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

- **Ruatapu Cave**
  E1874752 N5736770

Due to a rock fall some years ago there is no access to Ruatapu Cave; therefore the temperature was taken from the viewing platform with the IR gun. There have been slight temperature variations through the monitoring period, the maximum difference being 7.7 °C.

Table 24: Data from the Ruatapu Cave, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	35	nd	nd	-	Calm	Clear, Blue
26 June 2013	33	nd	nd	-	Calm	Clear, Blue
27 Sept 2013	40.7	nd	nd	-	Calm	Clear, Blue
28 Jan 2014	36.1	nd	nd	-	Calm	Clear, Blue

Figure 68: The Ruatapu Cave, Apr 2013 (A), Jul 2012 (B), Sept 2013 (C), Jan 2014 (D)

The water temperature appears to be consistent throughout the pool at the base of the cave.

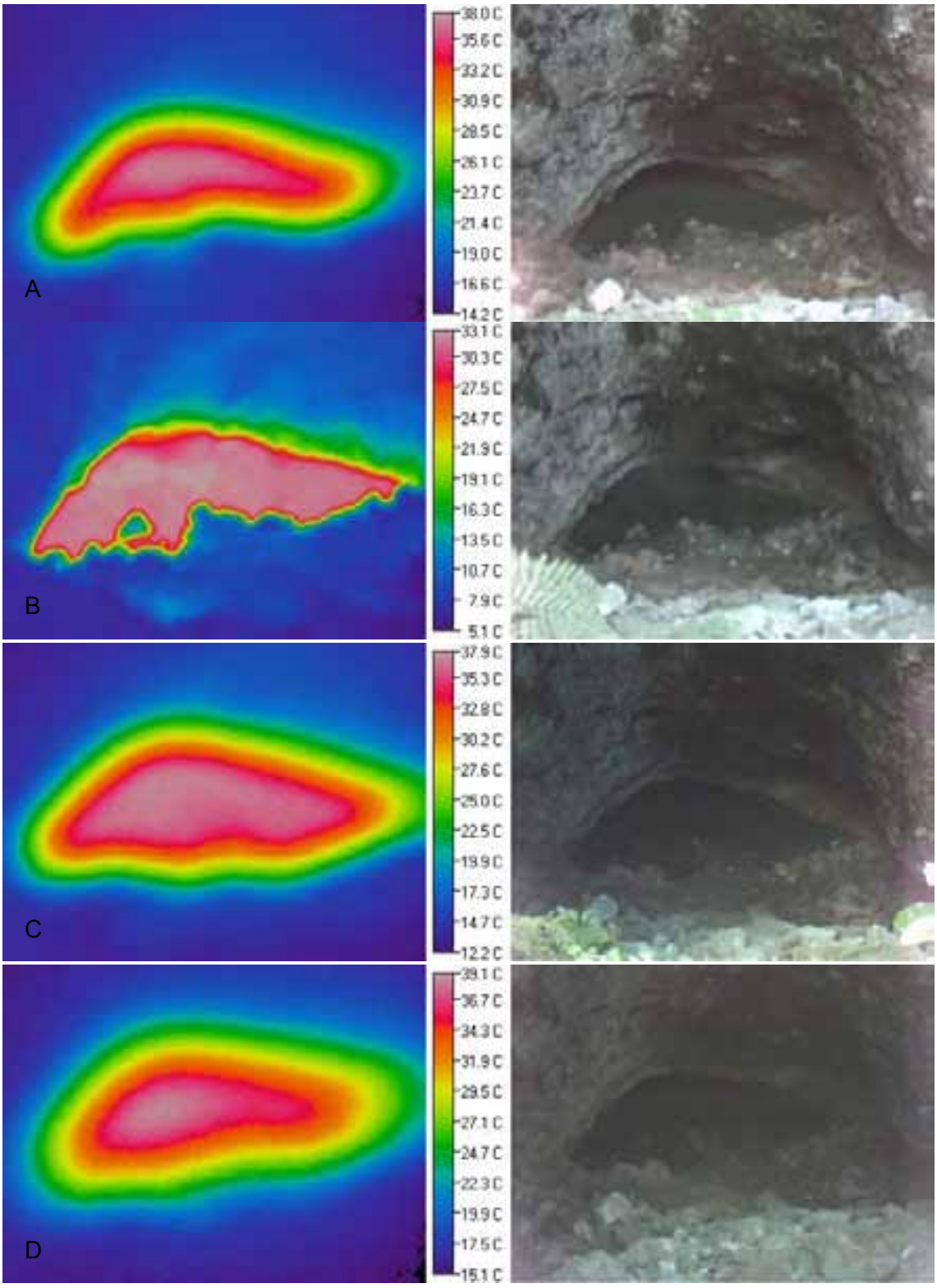


Figure 69: Infrared photo, Ruatapu Cave, Orakei Korako, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Soda Fountain**
  E1874555 N5736924

The water level has remained consistent throughout the monitoring period. The pH has increased from pH 7 to pH 8.

Table 25: Data from the Soda Fountain, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	97.9	7	~0.5	o/f	Constant upwelling	Clear, blue
26 June 2013	96.7	8	<0.5	o/f	Constant vigorous upwelling	Clear, blue
27 Sept 2013	96.9	8	~0.5	o/f	Boiling	Clear, blue
28 Jan 2014	97.6	8	<0.5	o/f	Constant, boiling	Clear, blue/green

Figure 70: Soda Fountain, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

- **Map of Australia**
  E1874160 N5736976; Located number 72.2998

There were no major changes throughout the monitoring period.

Table 26: Data from the Map of Australia, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 April 2013	81.7	7	~0.5	255 mm below top of ruler	Upwelling	Clear, blue (turquoise)
26 June 2013	79.6	8	~0.5	250 mm below top of ruler	Constant upwelling	Clear, blue (turquoise)
27 Sept 2013	80.3	7	~0.5	250 mm below top of ruler	Constant upwelling at right side	Clear, blue (aqua)
28 Jan 2914	81.7	7-8	<0.5	250 mm below top of ruler	Upwelling	Clear, blue (turquoise)

Figure 71: Map of Australia, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos in Figure 72 show that the warmest part of the pool is towards the Eastern side.

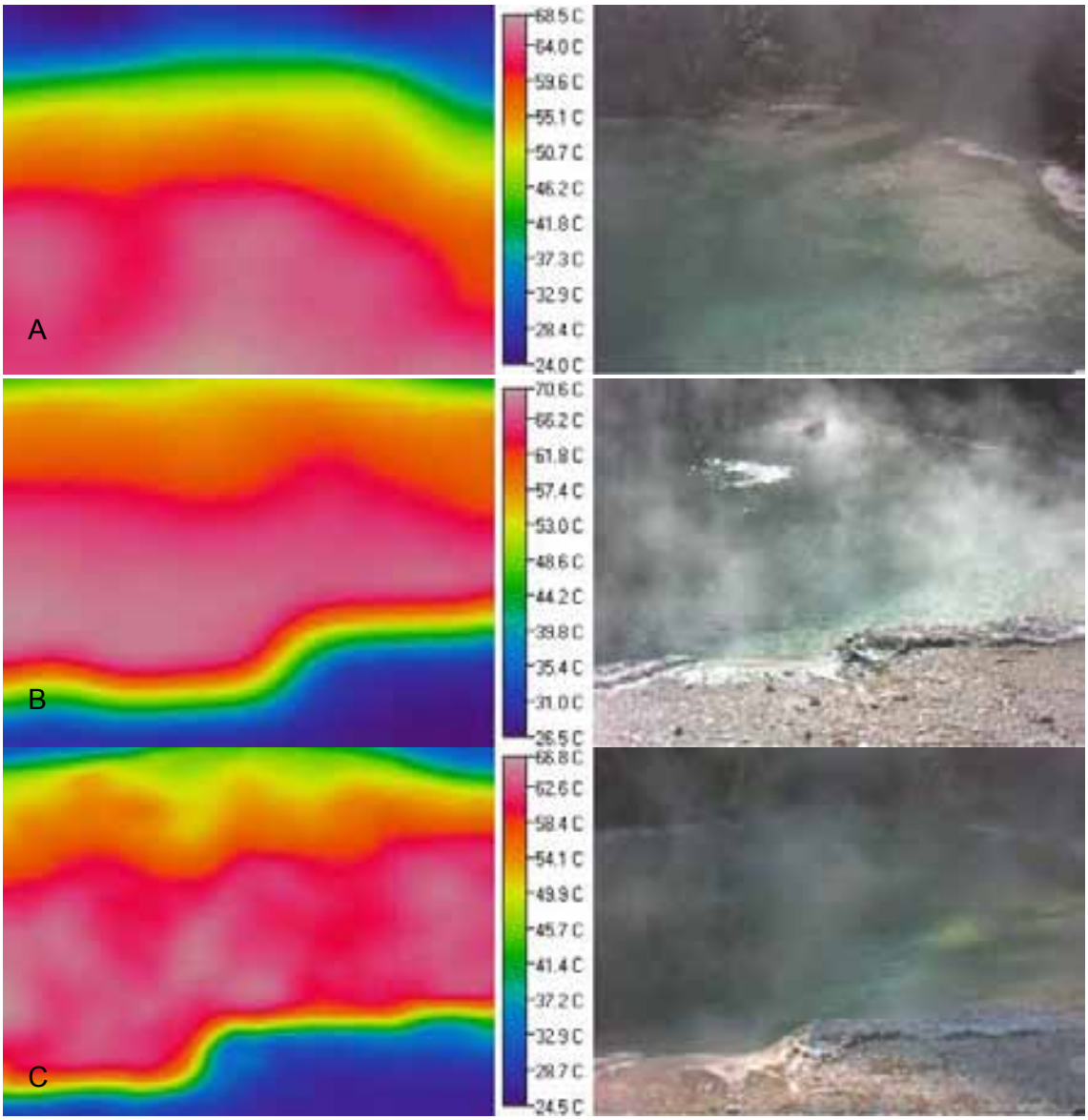


Figure 72: Infrared photos of Map of Australia, Orakei Korako, April 2013 (A), Sept 2013 (B) and Jan 2014 (C)

6.2 Waihunuhunu Inlet

- **Inlet 1**
  E1875427 N5739204

There were no bathers at the time of the surveys in September 2013 and January 2014. There were no significant changes to the feature.

Table 27: Data from Inlet 1, Waihunuhunu Inlet, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
26 Sept 2013	48.0	7	20-30	O/f from pipe	-	Clear
30 Jan 2014	48.5	7-8	~40	O/f from pipe	-	Clear

Figure 73: Waihunuhunu Inlet 1, Orakei Korako in Sept 2013 (A), Jan 2014 (B)

The heat of the water can be seen as it gushes out of the pipe.

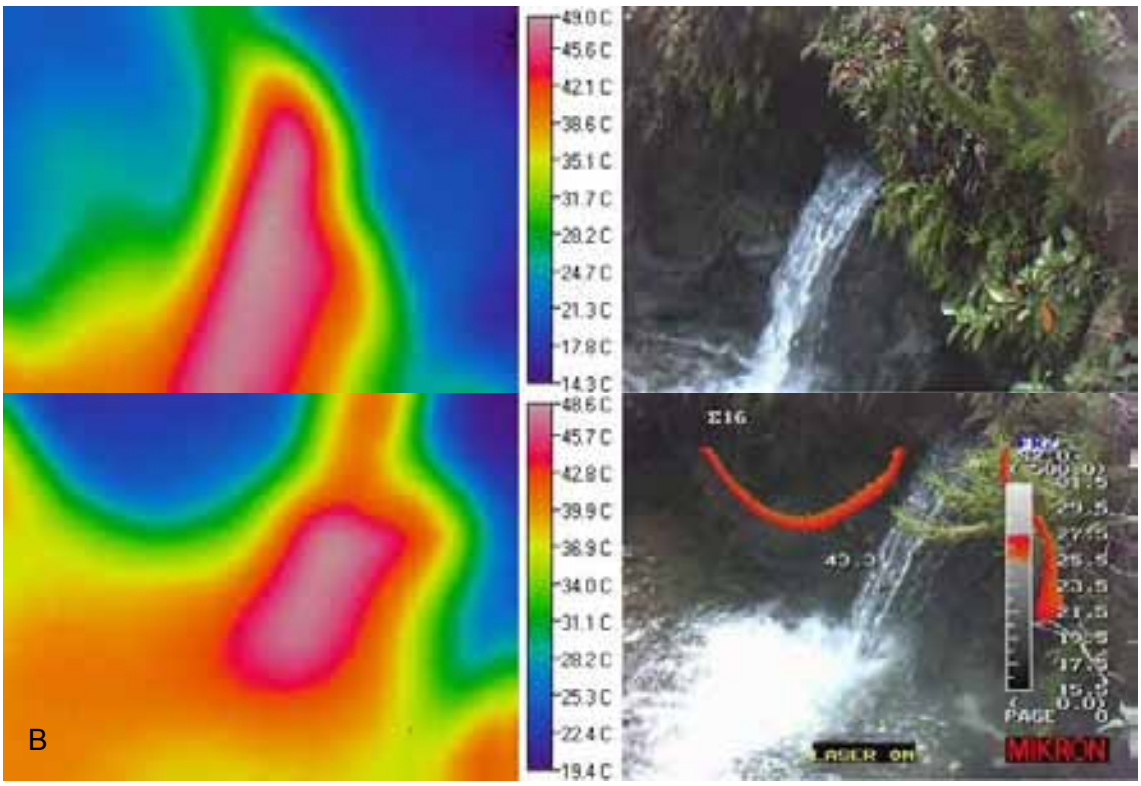


Figure 74: Infrared photos of Waihunuhunu Inlet 1, Orakei Korako, Sept 2013 (A) and Jan 2014 (B)

- **Inlet 2**
  E1875395 N5746213

There were no bathers at the time of the survey in September 2013 or January 2014. There were no discernible changes other than slight fluctuations in pH, temperature and flow.

Table 28: Data from Inlet 2, Waihunuhunu Inlet, Orakei Korako

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
26 Sept 2013	40.9	6	~3	O/f from pipe	-	Clear
30 Jan 2014	42.8	7-8	~5	O/f from pipe	-	Clear

Figure 75: Waihunuhunu Inlet 2, Orakei Korako in Sept 2013 (A), Jan 2014 (B)

The heat of the water can be seen as it flows out of the pipe.

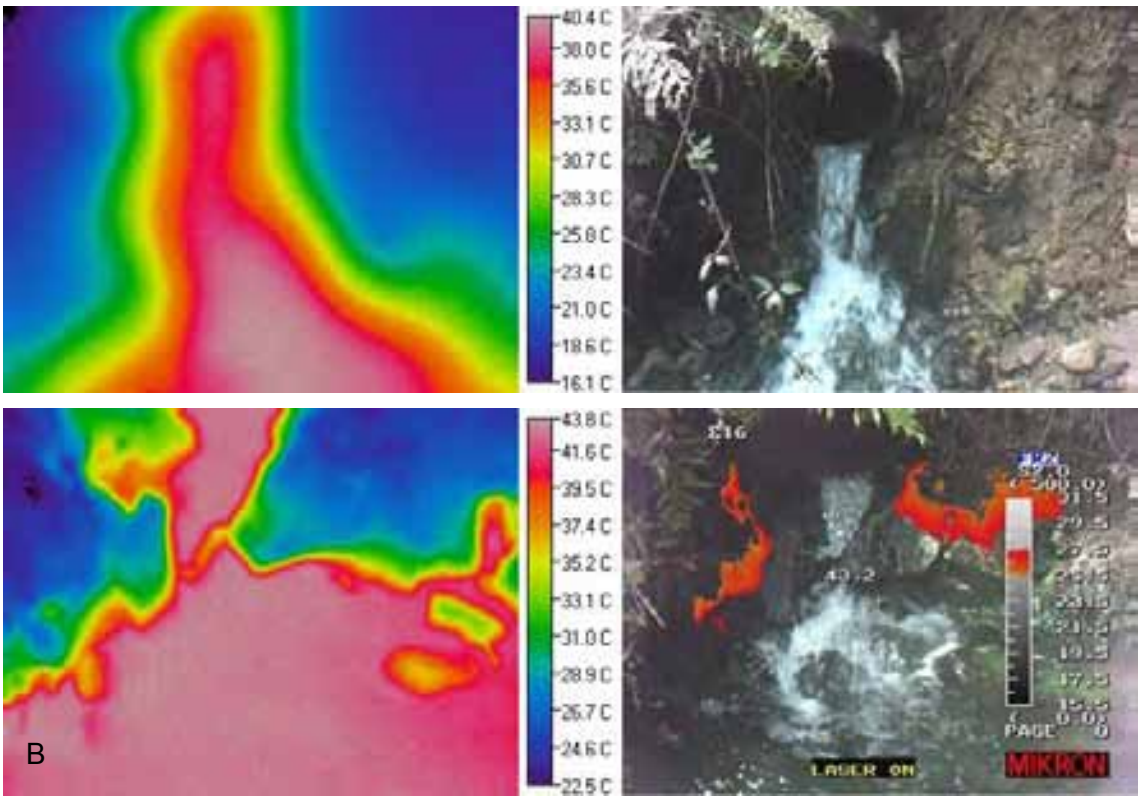


Figure 76: Infrared photos of Waihunuhunu Inlet 2, Orakei Korako, Sept 2013 (A) and Jan 2014 (B)

7 Reporoa

7.1 Butcher's Pool

- E1891720 N5738576

There is a significant amount of algal growth on the far end of the pool near the outlet. This has increased since the previous visit in January 2013. There has been a slight colour change to a paler green. The temperature has increased by 2.4 °C and the pH has risen from pH 6 to pH 7-8 since the previous visit. There were no bathers at either monitoring visit.

Table 29: Data from Butcher's Pool, Reporoa

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
31 Jan 2013	38.6	6	~1	o/f	Effervescing all over pool	Murky, green
04 Feb 2014	41.0	7-8	nd	o/f	Effervescing all over pool	Cloudy, green

Figure 77: Butcher's Pool, Reporoa in Jan 2013 (A), Feb 2014 (B)

Figure 78: Algal growth at Butcher's Pool, Reporoa in Feb 2014

7.2 Wharepapa Road

- **Fumaroles**
  E1890802 N5742769

The fumaroles are situated in a paddock and are not fenced off. There have been a few temperature differences, with the majority of the fumaroles decreasing in temperature; apart from vent number 3 (see Table 31). Some of the vents have changed slightly in size. Vent 6 is dry ground, which has cooled significantly since the previous visit.

The photo below shows the location of the fumaroles (vent 5 is off shot).

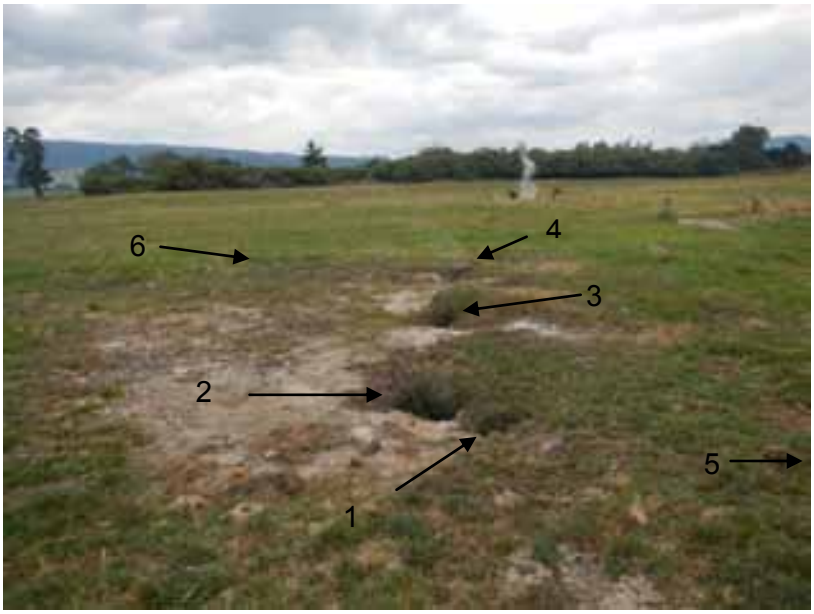


Figure 79: Overview of Fumaroles at Wharepapa Road, Reporoa

Table 30: Data from Fumaroles, Reporoa

Date	Vent	T(°C)	Flow	Depth (m)	Diameter (m)	Ebullition	Colour
23 Jan 2013	1	71.4	nd	~1.5	~0.23	Audible gas discharge	Black mud
04 Feb 2014	1	68.5	nd	~1.0	0.2x0.28	Audible gas discharge	Black mud
23 Jan 2013	2	71.2	steam	~1.7	~0.6	Audible gas discharge	Black mud
04 Feb 2014	2	60.9	nd	~1.1	0.73x0.5	Audible gas discharge	Black mud
23 Jan 2013	3	76.2	nd	~1.6	~0.5 x 0.66	Audible gas discharge	Black mud
04 Feb 2014	3	87.4	nd	~2.07	0.43x0.34	Audible gas discharge	Black mud
23 Jan 2013	4	61	nd	~3 (angled)	~0.67 x 1	Audible gas discharge	Black mud
04 Feb 2014	4	49.1	nd	~2.4	0.58x0.9	Audible gas discharge	Black mud
23 Jan 2013	5	65	nd	~0.6	~0.6 x 0.7	nd	nd
04 Feb 2014	5	51.9	nd	~0.22	0.75x0.9	Audible gas discharge	nd
23 Jan 2013	6	91.1	nd	ground level	~0.6	nd	nd
04 Feb 2014	6	53	nd	ground level	0.88x1.07	nd	nd

Figure 80: Jan 2013: Vents 1 & 2 (A), 3 (B), 4 (C), 5(D), 6 (E); Feb 2014: Vents 1 & 2 (F), 3 (G), 4 (H), 5(I), 6 (J)

The infrared photos below depict the heat emanating from Vents 3, 4 and 6. Vents 3 and 4 are hottest at the bottom. Vent 6 is warm ground, which is hottest in the centre of the bare patch of earth.

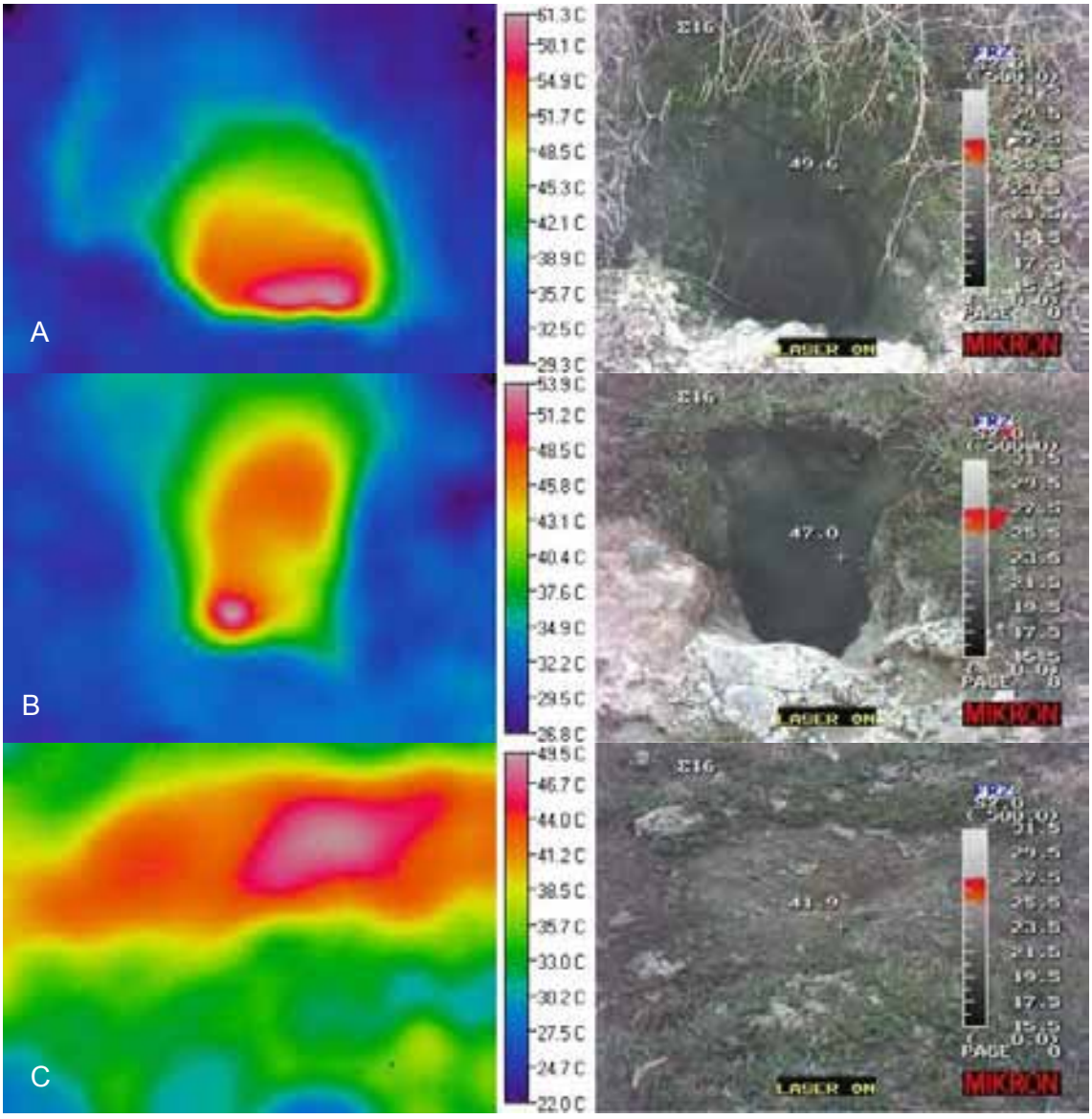


Figure 81: Infrared photos of Vents 3 (A), 4 (B) and 6 (C)

- **Figure 8 shaped pools**
  E1890786 N5742843

The small pool had a 2.5 °C temperature increase since the previous visit in January 2013. The larger pool was flowing into the smaller pool during surges.

Table 31: Data from Figure 8 shaped pools, Reporoa

Date	Pool	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	Large	96.6	8	nd	0.8 m below ground	Vigorous discharge, surging	Dark brown,0 visibility
04 Feb 2014	Large	96.6	8-9	nd	-	Constant discharge, surging	Brown, murky
23 Jan 2012	Small	81.2	8	nd	0.8 m below ground	Calm	Dark brown,0 visibility
04 Feb 2014	Small	83.7	7-8	nd	-	Small bubbles	Brown, murky

Figure 82: Figure 8 shaped pools, Reporoa in Jan 2013 (A) and Feb 2014 (B)

The infrared photo below was taken while the large pool was surging. The hottest areas of the pool appear to be where the ebullition is most apparent.

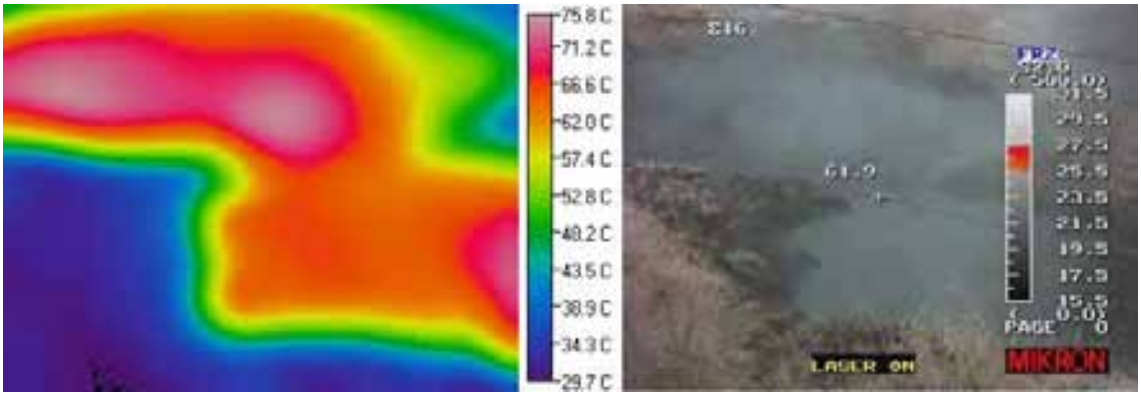


Figure 83: Infrared photo of Figure 8 pools, Reporoa

- **Hot Pool 3**
  E1890848 N5742777

This pool has been fenced off, however the fence posts were black and the wires loose and broken. There was an oily sheen on the surface. The pH had increased from pH 7 to pH 8 since January 2013.

Table 32: Data from Hot Pool 3, Reporoa

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	93	7	~1.5	o/f	Calm, some steam	Clear, blue
04 Feb 2014	93.7	8	1 – 2	o/f	Calm	Clear, blue

Figure 84: Hot pool 3, Reporoa in Jan 2013 (A&B), Jan 2014 (C&D)

- **Hot Pool 4**
  E1891154 N5743025

It was too hazardous to get close enough to get a sample for pH. The temperature was measured with the IR gun, and showed a 7.8 °C decrease in temperature since the previous visit in January 2013. The water level had increased and the colour of the pool changed from brown to grey.

Table 33: Data from Hot Pool 4, Reporoa

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	81	5	nd	1.5 m below rim	Constant gas discharge	Murky, brown
04 Feb 2014	73.2	nd	nd	~1.2 m below rim	Constant gas discharge	Murky, grey

Figure 85: Hot Pool 4, Reporoa in Jan 2013 (A), Jan 2014 (B)

The hottest part of the pool appears to be to the left of the pool.

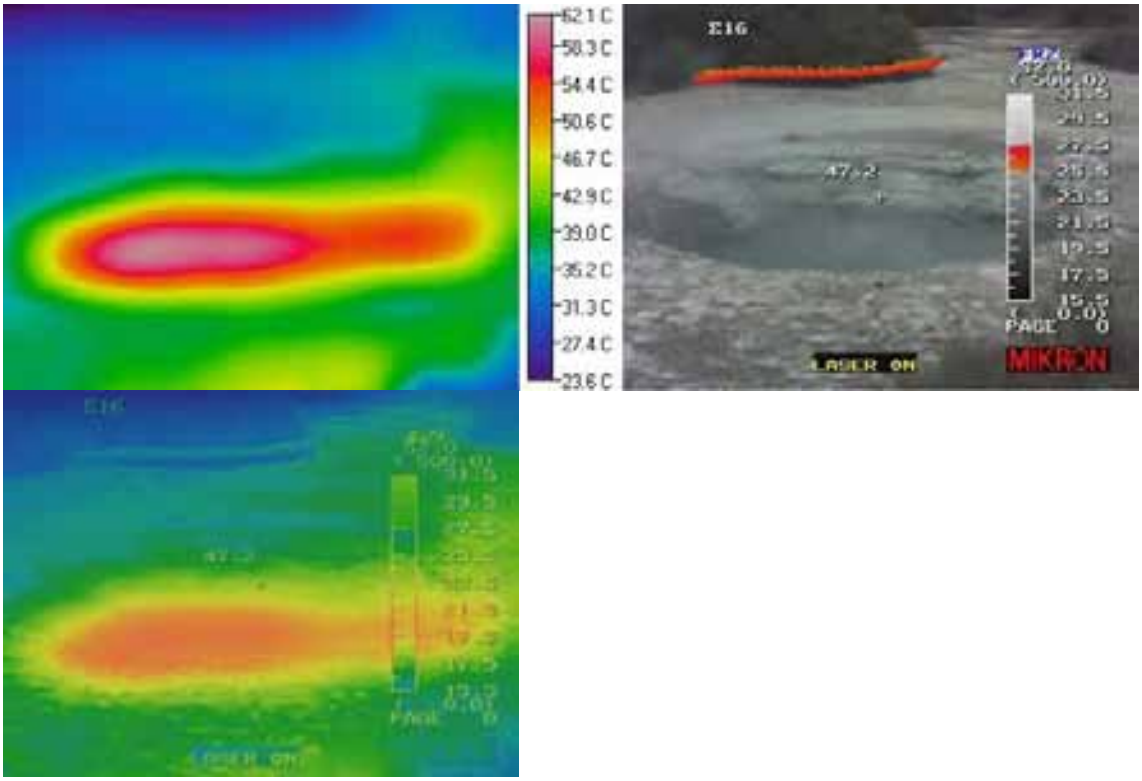


Figure 86: Infrared photos of Hot pool 4, Reporoa

7.3 Longview Road

- **Lake**

The lake could not be reached on this occasion due to the area around the mud pools being too soft and hazardous to walk on.

- **Mud Pool**

There were various mud pools in the area; we chose to sample the large one close to the lake. The water level in February 2014 was slightly higher than it had been in January 2013. There was also a temperature increase of 4.4 °C.

Table 34: Data from Lake, Longview Road, Reporoa

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
23 Jan 2013	23.2	<3	nd	1 m below rim	Gas discharge	Murky, brown
04 Feb 2014	27.6	3	nd	0.75 m below rim	Constant gas discharge	Murky, brown

Figure 87: Mud pool, Longview Road, Reporoa in Jan 2013 (A), Feb 2014 (B)

8 Rotokawa

In January 2014, we were only able to visit RK3 and RK4 at Rotokawa due to high gas concentrations around the pools.

8.1 Lagoon Springs

- **RK3**

The temperature had increased slightly (3.1 °C) from January 2013 to January 2014. There have also been changes in ebullition and colour (see Table 36).

Table 35: Data from RK3, Rotokawa

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 Jan 2013	54	3	nd	nd	Calm	Murky, blue
29 Jan 2014	50.9	3	nd	nd	Constant discharge	Cloudy, pale milky green

Figure 88: RK3, Rotokawa in Jan 2013 (A&B), Jan 2014 (C&D)

- **RK4**

The area around RK3 and RK4 seems to change quite often, so therefore I am unsure as to whether this is RK4a, b or c. The pool was flowing into RK3. The pool was about 3 m by 3 m.

Table 36: Data from RK4, Rotokawa

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
29 Jan 2014	80.2	2-3	nd	o/f into RK3	Constant discharge	Murky, grey/green

Figure 89: RK4, Rotokawa

The infrared photo below shows the heat of the geothermal pool, the highest temperatures appear to be in areas of ebullition.

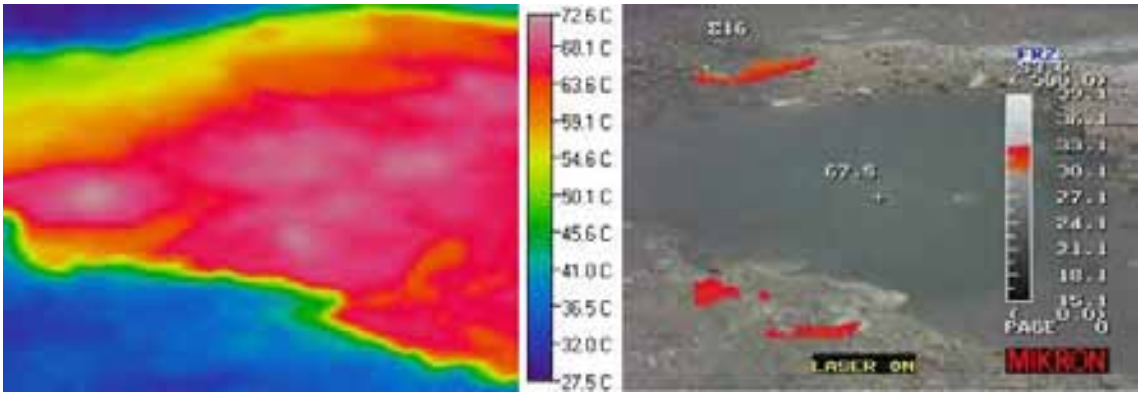


Figure 90: Infrared photo of RK4, Rotokawa

9 Tauhara

9.1 Lake Taupo Shore

- **Taharepa Spring**
  E1882989 N5733159; Located number 1197.1

Figure 91: Taharepa Spring, Apr 2013, Tauhara

Apart from the main Taharepa Spring, there are several small springs feeding into the main pool. The spring temperature had increased between April and June 2013, and then remained fairly consistent. There was an increase in flow in September 2013. There was an oily film and scum on the water surface in June 2013. In September 2013, there was an orange precipitate on the rocks surrounding the spring.

There were no bathers present during the April, June and September 2013 monitoring visits. There were two bathers noted at 17:15 during the February visit.

Table 37: Data from the Taharepa Spring, Tauhara

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
15 April 2013	54	6	seep	nd	No gas	Clear
27 June 2013	62.5	5	seep	nd	No gas	Clear
26 Sept 2013	64.3	5	<0.5	nd	No gas	Clear
04 Feb 2014	63.3	6-7	Seep	nd	No gas	Clear

Figure 92: Taharepa Spring, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos in Figure 93 show the heat emanating from the spring as it flows out of the rock and makes its way into Lake Taupo.

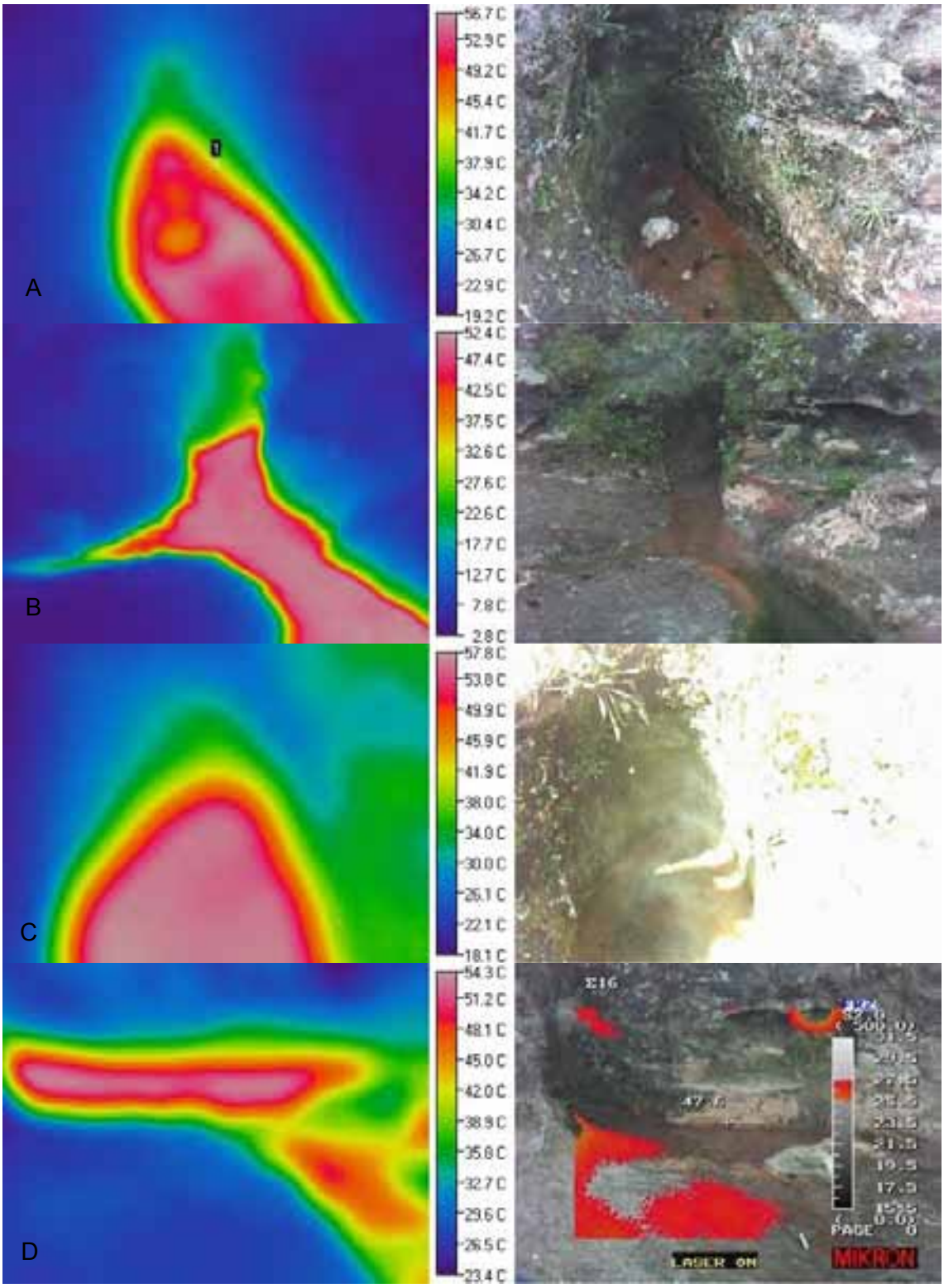


Figure 93: Infrared photos showing the Taharepa Spring in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Rocky Point Spring**
  E1868286 N5711795; Located number 72.2988

There were no bathers near the spring at any of the monitoring visits. The temperature fluctuated throughout the monitoring period with a low in April 2013 of 60.5 °C and a high of 66.1 °C in September 2013. In September 2013, the lake level was lapping over the top of the spring, therefore a pH reading of the spring could not be taken.

Table 38: Data from the Rocky Point Spring, Tauhara

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
15 April 2013	60.5	6	1	-	Constant bubbles	Clear
27 June 2013	65.8	6-7	~0.5	o/f	Constant	Clear
26 Sept 2013	66.1	-	-	-	-	Clear
04 Feb 2014	65.0	6	<0.5	o/f	-	Clear

Figure 94: Rocky Point Spring, Apr 2012 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos in Figure 95 show the origin and path of the water from the spring as it flows into Lake Taupo. In September 2013, the lake level was washing over the top of the spring, therefore the heat dissipated quickly as it flowed out of the spring.

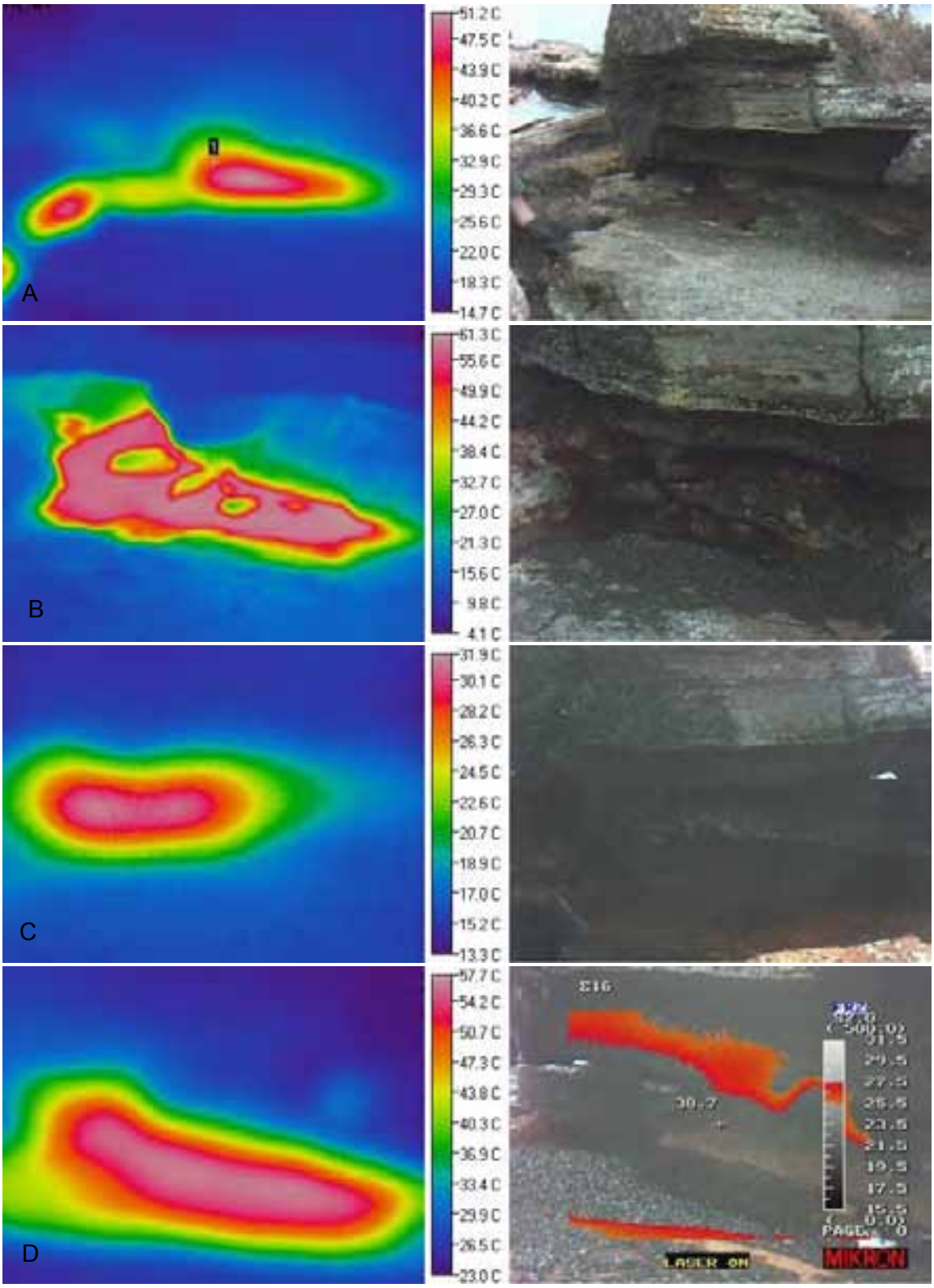


Figure 95: Infrared photos of Rocky Point Spring in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

9.2 Otumuheke

- **End of Ponga**
  E1869102 N5715081

The site is at the end of the ponga fence next to the Spa Hotel. There were green algae on the stream bed during all visits. The temperature has remained fairly consistent, with a slight increase in February 2014.

Table 39: Data from the Otumuheke Stream, the end of the Ponga fence, Tauhara

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	49.2	-	20-30	nd	Calm	Clear
25 June 2013	48.2	5	20-30	nd	Calm	Clear
26 Sept 2013	49.5	5	20-30	nd	Calm	Clear
04 Feb 2014	51.1	5-6	20-30	nd	Calm	Clear

Figure 96: Otumuheke Stream, Apr 2013 (A), Jul 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photo shows the warmth of the Otumuheke Stream. The heat is evenly spread across the stream, and cools at the edges.

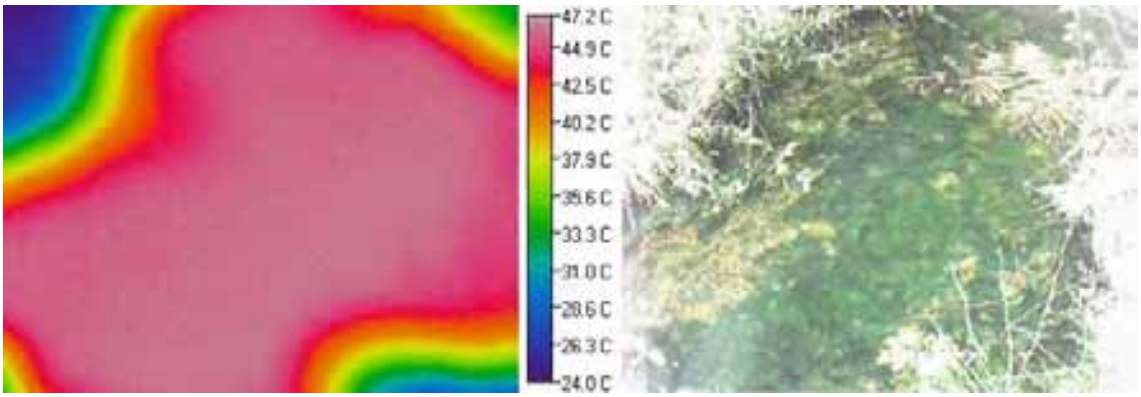


Figure 97: Infrared photos of Otumuheke Stream, Tauhara, Sept 2013

- **Confluence under bridge**

The site is located on the bridge next to the Spa Hotel. There were algae on the bed of both streams. The right tributary seems to have iron flock. The temperature in the right tributary was warmest in April 2013 and coolest in June 2013. The Otumuheke Stream was warmest in February 2014 and coolest in June 2013. The pH was variable in both streams throughout the monitoring period.

Table 40: Data from the right tributary to the Otumuheke Stream by the bridge, Tauhara

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	50.2	6	1	nd	Calm	Clear
25 June 2013	39.2	8	5	nd	Calm	Clear
26 Sept 2013	45.5	6	7	nd	Calm	Clear
04 Feb 2014	44.6	6-7	5	nd	Calm	Clear

Table 41: Data from the Otumuheke Stream by the bridge, Tauhara

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	48.5	6	20-30	nd	Calm	Clear
25 June 2013	47.2	6	~20-30	nd	Calm	Clear
26 Sept 2013	48.6	5	20-30	nd	Calm	Clear
04 Feb 2014	50.4	5-6	20-30	nd	Calm	Clear

Figure 98: Otumuheke Stream, Apr 2012 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

- **Spa Thermal Park**

The Otumuheke Stream runs into the Waikato River in Spa Thermal Park. Table 42 details the numbers of bathers present at the time of visiting the area.

In June 2013 there were also three bathers further upstream.

Table 42: Data from Spa Thermal Park, Tauhara

Date	Time	No. Of Bathers	No. Of Bystanders
15 April 2013	16:30	30	8
25 June 2013	16:10	4	0
26 Sept 2013	15:50	20	0
04 Feb 2014	17:00	14	17

Figure 99: Otumuheke Stream, Spa Thermal Park, Tauhara

9.3 Waipahihi Source

- **Source Spring**
  E1869804 N5711669; Located number 72.2989

There was a temperature decrease between April 2013 and February 2014 of 6.4 °C. The pH and flow fluctuated throughout the monitoring period.

Table 43: Data from the Waipahihi Source Spring, Tauhara

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
15 April 2013	72.0	7	~1	Overflowing	Calm, steam	Clear
26 June 2013	65.4	8	<0.5	Overflowing	Calm	Clear
26 Sept 2013	66.4	6	~0.5	Overflowing	Calm	Clear
04 Feb 2014	65.6	7	~0.5	Overflowing	Calm	Clear

Figure 100: Waipahihi Source, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos in Figure 101 show the hot area where the spring is situated and the flow path into the stream.

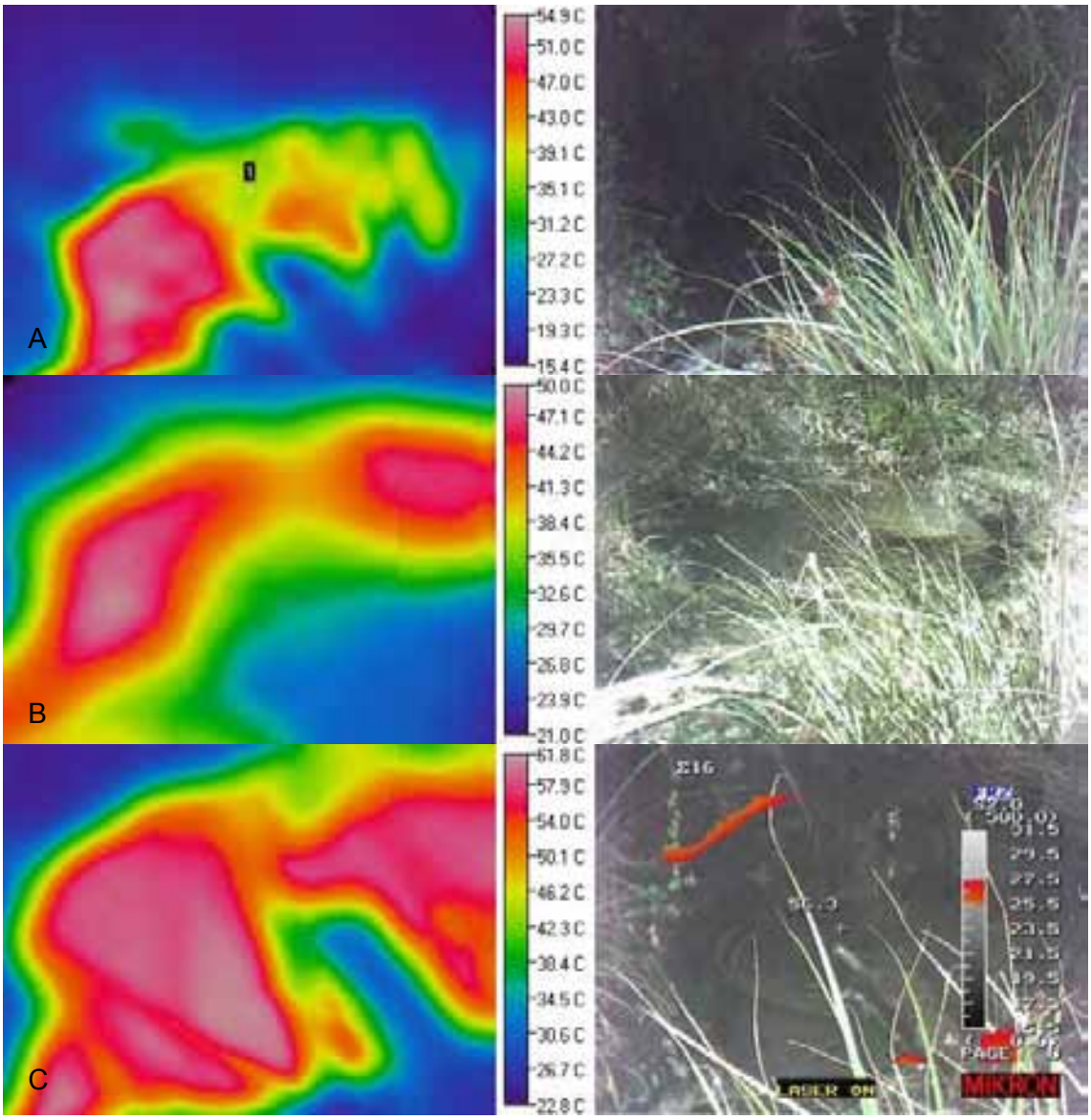


Figure 101: Infrared photos, Waipahihi Spring, in Apr 2013 (A), Sept 2013 (B) and Jan 2014 (C)

- **New Spring**

This is a spring that has formed near the weir. There are new deposits of exposed sinter and the stream appears to be widening. Yellow/green alga is growing on the streambed and on the sinter. Temperature, pH and flow fluctuate slightly throughout the monitoring period; however, there are no significant changes.

Table 44: Data from the New Spring, Waipahihi, Tauhara

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
15 April 2013	65.6	7	<1	Overflowing	Calm	Clear
26 June 2013	63.8	7	<0.5	Overflowing	Calm	Clear
26 Sept 2013	64.5	6	<0.5	Overflowing	Calm	Clear
04 Feb 2014	65.0	7	<0.5	Overflowing	Calm	Clear

Figure 102: New Spring, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos below show the flow of the water as it leaves the spring; there is also a small spring to right of the photo, which is adding hot water. The flow from these springs joins the Waipahihi Stream just below the weir.

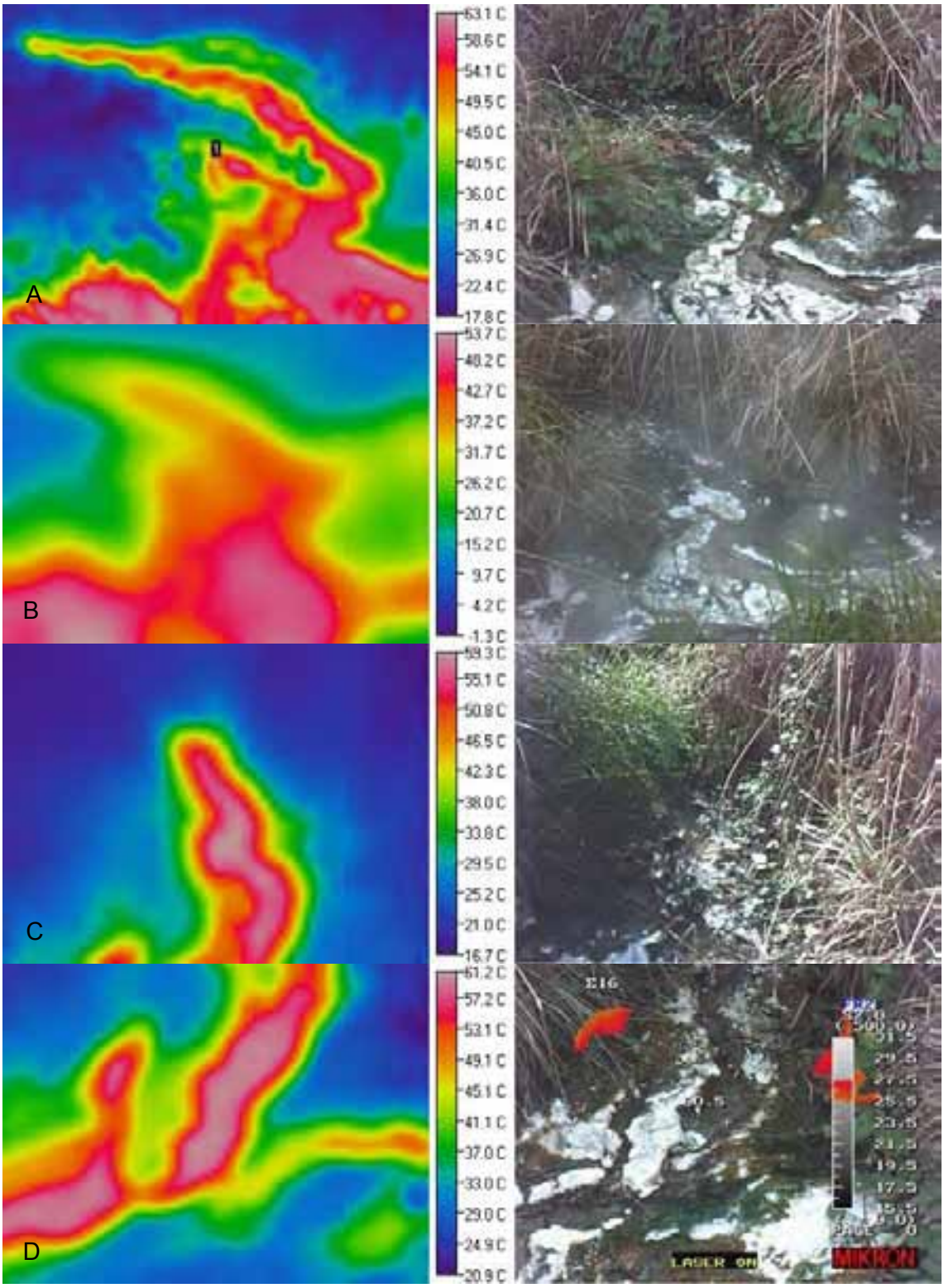


Figure 103: Infrared photos of New Spring, Tauhara, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

10 Te Kopia

Located number 72.2117

10.1 Mud Geyser and associated pools

- **Large pool and mud volcano**
  E1880802 N5744756

WRC staff could not access the large pool and mud volcano in January 2014. The Department of Conservation has recently been installing a walkway in the area, therefore, WRC should be able to access the site on the next monitoring visit.

Figure 104: Large pool, Te Kopia, Jan 2014

- **Large Pool and Mud Geyser on Geyser Ridge**
  E1880758 N5744696

During the January 2014 monitoring visit it was noted that the temperature was 51.7 °C (down from 77 °C in the previous visit in January 2013). However the infrared photo does show areas around the edges of the pool that are approximately 70 °C. The water level was approximately 8 m below the rim; it has dropped about 5 m since the previous visit. The water was brown/grey and murky. There was constant vigorous discharge in several areas of the pool.

There appears to have been recent activity from the pool, there is mud splatter up to approximately 5 m from the rim, and the mound in front of the pool appears to have increased in size. The mud geyser could not be seen due to the drop in water level and the increased amount of mud around the rim.

Figure 105: Large Pool (A) and Mud Geyser (B), Te Kopia, Jan 2013 (C) and (D), Jan 2014

Figure 106: Recent activity at Mud Geyser, Te Kopia, Jan 2014

The Large pool on Geyser Ridge appears to be warmest where it is closest to the mud geyser. Several hot spots can be seen in the January 2014 photo.

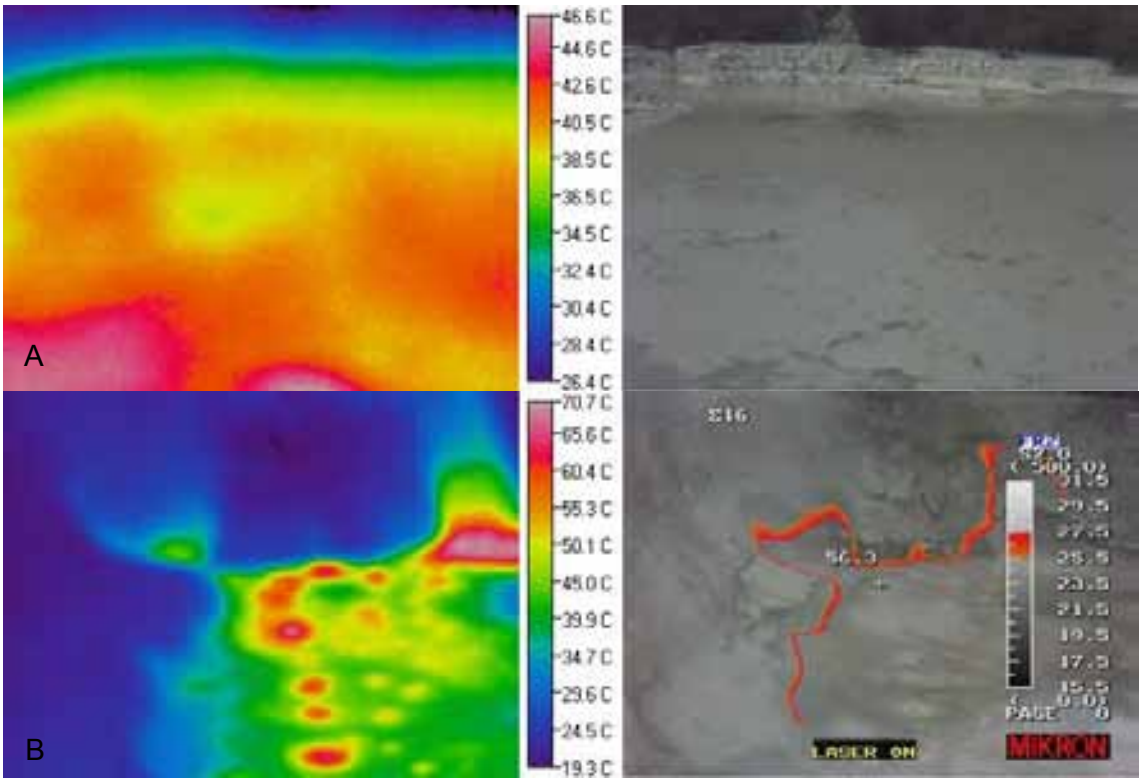


Figure 107: Infrared photos, Large Pool on Geyser Ridge, Te Kopia in Jan 2013 (A) and Jan 2014 (B)

- **Small Mud Pool on Geyser Ridge**
  E1880750 N5744694

There was evidence of a recent eruption in both Jan 2013 and January 2014. There was a large decrease in temperature decrease (48 °C) since the previous visit in January 2013.

Table 45: Data from the small mud pool on Geyser Ridge, Te Kopia

Date	T(°C)	Flow (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
22 Jan 2013	83	Steam	1.1	~1.3 x 2.2	Calm	Light grey mud
30 Jan 2014	35	Little steam	nd	~1.3 x 2.1	Calm	Light grey mud

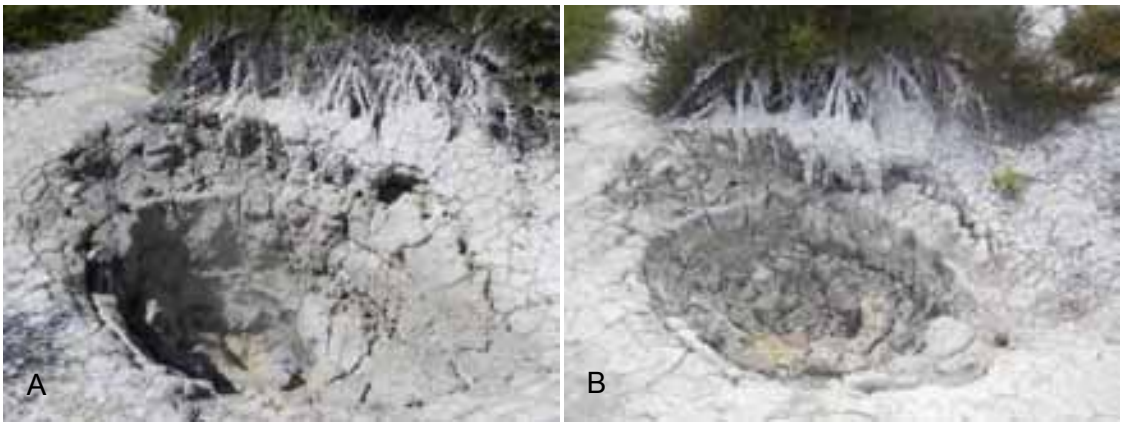


Figure 108: Small mud pool on Geyser Ridge, Te Kopia in Jan 2013 (A), Jan 2014 (B)

The hottest part of the mud pool appears to be near the front of the pool. It appears to be about 15 °C warmer than the IR gun measured. The pool was warmer in January 2013 than in January 2014.

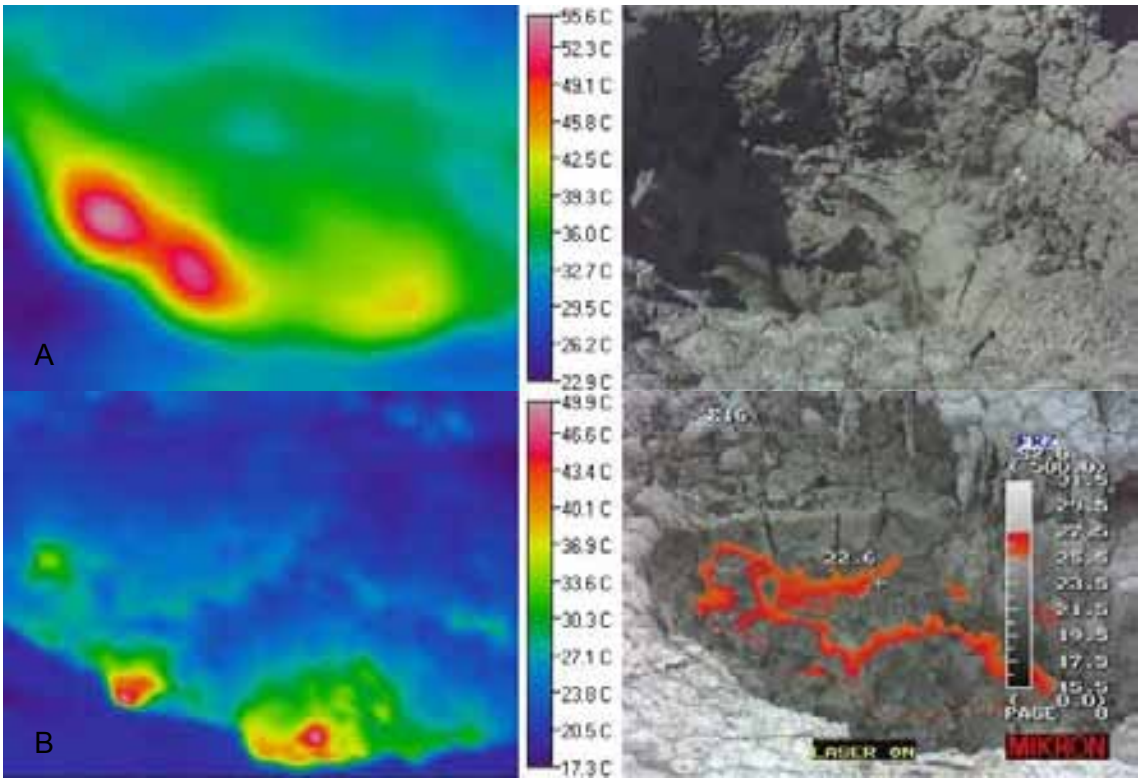


Figure 109: Infrared photos, small mud pool on Geyser Ridge, Te Kopia in Jan 2013 (A) and Jan 2014 (B)

10.2 Mud Pools (Tomos) on west of Te Kopia Road

- **TK8**

The temperature has increased by 38.4 °C since the previous visit in January 2013. There has been a significant increase in activity in the area over the previous six to nine months, according to the landowner. A hole has opened up which joins TK8 to Doom. There is vigorous activity in the vent and there is mud splatter surrounding TK8.

Table 46: Data from TK8 on Te Kopia Road

Date	T(°C)	pH	Flow (l/s)	Depth to water	Ebullition	Colour
22 Jan 2013	60	-	Steam	Dry	Audible discharge	Brown/grey mud at base
30 Jan 2014	98.4	-	Steam	3-4 m below lower rim	Vigorous discharge	Brown/grey mud and water

Figure 110: TK8, Te Kopia in Jan 2013 (A&B), Jan 2014 (C&D)

- **Doom**

In January 2013 there did not appear to be any activity in the vent, however this had changed significantly by January 2014. According to the landowner, in recent months the mud had erupted to a distance of several metres from the vent. The vent has joined up with TK8.

Table 47: Data from Doom on Te Kopia Road

Date	T(°C)	pH	Flow (l/s)	Depth to water	Ebullition	Colour
22 Jan 2013	20	-	-	Dry	Calm	nd
30 Jan 2014	97.7	-	-	6 m below top rim	Vigorous discharge	Brown/grey mud and water

Figure 111: Doom, Te Kopia, Jan 2013 (A) and Jan 2014 (B)

The photo below shows the area of mud splatter from Doom.

Figure 112: Doom, Te Kopia, Jan 2014

The infrared photos below show the heat being produced from Doom. The highest temperature is situated at the back of the vent, close to where it joins up with TK8.

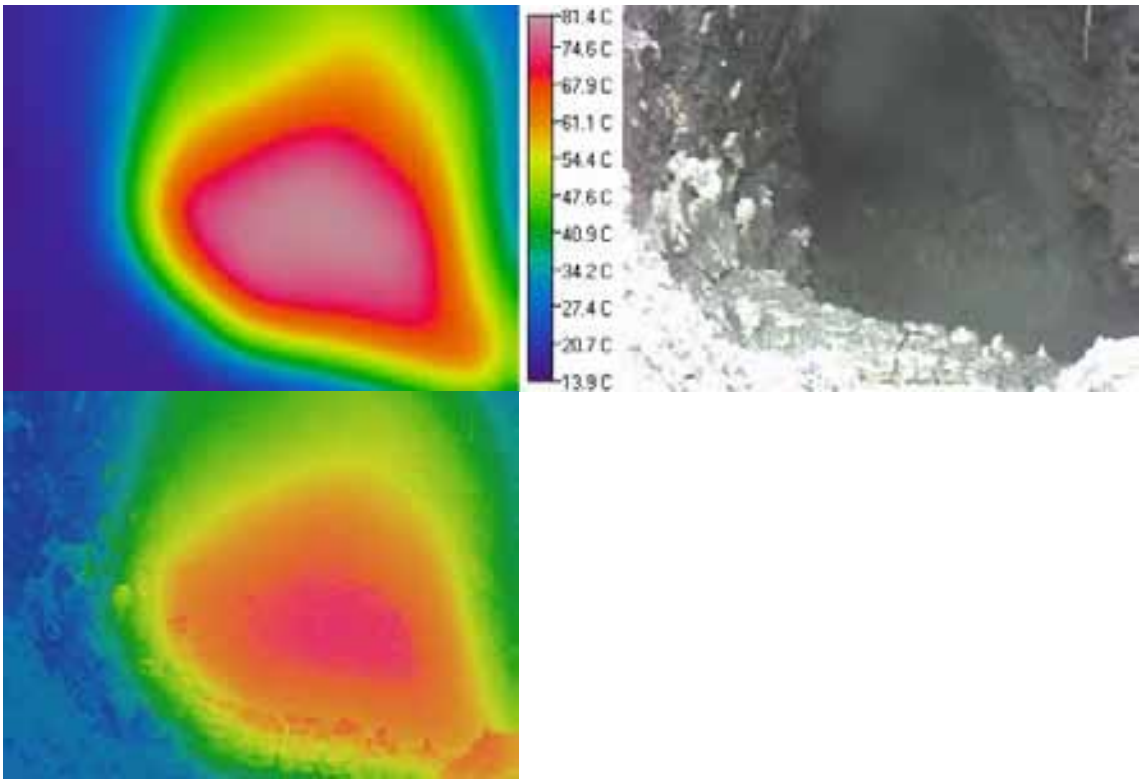


Figure 113: Infrared photos of Doom, Te Kopia, Jan 2014

- Pools by the stream

The temperature had decreased by 35.3 °C since the previous visit in January 2013. However, the temperature reading was taken approximately five metres away from the pool and is most likely not accurate. The pool was steaming. The ground surrounding was too soft to walk on; therefore, we could not get close to the pool.

Table 48: Data from Mud pools by the stream on Te Kopia Road

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
22 Jan 2013	92.3	-	-	Dry	Bubbling mud	Grey mud
30 Jan 2014	57	-	-	Non visible	Audible discharge	Grey mud

Figure 114: Mud pools by stream, Te Kopia in Jan 2013 (A), Jan 2014 (B)

The main mud pool can be seen in the infrared photo below. The heat appears to be consistent at the base of the pool; there are also several hot spots further up the bank from the pool.

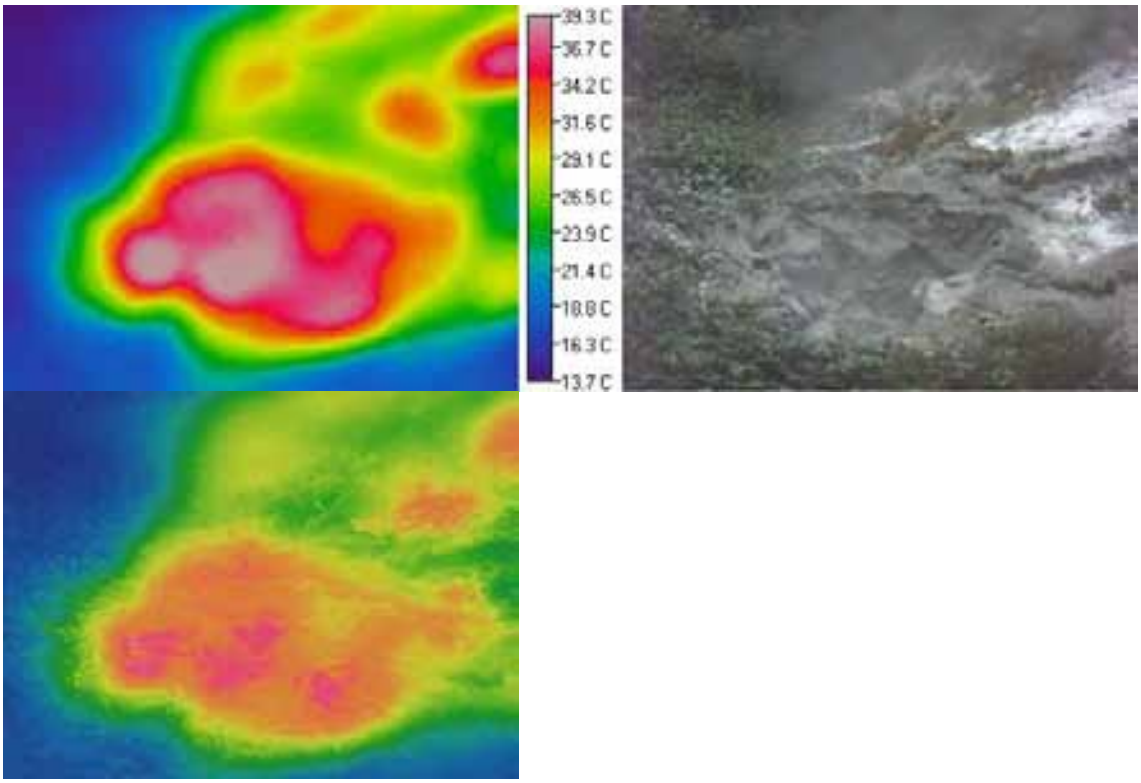


Figure 115: Infrared photos of mud pools by stream, Te Kopia, Jan 2014

- **Area below TK8**

The area below TK8 has shown recent activity. The ground is warm is several areas, and has been steaming for the past 6 months. There is a mud pool about the area of steaming ground that erupted recently, as there is mud splatter surrounding the pool. The mud pool is situated in the area to the right of the steaming ground.

Figure 116: Steaming ground below TK8

The infrared photo below shows that the steaming ground reaches temperatures of up to 47 °C.

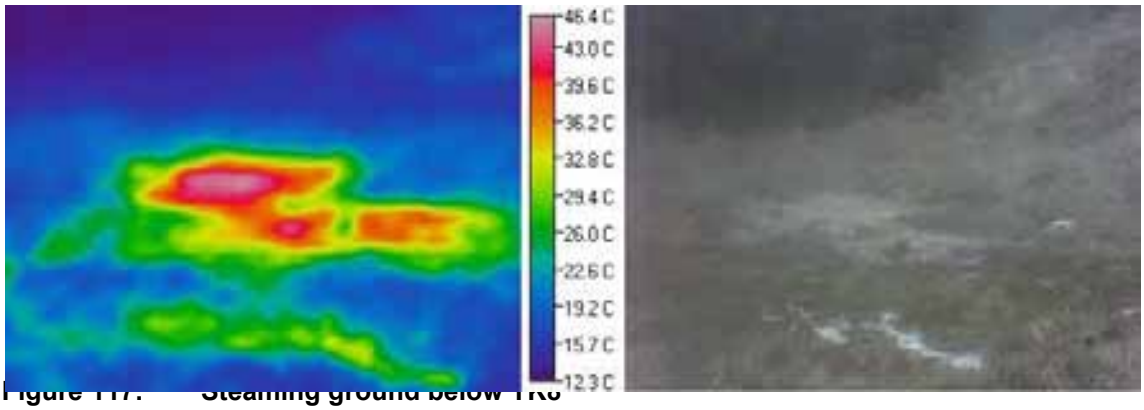


Figure 117: Steaming ground below TK8

The mud pool reached a temperature of 82.7 °C. It consisted of brown mud, there was audible gas discharge and the pool measured approximately four metres in diameter. There was no water in the pool.

Figure 118: Mud pool below TK8

11 Waikite

11.1 Waikite Swimming Pool area

- **Manaroa Pool**
  E1888904 N5752722; Located number 72.4227

There was a temperature decrease in September 2013; however, the temperature had increased again by February 2014. The pH dropped from pH 8-9 in April 2013 to pH 7-8 in February 2014. Readings were not taken in June or September due equipment limitations. There appears to be one main area of upwelling which surges vigorously. At some of the monitoring visits there were smaller areas of upwelling in the pool.

Table 49: Data from Manaroa Pool, Waikite

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	97.5	8-9	~40-50	Overflowing	Surging up to 0.5 m with vigourous upwelling in 2 other areas	Clear, blue
27 June 2013	96.8	nd	~40-50	Overflowing	Surging up to 1 m with vigorous upwelling	Clear, blue
25 Sept 2013	82.9	nd	~40-50	Overflowing	Surging up to 1 m extremely vigorous upwelling in centre	Clear, blue
04 Feb 2014	98.7	7-8	~40-50	Overflowing	Surging, vigorous upwelling	Clear, blue

Figure 119: Manaroa Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

Hot Pool Supply Gully

- **Upper Supply Spring**
  E1888866 N5752705; Located number 72.4227

The temperature and pH fluctuates with each visit. There was a temperature drop of 11.4 °C from June 2013 to September 2013 however; this had increased again by January 2014.

Table 50: Data from Upper Supply Spring, Waikite

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	92.5	9	Piped	Overflowing	Vigorous discharge, boiling	Clear
27 June 2013	94.2	8	Piped	Overflowing	Vigorous discharge, boiling	Clear
25 Sept 2013	83.6	8-9	Piped	Overflowing	Vigorous discharge, boiling	Clear
04 Feb 2014	95.0	7-8	Piped	Overflowing	Vigorous discharge, boiling	Clear

Figure 120: Upper Supply Spr, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

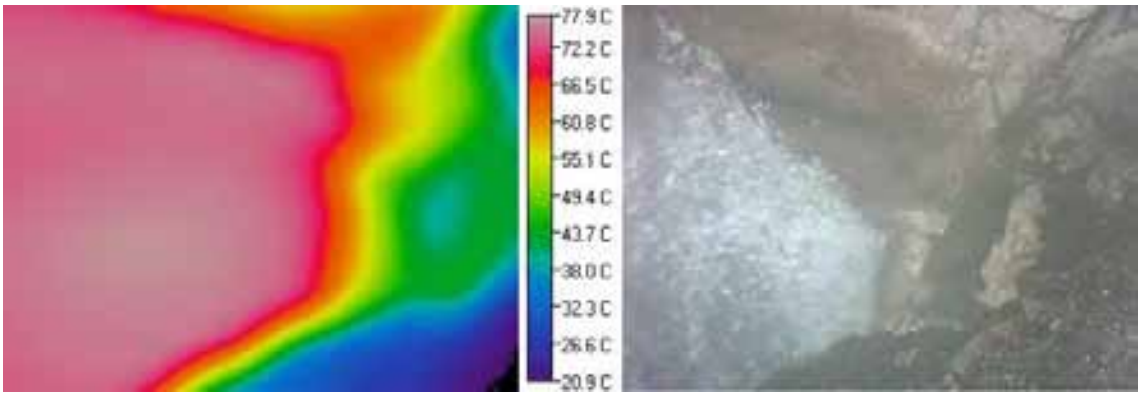


Figure 121: Infrared photo of Upper Supply Spring, Waikite, June 2013

- **Lower Supply Spring**
  Located number 72.4228

There are two areas of discharge associated with this spring, which flow into the same pool. In September 2013, the spring was discharging more vigorously than usual. The temperature and pH fluctuates with each visit. There was a temperature drop of 6.9 °C from June 2013 to September 2013; however, this had increased again by January 2014.

Table 51: Data from Lower Supply Spring, Waikite

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	94.8	9	Piped	Overflowing	Vigorous discharge, boiling	Clear
27 June 2013	94.7	7	Piped	Overflowing	Vigorous discharge, boiling	Clear
25 Sept 2013	87.8	9	Piped	Overflowing	Extremely vigourous	Clear
04 Feb 2014	95.6	8-9	Piped	Overflowing	Vigorous discharge, boiling	Clear

Figure 122: Lower Supply Spring, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

- **Pool adjacent to Lower Supply Spring**

There was a temperature drop between June 2013 and September 2013 of 5.7 °C. Temperature had risen back up to 81.3 °C by January 2014.

Table 52: Data from Pool adjacent to Lower Supply Spring, Waikite

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	84.5	7	<0.5	Overflowing	Upwelling from various areas across the whole pool.	Clear
27 June 2013	80.9	7	<0.5	Overflowing	Constant upwelling	Clear, blue
25 Sept 2013	75.2	7-8	<0.5	Overflowing	Constant upwelling	Clear, blue/grey
04 Feb 2014	81.3	7	<0.5	Overflowing	Constant upwelling	Clear

Figure 123: Pool adjacent Lower Supply, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2013 (D)

The infrared photo below shows that the heat of the pool originates from the centre and cools as it nears the edges.

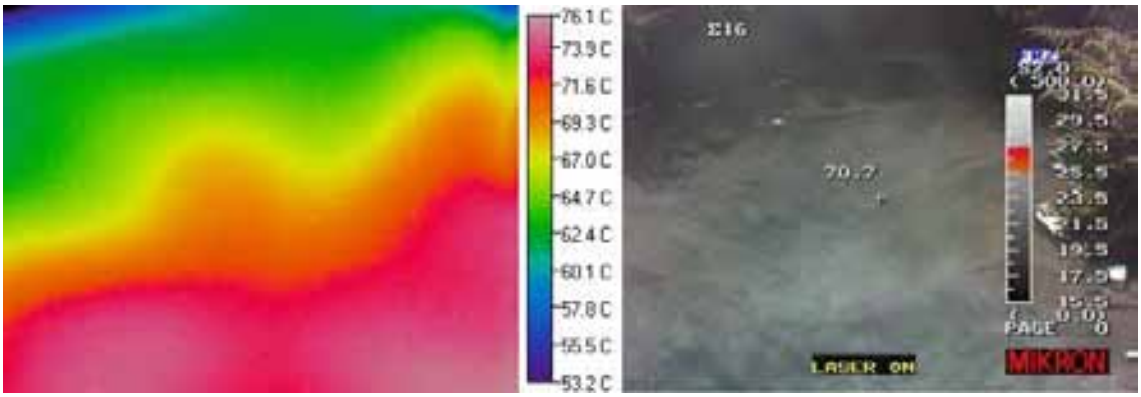


Figure 124: Infrared photo of Pool adjacent Lower Supply, Jan 2014

11.2 DOC Reserve on Landcorp Farm

- **Scalding Spring**

This spring is located in a stock paddock and had therefore been fenced off. A slightly submerged sinter shelf extends ~1 metre from the edge before the pool becomes very deep. The clarity of the water allows visibility to a depth of at least 5 m, although the bottom of the pool is not visible at this depth. The pool flows on to a sinter terrace and forms a small stream, which leads into the Otamakokore Stream.

April 2013: The water temperature of the Otamakokore stream above and below the outflow of the sinter terrace stream appears unaffected with a reading of 41.2 °C in both areas.

February 2014: The water temperature of the Otamakokore stream above and below the outflow of the sinter terrace stream appears unaffected with a reading of 44.3 °C upstream and 44.6 °C downstream of the outlet.

Table 53: Data from Scalding Spring, Waikite

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	94.0	8	<0.5	Overflowing	Constant near the outlet	Clear, blue
27 June 2013	93.4	8	<0.5	Overflowing	Constant near the outlet	Clear, blue
25 Sept 2013	84.5	8-9	Seep (0.5-1 during surges)	Overflowing	Constant near outlet	Clear, blue
04 Feb 2014	92.4	7-8	<0.5	Overflowing	Constant near outlet	Clear, blue

Figure 125: Scalding Spring, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photo below shows that the main area of heat in the pool is near the outlet where the upwelling occurs.

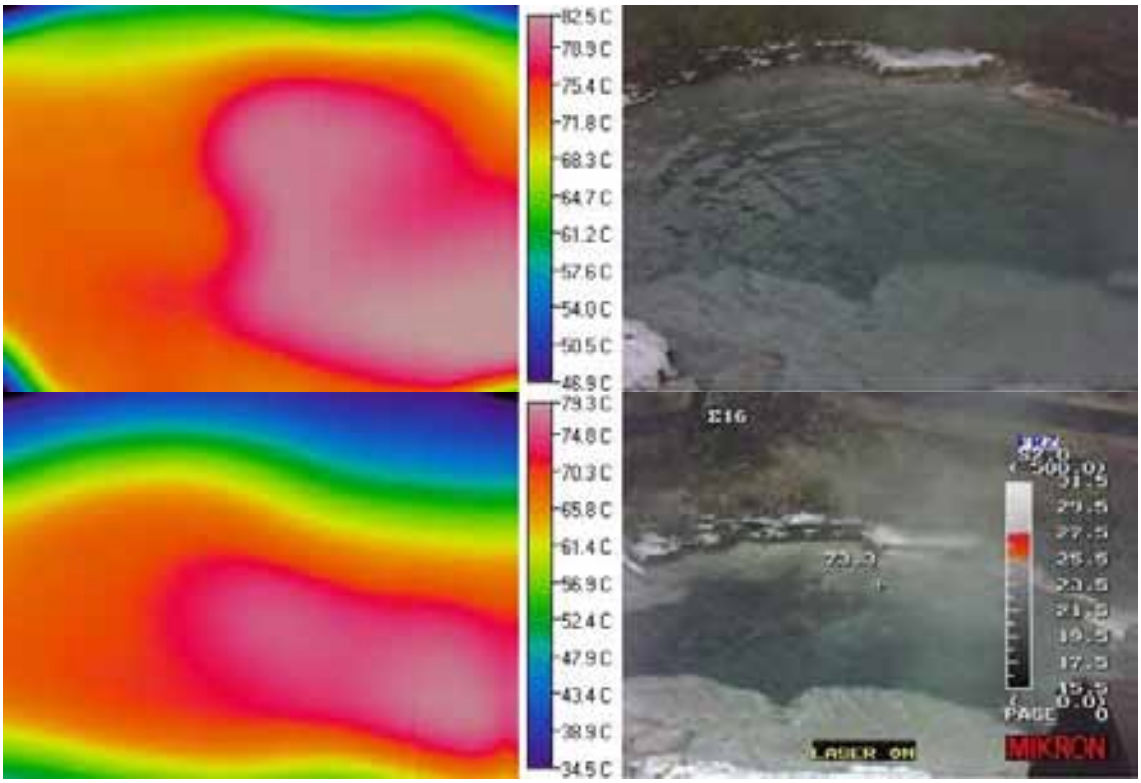


Figure 126: Infrared photo of Scalding Spring, Waikite, Sept 2013

- **Waikite Scarp and Spring**
  Located number 72.4393

The spring discharges into a small stream, which flows onto the sinter terraces. There is new sinter both in the channel and on the margins of the stream. The terrace that the stream flows onto appears to have green and yellow algae growing on it.

The temperature is less during the September 2013 and January 2014 monitoring visits as we could not access the spring itself, and the temperature reading was taken from the stream.

April 2013: The spring discharges into a small stream, which flows onto the sinter terraces. The vegetation had died back enough during this visit to allow access to the spring. The flow and pH have remained constant since the January visit but the temperature had dropped by 3.8 °C.

January 2014: The stream appears to be widening. The vegetation alongside the stream has grown up to 1.6 m tall. The algal growth has increased.

Table 54: Data from Spring, Waikite Scarp

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 13	92.5	9	0.5	-	Calm, steam	Clear
27 June 2013	92.5	9-10	~1	-	Constant upwelling	Clear
25 Sept 2013	72.1	9-10	-	-	Calm	Clear
04 Feb 2014	68.4	8-9	-	-	Calm	Clear

Figure 127: Hot stream (A), and discharge area onto terraces (B) and (C), Apr 2013

Figure 128: Hot spring (A&B). Hot stream (C&D) and discharge area onto terraces (E&F), June 2013

Figure 129: Hot stream (A) and (B) discharge area onto terraces (C) and (D), Sept 2013

Figure 130: Hot stream (A) and (B), discharge area onto terraces (C) and (D), Jan 2014

The warm water can be seen flowing over the sinter terrace of the Waikite Scarp in the infrared photos below.

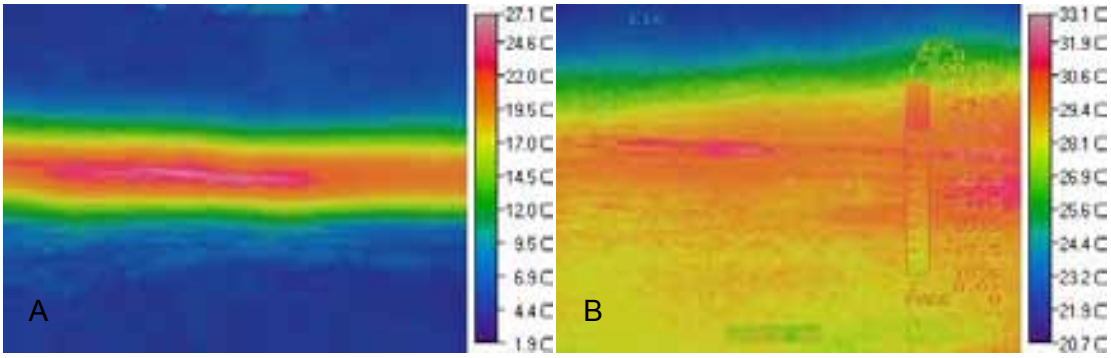


Figure 131: Infrared photos, Waikite scarp terraces, June 2013 (A) and Jan 2014 (B)

12 Waiotapu

12.1 Tourist Walk

- **Weather Pool**
  E1894318 N5749245

The temperature fluctuates throughout the monitoring period, ranging from 26.5 °C to 48.7 °C. This could be due to the amount of steam present as this will affect the reading with the IR gun. There are slight variations in the colour of the pool.

Table 55: Data from Weather Pool, Waiotapu

Date	T(°C)	Water level	Ebullition	Colour
16 April 2013	38.0	Overflowing	Calm	Murky, blue/grey
25 June 2013	26.5	Overflowing	nd	Cloudy, aqua
25 Sept 2013	48.5	Overflowing	Occasional bubbles	Murky, grey/green
29 Jan 2014	48.7	Overflowing	Occasional bubbles	Cloudy, blue/green

Figure 132: Weather Pool in Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

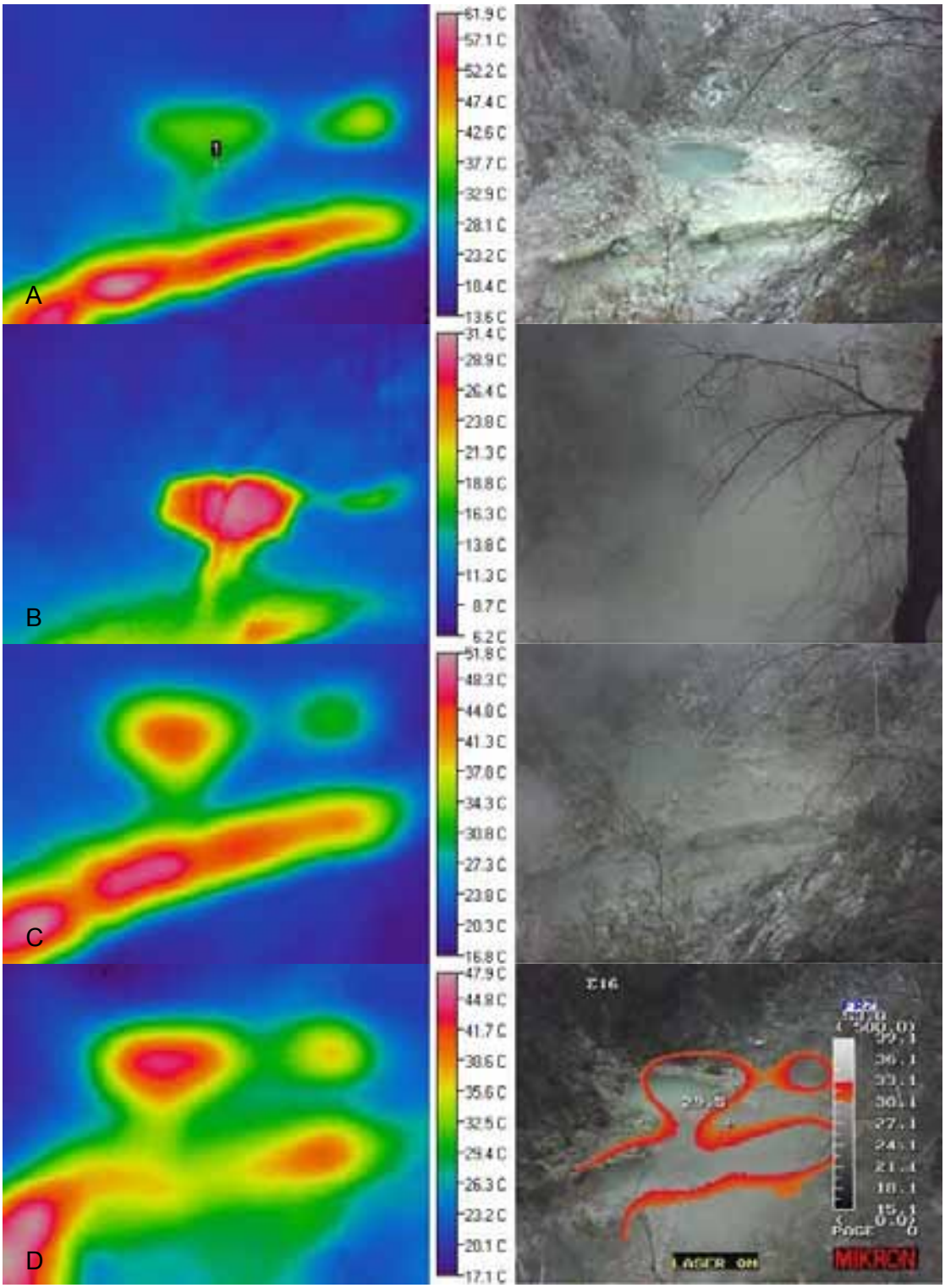


Figure 133: Infrared photos of Weather Pool, Waiotapu, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Pool north of Jean Batten Geyser**

The pool appears to be thermally inactive. It has not been warmer than 22 °C throughout the monitoring period. The pH was not measured in September 2013 and January 2014. The colour and level have varied during the period.

Table 56: Data from Pool north of Jean Batten Geyser, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	18.4	4	seep	overflowing	Calm	blue-green
25 June 2013	15.1	4	nd	Top of pool	Calm	Murky, blue/green
25 Sept 2013	22	5	nd	Top of pool	Calm	Clear
29 Jan 2014	21	nd	nd	Dry	-	-

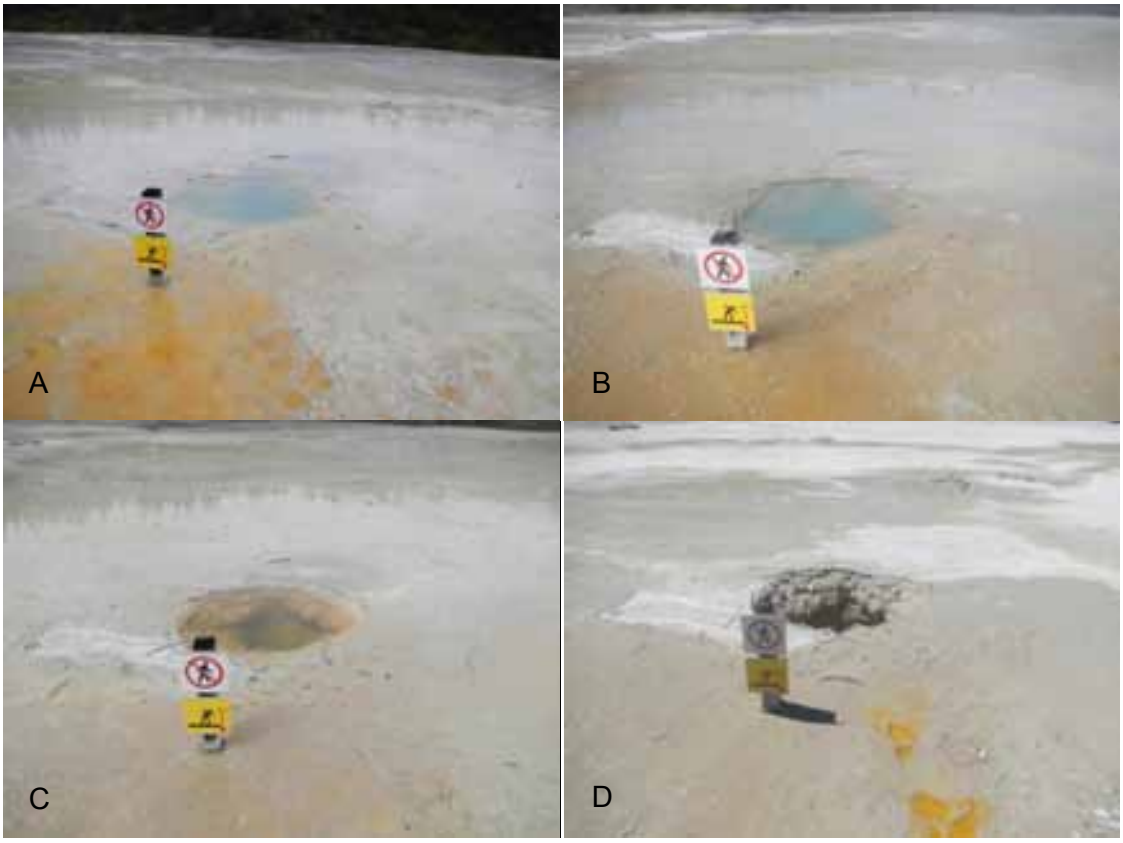


Figure 134: Pool N of Batten, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photos below show that the ground in front of the pool was warmer than the terraces behind it. The pool has some heat in it, but appears to be cooler on the surface than the ground in front of it.

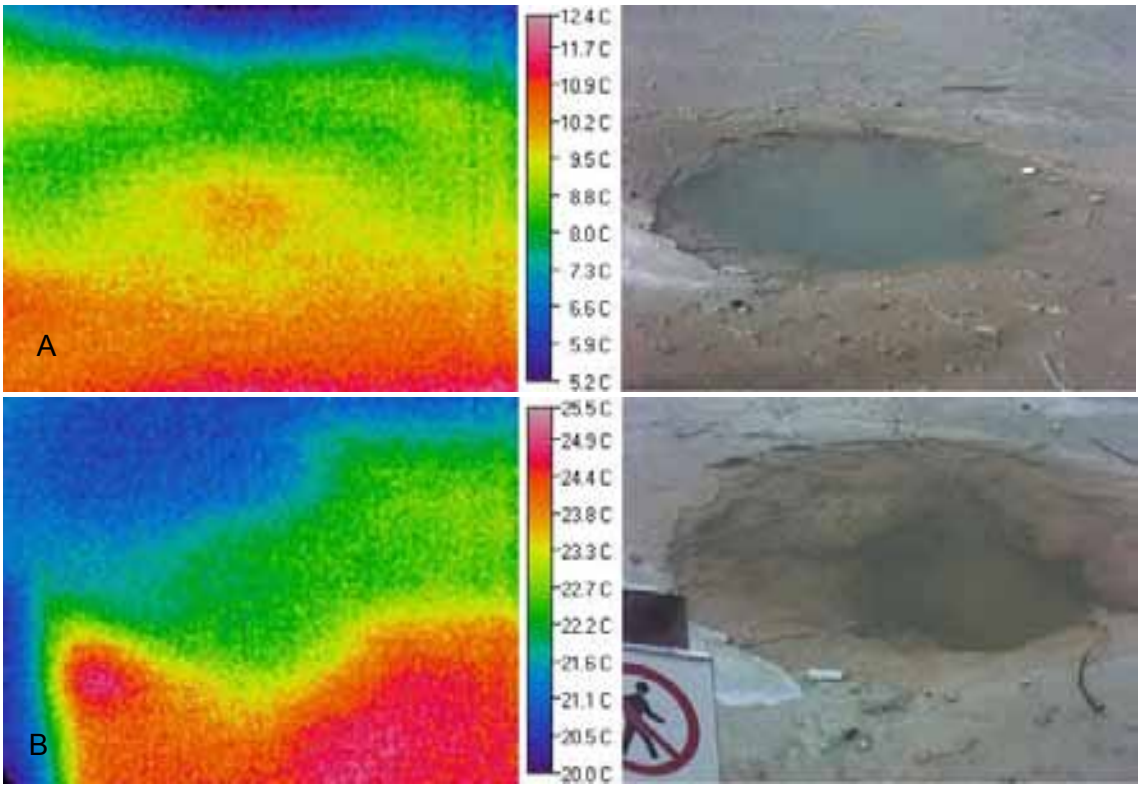


Figure 135: Infrared photos, pool next to the Jean Batten Geyser in June 2013 (A), Sept 2013 (B)

- **Jean Batten Geyser**

The temperature has fluctuated throughout the period. In September 2013 the temperature was measured with the IR gun which would account for the lower temperature as it wouldn't be able to reach the water.

Table 57: Data from Jean Batten Geyser, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	55.0	nd	In flow only	No visible water	-	-
25 June 2013	97.2	nd	nd	No visible water	steaming	-
25 Sept 2013	38.5	nd	In flow – seep	No water visible	Steaming, audible discharge	-
29 Jan 2014	94.3	nd	-	No visible water	Steaming, audible discharge	-

Figure 136: Jean Batten Geyser, Apr 2013 (A), June 2013 (B) and Sept 2013 (C)

The infrared photos in Figure 137 show the heat emanating from the geyser and the direction that the steam is blowing.

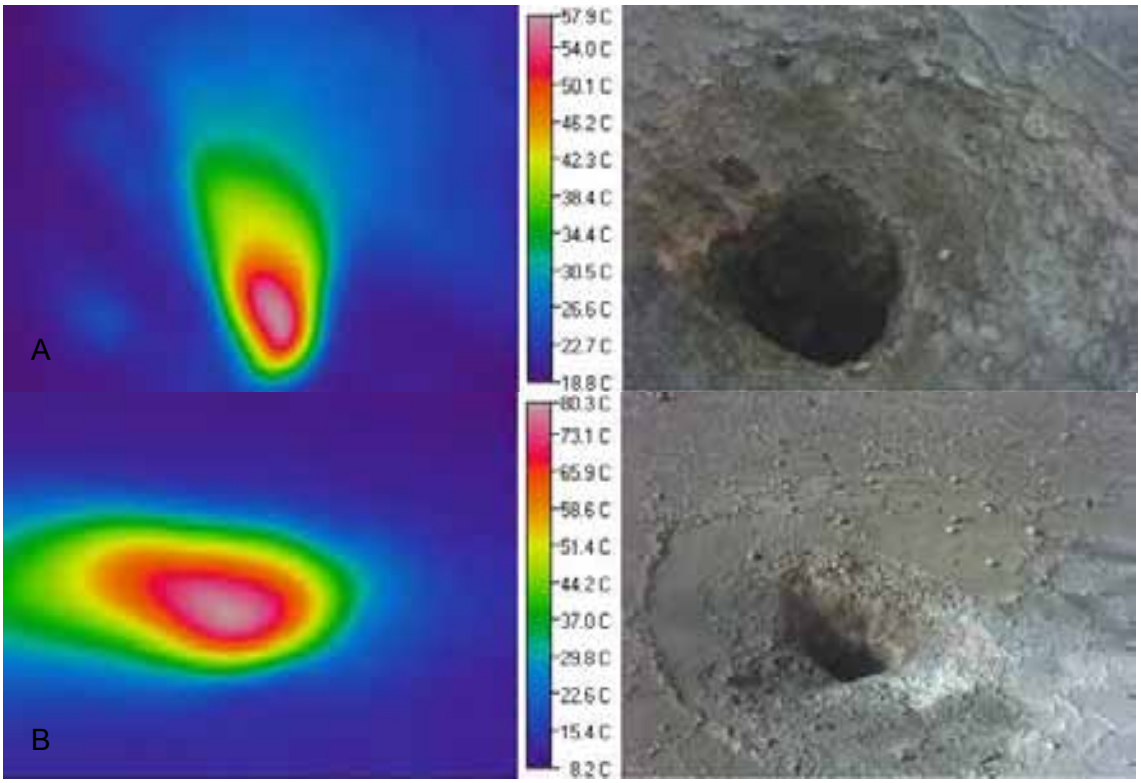


Figure 137: Infrared photos of Jean Batten Geyser, Waiotapu, April 2013 (A), June 2013 (B)

- **Sinter Terraces**

Figure 138: Sinter Terraces, Apr 2013 (A), June 2013 (B) and Sept 2013 (C)

Figure 139: Panoramic view of Artists Palette, Waiotapu, Jan 2014

The infrared image provides a good indication of the heat generated by the Champagne pool and its rapid dissipation over the Artists Palette.

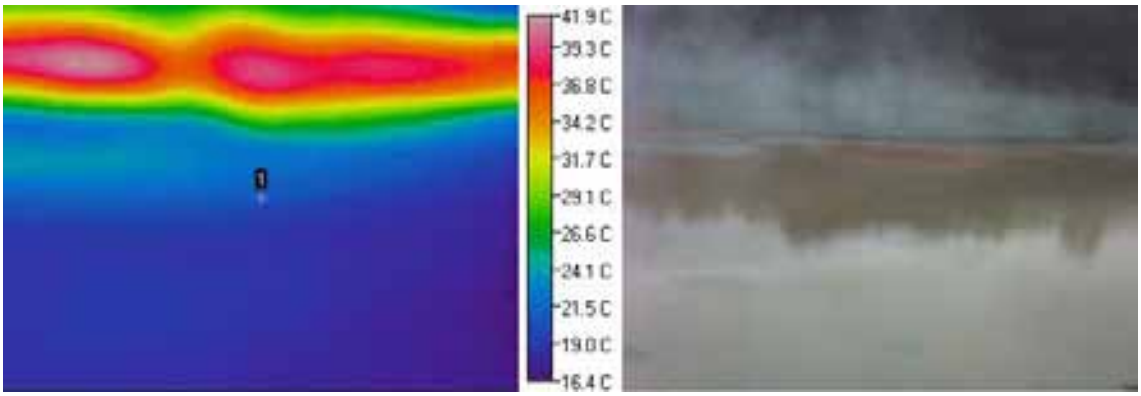


Figure 140: Infrared photos of Artists Palette, Waiotapu, April 2013

- **Sinter Terraces – Yellow coloured vent**

The colour is quite variable.

Table 58: Data from Sinter Terraces – Yellow coloured vent, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	nd	nd	-	submerged	Calm	Murky green/yellow
25 June 2013	nd	nd	-	submerged	Calm	Cloudy, aqua
25 Sept 2013	nd	nd	-	submerged	Calm	Murky, brown
29 Jan 2014	nd	nd	-	submerged	Calm	Green/blue with yellow edges

Figure 141: Yellow coloured vent, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

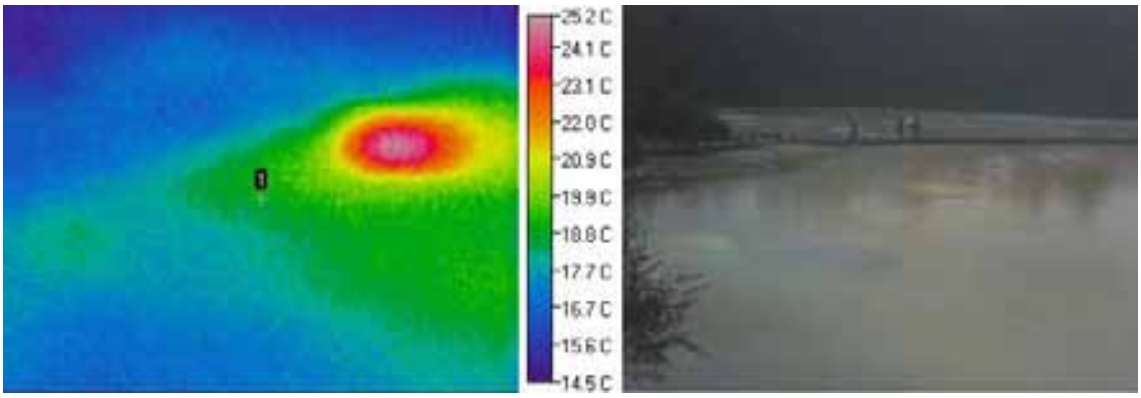


Figure 142: Infrared photos of Yellow Pool, Waiotapu, April 2013

- **Sinter Terraces – Foreground Pool**

The temperature is taken using the IR gun from the platform, which is some distance away so may not be accurate. There were temperature fluctuations through the monitoring period. The colour and ebullition have been inconsistent. In September 2013, there was a weather bomb prior to our visit.

Table 59: Data from Sinter Terraces – Foreground Pool, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	60	nd	-	Submerged	constant discharge	Cloudy green
25 June 2013	48	nd	seep	Overflowing	calm	Murky, Pale green
25 Sept 2013	64.7	nd	-	Not overflowing	Constant effervescing	Murky, brown
29 Jan 2014	69.3	nd	seep	Overflowing	Effervescing on far side	Murky, green

Figure 143: Foreground Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The pool heat seems to be evenly spread throughout the pool. The differences in temperature observed in the infrared photo are most likely due to the steam distorting the temperature reading of the pool itself.

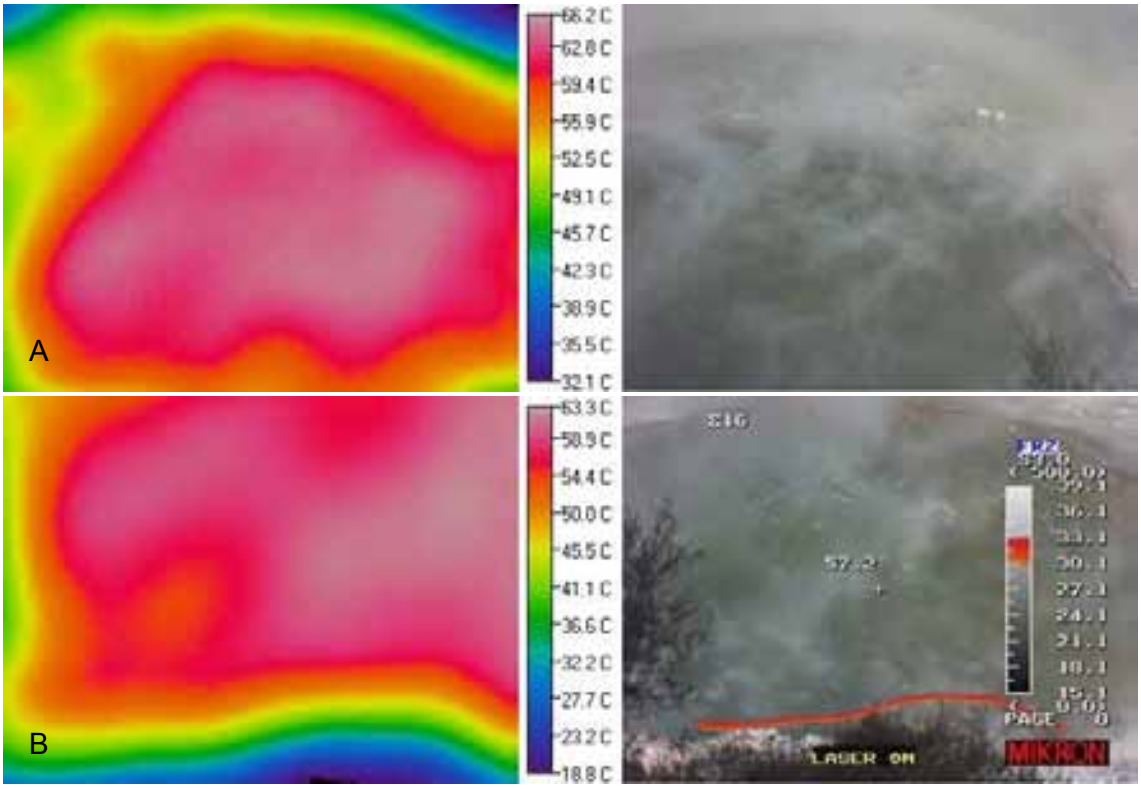


Figure 144: Infrared photos of Sinter Terraces – Foreground Pool, Waiotapu, Sept 2013 (A) and Jan 2014 (B)

- **Waiotapu Geyser**
  E1894389 N5748720; Located number 72.3007

The pH and water level were variable throughout the monitoring period. The temperature increased over the period from 67 °C in April 2013 to 80.3 °C in January 2014.

Table 60: Data from Waiotapu Geyser

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	67	4	-	0.1 m below overflow	Calm, occasional bubbles	Clear
25 June 2013	69.1	3	-	0.5 m below overflow	Calm, occasional bubbles	Clear
25 Sept 2013	67	4	-	0.1 m below overflow	Calm	Clear
29 Jan 2014	80.3	5-6	-	0.3 m below outflow	Calm	Clear

Figure 145: Waiotapu Geyser in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

It can be seen in the Infrared image that the hottest area within the geyser in April coincides with upwelling area. In June, the heat is evenly spread throughout the pool.

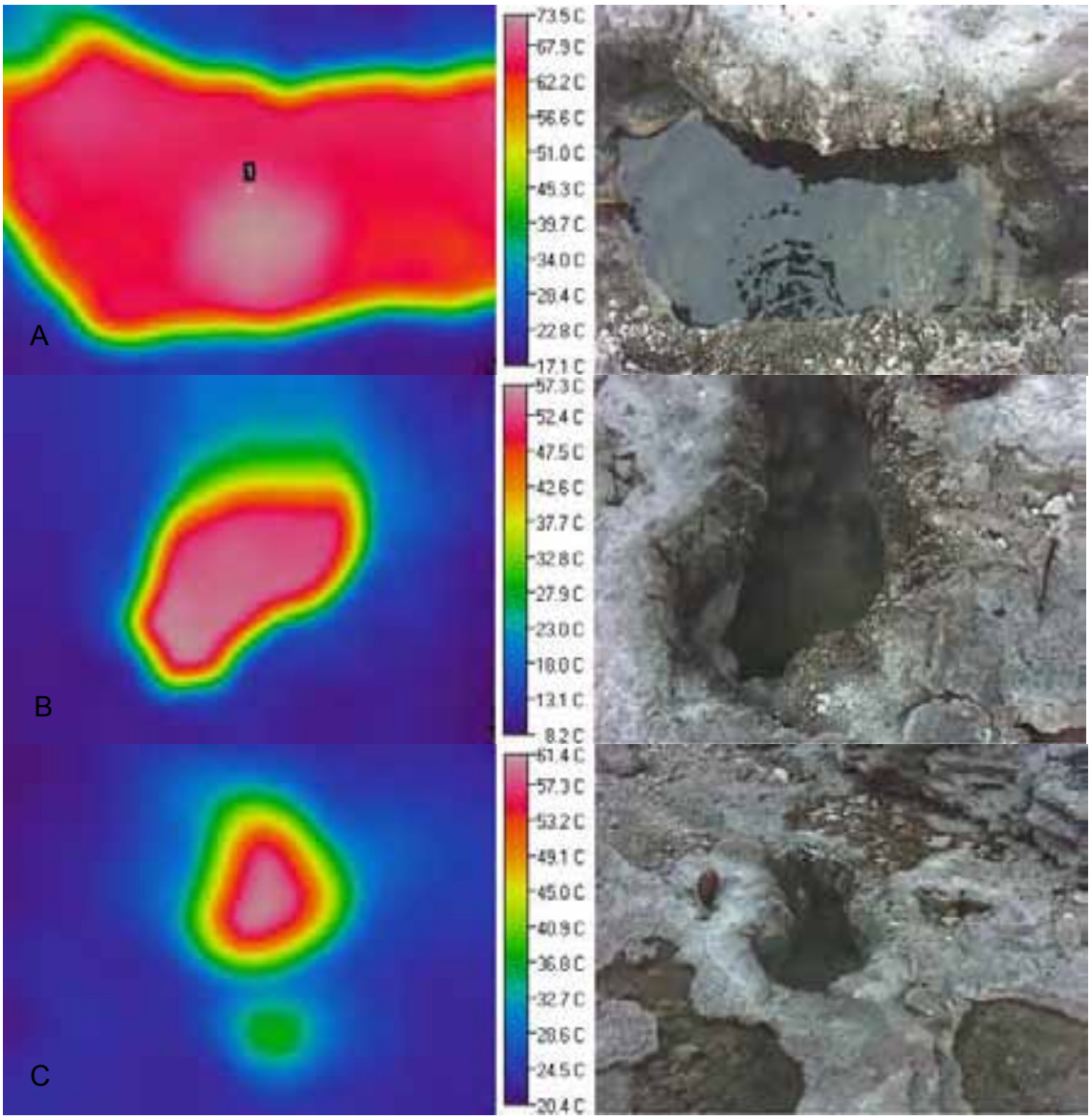


Figure 146: Infrared photos of Waiotapu Geyser, April 2013 (A), June 2013 (B), Sept 2013 (C)

- **Oyster Pool**
  E1894414 N5748668; Located number 72.4225

There does not appear to be any significant changes, apart from the temperature fluctuations.

Table 61: Data from Oyster Pool, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	63	5	Seep	Overflowing	Constant discharge	Cloudy pale green
25 June 2013	56.9	5	Seep	Overflowing	Constant discharge in centre	Cloudy pale green/blue
25 Sept 2013	61	5	Seep	Overflowing	Constant discharge	Cloudy, mint green
29 Jan 2014	51.9	5	Seep	Overflowing	Constant discharge in centre	Cloudy, green/blue

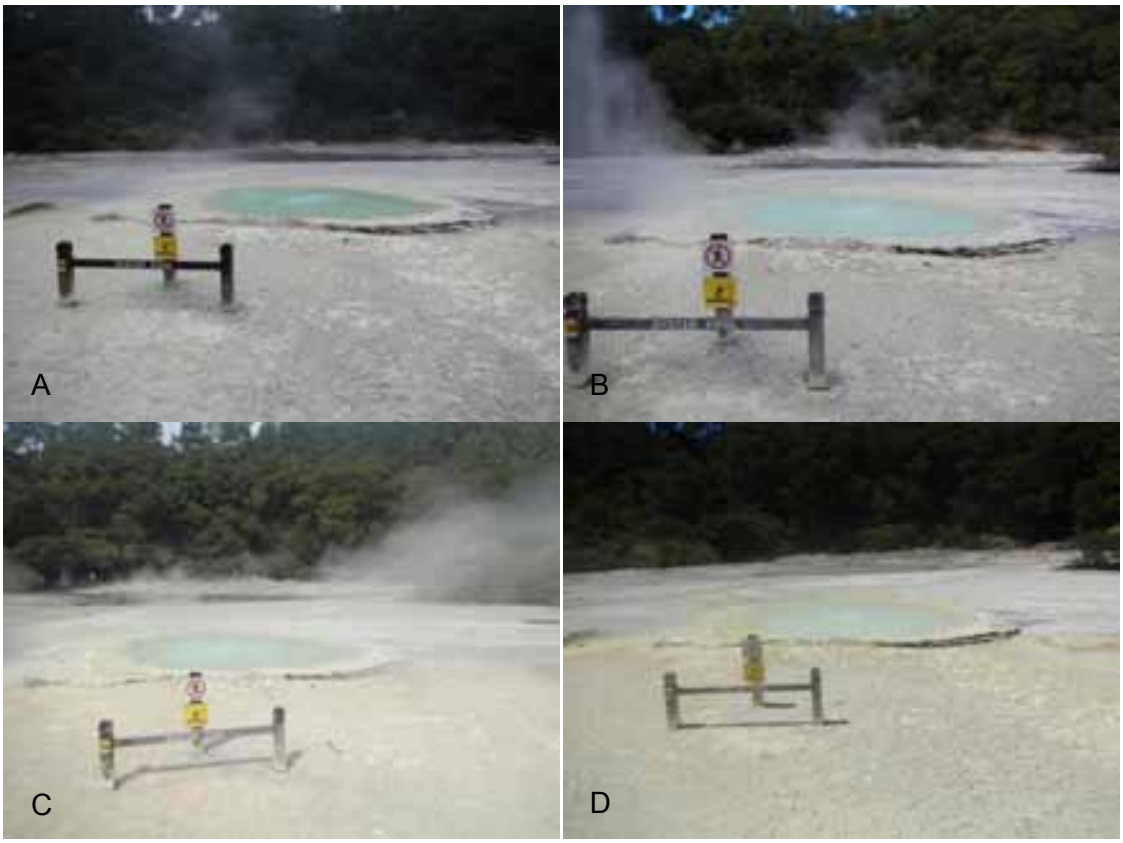


Figure 147: Oyster Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

In the infrared photos for June 2013 in Figure 148 it appears that the majority of the heat in the pool is in the centre and foreground of the pool. However, there is a quantity of steam towards the back of the pool, which may be dissipating the heat that the camera is reading. In September 2013, it appears that the main area of heat is to the right of the pool. However, there was abundant steam during this visit. In January 2014 the heat is spread evenly throughout the pool.

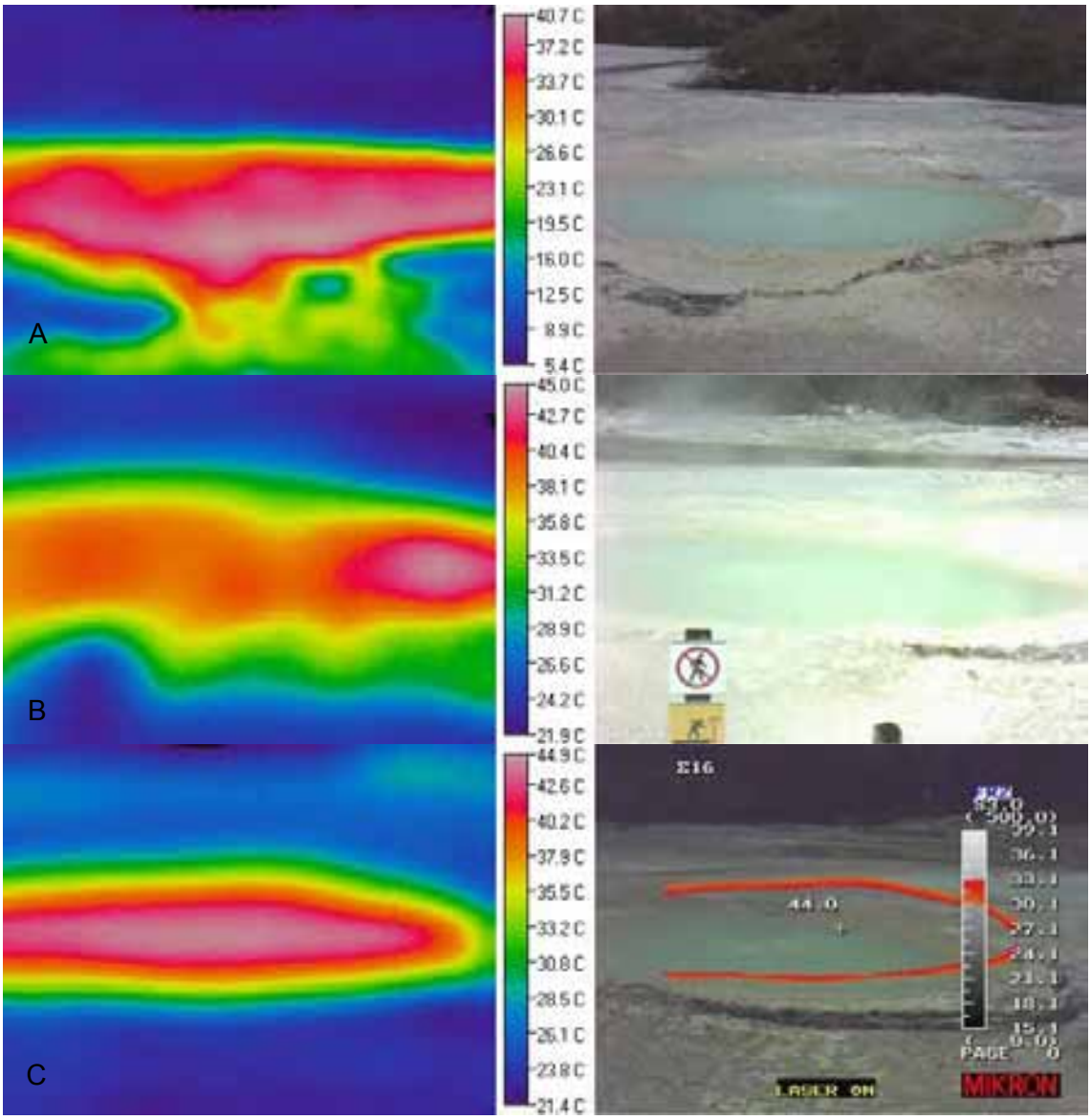


Figure 148: Infrared photos of Oyster pool, Waiotapu in June 2013 (A), Sept 2013 (B) and Jan 2014 (C)

- **Lake Ngakoro**
  Located number 72.4226

The pH is taken from the stream leading into the lake. The temperature has been variable throughout the monitoring period. The pH fluctuated slightly. In Jan 2014, the lake was cloudy green until about 30 m from the stream and then changed to dark green. In September 2013 and January 2014, it was a darker green than usual.

Table 62: Data from Lake Ngakoro, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	29.6	2	Inflow 20 l/s	nd	Bubbles around the edge	Cloudy, green
25 June 2013	33	3	nd	nd	Effervescing around the edges	Cloudy, Pale green
25 Sept 2013	17.2	2	Inflow 30 l/s	nd	Discharge around edges	Murky, green
29 Jan 2014	28.3	3	Inflow 20 l/s	nd	Discharge around edges	Cloudy green

Figure 149: Lake Ngakoro, Waiotapu in Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

The infrared photo below shows the edge of Lake Ngakoro near the inlet of the stream. An area of increased temperature can be seen along the edge near where the lake is effervescing.

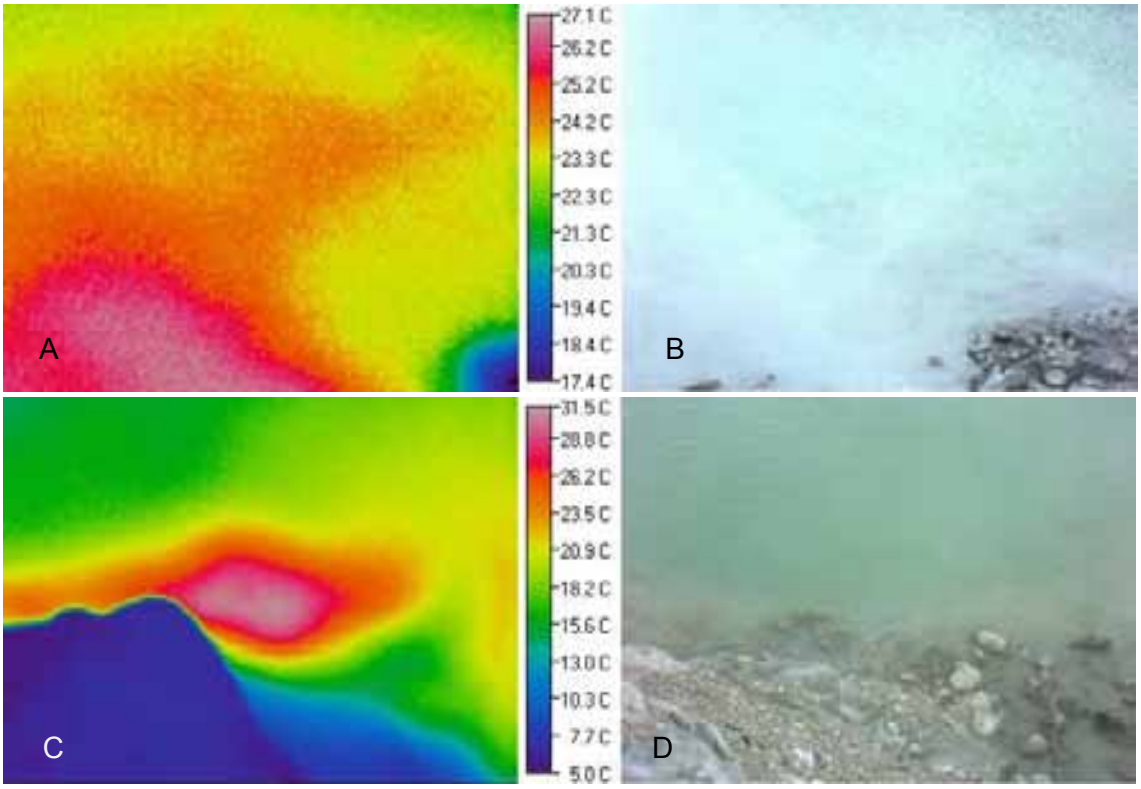


Figure 150: Infrared photos of Lake Ngakoro, Waiotapu in April 2013 (A), June 2013 (B)

- **Champagne Pool**
  E1894414 N5748950

There is orange algal growth around the edges. There are fluctuations in the temperature and pH throughout the monitoring period.

Table 63: Data from Champagne Pool, Waiotapu

Date	T (°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	63	4	-	-	Calm with a smell of H_2S	Green with visibility to 5 m depth.
25 June 2013	73.4	5	Seep	Overflowing	Effervescing around edges, upwelling further in.	Green with visibility to 5 m depth.
25 Sept 2013	63.9	6	Seep	Overflowing	Effervescing all over	Murky, green
29 Jan 2014	75.2	5	<0.5	Overflowing	Effervescing	Green, clear with 3 m visibility

Figure 151: Champagne Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

- **Devil's Bath**

The water level and temperature have risen since during the monitoring period. The colour has been variable.

Table 64: Data from Devil's Bath, Waiotapu

Date	T (°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	21.6	nd	-	2-3 m below high water mark	Constant discharge in several areas.	Bright green
25 June 2013	14.8	nd	Inflow ~4 l/s	2-3 m below high water mark	Constant discharge in several areas.	Cloudy, pale green
25 Sept 2013	26.2	nd	-	2 m below high water mark	Effervescing	Cloudy, lime green
29 Jan 2014	26.4	nd	Inflow ~10 l/s	2 m below high water mark	Small bubbles all over	Murky, bright yellow/green

Figure 152: Devil's Bath, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2013 (D)

The warmest area of the pool appears to be through the centre. The heat of the vent at the back of the pool can be seen in the infrared photo.

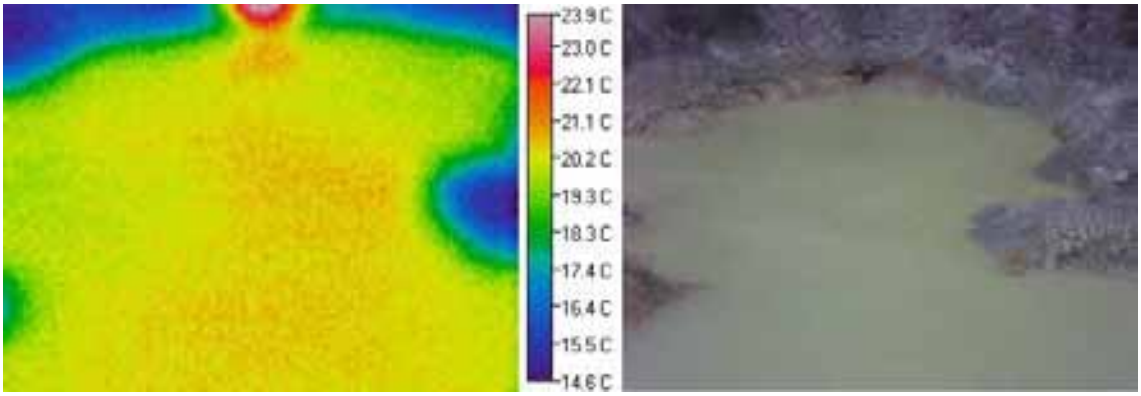


Figure 153: Infrared photos of Devil's Bath, Waiotapu, April 2013

12.2 Knox Geyser area

- **Lady Knox Geyser**

The Lady Knox Geyser erupts at ~10:15am daily, after a surfactant is dropped into the opening of the vent by the staff of Waiotapu. The eruptions we witnessed were all more than 30 minutes long. The pH is from the run-off of the geyser, and the temperature is read from about 5 m away using the IR Gun, so may not be representative of the water temperature as it erupts from the geyser, due to rapid atmospheric cooling.

The temperature of the geyser has fluctuated over the period, however rapid atmospheric cooling would account for cooler temperatures in winter. The pH of the water flowing out of the geyser has also been variable.

April 2013: The geyser was still erupting at 10:51 when the site was vacated.

June 2013: We arrived at 11:00 and it was still erupting when we left at 11:15.

September 2013: The geyser was still erupting at 10:55 when the site was vacated.

January 2014: The geyser was still erupting at 11:00 when we left. According to the proprietors, it had been erupting for only a few minutes in previous days.

Table 65: Data from Lady Know Geyser, Waiotapu

Date	T(°C)	pH	Height	Eruption duration	Colour
16 April 2013	-	-	5	Over 26 minutes	Clear
25 June 2013	74	8	5	Over 35 minutes	Clear
25 Sept 2013	80	5-6	3-6 m	Over 30 minutes	Clear
29 Jan 2014	84.5	5	4-6 m	Over 35 minutes	Clear

Figure 154: Lady Knox Geyser, Waiotapu in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

The geyser's heat can be seen as it moves up the chamber and erupts from the vent. Closer to the geyser a temperature of 74 °C was recorded in June 2013; however, the

water quickly cools as it erupts. The infrared photos are taken from the viewing platform.

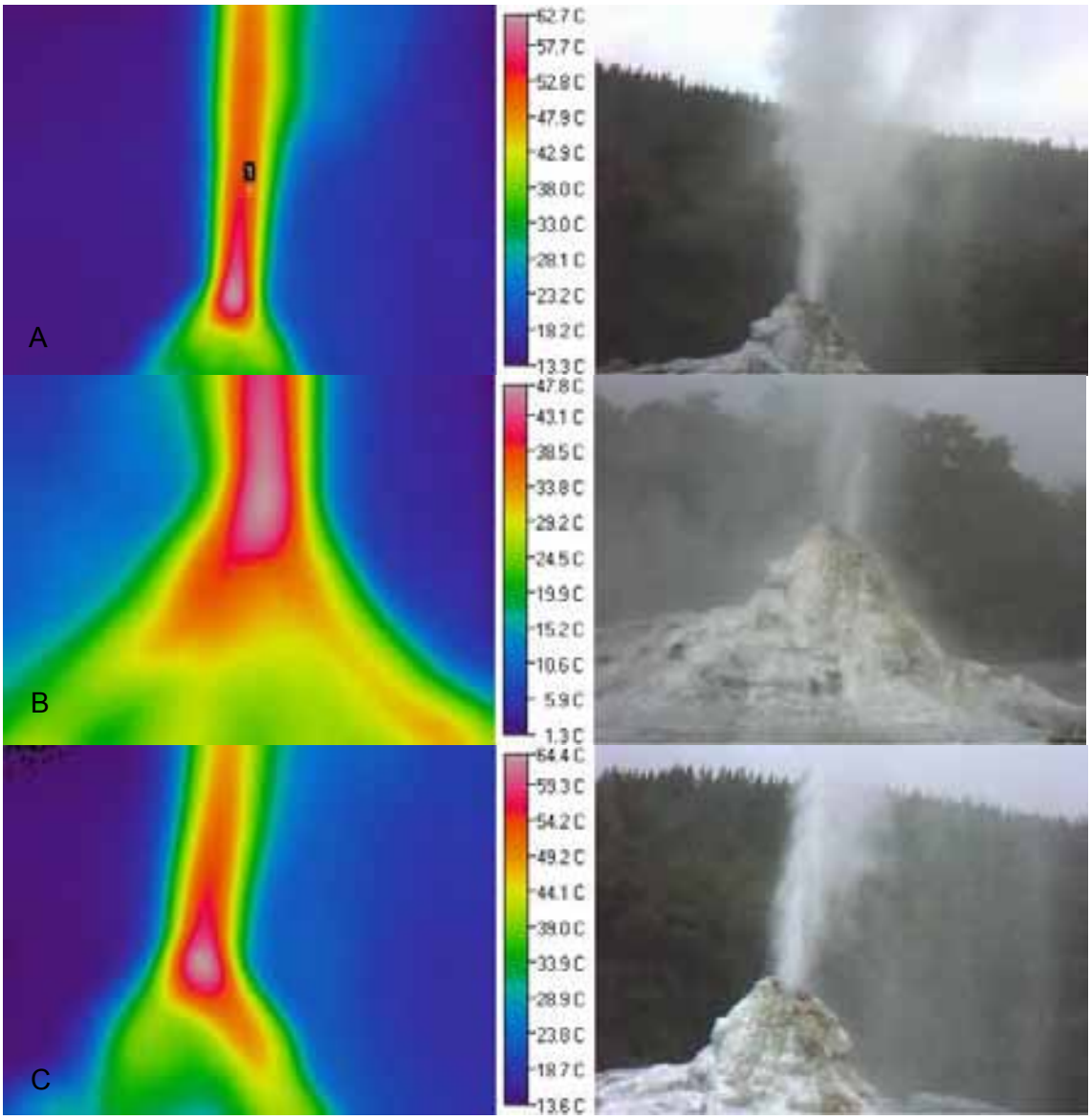


Figure 155: Infrared photos of Lady Knox Geyser, Waiotapu, April 2013 (A), June 2013 (B) and Sept 2013 (C)

- **Knox Hole Spring and Channel**
  E1895123 N5749869

The temperature fluctuates over the monitoring periods.

Table 66: Data from Knox Hole Spring, Waiotapu

Date	T (°C)	pH	Flow (l/s)	Level	Ebullition	Colour
16 April 2013	Spring 60 Channel 83.0	nd	<0.5 (from below spring)	Dry	Audible discharge and steam with an H_2S odour	Clear (from below spring)
25 June 2013	Spring 50.0 Channel 67.7	nd	<0.25 (from below spring)	Dry	Audible discharge and steam with an H_2S odour	Clear (from below spring)
25 September 2013	Spring 61.0	3	<0.5 (from below spring)	Small amount of water	Audible discharge and steam with an H_2S odour	Clear
29 Jan 2014	Spring 49.2 Channel 79.7	3	<0.5 (from below spring)	Dry	Audible discharge and steam with an H_2S odour	Clear, yellow/grey (from below spring)

Figure 156: Knox Spring Hole and Channel, Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

The infrared photos below show that there are two areas of heat in the vicinity of the Knox Spring hole, above and in front of it, in April, June 2013 and January 2014. The vent itself is also hot, however this cannot be seen in the thermal image as it is situated further back in the recess. In September 2013, the heat is spread more evenly and evident in the water that is in the vent.

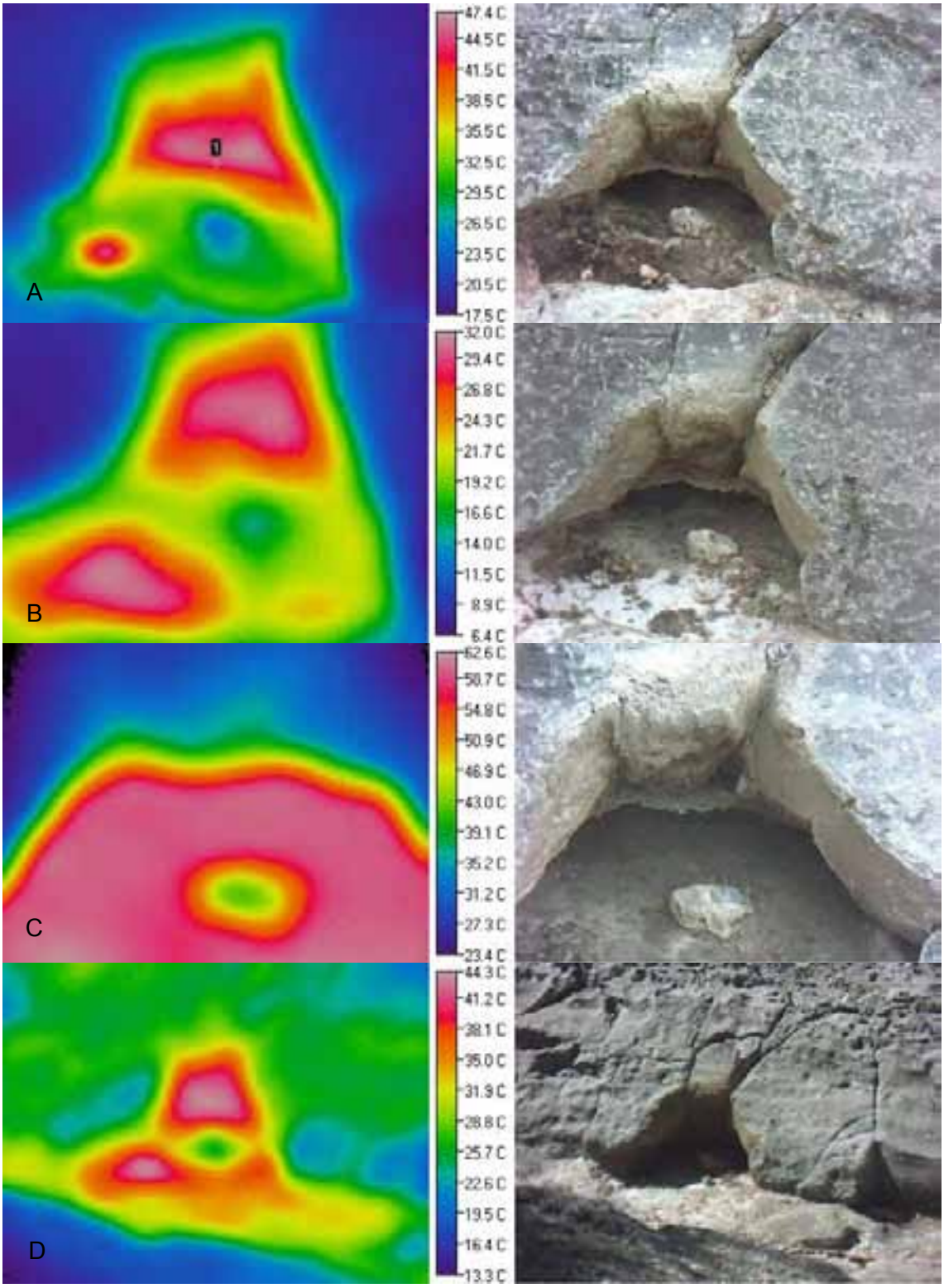


Figure 157: Infrared photos of Knox Spring Hole, Waiotapu, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Hidden Pool**
  E1894833 N5749981

There were no bathers in the pool in April, June, Sept 2013 or Jan 2014.

Green algae were present on the walls, with a pale yellow substance precipitating from areas where water seeps from the rocks. The pool was steaming.

Table 67: Data from Hidden Pool, Knox Geyser area, Waiotapu

Date	T (°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	37.0	3	~10	Overflowing	Calm, some steam	Murky, brown
25 June 2013	35.6	3	7	Overflowing	Calm, steaming	Murky (~0.5 m), brown.
25 Sept 2013	35.8	3	~20	Overflowing	Calm	Murky (~0.2 m), brown
29 Jan 2014	38.9	2-3	~9	Overflowing	Calm	Murky, grey

Figure 158: Hidden Pool, Knox Geyser area, Waiotapu in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

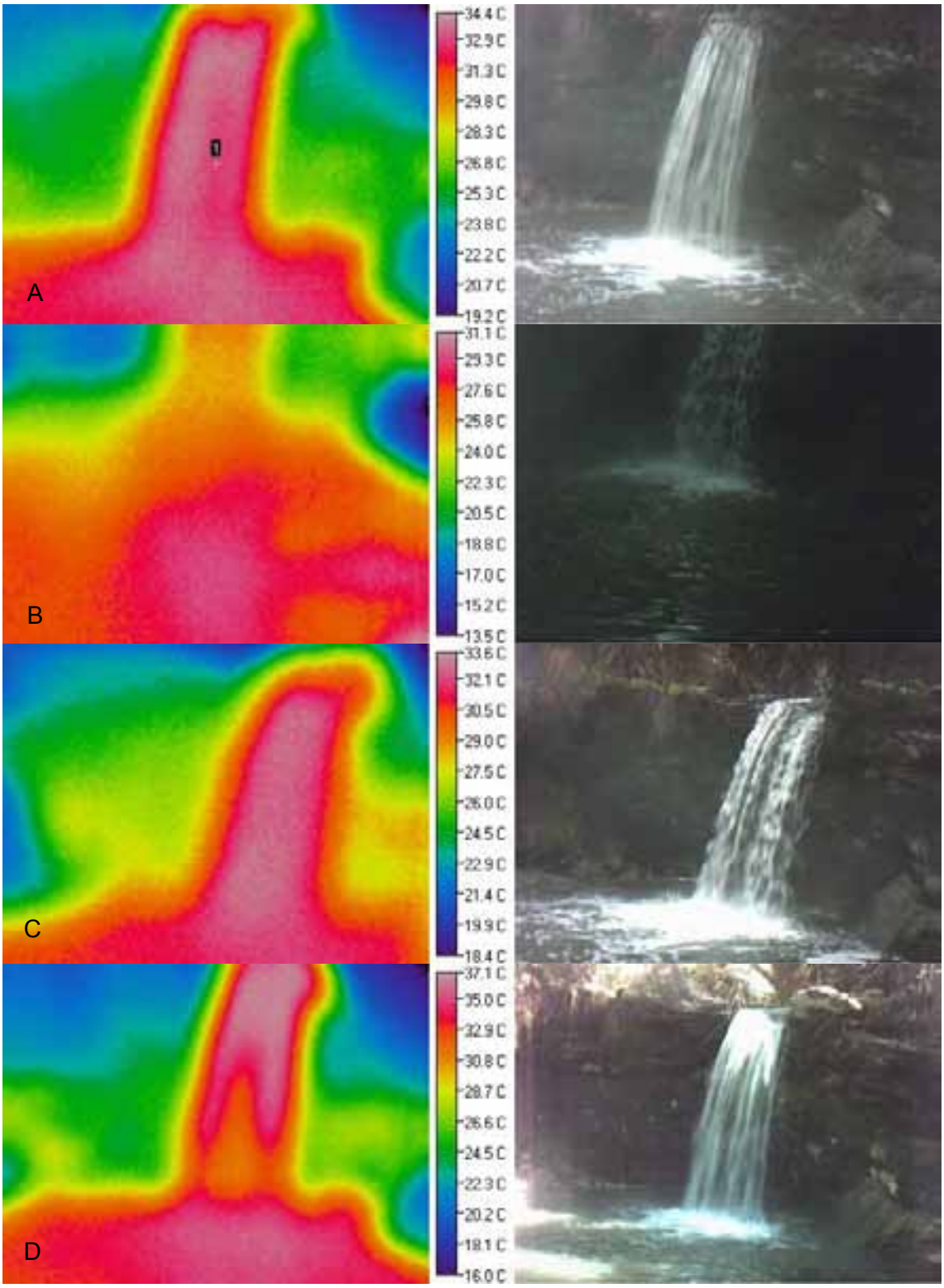


Figure 159: Infrared photos of Hidden Pool, Waiotapu, April 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

- **Venus Pool in creek on Lady Knox Road**
  E1895377 N5749891

This is a warm stream on Lady Knox Road. The temperature has fluctuated throughout the monitoring period.

Table 68: Data from Venus Pool, Knox Geyser area, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
16 April 2013	41.4	4	nd	Nd	Calm	Clear
25 June 2013	40.8	4	nd	Nd	Calm	Clear
25 Sept 2013	40	3-4	nd	Nd	Calm	Clear
29 Jan 2014	46.4	4	nd	Nd	Calm	Clear

Figure 160: Venus Pool, Waiotapu in Apr 2013 (A), June 2013 (B), Sept 2013 (C) and Jan 2014 (D)

The heat of the stream can be seen in the infrared photos in Figure 161; however, the vegetation and steam may be altering the view as it is not consistent.

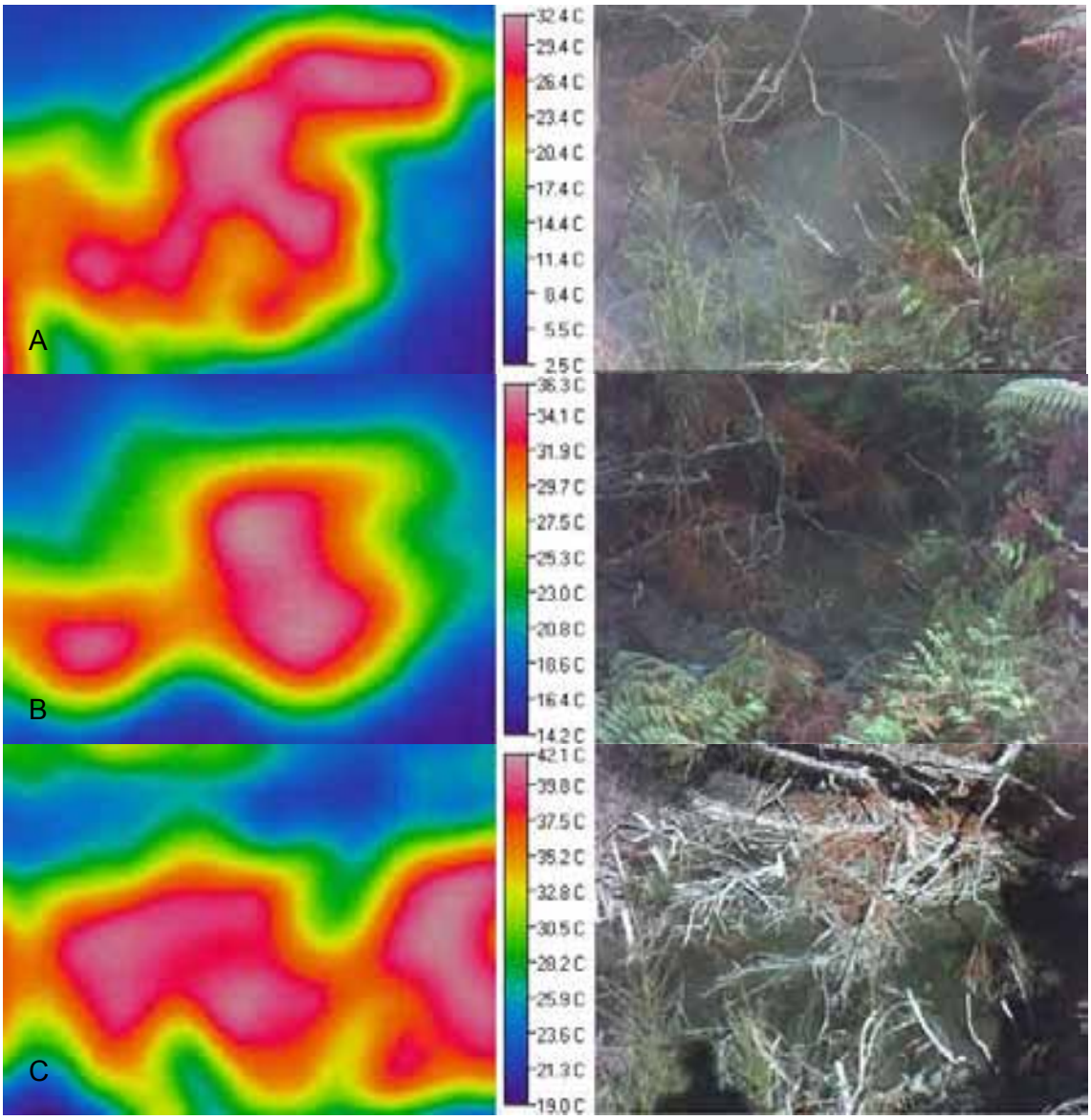


Figure 161: Infrared photos of Venus Pool, Waiotapu, June 2013 (A), Sept 2013 (B) and Jan 2014 (C)

12.3 Waiotapu Loop Road Pools

- E1893976 N5749319

Along Waiotapu Loop Road is a bridge, underneath which is a tributary of the Waiotapu Stream. There are two pools, one either side of the road. There were bathers noted during all of the monitoring visits:

April 2013: 2 bathers
June 2013: 7 bathers
September 2013: 2 bathers
January 2014: 7 bathers, 30 spectators.

Figure 162: Waiotapu Loop Road, Sept 2013

12.4 Kerosene Creek Area

- **Kerosene Creek Pool**
  E1896006 N5751572

The temperature has fluctuated over the monitoring period, with the warmest temperature being in January 2014 and the coolest in September 2013. The flow has been variable over the period.

June 2013: There were no bathers at 12:25. There appeared to be a larger volume of water than usual.

September 2013: 0 bathers. Vegetation on the TL bank appears to have been burnt for about 50 m. There appears to be more flow than usual.

Table 69: Data from Kerosene Creek Pool, Waiotapu

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	37.4	3	120	o/f	Calm, with a slight non definable odour	Clear, brown
25 June 2013	31.7	3	~120-130	o/f	Calm, with a slight odour	Murky, brownish
25 Sept 2013	28.3	3-4	~180	o/f	Calm, with a slight odour	Murky (0.5 m), brown
29 Jan 2014	37.6	3	~130-150	o/f	Calm, with a slight odour	Clear (~1 m), brown

Figure 163: Kerosene Creek Pool, Apr 2013 (A), June 2013 (B), Sept 2013 (C), Jan 2014 (D)

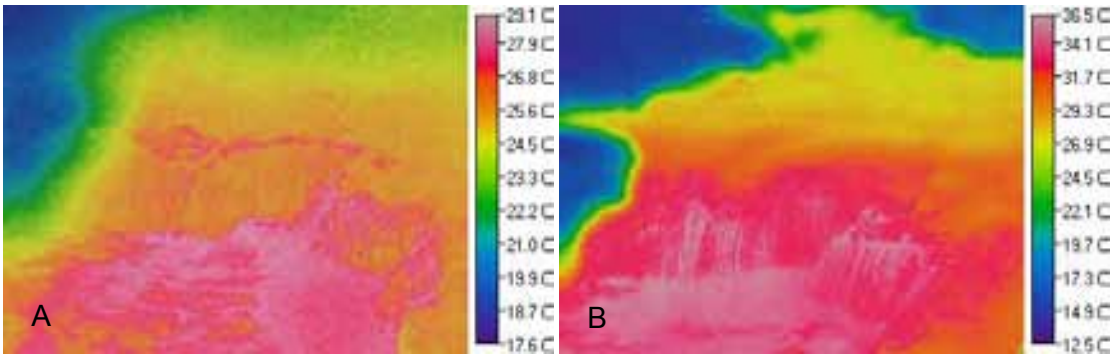


Figure 164: Infrared photos of Kerosene Creek, Waiotapu, Sept 2013 (A) and Jan 2014 (B)

- **Kerosene Creek Steaming Ground**
  E1896014 N5751240

Due to bank erosion and high levels of plant growth along the path it was not possible to reach the Kerosene Creek steaming ground during the monitoring period.

13 Whangairorohea

13.1 Tahunaatapu Pool

An incident at the pool in April 2012 resulted in the bank breaching. This incident has caused the level to drop by approximately one metre or 1 m. Pipes were placed at the outlet to control the outflow. Remediation of the pool had been carried out by June 2013.

Since remediation work has taken place, the water level has started rising. The temperature was highest in April 2013 (48.3 °C), and has fluctuated in the mid thirties since then. The colour of the water has changed from green to blue/green. The pH has been variable over the period.

Table 70: Data from Tahunaatapu Pool, Whangairorohea

Date	T (°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
30 April 2013	48.3	7-8	~3.5	o/f	Constant in the centre	Clear, Green
25 June 2013	35.1	8	nd	~0.5 m below outflow	Occasional bubbles	Clear, Bluish
26 Sept 2013	33.2	6-7	nd	0.4 m below outflow	Upwelling in centre	Clear, green/blue
30 Jan 2014	36.1	8-9	nd	~0.3 m below outflow 790 mm below top of Jetty	Intermittent upwelling	Clear, blue/green

Figure 165: Tahunaatapu Pool, Whangairorohea, April 2013

Figure 166: Tahunaatapu Pool, Whangairorohea, June 2013

Figure 167: Tahunaatapu Pool, Whangairorohea, Sept 2013

Figure 168: Tahunaatapu Pool, Whangairorohea, Jan 2014

The infrared photos show that the heat is evenly distributed around the pool.

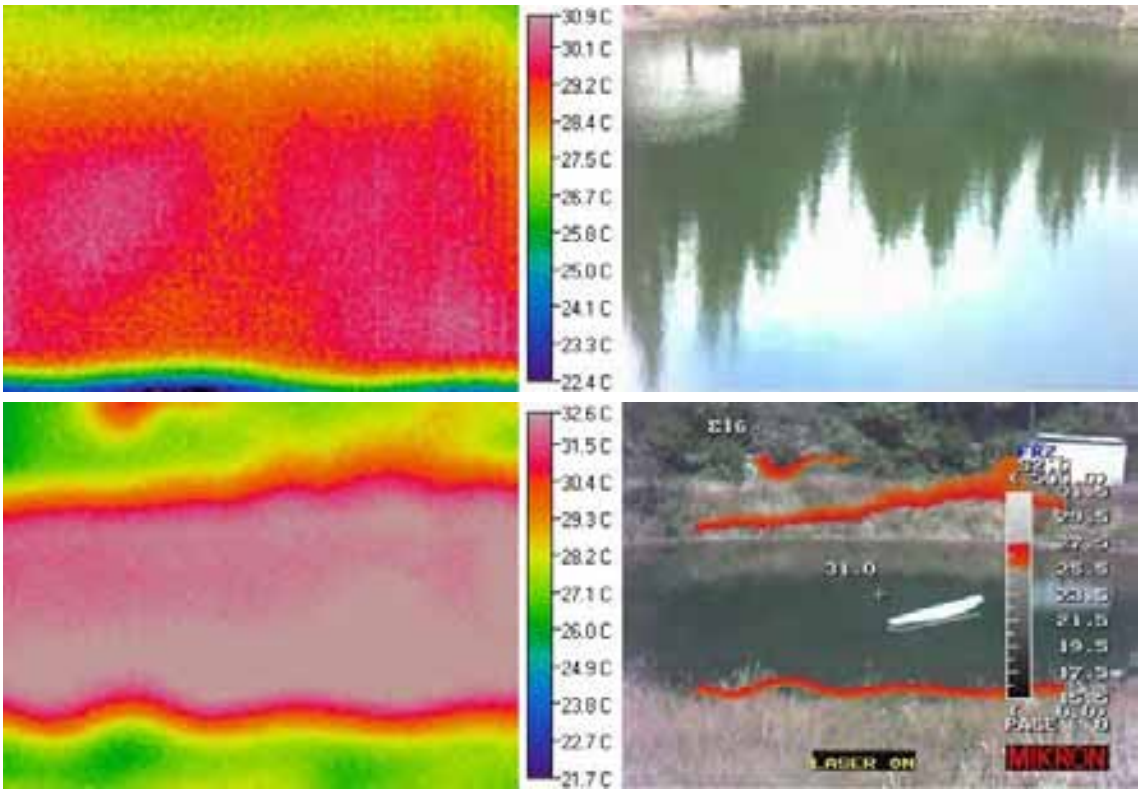


Figure 169: Infrared photos, Tahunaatapu pool, Whangairorohea in Jan 2014

14 Appendix 1

The appendix for this report is an Excel spreadsheet of the observations contained in this and previous reports, Waikato Regional Council document number 2142693. This can be obtained upon request from the Waikato Regional Council.