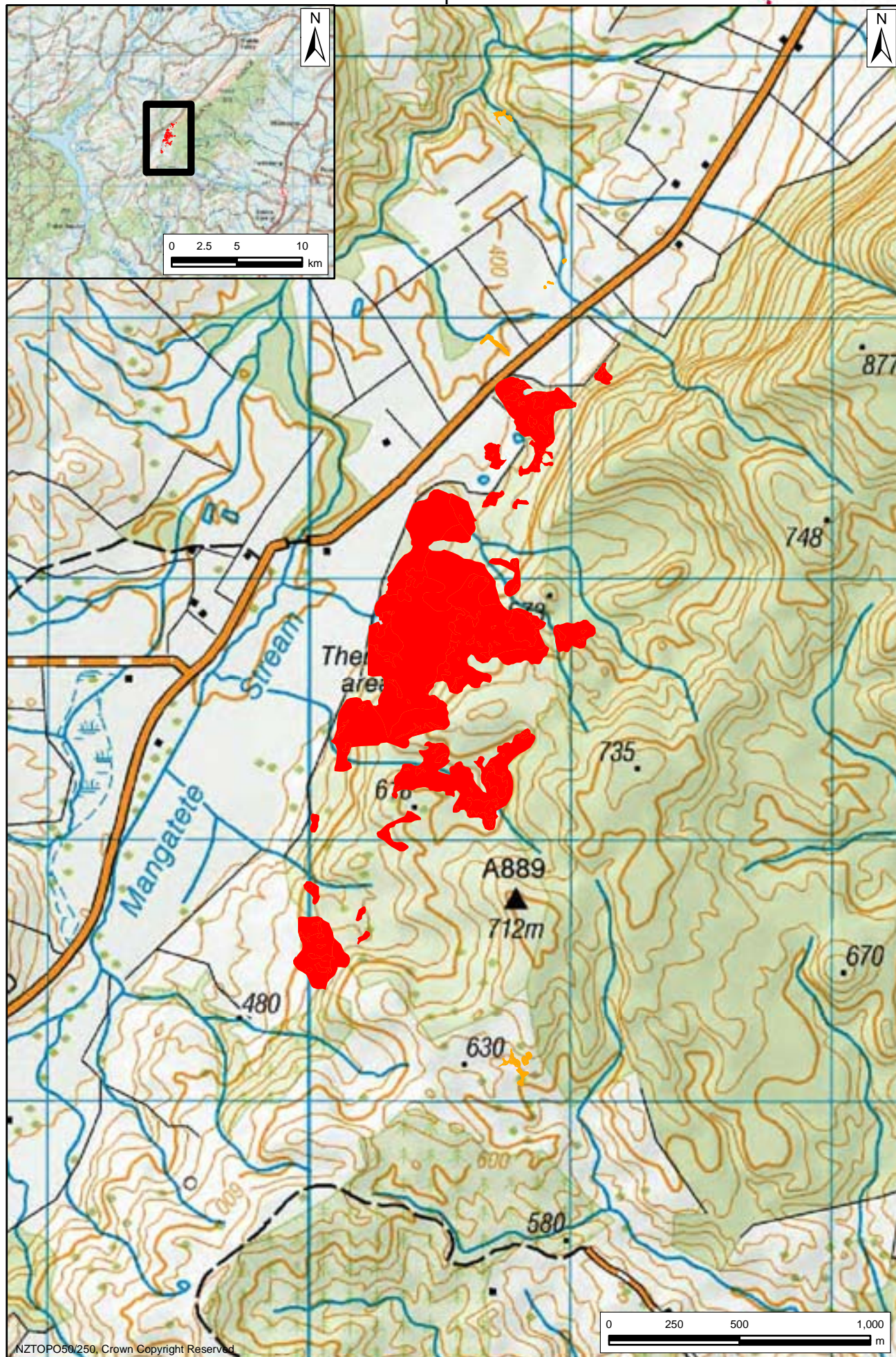
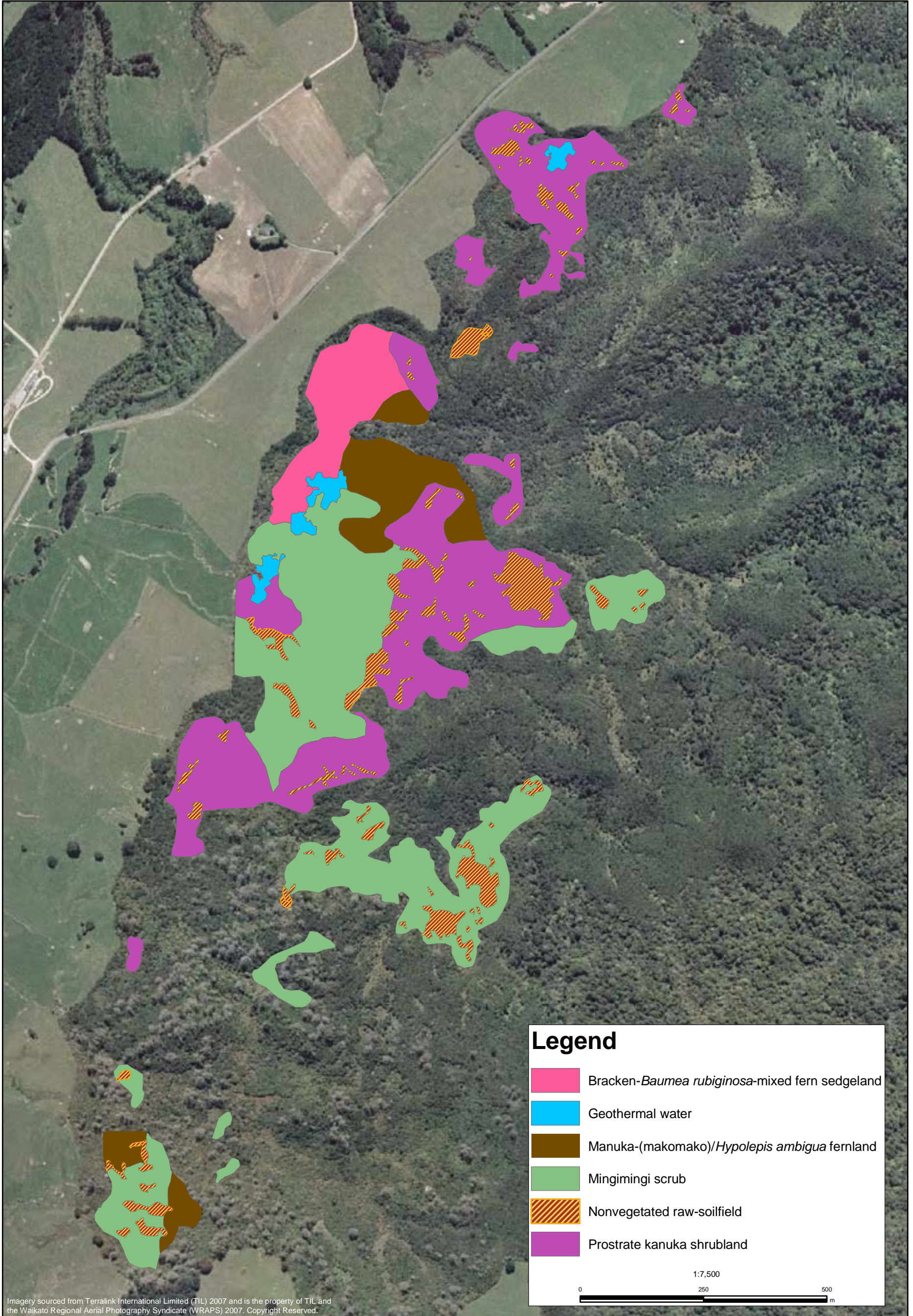


1.6 TE KOPIA GEOTHERMAL FIELD

List of Geothermal Sites

TKV01	Te Kopia
TKV02	Murphy's Springs
TKV03	Te Kopia Northwest
TKV04	Te Kopia West Mud Pools
TKV05	Te Kopia Red Stream
TKV06	Mangamingi Station





TE KOPIA

Site Number: TKV01¹
Grid Reference: NZTopo50 BF37 805 434
GPS reference: NZTM E1880502 N5743445
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Te Kopia
Bioclimatic Zone: Submontane
Tenure: Protected (Te Kopia Scenic Reserve) and unprotected private land
Altitude: c.440-620 m
Extent of Geothermal Habitat: c.59.9 ha
Extent of Geothermal Vegetation: c.58.8 ha
Date of Field Survey: 31 May & 1 June 2004

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
04.02 04.02.12	<p>Mingimingi-dominant scrub Mingimingi scrub Confined to relatively cooler soils, the 2-4 m high canopy is dominated by mingimingi, manuka and occasional kamahi, with locally common radiata pine. The subcanopy comprises the above species as well as prickly mingimingi, monoao, <i>Dicranopteris linearis</i> and bracken. The groundcover is dominated by turutu, and a moss and liverwort mat on which <i>Schizaea dichotoma</i> and <i>Schizaea</i> sp. (cf. <i> fistulosa</i>) occur (Burns & Leathwick 1995). Prostrate kanuka is abundant on soils with raised temperatures in this vegetation type.</p>	Foot of scarp; hillslopes	c.23.1 ha
05.01 05.01.01	<p>Prostrate kanuka-dominant shrubland Prostrate kanuka shrubland This occurs around the most active geothermal features, and comprises a sparse low canopy of prostrate kanuka (0.3-1 m high) with occasional mingimingi and monoao. The groundcover is dominated by <i>Campylopus</i> and <i>Dicranoloma</i> (mosses), with lichens, liverworts, and <i>Lycopodiella cernua</i> also present. Unvegetated areas occur locally throughout this vegetation type. Manuka-kamahi/prickly mingimingi scrub is locally common around the margins (Burns & Leathwick 1995). Scattered radiata pine and emergent rewarewa saplings are present. <i>Dicranopteris linearis</i> is abundant throughout this habitat type, while a small population of <i>Nephrolepis flexuosa</i> is present at the north end of geothermal activity.</p>	Foot of scarp; hillslopes	c.20.5 ha

¹ Previously identified as U17/13 in Wildland Consultants (2004).

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
07.05 07.05.16	Mixed fernland Manuka-(makomako)/<i>Hypolepis ambigua</i> fernland Occurs on an alluvial fan with raised soil temperatures. Manuka and makomako (<i>Aristotelia serrata</i>) comprise the canopy over a dense fernland of <i>Hypolepis ambigua</i> and <i>Histiopteris incisa</i> , with local dense patches of <i>Carex geminata</i> . Locally common species include <i>Muehlenbeckia australis</i> , wheki and <i>Baumea teretifolia</i> . (Burns & Leathwick 1995).	Alluvial fan	c.5.3 ha
07.05.17	Bracken-<i>Baumea rubiginosa</i>-mixed fern sedgeland A wetland in the base of an old explosion crater, where harakeke, <i>Cortaderia fulvida</i> , and manuka are emergent over a dense cover of bracken and <i>Baumea rubiginosa</i> and <i>Hypolepis ambigua</i> . Locally common species include <i>Gleichenia microphylla</i> , <i>Baumea tenax</i> , <i>Hypolepis distans</i> , <i>Histiopteris incisa</i> , swamp kiokio and kiokio.	Old explosion crater	c.4.4 ha
22.01 22.01.01	Geothermal water Geothermal water Hot springs and hot pools.	Foot of scarp; hillslopes	c.1.1 ha
28.01 28.01.01	Nonvegetated raw-soilfield Nonvegetated raw-soilfield Thermally altered clay, mud and sinter (Burns & Leathwick 1995) and mud pools.	Foot of the Paeroa fault scarp; hillslopes	c.5.5 ha

Indigenous Flora: Prostrate kanuka (classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009) dominates a large percentage of the geothermal vegetation present.

Large colonies of *Dicranopteris linearis* (classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009, and known from only c.24 sites in New Zealand) are present. *Schizaea dichotoma* (classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009), a fern which occurs in the kauri forests of Northland and South Auckland, and locally at geothermal sites, is known from this site. A small population of *Nephrolepis flexuosa* („At Risk-Declining’) is present and two „At Risk-Naturally Uncommon’ orchids (de Lange *et al.* 2009), *Calochilus paludosus* and *C. robertsonii* are also well represented here. *Schizaea* sp. (cf. *fistulosa*) has been recorded here in the past (Clarkson 1984; Burns & Leathwick 1995).

A survey of *Korthalsella salicornioides* (dwarf mistletoe; classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009) estimated the population at this site to be 100-200 plants (Anon 2000).

Fauna: Common indigenous and introduced bird species typical of the habitat are present.

Current Condition (2004 Assessment): The geothermal vegetation is virtually unchanged since 1948 (Burns 1996b) and the area is relatively free from adventive species, although pines were invading the mingimangi scrub up until recently. However, the Department of Conservation has undertaken control of wilding pines at this site in recent years, and it is significantly improved in condition. It is the most intact

remaining example of a natural vegetation zonation (extending over c.579 m in altitude) which includes geothermal vegetation, ranging from tall kamahi-dominated forest through to prostrate kanuka shrubland and geothermal wetland (see also Clarkson 1984).

**Threats/Modification/
Vulnerability:**

*Invasive pest plants
(2004 Assessment):*

Pine control is ongoing in the reserve over recent years. The invasion of pines (was previously about 6-25% cover, but has significantly reduced since 2004, now more likely to be 1-5% cover) is a continuing problem in this area, and there is potential for weed invasion along the walking tracks. Blackberry (1-5% cover) and gorse (<1% cover) are also present.

*Human impacts
(2004 Assessment):*

There are few walking tracks and human impact is low.

*Grazing
(2004 Assessment):*

The reserve is fenced, although the fence line was damaged in places in 2004.

*Adjoining land use
(2004 Assessment):*

The adjoining area comprises indigenous vegetation in Te Kopia Scenic Reserve.

Site Change:

Recent change:

The only significant change noted was the large number of dead pine trees in 2007 photographs, following control work at this site undertaken by the Department of Conservation. The changes to vegetation and site boundaries were based on better quality aerial photographs available in the current study, rather than real change.

Historical:

Previous geological investigations of the field included the drilling of two temporary wells (drilled 1965-67, plugged 1973) (Burns 1997).

Burns (1996b) has carried out an in-depth assessment of vegetation changes at Te Kopia using historical photos from 1948, 1963, 1975 and 1991. He found that areas of bare sinter or mud occur in the same relative locations in all photographs, but change in extent. There was a marked increase in bare areas between 1948 and 1963 on steep slopes (probably as a result of earthquake or an extreme storm event), but bare areas decreased from 1963 to 1975 and remained approximately unchanged. Areas with vegetation dominated by prostrate kanuka did not change in obvious extent, structure or composition since 1948 suggesting that this vegetation type is stable for long periods. Wilding pines are not present in 1948, but can be seen in the 1968 photos onwards. These have been controlled in recent years, and can be seen as dead trees on 2007 aerial photographs.

**Management
Requirements:**

Wilding pines spread should continue to be controlled and the geothermal area kept as weed free as possible. Fences should be regularly checked and maintained.

Significance Level:

International (Table 1 - Criteria 1, 3, 5, 6, 7, 9, 10; Table 2 - Factor 5).

**Significance
Justification:**

This site is of international significance because it forms the best quality example of a relatively intact area of geothermal vegetation which is part of

a high quality ecological sequence. The site is within Te Kopia Scenic Reserve which comprises an ecological sequence extending from geothermal vegetation (including prostrate kanuka shrubland and nonvegetated raw-soilfield) through to tall forest (including kamahirewarewa forest, rimu/black maire forest, rimu-northern rata/tawa-hinaurewarewa-mangeao-kamahi forest, rimu/kamahi forest, and Hall's totara/kanuka-broadleaf-tawheoheo forest; Clarkson 1984) and a small geothermal wetland area. The Te Kopia Scenic Reserve has an elevation range of 400 to 979 m.

This site is also an excellent, high quality example of geothermal vegetation with few weeds and little human-related disturbance.

One of the largest populations of *Dicranopteris linearis* (classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009, and known from only *c.*24 sites in New Zealand) in New Zealand occurs here. This site also contains one of the largest populations of prostrate kanuka (classed as „At Risk-Naturally Uncommon’), as well as good populations of four other species classed as „At Risk’ (*Nephrolepis flexuosa*, *Calochilus paludosus*, *C. robertsonii* and *Korthasella salicornioides*).

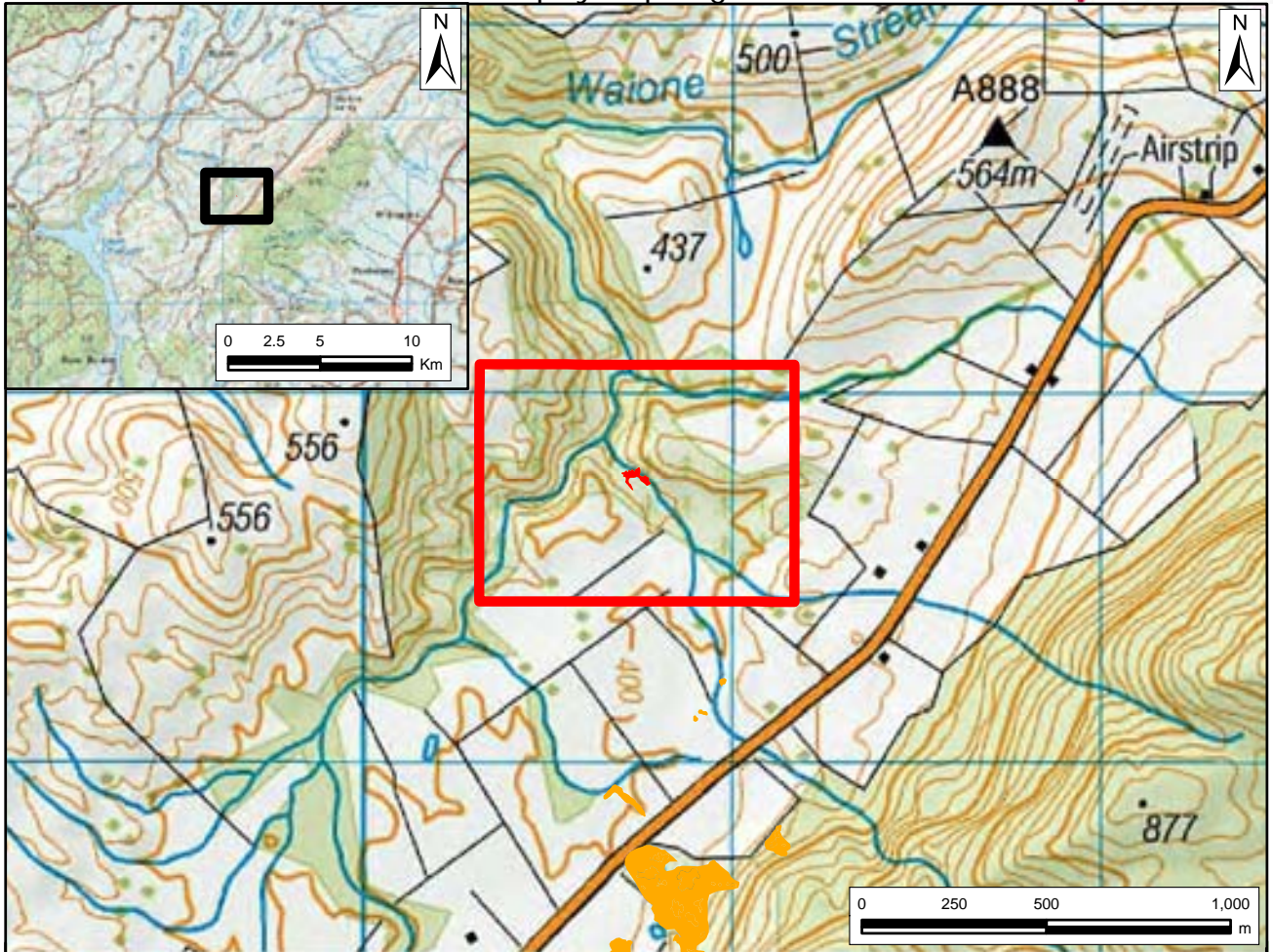
Notes:

Te Kopia Scenic Reserve was ranked as the protected natural area of highest conservation significance in the Atiamuri Ecological District (Unpublished Atiamuri PNAP data 1995).


Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region, and in this survey this site was classed as Category A - the highest category.

References:

Anon 2000; Beadel & Bill 2000; Burns 1996b & 1997b; Burns & Leathwick 1995; Clarkson 1984; Unpublished Atiamuri PNAP data 1995; Wildland Consultants 2004.



Legend

 Mixed indigenous shrubs/mixed fern species shrubland

0 100 200
1:1,500
m

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MURPHY'S SPRINGS

Site Number: TKV02¹
Grid Reference: NZTM BF37 807 458
GPS Reference: NZTM E1880740 N5745787
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Te Kopia
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: c.370-390 m
Extent of Geothermal Habitat: c.0.2 ha
Extent of Geothermal Vegetation: c.0.2 ha
Date of Field Survey: 29 June 2010

Code	Type	Landform	Extent
05.08 05.08.03	Mixed indigenous shrubland Mixed indigenous shrubs/mixed fern species shrubland Occasional plantation pines occur over mixed broadleaved and shrubland species, including kohuhu, karamu, manuka, wheki, <i>Coprosma propinqua</i> over an understorey of ferns (particularly bracken, kiokio, and <i>Deparia petersenii</i> subsp. <i>congrua</i>) and turutu. <i>Carex geminata</i> and <i>C. secta</i> are common on stream margins; at the time of the site inspection pines had recently been felled into the site. Black nightshade, exotic grasses (particularly Yorkshire fog), and lotus are common in recently disturbed areas. <i>Christella</i> aff. <i>dentata</i> ("thermal") is common in steam alongside geothermal springs and stream margins.	Gully	c.0.2 ha

Geophysical Assessment:²

Thermal Springs discharge into a stream along the edge of a pine plantation and a bank of recently felled pine. During the site visit, four thermal springs were identified, which discharge at various points along a c.200 m stretch of the gully. A small stream originates in an area of wetland on the east bank of cleared pines (Location 1 on sketch). The flow in this stream is approximately 10L/sec with a temperature of 32.8°C and a pH of 6.3.

On the western side of the gully there are three thermal springs which discharge along the steep bank into the main stream. The access to these springs is difficult and only one of them, the furthest south, was directly measured using a pH meter and thermometer. The remaining two were obstructed by vegetation and fallen trees and were measured using the IR thermometer. The flow rates in these were estimated to be in the order of 5L/sec, while the accessible spring had a flow rate of approximately 20L/sec. The temperatures ranged from 41°C to 47°C. The pH of the southern spring was 7.5 indicating a neutral spring. Pine forest, which has recently been felled around this site, would tend to have slightly acidic soils; therefore the neutral pH of the thermal spring fluid would suggest that the source is deeper chloride water. All springs were discharging clear water.

¹ Previously identified as U17/38 in Wildland Consultants (2004).

² Geophysical assessment undertaken by Juliet Newson and Julian McDowell, 2010.

Downstream of the thermal spring inputs the main stream has a flow of between 80-100L/sec, a temperature of 26°C, and a pH of 7.1.



Plate 56: Murphy's Springs Geothermal Area looking south across gully at largest spring on stream True Right. Note the abundant *Christella* sp. aff. *dentata* ("thermal") alongside stream margins.

Indigenous Flora: *Christella* aff. *dentata* ("thermal"), classed as an „At Risk-Declining’ species (in de Lange *et al.* 2009), is common alongside geothermally heated stream margins. An estimated 100 plants are present. Other species typical of geothermal habitats include manuka, bracken, and turutu.

Fauna: Common indigenous and exotic species typical of the habitats are present. Fantail were recorded during survey.

Possum sign. Cattle have had access to site, and damage from cattle is particularly notable on site margins.

Current Condition (2011 Assessment): The site is currently in a poor ecological condition, pine plantation trees have been recently felled into the site and stock have access to site. However the site has the potential to recover well if it is fenced and pest plants are controlled as required.

**Threats/Modification/
Vulnerability:**

Invasive pest plants (2011 Assessment): None noted.

Human impacts (2011 Assessment) : Trees have recently been felled into the site. The site is not fenced and cattle were recorded at the site.

Grazing (2011 Assessment): The site is not fenced, and cattle have had access to site following recent tree felling and conversion of neighbouring land to pasture.

Adjoining land use
(2011 Assessment):

Plantation; recently cleared plantation; and pasture.

Site Change:

Recent change:

Unknown. Some felling of pine trees into geothermal areas is evident.

Historical:

Site not assessed, no historical photos found. However surrounding margins have previously been plantation forest and geothermal features are in a steep sided gully that is unlikely to be visible on historical black and white aerial photographs.

Management Requirements:

The site should be fenced to exclude stock. Adjacent trees should be felled away from geothermal vegetation and habitats.

Significance Level:

Regional (Table 1 - Criteria 3, 5; Table 2 - Factor 12)

Significance Justification:

Murphy's Springs is a regionally significant site because it is a habitat of importance for an 'At Risk' species, *Christella* aff. *dentata* ("thermal"), which is known from only 14 other sites in New Zealand.

Notes:

The pine plantation around the site has recently been harvested, or is in the process of being harvested, and the adjacent land is in the process of being converted into pasture. Mapping is based on GPS waypoints obtained during field survey and not on assessment of aerial photographs as the vegetation of the site has changed markedly since 2007 aerial photographs.

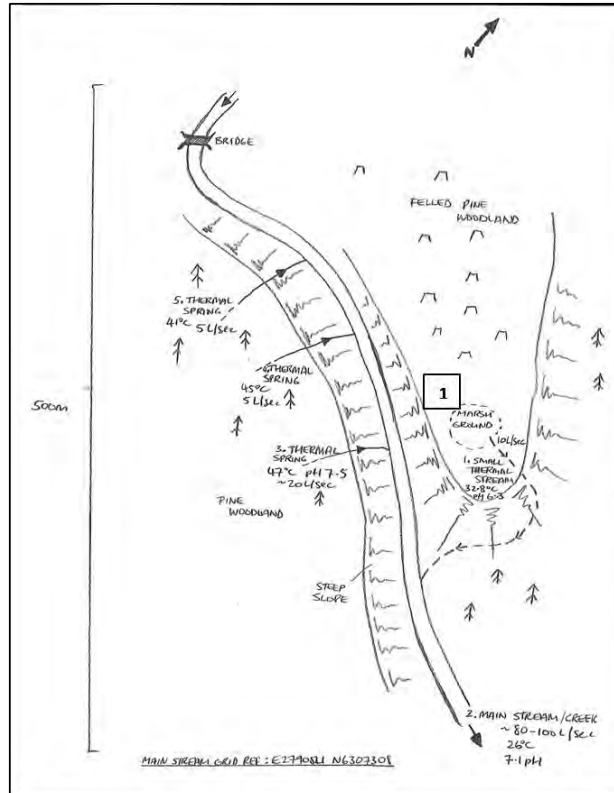
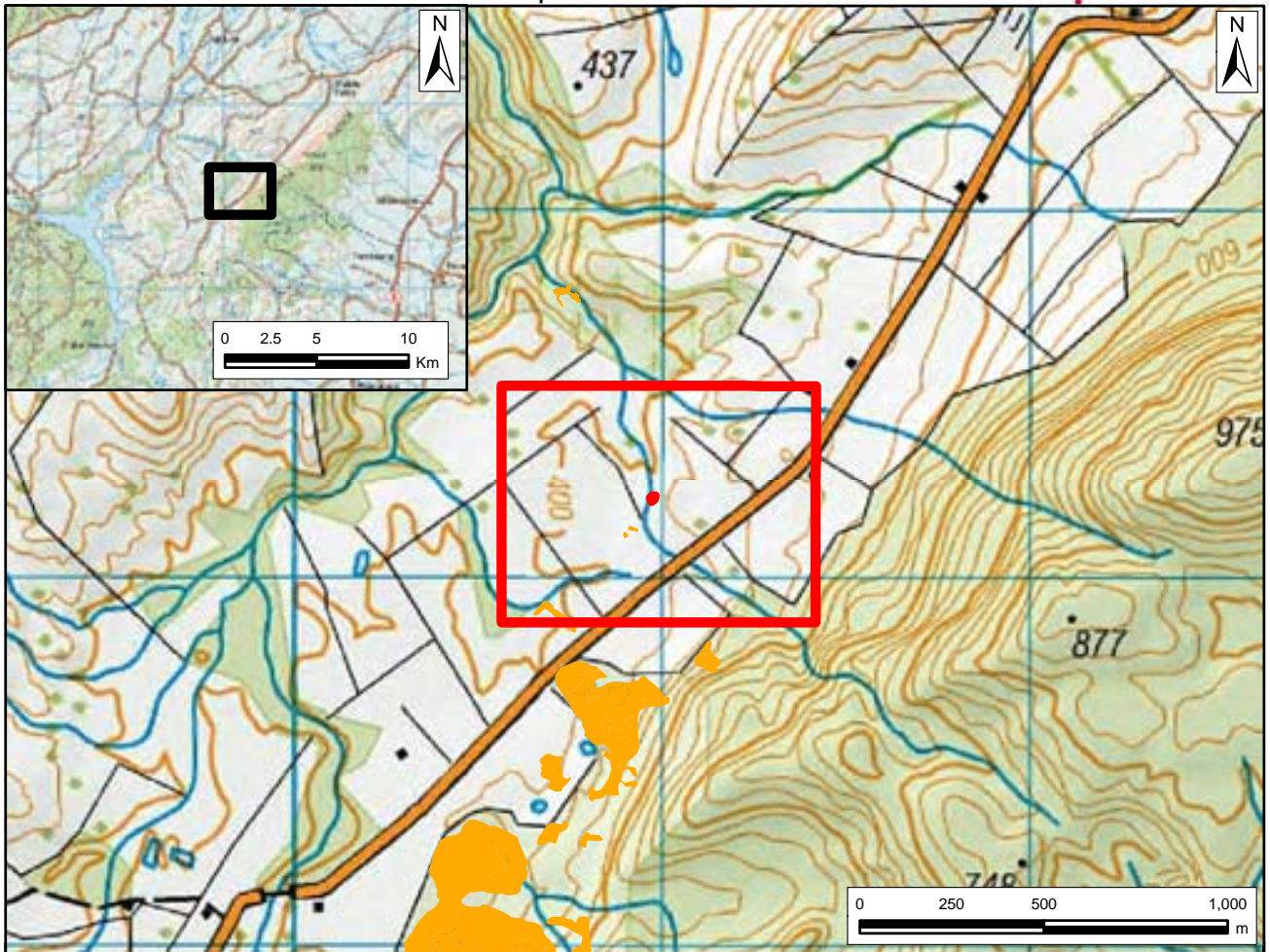


Figure A1-9: Murphy's Springs Geothermal Area:
Sketch Map showing main features and photograph location.
The grid reference labelled here is E1880411 N5745753 (NZTM).



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TE KOPIA NORTHWEST

Site Number: TKV03¹
Grid Reference: NZTopo50 BF37 810 452
GPS Reference: NZTM E1880972 N5745221
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Te Kopia
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: c.400 m
Extent of Geothermal Habitat: <0.1 ha
Extent of Geothermal Vegetation: <0.1 ha
Date of Field Survey: 29 June 2010

Code	Type	Landform	Extent
05.01	Prostrate kanuka shrubland	Gully	<0.1 ha
05.01.11	Prostrate kanuka/nonvegetated raw-soilfield shrubland A small geothermal manifestation in a gully to the north of Te Kopia Mud Pools. Much of the site is unstable bare ground with an extensive network of springs present. This contains areas of <i>Campylopus</i> mossfield, and scattered plants of Mercer grass and creeping bent. In one place, a few scattered macrocarpa (<i>Cupressus macrocarpa</i>) occur over prostrate kanuka scrub with occasional blackberry. Three plants of <i>Nephrolepis flexuosa</i> occur at N1880977 E5745224. Occasional <i>Lycopodiella cernua</i> are also present. Turutu and <i>Rubus schmidelioides</i> var. <i>schmidelioides</i> are common on geothermal margins. A stream passes through the southern part of the site. This is surrounded by kamahi, whauwhaupaku, karamu, makomako, wheki, kohuhu, and macrocarpa forest.		

Geophysical Assessment²:

This is an area of bare, steam-heated ground which lies to the west of the mud pools described in the site Te Kopia West Mudpools (TKV04). It comprises 15 × 25 m of thermal ground consisting of areas of silicified crust, steam vents/fumaroles and bubbling mud pools (Plate 57). The area has a northwest-southeast orientation and falls by approximately 0.5 m from north to south. A small stream (c.30l/sec) flows along the western margin of the area.

The southeastern part of the area is dominated by a thin silicified crust which lies above steam heated soil. The crust was found to be very thin and unstable limiting movement and inspection of the area to the boundaries only (Plate 58). One soil temperature measurement at 0.1 m depth showed 52°C (see map for location). Associated with this area are steam vents or fumaroles which are actively discharging gas with moderate H₂S content. Near one steam vent in this area, bubbling from beneath the crust could be heard. There is also active sulphur deposition occurring in this area.

¹ Previously identified as U17/39 in Wildland Consultants (2004).

² Geophysical assessment undertaken by Juliet Newson and Julian McDowell, 2010.

Between this area and the stream are some small steam vents where soil temperature was 100°C (see map for location).

The central part of the area appears to be less active. This area, while still covered by the silicified crust/sinter, is encroached by prostrate kanuka and moss cover indicating cooler temperatures (Plate 59).

The northeastern part of the area comprises a silicified crust along with two mud pools (Plate 59). At the back of this area, where the slope rises, it comprises bare ground with altered rock and soil. The lower parts of the slope have active pools. There was no safe access to these pools so it is not known if the pools are boiling or only near to boiling; however rising steam was observed from all pools. This area has noticeably more steam discharge than the southeastern area.

The stream flowing along the western boundary does not appear to be affected by the thermal ground or display evidence of heating. Temperatures ranged from 12.6-13.2°C with pH between 5.7 and 5.9.

Indigenous Flora: Three plants of *Nephrolepis flexuosa* classed as „At Risk-Declining’ in de Lange *et al.* (2009) are present. A small area of vegetation dominated by prostrate kanuka (classed as „At Risk-Naturally Uncommon’ in de Lange *et al.* 2009) was also present.

Fauna: None noted. Common indigenous and exotic species typical of shrubland habitat likely to be present.

Current Condition (2007 Assessment): The geothermal feature is in good condition, with an „At Risk’ fern species present. The site is surrounded by exotic plants.

**Threats/Modification/
Vulnerability:**

Invasive pest plants (2007 Assessment): Whilst surrounded by exotic species, there are no urgent management requirements for pest plants.

Human impacts (2007 Assessment): Macrocarpa has been planted close to the site.

Grazing (2007 Assessment): Site has been fenced to exclude stock.

Adjoining land use (2007 Assessment): Macrocarpa plantation and farm land.

Site Change:

Recent change: Site has not been inspected by Wildland Consultants previously.

Historical: Site not assessed, no historical photos found. As vegetation is in a gully, and site is small, changes are unlikely to be visible on historical black and white photographs.

Management Requirements: None noted.

Significance Level:

Local (Table 1 - Criteria 3, 5 ; Table 2 - Factor 19)

Significance Justification:

Te Kopia Northwest is a locally significant site because it is an example of a nationally uncommon habitat type (geothermal) and supports small populations of two „At Risk’ species (prostrate kanuka and *Nephrolepis flexuosa*).

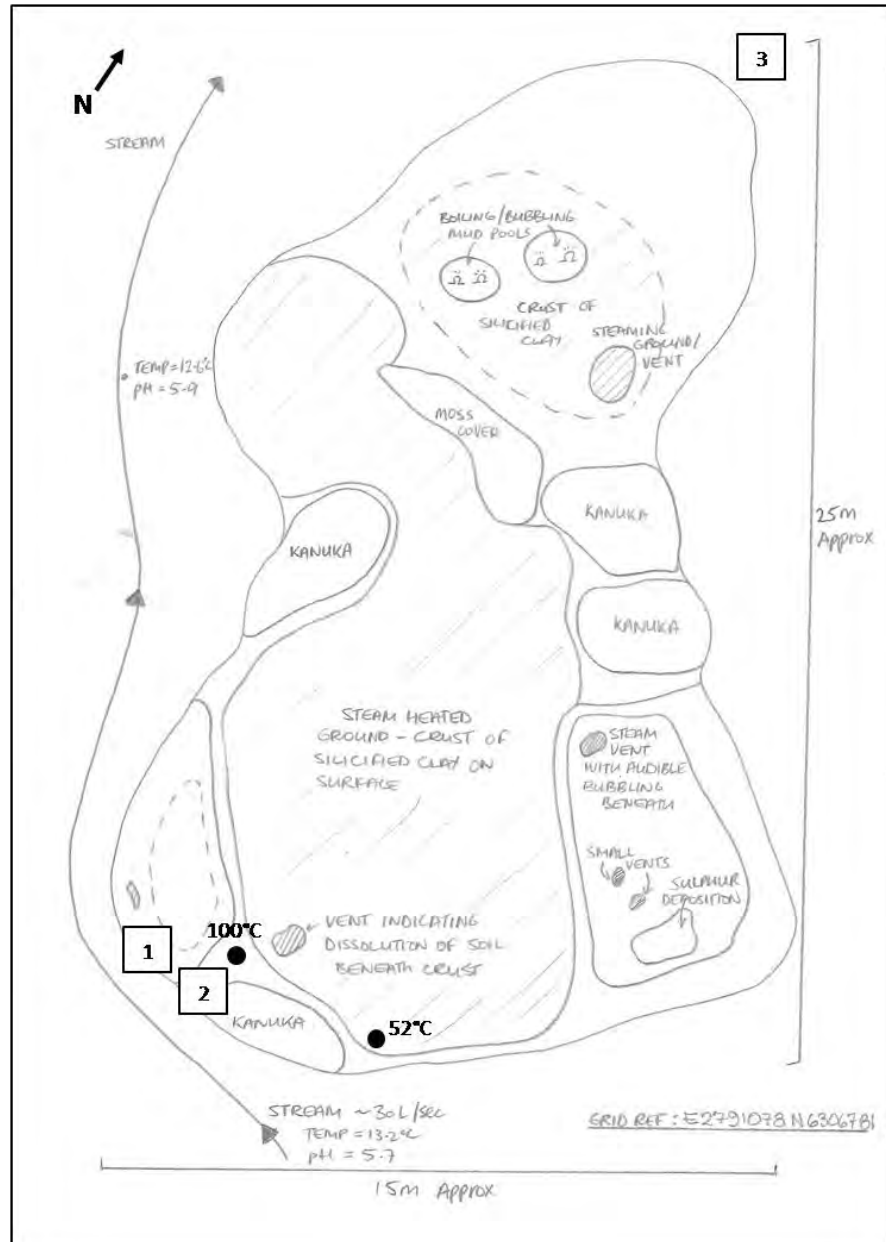
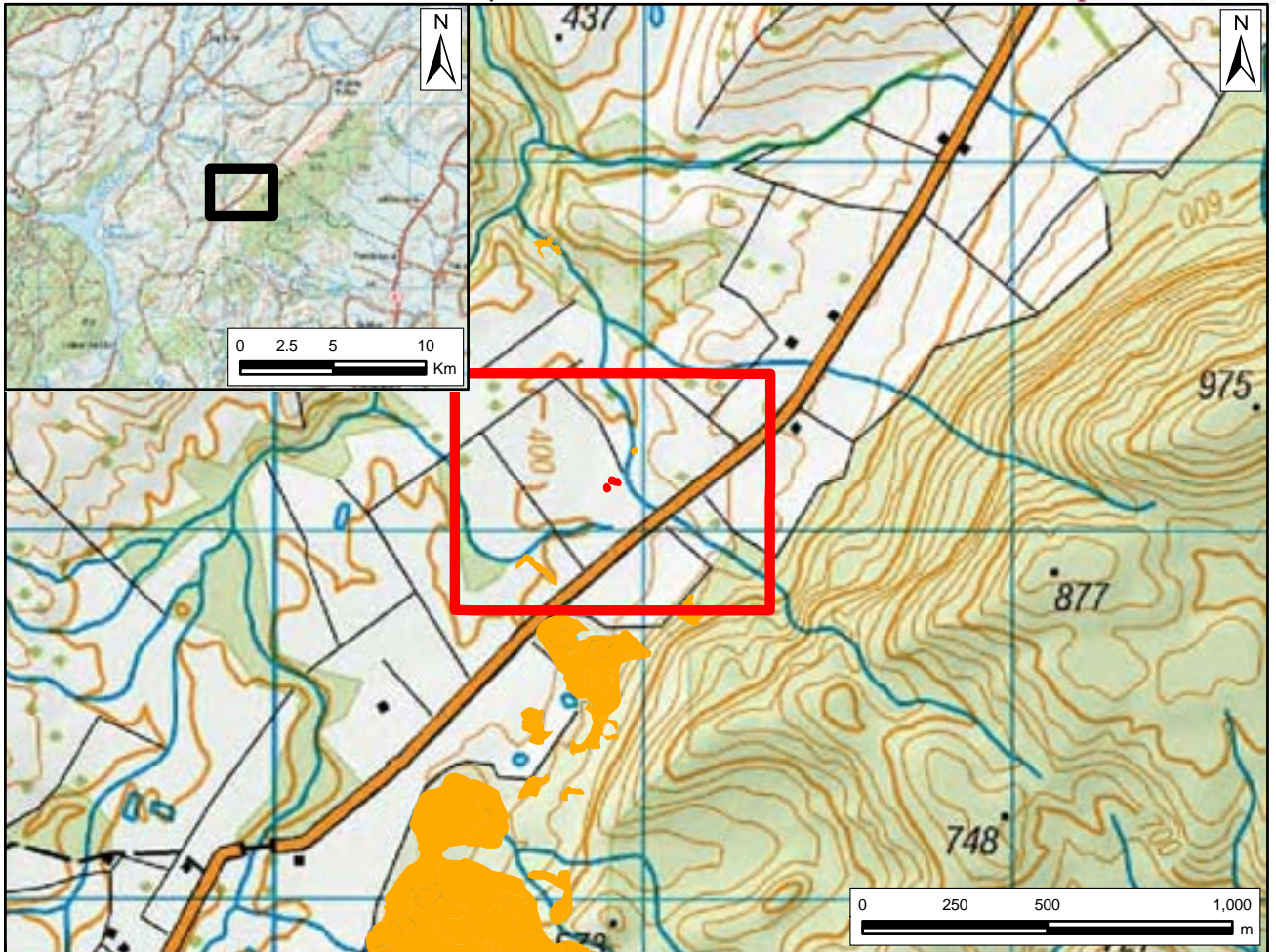


Figure A1-10: Te Kopia - Northwest. Field Sketch Map indicating main features and photo locations. The grid reference labelled here is NZMG.



Plates 57-59:


- 57. View of area from southwest corner. Note: prostrate kanuka and moss present in central area with steaming ground and mud pool in background.
- 58. View of silicified crust, steaming ground and sulphur deposition in southeastern corner.
- 59. View from elevated area in northeastern corner. Note mud pools in the foreground with adjacent central area of prostrate kanuka/*Campylopus* cover.



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Legend

 Tasmanian blackwood-manuka-kanuka-whauwhaupaku-kamahi-ti kouka/blackberry-rank exotic grasses forest

1:5,000

0 100 200 m

TE KOPIA WEST MUD POOLS

Site Number: TKV04
Grid Reference: NZTopo50 BF37 809 451
GPS Reference: NZTM E1880919 N5745136
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Te Kopia
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: c.400 m
Extent of Geothermal Habitat: c.0.1 ha
Extent of Geothermal Vegetation: c.0.1 ha
Date of Field Survey: 29 June 2010

Code	Type	Landform	Extent
01.09	Plantation-mixed broadleaved forest	Mud pools	c.0.1 ha
01.09.01	Tasmanian blackwood-manuka-kanuka-whauwhaupaku-kamahi-ti kouka/blackberry-rank exotic grasses forest Three mud pools surrounded by a mostly failed Tasmanian blackwood plantation, with brush wattle and indigenous tree species, including kanuka, whauwhaupaku, kamahi, and ti kouka. Turutu, <i>Hypolepis ambigua</i> and bracken are common in the understorey. A notable feature of the kamahi beside the eastern pool is the burnt foliage in the line of steam from the pool. Many of the trees surrounding all mud pools have a thin layer of mud from mud pool activity. Creeping bent is common on heated soils to the south of the southern pool. There are elevated soil temperatures in the upper 10 cm of soil. Dead blackberry present here indicates a recent increase in surface geothermal activity in this area.		

Geophysical Assessment:¹

This is a group of three mud pools on the slopes of a small north-south ridge on the west of the Te Kopia Rd. All these features must be approached from the downhill side; there is nothing to break a slip into these from the top, and sides are often undercut. The temperature in all of the mud pools is >80°C.

On the northern end of the ridge there are two deeply cut-in mud pools approximately 8 m apart.

Eastern Pool

The most eastern of these features is 1.5-2 m wide, and >6.5 m long. The southern end has undercut at least 3 m into the hill, although the full extent cannot be seen. The downhill lip of the pool has an apron of lumpy mud ejecta that extends at least 3 m downhill (Plate 60).

The pool has brown muddy water with two hot regions (81°C and 80°C), separated by a cool midsection (25°C). There is significant effervescing gas

¹ Geophysical assessment undertaken by Juliet Newson and Julian McDowell, 2010.

associated with the major upwelling at the back of the overhang (Plate 61). There are smaller upwellings in thicker mud near the northern end of the pool. There is no visible liquid discharge.

The water level in the pool is *c.*2 m below the downhill lip. The near vertical walls of the pool are coated with vertically fluted mud which has recently sloughed off in patches.

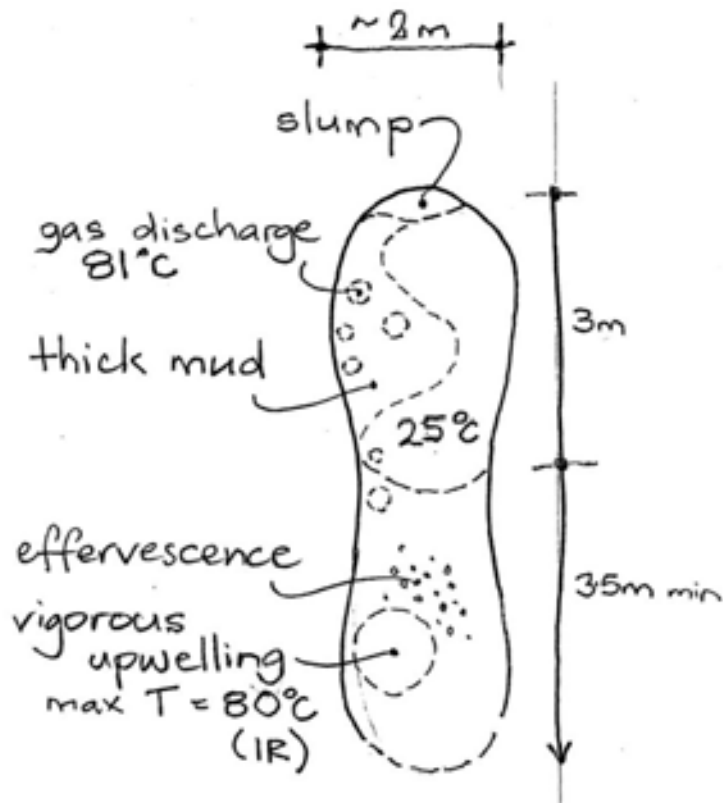


Figure A1-11: Sketch map of the eastern-most mud pool, Te Kopia West Mud Pools.



Plate 60: Apron of mud over the northern lip of the Northern mud pool, Te Kopia West Mud Pools.



Plate 61: Looking south into the pool. The major upwelling is at the far end of the pool, Te Kopia West Mud Pools.

Middle Pool

The middle feature is also on the northern slope. This is a 5 m diameter hole at the surface which narrows to a c.3 m diameter at the base, which is 4 m below the downhill lip.

There is an area of vigorous activity on the north side of the pool (99°C), accompanied by significant effervescing gas. The pool is lightly undercut in this area. There is a 0.4 m wide beach on the southern and east sides of the hole and a ledge, possibly indicating a past water level, c.0.7 m above the present water level.

There is no visible liquid discharge.

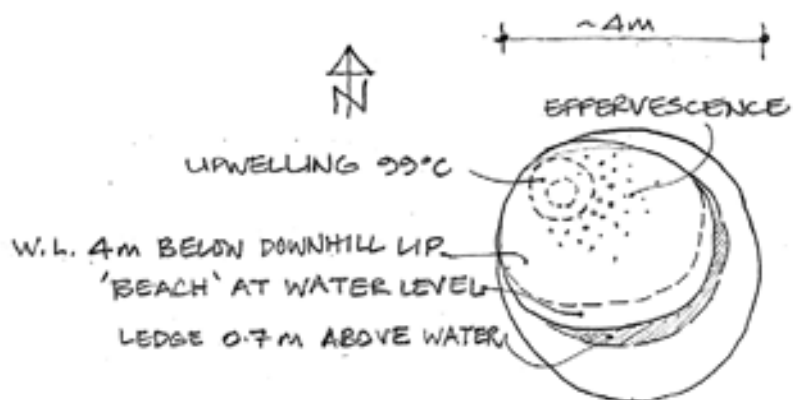


Figure A1-12: Sketch map of middle pool, Te Kopia West Mud Pools.



Plate 62: Middle pool, Te Kopia West Mud Pools.

Southern Pool

Grid Ref: E1880900 N5745117

The landowner has reported that this pool has become more active recently. The pool is set into the western side of the hill. The dimensions and form are shown in the accompanying sketch map and cross-section (Figures A1-13 and A1-14). A distinctive feature is the mud dam that is confining the present mud pool to the eastern portion of the feature. In front of the dam is a dry area with a floor that is 0.5 m below the pool water level, which may have been part of an earlier pool, and which is bounded to the west by the lip of the earlier pool.

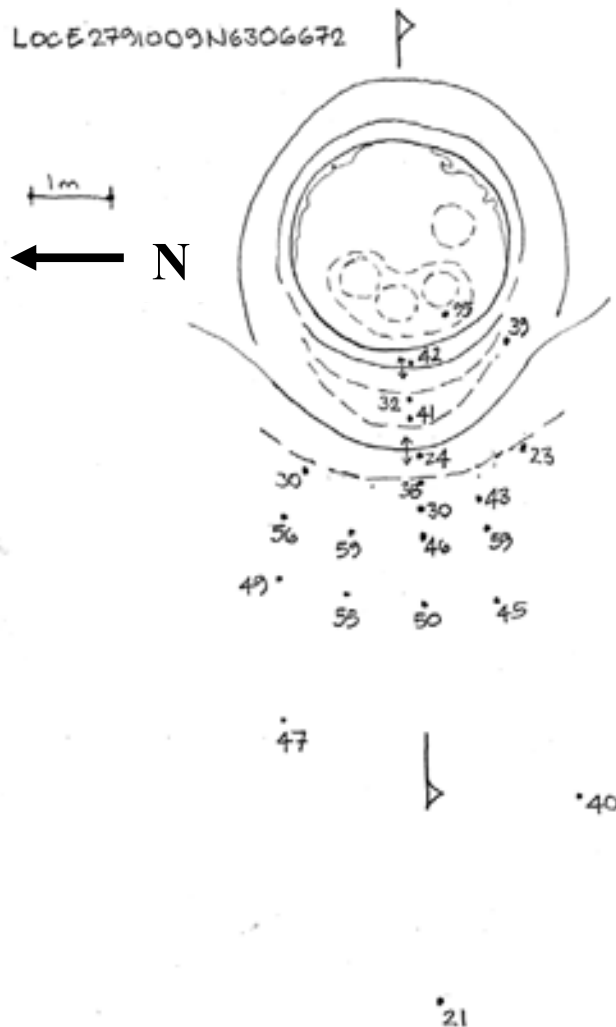


Figure A1-13: Sketch map of southern pool, indicating temperature in degrees Celsius. Reference is in New Zealand Map Grid.

The ground immediately in front of the pool has elevated temperatures (23 to 41°C), but between 1 and 5 meters away the ground temperature is in excess of 50°C, and the vegetation is dying. The temperature measurements were paced out, but give an indication of the temperature distribution down-slope of the pool.

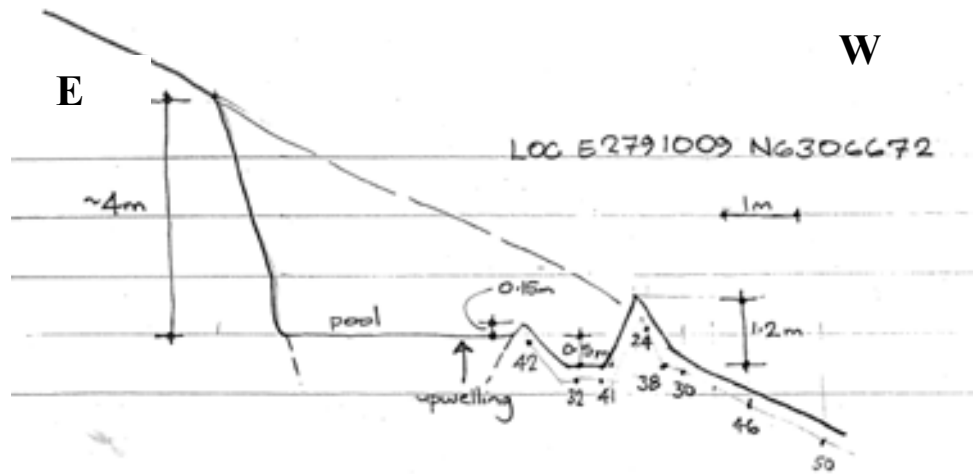


Figure A1-14: Sketch cross section E-W through the feature showing the inner dam confining the pool, and the soil temperatures at 0.1 m depth. Southern Pool, Te Kopia West Mud Pools. Grid reference is in New Zealand Map Grid.



Plate 63: The southern pool showing inner dam in foreground.

Indigenous Flora: No „Threatened’ or „At Risk’ species as listed in de Lange *et al.* (2009) are known from this site.

Fauna: Possum sign. Common indigenous and exotic species typical of the habitats present are likely to be present. Australasian magpie was recorded during the site inspection.

Current Condition (2011 Assessment): The site is surrounded by indigenous and exotic species, but geothermal features are in a good condition.

**Threats/Modification/
Vulnerability:**

*Invasive pest plants
(2011 Assessment):* Tasmanian blackwood and brush wattle, while pest plant species, are not having a significant impact on geothermal features of the site. However, control of these species is recommended.

*Human impacts
(2011 Assessment):* The site is fenced to exclude stock. A track has been made through blackberry to the southern mud pool. Tasmanian blackwood has been planted near the mud pools.

*Grazing
(2011 Assessment):* The mud pools are fenced to exclude stock.

*Adjoining land use
(2011 Assessment):* Tasmanian blackwood plantation; farmland.

Site Change:

Recent change: The farmer advised that the southern mud pool has become more vigorous in recent years.

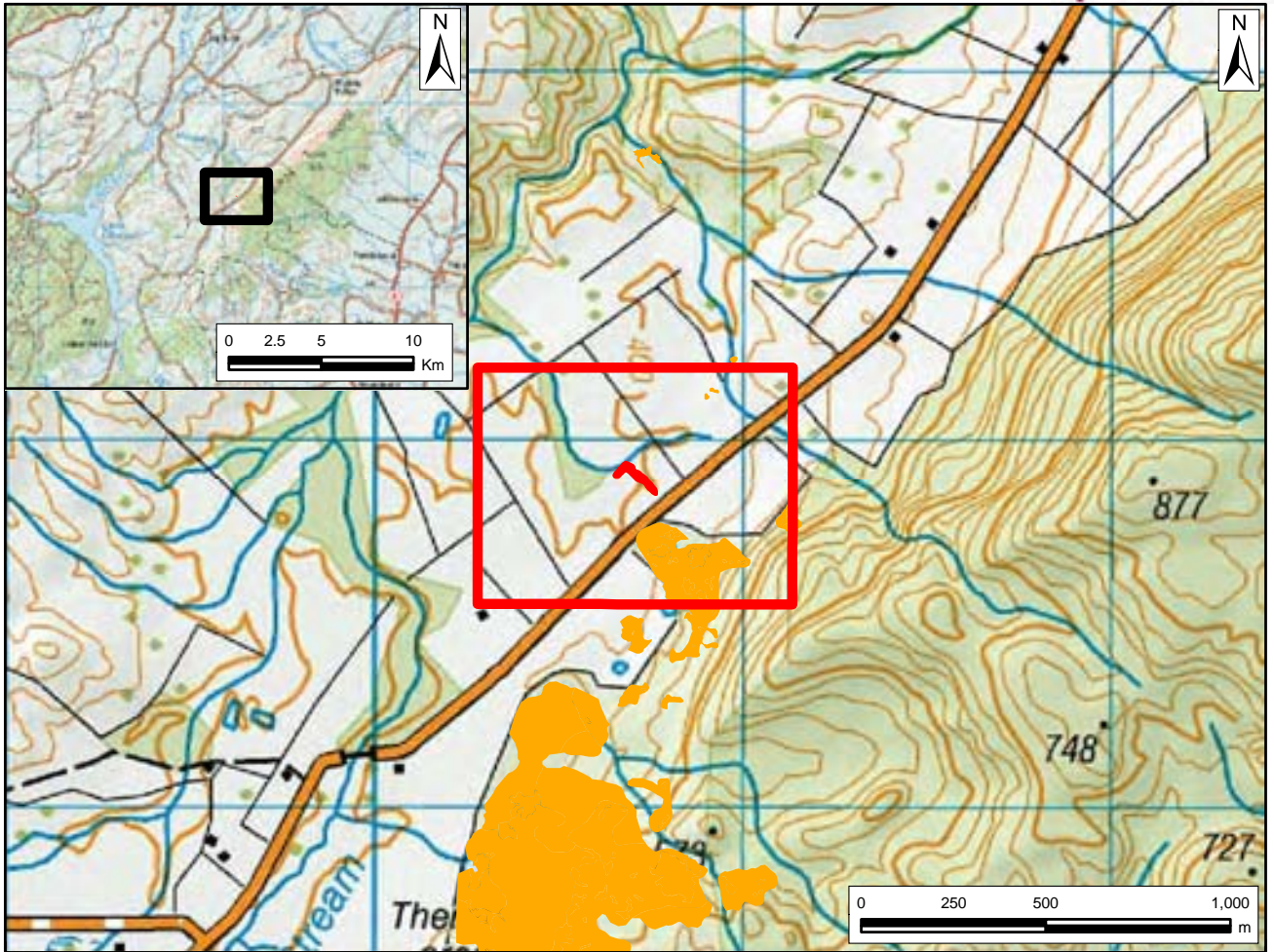
Historical: Site not assessed, no historical photos found. Unlikely to be visible on black and white aerial photographs.

**Management
Requirements:** None noted.

Significance Level: Local (Table 1 - Criterion 5; Table 2 - Factor 19).

**Significance
Justification:** Te Kopia Mud Pools is a locally significant site because it comprises a small example of a nationally uncommon vegetation and habitat type (i.e. geothermal habitat).

References: Hochstein 2007.



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TE KOPIA RED STREAM

Site Number: TKV05
Grid Reference: NZTopo50 BF37 807 449
GPS Reference: NZTM E1880706 N5744908
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Te Kopia
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: c.400 m
Extent of Geothermal Habitat: c.0.2 ha
Extent of Geothermal Vegetation: c.0.2 ha
Date of Field Survey: 29 June 2010

Code	Type	Landform	Extent
04.05 04.05.01	<p>Indigenous mixed shrubs-dominant communities</p> <p>Mingimingi-manuka-blackberry-indigenous broadleaved species scrub.</p> <p>Vegetation surrounding a small geothermal stream. Ferns (e.g. <i>Deparia petersenii</i> subsp. <i>congrua</i>, <i>Histiopteris incisa</i>, <i>Gleichenia microphylla</i>, and bracken), <i>Carex secta</i>, mingimingi, manuka, and wheki are common on upper stream margins with raised temperatures. Downstream on cooler stream margins kiokio, <i>Carex geminata</i> and blackberry become more common.</p> <p>Further upslope, away from the geothermal stream, indigenous broadleaved species are common including kamahi, whauwhaupaku, kohuhu, karamu, horoeka (<i>Pseudopanax crassifolius</i>), and occasional common alder (<i>Alnus glutinosa</i>) and <i>Cotoneaster glaucophyllus</i>. Scattered lianes of <i>Rubus schmidelioides</i> var. <i>schmidelioides</i> are present. Turutu is common in the understorey. Blackberry becomes increasingly dense away from geothermal stream margins until it is the dominant cover.</p> <p>This gully was steeply sided with unsafe access over much of the site, so only small parts of the stream were viewed.</p>	Gully	0.2 ha

Geophysical Assessment:¹

This is a small stream west of the Te Kopia Road. The stream runs from the road for about 70 m to join a cold stream (12-13°C, pH 6.3) flowing south through farmland. The flow rate of the cold stream is difficult to estimate as it flows through a large swampy area; the best estimate is 15 to 20 l/s. Below the confluence the temperature of the stream is 28°C. The thermal stream bed has a rich dark red coating, and the flow rate is also 15 to 20 l/s. Most of the stream is in a blackberry infested gully and access is difficult, however, there are sections where access is possible. Above the confluence the water temperature is 47°C, and as we moved upstream the temperature increased to a maximum of 61°C. Thereafter the next temperature

¹ Geophysical assessment undertaken by Juliet Newson and Julian McDowell, 2010.

measurement was 53°C (Plate 64), and another 3 m along the stream 22°C. This indicates that there is an approximately 50 m length of stream which has significant geothermal discharge. The soil on the edge of the stream (within 1 m of the water) was also warm (42 to 59°C at 0.01 m) but there is no thermal activity >1 m from the edge of the stream.

The accompanying map (see below) shows only measured temperatures at the recorded locations.

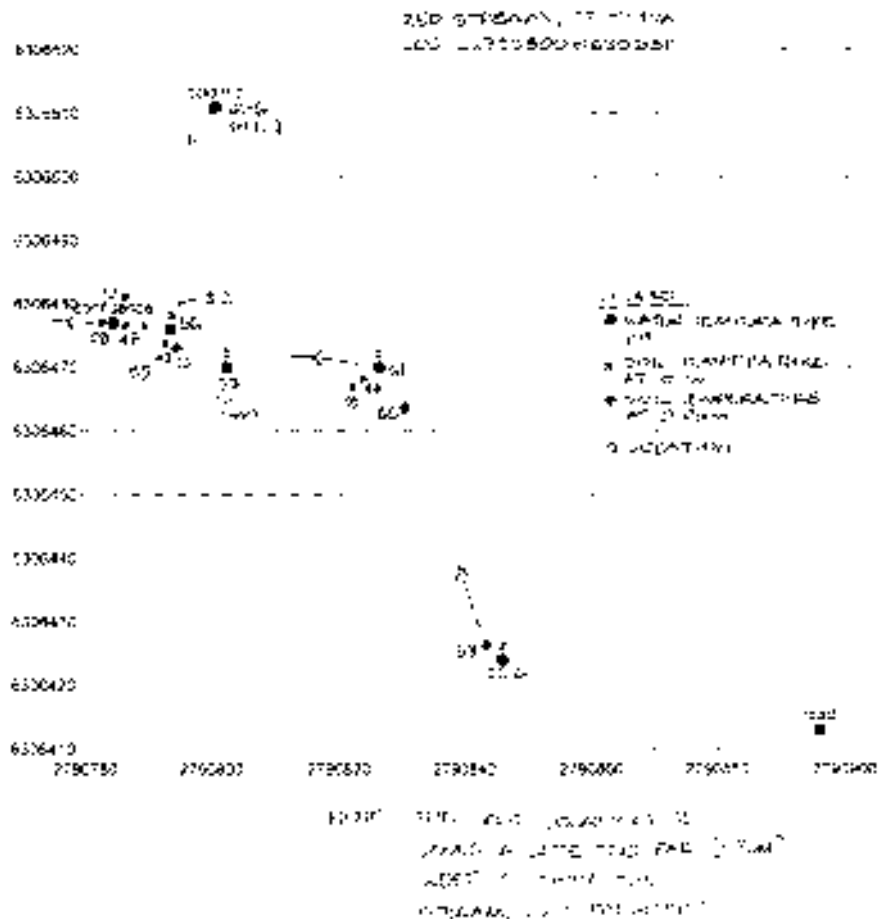


Figure A1-15: Red Stream, Te Kopia. The grid reference labelled here is NZMG.

Indigenous Flora: No „Threatened’ or „At Risk’ species (as listed in de Lange *et al.* 2009) were recorded from this site. However, other species typical of geothermal habitats present included manuka, mingimingi, *Deparia petersenii* subsp. *congrua*, *Histiopteris incisa*, *Gleichenia microphylla*, turutu, and bracken.

Fauna: None noted. Common indigenous and exotic birds typical of the habitats are likely to use this area.

Current Condition (2011 Assessment): The site is in a moderate ecological condition. The gully vegetation is fenced to exclude stock and the stream is surrounded by mixed indigenous

and exotic scrub vegetation. Exotic pest plants are common.

**Threats/Modification/
Vulnerability:**

*Invasive pest plants
(2011 Assessment):* Blackberry is very common alongside cooler stream margins and margins of the site (5-25% cover). Other pest plants present include common alder (<1% cover), and *Cotoneaster glaucophyllus* (<1% cover).

*Human impacts
(2011 Assessment):* Difficult access. None noted, and site has been fenced to exclude stock.

*Grazing
(2011 Assessment):* The site has been fenced to exclude stock.

*Adjoining land use
(2011 Assessment):* Scrub and farmland.

Site Change:

Recent change: Unknown: This site has not been assessed previously.

Historical: Site not previously assessed, no historical photos found. As features are all in a gully, it is unlikely to be visible on aerial photographs.

Blackberry and other pest plants will have in part changed the character of the site from historical times. The extent of the site is unlikely to have undergone significant change following human settlement.

Management Requirements: Fences should be maintained to exclude stock. The ongoing spread of pest plants should be monitored at regular intervals (e.g. five-yearly). *Cotoneaster glaucophyllus* and alder should be removed from the site.

Significance Level: Local (Table 1 - Criterion 5; Table 2 - Factor 19)

Significance Justification: Te Kopia Red Stream is a locally significant site because it comprises a small example of a nationally uncommon vegetation and habitat type (i.e. geothermal habitat).

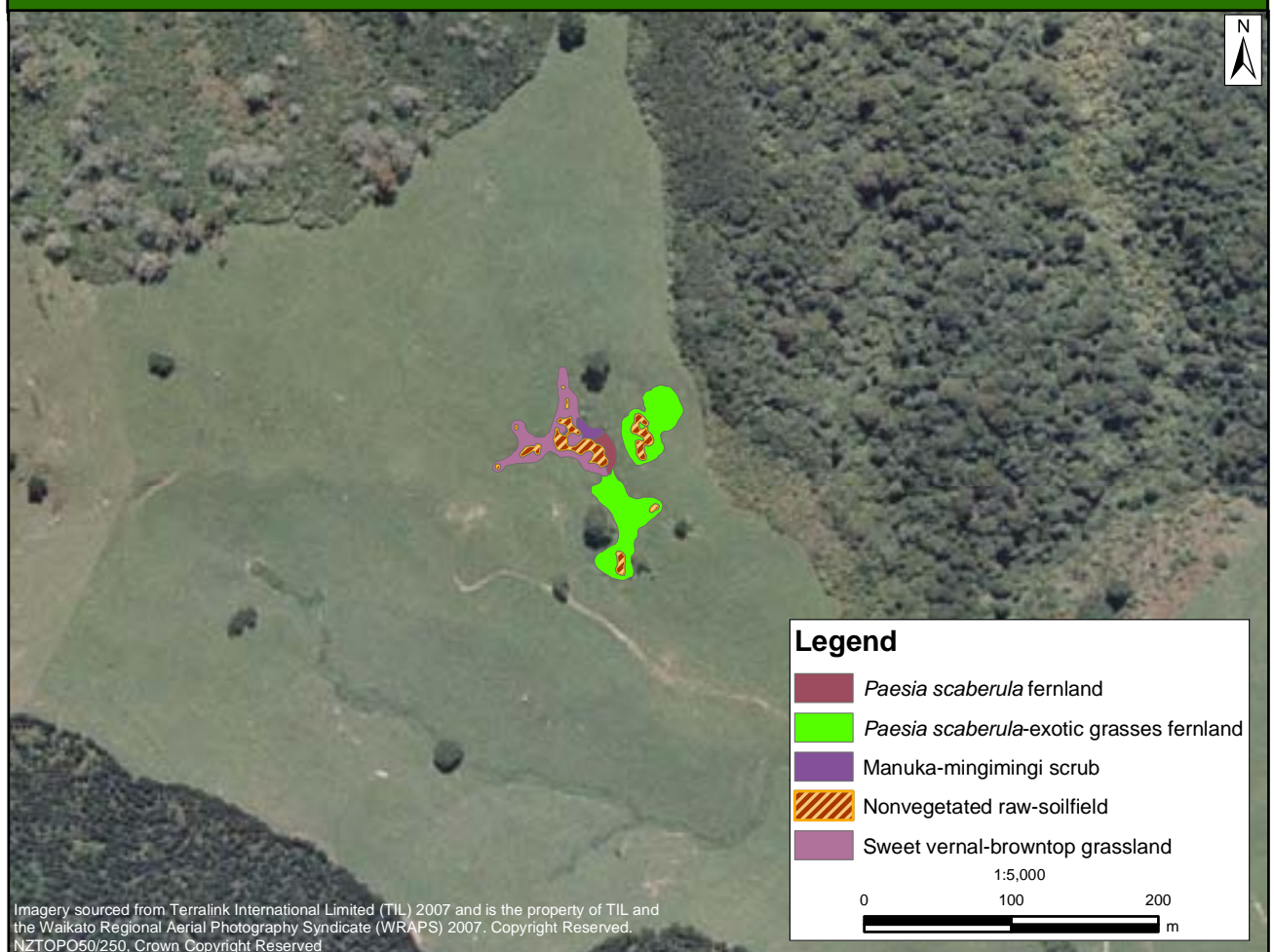
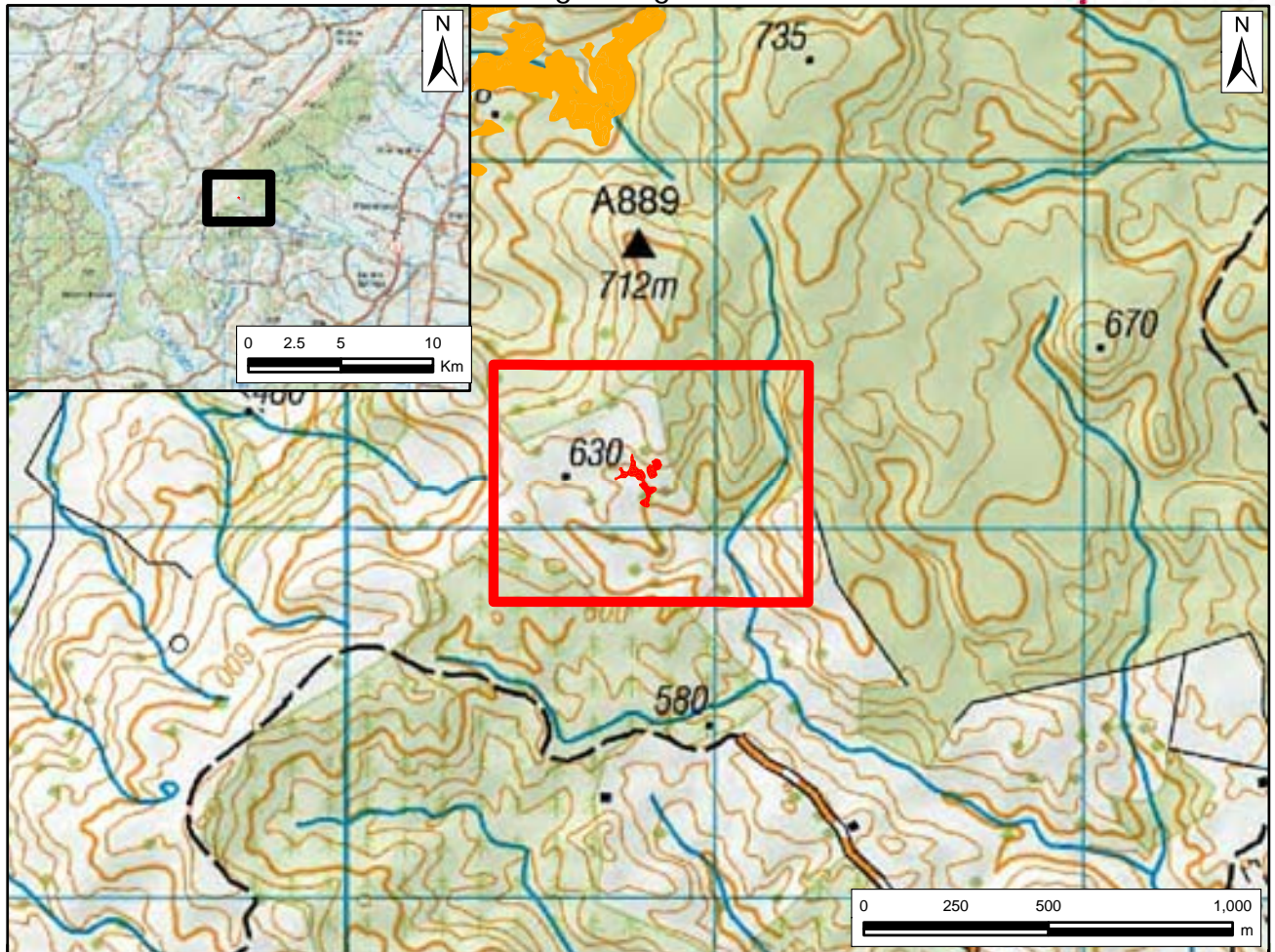
Notes: Background information on these sites was provided by Paul Cashmore and Pete Corson (Department of Conservation, Rotorua).

This site was referred to as „Road Spring’ in Hochstein (2007).

References: Hochstein 2005 & 2007



Plate 64: Te Kopia Red Stream showing water colour and vegetated banks.



MANGAMINGI STATION

Site Number: TKV06¹
Grid Reference: NZTopo50 BF37 808 422
GPS Reference: NZTM E1880782 N5742165
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Te Kopia
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: 600-630 m
Extent of Geothermal Habitat: c.0.5 ha
Extent of Geothermal Vegetation: c.0.5 ha
Date of Field Survey: 28 June 2010

Code	Type	Landform	Extent
04.03 04.03.02	Manuka dominant scrub Manuka-mingimingi scrub Small area of manuka and mingimingi dominant scrub above an area of geothermal activity. This area is influenced by geothermal activity below. Other species present include kohuhu, wheki, horoeke, and tawiniwini. One rimu seedling was also recorded. <i>Pyrrosia eleagnifolia</i> was epiphytic in this vegetation type. Lower banks are covered with non-vascular species and occasional <i>Asplenium flaccidum</i> . Sheep tracks are evident through the understorey and exotic grasses are common.	Hillslope	<0.1 ha
07.05 07.05.10	Mixed fernland <i>Paesia scaberula</i>-exotic grasses fernland This vegetation type is a mosaic of <i>Paesia scaberula</i> fernland (07.11.01) and sweet vernal-browntop grassland (08.06.02). Several patches of kiokio and <i>Doodia australis</i> are also present.	Hillslope	c.0.3 ha
07.11 07.11.01	<i>Paesia scaberula</i> dominant fernland <i>Paesia scaberula</i> fernland <i>Paesia scaberula</i> dominant fernland, with common patches of <i>Lycopodiella cernua</i> and <i>Hypolepis ambigua</i> , and scattered mingimingi, turutu, and prostrate kanuka. There are local patches of pasture dominated by sweet vernal, browntop, white clover (<i>Trifolium repens</i>), and sheep's sorrel. Three juvenile plants of <i>Dicranopteris linearis</i> were recorded at one location in this vegetation type (see flora section below).	Hillslope	<0.1 ha
08.06 08.06.02	Mixed exotic grassland Sweet vernal-browntop grassland Well grazed pasture. Common species present include sweet vernal, browntop, white clover, and sheep's sorrel with occasional Scotch thistle (<i>Cirsium vulgare</i>) and cocksfoot (<i>Dactylis glomerata</i>). Patches of <i>Paesia scaberula</i> were common. Occasional plants of <i>Gonocarpus micranthus</i> were present.	Hillslope, gully	c.0.1 ha

¹ Previously identified as U17/37 in Wildland Consultants (2004).

Code	Type	Landform	Extent
28.01 28.01.01	<p>Nonvegetated raw-soilfield</p> <p>Nonvegetated raw-soilfield</p> <p>Bare geothermal influenced clays and silicified rocks (see geophysical description below) and several pools of geothermally influenced water. Mostly bare ground, but scattered areas of mossfield and exotic grasses. Scattered plants of the following species are present; prostrate kanuka, <i>Lycopodiella cernua</i>, <i>Paesia scaberula</i>, <i>Histiopteris incisa</i>, mingimingi, prickly mingimingi, <i>Blechnum fluviatile</i>, and Spanish heath.</p> <p>Common non-vascular plant species present include <i>Campylopus capillaceus</i>, <i>Wijkia extenuata</i>, and <i>Monoclea fosteri</i>, however a detailed non-vascular plant survey was not undertaken.</p>	Hillslope, gully	<0.1 ha

Geophysical Assessment:¹

Overview of field work: This is an area of geothermal ground south of Te Kopia. The area was visited on 28 June 2010, in the afternoon. We arrived at the site at 1315 hrs. The weather was cold and overcast with a light wind. It rained intermittently all afternoon.

Areas are shown on diagrams at end of site sheet. The largest area of thermal ground (Area 5, which is $c.200 \text{ m}^2$) is situated on a southwest facing slope, with small areas of warm ground (Areas 1 and 2, which are 4 m^2 and 16 m^2 respectively) outcropping on an adjacent southeast facing slope. There are two small pools, which are slightly above ambient temperature. Over the ridge to the southeast there is another smaller area of warm ground (Area 6, $c.24 \text{ m}^2$), with steam issuing from a fracture in a rock outcrop.

Locality 1: This is a small exposed face consisting of thermally altered clay, which measures approximately 4 m^2 . The face is 1 metre high and comprises a band of altered white clay at the base (kaolin) and a red/ochre stained altered clay above it. The temperatures across the face and at the base range from 24°C to 41°C .

Localities 2 and 3: These areas are similar to Locality 1 approximately 15 m to the southeast. They comprise a small area of exposed altered pink and white clay measuring approximately 3 m^2 . The temperatures across the exposed face range from 28°C to 45°C at 10 cm depth.

Locality 3 (pool) This 0.4 m diameter pool is 17°C and has murky brown water.

Locality 4 (pool): This oval pool is $c.1 \text{ m}$ long by 0.5 m wide and is 18°C and also has murky brown water.

Locality 5: This is an approximately triangular area of thermal ground. Approximately

¹ Geophysical assessment undertaken by Juliet Newson and Julian McDowell, 2010.

30% of the ground is exposed white (kaolin) clay or pink clay. Rocks that outcrop or lie on the ground in the area are silicified white clay.

The north of the area is a 5 m wide shallow gully stepping 18 m up the hillside in four small scarps of exposed thermally altered ground. Temperatures in this thermal ground are up to 91°C at 10 cm depth.

In the southern half of the area there are five main areas of exposed ground (Figure A1-16). Three of these comprise altered pink and white clays and have temperatures ranging from 45°C to 75°C. There is minor diffuse steam discharge across all three areas. The two remaining areas have moderate steam discharge and temperatures ranging from 56°C to 99°C. Both of these areas are higher up approximately halfway up the slope. The most northern of these, has smectite banding associated with the altered pink and white clays. This type of alteration is distinctive by a green staining of the clay. The southern point source of steam discharge comprises altered clays and silicified clay fragments. The small steam vent measures approximately 5 cm in diameter. The temperature at this point was 85°C at 10 cm depth.

Locality 6:

This is a 24 m² area of thermal ground over the ridge from Locality 5. There is an outcrop of fractured silicified fine grained white rock. The junction of the fractures hosts a steam vent which is c.0.15 m wide. Ground temperatures at 0.1 m depth around the base of the rock range from 34 to 55°C. A second outcrop of silicified rock has a steam vent at the base of the rock where the ground is 92°C. There is an area of soft white and pink clay with no grass cover which has temperatures ranging from 48 to 57°C.

Flora:

Two species listed as „At Risk-Naturally Uncommon’ in de Lange *et al.* (2009) are present: *Dicranopteris linearis* and prostrate kanuka. Prostrate kanuka is scattered through the site, and three juvenile plants of *D. linearis* were recorded at NZTM E1880808 N6303706. *D. linearis* is known from only c.24 sites in New Zealand. Other species typical of geothermal habitats recorded were *Lycopodiella cernua*, turutu, *Campylopus capillaceous*, *Paesia scaberula*, manuka, mingimingi, prickly mingimingi, tawiniwini, *Blechnum penna-marina* subsp. *alpina*, *Doodia australis*, *Hypolepis ambigua*, *Gonocarpus micranthus*, and *Histiopteris incisa*.

Fauna:

No „Threatened’ or „At Risk’ bird species are known from this site. Common bird species recorded were goldfinch, paradise shelduck, and Australian magpie. The site is grazed by sheep.

**Current Condition
(2011 Assessment):**

The site is currently grazed by sheep and is in a poor condition with trampling and grazed vegetation present throughout the site. Despite this the site contains populations of two at risk plant species and has relatively few pest plants. If fenced to exclude sheep this site has the capacity to provide suitable habitat for prostrate kanuka and *Dicranopteris linearis* to extend further into this site if major pest plants such as blackberry and Spanish heath are controlled.

**Threats/Modification/
Vulnerability:**

*Invasive pest plants
(2011 Assessment):*

Several plants of Spanish heath were present.

<i>Human impacts (2011 Assessment):</i>	The site is farmed.
<i>Grazing (2011 Assessment):</i>	The site is part of a farm paddock which is currently grazed by sheep.
<i>Adjoining land use (2011 Assessment):</i>	Farmland.
Site Change:	
<i>Recent change:</i>	Unknown. The site has not previously been assessed but it is unlikely to have undergone significant recent change.
<i>Historical:</i>	Probably difficult to determine because of the small size of the site. Geothermal features on site suggest that the most significant change has been the conversion of land to farming. There are no obvious areas near this site that could previously have been geothermal areas, but at which geothermal activity has ceased. Site too small to locate on historical aerial photographs.
Management Requirements:	The ecological condition of this site will improve markedly if it is fenced to exclude stock. If fenced, monitoring and control of pest plants (particularly blackberry, wilding pines, and Spanish heath) should be undertaken.
Significance Level:	Local (Table 1 - Criteria 3, 5 ; Table 2 - Factor 19).
Significance Justification:	Mangamingi Station is locally significant because it is a small example of a habitat type that is nationally uncommon. It also supports small populations of two „At Risk’ species, prostrate kanuka and <i>Dicranopteris linearis</i> . However, if fenced to exclude stock, the indigenous vegetation of the site may improve markedly, and the ecological values of the site would increase. The character of geothermal activity at the site is suitable for prostrate kanuka and <i>Dicranopteris linearis</i> to establish in areas that are currently unvegetated because of stock impacts.
Notes:	The site is about 700 m to the east of other patches of geothermal vegetation mapped at Te Kopia (U17/13). It is on the Landcorp-owned Mangamingi Station and has only recently become known to ecologists and geologists. Paul Cashmore (Department of Conservation, Rotorua) provided background information on this site.

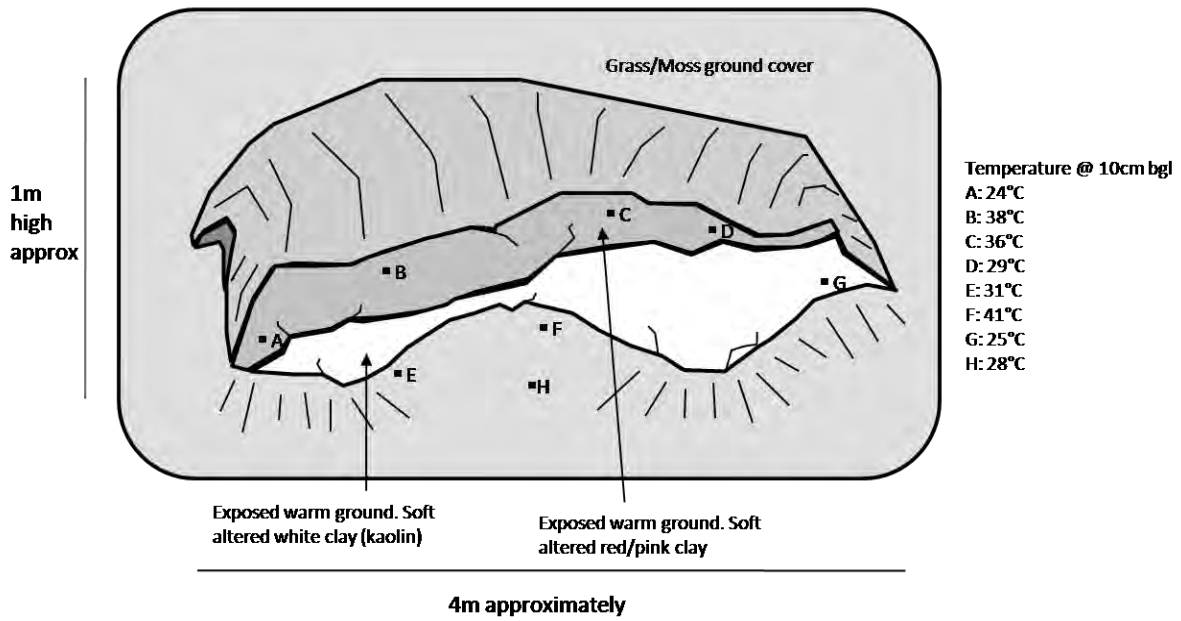


Figure A1-16: Geothermal activity at Locality 1.

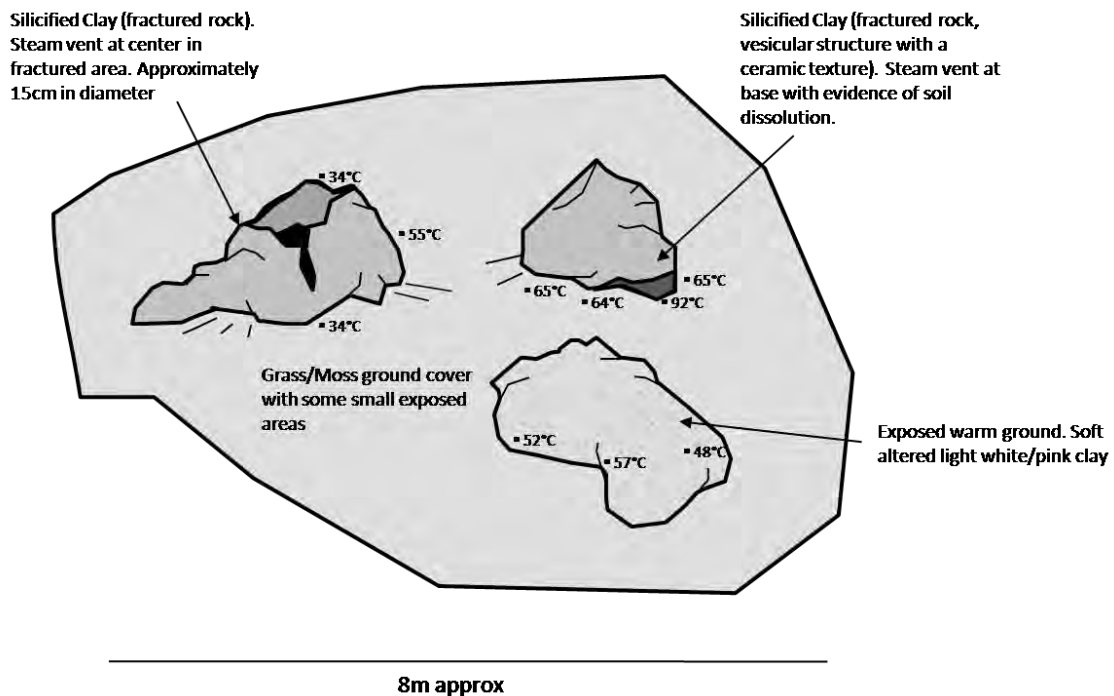


Figure A1-18: Geothermal activity at Locality 6.

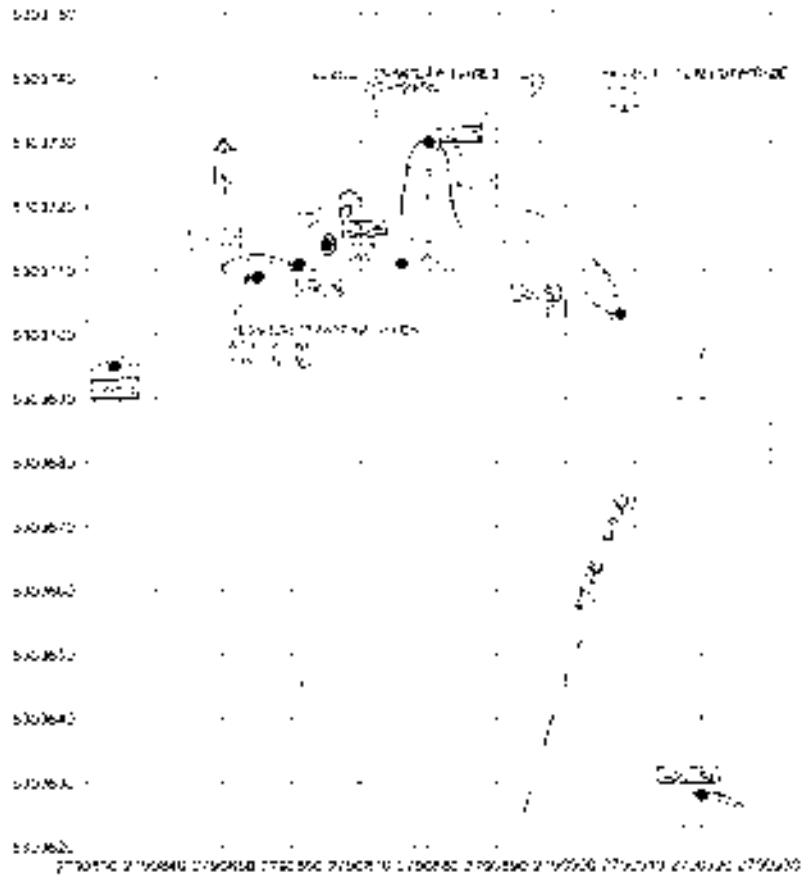


Figure A1-19:
 Sketch map of geothermal features at Mangamingi Station. Grid references are in NZMG in the sketch and NZTM in the table opposite.

1	1880729	5742138
2	1880750	5742152
4	1880760	5742157
3	1880756	5742154
5a	1880803	5742146
5b	1880771	5742154
5c	1880775	5742173
6	1880815	5742071

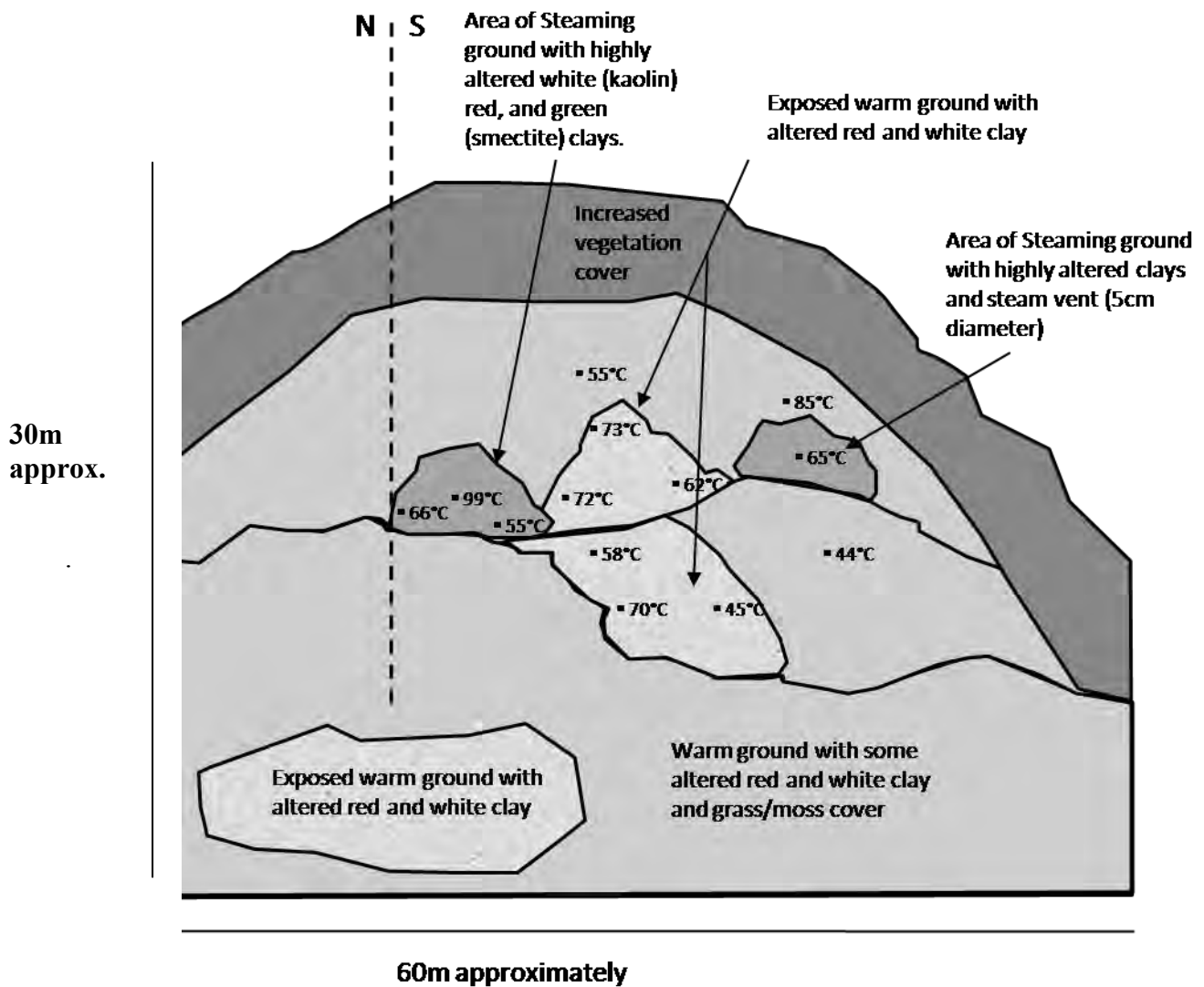


Figure A1-17: Sketch map of geothermal activity at Locality 5S (see other sketch map) at Mangamingi Station.

