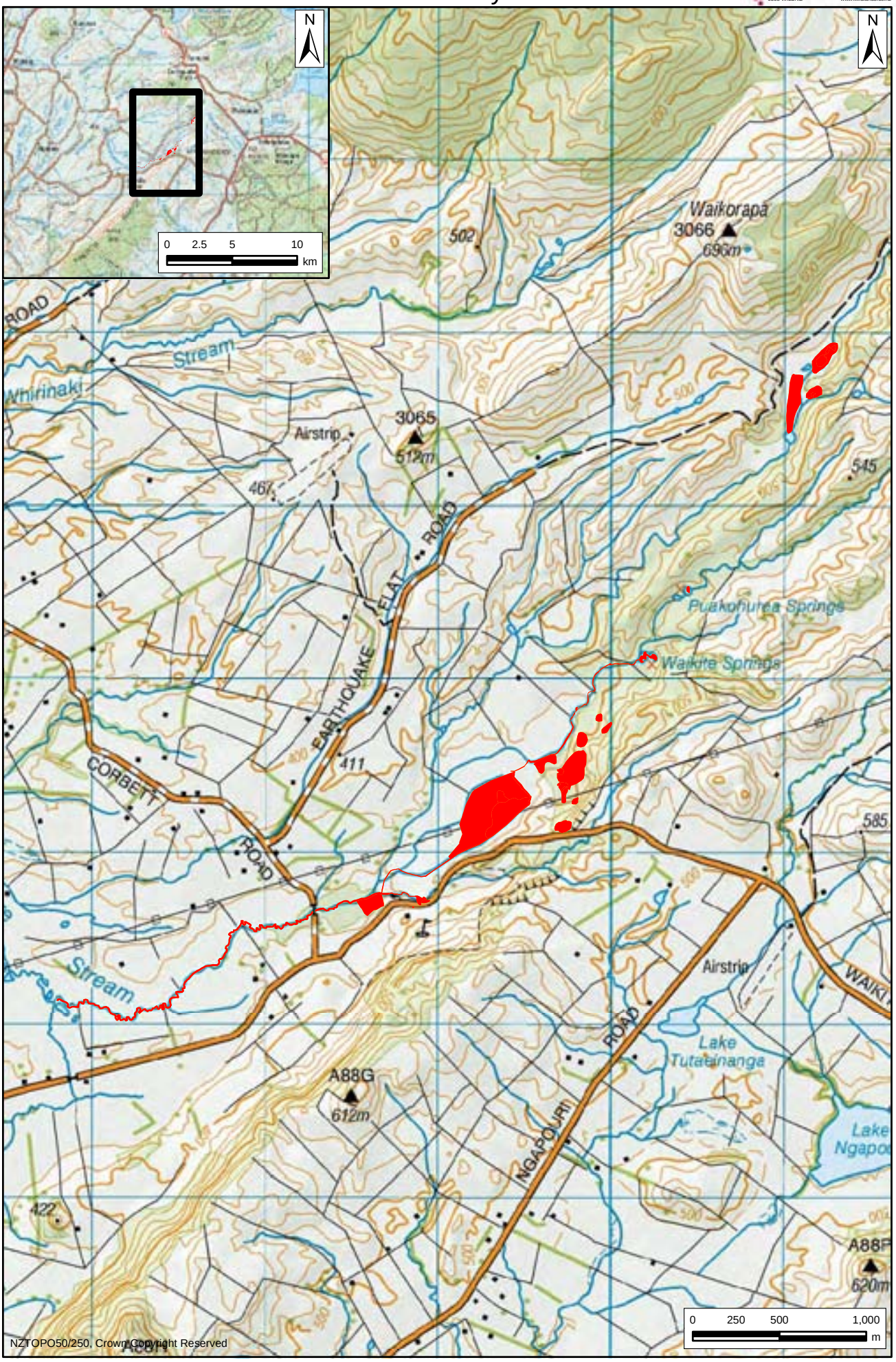
1.2 WAIKITE GEOTHERMAL FIELD

List of Geothermal Sites

WAV01	Waikite Valley
WAV02	Northern Paeroa Range

WAV01

Waikite Valley



WAV01

Waikite Valley

Wildlands
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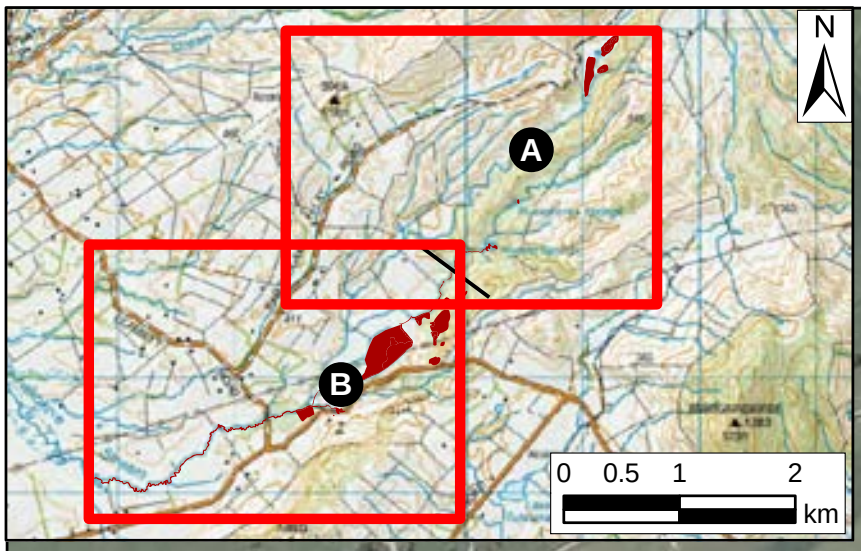

Legend

- *Nephrolepis flexuosa-Dicranopteris linearis* fernland
- Barberry/blackberry scrub
- Blackberry scrub
- Geothermal water
- Grey willow forest
- Manuka-harakeke-*Cyperus ustulatus* shrubland
- Mercer grass grassland
- Nonvegetated raw-soilfield
- Prostrate kanuka shrubland
- Prostrate kanuka/Yorkshire fog grassland
- Raupo reedland
- Raupo-*Schoenoplectus tabernaemontani-Carex secta-Baumea rubiginosa* reedland
- ***A*** **See text**

N

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0 250 500
m

WAIKITE VALLEY

Site Number: WAV01[1]
Grid Reference: NZTopo50 BF37 890 529
GPS Reference: NZTM E1889034 N5752934
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Waikite
Bioclimatic Zone: Submontane
Tenure: Protected (Waikite Stewardship Area; Otamakokore Stream Marginal Strip; Waikite Wildlife Management Reserve) and unprotected private land.
Altitude: *c.*380-440 m
Extent of Geothermal Habitat: *c.*25.8 ha
Extent of Geothermal Vegetation: *c.*24.5 ha
Date of Field Survey: 3 February 2011 (parts of this site were surveyed 17-29 May 2007)

VEGETATION		LANDFORM	EXTENT
CODE	**TYPE**		
01.06 01.06.03[2]	**Willow-dominant forest** **Grey willow forest** Grey willow (*Salix cinerea*) forms a canopy over raupo, *Carex secta*, *Baumea rubiginosa*, *Schoenoplectus tabernaemontani*, blackberry, water purslane (*Ludwigia palustris*), swamp kiokio (*Blechnum minus*), swamp millet (*Isachne globosa*), bracken (*Pteridium esculentum*), and harakeke (flax; *Phormium tenax*). Several areas with elevated water temperatures (up to 24°C) were found. In one of these areas, *Cyclosorus interruptus* was common with one small population of *Thelypteris confluens*. (Information collected in 2007).	Wetland	*c.*2.0 ha
04.08 04.08.01	**Blackberry-dominant scrub** **Blackberry scrub** Dense blackberry scrub is dominant beside many streams and drains with this site. Scattered plants of *Christella* aff. *dentata* ("thermal") and occasional *Cyclosorus interruptus* are present. Other species commonly present include swamp kiokio, kiokio (*Blechnum novae-zelandiae*), bracken, *Carex secta*, *Cyperus ustulatus*, *Histiopteris incisa*, pohue (*Calystegia sepium* subsp. *roseata*), *Hypolepis ambigua, Schoenoplectus tabernaemontani* and Mercer grass, and there is occasional manuka, patches of *Nephrolepis flexuosa*, *Baumea arthrophylla, Carex virgata,* and *Baumea juncea* on open margins. (Information collected in 2011).	Stream margins	*c.*1.8 ha

[1] Previously identified as U16/6 in Wildland Consultants (2004).
[2] Not surveyed in 2011.

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
04.09 04.09.01[2]	**Exotic-dominant scrub** **Barberry/blackberry scrub** For *c.*2.2 km west of the Corbett Road Bridge, the margins of Otamakokore Stream are dominated by a dense cover of blackberry, barberry (*Berberis glaucocarpa*), and bracken. The barberry is up to *c.*4 m tall. Pohue, introduced grasses (including Mercer grass and Yorkshire fog (*Holcus lanatus*)), and *Cyperus ustulatus* are common throughout. About 200 mature *Christella* aff. *dentata* ("thermal") are scattered along the stream margins with local patches of *Nephrolepis flexuosa*. Other species occurring along the stream margin include *Hypolepis distans, H. ambigua, Histiopteris incisa,* kiokio, *Deparia petersenii*, *Baumea rubiginosa, Carex geminata,* raupo, lotus (*Lotus pedunculatus*), ivy, feijoa (*Feijoa sellowiana*), Lawson's cypress (*Chamaecyparis lawsoniana*), pampas, and fleabane (*Conyza sumatrensis*), with local emergent grey willow, kohuhu (*Pittosporum tenuifolium*), karamu (*Coprosma robusta*), and ti kouka (*Cordyline australis*). Ten plants of *Hypolepis dicksonioides* are present. The site margins are mostly fenced on the true-right side of the stream, but on the true left stock have access to large parts of the stream. Rank exotic pasture grassland is common along stream margins in places. (Information collected in 2007). The vegetation along several hundred metres of stream margin was illegally cleared west of the Corbett Road Bridge in 2007. The nearby terrace above the stream has been replanted with indigenous species. Most *Christella* aff. *dentata* ("thermal") that was previously present alongside the stream margins in this area have been destroyed. (Information collected in 2007).	Stream margins	*c.*2.5 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka forms a low shrubland around loamfields, fumaroles and boiling mud, with scattered mingimingi and Spanish heath. Mats of moss (*Campylopus capillaceus* and *Sphagnum cristatum*) with local patches of *Nephrolepis flexuosa* and wild portulaca (*Portulaca oleracea*) form a sparse groundcover. *Dicranopteris linearis* and *Psilotum nudum* were recorded in this area in 1976 (Ecroyd & Coham 1976). In areas where this vegetation type merges with stream margins *Baumea arthrophylla* and *Baumea juncea* are present. (Information collected in 2011).	Gentle slopes at foot of scarp	*c.*4.9 ha
05.03 05.03.26[1]	**Manuka-dominant shrubland** **Manuka-harakeke-*Cyperus ustulatus* shrubland** Manuka, harakeke, and *Cyperus ustulatus*, with small	Wetland	*c.*1.1 ha

[1] Not surveyed in 2011.

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
	patches of raupo, are dominant over *Baumea rubiginosa,* swamp kiokio, *Carex secta, C. virgata*, and watercress, with occasional grey willow. Blackberry, bracken, *Hypolepis ambigua*, creeping buttercup (*Ranunculus repens*), and exotic grasses occur on dryer, cooler soils. Seepages of hot water are scattered throughout. *Christella* aff. *dentata* ("thermal") occurs near several of these seepages. Occasional plants of *Cyperus involucratus* are present near the northern margin of this area. (Information collected in 2007).		
07.08 07.08.02	***Nephrolepis flexuosa*-dominant fernland** ***Nephrolepis flexuosa-Dicranopteris linearis* fernland** A mosaic of several fern species, including *Nephrolepis flexuosa* and *Dicranopteris linearis* surrounding the Te-Manaroa Hot Spring and the stream that flows downstream. Several areas of *Nephrolepis flexuosa* and *Dicranopteris linearis* occur near the Te-Manaroa Spring. *Christella* aff. *dentata* ("thermal") plants are scattered downstream of the spring. *Lycopodiella cernua*, bracken, *Histiopteris incisa,* kiokio, *Deparia petersenii*, *Diplazium australe* and *Hypolepis ambigua* are also present in this area, with occasional kohuhu, karamu, whauwhaupaku (*Pseudopanax arboreus*), and kamahi (*Weinmannia racemosa*) on cooler sites. Blackberry becomes more abundant along stream margins downstream of the Waikite Pools. An exotic species, *Cyperus involucratus*, has spread from ornamental plantings into indigenous geothermal vegetation on stream margins, and surrounding wetlands outside of the area mapped as 07.08.02. (Information collected in 2007).	Stream gully	*c.*0.3 ha
08.01 08.01.02	**Yorkshire fog-dominant grassland** **Prostrate kanuka/Yorkshire fog grassland** A newly fenced area next to the raupo reedland is dominated by Yorkshire fog with emergent prostrate kanuka scattered throughout. (Information collected in 2007).	Flat	*c.*7.7 ha
08.04 08.04.03	**Mercer grass-dominant grassland** **Mercer grass grassland** Mercer grass dominates this area. Other species present include Indian doab (*Cynodon dactylis*), browntop, and Yorkshire fog. Scattered prostrate kanuka occur close to the margins of the hottest geothermal areas. Local patches of blackberry are also present, with small areas of nonvegetated raw-soilfield. (Information collected in 2011).	Flat areas and gentle slopes at the foot of scarp	*c.*0.4 ha
11.01 11.01.01	**Raupo-dominant reedland** **Raupo reedland** Raupo dominates this area with harakeke, *Carex secta*, *Cyperus ustulatus, Schoenoplectus tabernaemontani, Baumea rubiginosa*, *Deparia petersenii*, blackberry and bracken common around the margins. *Hypolepis*	Flat/wetland	*c.*2.6 ha

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
	distans, Juncus articulatus, Carex virgata and kiokio are also present, and emergent kanuka (*Kunzea ericoides*) is scattered throughout. *Nephrolepis flexuosa* and *Christella* aff. *dentata* ("thermal") occur locally where hot water flows into the reedland. Until recently, cattle accessed this wetland and trampling resulted in local damage to the vegetation. (Information collected in 2011).		
11.01.12[1]	**Raupo-*Schoenoplectus tabernaemontani-Carex secta-Baumea rubiginosa* reedland** A large wetland surrounding several small ponds. Elevated temperatures were recorded in parts of wetland (up to *c.*25°C). The vegetation cover is quite varied, with raupo, *Schoenoplectus tabernaemontani*, and *Carex secta* all locally dominant, in association with *Histiopteris incisa*, kiokio, and scattered *Baumea rubiginosa*, and grey willow. Manuka, blackberry, and bracken are common in dry parts. A large population of *Thelypteris confluens* occurs in the north-west corner (an estimated 800 fronds over *c.*10 m^2).	Wetland	*c.*1.0 ha
14.02 14.02.01[2]	***Campylopus* mossfield** ***Campylopus* mossfield (not mapped)** Small areas of *Campylopus capillaceus* are present amongst prostrate kanuka shrubland.	Gentle slopes at foot of scarp	
22.01 22.01.01	**Geothermal water** **Geothermal water** Hot springs, geothermally influenced ponds and streams. Arrow grass is present in small thermal streams.	Flat, gully	*c.*1.2 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Thermally altered clay, sinter, hot springs, and fumaroles. Occasional *Cheilanthes sieberi* and wild portulaca are present in Area A, amongst the nonvegetated raw-soilfield.	Hillslopes, gentle slope	*c.*0.3 ha

Indigenous Flora:

A large population of *Christella* aff. *dentata* ("thermal") (classed as „At Risk-Declining' in de Lange *et al*. 2009) is present. Some plants are threatened by grazing stock. Bycroft & Beadel (2007) estimated that there were *c.*400 plants at this site in 2007.

Scattered populations of *Nephrolepis flexuosa* are present alongside stream margins, Waikite scarp, and beside geothermal wetlands at the site. *N. flexuosa* is also classed as „At Risk-Declining' by de Lange *et al.* (2009). Bycroft & Beadel (2007) estimated that there were *c.*100 clumps of *N. flexuosa* at the Waikite site.

Also present are small populations of *Dicranopteris linearis* and *Hypolepis*

[1] Not surveyed in 2011.

[2] Areas of this vegetation type occur within the mapped area as 05.01.01, however they were too small to be mapped separately.

dicksonioides (both classed as ‚At Risk-Naturally Uncommon' in de Lange *et al*. 2009). Bycroft & Beadel (2007) recorded ten plants of *H. dicksonioides* from this site in 2007. All plants were downstream of the Corbett Road Bridge. The same survey estimated that there were about 20 clumps of *D. linearis* spread between Te Manaroa Hot Spring and Waikite Scarp. *D. linearis* is known from only *c.*24 sites in New Zealand.

Several populations of *Cyclosorus interruptus* and *Thelypteris confluens* (both classed as ‚At Risk-Declining' in de Lange *et al.* 2009) are present; generally these cover small areas but are often relatively healthy within those areas, e.g. over 800 fronds of *Thelypteris confluens* occurred in over two distinct areas of *c.*10 m^2. Some of the *Cyclosorus interruptus* plants are threatened by stock. Bycroft & Beadel (2007) identified two distinct populations of *C. interruptus* at this site. Sixteen clumps were recorded in Waikite Wildlife Management Reserve, while another eight clumps were recorded on Waikite Landcorp Farm. The Landcorp Farm plants were threatened by grazing, but more recently stock have been excluded from most of this area, protecting most of these plants from grazing by stock. The same study found about 800 fronds of *T. confluens* in Waikite Wildlife Management Reserve.

Prostrate kanuka (classed as ‚At Risk-Naturally Uncommon' in de Lange *et al*. 2009) and *Campylopus capillaceous*, which are both endemic and restricted to geothermal areas, occur at this site.

Psilotum nudum has been recorded from this site (Ecroyd & Coham 1976), and *Lycopodiella cernua*, *Cheilanthes sieberi*, *Baumea juncea*, *Baumea arthrophylla,* arrow grass, sea rush, and *Doodia australis* also occur here. These species are characteristic species of geothermal areas. Bycroft & Beadel (2007) found that *L. cernua* was common around Te-Manaroa Hot Spring, and in prostrate kanuka shrubland habitats.

Fauna:

Spotless crake (classed as ‚At Risk-Relict' in Miskelly *et al.* 2008), North Island fernbird and pied stilt (both classed as ‚At Risk-Declining' in Miskelly *et al.* 2008) are present at this site. Other common indigenous and introduced bird species typical of the habitat include spur-winged plover, grey warbler, silvereye, greenfinch, yellowhammer, paradise shelduck, fantail, pukeko, welcome swallow, grey duck, mallard, blackbird and Australian magpie.

Current Condition (2011 Assessment):

This site is highly significant in terms of its flora. The geothermal vegetation ranges from very high ecological quality to moderately poor quality. Whilst in places the geothermal vegetation is in excellent condition, in other places quality is poor due to a high density of adventive species. The geothermal vegetation is discontinuous and is often surrounded by vegetation dominated by adventives. Although many key geothermal areas are fenced, the margins are heavily infested with blackberry. Some populations of thermal ferns are open to stock access.

A geothermal stream has been rediverted into an area of raupo reedland. This wetland area and an adjacent paddock have also been fenced to exclude stock. Change in vegetation composition is expected to occur over time in this area. The location of the rediversion is thought to reflect the original location of the stream prior to human modification. Blackberry is locally invading geothermal habitat around some drains, and completing for

habitat with „At Risk' ferns.

Threats/Modification/ Vulnerability:

Invasive pest plants (2007 and *2011 Assessments*): Invasive exotic plants are common and include blackberry (51-75% cover), broom (1-5% cover), barberry (1-5% cover), Spanish heath (1-5% cover), water purslane (<1% cover), *Cyperus involucratus* (1-5% cover), pampas (<1%), and ivy (1-5%). It appears that the population of *Cyperus involucratus* at this site has increased in size between 2007 and 2011, particularly around the thermal swimming pool complex, and reaches 90% cover on some stream banks within the site.

Human impacts (*2007 and 2011 Assessments*): Human impacts associated with the public thermal baths are the responsibility of the Rotorua District Council who has specific management policies for its biological features (Rotorua District Council 1994).

A board walk has been built to Te-Manaroa Spring.

A portion of the thermal stream has recently been re-diverted and some restoration planting has occurred on the margins (see above). Vegetation composition change is likely to occur in this area over a period of time.

Grazing (*2007 and 2011 Assessments*): The central wetland north and north-east of the pool complex has recently had stock excluded from that part of the site.

Stock are excluded from most parts of Waikite Scarp.

The wetland near the pool complex and Te Manaroa Hot Springs are not grazed by stock.

Parts of the north-east area are under threat from farming operations. The hot streams with at risk ferns and areas alongside Otamakokore Creek are particularly vulnerable to trampling, pugging, and grazing damage by cattle.

Adjoining land use (*2007 and 2011 Assessments*): Farmland and public thermal baths.

Site Change:

Recent change: Recent geothermal stream diversion, management to raise water tables (to negate impacts of drains), restoration planting, and fencing to exclude stock from raupo wetlands and larger surrounding area will change the vegetation composition of the central part of this site (these works have been funded by Waikato Regional Council). Since 2004, the areas of known geothermal habitats identified have increased, however this does not generally represent a real change in the area of geothermal vegetation at this site. However, the geothermal wetland at the southern end of the farm is now larger due to water table management.

Historical: It appears that a pool complex and farm development have reduced the extent of geothermal vegetation and habitats since 1961 (Historical photo: SN 1394 Run 3170 Photos 18-20, 1961). Semi-heated nonvegetated raw-soilfield on Waikite Scarp has been invaded by blackberry and broom

scrub. It is difficult to make out the boundaries between geothermally-influenced scrub and other scrub habitats on Waikite Scarp in 1961 photographs. The wetlands on the Landcorp Farm, north of Waikite Valley Road, and the pool complex were grazed, with an extensive drain network similar to those observed in the field surveys undertaken in earlier 2000. The wetland above Corbett Road bridge and the vegetation around Te Manaroa Hot Spring appear similar to the current day. Below the Corbett Road bridge there has probably been little change to the extent of the geothermal vegetation between 1961 and the present day. It is likely that the stream margins have been fenced at some locations, however the buffer of scrub around the stream was wider in other locations in 1961 than it is today. Only the top part of Otumakokore Stream was viewed on the 1961 aerial photographs.

Management Requirements:

Blackberry and broom are now well established and are difficult to control without damaging the indigenous vegetation. Rotorua District Council has outlined policies for the protection of the biological features of Waikite Thermal Valley Reserve, although weeds remain a problem. Areas where water tables are being restored should be monitored for impacts on threatened fern populations. Ungrazed habitats where stock have been removed from stream margins should be monitored for pest plant invasion and management actions to control pest plants identified and implemented. Unfenced geothermal vegetation and habitats should be fenced to exclude grazing animals.

Pest plants have become a major management issue downstream of Te Manaroa Spring. Ivy is smothering populations of *Nephrolepis flexuosa*, and banks above the stream have become dominated by *Cyperus involucratus*. Both of these species require urgent control before they spread further within this site and into other nearby geothermal sites.

Significance Level:

National (Table 1 - Criteria 1, 3, 5, 7, 9; Table 2 - Factor 6, 8).

Significance Justification:

This site is of national significance because it is a good quality, representative, example of a habitat type that is nationally uncommon. It contains a good population of an „At Risk' species (*Christella* aff. *dentata* ("thermal") that is known at only 14 sites in the North Island. Six other „At Risk' plant species are present: *Cyclosorus interruptus,* prostrate kanuka, *Nephrolepis flexuosa*, *Thelypteris confluens*, *Dicranopteris linearis,* and *Hypolepis dicksonioides*. Spotless crake (classed as „At Risk-Relict' in Miskelly *et al.* 2008), North Island fernbird and pied stilt (both classed as „At Risk-Declining' in Miskelly *et al.* 2008) are also present

Notes:

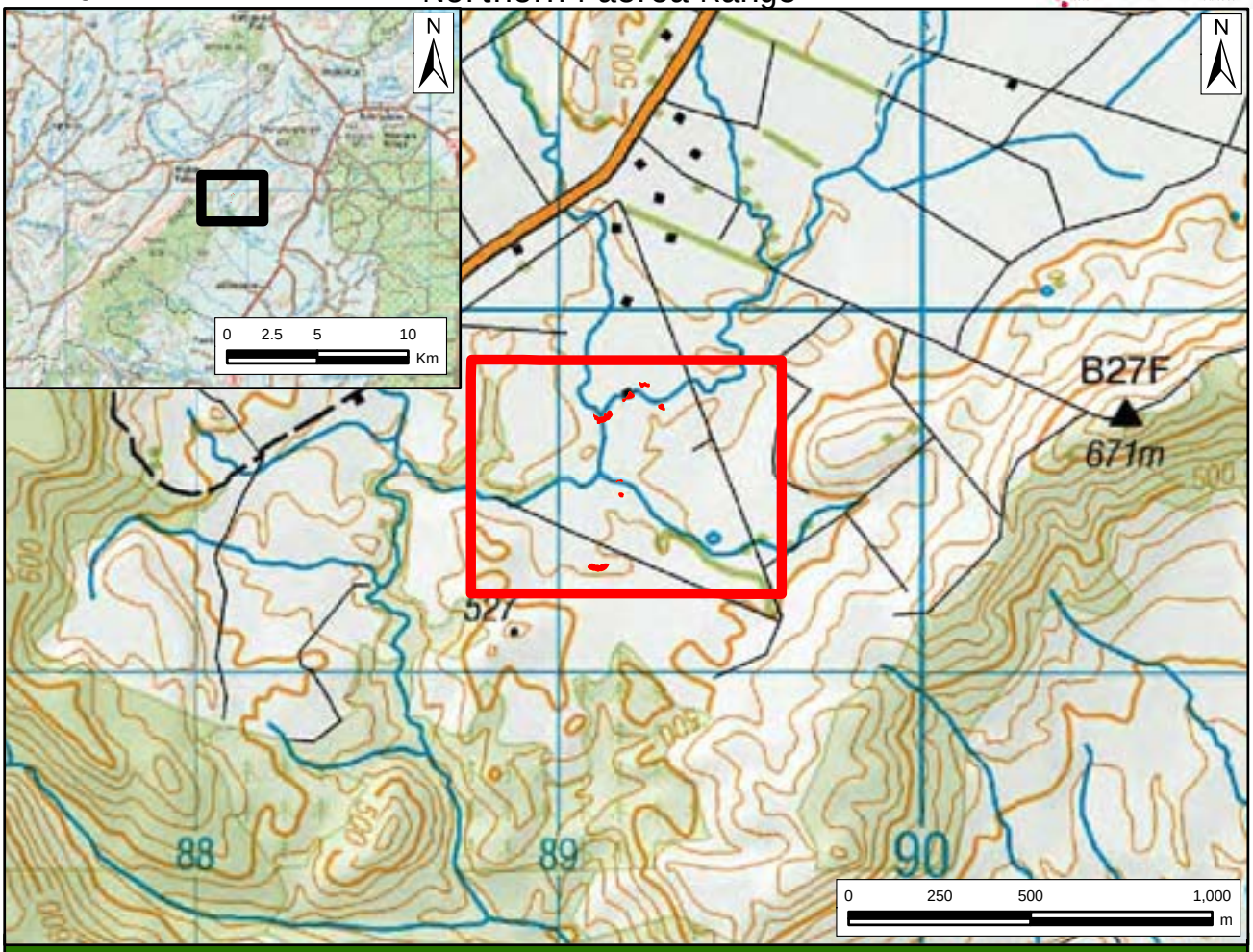
This site comprises three areas ranked in Given (1996): "Waikite Valley", "Paeroa Scarp" and "Otamakokore Stream". Given ranked these areas as A, B, and B respectively.

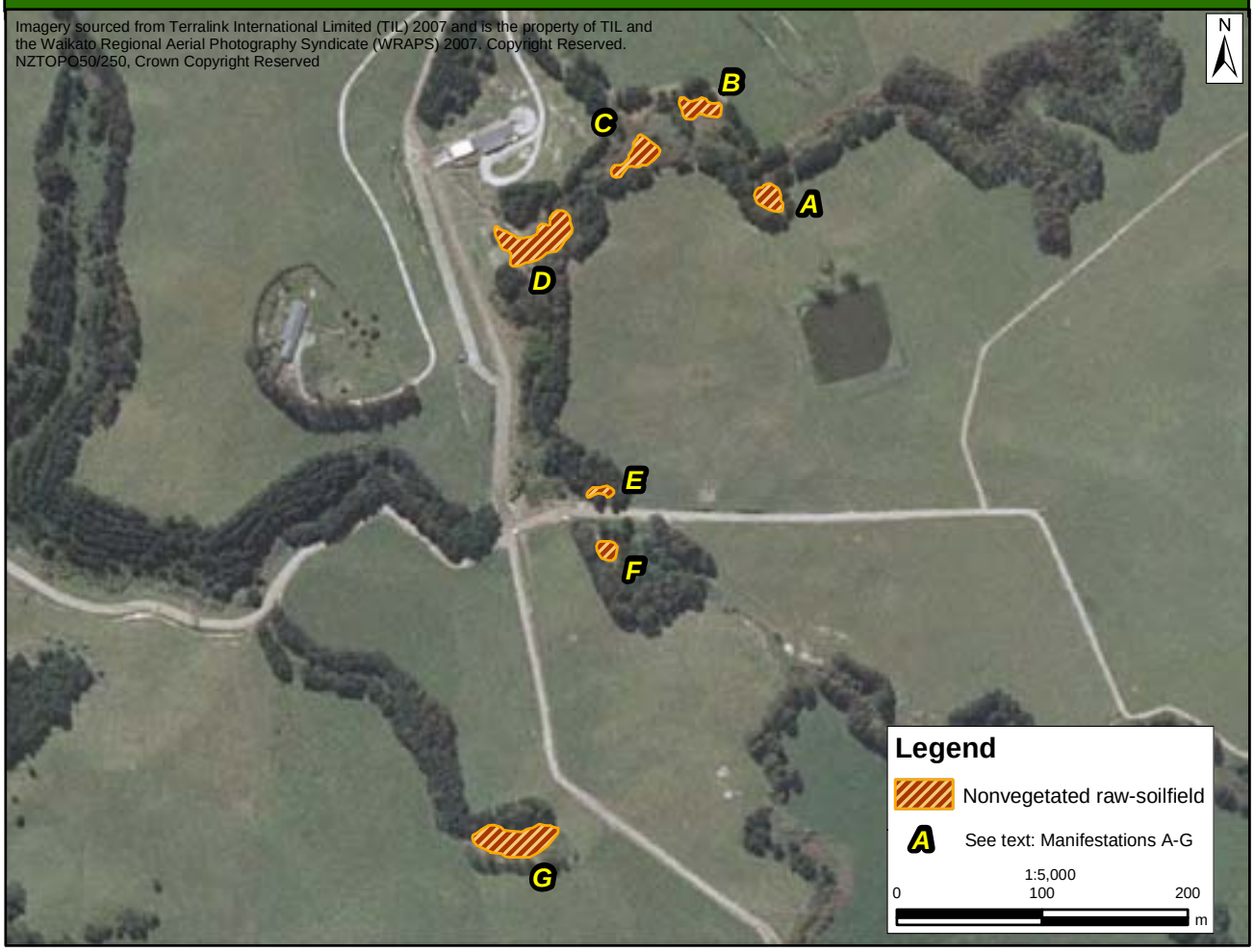
References:

Beadel 1995; Beadel & Bill 2000; Bycroft & Beadel 2007; Ecroyd & Coham 1976; Given 1996; Miller & Ecroyd 1993; Rotorua District Council 1994; Wildland Consultants 2004 & 2007b.

WAV02

Northern Paeroa Range





NORTHERN PAEROA RANGE

Site Number: WAV02[1]
Grid Reference: NZTopo50 BF37 891 497
GPS Reference: NZTM E1889118 N5749700
Local Authority: Rotorua
Ecological District: Atiamuri
Geothermal Field: Waikite
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: 520 m
Extent of Geothermal Habitat: *c.*0.3 ha
Extent of Geothermal Vegetation: *c.*0.3 ha
Date of Field Survey: 29 and 30 June 2010

Code	Type	Landform	Extent
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Seven units of nonvegetated raw-soilfield which are described in units as indicated on accompanying map from north to south. Area A: Nonvegetated raw-soilfield, surrounded by plantation pines with an understorey of manuka shrubland. Small patches of Yorkshire fog are present. While this area has been active in the recent past, there was no steaming evident. This unit was viewed with binoculars from across the creek. Area B: Nonvegetated raw-soilfield with abundant pine needles, and several plants of prostrate kanuka. A concrete pipe is present in the hottest area of geothermal activity. Occasional browntop present. Surrounded by maritime pine (*Pinus pinaster*) forest with a manuka subcanopy to *c.*3 m with occasional mingimingi, as well as a stand of grey willow and patches of blackberry scrub. Area C: Nonvegetated raw-soilfield. The site is surrounded by pine plantation, manuka-mingimingi scrub with occasional blackberry, broom and bracken. Several small patches of Yorkshire fog grassland. Most of this site is on the western side of the stream but a small portion is present on the eastern bank. Area D: The site is predominantly exposed geothermal clays, currently there is no elevated temperature noticeable at this site, but it has been actively geothermal in the past. The site is surrounded by planted exotic pines. Occasional manuka to 3 m on margins. *Histiopteris incisa* and mingimingi are also present on the margins beneath planted pines. A small wetland <5 × 5 m is present, with *Juncus edgariae* and rank exotic grasses, including Yorkshire fog, and browntop. Area E: Nonvegetated raw-soilfield. Surrounded by pine plantation with manuka and mingimingi with occasional *Histiopteris incisa,* and bracken in the understorey. Occasional	Gully (Area D is gully and wetland)	*c.*0.3 ha

[1] Previously identified as U17/36 in Wildland Consultants (2004).

Code	Type	Landform	Extent
	Yorkshire fog, sweet vernal (*Anthoxanthum odoratum*), manuka seedlings and four plants of prostrate kanuka on nonvegetated raw-soilfield. Area F: Nonvegetated raw-soilfield. Surrounded by pines and eucalyptus (*Eucalyptus* sp.) plantation. One monoao plant and five prostrate kanuka plants present. Area G: Nonvegetated raw-soilfield. This area is surrounded by plantation radiata pine (*Pinus radiata*), and planted eucalyptus to *c.*12 m tall, with an understorey of manuka scrub and shrubland, with common broom and bracken. Occasional manuka and prostrate kanuka are present on margins. Occasional sweet vernal and browntop were present on cooler parts of raw-soilfield. *Juncus prismatocarpus* was present by a warm spring.		

Geophysical Assessment:[1]

Area A

Viewed from other side of creek. Similar to sites B, D and E, but no geophysical assessment undertaken.

Area B

This is a 25 × 15 m outcrop of poorly sorted, moderately rounded, and weakly cemented gravelly pumice with weakly defined bedding. This overlies pinkish poorly sorted coarse clayey pumice sand. The entire outcrop is >50% covered by pine needles.

Unfortunately we did not record orientation data, but estimated north is shown on the sketch. The north end of the area is a roughly circular outcrop, with the margins showing moderate silicification; there is a strongly silicified outcrop on the western margin of this structure.

In the southern section of this area there is a 1 m diameter vertical concrete pipe around 1.2 m high. In the ground enclosed by this pipe are two small fumaroles with delicate sulphur structures (Plates 1 and 2). Within 2.5 m east and west of this pipe are two further fumaroles with sulphur encrusted walls, and south of these is a sulphur-encrusted east-west vent (Plates 3 and 4).

On the western margin of the area opposite the pipe is a 2 m diameter cracked and broken sinter mound (Plate 5).

Area C

Grid Reference: E1889201 N5749763

This is an area of bare ground and exposed altered rock. The area measures approximately 20 × 15 m. There is a dry gully on its southern flank with a small stream flowing past the northern boundary. A small low flowing/stagnant stream runs along the western boundary. Soil temperatures at 10 cm depth across the area were not elevated above ambient temperatures - 12°C. The exposed surface varies from altered

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

pumiceous rock which exhibit moderate alteration to brittle silicified gravelly soils/clay. There is evidence of sulphur deposition however no steaming ground was observed. A moderate sulphur odour was present although a source was not found. It could be diffuse H_2S or simply related to the adjacent area (Paeroa North 2) with steaming ground. The area is surrounded by pine woodland and farmland. Photographs were not taken at this site due to fading light.

Area D

This site measures approximately 28 × 40 m in area and comprises areas of exposed ground, clay banks, marshland, two gas discharging cold pools and two streams which meet at the centre of the southern end of the area. There is a slight H_2S odour at the area. The surrounding area is farmland and pine woodland.

On the western flank of the location is a clay slope or bank (Plate 6); soil temperatures were not above ambient conditions. The upper half of the slope is composed of poorly sorted gravelly clay. The gravels are coarse, angular to sub rounded, highly weathered and brittle. The clay matrix exhibits some flow banding in places. This would point towards the bank being formed as a result of a land slump or collapse. The lower half of the slope is a composed of fine-grained gravelly clay. A stream flows from the northwest along the base of the slope and as such may erode and shape this bank over time.

There are two cold pools in the centre of the site which have vigorous gas discharge (Plate 7). The gas is likely to be a combination of H_2S and CO_2. The temperature of the pools was 9.5°C and the pH was 3.5. Both pools are surrounded by a marsh/swamp area which includes various drainage channels which lead into the main stream which originates in the northeast.

The southeastern area of the site is dominated by a silt/sand bank with abundant rock outcrops and areas of fractured or broken sinter. Many of the rocks include silicified wood and other organic matter (Plate 8). Also present are rock outcrops with weakly cemented gravelly horizontally layers pumiceous rocks as well as occasional exposed welded ignimbrites with carbonized wood fragments. There is some minor sulphur deposition on the surface in this area (Plate 9). The main stream from the northeast flows past this area and joins the stream from the northwest at the southern end of the area. The main stream has a pH of 8. The soil temperatures at 10 cm depth across this area were not above ambient temperatures (11-12°C).

Area E

This is an area of bare ground and exposed altered rock (Plate 10). The area measures approximately 12 × 20 m. There is a dry gully on its southern flank with a small stream flowing past the western boundary (Plate 11). Soil temperatures at 10 cm depth across the area were not elevated above ambient temperatures and range from 9°C to 12°C. The exposed surfaces vary from altered pumiceous rock which exhibit moderate alteration to brittle silicified gravelly soils/clays with dissolution features in the clay matrix. Organic material was also noted in the pumiceous rock (Plate 12). There is little or no evidence of sulphur deposition and no steaming ground was observed.

Area F

Grid Ref: E1889165 N5749531

This is an easterly facing bank of bare rock partially covered by pine

needles (Plate 13). The bank is *c.*5 m high and 6 m wide.

The exposed rock is moderately acid altered pumiceous rock. The south and east margins of the outcrop are moderately to strongly silicified.

There is a stream running SW to NE along the base of the outcrop. The water temperature before and after it passes the outcrop is 12°C and the pH is 6.4 -6.5. There is no indication of any current thermal activity.

Area G

Grid Reference: E1889113 N5749294

This site measures approximately 50 × 20 m and is an area of exposed ground on the edge of a pine woodland area. The long axis of the area runs in an east-west orientation. The area consists of three main areas of exposed lightly sulphur encrusted gravelly pumice (maximum thickness 0.5 m) over pinkish poorly sorted pumice sandstone. There is minor silicification of both clay soil and rock and some areas of intense sulphur deposition around small warm vents. A small stream/drainage channel originates from two small pools on the southern boundary of the area.

The eastern end of the site, nearest the road access point, is dominated by an area of cold bare ground (temperatures of between 11-12^{o}C at 10 cm depth) (foreground Plate 14).

In the centre of the site there are two small pools from which a small stream flows to the west along the southern boundary of the area (Plate 15). There is also an area of bare ground with minor sulphur deposition on top of altered/weathered clays.

In the western end of the site is a third area of exposed ground with sulphur-encrusted fissures with some small (<0.1 m diameter) vents (Plate 16). The ground temperatures increase towards the most active vent which was 85^{o}C at 0.25 m depth. At 2m distance the temperatures are between 18-27^{o}C.

The stream on the southern boundary originates in a small oval pool in the east, which is 0.3 × 0.4 m × 0.2 m deep (temperature 21^{o}C) with a very low outflow rate (estimated to be < 0.1 l/s) (Plate 15). This drains into a second pool of around 0.6 m diameter and 0.2 m depth, which has a temperature of 22^{o}C and an estimated outflow of 0.5 l/s. As the stream reaches the western exposed rocks it has cooled to 15^{o}C, and after it has passed this area of weak thermal activity the temperature is 16^{o}C. The pH of the stream is between 3.2 and 3.7.

Flora:

Prostrate kanuka, classed as „At Risk-Naturally Uncommon' in de Lange *et al.* (2009) was present as occasional scattered plants scattered through small units of geothermal vegetation. Other species typical of geothermal habitats recorded were manuka, bracken, mingimingi, and *Histiopteris incisa*.

Fauna:

Common indigenous and exotic bird species are present including grey warbler, Australasian magpie and spur-winged plover. Cattle sign and rabbits were also present.

Current Condition

In a moderate condition. Most features have had some impact from stock.

(2011 Assessment):	Sites are surrounded by exotic plantation. One geothermal feature has been altered with a concrete pipe.
Threats/Modification/ Vulnerability:	
Invasive pest plants (*2011 Assessment*):	Most areas of geothermally-altered soils are largely devoid of vegetation. Blackberry and grey willow are common on margins in places. However management of pest plants at this site is a low priority compared with other geothermal sites in the Waikato Region.
Human impacts (*2011 Assessment*):	A concrete pipe is present in Unit B.
Grazing (*2011 Assessment*):	While all sites are fenced, stock sign was present in most sites.
Adjoining land use (*2011 Assessment*):	Plantation; farming; riparian margin vegetation.
Site Change:	
Recent change:	This site was not visited during the 2004-7 geothermal survey of geothermal vegetation in the Waikato Region. However the site is unlikely to have undergone any significant change over this time period.
Historical:	Site not assessed, no historical photos found. Site margins are currently plantation and have been grazed in the past. As most sites are in gullies and relatively small it is unlikely that changes will be visible on black and white aerial photographs.
Management Requirements:	Fences should be maintained to ensure stock cannot access site.
Significance Level:	Local (Table 1 - Criteria 3, 5; Table 2 - Factor 19)
Significance Justification:	Northern Paeroa Range is locally significant because it comprises several small examples of a nationally uncommon habitat type (i.e. geothermal habitat) and it includes a small population of an „At Risk' species, prostrate kanuka.
References:	Background information on this site from Paul Cashmore (Department of Conservation, Rotorua).

Northern Paeroa Range Geothermal Area B. Plates 1 to 5: refer to Geophysical text for Northern Paeroa Range Geothermal Area.

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Figure A1-1: Northern Paeroa Range Geothermal Area B. Field Sketch Map indicating main features and photo locations at manifestation B on Northern Paeroa Range Geothermal Area site map.

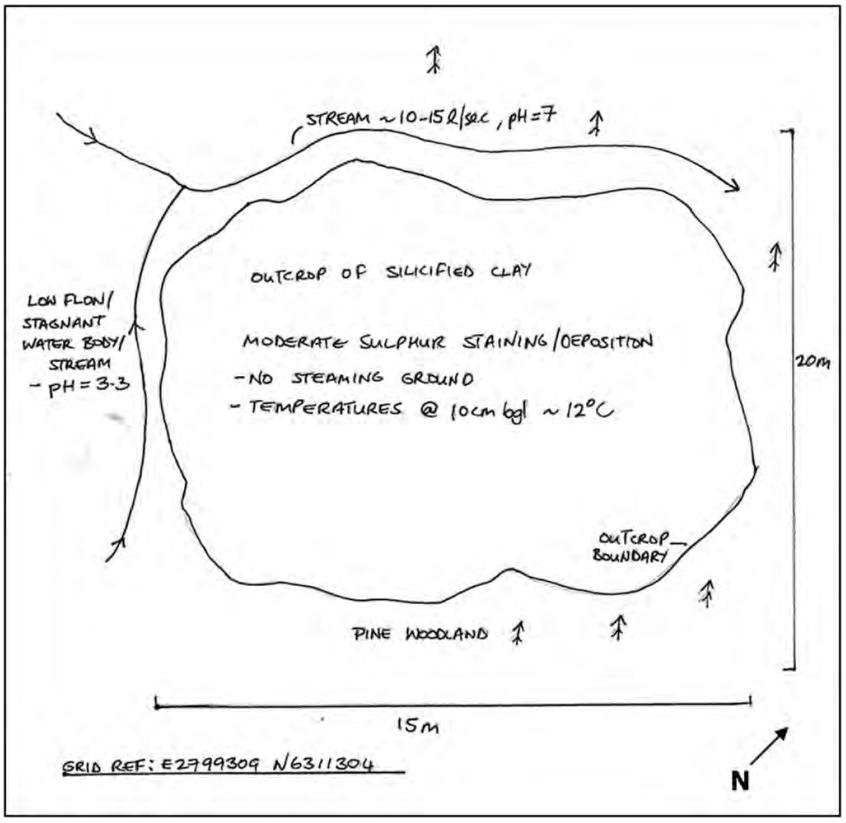
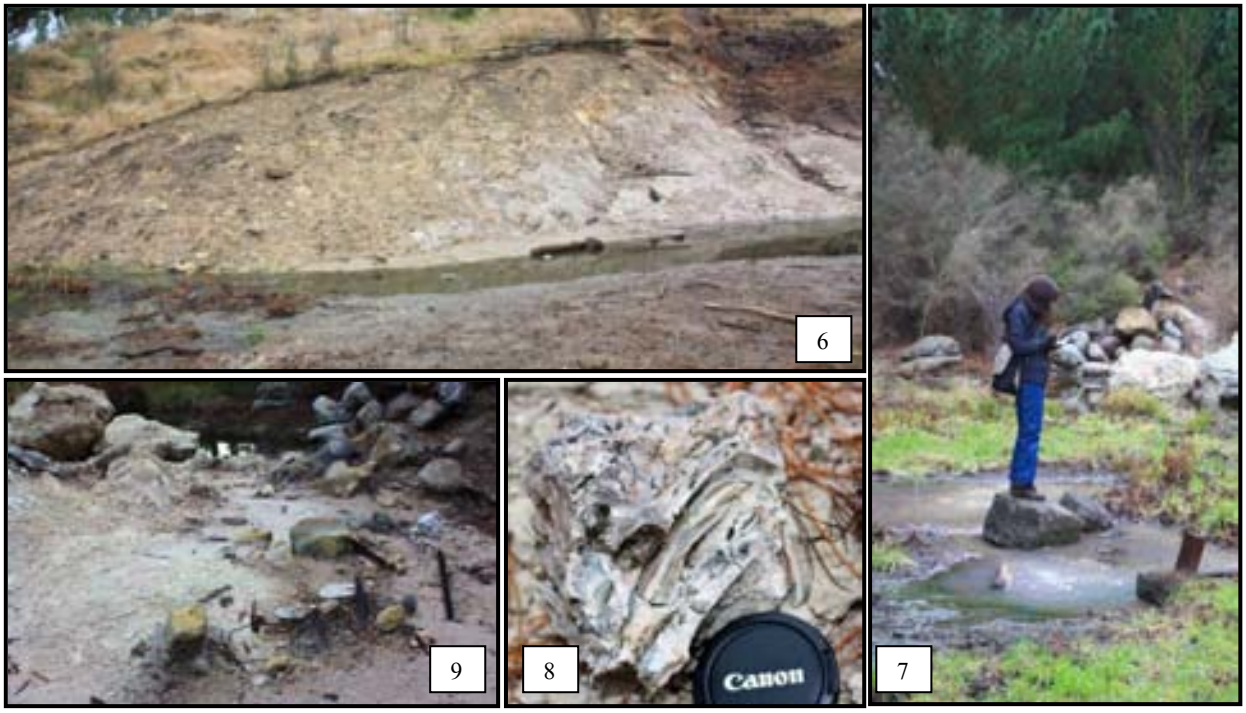


Figure A1-2: Northern Paeroa Range Geothermal Area C. Field Sketch Map indicating main features at manifestation C on Northern Paeroa Range Geothermal Area site map. The grid reference labelled here is NZMG.

Figure A1-3: Northern Paeroa Range Geothermal Area D. Field Sketch Map indicating main features and photo locations at manifestation D on Northern Paeroa Range Geothermal Area site map. The grid reference labelled here is NZMG.



Plates 8-9: Northern Paeroa Range Geothermal Area D. Area Photographs (clockwise from top left) - 6. Clay Bank/Slope, southwestern orientation: 7. Cold Gas Discharging Pools northeastern orientation; 8. Silicified clay with silicified wood; 9. Exposed ground with rock outcrops, sulphur deposits and sinter, northern orientation.

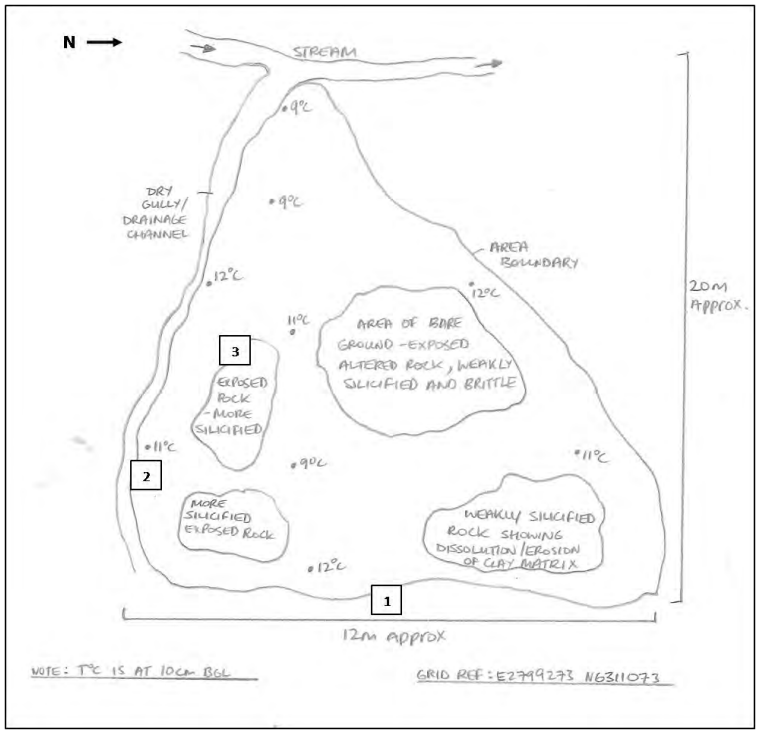
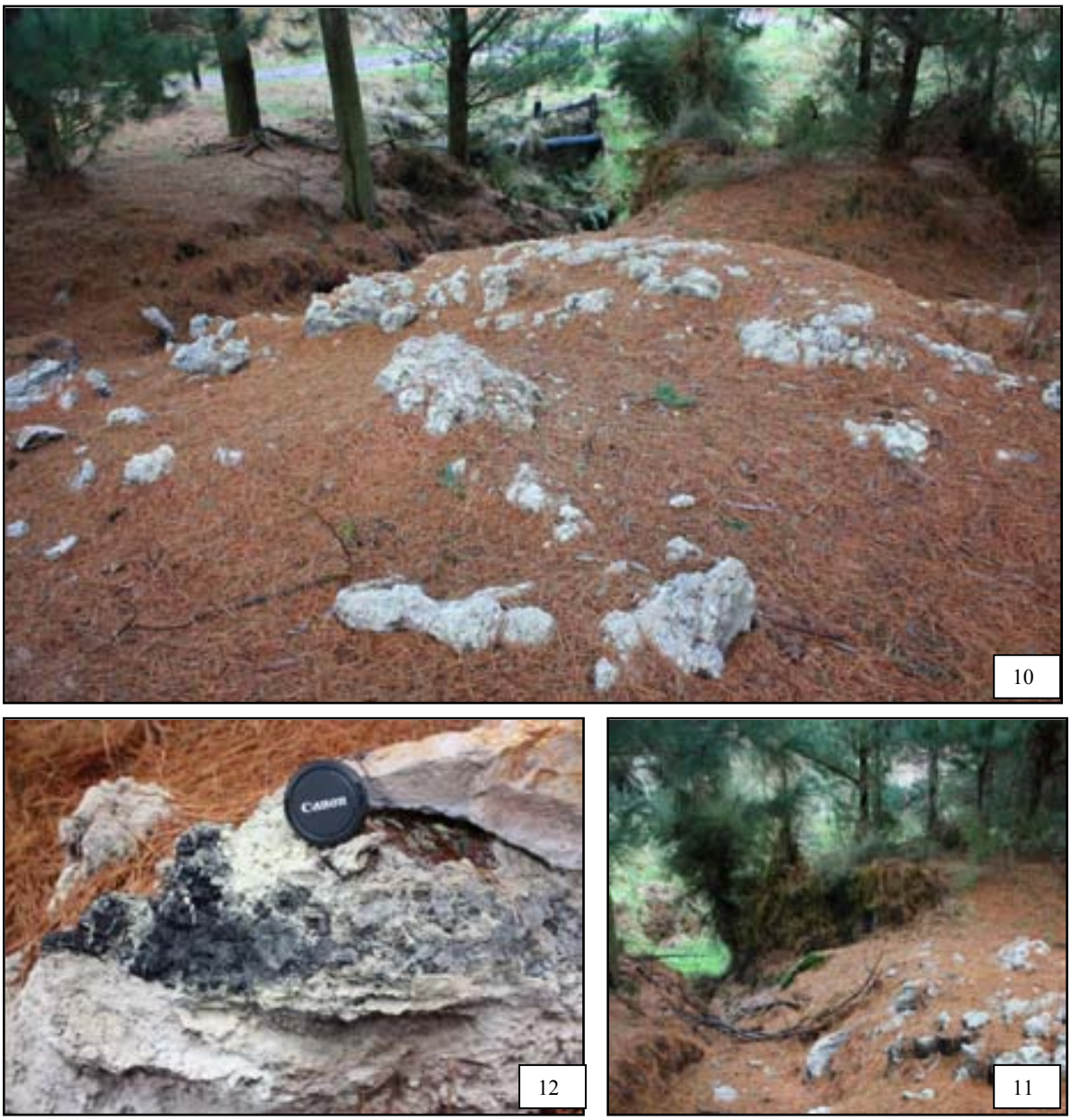


Figure A1-4:
Northern Paeroa Range Geothermal Area E. Field Sketch Map indicating main features and photo locations at manifestation E on Northern Paeroa Range Geothermal Area site map. The grid reference labelled here is NZMG.



Plates 10-12: Northern Paeroa Range Geothermal Area E. Photographs (clockwise from top left) - 10. Bare Ground and exposed altered rock; 11. Dry Gully with exposed rock on sides; 12. Pumiceous altered rock, top left, and more brittle/ weathered silicified soil/clay with organic material beneath

Figure A1-5: Northern Paeroa Range Geothermal Area F. Field Sketch Map indicating main features and photo locations at manifestation F on Northern Paeroa Range Geothermal Area site map. The grid reference labelled here is NZMG.

Plate 13: Northern Paeroa Range Geothermal Area F.

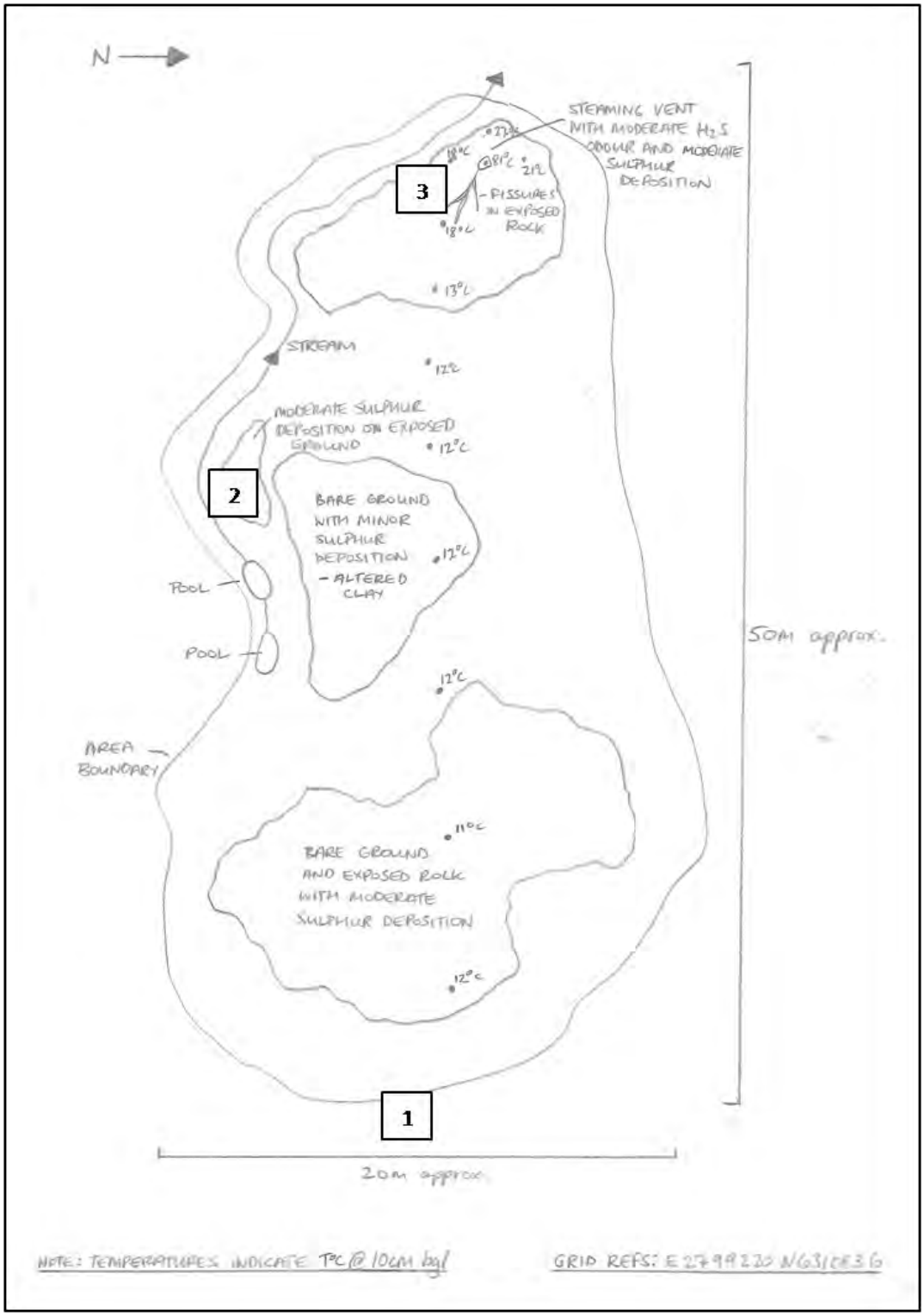


Figure A1-6: Northern Paeroa Range Geothermal Area G. Field Sketch Map indicating main features and photo locations at manifestation G on Northern Paeroa Range Geothermal Area site map. The grid reference labelled here is NZMG.

Plates 14-16: Northern Paeroa Range Geothermal Area G. Area Photographs (clockwise from top left) - 14. Full area view from eastern end; 15. Pools and stream along southern boundary; 16. Steam vent showing sulphur deposition around edge and fissure through silicified rock.