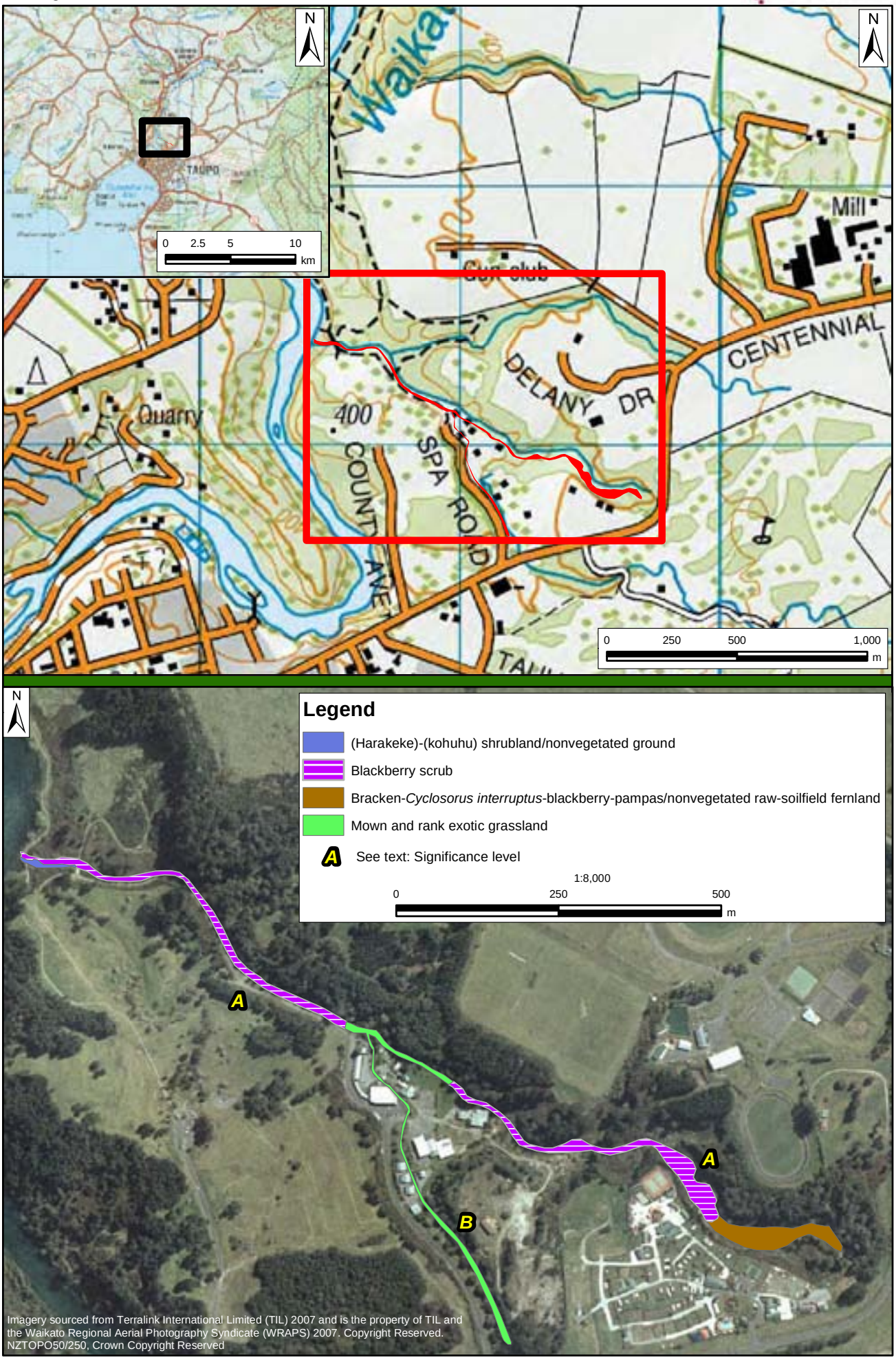
1.12 WAIRAKEI-TAUHARA GEOTHERMAL FIELD

List of Geothermal Sites

THV01	Otumuheke
THV03	Spa Thermal Park
THV04	Broadlands Road
THV05	Crown Park
THV06	Crown Road
THV07	Waipahihi Valley
WKV01	Te Rautehuia
WKV02	Te Rautehuia Stream
WKV03	Upper Wairakei Stream (Geyser Valley)
WKV04	Wairakei Borefield
WKV05	Te Kiri O Hine Kai Stream Catchment/Wairoa Hill
WKV06	Lower Wairakei Stream
WKV07	Karapiti Forest
WKV08	Hall of Fame Stream
WKV09	Waipouwerawera Stream/Tukairangi
WKV10	Craters of the Moon

THV01 Otumuheke



OTUMUHEKE

Site Number: THV01[1]
Grid Reference: NZTopo50 BG36 691 151
GPS Reference: NZTM E1869068 N5715075
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Protected (Patuiwi Marginal Strip) and unprotected private land
Altitude: *c.*380-400 m
Extent of Geothermal Habitat: *c.*2.3 ha
Extent of Geothermal Vegetation: *c.*2.3 ha
Date of Field Survey: 10 December 2010

Code	Type	Landform	Extent
05.07 05.07.02	**Planted indigenous shrubland** **(Harakeke)-(kohuhu) shrubland/nonvegetated ground** Nonvegetated ground with scattered indigenous plantings on the true left bank of the stream mouth. The bare ground is a result of herbicide application and subsequent planting of a small suite of indigenous species including harakeke, kohuhu, and manuka. The planted species are not thriving and several have died. In most places this vegetation type extends to the top of the stream bank, but the cleared vegetation extends to the stream margin in one location.	Stream margin	*c.*0.1 ha
07.05 07.05.13	**Mixed fernland** **Bracken-*Cyclosorus*-blackberry-pampas/nonvegetated raw-soilfield fernland** A mixed fernland dominated by bracken, *Cyclosorus interruptus*, *Hypolepis ambigua,* and *Histiopteris incisa. Cyclosorus interruptus* is increasingly common towards the eastern part of this vegetation type, near the most geothermally active part of the site. Occasional pampas and blackberry are present. There are patches of raupo, tall fescue*, Juncus edgariae*, *Carex secta* and *Cyperus ustulatus* in the cooler wetland areas, and prostrate kanuka on hummocks within the wetland. The eastern-most part of this vegetation type is the most geothermally active, with areas of sinter beside the stream and local patches of *Lycopodiella cernua*. The geothermally active parts of the wetland are difficult to access due to scalding water and an unstable streambed. Species present on dry, cooler sites include Indian doab, Yorkshire fog, sweet vernal, karamu, inkweed (*Phytolacca octandra*), umbrella sedge (*Cyperus eragrostis*), wilding pine seedlings, and extensive areas of giant bindweed.	Floor of an incised stream gully	*c.*0.5 ha
04.08 04.08.01	**Blackberry-dominant scrub** **Blackberry scrub** Blackberry, bracken, and *Muehlenbeckia australis* dominate the banks of the Otumuheke Stream, with exotic grasses such as	Stream margin	*c.*1.3 ha

[1] Previously identified as U18/3 (Otumuheke Stream) in Wildland Consultants (2004).

Code	Type	Landform	Extent
	tall fescue and Yorkshire fog, buddleia, and bracken. There are occasional patches of crack willow, wilding pine (mostly maritime pine), lupin (*Lupinus arboreus*), tradescantia (*Tradescantia fluminensis*), silver birch, gorse, and broom, which are encroaching from the margins. In places, the blackberry vineland is overhung by tall maritime pines and there are local patches of kanuka and false acacia (*Robinia pseudoacacia*). The false acacia trees, most of which are present a short distance upstream of the Spa Hotel, have been poisoned, but seedlings are establishing beneath them. *Histiopteris incisa* and occasional wheki-ponga occur above the vehicle bridge. On the steep stream banks downstream of the Spa Hotel there are small, scattered patches of *Nephrolepis flexuosa* and *Christella* aff. *dentata* ("thermal"). They become more common near the mouth of the stream but populations of both species, particularly *Nephrolepis flexuosa*, have been damaged by vegetation clearance at this location. Other ferns on the steep banks include *Deparia petersenii*, kiokio, and occasional *Cyclosorus interruptus*.		
08.06 08.06.03	**Mixed exotic-dominant grassland** **Mown and rank grassland** Within the grounds of the Spa Hotel, the banks of the Otumuheke Stream are dominated by mown and rank grasses with adventive plants and planted ornamentals. Grasses include Yorkshire fog, Indian doab, paspalum, and browntop. Occasional planted specimen trees include kahikatea (*Dacrycarpus dacrydioides*), totara, kohuhu, plum (*Prunus ×domestica*), and feijoa. Naturalised species include foxglove (*Digitalis purpurea*), lotus, flowering cherry, silver birch, ivy, blackberry, and umbrella sedge. Species present on the banks of the side stream that flow into Otumuheke Stream include umbrella sedge, lotus, silver birch seedlings, blackberry, and turutu. Upstream of the tavern, the stream has been redirected into a channel between low stone walls with overhanging harakeke, Tasmanian blackwood, and oak. There is a single clump of *Christella* aff. *dentata* ("thermal") and a clump of *Hypolepis dicksonioides* on the banks above the stream.	Stream margin	*c*.0.4 ha

Indigenous Flora:

Approximately 44 clumps of *Christella* aff. *dentata* ("thermal") (classed as „At Risk-Declining' in de Lange *et al.* 2009) and four clumps of *Nephrolepis flexuosa* (classed as „At Risk-Declining' in de Lange *et al.* 2009) occur near where the Otumuheke Stream flows into the Waikato River. A further three clumps of *Christella* aff. *dentata* ("thermal") occur at GPS Ref 1868683 5715377. There are also single plants of *Christella* aff. *dentata* ("thermal") alongside the stream in the lower half of the gully.

Cyclosorus interruptus (classed as „At Risk-Declining' in de Lange *et al.* 2009) is abundant in the upper part of the valley in Vegetation Type 07.05.13 with at least 200 plants present.

Hypolepis dicksonioides (classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) is present along the side stream, and may also be

present elsewhere. The plants recorded in 2004 are no longer present in the same location.

Lycopodiella cernua (a species characteristic of geothermal areas) is abundant at the eastern end of the site in Vegetation Type 07.05.13.

Fauna: Common indigenous and introduced bird species typical of the habitat are present including fantail, shining cuckoo, kingfisher, chaffinch, song thrush, tui, and grey warbler.

Current Condition (2010 Assessment): The geothermal wetland in the upper reaches of the site is in relatively good condition and is one of few such areas of sinter wetland remaining around Taupo. The remainder of the stream gully is highly modified and is dominated by invasive exotic plants. Some modification of the stream channel downstream from the Spa Hotel has occurred in the past and a geothermal wetland once occurred at the site of the Spa Hotel (Given 1989a).

Threats/Modification/ Vulnerability:

Invasive pest plants (*2010 assessment*)*:* Blackberry (50-75% cover) dominates the stream margins, and wilding pines (1-5% cover) and pampas (5-25% cover) are scattered throughout (each with 1-5% cover). Himalayan honeysuckle is also present (<1% cover).

Human impacts (*2010 assessment*)*:* Most of the lower part of this site has been highly modified through human use, with a wide walking track adjacent to most of the stream and leading to a popular bathing spot where Otumuheke Stream flows into the Waikato River. Other tracks and bridges are present and ornamental trees are present.

Additional draw-off from the Tauhara geothermal field has been consented (250 MW power plant) (www.nzgeothermal.org.nz site accessed 28/6/11) and this may further alter the geothermal vegetation.

Grazing (*2010 assessment*)*:* Livestock are not a current threat to this area.

Adjoining land use (*2010 assessment*)*:* Scrub comprising adventive and indigenous species.

Site Change:

Recent change: Since 2009, vegetation clearance works near the stream mouth has destroyed a large portion of the *Nephrolepis flexuosa* population and a few plants of *Christella* aff. *dentata* ("thermal"). The *Nephrolepis flexuosa* population has become particulary vulnerable because of increased erosion, and exposure to frosts.

An additional geothermal stream near the Spa Hotel was found. In previous surveys, this area was under thick blackberry and thus was not recorded.

Flooding has caused dieback of blackberry on stream margins and has

probably washed out some ferns recorded in earlier surveys. This may provide new habitat for establishment of „At Risk' fern species. Pines have also been removed from gully walls, and pampas has been controlled by the Waikato Regional Council, particularly in the upper stream gully (Waikato Regional Council 2011).

Historical: This site is too small to see any evidence of change since 1946 (Historical photos: SN 172 Run 1176 Photos 4, 1946). A geothermal wetland once occurred at the site of the Spa Hotel (Given 1989a).

Management Requirements: The geothermal wetland (Vegetation Type 07.05.13), and the stream and its margins should be managed as a single unit to ensure that the ecological sequence is preserved. Weed control efforts should focus on preventing the establishment of blackberry, pampas, and wilding pines within the geothermal swamp (07.05.13).

Given (1989a) suggested that this site could be restored as it is an "interesting geothermal site on a walkway route down the Waikato River and is highly accessible". Restoration of this site would enhance and sustain its ecological values and would be valuable for educational purposes.

Any restoration of the site or its margins needs to be planned and undertaken to minimise disturbance of threatened plant species. Specifically, herbicide should not be applied to the area near the stream mouth where *Nephrolepis flexuosa* and *Christella* aff. *dentata* ("thermal") are present.

Changes in vegetation associated with draw-off from the geothermal field need monitoring.

Significance Level: A: National (Table 1 - Criteria 3, 5, 6; Table 2 - Factor 8).
B: Local (Table 1 - Criteria 3, 5; Table 2 - Factor 19).

Significance Justification: The part of the site identified on the site map as A is of national significance because it is a good quality example of a nationally uncommon habitat type. The thermal swamp at the head of the Otumuheke Stream remains in excellent condition despite disturbances downstream. With its close proximity to Centennial Drive, it is one of few such areas close to Taupo.

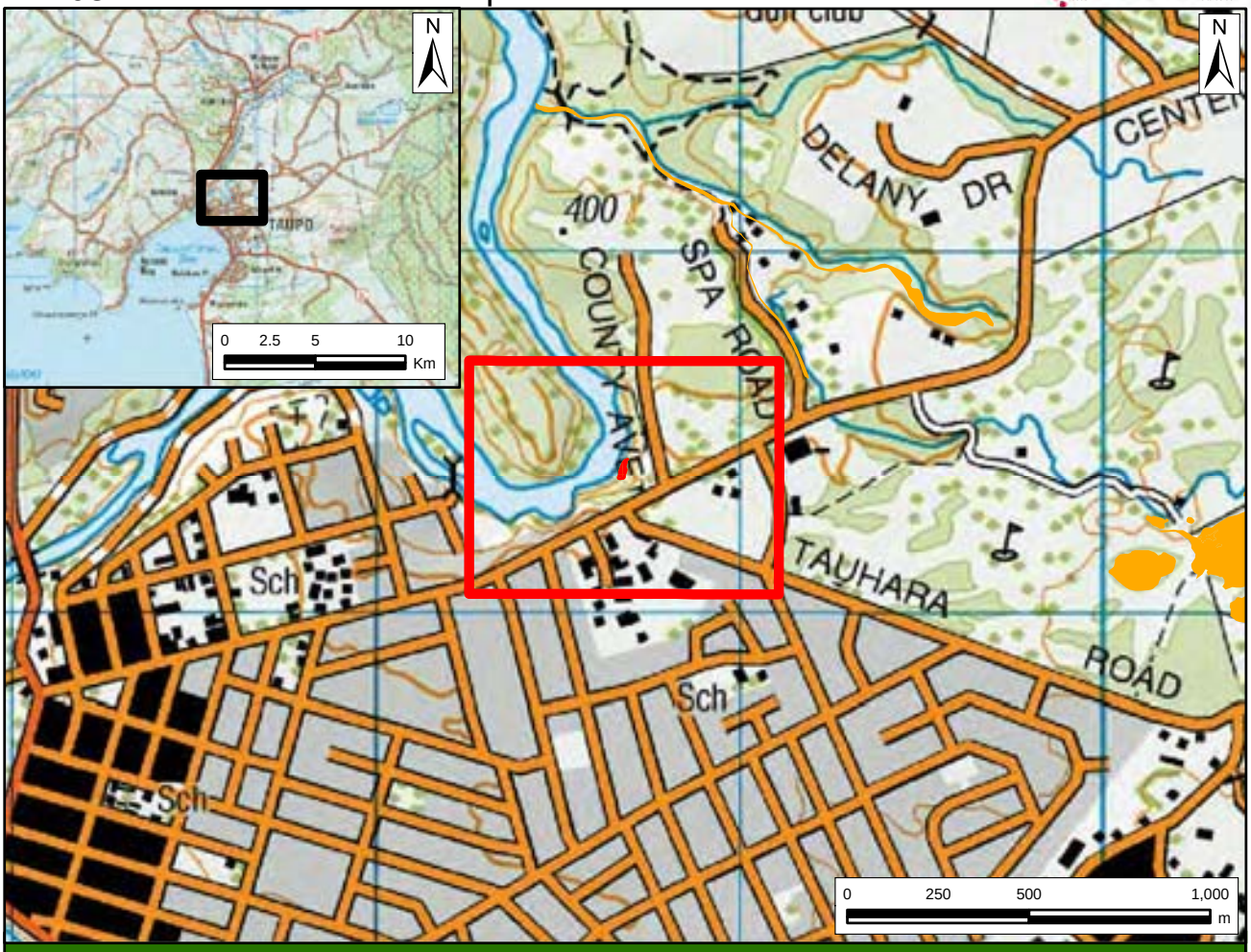
This site contains sizeable populations of two „At Risk' species: *Christella* aff. *dentata* ("thermal") and *Cyclosorus interruptus*. It is one of only 14 populations of *Christella* aff. *dentata* ("thermal") in existence and comprises at least 44 clumps. There are at least 200 plants of *Cyclosorus interruptus* at the eastern end of the site, and a small population of *Hypolepis dicksonioides* („At Risk-Naturally Uncommon') and *Nephrolepis flexuosa* („At Risk-Declining') are also present.

The part of the site identified on the site map as B is of local significance because it is a modified example of geothermal vegetation and habitat, a nationally rare habitat type. It contains a small population of *Christella* aff. *dentata* ("thermal") and geothermal habitat.

Notes:	This site comprises two areas ranked in Given (1996): "Upper Spa Stream" and "Lower Spa Stream", ranked as B and C sites respectively.
References:	Beadel & Bill 2000; Given 1989a & 1996; Waikato Regional Council 2011; Wildland Consultants 2004.

THV03

Spa Thermal Park



SPA THERMAL PARK[1]

Site Number: THV03[2]
Grid Reference: NZTopo50 BG36 687 144
GPS Reference: NZTM E1868685 N5714383
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Tauhara
Bioclimatic Zone: Submontane
Tenure: Protected (Taupo District Council Reserve)
Altitude: *c.*400 m
Extent of Geothermal Habitat: *c.*0.1 ha
Extent of Geothermal Vegetation: *c.*0.1 ha
Date of Field Survey: 7 April 2004 (partly revised on 20 December 2011)

VEGETATION		LANDFORM	EXTENT
CODE	**TYPE**		
04.01 04.01.02	**Prostrate kanuka-dominant scrub** **Prostrate kanuka-mingimingi scrub** Prostrate kanuka forms *c.*80% of the canopy in association with mingimingi and occasional broom. There is at least one wild radiata pine that is *c.*5m tall. This type occurs below the cliff.	Steep slopes	<0.1 ha
04.02 04.02.12	**Mingimingi-dominant scrub** **Mingimingi scrub** Mingimingi dominates the scrub above the cliff, with occasional prostrate kanuka and silver birch seedlings.	Steep slopes	<0.1 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka with mingimingi form a shrubland around small patches of nonvegetated raw-soilfield on the steep slopes above the true right side of the Waikato River. Other species present include occasional gorse, broom, browntop, koromiko, and karamu.	Steep slopes	<0.1 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Bare geothermal soils occur on a cliff near the Waikato River, with bracken present at the base of the cliff.	Steep slopes	<0.1 ha

Indigenous Flora: Prostrate kanuka, which is characteristic of geothermal habitats and is classed as „At Risk-Naturally Uncommon' (in de Lange *et al.* 2009), is present.

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

Current Condition: There is little sign of current geothermal activity, but the presence of nonvegetated raw-soilfield and prostrate kanuka indicate activity in recent times. Non-geothermal vegetation appears to be encroaching downslope at present, and this is likely to continue if geothermal activity at the site does

[1] This site is called Broadlands Road/Wairakei Park in Beadel & Bill (2000).
[2] Previously identified as U18/11 in Wildlands (2004 and 2006).

not increase.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 assessment*)*:* Broom (5-25% cover), gorse (1-5% cover), and wilding pine trees (1-5% cover) are present and are probably expanding in extent within the areas of geothermal vegetation.

Human impacts (*2011 assessment*)*:* Rubbish (e.g. beer bottles, tape decks, old clothing) is present on the site. Additional draw-off from the Tauhara geothermal field has been consented (250 MW power plant) (www.nzgeothermal.org.nz site accessed 28/6/11) and this may further alter the composition of the geothermal vegetation.

Grazing (*2011 assessment*)*:* No threat from grazing.

Adjoining land use (*2011 assessment*)*:* Riparian margin scrub and shrubland, and cliff faces. Most of the surrounding vegetation is blackberry, Himalayan honeysuckle, broom, and wilding pines. The site is about 20 m above the Waikato River. About 20 m above the site is a recreational park.

Site Change:

Recent change: The site appears similar to 2004. Although the 2011 site area is slightly larger than that mapped in 2004, this increase is mostly related to better quality aerial photographs.

Historical: This site is too small to see any evidence of change since 1946 (Historical photos: SN 172 Run 1176 Photos 3-4, 1946). According to Bromley *et al.* (2010), Spa Park was historically geothermally active, but has now cooled off resulting in areas of previously heated ground being covered in prostrate kanuka. According to Burns *et al.* (1995), in 1938 there was an area of prostrate kanuka comprising *c.*10 ha within Spa Park. Soil temperatures under the prostrate kanuka are lower than those usually found, suggesting that the remaining prostrate kanuka is a relict population from when soil temperatures were higher (Burns *et al.* 1995).

Management Requirements: Changes in vegetation associated with draw-off from the geothermal field should be monitored. This site is a low priority for management.

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

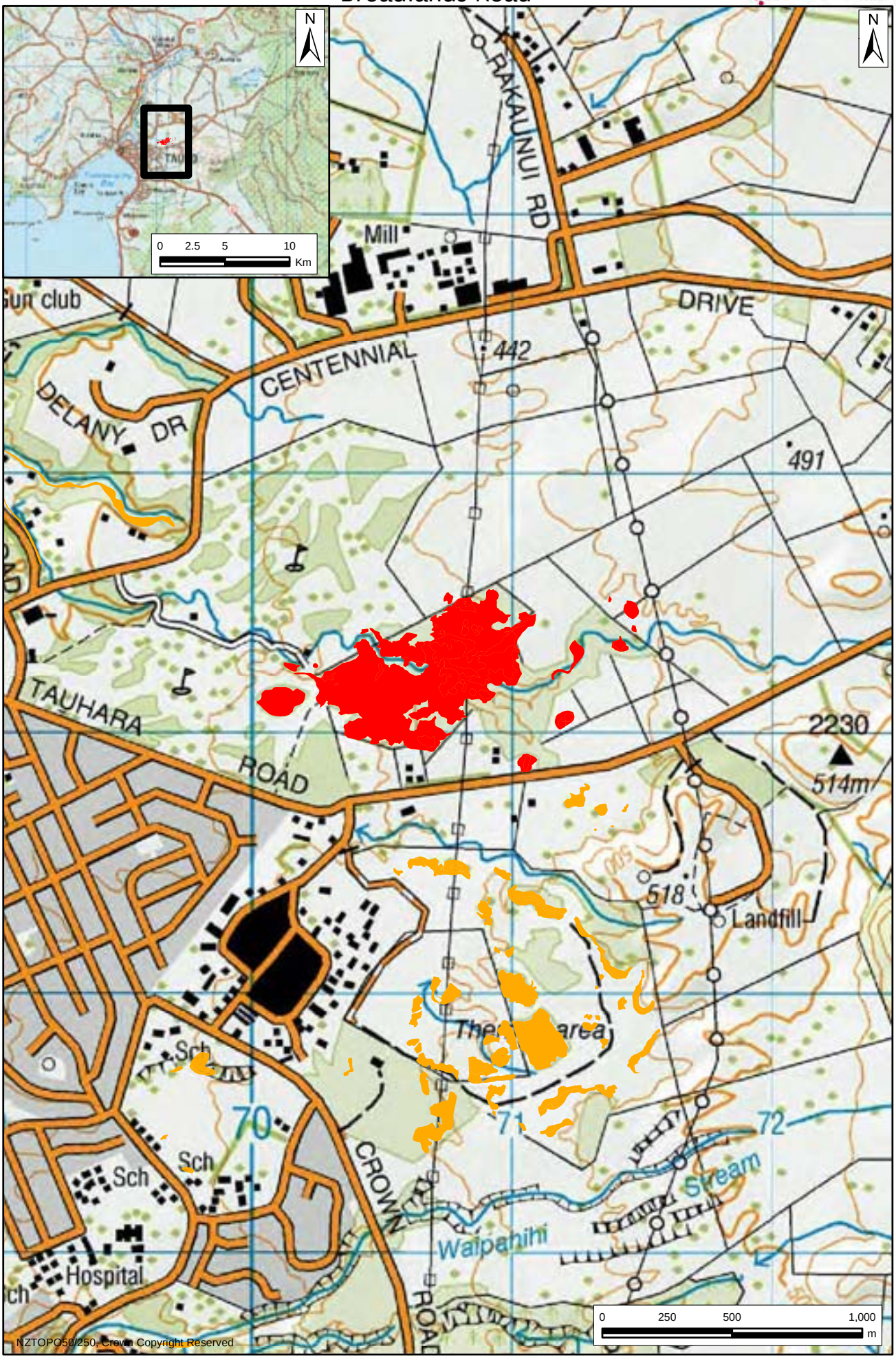
Significance Justification: This site is of local significance because it is a habitat that is nationally uncommon (geothermal), and it contains a small population of a species classed as „At Risk' (i.e. prostrate kanuka).

Notes: It is anticipated that soil temperatures will continue to cool, resulting in a reduction of geothermal vegetation over time. Proposed future development of the geothermal field is not expected to significantly affect this trend. (Bromley *et al.* 2010.)

References: Beadel & Bill 2000; Bromley *et al.* 2010; Burns *et al.* 1995; Given 1996; Wildland Consultants 2004 & 2006.

THV04

Broadlands Road



THV04

Broadlands Road

Wildlands
0508 WILDNZ
www.wildlands.co.nz

Legend

- Blackberry-broom/Yorkshire fog shrubland
- Geothermal water
- Kanuka shrubland
- Manuka/bracken-broom shrubland<->broom-bracken-blackberry shrubland<->prostrate kanuka scrub
- Nonvegetated raw-soilfield
- Prostrate kanuka scrub
- Prostrate kanuka shrubland
- State Highway constructed since 2007 (Approximate boundary)

1:6,500

0 500 1,000 m

BROADLANDS ROAD

Site Number: THV04[1]
Grid Reference: NZTopo50 BG36 706 140
GPS Reference: NZTM E1870625 N5713977
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Protected (Broadlands Road Geothermal Scenic Reserve) and unprotected private land
Altitude: 455 m
Extent of Geothermal Habitat: *c.*29.8 ha
Extent of Geothermal Vegetation: *c.*29.7 ha
Date of Field Survey: 3 March 2011

Code	Type	Landform	Extent
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** A dense canopy of prostrate kanuka (up to *c.*1 m high) with occasional monoao. The ground cover comprises a mixture of lichens, mosses (including *Campylopus* spp.) and liverworts, with occasional *Lycopodiella cernua*. There are occasional emergent maritime and radiata pine (more common on the western side of this site).	Undulating plateau	*c.*18.9 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka scrub to 0.5 m tall. Patches of *Lycopodiella cernua* and narrow-leaved carpet grass are common. Broom, exotic grasses (including paspalum, browntop, Indian doab, and Yorkshire fog), and blackberry are common on margins.	Explosion crater; undulating plateau	*c.*0.3 ha
05.03 05.03.24	**Manuka-dominant shrubland** **Manuka/bracken-broom shrubland ⇔ broom-bracken-blackberry shrubland ⇔ prostrate kanuka scrub** A large area dominated by exotic shrubs (broom and blackberry) with occasional emergent manuka and maritime pine. Small areas of prostrate kanuka shrubland are present within this area. Bracken and kiokio are abundant throughout and Mercer grass and Indian doab are dominant in open areas which occur locally.	Undulating plateau	*c.*5.9 ha
05.13 05.13.05	**Blackberry-dominant shrubland** **Blackberry-broom/Yorkshire fog shrubland** This type is dominated by blackberry, broom, Himalayan honeysuckle and Yorkshire fog along a narrow strip in a valley floor. There are scattered prostrate kanuka. Small wetland areas are present dominated by *Carex virgata* and *Baumea rubiginosa,* and are surrounded by Yorkshire fog.	Gully	*c.*0.1 ha
22.01 22.01.01	**Geothermal water** **Geothermal water** Geothermal pond.	Explosion crater	*c.*0.1 ha

[1] Previously identified as U18/7 in Wildland Consultants (2004, 2006)

Code	Type	Landform	Extent
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Steaming ground, mud pools, explosion craters and fumaroles. Small patches of prostrate kanuka occur on the margins. No sinter was recorded from this site.	Plateau	*c.*4.5 ha

Indigenous Flora: Prostrate kanuka (classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) and *Campylopus* spp., which are restricted to geothermal areas occur here. *Lycopodiella cernua*, and *Psilotum nudum*, which are both characteristic of geothermal areas, are also present. (Note the latter of these was observed at the site in 2007).

Fauna: New Zealand pipit classed as „At Risk-Declining' (Miskelly *et al.* 2008) have been recorded at this site. Common indigenous and introduced bird species typical of the habitat, including spur-winged plover, fantail, Australasian blackbird and magpie have been recorded at this site.

Current Condition (2011 Assessment): Anew State Highway 1 bypass around Taupo has been constructed over part of the site, however no geothermal vegetation has been lost from this site due to this construction.

This site contains a relatively large area of prostrate kanuka shrubland and scrub. Whilst adventive species are common in the reserve, the areas of prostrate kanuka are relatively free of invasive pest plants, except for wilding maritime pines and occasional blackberry on margins.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 Assessment*): Invasive pest plants include blackberry (25-50% cover), wilding pines (including radiata and maritime pine, 5-25% cover), occasional gorse (1-5% cover), broom (5-25% cover), poplars (<1%), grey willow (<1%), strawberry tree (*Arbutus unedo*; one recorded in 2007).

Human impacts (*2011 Assessment*): The new State Highway 1 bypass around Taupo has been constructed over part of the site, although not through areas of geothermal activity. The site is still vulnerable to further degradation from farming activities and Golf Course expansion. The new highway has made part of the site more accessible to people. This may increase the likelihood of dumping of litter, informal tracks, weed invasion, and vegetation trampling at this site. A fire was recorded near the site on 7 June 2007.

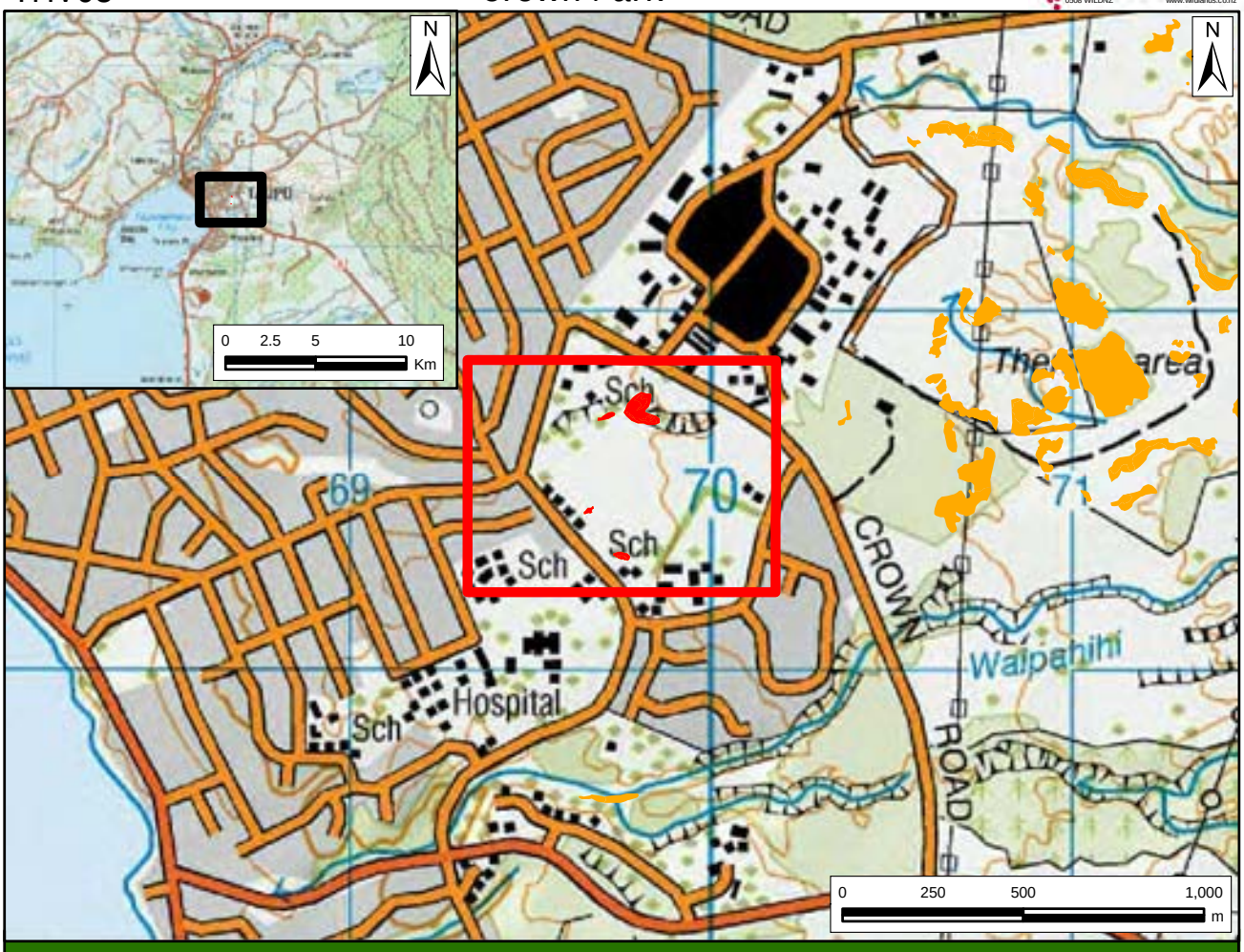
This site is also vulnerable to the impacts of draw-off from the geothermal field and the vegetation and geothermal features underwent large changes with the establishment of Wairakei Power Station (Burns 1996a). Additional draw-off from the Tauhara geothermal field has been consented (250 MW power plant) (www.nzgeothermal.org.nz site accessed 28/6/11) and this may further alter the geothermal vegetation.

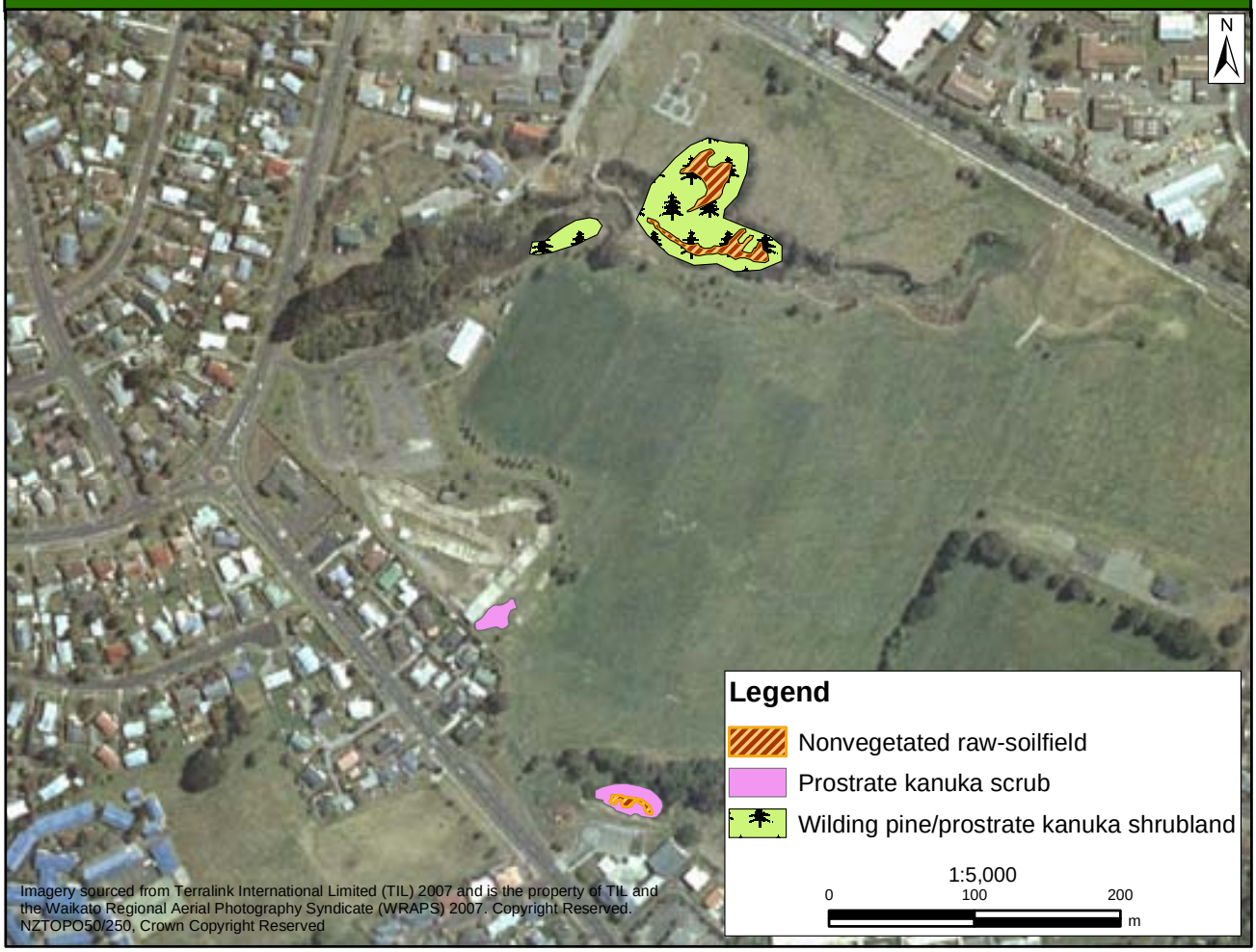
Grazing (*2011 Assessment*): Small areas to the east of the reserve are accessible to stock. Pest animals, including rabbits, hares, and possums, are also likely to impact geothermal sites by grazing and browse.

Adjoining land use (*2011 Assessment*):	Golf course; farming; state highway.
Site Change:	
Recent change:	The new State Highway 1 bypass around Taupo now passes through this site (see above). Otherwise, the site is similar to earlier surveys. Some pest plant control (e.g. wilding pine) has been undertaken by Department of Conservation.
Historical:	In 1946 there was bare ground in the vicinity of the site. This may indicate that the cover of geothermal vegetation and habitat was more extensive at that time than it is today (Historical photos: SN 172 Run 1176 Photos 5-6, 1946). Burns *et al* (1995) also noted that the 1938 and 1963 photographs showed respectively that "no" and "little" geothermal shrubland was present, although two bare sinter areas with pools suggest some geothermal activity. Urban, road and farming development have all reduced the size of this site. Two hydrothermal eruption craters formed in 1974 and 1981 (Bromley *et al.* 2010).
Management Requirements:	Wilding pines should continue to be removed from areas where prostrate kanuka is dominant. Changes in vegetation associated with draw-off from the geothermal field need monitoring.
Significance Level:	Regional (Table 1 - Criteria 1, 3, 5, 7, 9; Table 2 - Factors 9, 12, 14).
Significance Justification:	Broadlands Road is of regional significance because it is protected under the Reserves Act (1977) as a Scenic Reserve, contains a large population of prostrate kanuka (an „At Risk' species), and comprises a relatively large example of geothermal habitat, a nationally uncommon habitat type.
Notes:	Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region, and in this study this site was classed as Category B - the second highest category. Several small areas of nonvegetated raw-soilfield amongst pasture to the northeast of the site have been excluded from the significant geothermal vegetation mapped at this site. They were included as part of this site in the report Wildland Consultants 2004.
References:	Beadel & Bill 2000; Bromley *et al.* 2010; Burns 1995 & 1996a; Given 1989a & 1996; Grove *et al*. 1999; Wildland Consultants 2004, 2006 & 2007e.

THV05

Crown Park





CROWN PARK

Site Number: THV05[1]
Grid Reference: NZTopo50 BG36 698 127
GPS Reference: NZTM E1869808 N5712732
Local Authority: Taupo
Ecological District: Taupo
Geothermal Field: Tauhara
Bioclimatic Zone: Submontane
Tenure: Protected (Taupo District Council Reserve)
Altitude: *c.*440 m
Extent of Geothermal Habitat: 0.7 ha
Extent of Geothermal Vegetation: 0.7 ha
Date of Field Survey: 7 April 2004 (partly revised on 7 June 2006)

VEGETATION		LANDFORM	EXTENT
CODE	**TYPE**		
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** Two small units of prostrate kanuka. The small unit to the east surrounds a small patch of nonvegetated raw-soilfield and contains occasional broom, blackberry, manuka, and *Banksia* sp. Several patches of narrow-leaved carpet grass were present. The small patch of prostrate kanuka to the west contains occasional pampas.	Plateau, gully	0.1 ha
05.01 05.01.14	**Prostrate kanuka-dominant shrubland** **Exotic pine/prostrate kanuka shrubland** Maritime pine on margins occurs over a prostrate kanuka shrubland. Other species present include the occasional broom, blackberry, pampas, Himalayan honeysuckle, and eucalyptus. Blackberry occurs with prostrate kanuka in the eastern unit of this geothermal area. Several plants of *Lycopodiella cernua* are present.	Shallow gully	0.5 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Heated soils, fumaroles with small patches of prostrate kanuka.	Shallow gullies	0.1 ha

Indigenous Flora: The site supports a small area (i.e. less than 1 ha) of prostrate kanuka (classed as an „At Risk-Naturally Uncommon' species in de Lange *et al.* 2009). *Lycopodiella cernua*, a species characteristic of geothermal areas, is also present.

Fauna: No „Threatened' or „At Risk' species as listed in Miskelly *et al.* (2008) are known from this site. Common indigenous and introduced bird species typical of the habitat are present.

[1] Previously identified as U18/12 in Wildland Consultants (2006).

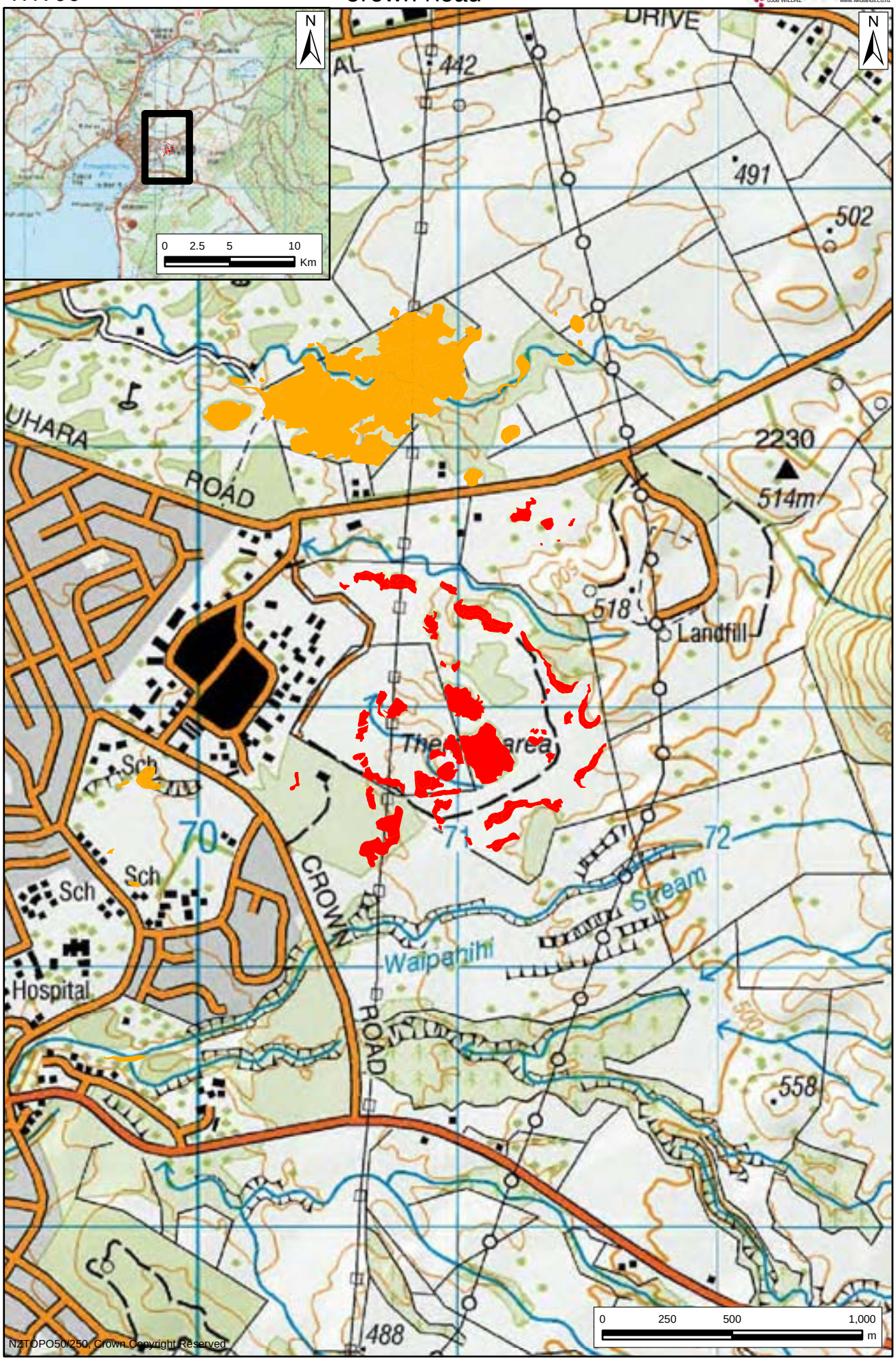
Current Condition (2006 Assessment):	The site is in poor condition with a large number of pest plants present amongst the prostrate kanuka. Rubbish and walking tracks dissect areas of prostrate kanuka.
Threats/Modification/ Vulnerability:	
Invasive pest plants (*2006 Assessment*)*:*	The site is threatened by pest plant species infestation, particularly blackberry which currently covers 5-25% of the site, and wilding maritime pines which cover 5-25% of site. Control of wilding pines has been undertaken by Waikato Regional Council in recent years (Katherine Luketina pers. comm. 2011) and the cover of pines is likely to have reduced to <5%. Following the pine control work, ongoing pest plant control (particularly pine seedlings and broom) has been carried out by Waikato Regional Council. Other pest plant species present include flowering cherry, eucalyptus, pampas, broom, and Himalayan honeysuckle, each with 1-5% cover.
Human impacts (*2006 Assessment*)*:*	The site has been modified through rubbish dumping, and tracks created by people wandering through the geothermal area. It is surrounded by a recreational park. Additional draw-off from the Tauhara geothermal field has been consented (250 MW power plant) (www.nzgeothermal.org.nz site accessed 28/6/11) and this may result in further changes to the geothermal vegetation cover.
Grazing (*2006 Assessment*)*:*	Livestock are not a threat to this area.
Adjoining land use (*2006 Assessment*)*:*	Recreation reserve.
Site Changes:	
Recent change:	This site was not revisited as part of this study, however pest plant control and the removal of rubbish has been undertaken by Waikato Regional Council (Katherine Luketina, pers. comm. 2011) and therefore the extent of pest plants at the site is likely to be smaller than in 2006.
Historical:	This site is too small to see any evidence of change since 1946 (Historical photos: SN 172 Run 1176 Photos 4-5, 1946). Burns *et al.* (1995) found that 1963 aerial photos showed a 10-20% loss of the gully area due to infilling.
Management Requirements:	Any reinvasion of wilding pines and other pest plants in this site should be contained. Monitoring of vegetation changes as a result of geothermal draw-off should be carried out.
Significance Level:	Local (Table 1 - Criteria 3, 5; Table 2 - Factor 19).
Significance Justification:	This site is of local significance because it is an example of a nationally uncommon habitat type and contains a small population of an „At Risk' species - prostrate kanuka.
Notes:	This site was previously identified as being of regional significance because it provides habitat for prostrate kanuka, an „At Risk' species (Wildland

Consultants 2006). However, the revised criteria for relative significance state that a site must be a habitat of "considerable importance" for an „At Risk' species to achieve regional significance status. This site is in poor condition and includes only a small population of prostrate kanuka.

References: Burns *et al.* 1995; Wildland Consultants 2004 & 2006.

THV06

Crown Road



THV06

Crown Road

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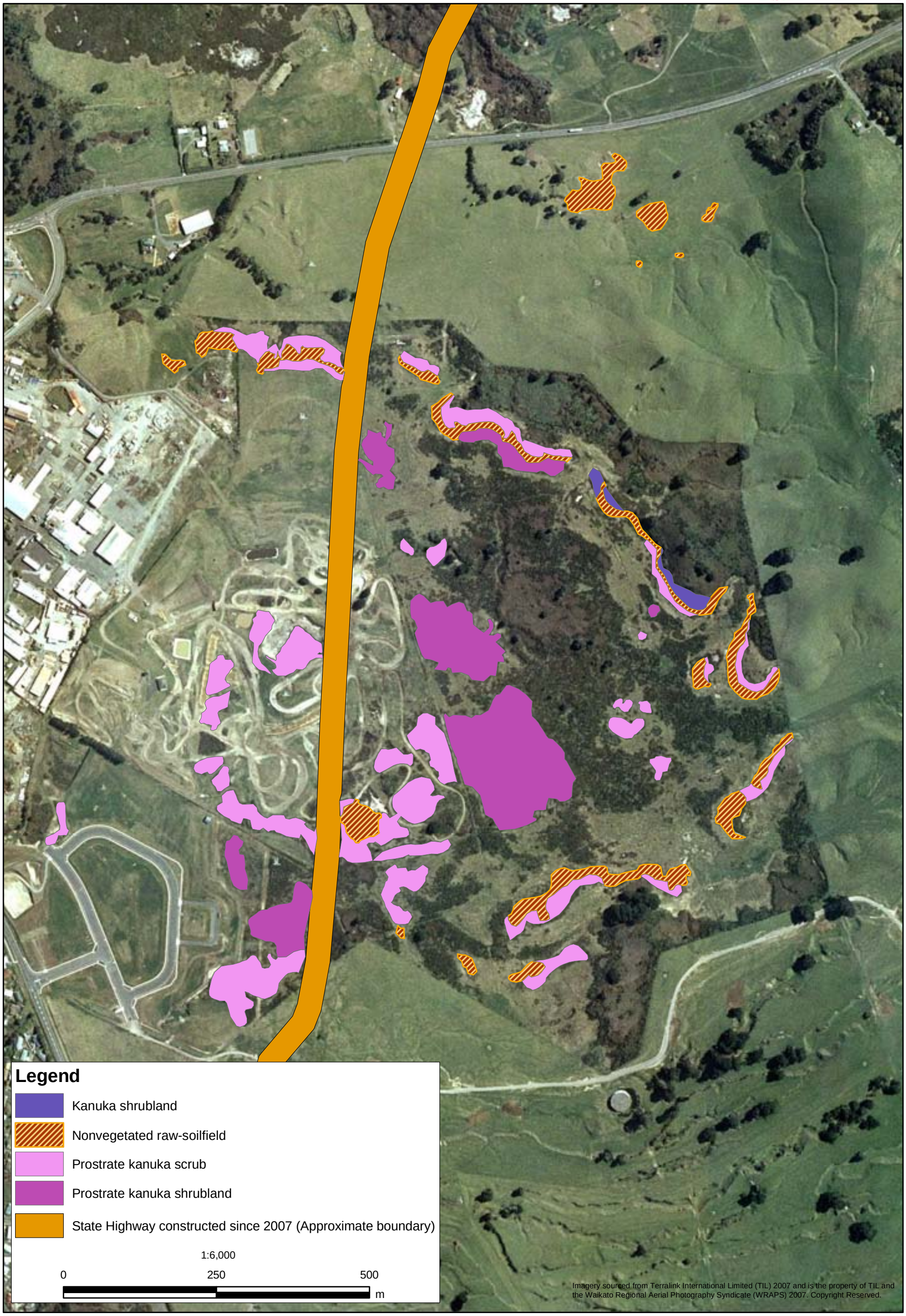


CROWN ROAD

Site Number: THV06[1]
Grid Reference: NZTopo50 BG36 711 128
GPS Reference: NZTM E1871110 N5712827
Local Authority: Taupo
Ecological District: Taupo; Atiamuri
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: 460 m
Extent of Geothermal Habitat: *c.*17.5 ha
Extent of Geothermal Vegetation: *c.*17.5 ha
Date of Field Survey: 3 March 2011

Code	Type	Landform	Extent
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** Prostrate kanuka is abundant in association with occasional mingimingi. Occasional broom and emergent wilding pines (maritime pine and radiata pine) are scattered throughout with local patches of blackberry. Mosses and patches of *Lycopodiella cernua* are present locally, particularly around steam vents.	Shallow gullies and flat plateau	*c.*7.4 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka is common with scattered broom, blackberry and exotic grasses. An area of prostrate kanuka that had previously been burned (in 2002) has now re-established as prostrate kanuka shrubland. Broom, buddleia and blackberry occur in localised areas.	Flat plateau	*c.*6.0. ha
05.04 05.04.06	**Kanuka-dominant shrubland** **Kanuka shrubland** Kanuka shrubs dominate the margins of several geothermal areas in association with mingimingi. Broom, blackberry and occasional emergent maritime pine and are also present.	Hillslope	*c.*0.3 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Fumaroles and geothermally heated bare ground is dominant with small patches of prostrate kanuka and exotic grasses.	Shallow gullies	*c.*3.7 ha

Indigenous Flora: The site supports sizeable areas of prostrate kanuka (classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) scrub and shrubland. The area of prostrate kanuka scrub and shrubland burnt in 2002 (*c.*1 ha) is recovering well. *Lycopodiella cernua*, a species characteristic of geothermal areas, is also present.

Dicranopteris linearis (1-2 plants), an „At Risk-Naturally Uncommon' species and *Psilotum nudum* were recorded in the southeast corner of the

[1] Previously identified as U18/2 in Wildland Consultants (2004).

site. *D. linearis* is known from only *c.*24 sites in New Zealand.

Fauna: New Zealand pipit (classed as 'At Risk-Declining' in Miskelly *et al.* 2008), tui, bellbird, Australasian harrier hawk, grey warbler, black-backed gull, fantail, paradise shelduck and spur-winged plover were recorded at the site.

Current Condition (2011 Assessment): The new State Highway 1 bypass around Taupo has been constructed through the middle of this site, which has destroyed some geothermal vegetation. Additional vegetation has been destroyed as part of the Ashwood Park retail development to the south of the site.

The site includes more than 20 separate areas of prostrate kanuka scrub and shrubland, with the development and use of a motorcross track having caused considerable fragmentation of part of the site.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 Assessment*): The most abundant pest plants at the site are broom and blackberry, which occur both as scattered shrubs and dense scrub, and cover 1-5% of the site. Chinese privet and wilding pines, both with 1-5% cover, are also present. Buddleia covers <1%. This site is vulnerable to further weed invasion because of continual disturbance, particularly in the south-western area (motocross track and neighbouring industrial area). Recent control of broom and wilding pines in areas adjoining the new highway has been carried out by the Waikato Regional Council, particularly within areas of prostrate kanuka scrub and shrubland.

Human impacts (*2011 Assessment*): The site has been bisected by the new State Highway 1 bypass around Taupo and is vulnerable to further degradation by farming, motorcycles, and further development for industrial and residential uses. It is also threatened by urban sprawl and human-induced changes to the geothermal field. A fire in the south-western part of the site in March 2002 greatly reduced the cover of prostrate kanuka scrub; however this vegetation type is recovering. Geothermal prospecting and field development for energy use have the potential to impact surface geothermal features and their character, and should be monitored for change.

Additional draw-off from the Tauhara geothermal field has been consented (250 MW power plant) (www.nzgeothermal.org.nz site accessed 28/6/11) and this may further alter the geothermal vegetation.

Grazing (*2011 Assessment*): The eastern part of the site is farmed and has not been fenced to exclude stock.

Adjoining land use (*2011 Assessment*): Farmland; motorbike track; state highway; industrial area.

Site Change:

Recent change: Approximately 1.5 ha of geothermal vegetation has been lost since 2004. The loss was due, in part, as a result of roading development and construction of an industrial subdivision. Prostrate kanuka shrubland is still recovering after a fire in 2002. Parts of the western side of the new highway are now fenced to exclude stock. The Waikato Regional Council

has recently carried out control of pest plants in areas of prostrate kanuka scrub and shrubland adjoining the new highway.

Historical: Burns *et al*. (1995), following a study of aerial photographs taken in 1963, indicates that this site had declined in size due to the establishment of a motorcross track and encroachment of the adjacent industrial land uses. Geothermal activity at this site probably increased briefly following the Wairakei power development, and then has steadily declined in intensity (Bromley *et al.* 2010). Historical photos (1946: SN 172 Run 1176 Photos 5-6) show more bare ground than is currently present.

Management Requirements: Formal protection could be considered for parts of this site, which contains good examples of prostrate kanuka shrubland and associated areas of hydrothermally altered soils and heated soilfield. Broom, wilding pines and blackberry should be controlled. Changes in vegetation cover associated with draw-off from the geothermal field and the response of vegetation following fire should be monitored.

Significance Level: Regional (Table 1 - Criteria 3, 5, 9; Table 2 - Factors 12, 14).

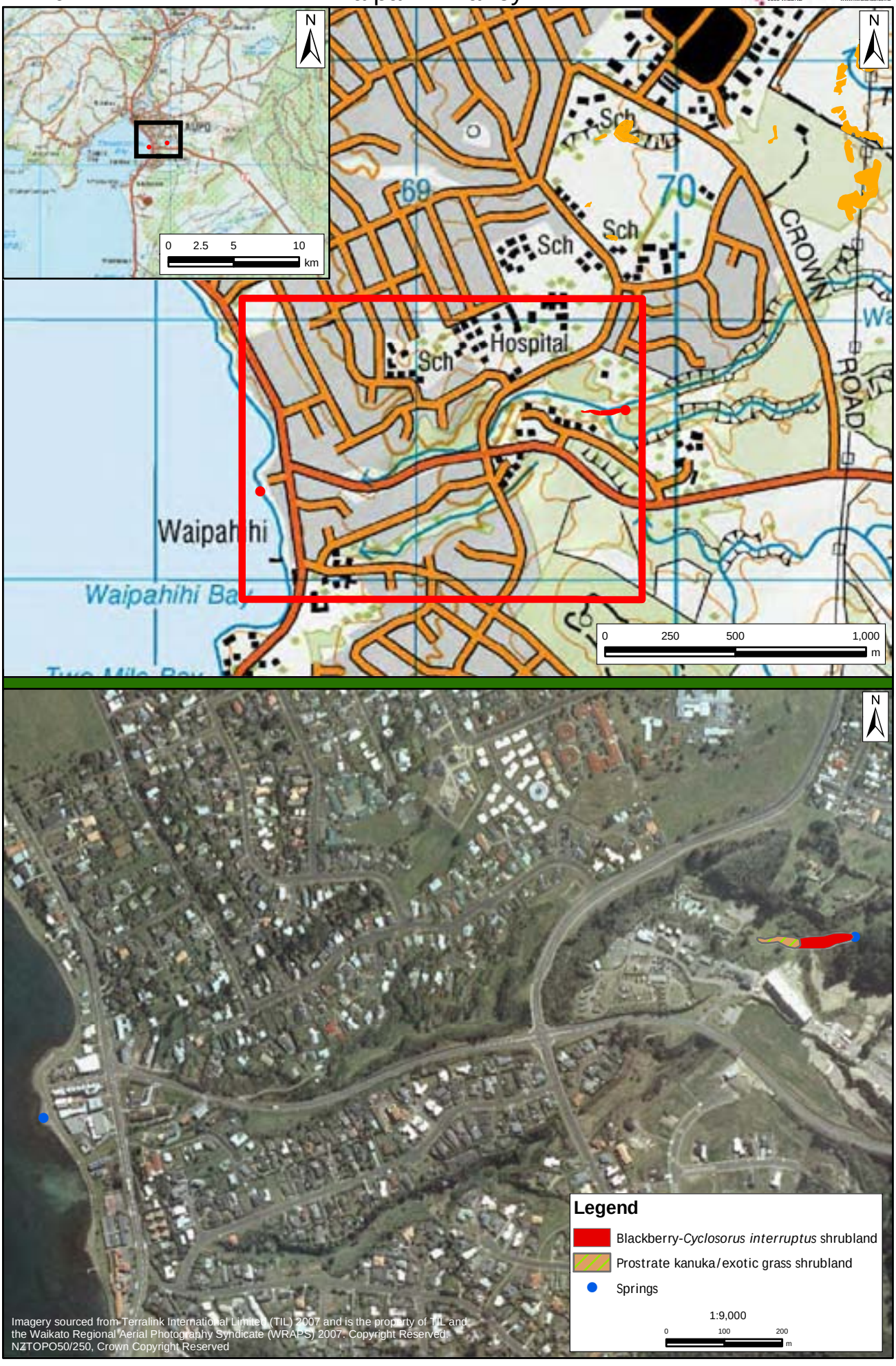
Significance Justification: This site is of regional significance because it comprises a relatively large example of geothermal habitat, which is a nationally uncommon habitat type. It includes prostrate kanuka shrubland and a small population of *Dicranopteris linearis*, both of which are 'At Risk' species. Areas of hydrothermally altered soils and heated soilfield are also present.

Notes: Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region, and in this study this site was classed as Category B - the second highest category for protection.

References: Beadel & Bill 2000; Bromley *et al.* 2010; Burns *et al.* 1995; Given 1989a & 1996; Grove *et al.* 1999.

THV07

Waipahihi Valley



WAIPAHIHI VALLEY[1]

Site Number: THV07[2]
Grid Reference: NZTopo50 BG36 697 116
GPS Reference: NZTM E1869718 N5711647
Local Authority: Taupo
Ecological District: Taupo
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Protected (Waipahihi Stream Conservation Area) and unprotected private land.
Altitude: 420 m
Extent of Geothermal Habitat: *c.*0.3 ha
Extent of Geothermal Vegetation: *c.*0.3 ha
Date of Field Survey: 16 December 2009

Code	Type	Landform	Extent
05.01 05.01.16	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka/exotic grass shrubland** A grassed area has been mown to the stream edge. Scattered prostrate kanuka (1.5-2 m tall) occur on the margins. Small seedlings (up to 3 cm tall) are abundant in areas that are not heavily mown. Grassland species include Yorkshire fog, sweet vernal, prairie grass (*Bromus willdenowii*), browntop, and tall fescue. Occasional harakeke and *Carex secta* are also present. A small modified pool is within this vegetation type.	Valley floor	*c.*0.1 ha
05.13 05.13.06	**Blackberry-dominant shrubland** **Blackberry-*Cyclosorus interruptus* shrubland** Blackberry dominates the stream edges below a geothermal spring. *Cyclosorus interruptus* (*c.*20 clumps) is scattered along stream margins and, in places, is emergent over small plants of blackberry, and exotic herbs and grasses (including sweet vernal, Yorkshire fog, pohue, and Californian thistle). Arrow grass is present on sinter and prostrate kanuka (1.5-2 m tall) occurs along the stream margins. Planted olive (*Olea* sp.) trees and ornamental cherry (*Prunus* sp.) trees are present near the spring.	Valley floor	*c.*0.2 ha

Indigenous Flora: A small population (*c.*20 clumps) of *Cyclosorus interruptus* classed as ‚At Risk-Declining' (de Lange *et al.* 2009) is present, near the spring on the stream margins. Prostrate kanuka and *Hypolepis dicksonioides*, both classed as ‚At Risk-Naturally Uncommon' (de Lange *et al.* 2009) are also present. Arrow grass, which is present near the stream, is more commonly found in coastal situations.

[1] Previously named Waipahihi Stream (De Bretts Thermal Pool) in Beadel & Bill 2000.
[2] Previously identified as U18/5 in Wildland Consultants (2004).

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

Current Condition (2010 Assessment): The spring is fenced, grassed and planted with exotic trees including olive and ornamental cherry. Recent control work to reduce the dominance of blackberry below the spring has provided increased potential habitat for *Cyclosorus interruptus*. Prostrate kanuka occurs in local patches and reaches a height of *c.*2 m. Heated water enters the stream close to the lake edge.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2010 Assessment*): Extensive control work has been undertaken to reduce blackberry (1-5% of cover) along the stream margins near the spring. Other pest plant species include radiata pine (1-5% total cover), ivy (1-5% total cover), ornamental cherry (<1% total cover), olive (<1% total cover), pampas <1% total cover). The Waikato Regional Council has undertaken some small-scale pampas control at this site.

Human impacts (*2011 Assessment*): Vegetation clearance and other site modifications (surface water draw off, pool complex development) have altered natural geothermal expressions and vegetation composition. Lawn mowing may reduce the likelihood of natural regeneration of prostrate kanuka and *Cyclosorus interruptus* populations. The adjoining landowner has damaged geothermal sinter and surrounding geothermal and non-geothermal vegetation by undertaking earthworks downstream of the geothermal spring.

Additional draw-off from the Tauhara geothermal field has been consented (250 MW power plant) (www.nzgeothermal.org.nz accessed 28/6/11) and this may further alter the geothermal vegetation.

Grazing (*2011 Assessment*): Grazing occurs in fenced area above spring, but stock are excluded from the spring area.

Adjoining land use (*2011 Assessment*): Grazing occurs to the north of this site. Parking, recreational areas and the spa pool complex are present further along the gully floor. A mosaic of indigenous and exotic forest, and restoration plantings occur on the gully sides. Residential dwellings, subdivision and accommodation amenities occur on the valley terraces.

Site Change:

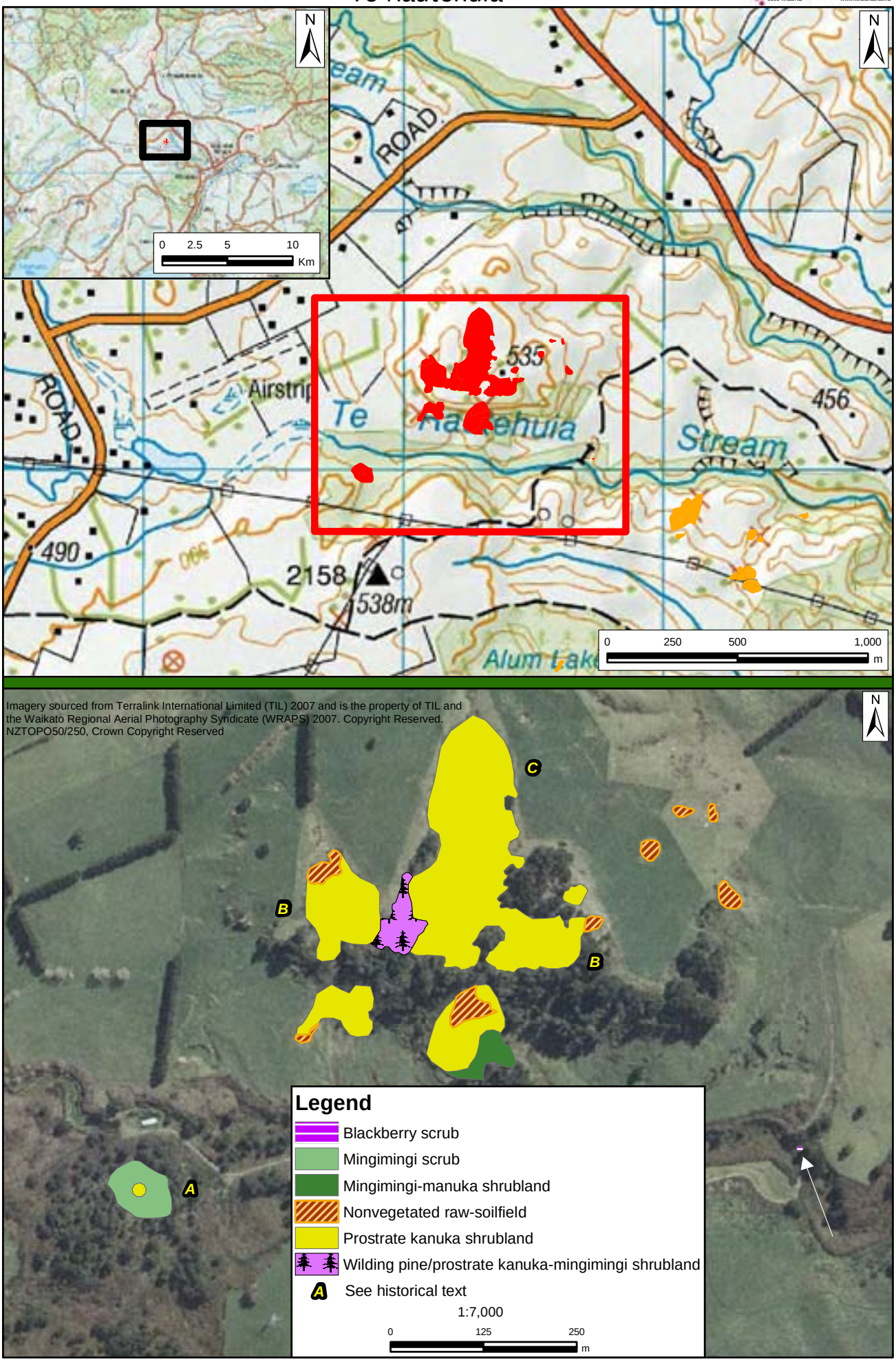
Recent change: Weed control has reduced the blackberry infestation below the spring area.

Historical: An assessment of change in extent and character of geothermal vegetation was made between 1946 historic photographs (Historical photo: SN 172 Run 1177 Photo 5, 1946) and 2007 aerial photographs. In 1946 there was substantially less urban and commercial development surrounding this site than exists presently, and the cliffs surrounding the site were less densely covered with vegetation. There appears to be a more extensive area of wetland and open water at the site, although the vegetation in the gully floor is unclear in places. The site was probably significantly larger in the 1940s, and may be at least five to ten times its current size (2007/2011). The stream below the site is likely to have been more geothermal in character.

	The first recorded history of the physical features of the Waipahihi Spring reports a temperature of up to *c*.31°C in the stream as it flowed towards Lake Taupo (Hochstetter 1864 in Cody 1993). Heated pools near the spring head, as large as *c*.50 × 30 m, and a stream, 1-2 m across, were present in the 1870s (Fox 1874, Skey 1878 and Harris 1878 in Cody 1993). The pools were described as having raupo and rushes on the margins (Cody 1993). The Terraces Hotel was built in 1889 above the upper reaches of the stream at the top of 'a black sinter slope', and utilised the heated water in the valley below as swimming baths for their guests. These pools were renowned as the 'finest natural hot swimming baths in the Thermal District', ranging in temperature from 36.7 to 76.7°C (ibid).
Management Requirements:	A conservative approach to blackberry control is recommended to minimise the risk of sudden exposure to *Cyclosorus interruptus* from the heat of summer or winter frost (i.e. no more than 25% of the total area of the site should be cleared of blackberry or other pest plants at one time) The site should be monitored to identify any potential changes in vegetation associated with draw-off from the geothermal field.
Significance Level:	Regional (Table 1 - Criteria 1, 3, 5; Table 2 - Factor 9)
Significance Justification:	Waipahihi Valley is of regional significance because parts of the site are protected as a Conservation Area and it provides habitat for three 'At Risk' species: prostrate kanuka, *Hypolepis dicksonioides,* and *Cyclosorus interruptus*.
Notes:	Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region, and in this study this site was classed as Category C - the third highest category for protection.
References:	Beadel & Bill 2000; Cody 1993; Given 1996; Wildland Consultants 2004.

WKV01

Te Rautehuia



TE RAUTEHUIA

Site Number: WKV01[1]
Grid Reference: NZTopo50 BG36 663 225
GPS Reference: NZTM E1866262 N5722450
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: 427 m
Extent of Geothermal Habitat: *c.*7.7 ha
Extent of Geothermal Vegetation: *c.*7.7 ha
Date of Field Survey: 27 January 2011

Code	Type	Landform	Extent
04.02 04.02.12	**Mingimingi-dominant scrub** **Mingimingi scrub** Mingimingi dominates with kanuka, manuka and wheki common throughout and scattered emergent wilding pines.	Hillslope	*c.*0.5 ha
04.08 04.08.01	**Blackberry-dominant scrub** **Blackberry scrub** A small heated spring (73°C at time of survey) is surrounded by blackberry and pohue with lesser amounts of broom and lotus. Water purslane is present in the cooler margins of the pool.	Shallow gully	<0.1 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka forms a low, discontinuous canopy c.0.3-0.75 m high, with mingimingi scattered around the outer margins. Groundcover includes moss cushions (mainly *Campylopus* sp.) and *Lycopodiella cernua*. Grasses including Indian doab, sweet vernal, browntop, and paspalum occur locally on cooler and disturbed ground. There are scattered emergent radiata pine and maritime pine. Patches of blackberry and Spanish heath, and small areas of bare, steaming ground occur throughout.	Plateau and hillslope	*c.*6.1 ha
05.01.17	**Wilding pine/prostrate kanuka-mingimingi shrubland** Radiata pine and maritime pine occur over prostrate kanuka and mingimingi.	Hillslope	*c.*0.4 ha
05.02 05.02.02	**Mingimingi-dominant shrubland** **Mingimingi-manuka shrubland** Occasional maritime pine occur over scrub dominated by mingimingi and manuka. Prostrate kanuka occurs on heated soils near the margins of this type where it adjoins prostrate kanuka shrubland.	Hillslope	*c.*0.3 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Heated clays, fumaroles and mud pools. Occasional prostrate kanuka and *Lycopodiella cernua*. Heated fumaroles present in open pasture with Indian doab on margins.	Shallow gullies, crater, hillslope	*c.*0.5 ha

[1] Previously identified as U17/22 in Wildland Consultants (2004 and 2006).

Indigenous Flora: Prostrate kanuka (classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) is the dominant species at this site. *Lycopodiella cernua*, a species characteristic of geothermal areas, is also present. *Dicranopteris linearis* („At Risk-Naturally Uncommon') and *Nephrolepis flexuosa* („At Risk-Declining' in de Lange *et al.* 2009) were recorded at this site in 2006. *D. linearis* is known from only *c.*24 sites in New Zealand.

Fauna: Common indigenous and introduced bird species typical of the habitat have been recorded at this site including Australasian harrier, paradise shelduck, magpie, tui, yellowhammer, chaffinch, green finch, Californian quail, and blackbird. New Zealand pipit (classed as „At Risk-Declining' in Miskelly *et al.* 2008) is also present.

Deer graze parts of the prostrate kanuka shrubland and fumaroles within pasture.

Current Condition (2011 Assessment): This site comprises several small geothermal areas surrounded by pine plantations and farmland. Domestic livestock, particularly deer, have access to some geothermal areas, although parts have been fenced off and stock excluded. The overall condition is very good with few weeds; however areas that are grazed are more degraded.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 Assessment*): There is a pine plantation contiguous with the geothermal area and wilding pines are a key threat to this site. Broom and blackberry in low densities are present (each of <1% cover). Exotic grasses occur in cooler areas and on margins (particularly Indian doab, sweet vernal, browntop and paspalum).

Human impacts (*2011 Assessment*): This site is on private property and is seldom visited, so direct human impact is low.

Grazing (*2011 Assessment*): The site is mostly fenced, however deer graze some fenced areas.

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

Site Change:

Recent change: Radiata pine and maritime pine continue to invade naturally occurring geothermal vegetation, particularly prostrate kanuka scrub and shrubland. Prostrate kanuka does not tolerate shading well. Feral deer access the fenced prostrate kanuka shrubland with tracks and signs of trampling throughout. Blackberry (<1%) is scattered through parts of the prostrate kanuka shrubland.

Historical: Burns *et al.* (1996) assessed vegetation change at this site using aerial photographs from 1945 to 1993. In an area inclusive of Te Rautehuia Stream (WKV02), they found that geothermal vegetation decreased by at least 23% between 1945 and 1993.

An assessment was made of 1961 aerial photographs (Historical photos: SN

1394 Run 3187 Photos 22-23, 1961) with 2007 aerial photographs (WRAPs). This estimate of a decline of one-quarter by Burns seems reasonable when viewing historical photos for this site, although some of this decline would have already taken place by the 1960s. The area to the southwest labelled as A appears considerably larger in aerial photographs. While it is difficult to determine the boundaries of geothermal and non-geothermal scrub on black and white aerial photographs, the site could well be twice the current (2007) size. Fewer pines were present in this unit. There is an area of raw-soilfield to the south which is no longer present which may have been caused by surface geothermal activity, but may also be caused by farming activities. The units labelled as B are in shadow, so are hard to determine boundaries, but are probably similar in size to current day. The area labelled as C appears very similar to 2007 photographs, with pines having a very similar distribution on margins. Stock may have had access to this area in the early 1960s.

Management Requirements: Livestock should be removed from all geothermal areas and fumaroles in open pasture should be fenced. Wilding pines (<1% of total cover) should be controlled within prostrate kanuka shrubland. Blackberry (<1% of total cover) should be controlled before it out-competes indigenous vegetation present, and detracts from the ecological values.

Significance Level: Regional (Table 1 - Criteria 3, 5, 9; Table 2 - Factor 14).

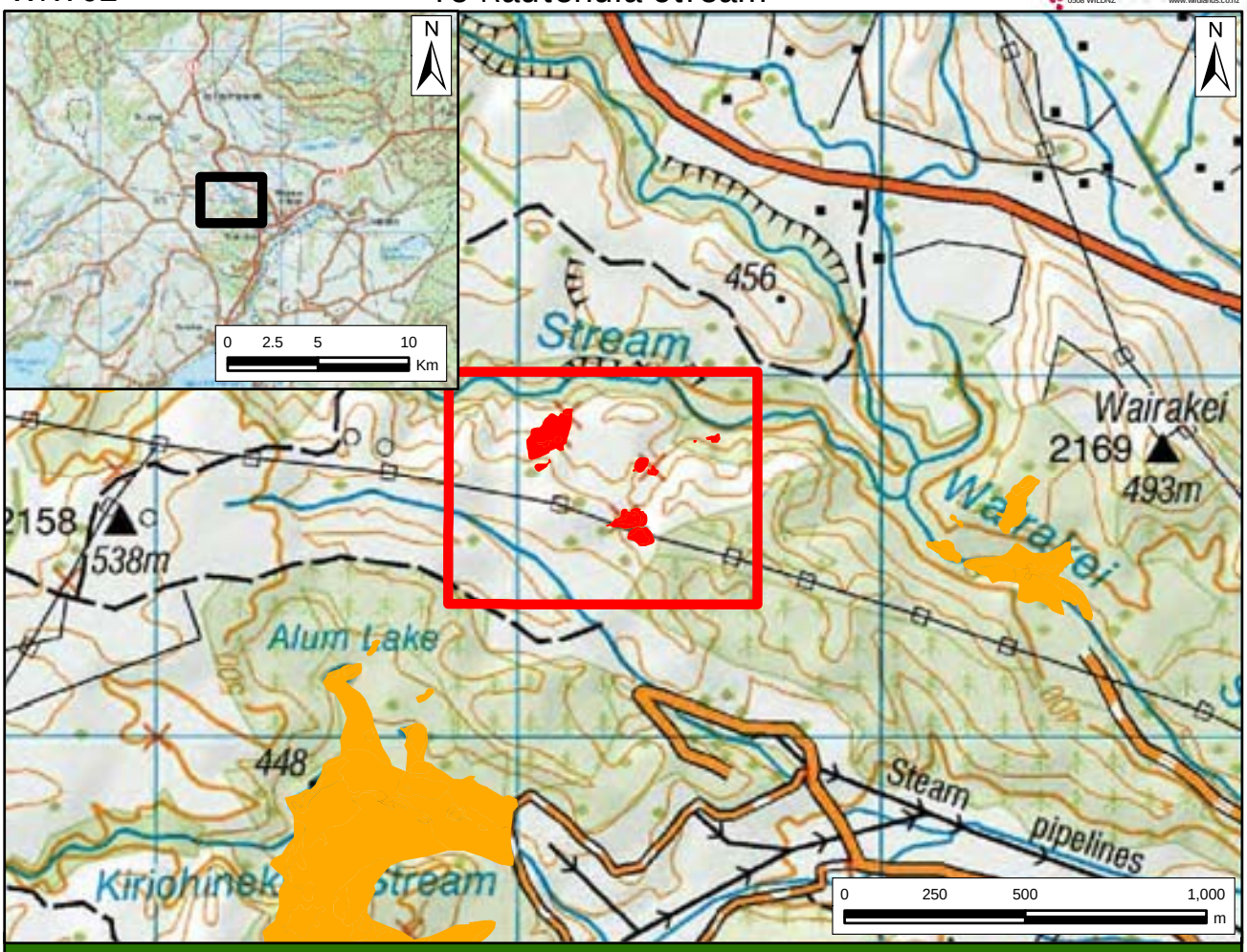
Significance Justification: This site is of regional significance because it is a relatively large example of a nationally uncommon habitat type. It also contains populations of three 'At Risk' species (*Dicranopteris linearis*, *Nephrolepis flexuosa*, and prostrate kanuka).

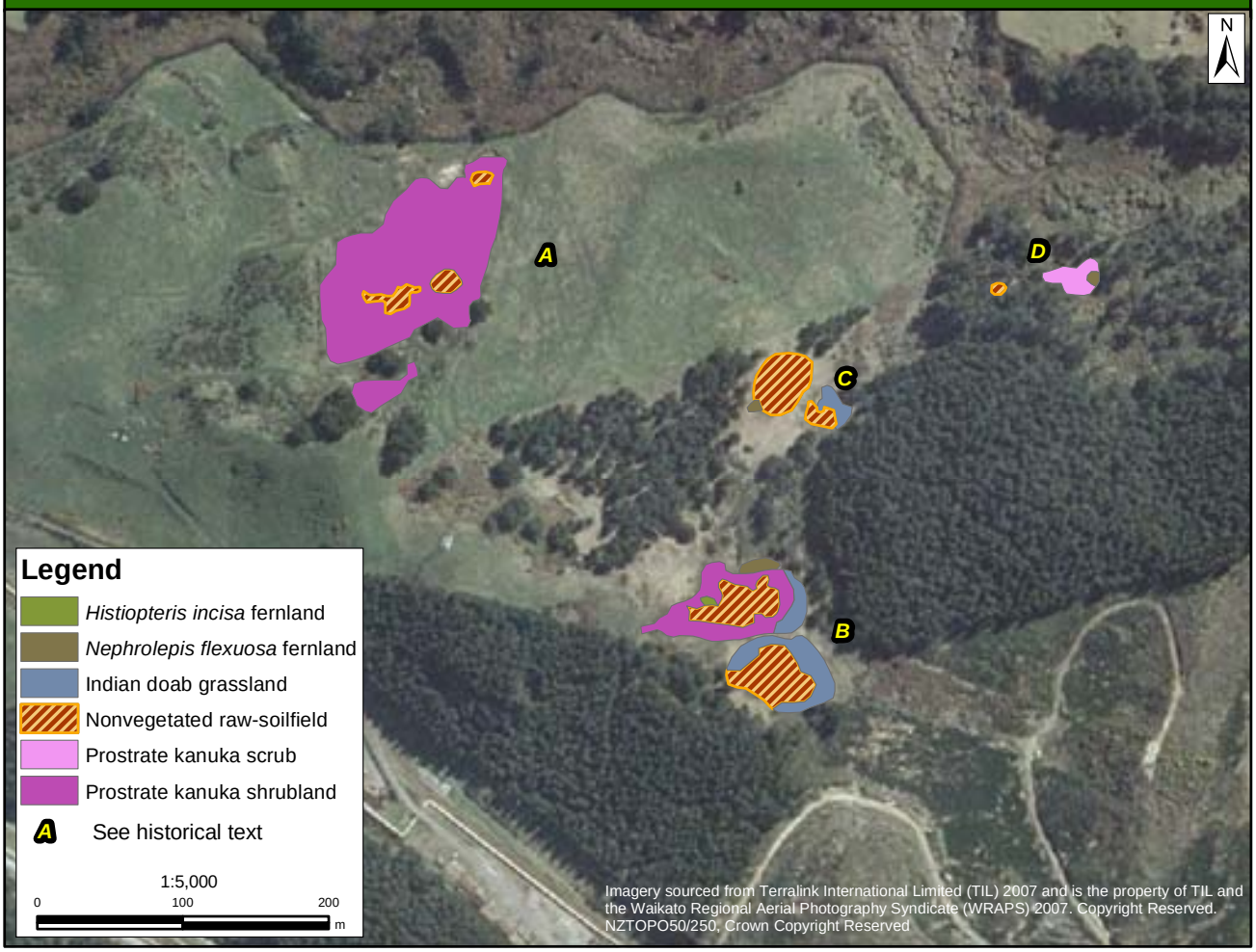
Notes: This site is to the west of Te Rautehuia Stream site and is considered part of the same site in some studies (e.g. Burns *et al.* 1996).

References: Beadel & Bill 2000; Burns *et al*. 1996; Merrett & Burns 1998b & 1998c; Wildland Consultants 2004 & 2006.

WKV02

Te Rautehuia Stream





TE RAUTEHUIA STREAM

Site Number: WKV02[1]
Grid Reference: NZTopo50 BG36 671 218
GPS Reference: NZTM E1867084 N5721842
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Unprotected private land, Wairakei Tourist Park, Riparian marginal strip.
Altitude: 430 m
Extent of Geothermal Habitat: *c.*2.1 ha
Extent of Geothermal Vegetation: *c.*2.1 ha
Date of Field Survey: 27 January 2011

Code	Type	Landform	Extent
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** Prostrate kanuka up to *c.*1 m high dominates this vegetation type, with local patches of *Lycopodiella cernua* and *Nephrolepis flexuosa.*	Valley sides	*c.*0.1 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka with scattered mingimingi forms a low cover (up to *c.*1 m tall) with abundant *Lycopodiella cernua* and *Campylopus capillaceus*, and occasional emergent maritime pine and radiata pine. Some geothermally-influenced bare ground is present. There is scattered bracken, *Histiopteris incisa*, Spanish heath, monoao, manuka, broom, blackberry, karamu, prickly mingimingi, manuka and turutu throughout. Occasional patches of paspalum, Indian doab, narrow-leaved carpet grass, radiata pine seedlings, and pampas are also present within this vegetation type.	Hillslope, gentle hillslope	*c.*1.3 ha
07.04 07.04.01	***Histiopteris incisa*-dominant fernland** ***Histiopteris incisa* fernland** *Histiopteris incisa* fernland occurs on a hillslope above a steaming fumarole.	Hillslope	<0.1 ha
07.08 07.08.01	***Nephrolepis flexuosa*-dominant fernland** ***Nephrolepis flexuosa* fernland** These areas comprise small patches of *Nephrolepis flexuosa* fernland surrounded by exotic grasses (e.g. Indian doab and paspalum). Bracken, prostrate kanuka and *Lycopodiella cernua* occur throughout. Blackberry is encroaching from the margins.	Hillslope	<0.1 ha
08.07 08.07.01	**Indian doab-dominant grassland** **Indian doab grassland** Indian doab occurs around the margins of areas of heated soils.	Shallow gullies, hillslopes	*c.*0.2 ha

[1] Previously identified as U17/20 in Wildland Consultants (2004).

Code	Type	Landform	Extent
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Fumaroles, a geothermal crater (with boiling mud) and heated sinter clays. Prostrate kanuka, mingimingi, *Histiopteris incisa*, *Hypolepis ambigua*, maritime pine, radiata pine, pampas, blackberry, Spanish heath and *Lycopodiella cernua* occur on the margins.	Shallow gullies, crater, hillslope	*c.*0.5 ha

Indigenous Flora: *Nephrolepis flexuosa* and prostrate kanuka (classed as „At Risk-Declining' and „At Risk-Naturally Uncommon' respectively in de Lange *et al.* 2009) occur at this site. *Lycopodiella cernua*, which is typical of geothermal sites, is also present.

Fauna: Common indigenous and introduced bird species typical of the habitat are present including magpie, tui, yellowhammer, chaffinch, green finch, Californian quail, and blackbird.

Current Condition (2011 Assessment): This site comprises several areas of geothermal expressions. It is surrounded by pine plantations and farmland. Stock access and trampling is occurring within the western portion of this site. Blackberry and scattered wildling pines are present. If the site is fenced and stock were to be excluded, the quality of geothermal vegetation is likely to improve markedly.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 Assessment*): Wilding radiata pines occur locally within the geothermal vegetation (<1% cover). Occasional blackberry and broom are also present (1-5% cover).

Human impacts (*2011 Assessment*): Ongoing farming and plantation operations are having a negative impact within some parts of this site.

Grazing (*2011 Assessment*): The western part of this site is grazed and vegetation disturbance to the area is significant.

Adjoining land use (*2011 Assessment*): Farmland and pine plantation.

Site Change:

Recent change: Mixed fernland on the walls of the geothermal crater (NZTM E1867136 N5721902) which was recorded in 2006 (Wildland Consultants 2006), appears to be no longer present and this area now comprises predominantly nonvegetated raw-soilfield with prostrate kanuka, manuka, mingimingi, blackberry, broom, *Lycopodiella cernua*, and bracken scattered around the margins. Otherwise site is similar to previous survey.

Historical: Burns *et al.* (1996) assessed vegetation change between 1945 to 1993 at this site using aerial photographs. He found that, in an area inclusive of Te Rautehuia (WKV01), geothermal vegetation decreased by at least 23% between 1945 and 1993.

This estimate seems reasonable when viewing historical photos for this site from 1961 (Historic Photos: SN 1394 Run 3187 Photo 23, 1961). The area labelled as A has been converted to pasture and appears to about half the size of earlier surveys. This part of the site extended further to the south in 1961. Other units were more difficult to assess site change. The area labelled B currently has fewer pines than in the 1961, but overall there is no strong evidence of change in site area since 1961. Area C was likely to be in a better condition, surrounded by pine plantation and may not have been heavily browsed. Area D is difficult to determine nongeothermal and geothermal scrub amongst scattered emergent pines. There are more areas of raw-soilfield alongside the stream to the north of the site in 1961. This may be indicative of more geothermal surface activity alongside stream margins in the past.

Management Requirements: Wilding pines should be removed from geothermal areas. Where stock have access, geothermal features and vegetation should be fenced. Blackberry requires control.

Significance Level: Regional (Table 1 - Criteria 3, 5; Table 2 - Factor 12).

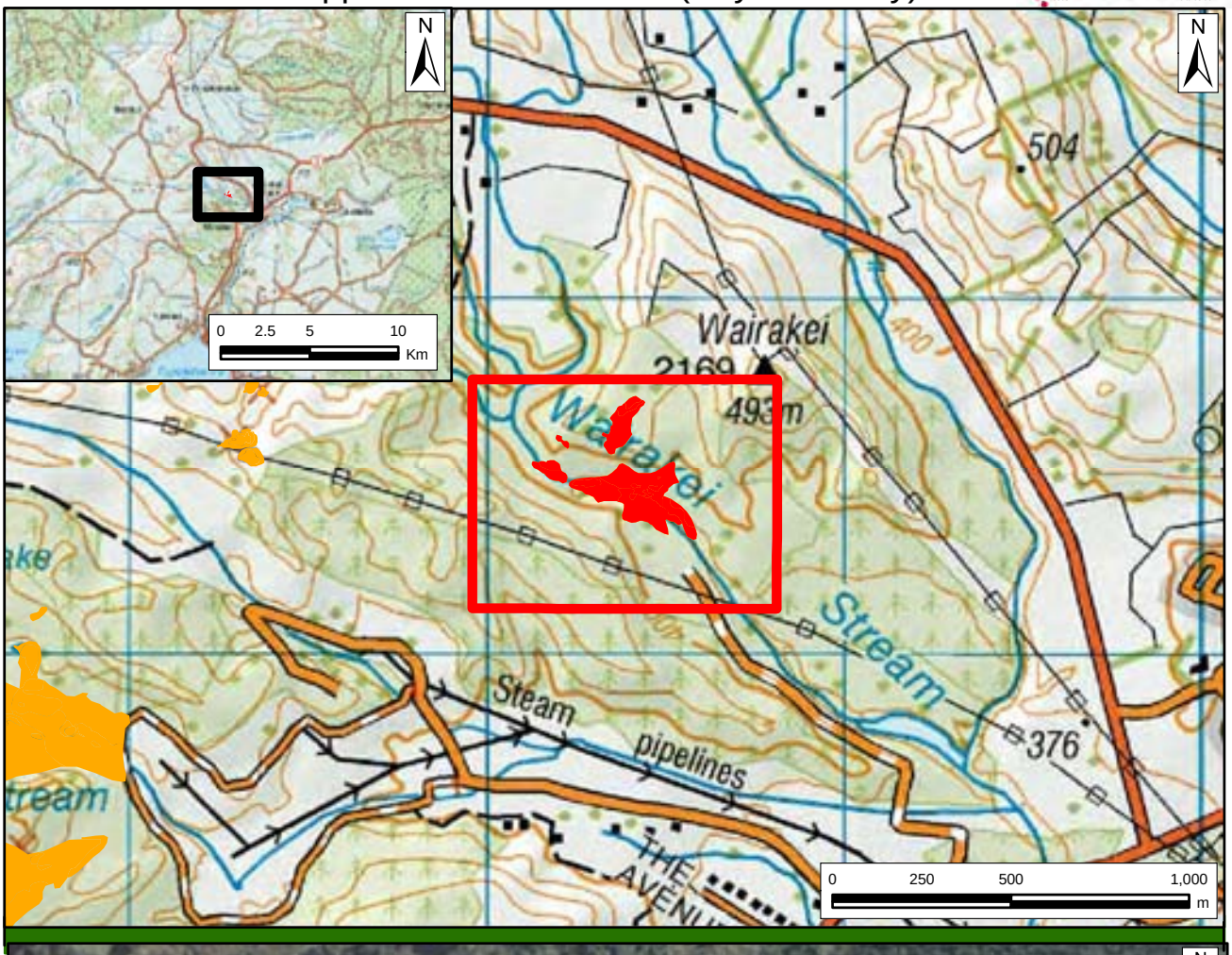
Significance Justification: This site is of regional significance because it is an important habitat for an ‚At Risk' species, *Nephrolepis flexuosa*, and contains moderate-sized areas of prostrate kanuka scrub and shrubland (also an ‚At Risk' species).

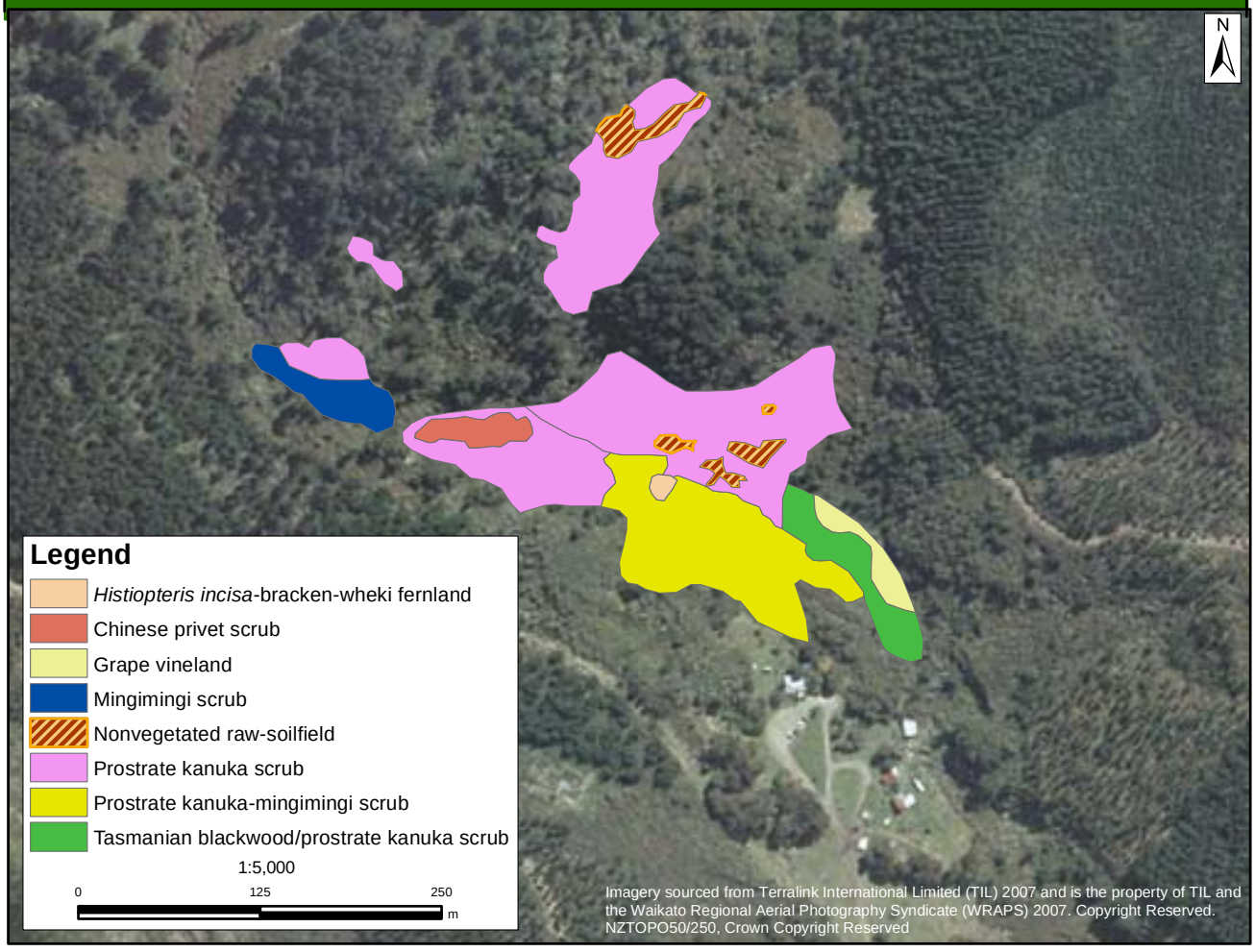
Notes:

References: Burns *et al.* 1996; Department of Conservation 1997; Merrett & Burns 1998a; Wildland Consultants 2004 & 2006.

WKV03

Upper Wairakei Stream (Geyser Valley)





UPPER WAIRAKEI STREAM (GEYSER VALLEY)

Site Number: WKV03[1]
Grid Reference: NZTopo50 BG36 684 214
GPS Reference: NZTM E1868407 N5721446
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Protected (Wairakei Thermal Park)
Altitude: 386 m
Extent of Geothermal Habitat: *c.*4.7 ha
Extent of Geothermal Vegetation: *c.*4.7 ha
Date of Field Survey: 28 January 2011

Code	Type	Landform	Extent
03.02 03.02.01	**Grape vine-dominant vineland** **Grape vineland** A large area on the northern side of the thermal stream is dominated by a grape vine. It has spread over the prostrate kanuka and is smothering it.	Hillslope	*c.*0.1 ha
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** Prostrate kanuka forms a dense monotypic cover, generally up to *c.*1.0 m high. The groundcover comprises mosses and lichens with scattered *Lycopodiella cernua*, local *Dicranopteris linearis*, and turutu around the margins. Fumaroles and dried mud pools occur throughout.	Terrace, hillslope	*c.*2.7 ha
04.01 04.01.02	**Prostrate kanuka-dominant scrub** **Prostrate kanuka-mingimingi scrub** Prostrate kanuka (up to *c.*3.0 m high) occurs with scattered mingimingi, mapou (*Myrsine australis*), wilding pine, false acacia, Chinese privet, and Tasmanian blackwood. There is occasional pampas, Spanish heath, blackberry, and turutu present on the track margins. *Dicranopteris linearis* and *Nephrolepis flexuosa* occur locally. Steaming vents occur throughout this type.	Terrace, hillslope	*c.*1.1 ha
04.01 04.01.07	**Prostrate kanuka-dominant scrub** **Tasmanian blackwood/prostrate kanuka scrub** Tasmanian blackwood is emergent over prostrate kanuka, mingimingi and mapou with a variety of exotic species including wilding pines, Chinese privet, false acacia, ovens wattle (*Acacia pravissima*), Himalayan honeysuckle and Spanish heath also present in the canopy. Manuka and mapou are common in the shrub tier with broom and karamu scattered throughout. There are patches of prostrate kanuka and *Dicranopteris linearis*. Mingimingi scrub dominates on lower hillslopes (refer to 04.02.12). Several steaming vents occur adjacent to a warm stream, and whauwhaupaku, kamahi, mahoe and several fern species (e.g. kiokio, *Pneumatopteris pennigera*, *Gleichenia microphylla*, and sapling wheki) are	Hillslope; gully	*c.*0.3 ha

[1] Previously identified as U17/3 in Wildland Consultants (2004).

Code	Type	Landform	Extent
	common. Tradescantia occurs along stream banks.		
04.02 04.02.12	**Mingimingi-dominant scrub** **Mingimingi scrub** Mingimingi scrub is present on the southern side of the stream with mapou and bracken common throughout, scattered wheki-ponga, kiokio and pohue, and several exotic species including Chinese privet, Himalayan honeysuckle and maritime pines. Occasional prostrate kanuka plants are present.	Hillslope	*c.*0.2 ha
04.11 04.11.01	**Chinese privet-dominant scrub** **Chinese privet scrub** Chinese privet dominates a small area (*c.*40 × 15 m) north of the thermal stream. Prostrate kanuka scrub (Type 04.01.01) surrounds this type.	Hillsope	*c.*0.1 ha
07.05 07.05.11	**Mixed fernland** ***Histiopteris incisa*-bracken -wheki fernland** *Histiopteris incisa*, bracken and wheki form the dominant cover on the steep face of a large steaming vent (named the 'Witches Cauldron'). Blackberry, inkweed, turutu, mingimingi, *Gleichenia microphylla*, prostrate kanuka, *Dicranopteris linearis,* pampas, and mapou are also present.	Steaming vent	<0.1 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Steaming sinter clay soilfield occurs on a scarp with patches of *Lycopodiella cernua*, prostrate kanuka, turutu, and *Campylopus* sp. Blackberry, beggars' ticks (*Bidens frondosa*), mingimingi, prostrate kanuka, pohue, wheki, kiokio, turutu, *Histiopteris incisa*, and koromiko are present on the margins of a thermal stream at the base of the scarp. A small area of sinter terrace (not mapped) occurs here.	Scarp	*c.*0.2 ha

Indigenous Flora: Prostrate kanuka, *Dicranopteris linearis* (both classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009), *Nephrolepis flexuosa* (classed as „At Risk-Declining' in de Lange *et al.* 2009), *Lycopodiella cernua* and *Campylopus capillaceus*, are all plants characteristic of geothermal areas which occur at this site. *D. linearis* is known from only *c.*24 sites in New Zealand.

Given (1976) recorded *Christella* aff. *dentata* ("thermal") from this site in the early 1970s, but it has not been recorded from this site in recent surveys (Bycroft *et al*. 2007, Merrett & Burns 1998).

Fauna: Common indigenous and introduced bird species typical of this type of habitat are present including whitehead, bellbird, tui, North Island robin, grey warbler, fantail, yellowhammer, shining cuckoo, house sparrow, and song thrush.

Current Condition (2011 Assessment): Geothermal vegetation at this site is under serious threat of weed invasion from adventive weed species, particularly grape. It appears that some geothermal features have become less active. The slopes surrounding the site have become dense with pest plant infestations, particularly blackberry, which may have covered previously bare ground. Some areas of geothermal vegetation and habitats remain relatively intact.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 Assessment*): Parts of this site are highly modified by invasive pest plants, particularly on cooler ground at the lower end of the valley. A grape vine covers a large area along the side of the gully (cover of 6-25%). Tasmanian blackwood and Chinese privet comprise 6-25% cover each, with the latter scattered throughout the prostrate kanuka scrub. Wilding pines (6-25% cover), false acacia (1-5% cover), broom (1-5% cover), pampas (<1% cover), tradescantia (<1% cover), heather (*Calluna vulgaris*) (<1% cover), *Cotoneaster glaucophyllus* (<1%), blackberry (<1%), and Spanish heath (1-5% cover) are also present.

Human impacts (*2011 Assessment*): The geothermal valley is run as a tourism venture with a circuit walking track which appears to be well adhered to. Some geothermal features described as part of the tourist venture (and for which this valley was once renowned) have become quiescent due to the continued field drawdown (Given 1989a). Lowered soil temperatures have enabled the establishment of many adventive plant species, although in some areas the soil temperatures are increasing (Merrett & Burns 1998c).

Chickens and other domesticated fowl from the tea rooms have free access to the site, but are unlikely to have negative impacts on the site.

Grazing (*2011 Assessment*): Livestock do not have access to the site.

Adjoining land use (*2011 Assessment*): Plantation forest; scrub dominated by woody exotic species; indigenous scrub.

Site Change:

Recent change: It appears that some minor weed control has occurred on the track margins but the grape infestation covers a larger extent than previously mapped in 2004. False acacia is emergent in the prostrate kanuka-mingimingi scrub on the south side of the thermal stream.

Historical: Burns *et al.* (1996) has assessed vegetation change at this site using aerial photographs from 1945 to 1993 (named Wairakei Thermal Valley) and found that the extent of geothermal vegetation at this site decreased by at least 74% between 1945 and 1993.

A 1961 aerial photograph was located for this site (Historical photo: SN 1394 Run 3187 Photos 25, 1961). The geothermal vegetation in this photo appears more extensive to the north, west, and to the east of the site. The geothermal vegetation is significantly wider in the middle of the site in 1961. Invasion of wilding pines into geothermal habitat occurred between 1961 and the present day, and the area of geothermal vegetation has become significantly more fragmented.

Management Requirements: Large areas within this site require weed control of species such as grape vine, wilding pines, Tasmanian blackwood, Chinese privet, false acacia,

blackberry, and tradescantia. Education on ecological values and issues could be enhanced by the placement of signs explaining geothermal features, vegetation, and the changes which occurred as an impact of energy drawdown.

Significance Level: Regional (Table 1 - Criteria 1, 3, 5; Table 2 - Factors 10, 12).

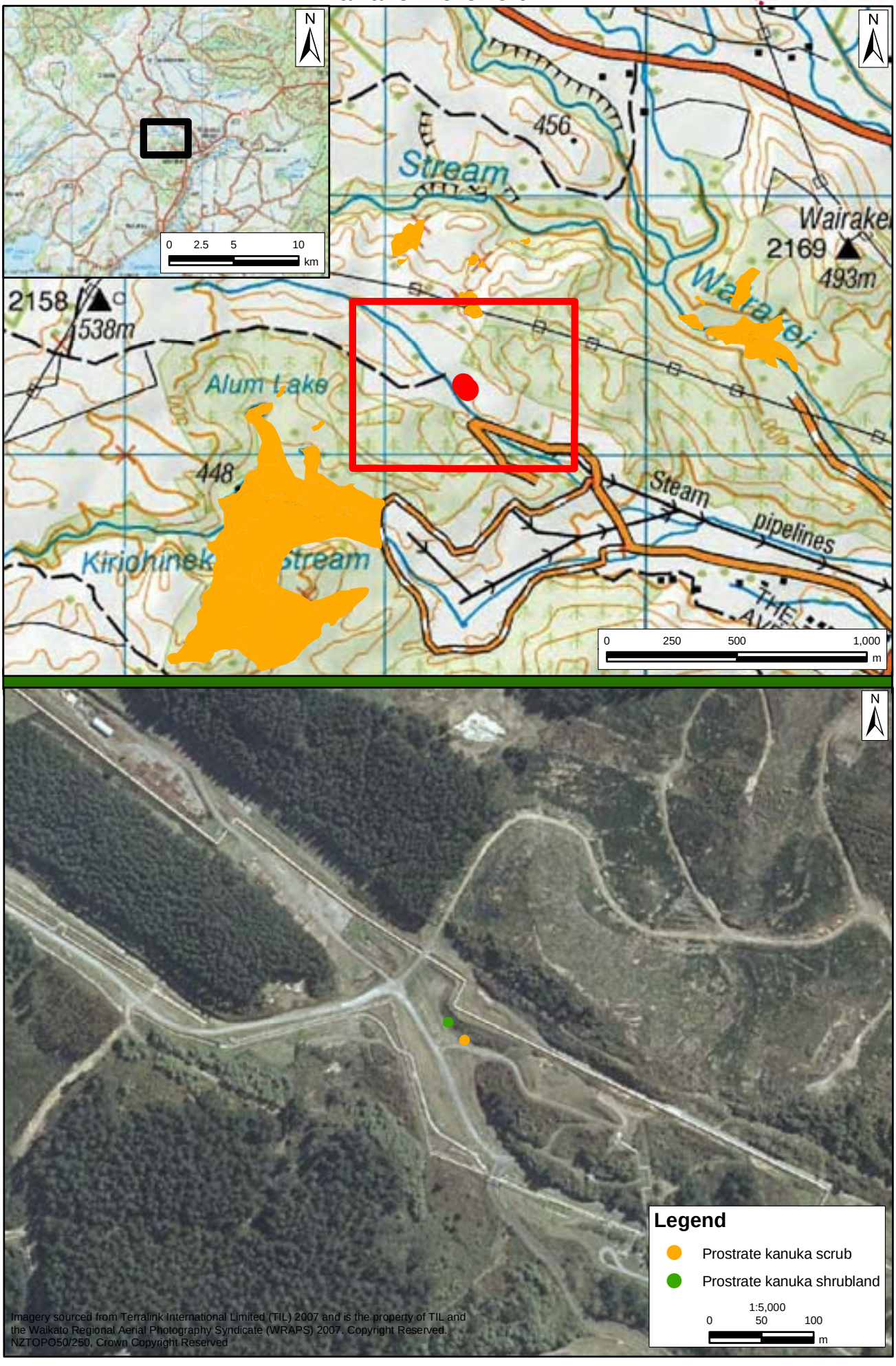
Significance Justification: This site is of regional significance because it is protected under the Reserves Act (1977) and contains stable populations of three „At Risk' species: prostrate kanuka, *Dicranopteris linearis* and *Nephrolepis flexuosa.*

Notes: Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region, and in this study this site was classed as Category B - the second highest category.

References: Beadel & Bill 2000; Burns *et al*. 1996; Bycroft *et al*. 2007; Given 1976, 1989a & 1996; Merrett & Burns 1998c; Wildland Consultants 2004.

WKV04

Wairakei Borefield



WAIRAKEI BOREFIELD

Site Number: WKV04[1]
Grid Reference: NZTopo50 BG36 672 212; BG36 673 212
GPS Reference: NZTM E1867298 N5721272; E1867314 N5721248
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: *c.*440 m
Extent of Geothermal Habitat: <0.1 ha
Extent of Geothermal Vegetation: <0.1 ha
Date of Field Survey: 25 January 2007

VEGETATION		LANDFORM	EXTENT
CODE	**TYPE**		
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** Prostrate kanuka up to *c.*0.75 m high with local *Lycopodiella cernua*. Occasional narrow-leaved carpet grass and broom present. Soil temperature at 10 cm depth was 50°C. Geothermal vegetation covers an area of 5 × 5 m.	Hillslope	<0.1 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka to *c.*0.75 m tall with occasional patches of bare ground. Lotus, gorse, broom and narrow-leaved carpet grass are common on margins. Geothermal vegetation covers an area of 10 × 10 m. Soil temperature at 10 cm depth was 49.8 °C.	Hillslope	<0.1 ha

Indigenous Flora: Prostrate kanuka (classed as an „At Risk-Naturally Uncommon' species in de Lange *et al.* 2009) is present. *Lycopodiella cernua*, a species typical of geothermal habitat, is also present.

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

Current Condition (2007 Assessment): Two small patches of prostrate kanuka surrounded by an industrial site.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2007 Assessment*)*:* Broom (1-5% cover) and gorse (1-5% cover).

[1] Previously identified as U17/35 in Wildland Consultants (2004).

Human impacts (*2007 Assessment*)*:*	Industrial site. This site is an operational industrial site and the vegetation is likely to be regularly disturbed - either cleared or damaged as part of the ongoing operational use of the site.
Grazing (*2007 Assessment*)*:*	The site is not grazed by stock.
Adjoining land use (*2007 Assessment*)*:*	Industrial
Site Change:	
Recent change:	This site has only been field surveyed once for Waikato Regional Council as part of this study, and because of its small size, recent changes to vegetation are not clearly visible on aerial photographs. There is probably no change in extent of vegetation present.
Historical:	This site is too small to be assessed on the historical aerial photographs available.
Management Requirements:	None noted.
Significance Level:	Local (Table 1 - Criterion 5; Table 2 - Factor 19).
Significance Justification:	This site is of local significance because it is an example of a nationally uncommon habitat type (geothermal) and contains a small population of prostrate kanuka (an „At Risk-Declining' species).
References:	Wildland Consultants 2004 & 2007a.

WKV05 Te Kiri O Hine Kai Stream Catchment/Wairoa Hill

WKV05 Te Kiri O Hine Kai Stream Catchment /Wairoa Hill

Wildlands
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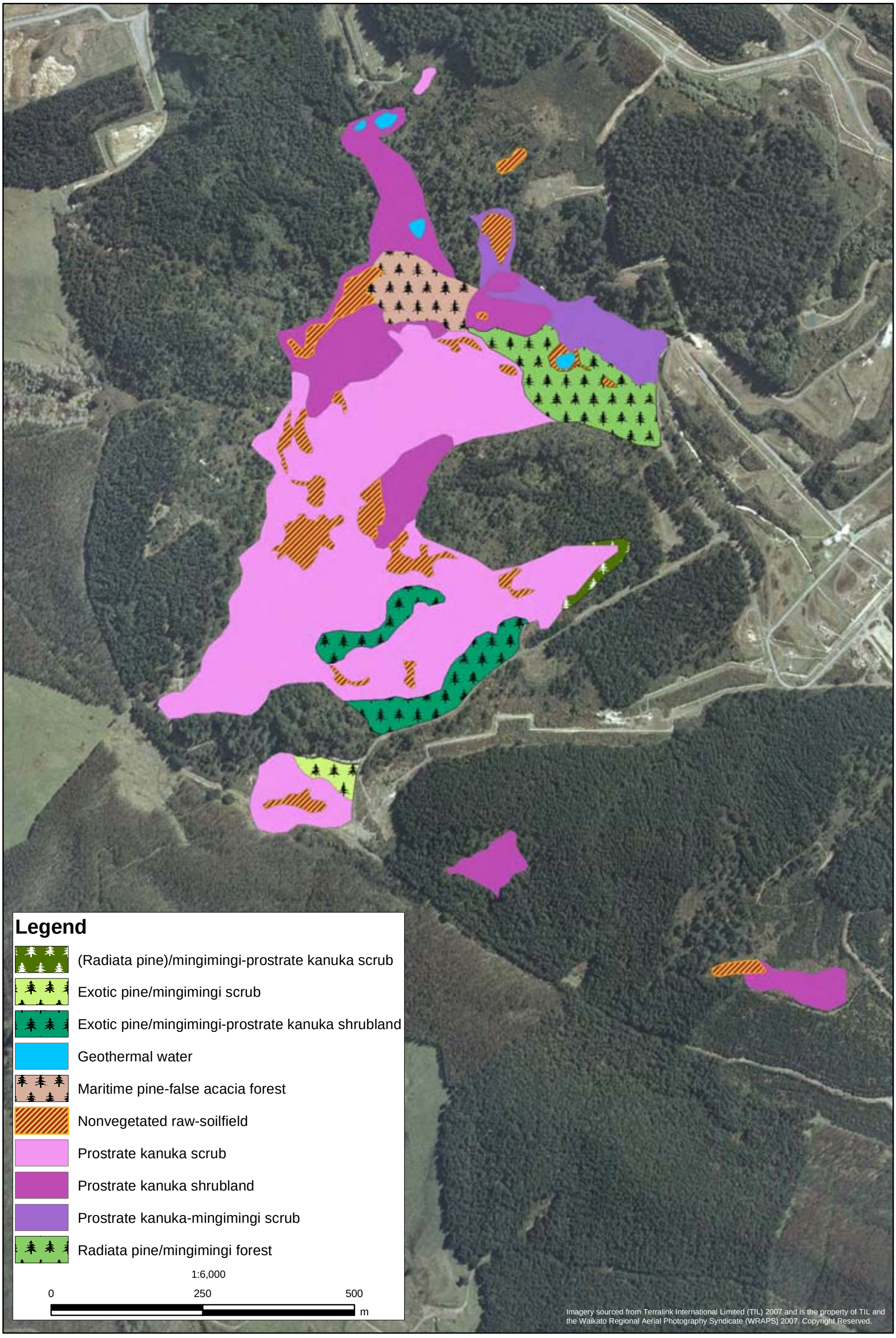


TE KIRI O HINE KAI STREAM CATCHMENT/WAIROA HILL

Site Number: WKV05[1]
Grid Reference: NZTopo50 BG36 666 206
GPS Reference: NZTM E1866576 N5720644
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Unprotected private land (Unallocated Crown Land administered by Contact Energy)
Altitude: *c.*460-520 m
Extent of Geothermal Habitat: *c.*40.3 ha
Extent of Geothermal Vegetation: *c.*40.1 ha
Date of Field Survey: 27 January 2011

Code	Type	Landform	Extent
01.05 01.05.03	**Exotic pines forest** **Maritime pine-false acacia forest** Maritime pine and false acacia are common over an understorey comprising bracken and mingimingi.	Hillslopes	*c.*1.6 ha
01.05.04	**Radiata pine/mingimingi forest** Radiata pine is emergent over mingimingi. Other species include blackberry, buddleia, Spanish heath, bracken, whauwhaupaku, and Himalayan honeysuckle.	Hillslopes	*c.*2.7 ha
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** Prostrate kanuka forms a dense cover up to *c.*0.5 m high, with *Sphagnum* sp., *Campylopus capillaceus,* and *Dicranoloma* sp. comprising the groundcover. Scattered lichen is also present. Monoao and local patches of mingimingi occur on rocky outcrops throughout, with monoao becoming more common in the scrub on the eastern side of a deep and geothermally active gully. Small fumaroles are scattered throughout the area. Patches of *Dicranopteris linearis, Nephrolepis flexuosa* and *Lycopodiella cernua* are present. Exotic species are present throughout include Spanish heath, buddleia, pampas and blackberry.	Undulating plateau	*c.*20.0 ha
04.01.02	**Prostrate kanuka-mingimingi scrub** Prostrate kanuka forms the canopy in association with mingimingi. There is locally scattered monoao and emergent wilding radiata pine, false acacia and maritime pine. The groundcover includes local *Campylopus* sp. and *Lycopodiella cernua*. Small patches of *Dicranopteris linearis* and *Nephrolepis flexuosa* are present.	Hillslopes, gully	*c.*2.1 ha
04.02 04.02.13	**Mingimingi-dominant scrub** **Exotic pine/mingimingi scrub** Scattered radiata pine and maritime pine occur over mingimingi, with wheki-ponga and prickly mingimingi common throughout. The groundcover is dominated by turutu	Hillslopes	*c.*0.4 ha

[1] Previously identified as U17/5 in Wildland Consultants (2004).

Code	Type	Landform	Extent
	and bracken. Small patches of prostrate kanuka, *Dicranopteris linearis*, and *Nephrolepis flexuosa* are present.		
04.02.14	**(Radiata pine)/mingimingi-prostrate kanuka scrub** Emergent radiata pine over mingimingi and prostrate kanuka, with occasional manuka.	Hillslopes	*c.*0.3 ha
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka forms a low cover (up to 0.5 m high) with abundant *Lycopodiella cernua* and *Campylopus capillaceus*. Local patches of mature, wilding, maritime pine and radiata pine (up to 10 m tall) are present, with an understorey of mingimingi, prickly mingimingi, karamu, turutu, and *Gleichenia microphylla*. At the southern end of the site prostrate kanuka occurs in association with *Dicranopteris linearis*, local patches of *Nephrolepis flexuosa*, and adventive species such as Himalayan honeysuckle, fleabane, foxglove, Yorkshire fog, wild portulaca, and occasional aloe (*Aloe* sp.).	Undulating plateau; valley floor, hillslopes	*c.*7.5 ha
05.02 05.02.05	**Mingimingi-dominant shrubland** **Exotic pine/mingimingi-prostrate kanuka shrubland** Radiata pine and scattered maritime pine are emergent and, in some areas, dominant over mingimingi, prostrate kanuka, tawiniwini, and bracken. Occasional plants of *Dicranopteris linearis* are present.	Hillslopes	*c.*2.3 ha
22.01 22.01.01	**Geothermal water** **Geothermal water** Hot water and mud lakes, including Alum Lake. The two northernmost lakes are within a steep sided depression. Pampas, *Carex secta*, raupo, and *Histiopteris incisa* occur on the margins, with *Lemna minor* and *Azolla rubra* present in the cooler water.	Lakes	*c.*0.2 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Geothermal clays, mud pools, and fumaroles with patches of prostrate kanuka shrubland scattered throughout. Pampas, kiokio, *Histiopteris incisa*, radiata pine seedlings and bracken also occur in these areas.	Hillslopes, undulating plateau, crater	*c.*3.2 ha

Indigenous Flora: Prostrate kanuka, *Dicranopteris linearis* (both classed as „At Risk-Naturally Uncommon'), and *Nephrolepis flexuosa* (classed as „At Risk-Declining' in de Lange *et al.* 2009) occur at this site. The site supports the largest populations of both *Nephrolepis flexuosa* and *Dicranopteris linearis* of any of the geothermal sites in the Wairakei-Tauhara Geothermal field. *Christella* aff. *dentata* ("thermal") was recorded near geothermal lakes at this site in 2001 (Nick Singers pers. comm. 2007).

D. linearis is known from only *c.*24 sites in New Zealand.

Fauna: Common indigenous and introduced bird species typical of the habitat are present including, tui, Australasian harrier, shining cuckoo, kingfisher, tui, chaffinch, grey warbler, fantail, blackbird and bellbird. New Zealand pipit (classed as „At Risk-Declining' in Miskelly *et al.* 2008) has been recorded at this site. Skink and gecko have been reported from this site (Unpublished

Atiamuri PNAP data 1995).

Current Condition (2011 Assessment): A large and mostly contiguous area of geothermal features and vegetation surrounded by pine plantations and geothermal extraction operations. Geothermal drawdown is ongoing.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 Assessment*): Wilding radiata pine and maritime pine threaten geothermal vegetation at this site. Other adventive species present include blackberry, pampas and Spanish heath.

Human impacts (*2011 Assessment*): Access tracks, logging, and geothermal extraction all occur along the boundaries of this site.

Grazing (*2011 Assessment*): The surrounding land is not farmed.

Adjoining land use (*2011 Assessment*): Pine plantation and geothermal gas extraction.

Site Change:

Recent change: Radiata pine growth has seen mingimingi scrub (recorded in 2007) at the southern end of the site change to (exotic pine)/mingimingi-kanuka scrub. In the middle of this site an area recorded as prostrate kanuka-mingimingi scrub in 2007 is now classed as radiata pine/mingimingi forest.

Historical: Burns *et al.* (1996) assessed vegetation change at this site using aerial photographs from 1945 to 1993 and found that geothermal vegetation decreased by 20% between 1945 and 1993. In addition, an assessment of aerial photos from 1961 (Historical photos: SN 1394 Run 3187 Photos 22, 23, 1961; SN 1394 Run 3188 Photos 23, 24, 1961) compared with more recent aerial photographs indicate a marked increase in wilding pines in the site.

Management Requirements: Wilding pines that are invading and, in some places, dominating to the point of almost complete canopy closure over geothermal vegetation should be controlled. Most threatened geothermal species do not respond to shading well. Areas where blackberry is scattered either on the margins or within the geothermal vegetation should be controlled before it becomes dominant.

Significance Level: Regional (Table 1 - Criteria 1, 3, 5, 7; Table 2 - Factors 12, 14).

Significance Justification: This site is of regional significance because it comprises a relatively large area of geothermal vegetation (a nationally uncommon habitat type), and contains a relatively large population of three „At Risk' species (prostrate kanuka, *Dicranopteris linearis*, and *Nephrolepis flexuosa*). The site is somewhat degraded in quality, with adventive plant species common. A small population of *Christella* aff. *dentata* ("thermal") (an „At Risk' species) has been recorded from the site in the past, but it has not been recorded since 2001.

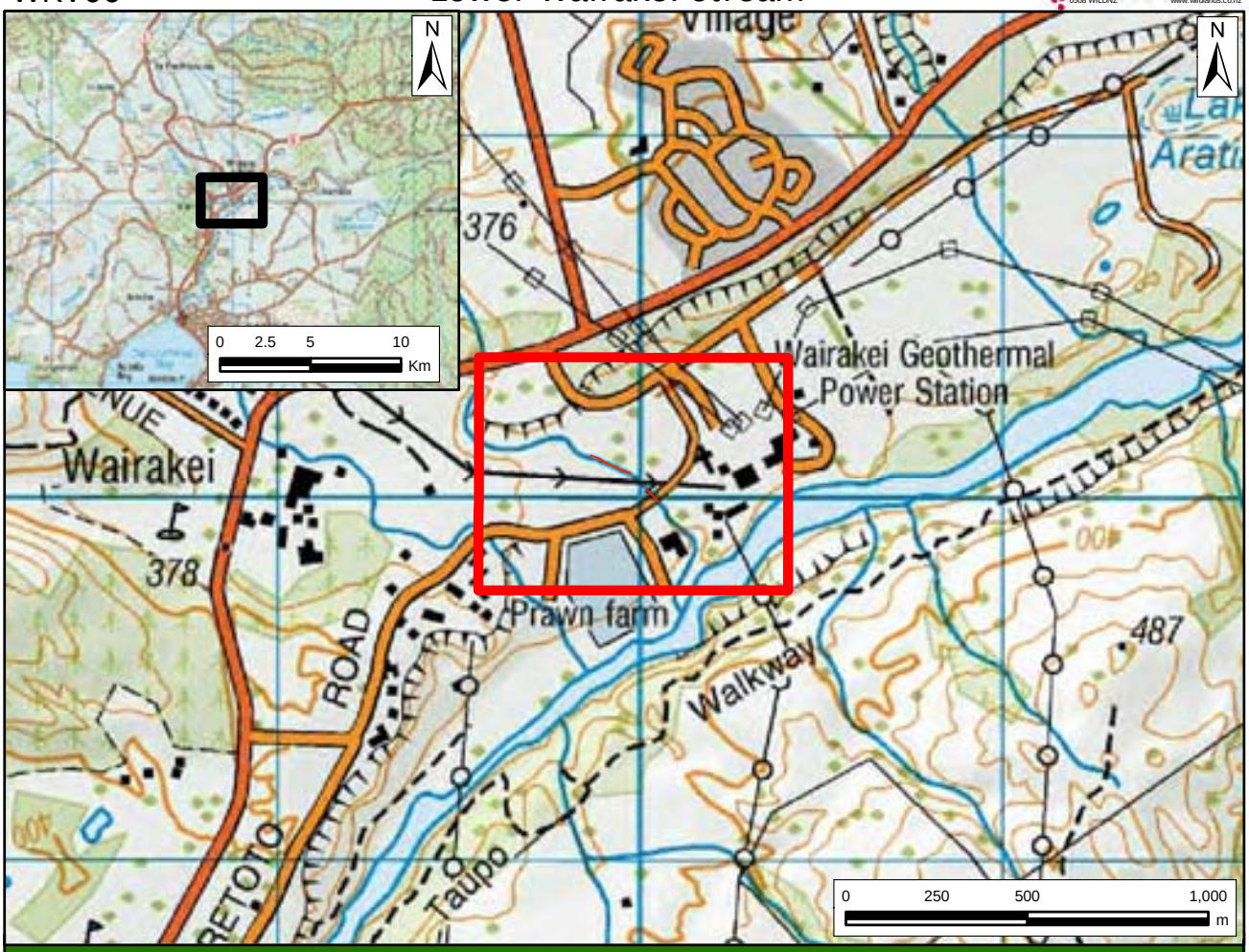
Notes: This site comprises two areas ranked in Given (1996) as Category A (the

highest category) - “Wairakei: Waiora Hill” and “Wairakei: Upper Wairakei Stream”.

References: Anon 1990; Beadel & Bill 2000; Burns *et al.* 1996; Given 1989; Merrett & Burns 1986b & 1986c; Unpublished Atiamuri PNAP data 1995; Wildland Consultants 2004 & 2007b.

WKV06

Lower Wairakei Stream



Legend

- Blackberry-Himalayan honeysuckle-*Calystegia sepium* scrub
- Geothermal water
- Gorse shrubland

1:5,000
0 100 200
m

LOWER WAIRAKEI STREAM

Site Number: WKV06[1]
Grid Reference: NZTopo50 BG36 699 201
GPS Reference: NZTM E1869918 N5720089
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: 350 m
Extent of Geothermal Habitat: <0.1 ha
Extent of Geothermal Vegetation: <0.1 ha
Date of Field Survey: 25 January 2007

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
04.08 04.08.02	**Blackberry-dominant scrub** **Blackberry-Himalayan honeysuckle-pohue scrub** Stream margins are surrounded by blackberry with common Himalayan honeysuckle, pohue, and Japanese honeysuckle. Scattered plants of buddleia, *Deparia petersenii,* kiokio, pampas, and karamu are present. Patches of rank exotic grassland species (e.g. lotus, yarrow (*Achillea millefolium*), Yorkshire fog, sweet vernal, and cleavers are also present. Scattered populations of *Christella* aff. *dentata* ("thermal") (47 clumps) are present between the outlet of geothermal water into the Wairakei Stream (E1869871 N5720120) and where the stream enters a culvert (E1869999 N5720067).	Stream margins	<0.1 ha
05.06 05.06.01	**Gorse-dominant shrubland** **Gorse shrubland** An area of gorse shrubland on stream margins. Two clumps of *Christella* aff. *dentata* ("thermal") were present on margins in this type. Exotic grassland species (e.g. lotus, fleabane, pohue, Yorkshire fog, and sweet vernal) and montbretia (*Crocosmia* ×*crocosmiiflora*) are common, with occasional lupin, and *Deparia petersenii*.	Stream margins	<0.1 ha
22.01 22.01.01	**Geothermal water** **Geothermal water** Geothermal stream with a temperature of 32°C at one location. Temperatures are likely to be significantly warmer at other locations (not mapped); however most of the stream was inaccessible. Geothermal water is fed into the Wairakei Stream through an outlet at E1869871 N5720120.	Stream	<0.1 ha

Indigenous Flora: Forty-nine clumps of *Christella* aff. *dentata* ("thermal") (AK297076) were found in 2007, compared to seven clumps recorded at this site in 1998 (Merrett & Clarkson 1998a). *Christella* aff. *dentata* ("thermal") is

[1] Previously identified as U17/2 in Wildland Consultants (2004, 2007a).

classified ‚At Risk-Naturally Uncommon' (de Lange *et al.* 2009).

Hypolepis dicksonioides (also ‚At Risk-Naturally Uncommon') has been recorded from this site in the past (Merrett & Clarkson 1998), but was not recorded in 2007.

Fauna: Common indigenous and introduced bird species typical of the habitat are likely to be present. Mallard, silvereye, chaffinch and Indian myna were recorded.

Current Condition (2007 Assessment): This site is in a poor condition and pest plants are common. However, the site provides habitat for a threatened plant species and comprises geothermal habitat.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2007 Assessment*)*:* Blackberry (50% cover), Himalayan honeysuckle (5-25% cover), Japanese honeysuckle (1-5% cover), gorse (1-5% cover), buddleia (<5% cover), pampas (<5% cover), and lotus are present.

Human impacts (*2007 Assessment*)*:* The geothermal vegetation occurs alongside a stream which has been modified as part of the ongoing management of the Wairakei Power Station.

Grazing (*2007 Assessment*)*:* Not a threat to this site.

Adjoining land use (*2007 Assessment*)*:* Industrial site.

Site Change:

Recent change: This site was not re-surveyed. Any changes to vegetation boundaries are a result of better quality aerial photographs and are not likely to be significant.

Historical: This site is too small to see any evidence of change since 1941 (Historical photo: SN 172 Run 1173 Photo 3, 1941). However, changes are likely to have been significant with the construction of the Wairakei Power Station in close proximity to this site. Stream channels have been significantly altered as a consequence, which will have altered the extent of geothermal vegetation. Draw-down of geothermal water for power generation will have also probably changed the vegetation composition of the site through water table and temperature changes.

Management Requirements: The population of *Christella* aff. *dentata* ("thermal") should be monitored at regular intervals. It is threatened by dense infestations of exotic pest plants (e.g. blackberry), and the ongoing maintenance of the stream margins as part of an operational industrial site.

Significance Level: Regional (Table 1 - Criterion 3, 5; Table 2 - Factor 12)

Significance Justification: This site is of regional significance because it contains an important population of an ‚At Risk' species - *Christella* aff. *dentata* ("thermal"). This species is currently only known from 14 sites in New Zealand (Bycroft

& Beadel 2007).

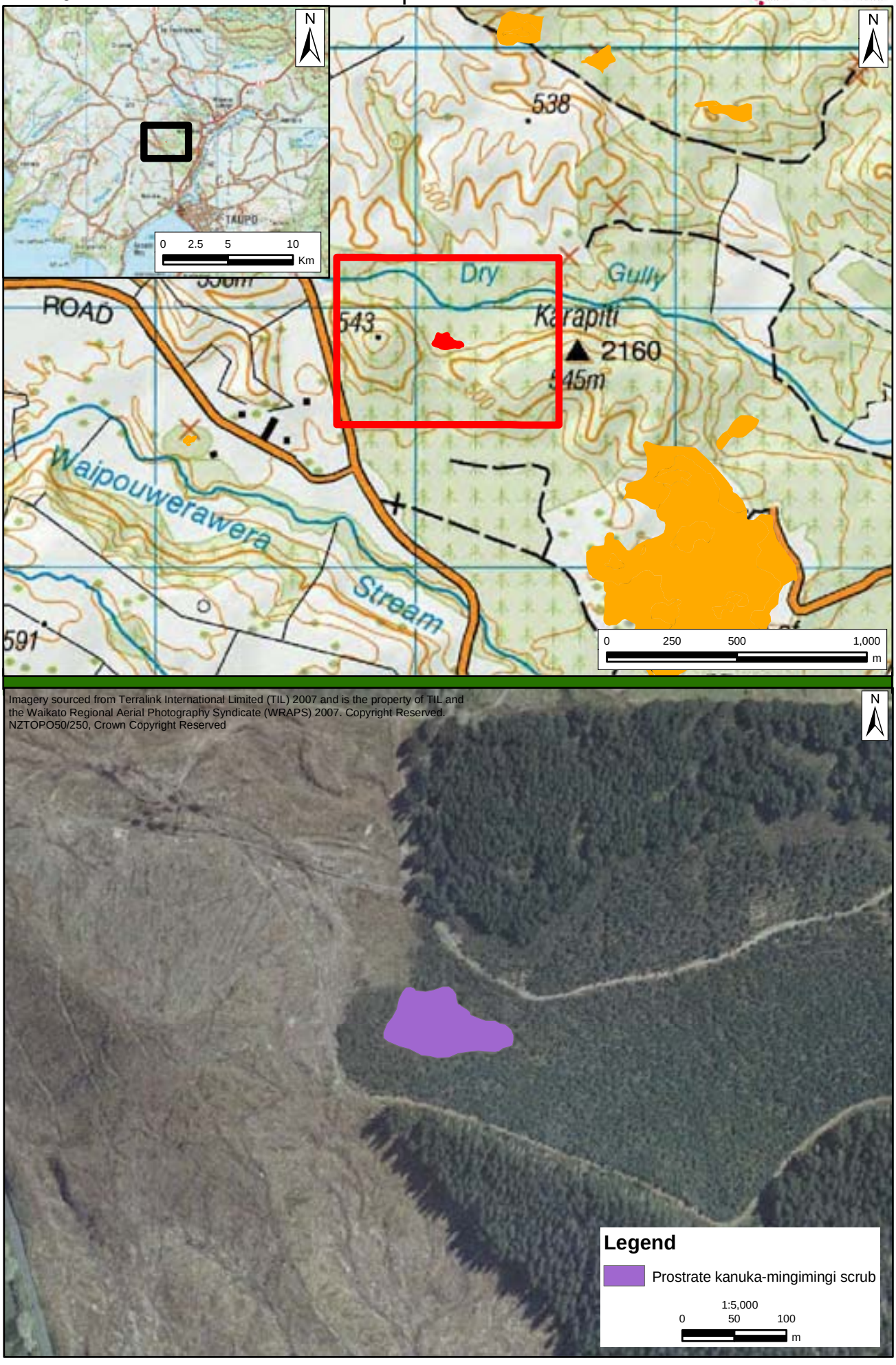
Notes: Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region, and in this study this site was classed as Category B - the second highest category.

In 2007 this site was assessed as nationally significant because, at that time *Christella* aff. *dentata* ("thermal") was classified as „Chronically Threatened-Gradual Decline' (de Lange *et al.* 2004). This species is now classified as „At Risk-Naturally Uncommon' (de Lange *et al*. 2009), which in turn affects the significance assessment.

References: Bycroft & Beadel 2007; Given 1989a & 1996; Merrett & Burns 1998b; Wildland Consultants 2004 & 2007a.

WKV07

Karapiti Forest



KARAPITI FOREST

Site Number: WKV07[1]
Grid Reference: NZTopo50 BG36 661 189
GPS Reference: NZTM E1866117 N5718870
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei
Bioclimatic Zone: Submontane
Tenure: Unprotected private land
Altitude: *c.*480 m
Extent of Geothermal Habitat: *c.*0.6 ha
Extent of Geothermal Vegetation: *c.*0.6 ha
Date of Field Survey: 20 April 2004

VEGETATION		LANDFORM	EXTENT
CODE	**TYPE**		
04 01 04 01 02	**Prostrate kanuka-dominant scrub** **Prostrate kanuka-mingimingi scrub** Prostrate kanuka up to *c.*0.3 m high forms a dense cover with locally common monoao, occasional wilding radiata pine and maritime pine, and scattered mingimingi. The groundcover comprises patches of *Campylopus capillaceus*. Numerous fumaroles occur throughout this area. On the margins, mingimingi up to *c.*3 m high is dominant, with occasional manuka and scattered wilding radiata pines. Blackberry, Himalayan honeysuckle, bracken, turutu and large patches of *Dicranopteris linearis* are common in the understorey, and *Lycopodiella cernua,* mosses, and *Histiopteris incisa* are common around fumaroles which are scattered throughout this area.	Toe slope	*c.*0.6 ha

Indigenous Flora: Prostrate kanuka (classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) and *Lycopodiella cernua*, both of which are characteristic of geothermal areas, are present.

Also present is *Dicranopteris linearis* (also classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) which is known from only *c.*24 sites in New Zealand.

Fauna: Common indigenous and introduced bird species typical of the habitat are present, including bellbird, fantail, and silvereye.

Current Condition (2004 Assessment): This is a small site in relatively good condition with relatively few weeds. Recent harvesting operations have resulted in disposal of slash in some of the hotter parts of geothermal activity which has damaged these sites. A larger buffer would help protect geothermal features in the future.

[1] Previously identified as U17/19 in Wildland Consultants (2004).

Threats/Modification/ Vulnerability:

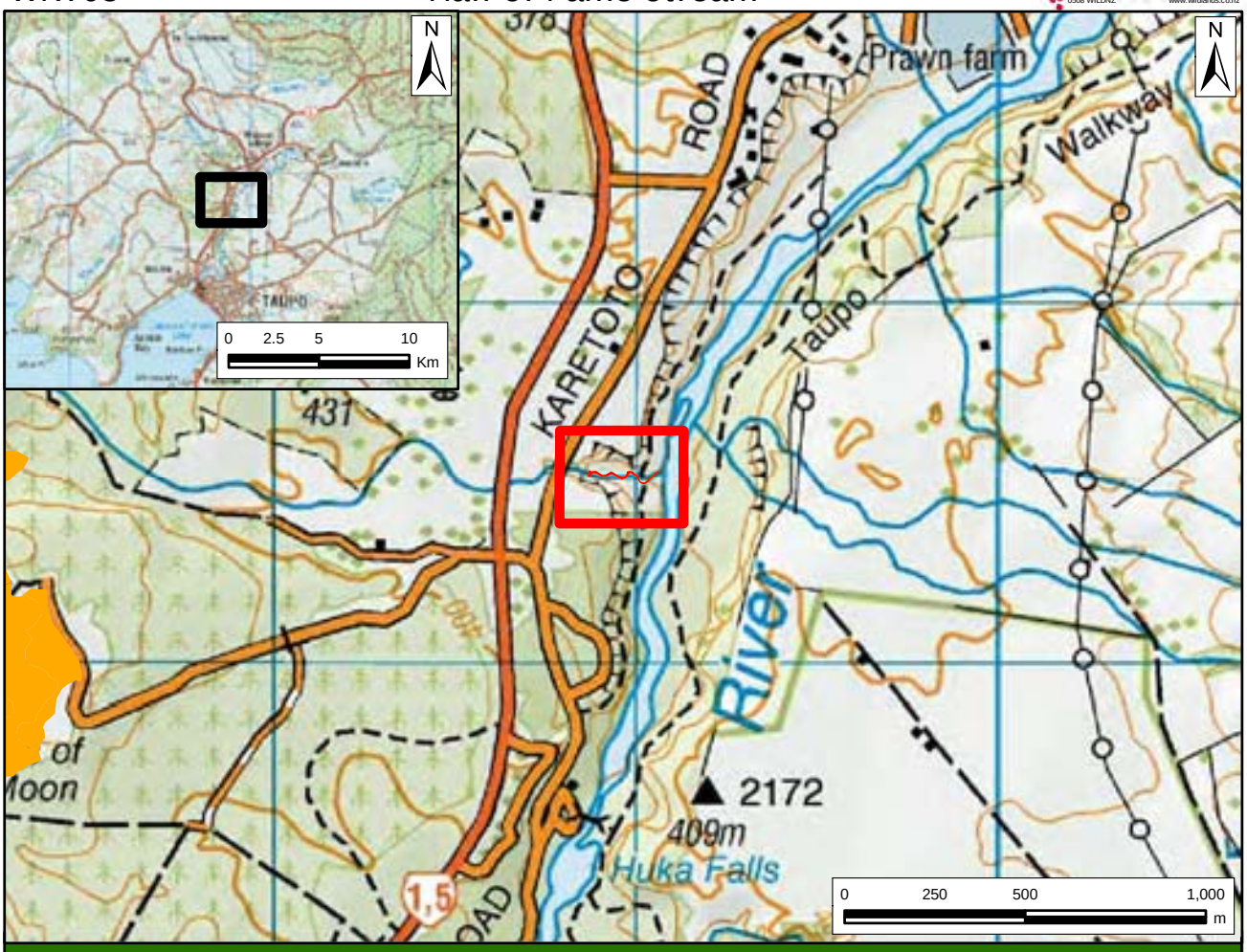
Invasive pest plants (*2004 Assessment*)*:*	The site is surrounded by plantation pine forest, however the number of wilding pines (1-5% cover) establishing is limited by high soil temperatures. Provided soil temperatures do not cool (see below), wilding pine invasion should remain static. Himalayan honeysuckle and blackberry are also present (1-5% cover), and occasional pampas (<1% cover), but these species are mainly confined to the margins of the geothermal area.
Human impacts (*2004 Assessment*)*:*	This site is in the Wairakei Geothermal Field and is vulnerable to changes in ground temperature associated with power station draw-off (refer to Burns *et al.* 1996; Merrett & Burns 1998b&c), however the impacts of draw-off on this area are not currently known. Recent harvesting has left piles of slash along some of the geothermal vegetation margins.
Grazing (*2004 Assessment*)*:*	Livestock are not a threat to this area.
Adjoining land use (*2004 Assessment*)*:*	Harvesting and ongoing management operations of the surrounding pine plantation could result in ongoing damage to the geothermal vegetation.

Site Change:

Recent change:	The site appears similar on 2007 aerial photographs to the 2004 assessment. Plantation trees near the site are markedly taller than they were at the time of the 2004 survey.
Historically:	An assessment was made between 1961 aerial photographs (Historical photos: SN 1394 Run 3188 Photos 22-23, 1961) and 2007 aerial photographs. There is a more extensive area of scrub around the site in 1961, although most of this is unlikely to be geothermal. There is also more disturbance around the site and it is difficult to assess whether some of the bare ground is geothermal or human-induced disturbance. There has probably been a small reduction of size of this site since 1961, with the establishment of pine plantation right to its margin. A broad estimate of reduction of geothermal habitat would be *c.*10-20% since 1961.
Management Requirements:	A buffer zone around the geothermal area should be created to avoid damage to the site during harvesting and ongoing management of the surrounding pine plantation. No buffer has been allowed for in recent plantings. This site should be monitored to assess the impact of geothermal power extraction.
Significance Level:	Local (Table 1 - Criteria 3, 5; Table 2 - Factor 19).
Significance Justification:	Karapiti is of local significance because it is a small example of a nationally uncommon habitat type and provides habitat for two „At Risk' species, prostrate kanuka and *Dicranopteris linearis*. This site is a small, highly active geothermal area, relatively undisturbed and currently has very low densities of invasive exotic plants.
References:	Beadel & Bill 2000; Burns *et al.* 1996; Department of Conservation 1998; Merrett & Burns 1998b, 1998c; Wildland Consultants 2004.

WKV08

Hall of Fame Stream



HALL OF FAME STREAM

Site Number: WKV08[1]
Grid Reference: NZTopo50 BG36 689 186
GPS Reference: NZTM E1868965 N5718516
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei
Bioclimatic Zone: Submontane
Tenure: Protected (Huka Falls Scenic Reserve)
Altitude: *c.*360 m
Extent of Geothermal Habitat: *c.*0.1 ha
Extent of Geothermal Vegetation: *c.*0.1 ha
Date of Field Survey: 14 May 2003

VEGETATION		LANDFORM	EXTENT
CODE	**TYPE**		
07.05 07.05.15	**Mixed fernland** **Mixed fernland** Hot seepage surrounded by bare ground, with several plants of *Christella* aff. *dentata* ("thermal"), kiokio, *Adiantum cunninghamii*, *Blechnum vulcanicum*, *Pneumatopteris pennigera*, makomako, kotukutuku, rangiora, *Urtica incisa*, and wall lettuce.	Steep hillslope	<0.1 ha
05.13 05.13.07	**Blackberry-dominant shrubland** **Blackberry shrubland** Shrubland dominated by blackberry, Himalayan honeysuckle, and radiata pine surrounds a stream gully in which there are several hot springs. There is occasional Chinese privet, kotukutuku, *Carex geminata*, mahoe, kiokio, *Pneumatopteris pennigera*, and bracken.	Gully flowing water	<0.1 ha

Indigenous Flora: A small population of *Christella* aff. *dentata* ("thermal") (classed as „At Risk-Declining' in de Lange *et al.* 2009) occurs at the head of the gully.

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

Current Condition (2003 Assessment): The main stream gully is dominated by blackberry, Himalayan honeysuckle and radiata pine.

Threats/Modification/ Vulnerability:

Invasive pest plants (2003 Assessment): The main stream gully is dominated by blackberry and Himalayan honeysuckle (>75% cover).

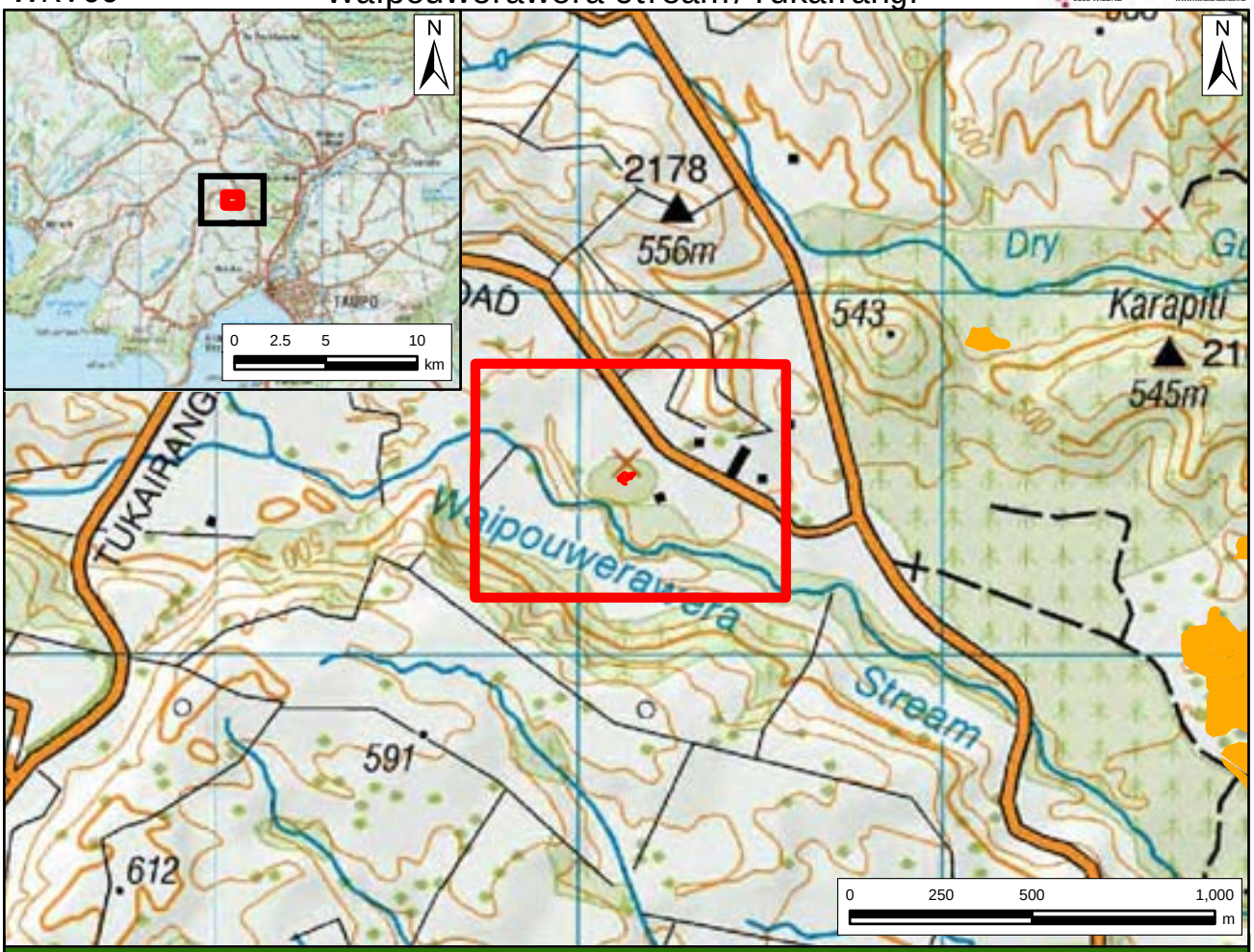
Human impacts (2003 Assessment): This site is in the Wairakei geothermal field and is vulnerable to changes in ground temperature associated with power station draw-off (refer to Burns

[1] Previously identified as U17/6 in Wildland Consultants (2004).

	et al. 1996; Merrett & Burns 1998b&c), however the impacts to this area of draw-off are not currently known.
Grazing (*2003 Assessment*)*:*	Livestock are not a threat to this area.
Adjoining land use (*2003 Assessment*)*:*	Scenic Reserve administered by Department of Conservation. A walking track passes through the site.
Site Change:	
Recent change:	Not assessed. Any significant change unlikely.
Historical:	This site is too small to see any evidence of change since 1941 (Historical photos: SN 172 Run 1174 Photos 2, 3, 1941).
Management Requirements:	None required at present.
Significance Level:	Regional (Table 1 - Criteria 1, 3, 5; Table 2 - Factors 9, 12).
Significance Justification:	This site is of regional significance because it is within a Scenic Reserve. It contains a small population of an „At Risk' plant species (*Christella* aff. *dentata* "thermal").
Notes:	Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region, and in this study this site was classed as Category C - the third highest category.
References:	Given 1989a & 1996; Merrett & Burns 1998a; Wildland Consultants 2004.

WKV09

Waipouwerawera Stream/Tukairangi



WAIPOUWERAWERA STREAM/TUKAIRANGI

Site Number: WKV09[1]
Grid Reference: NZTopo50 BG36 651 185
GPS Reference: NZTM E1865128 N5718488
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei-Tauhara
Bioclimatic Zone: Submontane
Tenure: Protected (Waipouwerawera Stream Conservation Area)
Altitude: 468 m
Extent of Geothermal Habitat: *c*.0.1 ha
Extent of Geothermal Vegetation: *c*.0.1 ha
Date of Field Survey: 3 March 2011

Code	Type	Landform	Extent
05.03 05.03.25	**Manuka-dominant shrubland** **(Maritime pine)/manuka-broom-blackberry-Himalayan honeysuckle shrubland** This vegetation type covers most of the side walls of the explosion craters and appears to be expanding downslope as the ground cools. Occasional maritime pine are emergent over a mixed shrub layer of manuka, prostrate kanuka, broom, blackberry, and Himalayan honeysuckle. Tawiniwini, turutu, and small patches of *Paesia scaberula* and *Gleichenia microphylla* are also present. Small areas of nonvegetated raw-soilfield occur on the crater floor, and also amongst larger patches of manuka and mingimingi. On the cooler crater rim whauwhaupaku is emergent over manuka, broom, and a thick margin of blackberry.	Crater walls	*c*.0.1 ha
05.15 05.15.01	**Monoao-dominant shrubland** **Monoao shrubland** A patch of monoao shrubland occurs on crater walls in the north-east corner of the explosion craters. There are occasional emergent maritime pines and radiata pines. Prostrate kanuka, kanuka, mingimingi, bracken, *Lycopodium volubile* and broom are scattered throughout, and whauwhaupaku occurs on the upper margins of this area.	Crater floor, steep crater walls	*c*.0.1 ha
28.01 28.01.01	**Nonvegetated raw-soilfield (not mapped)** **Nonvegetated raw-soilfield** Patches of geothermally-influenced bare soil are present. No elevated temperatures were found, although access around the site is very difficult.	Crater floor and walls	

[1] Previously identified as U18/10 and U17/9 in Wildland Consultants (2004).

Indigenous Flora: Prostrate kanuka (classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) is present. *Dicranopteris linearis* (classed as „At Risk-Naturally Uncommon' in de Lange *et al.* 2009) and *Lycopodiella cernua* have been recorded at the site in the past (Given 1989), but were not seen in 2003 or during the current survey, and are unlikely to still be present.

Fauna: Common bird species typical of the habitat (including magpie and blackbird) are present.

Current Condition (2011 Assessment): The extent of geothermal vegetation and habitat appears to be declining at this site. There was no evidence of the fumaroles or hot ground previously recorded in 1989 (Given 1989), but not seen in 2003 or 2011 surveys. It appears that, since 1989, vegetation cover comprising a mixture of species typical of geothermal and non-geothermal habitats) on the crater floor has increased and only small areas of nonvegetated raw-soilfield remain scattered amongst monoao shrubland. Weeds are a problem on the margins with broom, Himalayan honeysuckle, blackberry, and wilding maritime pine on the crater walls and rim terrace.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2011 Assessment*): Wilding pines (maritime pine, radiata pine) (1-5% cover), blackberry (25-50% cover), Himalayan honeysuckle (5-25% cover), poplar (<1%) and broom (25-50% cover) are spreading down the crater sides.

Human impacts (*2011 Assessment*): None observed

Grazing (*2011 Assessment*): This area is fully fenced and stock does not have access.

Adjoining land use (*2011 Assessment*): This site is surrounded by farmland.

Site Change:

Recent change: An increase in vegetation cover in the crater and a reduction in nonvegetated raw-soilfield suggests that the site has experienced reduced geothermal activity and that soil temperatures have decreased since Given surveyed the site in 1989.

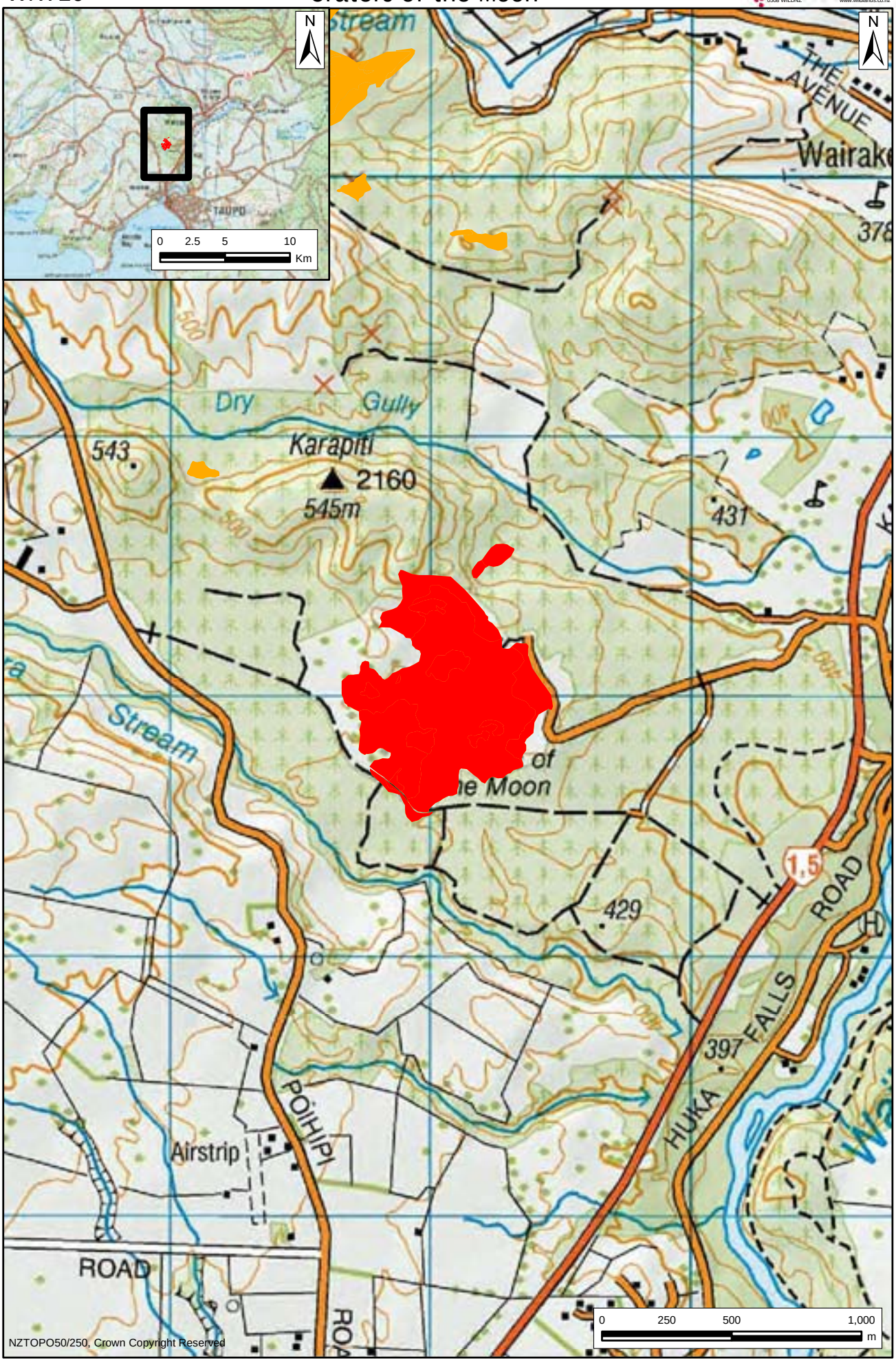
Historical: In the 1961 photos (Historical photos: SN 1394 Run 3188 Photos 22-23, 1961) a greater extent of bare ground is visible to that which is visible in the 2007 photos (i.e. there is an increase in extent of vegetation in the 2007 aerials). Increased extent of vegetation (including non-geothermal vegetation) could be due to a number of factors including reduced heat from geothermal systems. The extent of geothermal vegetation and habitat appears to be declining at this site (see current condition above).

Management Requirements: Maritime pine and radiata pine wildings should be removed and weed species such as broom and blackberry should be controlled on the rim terrace and crater walls. The landowner proposes to undertake restoration plantings along the stream margins in the near future.

Significance Level:	Local (Table 1 - Criteria 1, 3, 5; Table 2 - Factor 19)
Significance Justification:	This site is of local significance because it contains a small example of a „nationally uncommon' habitat (geothermal), and a small population of an „At Risk' species (prostrate kanuka).
Notes:	Given (1996) assessed the botanical value of many of the geothermal sites in the Waikato Region and this site was classed as Category B - the second highest category.
References:	Department of Conservation 1997; Given 1989a & 1996; Merrett & Burns 1998a; Wildland Consultants 2004.

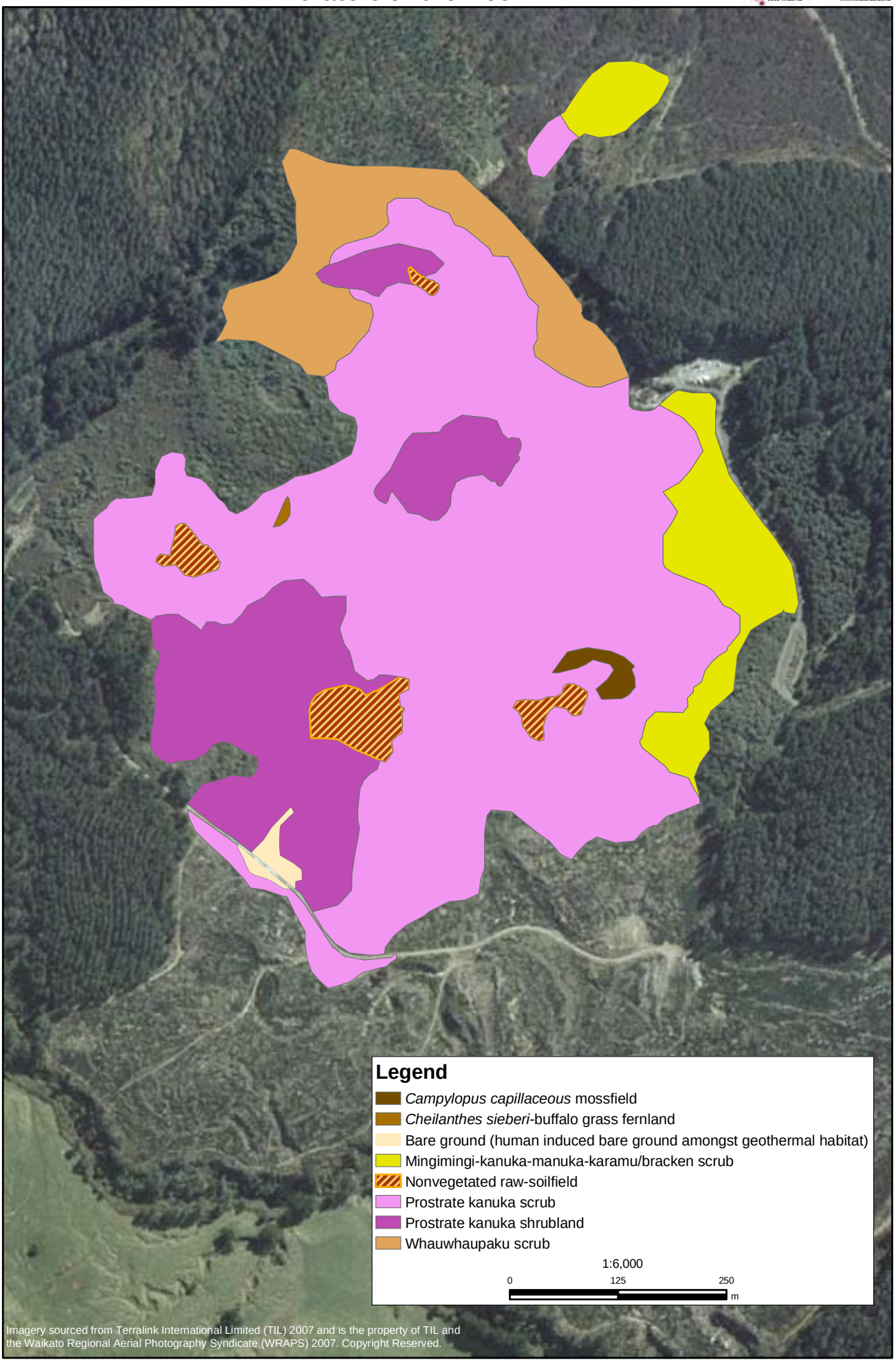
WKV10

Craters of the Moon



WKV10

Craters of the Moon



CRATERS OF THE MOON[1]

Site Number: WKV10[2]
Grid Reference: NZTopo50 BG36 671 180
GPS reference: NZTM E1867064 N5718041
Local Authority: Taupo
Ecological District: Atiamuri
Geothermal Field: Wairakei
Bioclimatic Zone: Submontane
Tenure: Protected (Ministry of Tourism Reserve)
Altitude: *c.*440-460 m
Extent of Geothermal Habitat: *c.*44.6 ha
Extent of Geothermal Vegetation: *c.*44.6 ha
Date of Field Survey: 12 August 2004 (a partial site inspection was undertaken on 29 August 2007)

VEGETATION		LANDFORM	EXTENT
CODE	**TYPE**		
04.01 04.01.01	**Prostrate kanuka-dominant scrub** **Prostrate kanuka scrub** Prostrate kanuka up to *c.*1 m high dominates these areas, with scattered monoao and patches of *Lycopodiella cernua* and *Dicranopteris linearis*. Patches of *Campylopus capillaceus* are common and there are occasional wilding pines throughout.	Flat	*c.*27.4 ha
04.02 04.02.15	**Mingimingi-dominant scrub** **Mingimingi-kanuka-manuka-karamu/bracken scrub** A mixture of mingimingi, kanuka, manuka and karamu forms a dense scrub cover, with small patches of bracken, blackberry, Himalayan honeysuckle and *Dicranopteris linearis* around the margins. Near the main entrance of the reserve, Himalayan honeysuckle and bracken dominate a recently cleared hillslope, with broom and mingimingi scattered throughout and patches of *Dicranopteris linearis* on steep banks at the base of the hillslope.	Flat	*c.*3.6 ha
04.05 04.05.02	**Indigenous broadleaved species-dominant communities** **Whauwhaupaku scrub** Occasional wilding radiata pine up to *c.*10 m tall are emergent over abundant whauwhaupaku. Scattered Himalayan honeysuckle, koromiko, mingimingi, and bracken dominate the understorey. *Nephrolepis flexuosa* occurs locally on the margins, and *Dicranopteris linearis* is abundant on small banks at the edge of the crater. Near the main entrance of the Reserve, mamaku, in association with mahoe and young kamahi, dominates a recently cleared hillslope.	Hillslope	*c.*4.3 ha

[1] This site was called Karapiti (Craters of the Moon) in Beadel & Bill (2000).
[2] Previously identified as U18/4 in Wildland Consultants (2004).

VEGETATION		LANDFORM	EXTENT
CODE	TYPE		
05.01 05.01.01	**Prostrate kanuka-dominant shrubland** **Prostrate kanuka shrubland** Prostrate kanuka to a height of *c.*0.3-0.5 m is dominant, with patches of *Lycopodiella cernua, Campylopus capillaceus,* lichen, and loamfield throughout.	Flat	*c.*7.5 ha
07.01 07.01.01	***Dicranopteris*-dominant fernland (not mapped)** ***Dicranopteris linearis* fernland** *Dicranopteris linearis*, in association with *Lycopodiella cernua*, forms the dominant cover, with prostrate kanuka, turutu and emergent manuka scattered throughout. Monoao and *Histiopteris incisa* occur occasionally. This vegetation type occurs amongst prostrate kanuka scrub and shrubland but is too small to map separately.	Flat and hillslope	*c.*1.2 ha
07.05 07.05.14	**Mixed fernland (not mapped)** ***Dicranopteris linearis-Histiopteris incisa* fernland** *Dicranopteris linearis* and *Histiopteris incisa* dominate the margins of an active fumarole, with local patches of *Paesia scaberula*, bracken, monoao, *Campylopus capillaceus* and *Sphagnum cristatum*. Occurs amongst prostrate kanuka scrub and shrubland but is too small to map separately.	Fumarole	*c.*<0.1 ha
07.07 07.07.01	***Lycopodiella*-dominant fernland (not mapped)** ***Lycopodiella* fernland** A discontinuous cover of *Lycopodiella cernua* over dense mats of *Campylopus capillaceus* occurs in association with heated loamfield. Occurs amongst prostrate kanuka scrub and shrubland but is too small to map separately.	Flat	*c.*2.8 ha
07.13 07.13.01	**Cheilanthes-dominant fernland** ***Cheilanthes sieberi*-buffalo grass fernland** This small area is dominated by *Cheilanthes sieberi* and mixed exotic grasses, mainly buffalo grass and Indian doab. It is near a walking track and appears to have developed following disturbance.	Flat	<0.1 ha
14.02 14.02.01	**Campylopus-dominant mossfield** ***Campylopus capillaceus* mossfield** *Campylopus capillaceus* forms the dominant cover with patches of buffalo grass, Indian doab, and locally scattered prostrate kanuka. Fumaroles, steaming pits, and areas of nonvegetated raw-soilfield are common throughout.	Flat	*c.*0.3 ha
28.01 28.01.01	**Nonvegetated raw-soilfield** **Nonvegetated raw-soilfield** Sinter pavement. Small patches of *Campylopus capillaceus* mossfield with occasional *Lycopodiella cernua* are present.	Flat	*c.*1.3 ha
28.01 28.01.05	**Nonvegetated raw-soilfield** **Bare ground (human-induced bare ground amongst geothermal habitat)** These areas comprise human-induced bare ground within areas of geothermal habitat.	Flat	*c.*0.2 ha

Indigenous Flora:

Prostrate kanuka (classed as an 'At Risk-Declining' species in de Lange *et al.* 2009) and *Campylopus capillaceus*, which are both endemic and restricted to geothermal areas, are common throughout this site.

Other 'At Risk' species present include *Dicranopteris linearis* and *Hypolepis dicksonioides* (both classed as 'At Risk-Naturally Uncommon'), and *Nephrolepis flexuosa* (classed as 'At Risk-Declining' in de Lange *et al.* 2009). *D. linearis* is known from only *c.*24 sites in New Zealand. *Lycopodiella cernua* and *Psilotum nudum* (both of which are characteristic of geothermal areas) are also present.

Other species of interest include *Cheilanthes sieberi* (currently known to be present at this site). Given (1989a) recorded *Asplenium flabellifolium* growing on hot siliceous soil (which is not its usual habitat) and *Fimbristylis velata*, which was reported to be at its southern limit. *A. flabellifolium* and *F. velata* have not been recorded from this site since then.

Fauna:

Common indigenous and introduced bird species typical of the habitat are present including, tui, New Zealand pipit and grey warbler.

Current Condition (2004 Assessment):

This is a large site and is in good condition. There is clear vegetation zonation in response to different levels of heat flux (Given 1980a). Commissioning of the Wairakei geothermal power station resulted in an increase in steam-heated activity at Karapiti which has increased the size of the site and the extent of geothermal vegetation present (Burns *et al*. 1996; Cave *et al*. 1993).

The site is threatened by wilding pine and other weed species. Control of these species will be necessary to maintain the high quality geothermal vegetation at the site.

Threats/Modification/ Vulnerability:

Invasive pest plants (*2007 Assessment*)*:*

Several wilding pines (particularly radiata pine and maritime pine), and eucalyptus are scattered through the site, despite some control of wilding pines having been recently undertaken. Other invasive plant species present are blackberry, privet, tree lucerne, Himalayan honeysuckle, broom, buddleia, pampas, Spanish heath, buffalo grass, and paspalum (each with 1-5% cover). Where present, these species are having a negative impact on the indigenous character of the site. The Waikato Regional Council has recently undertaken aerial control of pampas at this site. Buffalo grass is present on the edge of many craters. Its bright green colour is not typical of indigenous geothermal vegetation, and it therefore negatively impacts on the indigenous character of the site.

Human impacts (*2004 Assessment*)*:*

The extent of heated ground around Craters of the Moon increased significantly following the development of the Wairakei geothermal field for electricity generation and there have been many changes in geothermal activity. The vegetation and geothermal features of this site continue to respond to the heating and cooling of soils, remaining vulnerable to the management of the geothermal power plant (Given 1989a).

This area is a popular spot for visitors. It is riddled with old paths, but visitors are now encouraged to keep to the main path which is maintained by the Craters of the Moon Trust. The site caretaker is utilising a variety of techniques to discourage people from walking off tracks.

The network of informal tracks created by visitors trying to get closer to geothermal features is compacted, which limits the potential for indigenous plants to recolonise these areas. In addition, there may be a significant effect of compaction on soil micro-organisms.

The removal of some wilding pines from the reserve has improved the long-term viability of the site.

Grazing (*2004 Assessment*)*:* Livestock are not a threat to this site, however brushtail possum, hares, and rabbit are present and are browsing the vegetation.

Adjoining land use (*2004 Assessment*)*:* Plantation forests.

Site Changes:

Recent change: Some management of pest plants has been undertaken recently by site managers. Techniques to discourage use of informal tracks have been implemented by the Craters of the Moon Trust. The Waikato Regional Council undertook control of patches of pampas at this site in April 2011 by the aerial application of herbicide.

Historical: Burns *et al.* (1996) have assessed vegetation change at this site using aerial photographs from 1945 to 1993 and found that there has been an eight-fold increase in geothermal vegetation at this site. However, there is no information on changes of structure or composition of this vegetation.

Management Requirements: Control of wilding pines and other pest plants needs to continue. Continued monitoring of this area will be invaluable for assessing the impacts of geothermal power extraction (refer to Burns *et al.* 1996; Merrett & Burns 1998b&c). The practice of discouraging the use of informal tracks should be continued.

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

Significance Justification: Craters of the Moon is of national significance because it contains a good quality representative example of geothermal vegetation, which is a nationally uncommon vegetation type. It contains one of the best examples of thermotolerant vegetation zonation which has developed in response to soil temperatures, and is an area of high geothermal activity (Given 1980a). Four species classed as 'At Risk' are present: prostrate kanuka, *Dicranopteris linearis*, *Hypolepis dicksonioides* and *Nephrolepis flexuosa*.

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

References: Beadel & Bill 2000; Burns *et al.* 1996; Clarkson 1989; Given 1980a, 1989a & 1996; Merrett & Burns 1998b&c; Unpublished Atiamuri PNAP data 1995; Wildland Consultants 2004 & 2007d.