GEOHERITAGE ASSESSMENT OF VILLA MARIA ESTATE LAND, WAITOMOKIA VOLCANO

2018

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SUMMMARY

This document provides an account of the volcanic history of Waitomokia Volcano and an assessment of the geoheritage values within the former Villa Maria Estate land that is to be redeveloped. Waitomokia Volcano had a classic "castle and moat" landform. It is one of the youngest volcanoes in the Auckland Field, having erupted ~20,000 yrs ago. It consists of a large, composite explosion crater that was erupted from several different vents. It is surrounded by a tuff ring that was built up from layers of erupted ash. The outline of the crater is scalloped as a result of numerous portions slumping back into the crater as the volcano was erupting, creating steep arcuate slump scarps. Three small scoria/spatter cones (the castle) that erupted in the centre of the crater have been removed by quarrying in the 1950s. The last phase of eruption was the creation of a lava lake that filled the crater "moat" between the central cones and crater walls. The lava lake cooled and solidified to basalt and is now overlain by up to 6 m thickness of silt and peat that accumulated in a shallow lake and swamp that developed in the moat after eruptions had ceased.

There are no significant rock exposures within the Villa Maria Estate redevelopment land. The highest value geoheritage features present are the sinuous crest of the tuff ring and the steep inner slopes of the crater. It is hoped that most of these within the redevelopment will not be modified further and be retained as open space areas that provide access for the public and visual evidence of the size and location of the crater. The flat floor of the crater and the overflow stream channel are significant features of the later history of Waitomokia and hopefully will be sufficiently retained for visual appreciation and for telling of the crater's history. Unfortunately, one sector of the outer slopes of the tuff ring is likely to be compromised by development but the impact of this is lessened by the adjacent presence of the Oruarangi Road Reserve which comprises an excellent and better example of the gentle outer tuff ring slopes with panoramic views over this part of the Manukau Harbour.

CONTENTS

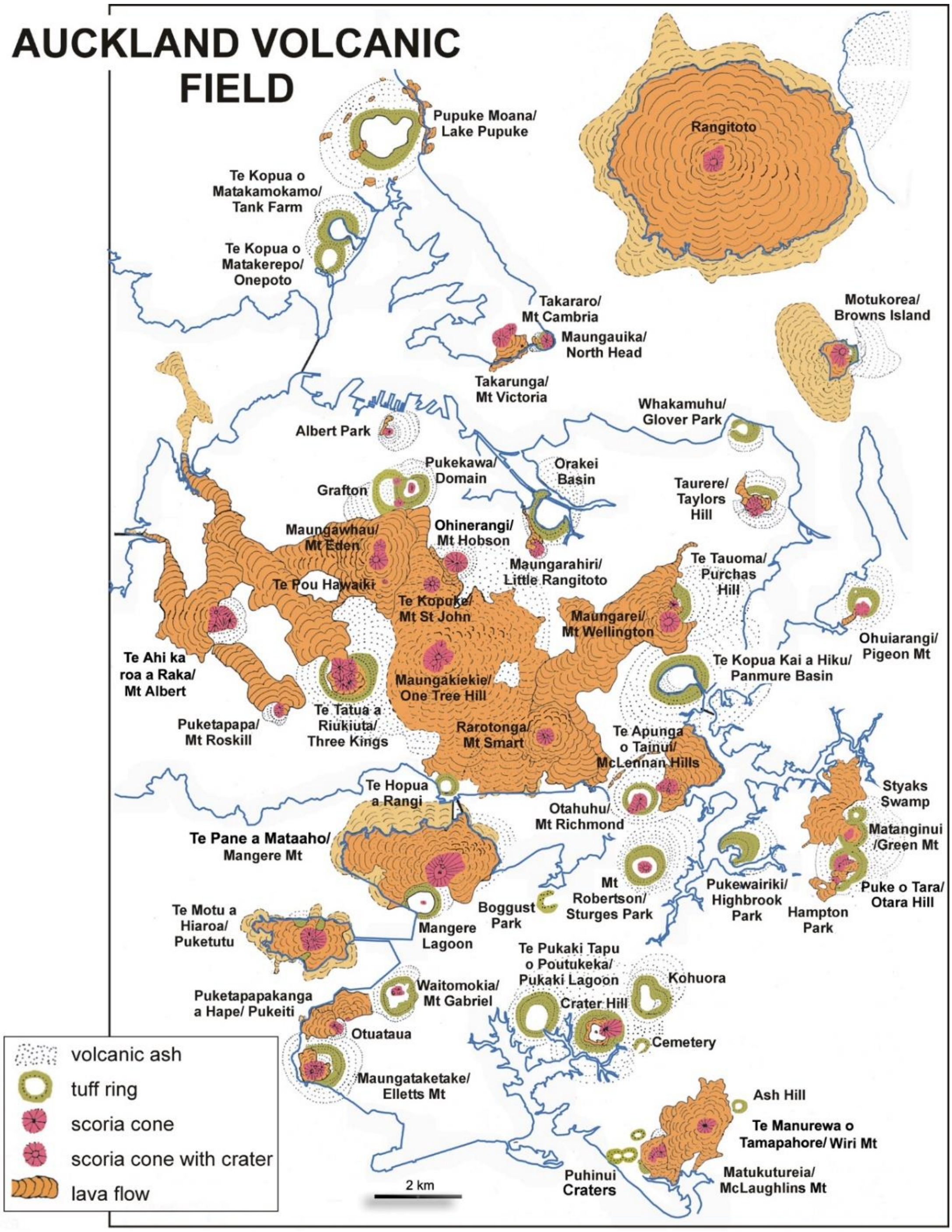
2018

INTRODUCTION

This report has been prepared at the request of Goodman who are in the early stages of planning redevelopment of the Villa Maria winery estate on part of Waitomokia Volcano, Mangere. The report has been requested to inform the preparation of a Cultural Impact Assessment of redevelopment plans.

AUCKLAND VOLCANIC FIELD

Waitomokia is one of the 53 identified volcanoes in the young Auckland Volcanic Field.



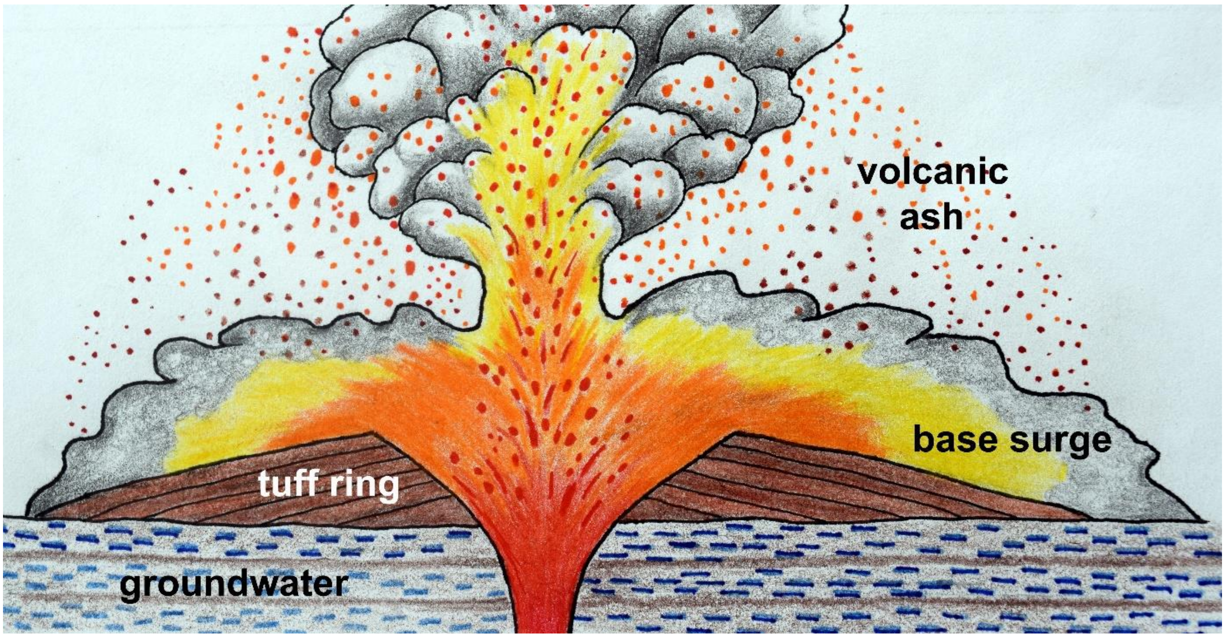
THREE STYLES OF ERUPTION PRODUCED AUCKLAND'S VOLCANOES

The volcanic landforms in the Auckland Volcanic Field were produced by three different styles of eruption (Hayward et al., 2011; Hayward, 2019):

1. Wet explosive eruptions

When many of Auckland's volcanoes first erupted, the rising magma came into contact with near-surface groundwater in aquifers or swampy ground. Initially, the heat from the extremely hot magma (about 1000–1200 ˚C) caused the water to flash to steam, resulting in a violent explosion. These first explosive eruptions may have involved only steam and are referred to as phreatic or steam eruptions. Commonly, but not always, the steam blast eruptions were followed by those that also involved the rising magma, the surface of which was instantly chilled, solidified and explosively fragmented when it encountered the cold water. These eruptions are called phreatomagmatic as they involve both steam and magma. They result in the upwards and outwards ejection of a rapidly expanding cloud of steam, magmatic gas, fragmented lava and other pieces of rock from the vent walls. Wet explosive eruption columns rose to heights of a kilometre or more and the less dense volcanic ash within them were dispersed by the wind.

Around the denser base of the eruption column, base surges of superheated steam, gas, ash and lapilli were blasted out sideways at speeds up to 200 km/h. These turbulent base surges devastated and partly buried areas within 3–5 km of the vent and were the most dangerous style of eruption produced by Auckland's volcanoes.



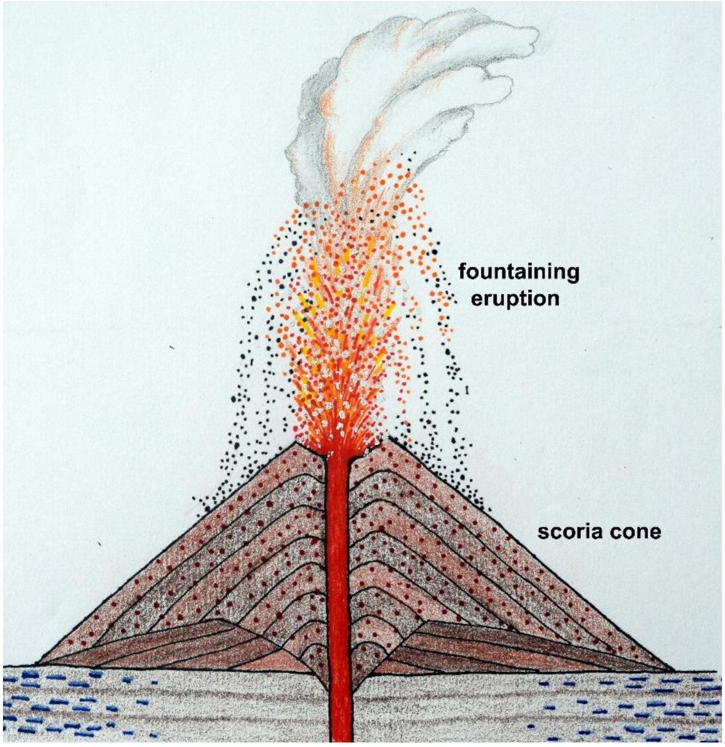
Wet explosive eruptions usually come in a series of pulsating episodes interspersed by short periods of inactivity. These eruptions typically produced a relatively shallow (50–100 m deep), wide (200–1000 m across), circular explosion crater surrounded by a low ring of bedded wet volcanic ash. As the layers dried out, they hardened into a creamy-brown rock called tuff. The raised ring of tuff rock around the explosion crater is called a tuff ring. A tuff ring usually has its circular crest forming the rim of the crater with relatively steep slopes back into the crater and gentler slopes (*c.* 5–10 degrees) on the outside. The steeper inner slopes are often formed by a series of arcuate slump scarps as a result of sections of the tuff ring slipping back into the crater after being deposited.

If magma supply ceased before all the groundwater was used up, then the only landform produced by the volcano was an explosion crater surrounded by a tuff ring. After eruptions finished, the explosion craters gradually filled with rainwater, creating crater lakes. Many of these lakes subsequently filled with sediment to become tidal lagoons, swamps or wetlands.

2. Fire-fountaining and fiery explosive eruptions

If the water in the vent was all used up (during the wet explosive eruptions) before the magma supply waned, then eruptions switched to a dry style and scoria cones were built. These partly or completely filled the explosion crater and maybe even buried all trace of the tuff ring.

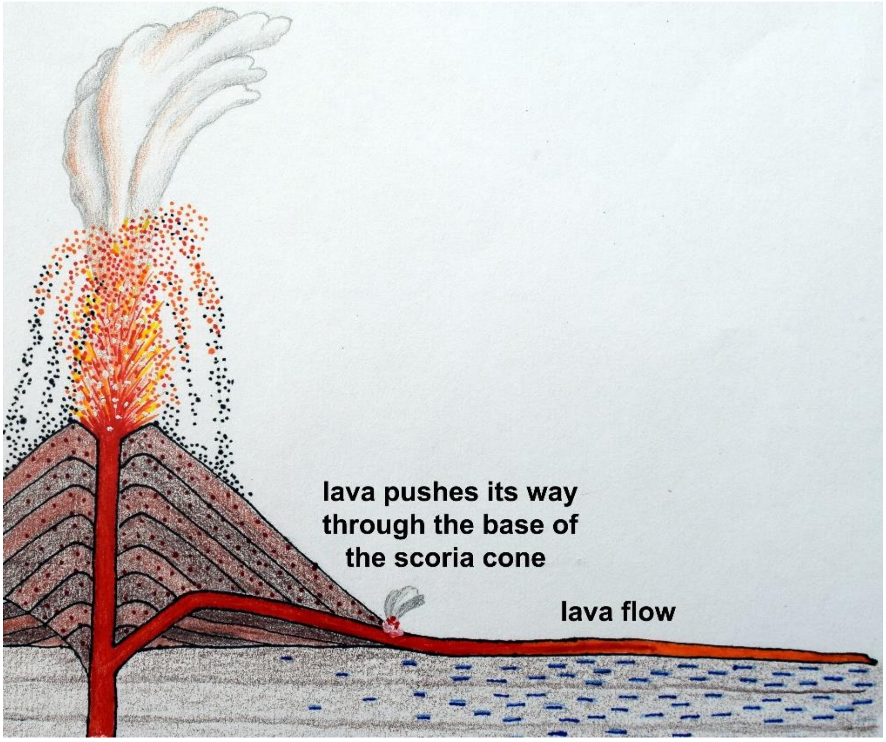
The magma that erupted to form Auckland's volcanoes was molten rock containing dissolved gas (mostly water vapour and carbon dioxide) under pressure. As the rising magma neared the surface, pressure reduced and the releasing gas drove a fountaining of frothy liquid from the vent, called fire-fountaining. As the fountaining frothy lava flew through the air, it cooled and solidified, forming the frothy rock known as scoria. The erupted scoria accumulated around the vent, building a steep-sided scoria cone with a deep crater. The slope of scoria cones is about 30 degrees, the angle at which scoria came to rest as it rolled downhill.



Within some of the scoria cones there are layers of larger, ragged chunks of coarsely vesicular or more dense basalt that were expelled from the vent by discrete fiery explosive eruptions of more pasty lava. These incandescent lumps often landed in a sticky molten form and tended to weld together into hard layers. These fiery explosive eruptions often occurred towards the end of the dry fire-fountaining phase as the rate of magma ascent slowed and it became cooler, thicker and less gaseous. Several of the smallest cones (e.g. in Waitomokia) are composed almost entirely of the more welded deposits thrown out by fiery explosive eruptions.

3. Lava flows

During the dry fire-fountaining and fiery explosive phase of eruption of Auckland's scoria cones, the partly degassed molten magma often rose up inside the throat of the volcano. If it reached the height of the base of the scoria cone, this magma could push its way through the loose scoria and emerge as a flow of lava from near the base of the cone. The outpouring of lava flows was usually accompanied by fire-fountaining or fiery explosions. The size of the lava flow or field of coalescing lava flows depended on the supply of lava.

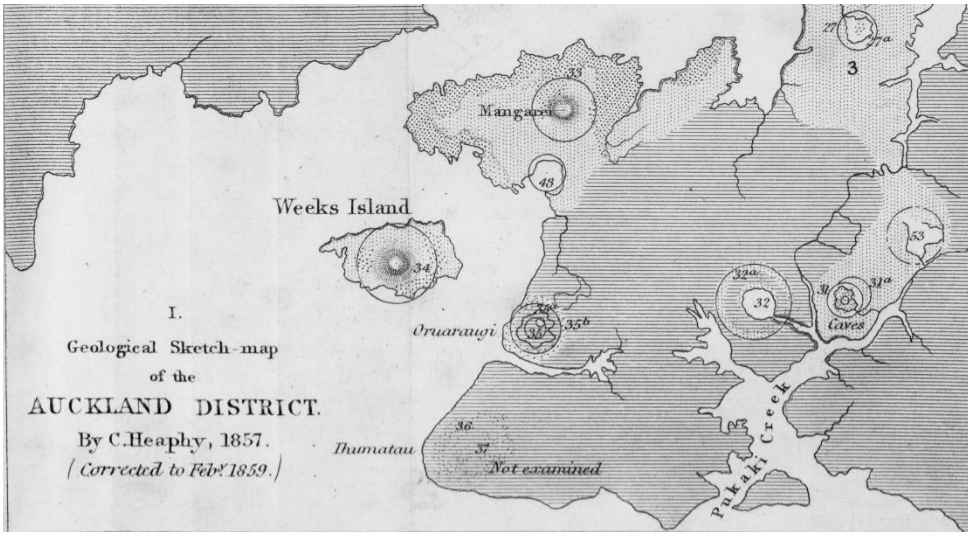


Where the volume of outpouring lava was less, the shape of the land over which it erupted influenced the resulting form of the lava-flow field. In some instances, the lava flowed out from around the base of small scoria cones within a large explosion crater and the lava partly filled the surrounding crater creating a lava lake, which cooled and solidified to form solid basalt.

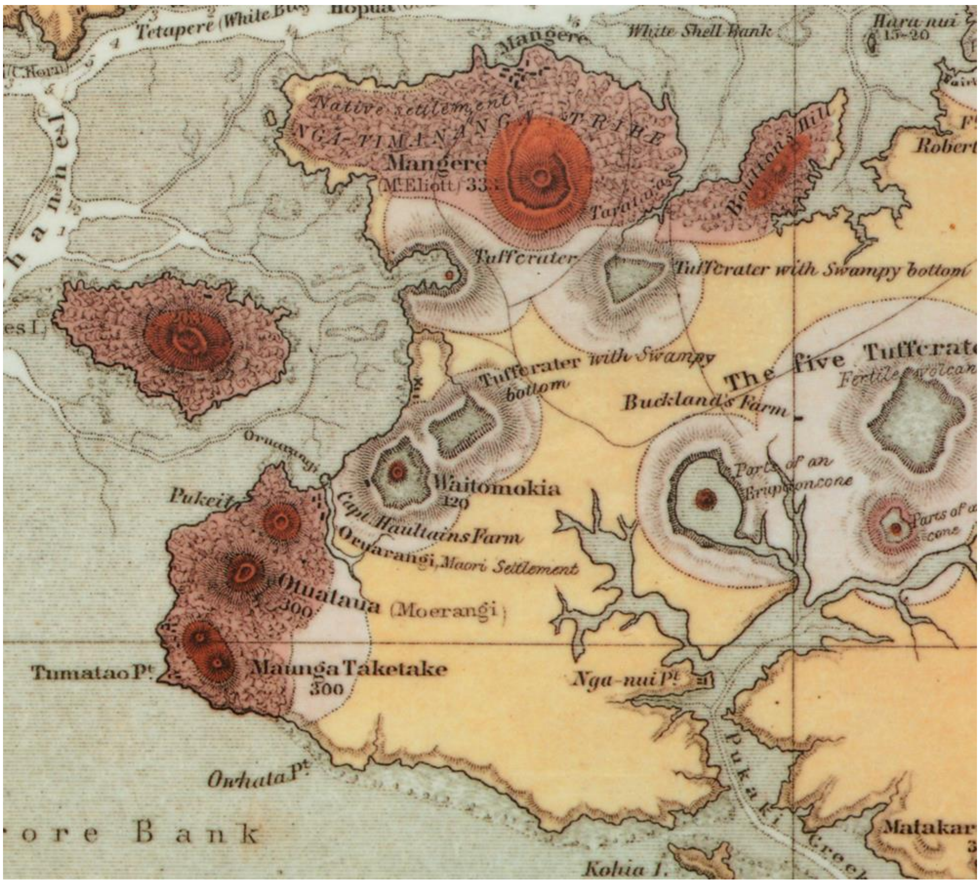
WAITOMOKIA VOLCANO

Previous work

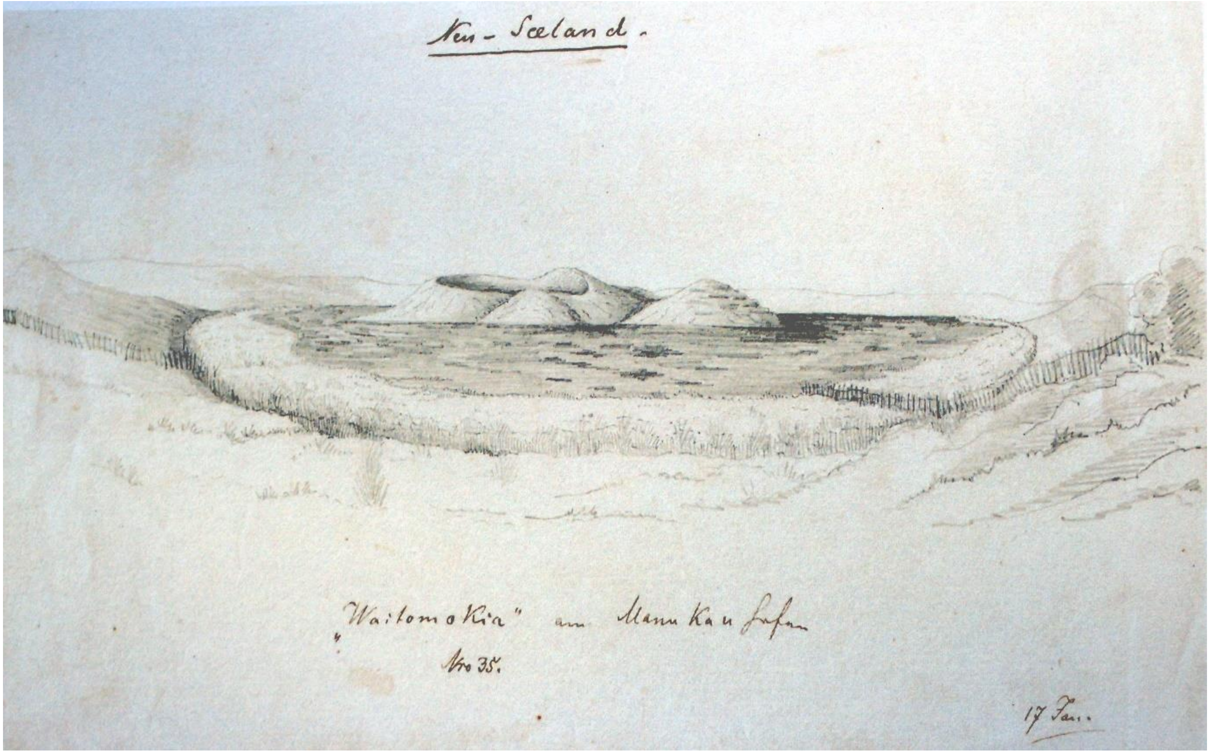
1. The first two geological maps of the Auckland Volcanic field showing the location of Waitomokia as one of those volcanoes were published by Heaphy (1960) and later by Hochstetter (1964):



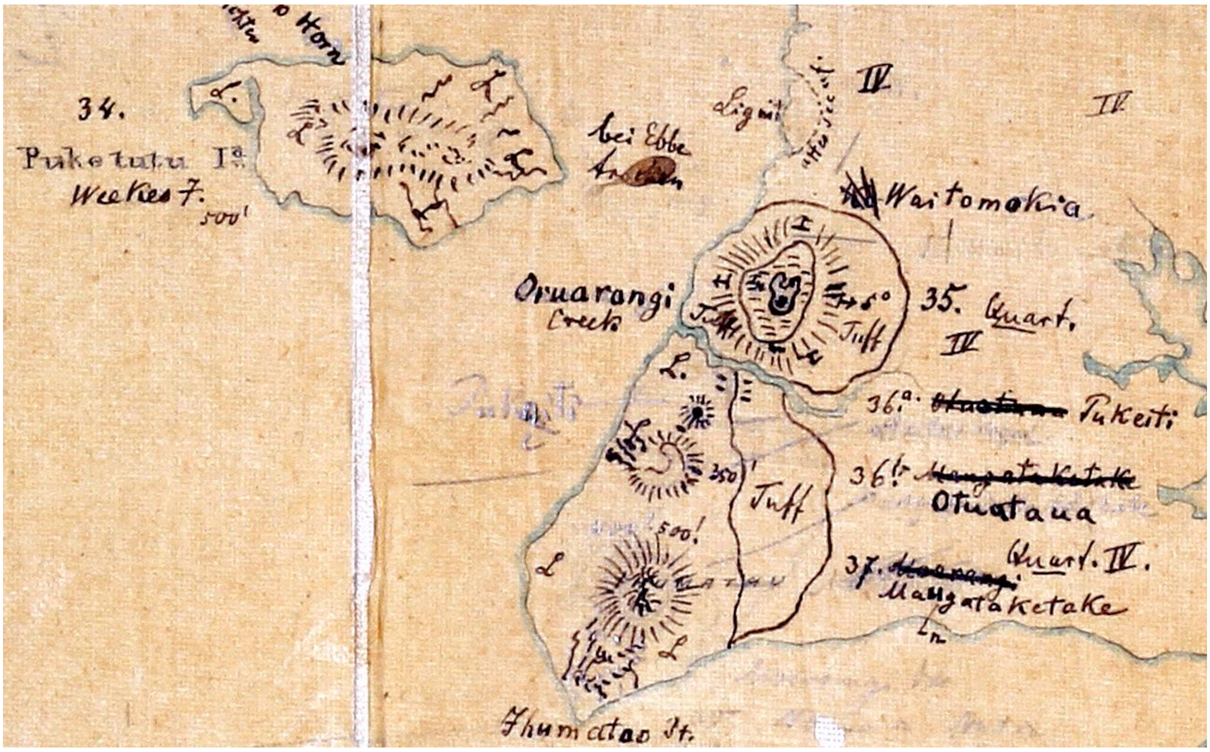
Part of Heaphy's (1860) map of Auckland's volcanoes showing "Oruarangi" Volcano.



Part of Hochstetter's (1864) map of Auckland's volcanoes showing "Waitomokia" Volcano.



Original sketch of Waitomokia and cones by Ferdinand von Hochstetter, 17 Jan 1859.



Part of the original sketch map of the Auckland Volcanic Field made in Auckland in 1859 by Hochstetter showing the location of his volcano "35. Waitomokia".

2. More detailed study of the volcanoes of this part of Auckland did not appear until Firth (1930) published the following short description:

Waitomokia (Gabriel Hill).

Waitomokia is a perfect tuff-ring almost one-half mile in diameter which rises 70 ft. above sea-level and encloses a crater, now occupied by a swamp, in the centre of which there is a group of three small scoria cones (Fig. 21). These latter attain an elevation of 120 ft. above sea-level, or 80 ft. above the crater floor, the crest of the most southerly one possessing a deep, symmetrical crater. The tuff comprising the crater-rim is similar to that at Puketutu, and at Oruarangi Creek is overlain by extensive basaltic flows from Puke-iti.

3. The next work that described Waitomokia Volcano in detail was Searle (1959) who wrote:

Waitomokia (Gabriel Hill)

In the middle of the group is Waitomokia (Gabriel Hill), Figs 2 and 3, with a wide explosion crater about half a mile in diameter, surrounded by a low tuff ring of light-grey fairly well consolidated tuff consisting of comminuted sedimentary material, blocks of partly baked sediments, fine ash, and other juvenile volcanic debris. Much of the material is stratified in thin beds of lapilli in a matrix of fine ash, whilst close to the crater and in the higher parts of the ring the tuff is poorly sorted, has ill-defined stratification, and contains many large blocks. The explosion ring is roughly oval in shape and the western flank is cliffed on its inner margin. The floor is flat, with swamp deposits filling it to 20 ft above M.S.L., and in the centre of the crater is a group of three small scoria cones that barely rise above the crest of the higher portions of the ring.

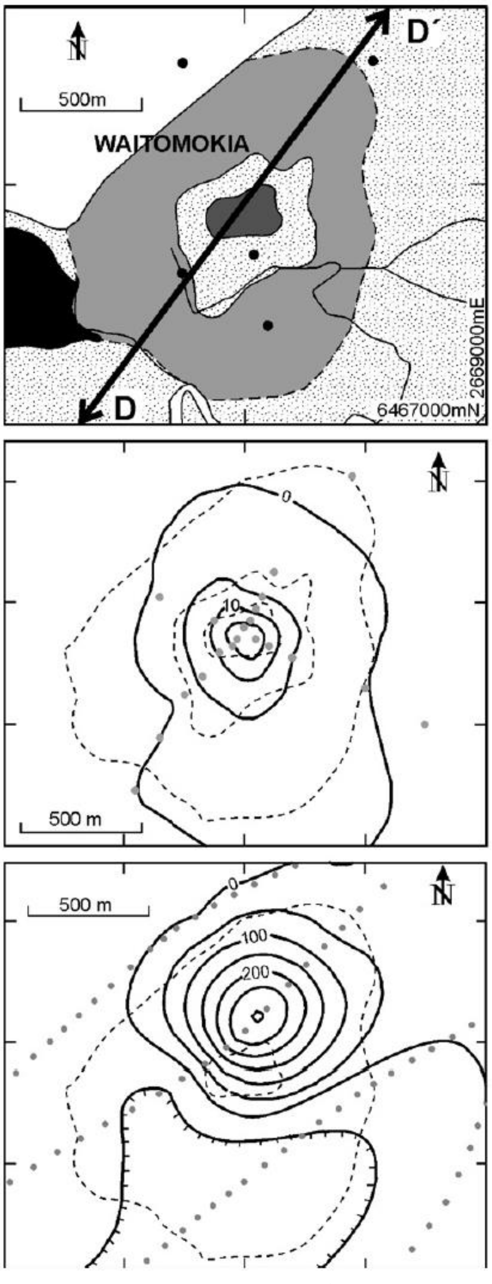
It is unlikely that this wide and shallow crater could have been produced by explosions from any single vent. Embayments in the perimeter of the crater point to a number of closely spaced centres of eruption whose combined activity would explain both the size of the basin and the fact that it is so shallow—the debris from later explosions tending to fill in the small craters of earlier ones. It is probable that most of the large tuff rings of Auckland were similarly formed by explosions from a number of centres in a group, just as many of the scoria cones were built by more than one vent; multiple vents are just as likely to produce a near circular crater as a single one. However, the evidence of a series of explosive eruptions separated in time as well as in position is clearer at Waitomokia than in most other cases, for here a line of small explosion craters lies across the north-east section of the tuff ring and they have obviously been blasted through the earlier tuff accumulation (see Fig. 2). There is fairly clear evidence of at least 7 or 8 explosive vents, indicated either by embayments in the outline of the crater or by definite pits; it is probable that even more small centres were active on the floor of the crater but have been filled in or covered over by the debris of later eruptions.

The scoria cones are composed of the coarse slaggy products of fire-fountaining but there is no evidence of lava flows and if any such were formed they must have been contained within the tuff ring and now lie buried beneath the alluvial and swampy fill. Only the westerly cone of the group has a crater and this is elliptical in outline with a narrow swampy base at about the same level as the floor of the main explosion crater. The northerly cone is slightly crescentic in cross-section and appears to be a flanking remnant of an earlier cratered cone which has been destroyed by explosive eruptions associated with the opening of later vents. The third cone may also be a remnant of this older structure or of another early-built cone. The symmetry of the system suggests that the westerly unit was the last to be built and it may well be that the initial eruptions that culminated in the short-lived episode of fire-fountaining, by which it was produced, were responsible for the destruction of the former scoria cone. However, this explanation is not wholly satisfying, as the direction of elongation of the crater of the younger cne lies athwart the rupture between the other two, and vigorous quarrying during the last two years, which has almost completely eliminated two of these cones and doubtless within a short time will cause the whole group to vanish from the landscape, has revealed differences in constitution of the cones that support the contention that they are all separate units built by different vents.

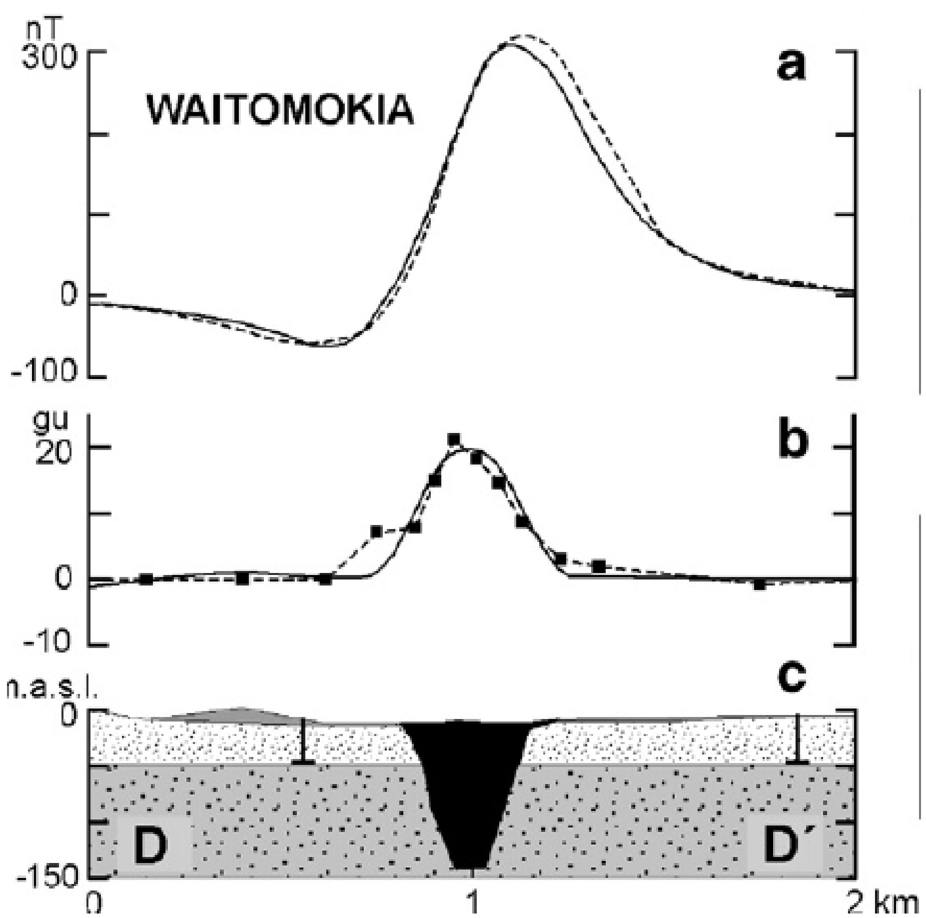
The topographic form, the constitution of the tuff and scoria accumulations, and the large number of explosion pits associated with this small volcano draw attention to the complex eruptive patterns of even very minor centres. The scoriaceous slag and abundant lapilli in the tuff indicate a measure of activity of the fire-fountaining type even during phases of eruption which were dominantly phreatic, and the existence of craters in the tuff ring suggests explosive episodes late in the history of the centre. Although it need not necessarily be so, the whole picture is not incompatible with a history of activity recrudescent over a much longer period of time than is generally assumed for the building of such minor volcanic structures. The distribution of individual vents in the volcano shows a distinct linear disposition along a line trending east of north. It is felt that much more significance may be attached to linear distribution, between the vents of particular systems than may be to lines linking the less intimately related centres in the field as a whole. At Waitomokia the distribution of vents clearly suggests activity along a N.N.E. rupture, eruptions at the northern end of the line being later than those at the southern end.

The tuff surface dips outwards from the crater at a low angle to the shore where thinly bedded and well cemented tuffs are exposed in a wide cut platform. In the south, they continue across Ourangi Creek and pass under massive basalt flows from Pukeiti. It may be accepted, therefore, that activity at Waitomokia antedates that at Pukeiti.

4. As part of a geophysical study of several of the maar craters in the Auckland Volcanic Field, Cassidy et al. (2007) undertook a gravity and aeromagnetic survey of Waitomokia.



Cassidy et al. (2007) Fig. 3 (in part). Upper: Location of boreholes and transect line of modelled subsurface geology of Waitomokia. Middle: Contours on gravity anomaly showing dense rock beneath crater. Lower: Contours on aeromagnetic anomaly showing large magnetic anomaly produced during period of normal magnetic polarity.



Cassidy et al (2007) Fig. 5 (in part) showing gravity (upper) and aeromagnetic (middle) anomaly values along the transect in Fig. 3 (above). The lower section shows their modelled size and shape of dense basalt (black) within the Waitomokia crater.

Cassidy et al. (2007) identified a large gravity and magnetic anomaly beneath the crater of Waitomokia. They inferred this to be caused by a body of solidified basalt up to 150 m thick extending beneath at least the central half of the crater. They had very little borehole data to constrain their model, unlike the present time which now allows a far better idea of what lies beneath the crater floor.

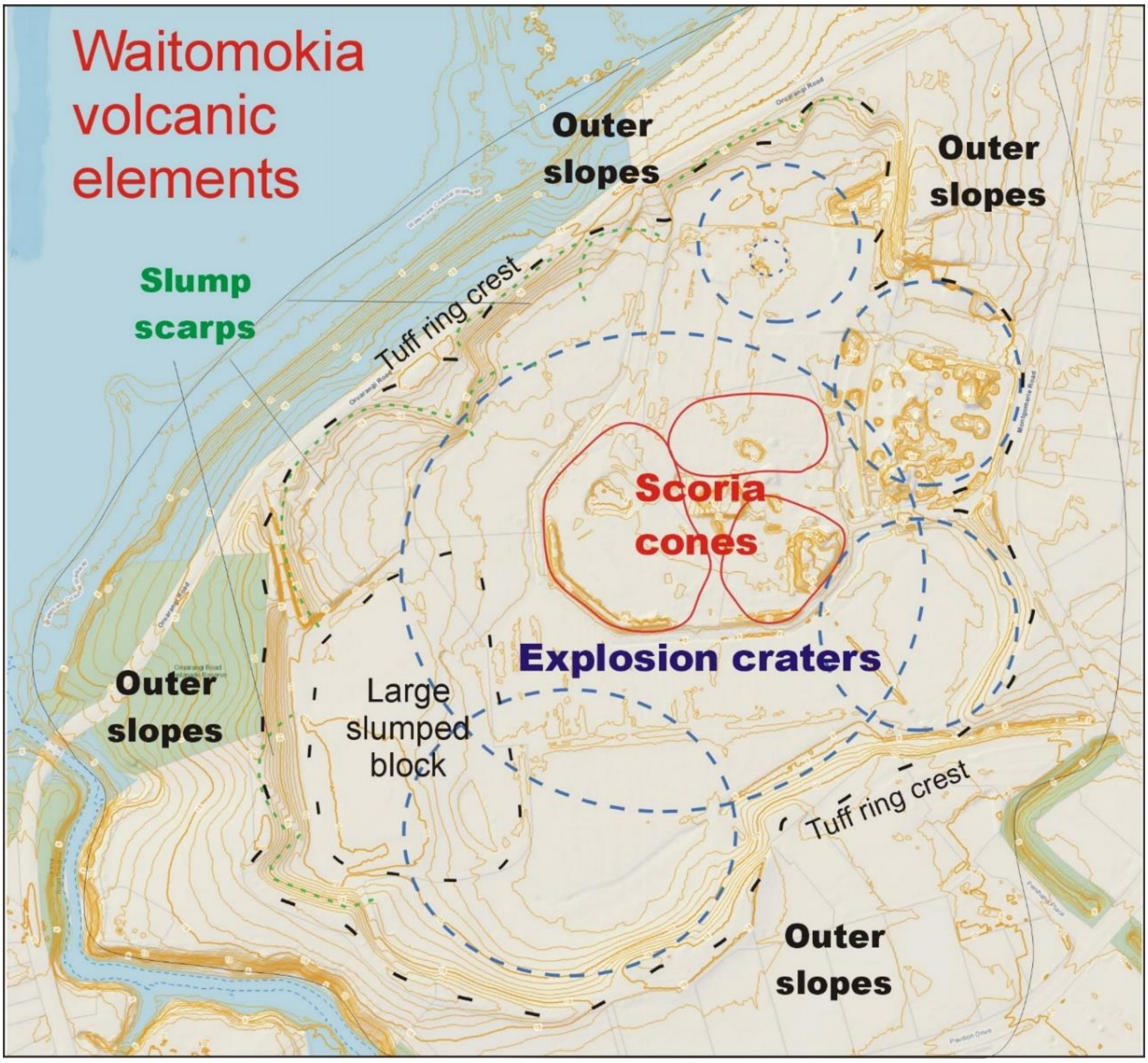
5. The most recent published studies of Waitomokia focused on the composition and structure of the tuff in the western part of Waitomokia's tuff ring. Hayward (2015) documented large blocks of volcanic sedimentary conglomerate in the tuff exposed along the western foreshore and inferred they were derived from underlying Cornwallis Formation, which outcrops at the surface in the cliffs of Cornwallis to Huia. Nemeth et al. (2012) described the exposures visible in cuttings through the western tuff ring behind the winery buildings. They inferred the layers were deposited from phreatomagmatic airfall and base surges. An unconformity within the section was inferred to be caused by syn-eruptive slumping of some of the tuff ring back into the crater.

Tuff exposure along harbour foreshore, west margin of Waitomokia tuff ring.

History of eruption

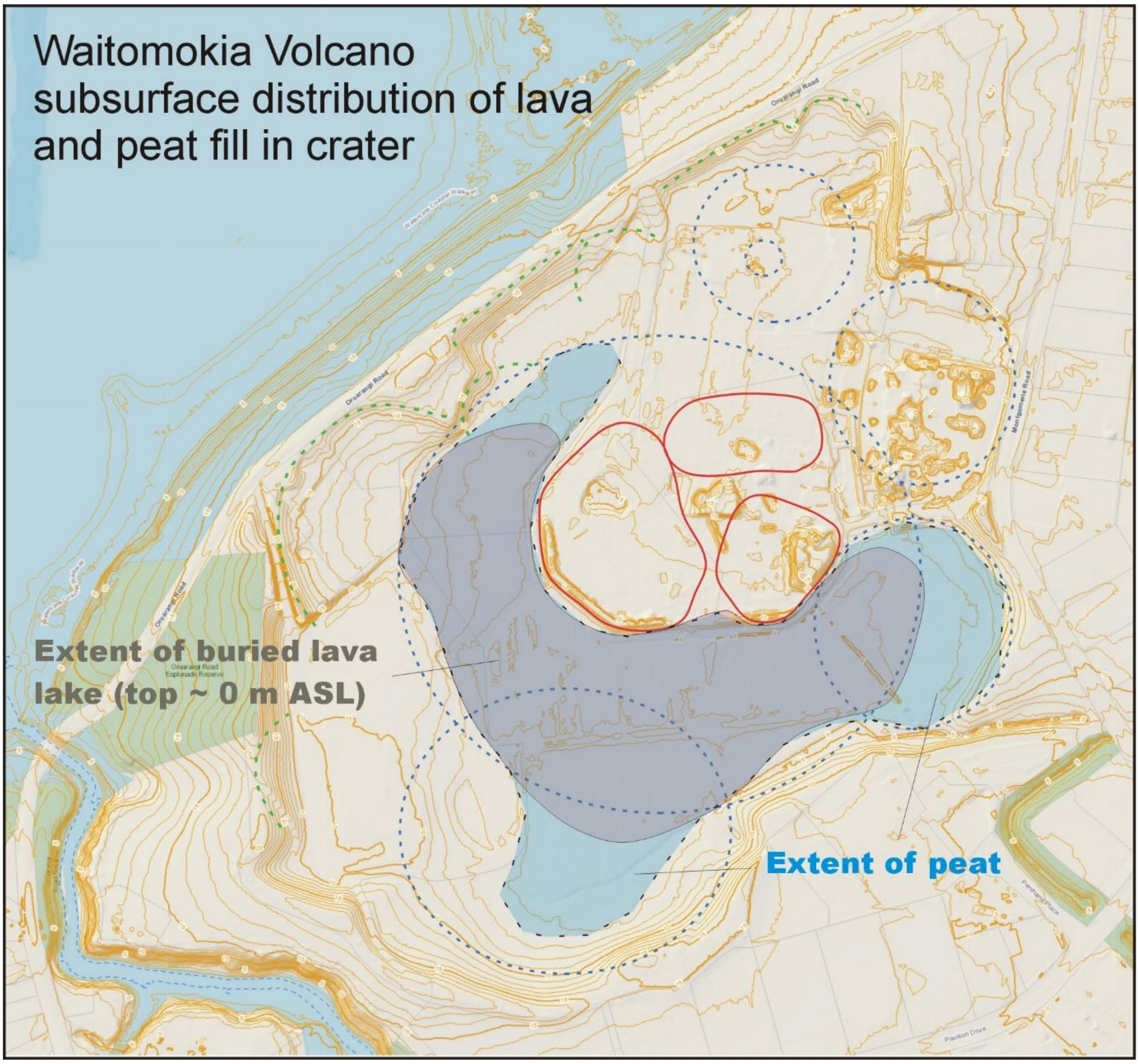
Waitomokia Volcano erupted in the Manukau Lowlands 20,000 ± 2000 yrs ago when sea level was ~130 m below present and the Manukau Lowlands would have been dominantly beech forest. Volcanic ash from Waitomokia has been identified in Pūkaki Lagoon and dates the eruption at close to 20,300 years ago.

As with most Auckland volcanoes, the initial phase of eruption was of the wet explosive kind with a mix of airfall and base surge building up a low tuff ring around a 50-100 m deep crater. Eruptive pulses came from a number of different vents with their craters combining to form a 1 x 0.7 km composite crater. As shown on the associated map, the crater appears to consist of a large central crater which overlaps with a 300-m-diameter crater in the south and two 150-m-diameter craters in the east. A fifth, 120-m-diameter crater forms the northern part of the composite crater. These craters threw out quantities of wet ash that rapidly accumulated around them as a tuff ring. The outer slopes of the tuff ring sloped gently away from the crater whereas the inner slopes were steep and continuously being undercut and eroded by the eruptive blasts. As a result, the crest of the tuff ring was unstable and periodically large sections of the wet tuff pile slid back into the crater leaving cookie-bite-shaped slump scarps, especially along the western side. The last slump in the southwest resulted in a large 200 m-wide block filling up part of the crater, where the winery now stands.



Tuff exposure behind winery showing slump scarp unconformably overlain by further tuff layers.

Eventually all the ground water was used up by the explosive blasts and the eruption style became dry and erupting from three central vents. Fiery explosive eruptions of viscous lava produced three small, miniature scoria/spatter cones. The east cone was a small conical pile, the northern one was an arcuate ridge and the western a wider cone surmounted by a deep crater. The first two may have been produced by slumping of part of their cones into the crater or by wind-directed scoria fall from unidentified vents. As the small fiery explosive eruptions progressed, degassed magma upwelled through their lower sides and filled up most of the floor of the surrounding explosion crater with a lava lake, up to approximately mean sea level today. This lava lake cooled and solidified in place to hard, dense basalt. The lava lake does not appear to have filled the eastern half of the small southeastern crater and there is no borehole data on whether it filled the northern part of the composite crater or not.



The eruption of Waitomokia Volcano may have lasted as little as 1-3 months or maybe as long as a year or two. Once eruptions ceased, rain water progressively accumulated inside the composite crater creating a shallow circular lake (or moat) around the scoria cones (castle). At times this shallow lake became a vegetated swamp (at least in part). Fine sediment (silt) accumulated in the lake and black peat in the swampy parts with an average thickness of about 6 m now overlying the basalt lava lake. Periodically the lake water rose and would have spilled over the lowest portion of the tuff ring (in the southeast) eventually creating an overflow water course, which has been lowered in European farming days to drain the crater swamp.

Relevant aspects of human history

The name Waitomokia means ‘water seeping into the ground’ and refers to the ponds in the crater which commonly dried up in summer. The small cones in the centre were known as Moerangi. Some long-time locals still know this volcano by its early European name of Mt Gabriel, after an early settler. Pre-European Māori recognised the natural defensive advantages of building pa on the two conical cones in the swamp which were extensively terraced. Kumara storage pits were dug on the crest of the cratered cone. The scoria/spatter cones (castle) were removed by quarrying in the late 1950s for use in the creation of the Māngere sewage treatment works across the road. Quarrying, road works and development has modified or removed significant portions of the original detail of the tuff ring.

2018. The industrial yard in the centre overlies the footprints of the three quarried away cones in the centre of Waitomokia Crater.

Map showing extent of Villa Maria redevelopment land (within red boundaries).

Rock exposures

Rock exposures are a significant part of the geoheritage of a site and provide valuable information about the origins and history of an area and its landforms. The best exposures of the tuff erupted by Waitomokia Volcano forming the tuff ring are along the high tidal foreshore on the Manukau Harbour in the north west and the weathering and partly vegetated cuttings that provide access to the winery buildings, also in the northwest. Neither of these areas are within the land being planned for redevelopment and there are no significant rock exposures within the area of consideration.

Landforms

The landform shapes are often the most readily seen geoheritage aspects of a site and the most easily understood by the public. The volcanic landforms of the land under consideration can be divided into five interconnected elements: flat crater floor, overflow stream valley, steep slopes of the crater, the tuff ring crest, and the gentle outer slopes of the tuff ring.

1. Flat crater floor/former swamp

This provides visual evidence of the former lava lake that surrounded the central scoria cones, which produced the classic “castle and moat” volcanic landform within the large explosion crater. It also provides visual clues for explaining how the surface of the solidified lava lake was later submerged by a shallow freshwater lake that was transformed into a vegetated swamp as sediment and rotting vegetation (peat) accumulated over the basalt. While the proposed developments will cover large portions of the crater floor with buildings, its nature will still be readily appreciated in the roads and open areas between buildings.

2. Overflow stream

This was a natural and essential part of the post-eruption history of Waitomokia. It flowed over the lowest part of the tuff ring and had naturally eroded a winding stream channel through it. The bottom of this stream course has clearly been deepened in European times but this only slightly impacts the geoheritage values. Undoubtedly the crater will continue to need drainage to prevent flooding after heavy rain, and it is to be hoped that even if large additional drains are added that the original stream course will not be completely obliterated.

The overflow stream flows towards the camera through the tree-lined depression just to the left of the centre of the photograph.

3. Steep inner slopes of the crater

The crater owes its steep inner slopes to unstable portions of the tuff ring slipping back into the large hole during the explosive eruption phases. This has created numerous large and small arcuate slump scarps that together comprise the steep slopes inside the crater. These inner slopes together define the extent of the crater and together with the tuff ring crest are the most significant geoheritage features now remaining at Waitomokia. They are readily seen and appreciated by the public and assist in an appreciation of the size of the crater and the number and location of individual vents that erupted to produce it. Wherever possible it would be desirable to retain these steep slopes and a clear view of them not hidden behind buildings.

4. Tuff ring crest

A relatively narrow crest of the tuff ring is still present around the western and southern sides of the crater. Its sinuous trace outlines the arcuate slump scarps and its variations in elevation result from differing volumes of ash landing on different sectors of the growing tuff ring as a result of proximity to the different vents and wind direction at the time, as well as the extent of slumping back into the vent.

The crest of the tuff ring defines the shape and extent of the crater and the natural height of the tuff ring that was built around it. It would be desirable to retain as much of the remaining tuff ring crest as an accessible open space pathway with views down over the crater. It would be desirable to extend this pathway along the crest within the Oruarangi Road Reserve land in the west and also consider the possibility of doing so along the boundary of the Villa Maria land with Oruarangi Rd in the northwest. Eventually linking these two pathways along the tuff ring crest through the Wedding properties in the west could be a long-term goal that should not be compromised by the current planned developments.

5. Gentle outer slopes of the tuff ring
In many tuff rings these are the least well-defined and least distinctive parts of the volcano and this is certainly true around the north and east sides of Waitomokia. In the west and south the outer slopes of Waitomokia tuff ring are still well-efined because they were built up over lower-lying land of the Manukau Lowlands and Oruarangi Stream and these have now been flooded by rising sea level on the fringes of the Manukau Harbour.

The western (left) half of the grassed, gently-sloping outer slopes of the southwest corner of Waitomokia crater are in Oruarangi Road Reserve and the eastern (right) half is the Harbour View block of the proposed development, 2018.

The outer western slopes of the tuff ring that slope down to the harbour edge are partly protected in Oruarangi Road Reserve, or in the open public space of Oruarangi Rd and the modified foreshore strip. All the privately owned land on the outer western slopes is not within the present development being considered. Similarly, virtually all the outer slopes to the east and southeast are now developed and not being considered here. This leaves the southwest sector of the outer tuff ring. Much of the outer slopes here has been naturally steepened by erosion of Oruarangi Creek to create the vegetated cliffs along the estuary’s northern border. Apparently this cliffed section (and the pa site area above them) will not be part of any development and will be retained in their natural shape. There will be some loss of geoheritage values assuming the proposed development of the harbour view block proceeds. This loss is partly offset by the protection of a similar portion of the outer tuff ring slopes in the adjacent Oruarangi Road Reserve, which has better views out over the harbour and is more readily seen by the public travelling along Oruarangi Rd and the Watercare Walkway/Cycleway.

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HISTORIC PHOTOGRAPHS

Photo: Bruce Hayward, 2009 – view from north.

Photo: Bruce Hayward, 2009 – view from southwest.

Photo: Bruce Hayward, 1994 – viewing from west.

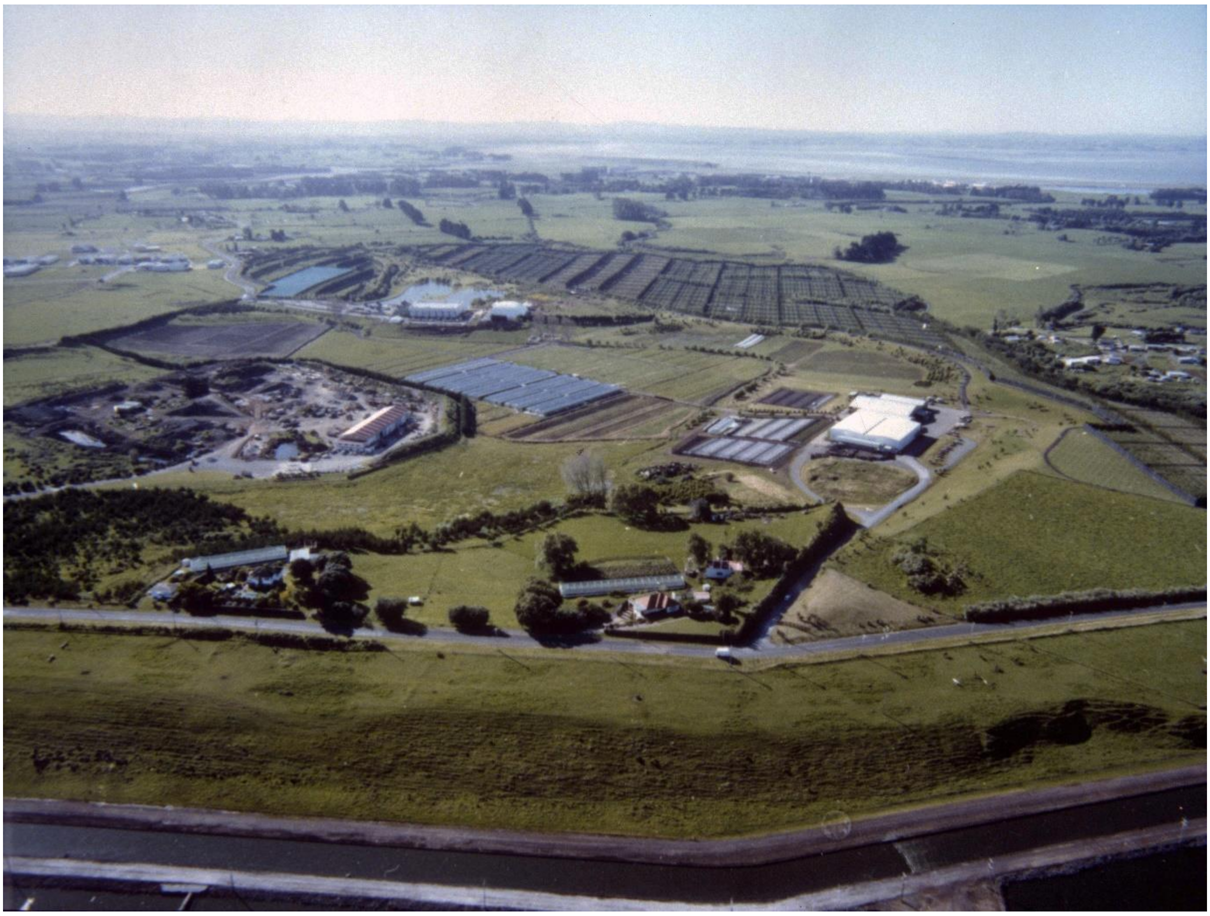


Photo: Les Kermode, 1990 – view from west.

Photo: Les Kermode, 1987 – view from north.

View from northwest 1957.

View from northeast, 1957.

Photo: Whites Aviation, 1958 – vertical with north up the page.

Photo: Jack Golson, 1957 – from northwest.

Photo: Jack Golson, 1957 – from southwest.

Photo: Jack Golson, 1957 – view from north.

Photo: Jack Golson, 1957 – view from south.

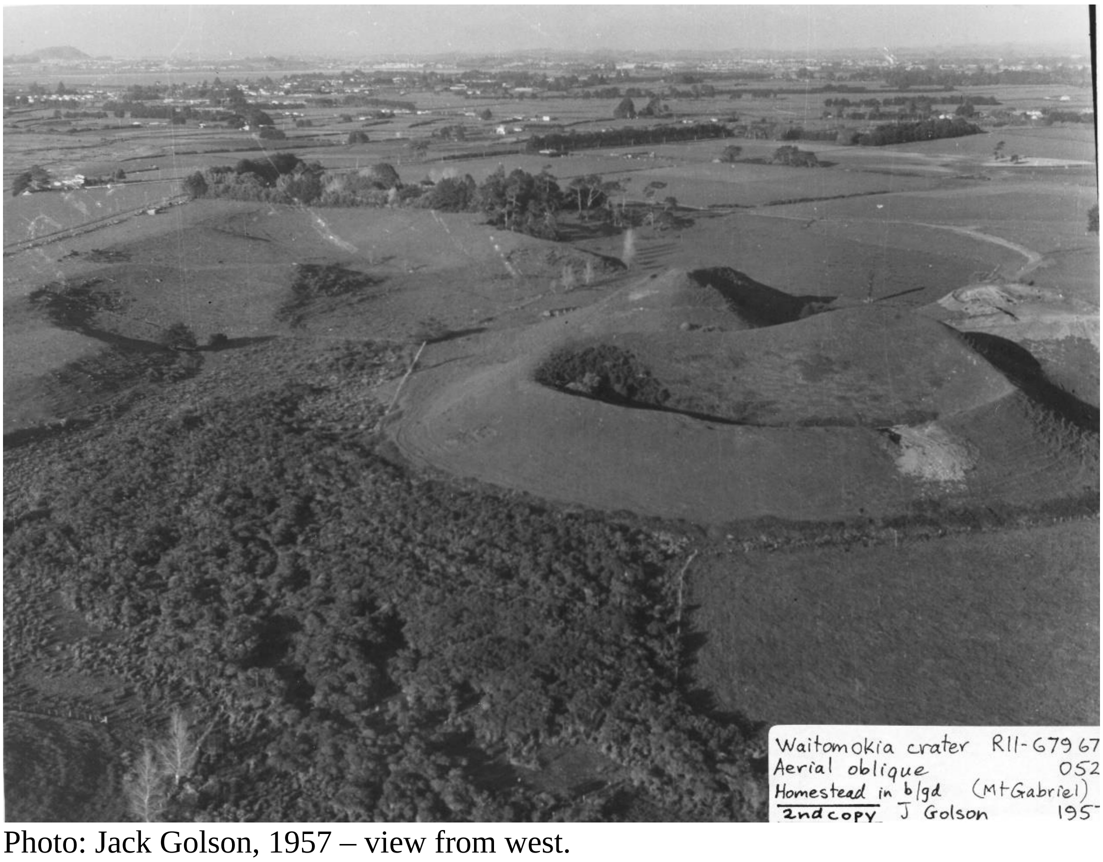


Photo: Jack Golson, 1957 – view from west.

Photo: Sparrow Industrial. ~1957. Crater of southern cone.

Photo: Jack Golson, 1957 – view from north.

Photo: 1955 – view from south.

Photo: Whites Aviation, 1955 – view from west.

Photo: 1955 – view from northwest.

Photo: 1949 – view from southeast.


Photo: 1949 – view from northeast.


Photo: 1949 – view from northeast.

Photo: 1949 – view from northeast across crater.

Scoria-cones on floor of crater of tuff-cone of Waitomokia. Otuataua rises above tuff-ring in distance on left.

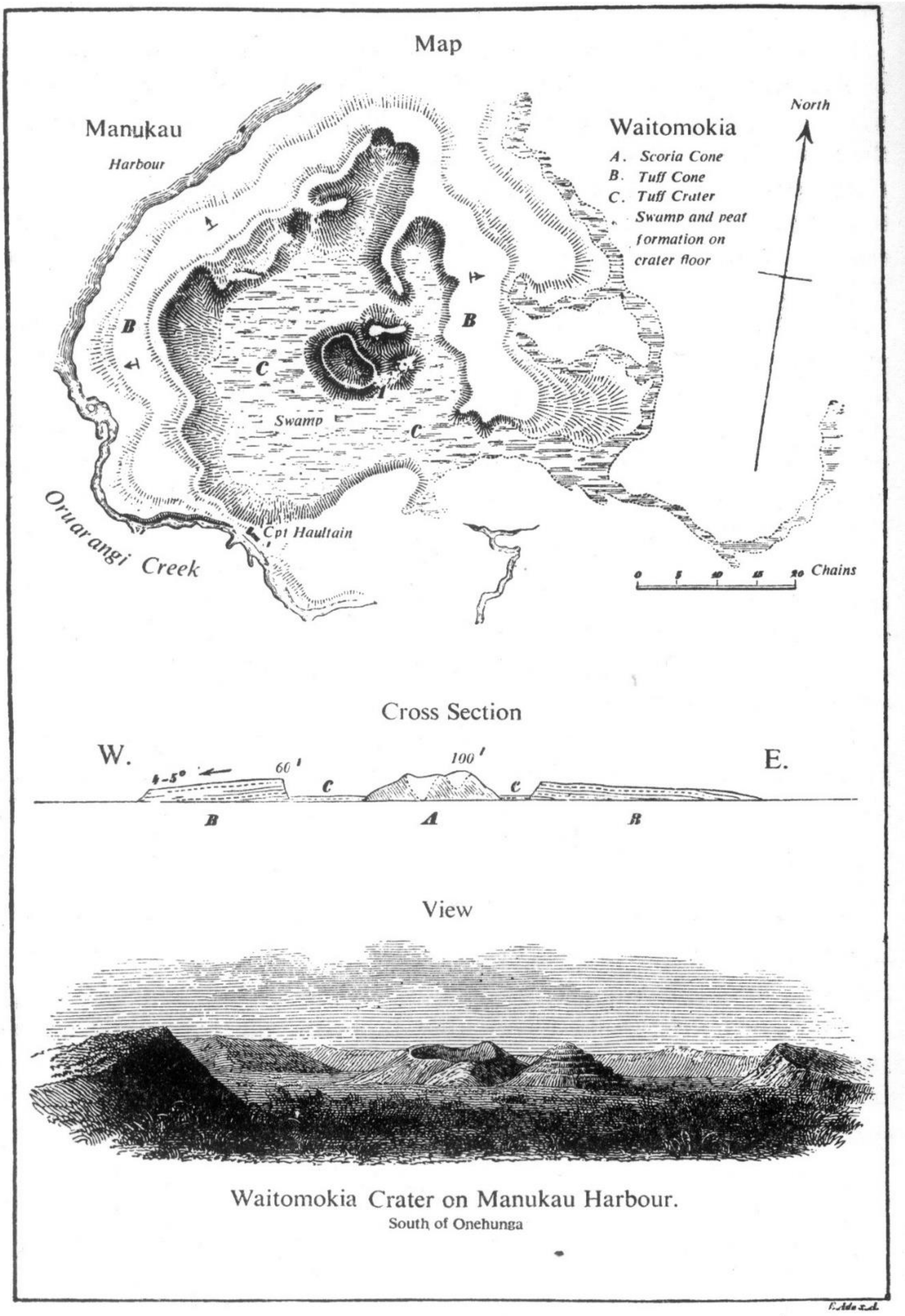
Photo: Cyril Firth, 1930 – view from east across crater.

Pa surrounded by swamp near Ihumatao

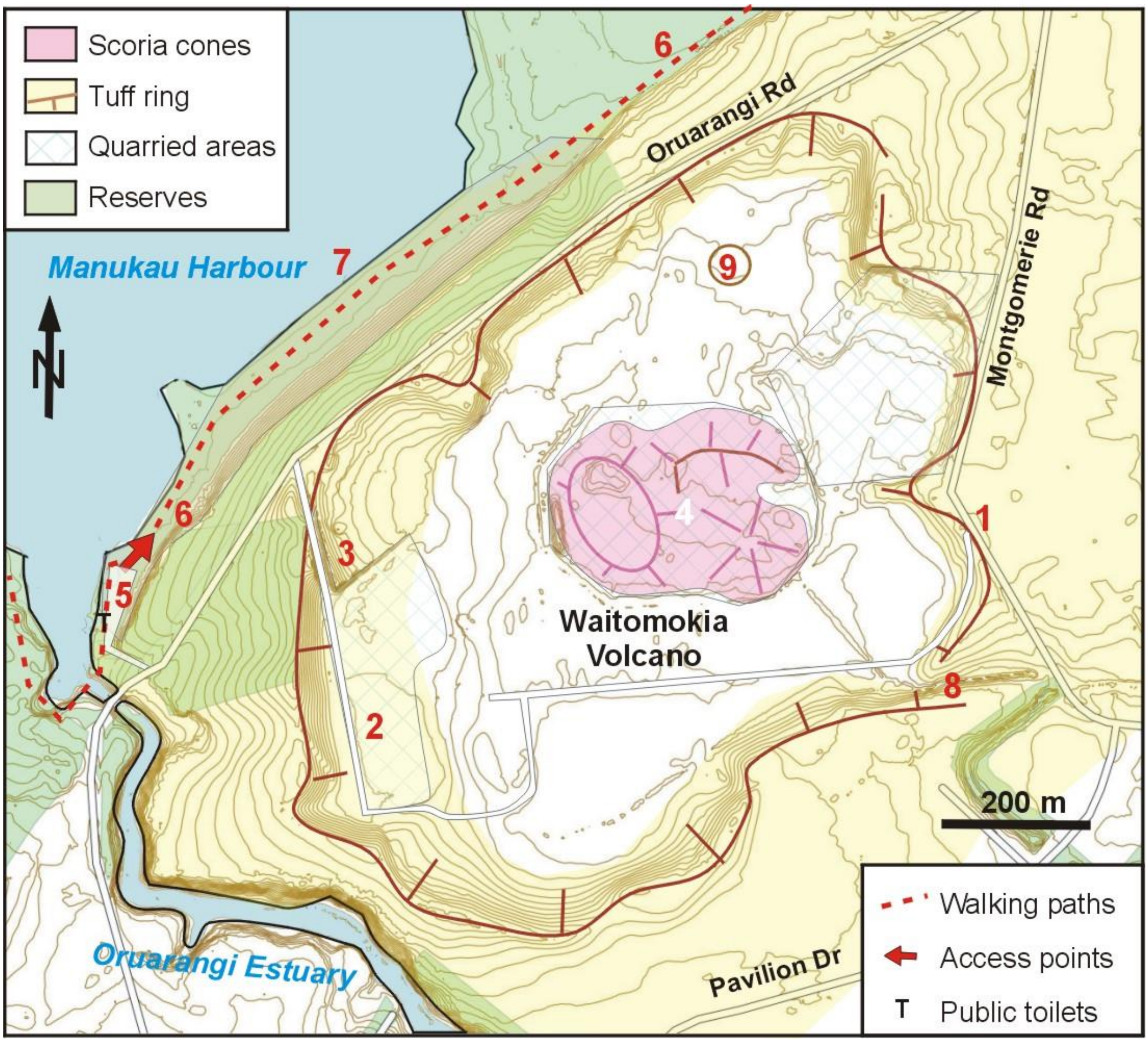
Photo: Hugh Boscawen, 1899 – view from north across crater.

Pa surrounded by swamp near Ihumatao

Photo: Hugh Boscawen, 1899 – view from east across crater.



Hochstetter, 1859 – view from east across middle of crater.



Map of Waitomokia Volcano from Hayward (2019)

Places of interest around Waitomokia Volcano
1. Vehicle entrance to Villa Maria Vineyard Café.
2. Villa Maria Vineyard Café and carpark (accessible when open).
3. Road cuttings through tuff ring.
4. Site of former small scoria cones (private industrial yard).
5. Carpark and toilets.
6. Watercare Coastal Walkway.
7. High tidal exposures of tuff with projectile blocks of sandstone and conglomerate.