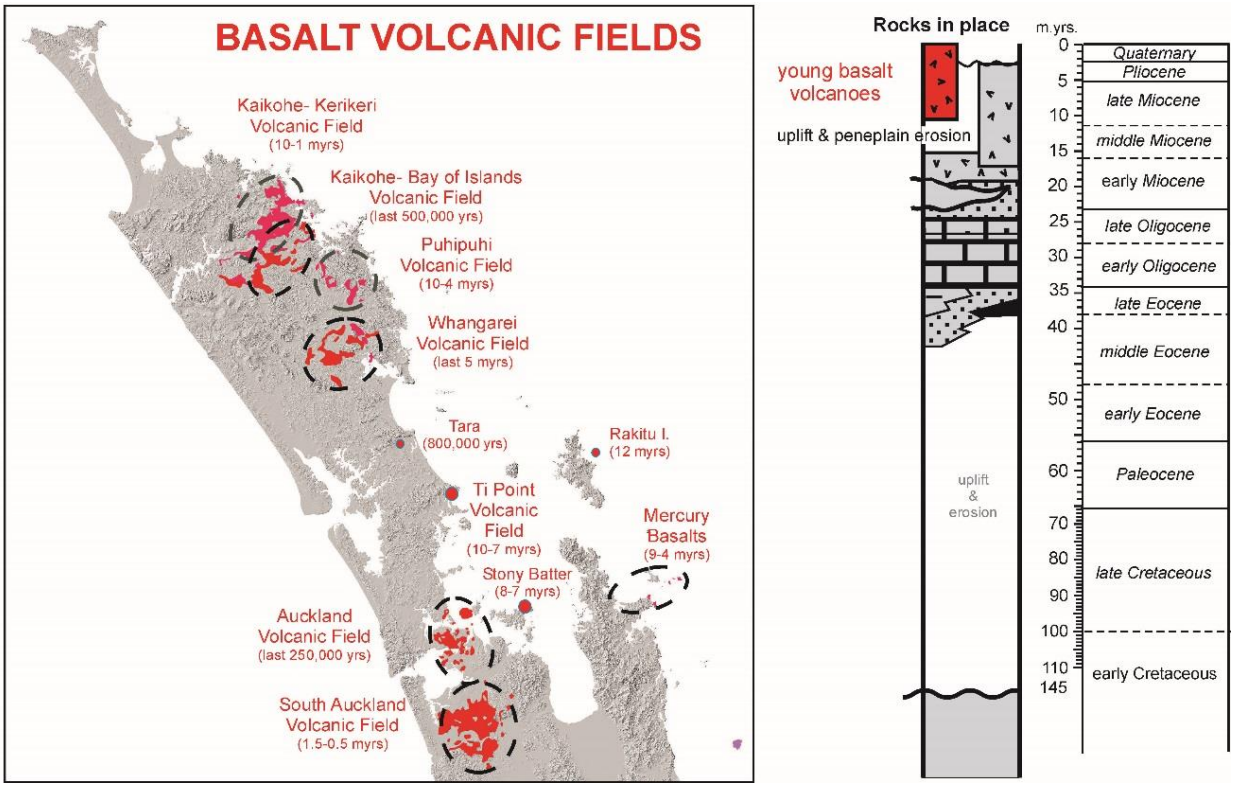
APPENDIX 2. SOUTH AUCKLAND VOLCANIC FIELD GEOHERITAGE

1. Summary

The young (younger than 10 million years old), intra-plate basalt volcanoes of northern New Zealand erupted magma sourced from the partially molten upper mantle, 60-90 km beneath our feet, and were mostly unrelated to the subducting plate boundary that had migrated away to the east by this time. The South Auckland Volcanic Field erupted between 1.6-0.5 million years ago and has over 84 recognised volcanoes – mostly explosion craters and small shield volcanoes (e.g. Pukekohe Hill, Pukekawa), but with a few prominent scoria cones in the south. The South Auckland Volcanic Field is now extinct.

The style of eruption and kind of volcanic landforms produced by these small basalt volcanoes depended on a number of factors. If erupting through wet ground the initial eruption was explosive and produced a large explosion crater and surrounding ring of hardened ash, called a tuff ring. Dry eruptions of gas-rich lava produced episodic or continuous fire-fountaining of frothy lava that built steep-sided scoria cones. Dry eruptions of gas-poor lava produced lava flows, which if voluminous built gently-sloping shield volcanoes.



Distribution and age of the basalt volcanic fields in northern New Zealand.

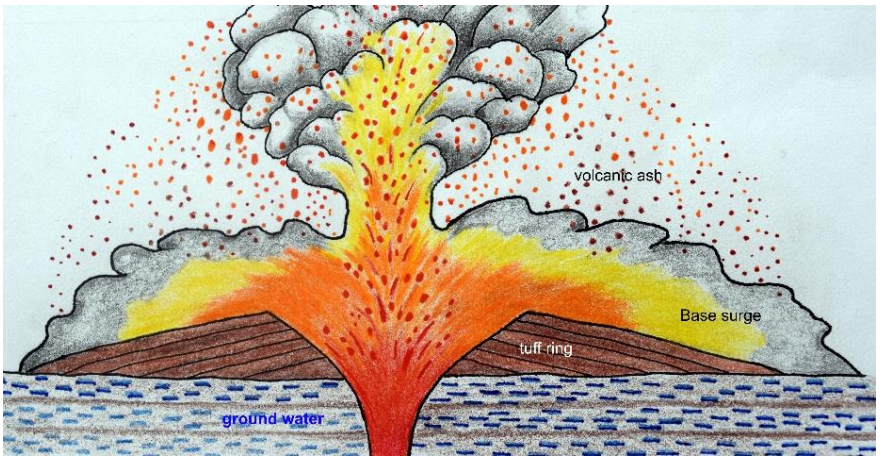
2. The South Auckland Volcanic Field

2.1 The shape of a South Auckland basalt volcano depends on the styles of eruption that formed it. Its size depends on the volume of magma expelled and duration of the eruptions. These volcanoes erupted in three basic styles resulting in the production of three different types of volcanic rock and three different kinds of landform.

The styles of eruption, types of rock produced and the resulting landforms in the S Auckland Volcanic Field

Eruption style	Scientific term	Rock produced	Landform
Wet explosive	Phreatomagmatic Surtseyan	Tuff (hardened volcanic ash)	Explosion crater (maar), tuff cone or tuff ring
Fire-fountaining & fiery explosive	Hawaiian & Strombolian	Scoria (lapilli, cinders), spatter, volcanic bombs	Scoria cone (cinder cone)
Lava outpouring	Strombolian & Hawaiian	Basalt lava	Lava flow, lava field, or lava shield

3. Wet explosive eruptions



Cartoon of a wet explosive eruption from a small basalt volcano. These typically form an explosion crater surrounded by a tuff ring composed of hardened layers of volcanic ash.

3.1 When many of South Auckland's basalt volcanoes first erupted, the rising magma came in contact with near-surface water in aquifers or swampy ground. As this hot magma (about 1200˚C) encountered cold water its surface chilled instantly, solidified, and explosively fragmented. The

water flashed to steam resulting in a violent explosion. A rapidly expanding cloud of steam, magmatic gas, fragmented lava and other pieces of rock from the vent walls was erupted upwards and outwards.

3.2 The solid particles that were blasted into the air and fell back to the ground are called tephra. Tephra is divided on the basis of particle size into ash (fragments smaller than 2 mm), lapilli (2–64 mm across), and blocks and bombs (greater than 64 mm). Wet explosive eruption columns rise to heights of several kilometres and the volcanic ash and lapilli within them might be blown away by the wind. Fallout tephra accumulates on the ground downwind of the volcano. Blocks of solid rock ripped from the walls of the volcano's throat might be thrown out of the vent on ballistic trajectories to land nearby.

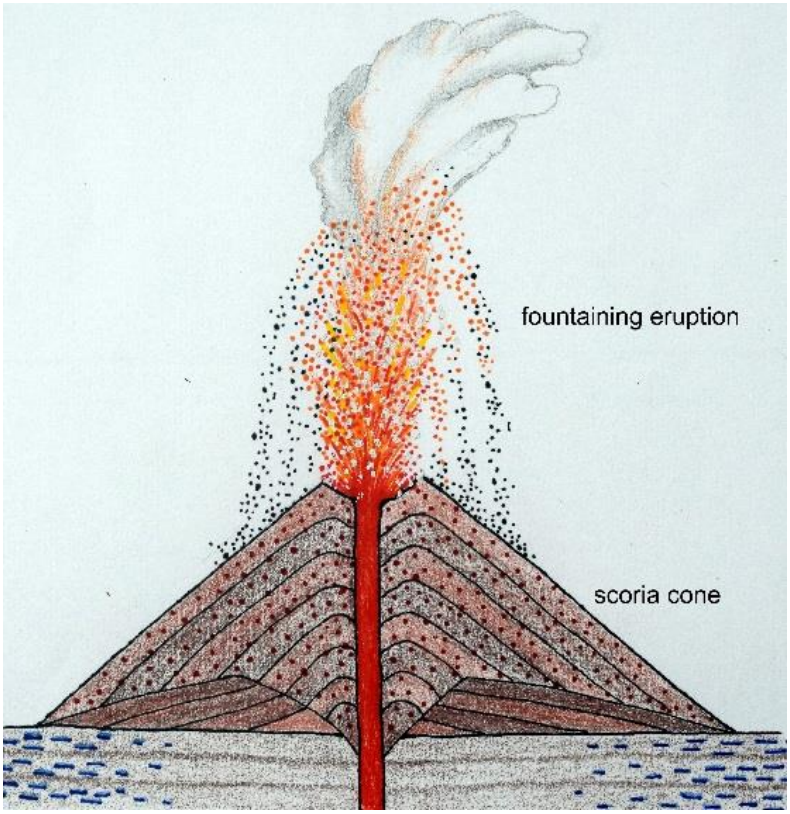
3.3 Around the denser base of the eruption column, base surges of superheated steam, gas, ash and lapilli can be blasted out sideways at speeds up to hundreds of kilometres per hour. These turbulent ground-hugging surges might devastate and partly bury areas within 3–5 km of the vent and are the most dangerous style of eruption produced by these small basalt volcanoes. As these surges pass they commonly leave behind wavy beds of fine ash, sometimes with cross-bedded dune forms.

3.4 Wet explosive eruptions usually come in a series of pulsating episodes interspersed by short periods of inactivity. Typically these eruptions produced a relatively shallow (50–100 m deep), wide (200–1000 m), circular explosion crater surrounded by a low ring of bedded volcanic ash and lapilli. The ash and lapilli were erupted wet, and as the layers dried out they hardened into a creamy-brown rock called tuff. Thus the raised ring of 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˚) on the outside (*9.4*). The steeper inner slopes are often formed by a series of slump scarps as a result of sections of the tuff ring slipping back into the crater after being deposited.

3.5 If magma supply ceased before all the groundwater was used up, then the only landforms produced by the volcano would have been an explosion crater surrounded by a tuff ring. There are three explosion craters with surrounding tuff rings in the Kaikohe-Bay of Islands Field, 19 in Auckland and dozens of eroded tuff ring segments in the South Auckland Field.

3.6 After eruptions finished, most explosion craters filled with rainwater, creating crater lakes. Many of these lakes subsequently filled with sediment and became swamps or reclaimed wetlands.

4. Fire-fountaining and fiery explosive eruptions



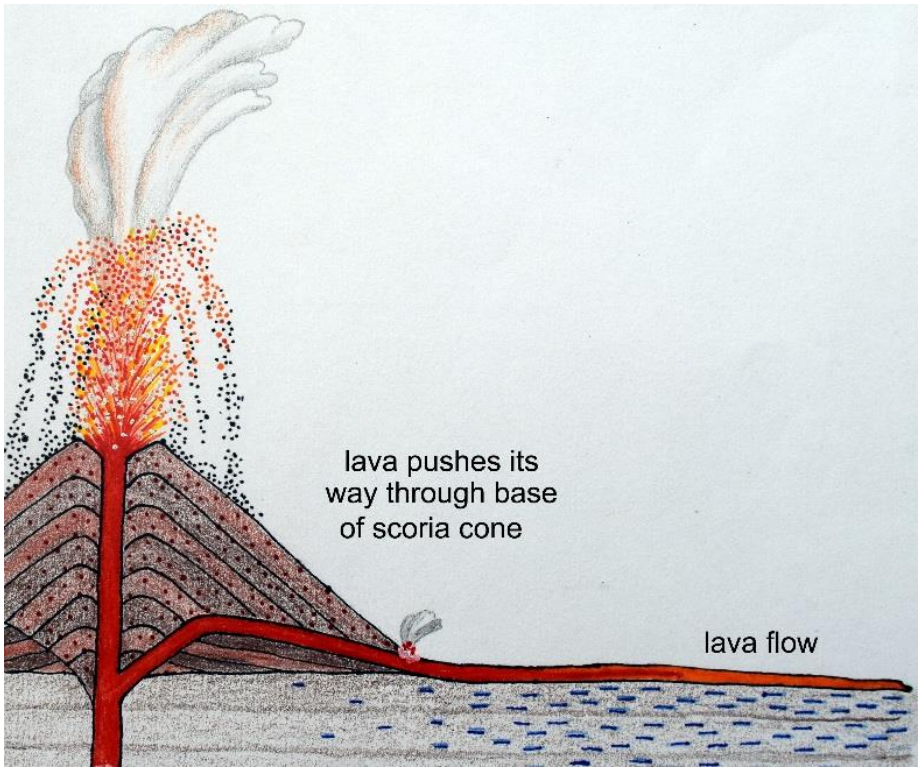
Cartoon of a fire-fountaining eruption that produced a scoria cone capped with a central crater.

4.1 If the wet explosive eruptions used up all the water in the vent, then volcanic activity switched to a dry style of fiery eruptions or fountaining. These built scoria cones that partly or completely filled the explosion crater and might have buried all trace of the tuff ring.

4.2 The basalt magma 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 magma flew through the air, it cooled and solidified, forming the frothy rock known as scoria. This rock is initially black, but oxidation of iron (reaction with oxygen) in the still hot scoria deposits from fire-fountaining, turned much of it to its characteristic red colour. Scoria that remained black, was cooler when it landed and did not remain hot for long enough to become red oxidised.

4.3 The erupted scoria built up a steep-sided scoria cone, with a deep crater. Scoria cones consist of layers of scoria of various sizes. Larger and denser fragments landed closer to the vent and the smallest lapilli and scoriaceous ash could be blown many kilometres away. A 30 m-high scoria cone can be thrown up in a day, and a 100 m cone in little more than a week.

5. Lava outpouring eruptions



Cartoon cross-section of the plumbing and eruption style that resulted in the outpouring of lava flows from the base of a scoria cone.

5.1 During the fire-fountaining phase of eruption of South Auckland's scoria cones, the molten magma often became less gaseous and rose up inside the throat of the volcano. If it reached the height of the base of the cone, this magma would often push a way through the loose scoria and emerge as a flow of lava from near the base of the cone. Sometimes the loose scoria collapsed and the side of the scoria cone was rafted away by the outflowing lava. This created a horseshoe-shaped or breached crater.

5.2 Gas in the fluid magma was released in the volcano's throat and powered the fountaining eruptions from the vent directly above. The lava that flowed out the side had lost most of its dissolved gas and when this lava cooled and solidified it became a relatively dense, dark grey basalt rock. Small amounts of gas that were still trapped in this lava often rose towards the surface of the flow as it cooled. This sometimes resulted in a zone of more vesicular or holey basalt near the top of the flow.

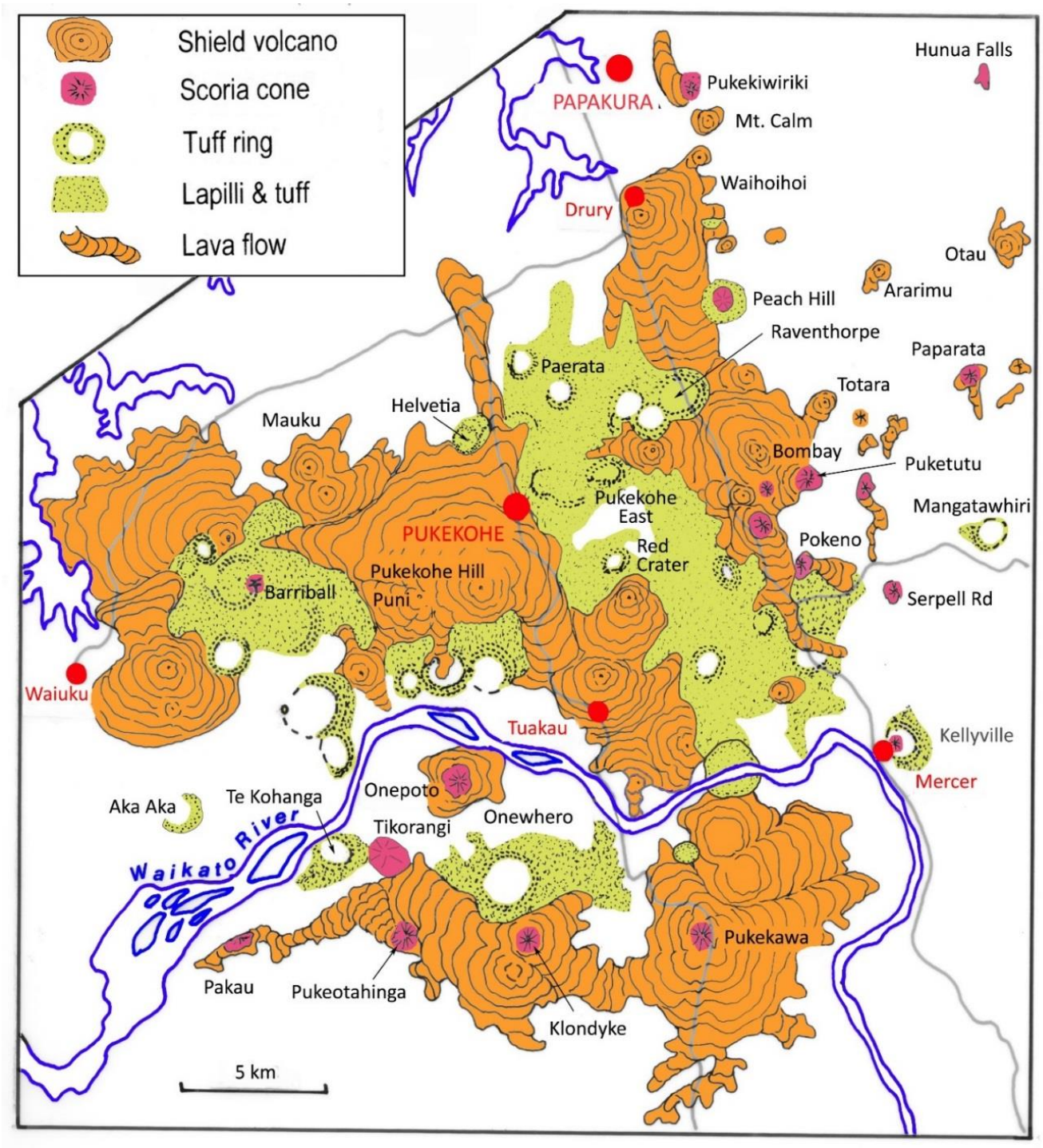
5.3 As molten basalt lava cools and solidifies, it contracts and cooling cracks form. These cracks often form fairly regular hexagonal-shaped columns (called columnar joints) that are vertical (or more accurately, perpendicular to the cooling surfaces at the top and bottom of the flow, *9.9*). Near-horizontal cooling joints sometimes form near the top or bottom of a flow. The size of the lava flow or field of coalescing lava flows depended on the supply of lava.

5.4 The speed and distance travelled by individual flows was controlled by the eruption rate and the temperature of the erupted lava and hence its viscosity. The hotter, more liquid lava flowed downhill at running pace. Its surface quickly chilled to a thin, elastic, black crust but the fluid lava beneath continued to flow and deform the surface skin into curved ropey rolls, rather like the skin on a pot of cooling jam. Flows with such a smooth surface texture are known by their Hawaiian name as pahoehoe flows. As the flows moved downhill they cooled and became stickier, eventually stopping and solidifying into basalt rock.

5.5 In two of the volcanic fields (Kaikohe-Bay of Islands and South Auckland) vast quantities of gas-poor magma was erupted as numerous lava flows from one vent over periods of one or more years. These flows cooled and solidified on top of each other to build up roughly circular shield volcanoes with gentle slopes of about 10 degrees.

6. South Auckland Volcanic Field

6.1 The South Auckland (sometimes called Franklin) Volcanic Field contains at least 84 volcanoes that erupted over a span of about a million years, between 1.6 and 0.5 myrs ago. This field stretches from Papakura in the north to Pukekawa in the south, on the south side of the Waikato River, and from the Hunua Falls in the east almost to Waiuku and Port Waikato in the west – an area of nearly 300 km^2. Some geologists speculate that whatever caused the partial melting of the upper mantle beneath the South Auckland Volcanic Field, migrated northwards between 0.5 and 0.2 myrs ago to then erupt as the Auckland Volcanic Field.



Map of the South Auckland Volcanic Field. Adapted from Briggs et al. (1994) and Nemeth et al. (2012). From Hayward (2017) Out of the Ocean into the Fire, p. 208.

6.2 Because the South Auckland volcanoes are older than those erupted in Auckland and the latter phases of the Whangarei and Kaikohe-Bay of Islands fields, they are slightly more eroded and weathered and many are mantled in thick rhyolitic ash and ignimbrite (Hamilton Ash) erupted in the

last 0.5 million years from the centre of the North Island. a little more difficult to recognise. For this latter reason there is no basalt scattered over the surface of the lava fields and thus drystone walls, so typical of the other basalt lava fields, are absent. The scoria of the cones is weathered near the surface and the cones themselves more rounded because of the mantle of thick ash than those further north and their craters are generally partly filled and less distinct. The explosion craters have been filled with sediment and none remain as lakes and in many instances their surrounding tuff rings have been partly removed by erosion. This is particularly true on the lowland areas north of the Waikato River, where the meandering river has left only partial tuff ring arcs from the original circular tuff rings.

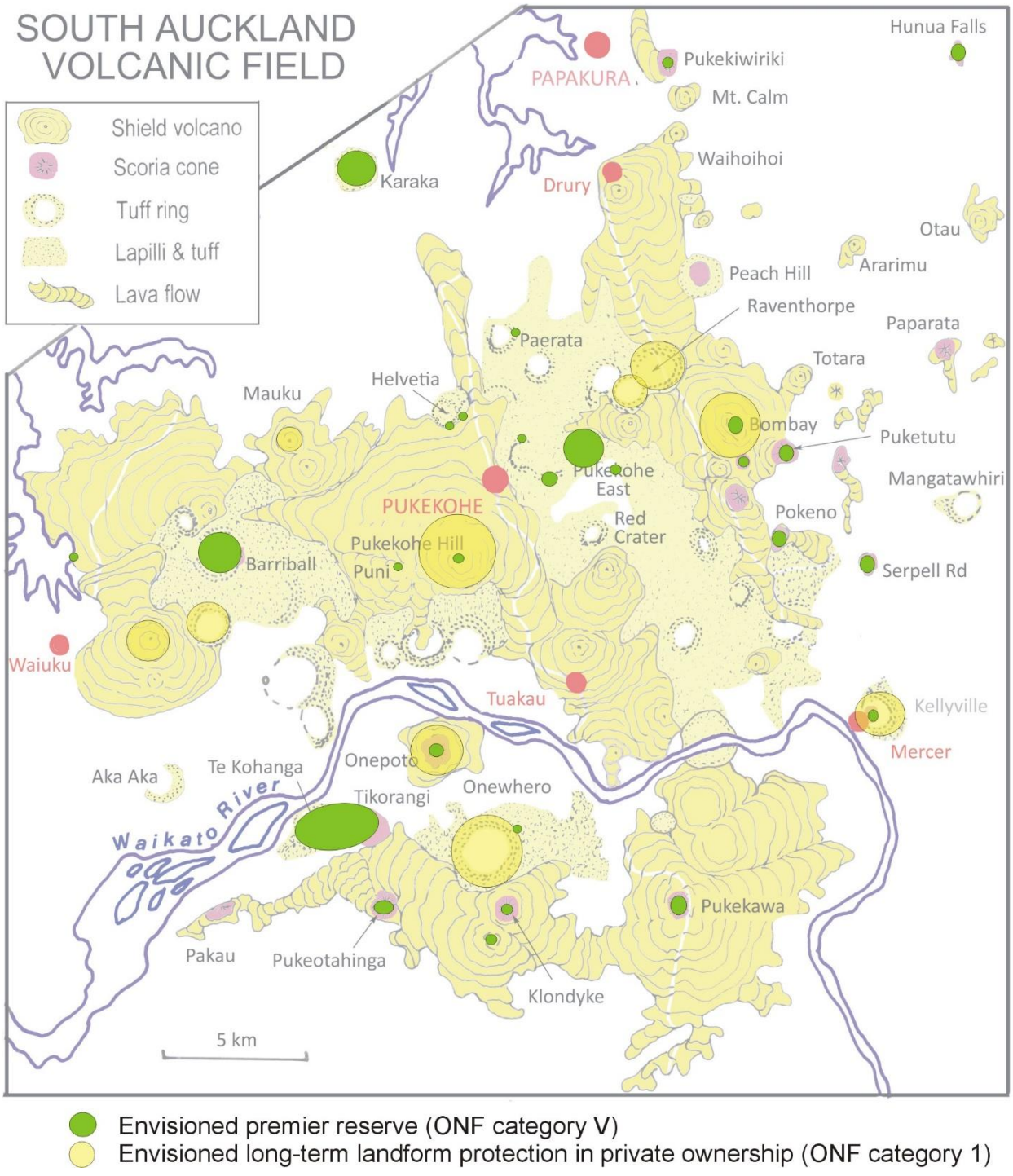
6.3 Many of the volcanoes in the north eastern part of the South Auckland Field, erupted along fault lines (e.g. Wairoa and Drury faults) through the greywacke uplands of the western Hunua Ranges. Being at a higher elevation, these flows and scoria cones have been subjected to more erosion than those that form the low divide between the Manukau and Waikato lowlands. The largest, and one of the youngest (600,000 yrs old), of these volcanoes in the east, is the Bombay shield volcano traversed by all who travel along SH1 between Auckland and Hamilton. The effusive centres of this shield volcano from where most of the lava flows were sourced are the small twin conical peaks clearly seen to the east of Collison Crossroads motorway interchange.

6.4 Most of the volcanoes in the Hunua Ranges are older than 1 myrs, whereas all those to the west and south in the Manukau Lowlands and around the Waikato River are less than 1 myrs old. The one exception is the large Kellyville Explosion Crater at Mercer, which has been dated at about 1.5 myrs old.

6.5 Explosion craters and tuff rings are more common in the South Auckland Field than in the other northern basalt fields. Many of them occur in the Manukau lowlands area, which is underlain at shallow depth (100-150 m below the surface) by a major near-horizontal aquifer – the Kaawa Shellbeds. It is inferred that it was the rising magma interacting with water in this aquifer, which was responsible for the many explosive eruptions. Of the 38 recognised explosion craters, the widest is Onewhero Crater (2.7 km across) located south of the Waikato River.

6.6 The South Auckland Volcanic Field has more shield volcanoes than all the other northern basalt fields combined. Of the forty lava shields identified, the largest are Pukekohe Hill, Waiuku, Mauku, Bombay and the three Pukekawa shield volcanoes. Many of the shield volcanoes might have had low levels of dissolved gas and had no fire-fountaining eruptive phase, but some in the south did and are capped by scoria cones. The most prominent scoria cones include Pukekawa, Klondyke Rd, Pukeotahinga, Tikorangi and Onepoto – all located south of the Waikato River in Waikato District.

7. A 30-50-year vision for the South Auckland Volcanic Field



7.1 The RMA is aimed at sustainable and long-term outcomes, not just for the lifetime of an elected Council, Government or District Plan. GSNZ is advocating for the protection in perpetuity of the Outstanding Natural Features (=Geoheritage features) of New Zealand. We use our knowledge of the positive and negative aspects of the history of protection of the Auckland Volcanic Field as a guide to what we (and hopefully most New Zealanders) would envisage for the long-term outcome for the South Auckland Volcanic Field.

7.2 Our vision is for 30-50 years' time and beyond. It is that the landforms of all the best examples of the volcanoes of the South Auckland Field will be largely intact and retain their natural unmodified shapes that record each volcano's individual history of eruption. As such we envision that each of these major volcanic heritage features of the district (south Auckland and north Waikato) will be in publicly-accessible and publicly-owned parks as THE major passive recreational reserves for the local community and outside tourists to enjoy and learn about, just as the remaining volcanoes on the Auckland Isthmus are today (see point 8.4 below).

7.3 We have no way of predicting the size and distribution of the human population that will be living within the footprint of the South Auckland Volcanic Field by that time, but we can sure it will be many times greater than at present. Already the southern limits of Auckland city residential developments are expanding around Paerata, Drury and Pokeno in the northeastern parts of the field.

7.4 Without ONF designations on all the best examples of South Auckland's volcanoes, we can expect proposals to quarry away the scoria of some cones; proposals to site wind turbines or solar panel farms on the tops or slopes of some volcanoes with major access driveways up to them; proposals to plant exotic forestry blocks on the top and slopes of some volcanoes with consequent major landform modification and soil erosion when the trees are eventually harvested from these steep slopes; proposals to build private houses on the top of some cones with driveways carved into the sides of these cones; proposals to subdivide the volcanoes into numerous smaller land holdings/life style blocks even if the houses are built at the foot of the volcano; and proposals for dense housing subdivisions to take advantage of the views and better drainage away from the surrounding lowlands.

7.5 Each of the possibilities mentioned in 7.4 would greatly limit the ability to achieve the long-term vision for the volcanic heritage of the field in your Waikato District.

7.6 We recognise that this vision of public ownership and parks for the largest volcanic features (e.g. Pukekohe Hill shield volcano, Bombay shield volcano, Kellyville crater, tuff ring and tholoid,

and Onewhero crater and tuff ring, Patumahoe cone) and all of the gently sloping shield volcanoes is impractical. Even if it was not impractical, then the opportunity has already been lost because they have already been subdivided into numerous private property lots. In these instances we advocate recognising the outstanding importance of these major volcanoes by retaining their ONF status (3 currently have ONF status from the crest of their tuff rings inwards to encompass their entire craters) and developing policies that will allow long term recognition of the landforms by various mechanisms such as defined less intense subdivision and requiring subdivisions to build over the natural land shape rather than wholesale land reshaping as is the norm in most subdivisions today.

7.7 The best examples of the smaller outstanding volcanoes that we envisage as being able to become the future "Cornwall Parks or Maungawhau/Mt Edens" of the northern Waikato and southern Manukau districts are (but may not be entirely limited to): the scoria cones of Barriball Rd Volcano including Bald Hill (near Waiuku), Karaka Volcano, Bombay Volcano (top), Pokeno Volcano, Pukekawa (III), Serpell Rd, Onepoto, Pukeotahinga, Onewhero, Kauri Rd, Jericho cone, Razorback Rd cone, Puketutu Cone and the tuff ring and crater of Te Kohanga volcano and hopefully East Pukekohe crater, Barriball Rd crater/tuff ring (Waiuku), Rasmussen Tuff Ring and crater and maybe Waiuku Volcanic cone.

7.8 We realise that the opportunity to achieve this may have already passed because of subdivision and private development even on some of the above best examples (e.g. East Pukekohe Crater, Rasmussen Crater).

7.9 We are confident that all the above smaller volcanoes in 7.7, that are in the Waikato District, would exceed the threshold for Outstanding Natural Features at the district, regional or national level, based on the standard geoheritage assessment criteria for ONFs. These are the high value volcanoes proposed by GSNZ for inclusion in the Waikato District Plan as ONFs.

7.10 The volcanic heritage ONFs we recommend are selected from the ~44 known volcanoes in Waikato District and represent just 27% of the volcanoes in the South Auckland Volcanic Field in the District.

7.11 Now is your opportunity as councillors and staff of Waikato District to do the right thing and set in motion the process for the long-term survival and eventual public ownership and enjoyment of the volcanic heritage of the South Auckland Volcanic Field. It is beholden on our generation to have the long-term vision to protect this heritage for future generations.

8. Learn from examples of volcanic heritage protection coming too late further north

8.1 We provide a brief background to two examples of the consequences of lack of implementation of planning protection early enough to save desecration of our volcanic geoheritage at Maungakaramea, Whangarei District and in the former Manukau City. We also provide an example where early foresight and planning "saved" many of the volcanoes of the Auckland isthmus

8.2 In all of the above examples the surviving volcanoes or those with significant remains are now scheduled as ONF, but this planning recognition that they were Outstanding Natural Features and needed planning protection has come too late for many.

8.3 The case of **Maungakaramea scoria cone.**

Maungakaramea volcanic cone ONF, 2016 showing the zig zag forest harvesting roadways and the five residences built on the reshaped top.

8.3.1 This cone is similar in size and shape to Pukekawa (Waikato District) and has a similar small farming village at its foot set in a rural setting. In the ~1990s before it was scheduled as and ONF, the owner of the volcano obtained permission to subdivide the cone into 8 lifestyle-size blocks.

8.3.2 A road was bulldozed up the slopes of the cone to the centre of the former crater and five houses were built on the summit with consequent modification of the summit landforms.

8.3.3 Exotic pines had been planted on the outer slopes of the cone and most of these have recently been harvested with the creation of permanent zig-zag forestry roadways on these slopes.

8.3.4 Maungakaramea would have been a magnificent little volcanic cone reserve for future generations to explore and enjoy – this opportunity for public access has been lost forever. The ONF designation it now has may prevent attempts to quarry parts of it or erect wind turbines but it cannot bring back much of the lost detail of the volcano's eruptive history and landform.

8.4 **Lack of protection of volcanoes in the former Manukau City portion of the Auckland Volcanic Field**

8.4.1 Twenty-one of the 53 volcanoes of the Auckland Volcanic Field occur within the former Manukau City boundaries.

8.4.2 Up until 40 years ago there was no planning protection for any of them, except that Mangere Mt was in Crown ownership as a Domain, but even then quarrying was allowed in the 1960s to remove one portion of this World Heritage quality cone.

8.4.3 A public campaign by the Historic Auckland Society (forerunner of Heritage NZ) in 1957 called for the cessation of quarrying and the long-term legal protection of the best remaining, unquarried or little quarried volcanic cones in the Manukau area (Maungataketake, Pukewairiki, Puketutu, Pigeon Mt, Otara Hill, Mangere Mt, McLaughlins Mt and Green Mt). The upwelling of public support resulted in the permanent cessation of quarrying on a few volcanoes in Auckland City (Mt Wellington, Mt Albert, Taylors Hill), but had no immediate results in Manukau.

8.4.4 In the 1950s, the Manukau district was very much like the northern Waikato District today. There were several centres of suburban housing (Otahuhu, Papatoetoe, Manurewa) but mostly it was pastoral farmland. There was not the huge residential population (more than half a million people) we now have, living in and around where the volcanoes stood. If there had been it is likely that local opposition to the damage being down to their local volcanoes would have stopped much of the desecration and communities that today live in a desert of modified land would have been able to focus their recreational leisure lives on such magnificent volcanic features as: Green Mount, Otara Hill and Waitomokia scoria cones nestled within their tuff ring craters, the small crater lakes of Pakuranga and Styaks Swamp; the twin cones of Otuataua and Maungataketake or the beautiful breached scoria cone of Matukutureia/McLaughlins Mt to name just a few.

8.4.5 Of the 21 volcanoes in the former Manukau city boundaries, scoria cones of 10 volcanoes have been more than 50% quarried away (many entirely) (e.g. Pigeon Mt, Green Mt, Otara Hill, Hampton Park, Puketutu, Waitomokia, Otuataua, Crater Hill, Wiri Mt, Matukutureia) and three small craters completely filled in and built over. Of the volcanic cones, all we have left are Mangere

Mt (slightly damaged), Puketutu (more than 50% removed), Pukeiti (badly damaged), Matukutureia/McLaughlins (badly damaged pyramid remains) and Pigeon Mt (more than 50% removed).

8.4.6 In the last 30 years, what the remains of most of the volcanoes in this area have been scheduled as ONFs. Multi-millions of dollars of public money have been spent trying to achieve some long-term protection for some of them (purchase of Pukaki Lagoon crater and tuff ring, purchase of Otuataua and Pukeiti lava flow fields, restoration of Mangere Lagoon crater and small scoria cone, defence in the Environment Court of the ONF status of Crater Hill to prevent dense subdivision inside the crater). Much of this huge expenditure could have been avoided if there had been planning vision 50 or more years ago.

8.4.7 Having ONF status over Pukewairiki crater (Highbrook) did result in it being set aside as a reserve as part of the obligations of subdivision of the land in the 1990s. This is the kind of result we envision for Waikato District's Outstanding Volcanic Heritage.

8.4.8 Having ONF status over Mangere Lagoon Explosion crater in the 2000s did assist in having Watercare restore it to a tidal lagoon with a restored central scoria cone rather than turn it into a planned sports field.

8.4.9 Please do not let the "flatten the Earth" destruction and infilling of the Manukau volcanoes happen in the north Waikato half of the South Auckland Volcanic Field as well. The chance to prevent this is now.

8.5 **Protection of the volcanic heritage on the isthmus portion of Auckland City**

8.5.1 Twenty of the 53 volcanoes in the Auckland Volcanic Field occur on the Auckland isthmus within the boundaries of the former Auckland City, which has recognised many of its volcanoes as ONF since the RMA process was first instigated in the 1990s. The 14 (70%) that are still the most intact are currently scheduled as ONFs. Six of the cones have been completely or more than 75% quarried away (Albert Park, Little Rangitoto, Te Pou Hawaiki, most of Three Kings, Mt Smart, Purchas Hill) and two of the craters/tuff rings are hardly recognisable beneath suburbia and motorways (Grafton, Te Hopua).

8.5.2 The good news is that the best parts of the 13 remaining, largely intact volcanoes are protected and publicly accessible as Auckland Central's premier parks (Pukekawa/Auckland Domain, Maungakiekie/One Tree Hill, Maungawhau/Mt Eden, Maungarei/Mt Wellington, Ohinerangi/Mt Hobson, Te Kopuke/Mt St John, Puketapapa/Mt Roskill, Owairaka/Mt Albert, Orakei Basin, Panmure Basin, Taurere/Taylors Hill, Whakamuhu/St Heliers, Big King).

8.5.3 These volcano ONFs are dearly loved and much used for leisure by those who live on the isthmus. Most are the centrepiece and name-bearer for the inner suburbs of Auckland. They are currently cared for by the Tupuna Maunga Authority and many are recognised as an integral part of the proposed Auckland Volcanoes World Heritage nomination.

8.5.4 While by no means perfect, this is what GSNZ envisages for the long-term protection and celebration of the volcanic heritage of the South Auckland Volcanic Field.

8.5.5 If we could go back in time to 1840 and were to plan for the best long-term design for a 21st century Auckland City, we are certain the planners would have scheduled all but two (Albert Park, Grafton) of the original 20 volcanoes on the isthmus for heritage protection, set aside to become publicly-owned reserves as the city grew around it. They would have planned to prevent some of the creep of houses up the sides of the cones that partially obscures the views to and from them and they would have zoned the insides of Orakei, Panmure and Te Hopua crater basins as public open spaces to prevent the encroachment of houses, main roads and railway lines into and through them.

8.5.6 The fact that Auckland central still retains much of its volcanic heritage owes a lot to the foresight and vision of Governor George Grey. In 1845 Grey set aside the Auckland Domain Volcano and springs as Auckland Domain – New Zealand's first public park. In 1845 and 1851 Grey recognised the considerable scenic and heritage values of Auckland's volcanoes and proposed that "all the volcanic hills of Auckland" should be reserved for parks and natural objects of beauty

for the city. Unfortunately some of these were subsequently sold off by the crown or leased for quarrying by the Domain Boards set up to manage them but without any other source of funding.

8.5.7 As a result of Grey's lobbying, Executive Council reserved One Tree Hill, Mt Smart, Mt St John and One Tree Hill as crown land for public purpose in 1861. Mt Wellington Domain was gazetted in 1866 and Mt Eden Domain in 1879.

8.5.8 In the 1840s-1860s when Grey was about, Auckland was just a fledgling town and most of the area was pastoral farmland, just like northern Waikato District is today. Grey's actions before great pressure for subdivision and quarrying built is responsible for setting aside these heritage volcanoes.

8.5.9 Some of the other volcanoes on the isthmus have become reserves because their private owners recognised their high values and donated them to the people of New Zealand to become reserves – Sir John Logan Campbell donated Cornwall park in 1901, the estate of William Innes Taylor donated Taylors Hill in 1924, George Winstone donated Mt Roskill in 1928, the Wesley College Trust donated Big King in 1927 and the Dilworth Trust donated the western slopes of Mt Hobson, facing Newmarket viaduct in 1921.

8.5.10 If Sir George Grey and these private owners had not appreciated the heritage value of Auckland's central volcanoes, 90-175 years ago, Auckland would not be blessed with these magical volcano reserves today. Present day Aucklanders owe a great deal to these visionaries' foresight. This is surely the lesson for Waikato District to follow at this critical time for the future of its volcanic geoheritage.

9. Outstanding Natural Feature status for other similar small basalt volcanoes in northern New Zealand

9.1 Small basalt volcanic fields with many little-eroded volcanic landforms, like the South Auckland field, only occur in northern New Zealand – north of Pukekawa.

9.2 **ALL** other Councils that have these young volcanoes within their districts have recognised their high geoheritage values and have assessed them against the geoheritage criteria for recognising ONFs and have scheduled the vast majority as Outstanding Natural Features with appropriate policies and rules for their long-term protection.

9.3 So why does Boffa Miskell say none of those in the Waikato District reach the threshold for ONF status? Because they have used a novel and **wrong** definition for a geoheritage ONF!

9.4 The Auckland Unitary Plan schedules as ONFs the remains of 38 of the 53 (**72%**) volcanoes recognised in the Auckland Volcanic Field and another 34 volcano-related sites (rock exposures, lava flows, lava caves). **This is a total of 72 volcano ONFs in Auckland!** The remaining volcanoes have been completely or almost completely destroyed by quarrying, subdivision and reclamation.

9.5 The Whangarei District Plan schedules 12 of the 13 volcanoes (**92%**) in the Whangarei Volcanic Field as ONFs.

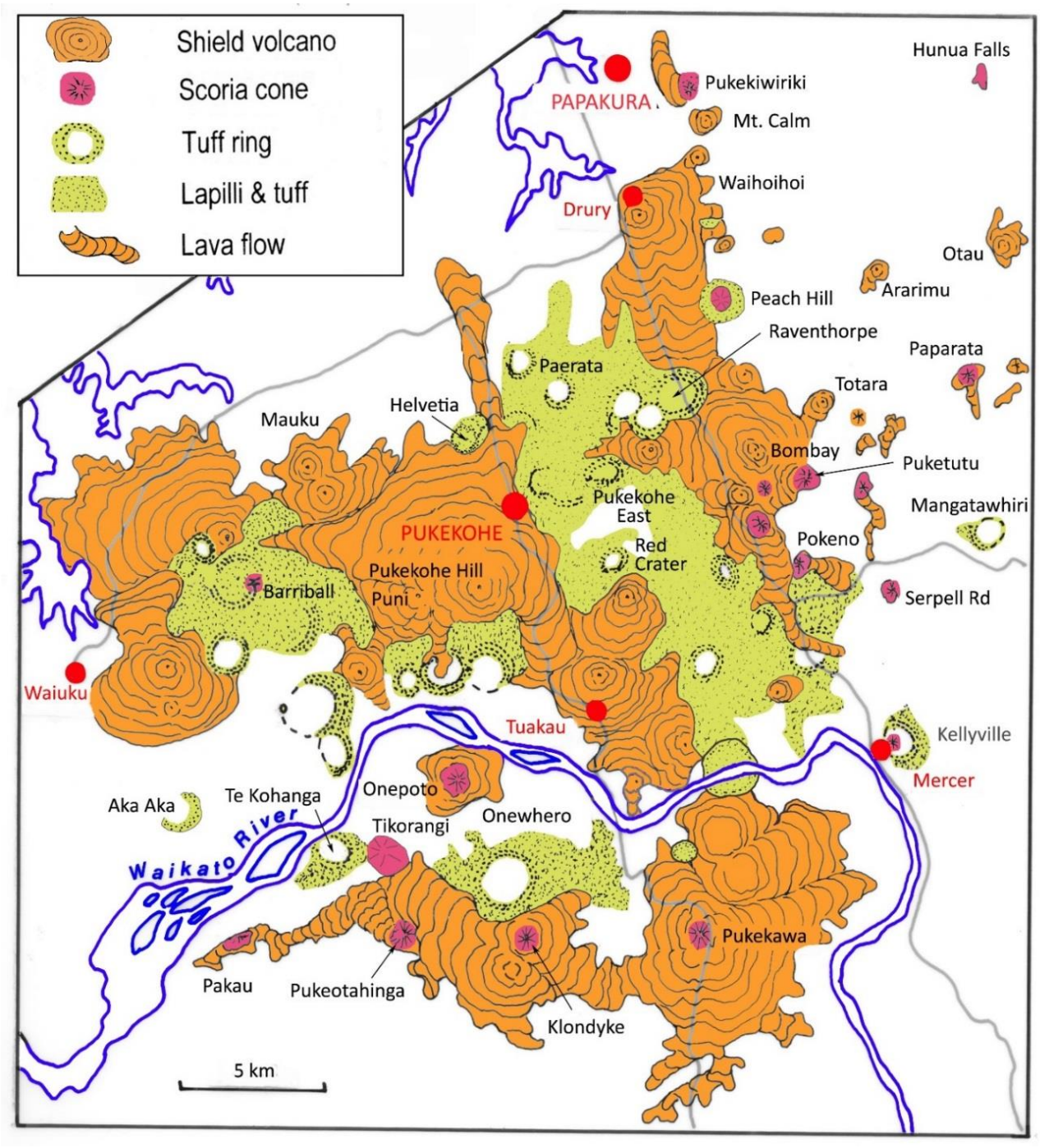
9.6 The revised Far North District Plan proposes to schedule 14 of the 14 volcanoes (**100%**) in the Kaikohe-Bay of Islands Volcanic Field as ONFs plus a further 9 volcano-related features (lava flows, waterfalls over lava flows, lava-dammed lakes, natural bridges, geothermal field). Total 23 volcano-related ONFs in Far North District.

9.7 The Auckland Unitary Plan has scheduled 6 of the ~40 volcanoes **(15%)** in the northern part of the South Auckland Volcanic Field as ONFs and has proposals before it to schedule another 7 volcanoes or part of volcanoes (**18%**) in the northern part of the field.

9.7 The Proposed Waikato District Plan proposes to schedule none of the ~44 volcanoes (**0%**) in the southern part of the South Auckland Volcanic Field as ONFs. Three are currently ONFs in the Operative WDP but these are proposed not to be carried forward into the PWDP.

9.8 GSNZ assesses that at least 12 volcanoes of the South Auckland Volcanic Field in the northern Waikato District will meet the threshold for ONF status and recommends that all be scheduled as ONF. Part of our submission points 8.2 and, 8.3.

10. Existing or proposed protected status of the best-preserved volcanic heritage of the South Auckland Volcanic Field, 2020



Many of the volcanoes mentioned below are labelled on this map. The list below refers to 26 of the 84 (31%) named volcanoes recognised in the South Auckland Volcanic Field.

10.1 In Auckland City contains ~40 of the volcanoes of the field, including many of the oldest and more eroded in the Hunua Ranges.

1. Barriball Rd tuff ring and cone – assessed, mapped and scheduled as ONF within AUP.

2. Hunua Falls volcanic neck – assessed, mapped and scheduled as ONF within AUP.

3. Ingram Road III tuff ring – assessed, mapped and scheduled as ONF within AUP.

4. Pukekohe East tuff ring – assessed, mapped and scheduled as ONF within AUP.

5. Raventhorpe tuff ring – assessed, mapped and scheduled as ONF within AUP.

6. Red Hill volcanic centre – assessed, mapped and scheduled as ONF within AUP.

7. Waitangi Falls, Glenbrook over lava flow – assessed, mapped and scheduled as ONF within AUP.

8. Karaka volcano – recently recognised. Auckland Council contract report recommends it to be added as an ONF in Plan Change.

9. Puni Domain shield volcano – Recommended to add peak of volcano to AUP as an ONF as part of a planned Plan Change in 2014 report by commissioned by Auckland Council as part of Pukekohe Heritage Survey.

10. Pukekohe shield volcano - – Recommended to add peak of volcano to AUP as an ONF as part of a planned Plan Change in 2014 report by commissioned by Auckland Council as part of Pukekohe Heritage Survey.

11. Paerata tuff ring bluffs – Recommended to add prominent bluffs of volcanic ash to AUP as an ONF as part of a planned Plan Change in 2014 report by commissioned by Auckland Council as part of Pukekohe Heritage Survey.

12. Rooseville Park tuff bluffs - Recommended to add prominent bluffs of volcanic ash to AUP as an ONF as part of a planned Plan Change in 2014 report by commissioned by Auckland Council as part of Pukekohe Heritage Survey.

13. Cape Hill Reserve tuff bluffs - Recommended to add prominent bluffs of volcanic ash to AUP as an ONF as part of a planned Plan Change in 2014 report by commissioned by Auckland Council as part of Pukekohe Heritage Survey.

14. Helvetia tuff ring knolls - Recommended to add prominent bluffs of volcanic ash to AUP as an ONF as part of a planned Plan Change in 2014 report by commissioned by Auckland Council as part of Pukekohe Heritage Survey.

10.2 In Waikato District – contains ~44 of the field's volcanoes including most of the younger and better-preserved scoria cones

1. Pukekawa II Scoria Cone – Currently an ONF within Operative Waikato District Plan, Franklin Section. Boffa Miskell assessment for PWDP is "Does not reach ONF threshold" - downgrade to Pukekawa SAL recommended.

2. Kellyville Tuff Ring – Currently an ONF within Operative Waikato District Plan, Franklin Section. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

3. Onewhero Tuff Ring – Currently an ONF within Operative Waikato District Plan, Franklin Section. Boffa Miskell assessment for PWDP is "Does not reach ONF threshold" - downgrade to Onewhero Tuff Ring SAL recommended.

4. Pukeotahinga Scoria Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

5. Onewhero Scoria Cone (sometimes named Klondyke) – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – "identified as SAL Onewhero Tuff Ring".

6. Kauri Rd Scoria Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

7. Onepoto Volcanic Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

8. Te Kohanga Tuff Ring/Tikorangi cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

9. Rasmussen Rd Tuff Ring – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended. Part was identified as SNF (OWDP). Part was identified as SNF (OWDP).

10. Waiuku Volcanic Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended

11. Pokeno Scoria Cone– No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended. Part was identified as SNF (OWDP).

12. Serpell Rd Tuff Ring and cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

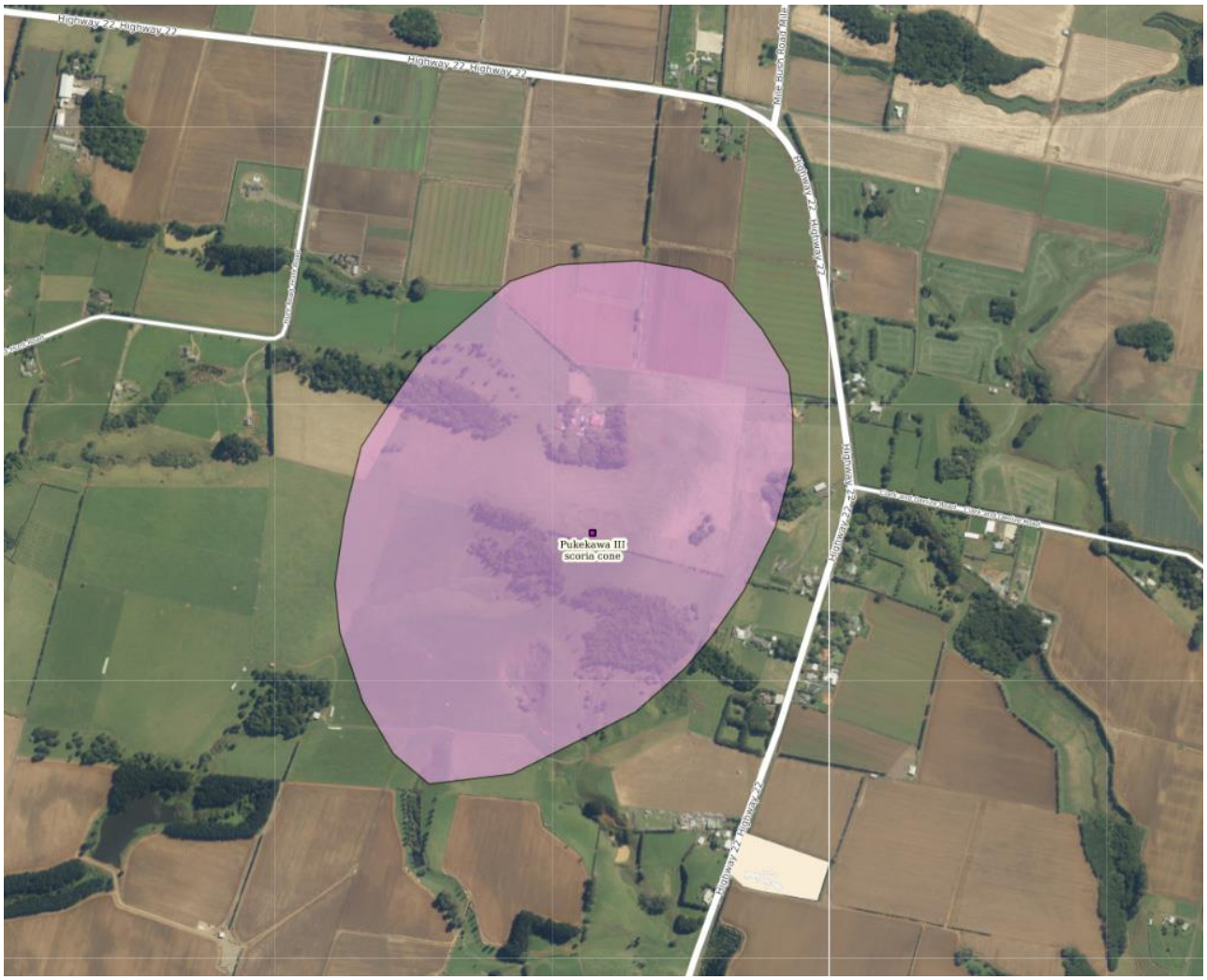
13. Bald Hill cone – No current protection. This small scoria cone sits on the crest of the Barriball tuff ring ONF on the south side of Bald Hill Rd and should also be protected as ONF contiguous with the Auckland ONF, even though it occurs on the other side of the Waikato-Auckland boundary. This was overlooked in GSNZ's submission.

14. Jericho volcanic cone – No current protection. Small cone just on the Waikato District side of the boundary with Auckland on Harrisville Rd. This was overlooked in GSNZ's submission.

11. Existing maps (taken from internet) and photographs of major volcanoes suggested for scheduling as ONFs in Waikato District

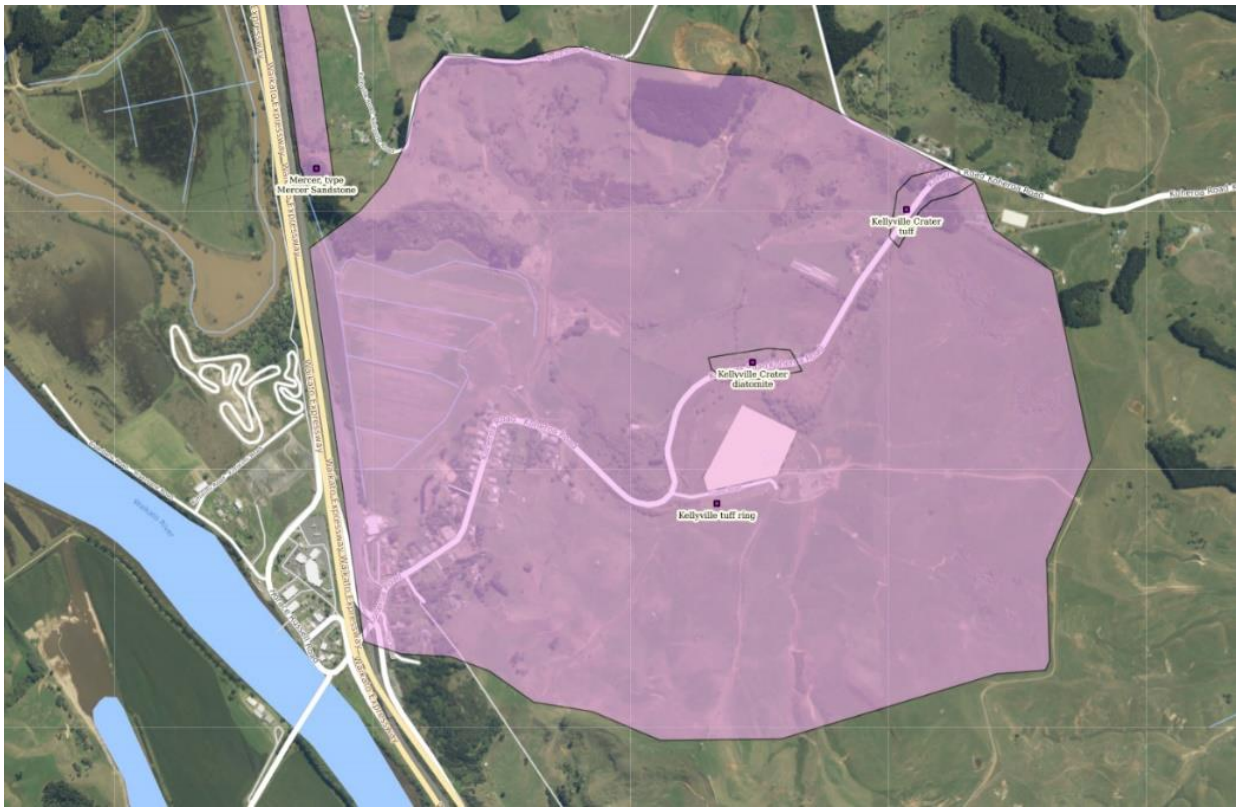
Maps and brief descriptions copied from the publicly accessible internet.
https://services.main.net.nz/geopreservation/

1. Pukekawa II Scoria Cone – Currently an ONF within Operative Waikato District Plan, Franklin Section. Boffa Miskell assessment for PWDP is "Does not reach ONF threshold" - downgrade to Pukekawa SAL recommended.



A well-preserved, small steep-sided scoria cone with a preserved crater. Together with two volcanic centres to the NE, Pukekawa I cone or Smeed's Volcano and Pukekawa II or Mile Bush Volcano, this centre has built large coalescing cones of basaltic lava flows which cover an area above the west bank of the Waikato River opposite Mercer township.

2. Kellyville Tuff Ring – Currently an ONF within Operative Waikato District Plan, Franklin Section. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

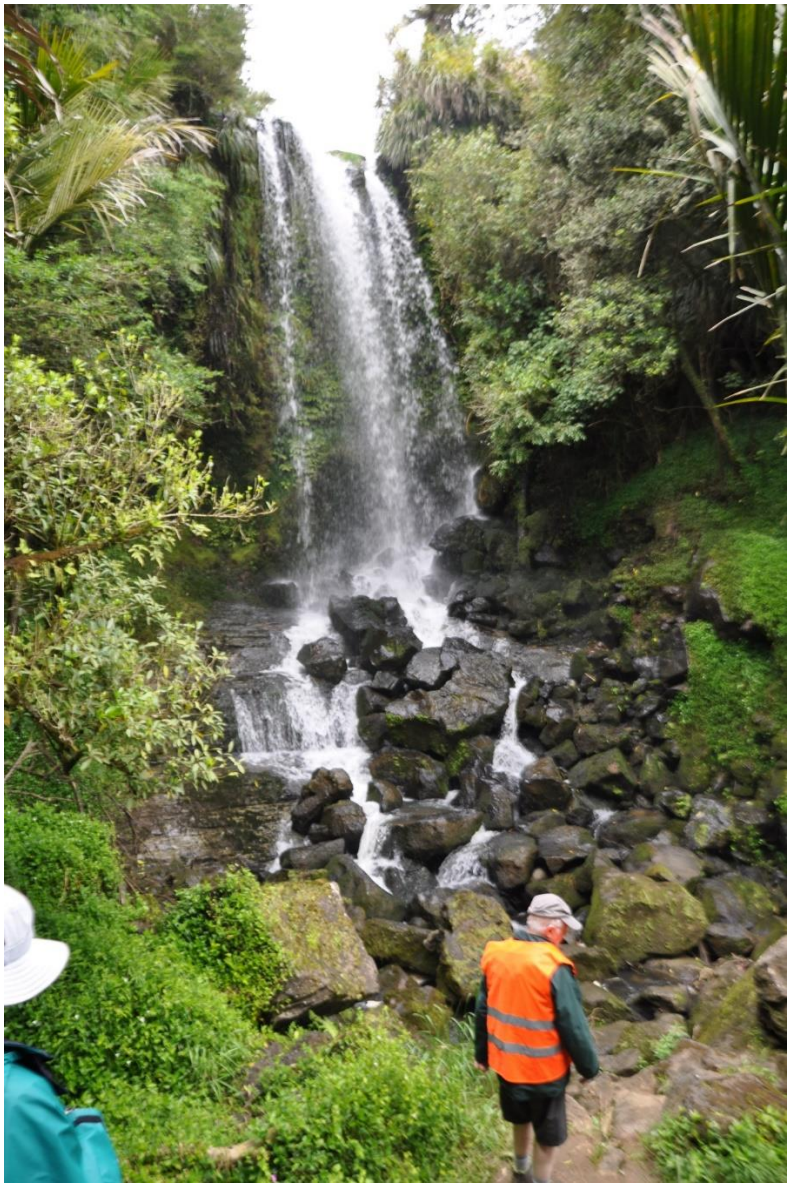


One of the larger centres with a diameter of approximately 2.2 km. A complex centre associated with initial phreatomagmatic activity. Later activity produced a central tholoid, represented by a small prominent conical hill of basaltic lava and strombolian deposits within the crater. The tuff ring rises to 110 m and has been breached on its western side. The ring predates terraces at 35 m and 55 m that include diatomaceous lake sediments with fossil leaves deposited within the crater and exposed in road cuttings.

Exposure of diatomite lacustrine sediments deposited on the floor of the lake inside the Kellyville crater, many hundreds of thousands of years ago.

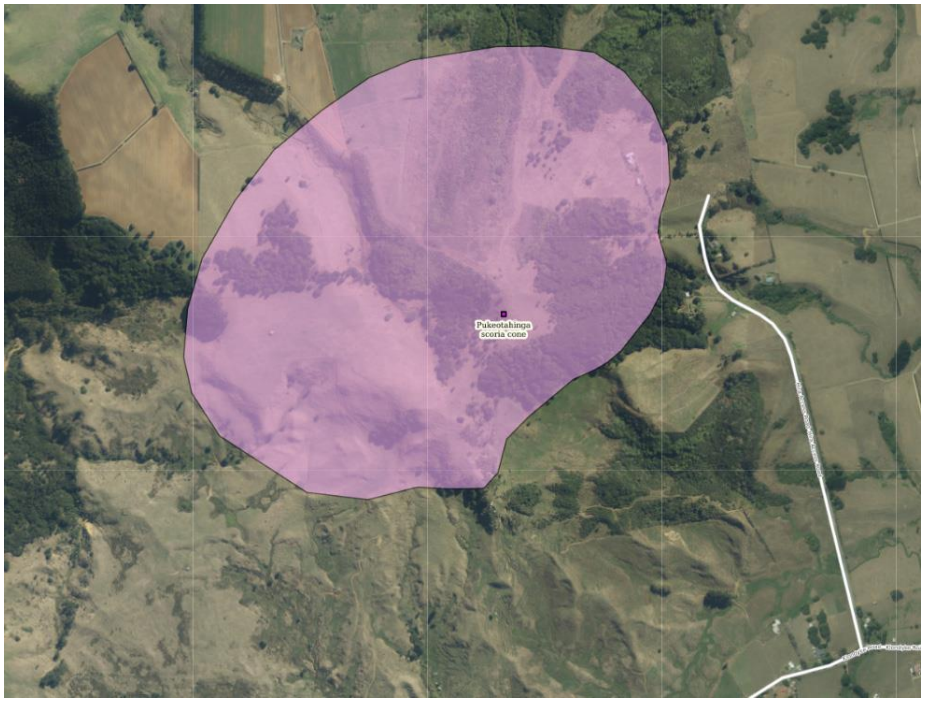
3. Onewhero Tuff Ring – Currently an ONF within Operative Waikato District Plan, Franklin Section. Boffa Miskell assessment for PWDP is "Does not reach ONF threshold" - downgrade to Onewhero Tuff Ring SAL recommended.

Well preserved tuff ring blasted through pre-existing lava flows of the Onewhero Cone whose lavas are now preserved in the south wall and north outlet of the tuff ring. The tuff ring has no plug and bore holes have failed to detect any basalt, at least to depths of 100 m below the present floor implying either collapse of the floor, if it originally had a plug, or lack of a magma chamber. The Onewhero tuff ring is the largest in the South Auckland field, with a diameter of approximately 2.5 km. The tuff ring is well preserved and the crater is infilled with sediments.



Vivian Falls outflow over basalt lava flows from Onewhero Crater.

4. Pukeotahinga Scoria Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.



A prominent scoria cone, approximately 302 m elevation, with a breached crater, and a flow to the NW.

Pukeotahinga scoria cone, 301 m

5. Onewhero Scoria Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – "identified as SAL Onewhero Tuff Ring".

Prominent small scoria cone on ridge crest. 251 m elevation, somewhat weathered and rounded in shape with flows to the NW.

See map below under 6.

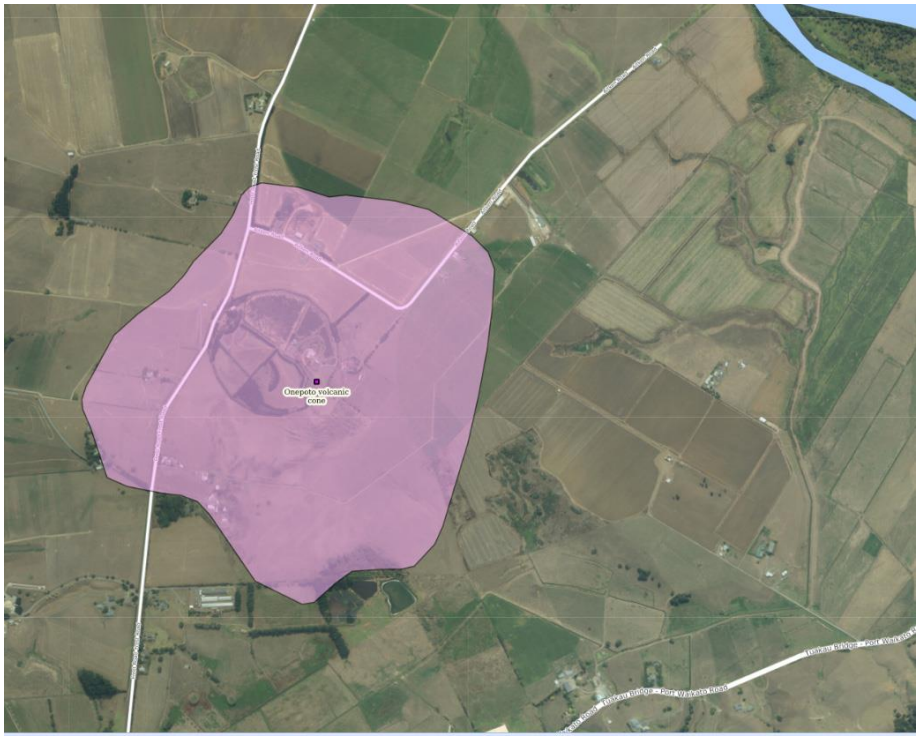
6. Kauri Rd Scoria Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

A small scoria cone, elevation 238 m, with a breached crater.

Onewhero scoria cone

Kauri Rd scoria cone

7. Onepoto Volcanic Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is “Does not qualify as ONF” – no protective status recommended.



A cone with fresh scoria at the top and to the west surrounded by an apron of basalt. Approximately 128 m high.

Onepoto volcanic cone

8. Te Kohanga Tuff Ring and Tikorangi scoria cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

A tuff ring approximately 1.2 km in diameter, breached to the NW where the Waikato River now passes. The tuff ring is infilled with tuff and alluvium. Tikorangi scoria cone with breached crater.

Tikorangi scoria cone

Tikorangi scoria cone

9. Rasmussen Rd Tuff Ring – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended. Part was identified as SNF (OWDP). Part was identified as SNF (OWDP).

A tuff ring approximately 1 km in diameter, infilled with alluvium. The Waiuku Fault displaces the walls of the tuff ring.

See map below under 10.

10. Waiuku Volcanic Cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

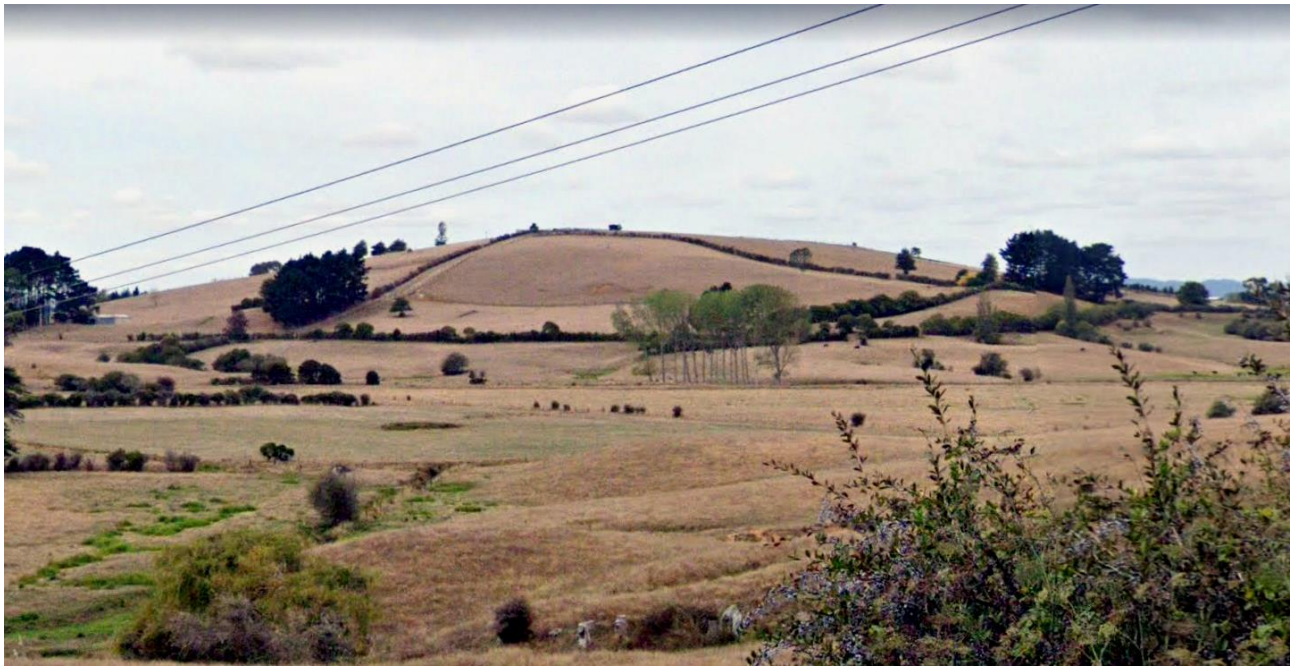
A low-profile cone, with scoria present in minor abundance. The Waiuku Fault postdates the volcanism in the area since it can be traced across the top of Waiuku cone

11. Pokeno Scoria Cone– No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended. Part was identified as SNF (OWDP).

"A small steep sided scoria cone associated with a small lava flow. The remains of a breached crater exist. The scoria o: contains bombs and is very fresh, that is, not as strongly weathered as is common elsewhere in this field. The cone is located at the intersection of the Drury and Pokeno Faults."

12. Serpell Rd Tuff Ring and cone – No current protection. Requested by GSNZ for addition to PWDP as ONF. Boffa Miskell assessment for PWDP is "Does not qualify as ONF" – no protective status recommended.

"A small tuff ring approximately 400 m in diameter, infilled with flow basalt probably from the cone in the centre."



Serpell Rd cone from Hwy 2.