Technical Report 6:

Geological Evaluation

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MCLAUGHLINS QUARRY PRIVATE PLAN CHANGE REQUEST

GEOLOGICAL EVALUATION OF OUTSTANDING NATURAL FEATURE: MATUKUTŪREIA AND MATUKUTURUA LAVA FIELD AND TUFF RING

Author: Professor Shane Cronin

University of Auckland

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1.0 INTRODUCTION

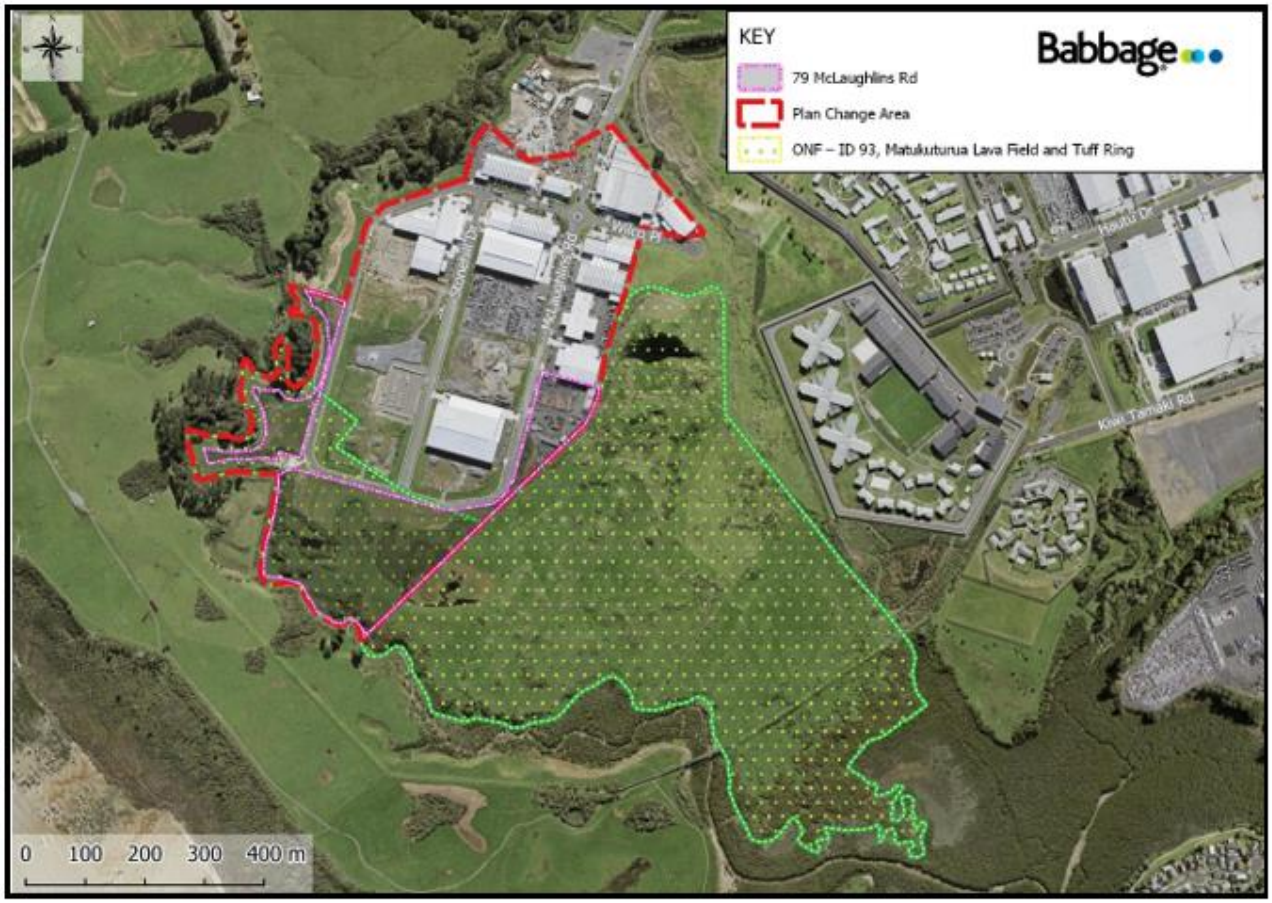
Executive Summary

1.1 The purpose of this geological evaluation report is to inform the McLaughlins Quarry Private Plan Change Request to the Auckland Unitary Plan (Operative in Part) [AUP(OP)].

1.2 Matukutūreia and Matukuturua comprise the scoria cone and lava flow components of a volcanic centre formed in the southern portion of the Auckland Volcanic Field. This area is scheduled as an Outstanding Natural Feature, item 93, (ONF 93) within the AUP(OP).

1.3 This report contains a geological assessment of ONF 93, with a focus on the mapped portion of the ONF that lies within the Plan Change area, this largely being the site at 79 McLaughlins Road (see Figure 1 below).

Figure 1: Mapped extent of ONF 93 in the AUP(OP) relative to the Plan Change area.



1.4 The geological assessment contained within this report, is based on the following methodology:

- Review the geological literature pertaining to ONF 93.
- Conduct a field geological survey of the ONF 93 located within the Plan Change area.
- Evaluate the geological values of ONF 93 within the Plan Change area as a place of "outstanding natural feature", considering the factors set out in Policy B4.2.2(4) of the AUP(OP).

1.5 This report presents the following conclusions and recommendations for the ONF 93 sub-areas 1-3 identified in Figure 2:

Area 1 (part of ONF 93 recommended to be removed)

- Area 1 which is currently included as part of ONF 93, has no direct value as a primary geological feature because this area either had no original volcanic cover, or those parts of it that did are highly modified with much of the material removed. Although this area is included as part of ONF 93 in the AUP(OP), its value as a geological feature area is not supported. Overall, this area contains no value as a geological feature characteristic of the Auckland's Volcanic Field. It is recommended that Area 1 be removed from ONF 93.

Area 2 (explosion crater and its margins)

- Area 2 which is also currently included as part of ONF 93, is an explosion crater and forms a more appropriate western boundary of the ONF 93 due to its geological interest. The feature is part of the distinctive Matukuturua lava field that makes up the eastern part of ONF 93. It is recommended that the western boundary of ONF 93 be realigned along the western margin of the explosion crater (Area 2). This area is partially located within the Plan Change area.

- The description of Area 2 within ONF 93, is incorrectly described in Schedule 6: Outstanding Features Overlay Schedule in the AUP(OP) as a "tuff ring". It is recommended that the description in Schedule 6 be amended to delete the reference to "tuff ring" and be replaced with "an explosion crater".

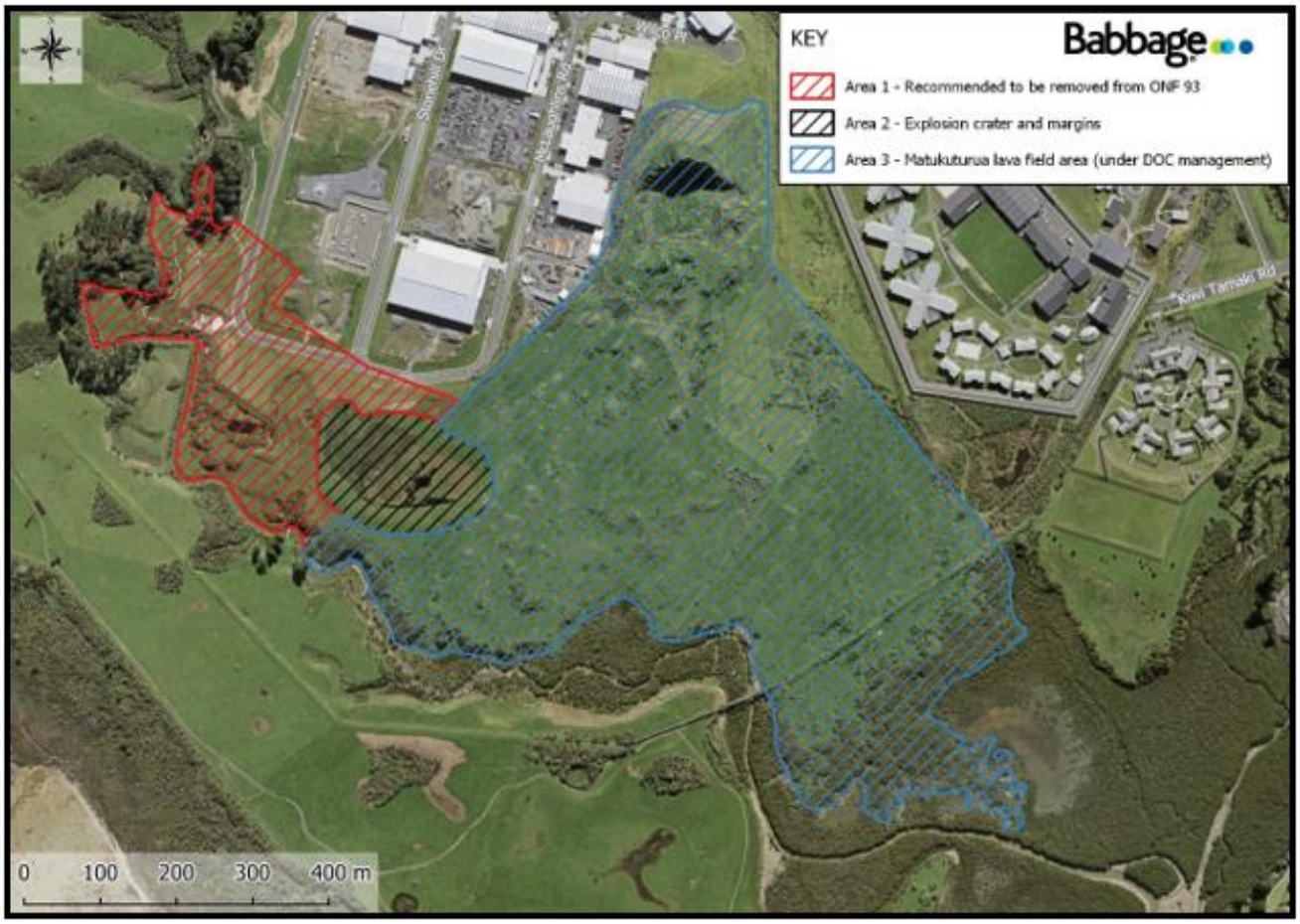
- Area 2 of ONF 93 is of specific geological interest because the explosion crater comprising Area 2 was formed more than 15,000 years ago by a single steam, or gas – driven, explosion with no magma involved. This represents a rare type of 'near-miss' eruption in the Auckland Volcanic Field where magma came close to the surface, but shed only gas and heat to disrupt the surface. This is possibly similar to the events that formed the nearby Puhinui Craters. Due to its unique value, it is recommended that Area 2 be protected, by purchasing it from the

current owner and adding it to the contiguous area of the lava field under protection to the east (i.e. the area currently managed by the Department of Conservation).

Area 3 (Matukuturua Lava Field)

- forms the margin of the Matukuturua Lava Flow, and is located outside the Plan Change area. No changes are recommended to this part of ONF 93.

Figure 2: Sub-areas within ONF 93



Author's Experience and Expertise

1.6 This report has been prepared by Professor Shane J Cronin, BSc (Hons 1st Class, Massey University, PhD (Earth Science, Massey University, 1997), Full Professor of Volcanology at The University of Auckland (School of Environment). Dr Cronin is also the current Director of the Resilience to Nature's Challenges, National Science Challenge (Ministry of Business, Innovation and Employment).

1.7 Dr Cronin's expertise, gained over 22 years of research into the nature and origin of Auckland's volcanoes, has been recorded in over 180 published scientific outputs in international refereed journals, along with book chapters and conference presentations. His work on volcanic geology, volcanic hazard and the social and environmental consequences of volcanic activity has been cited over 5800 times, making him one of the top-cited geologists in New Zealand.

1.8 Dr Cronin has led over ten major NZ Government research programs into the volcanic geology of Ruapehu, Taranaki and Auckland volcanoes, along with international analogues in the Southwest Pacific, Indonesia, Korea and Saudi Arabia. His work in the Auckland Volcanic field includes over 20 published studies on volcano formation, chemical and physical processes of eruptions and hazard. This includes international publications on Orakei, North Head, Motukorea, Pupuke, Mangataketake, and Rangitoto volcanoes, as well as several works on the formation of the volcanic field, statistical estimates of eruption hazard, and the social and economic consequences of volcanism. His 2011 co-authored paper (with Professor Mark Bebbington) on the eruption recurrence/hazard of the Auckland field is one of the two most highly cited papers on this volcano.

1.9 In preparing this report, Dr Cronin has drawn on all available published information on the Auckland Volcanic Field as well as extensive research notes collected over his 22 years of research. A description of the key volcanological features referred to in this report are set out in section 2.0 – The volcanological context.

2.0 THE VOLCANOLOGICAL CONTEXT

Volcanoes

1.10 The general concept of a volcano is that of a single volcanic cone built up by a succession of eruptions over a period of time that may extend to several thousand years. The eruptions are typically from a focused plumbing system feeding a single centralised vent at the surface. They are commonly referred to as central volcanoes or cone volcanoes.

Volcanic Fields

1.11 In contrast to central, or cone, volcanoes, volcanic fields occur where the rate of production of magma is very small, so that a focused plumbing system does not develop. Volcanic fields consist of clusters of small volcanoes which are formed during a single sequence of eruptions. Each volcano in a volcanic field may include "destructive" landscape features (such as maar craters), as well as constructional features (including tuff rings around maar craters, scoria (cinder) cones, and lava flows). Volcanic fields vary in size, total volume, longevity and rates of eruptive activity.

1.12 Much of Auckland is built on and around the volcanoes of the Auckland Volcanic Field. The Auckland Volcanic Field is a feature of the Auckland area, has international scientific significance as an excellent example of young volcanic system, and has considerable cultural importance to Māori. Examples of other volcanic fields in northern New Zealand are the Kaikohe Field, the Whangarei Field, the Auckland Field and the South Auckland Field.

Volcanic Cones

1.13 Volcanic cones are the accumulation of erupted material around the vent of a volcano. There are considerable variations in the size, shape and deposits of volcanic cones. On the smallest scale, cones develop from single eruptions on timescales as short as a few days. On the largest scale, volcanic mountains are the product of multiple eruptions and eruption types over a period of several hundred thousand years.

1.14 There are several terms used to classify volcanic cones that have been formed from different eruption styles or that have a particular shape. These are:

- **Scoria cones**: these are referred to as cinder to tephra cones. These are relatively common volcanic cones formed by the energetic eruption of low viscosity, and that have been expanded and fragmented during the eruption to produce a low density rock known as scoria. Scoria cones may build up over 100m high. They commonly involve basaltic magma with so-called Strombolian and Hawaiian type eruptions. Excellent Auckland examples are Mt. Eden and Mt. Wellington.

- **Spatter cones**: these Spatter cones are generally smaller than scoria cones and are formed by the eruption of large pieces of less-expanded low-viscosity lava that "spatter" and flatten and weld together as they hit the ground around the volcano.

They typically form small (<50 m high) mounds of lava spatter at the vent areas of lava flow. At times, the spatter output is so high that the welded-together ejecta begin to flow away as lava flows. A good example of this is Matukutūreia (McLaughlin's Mountain.

- **Tuff rings:** these are rings of exploded material that partly or entirely surround and enclose a maar crater. Generally, tuff rings are <50 m high at their highest point and are steep on their inner-crater side, with long low slopes of aprons or ejected pyroclastic debris (tuff) extending outward. The ejected pyroclastic debris (tuff) consists of a mixture of juvenile/fine (produced from magma) and accidental/course (broken rock from the surrounding landscape) fragments, the composition varying from volcano to volcano. An excellent example of this are Maugataketake (low tuff cone with >80% accidental fragments).

- **Explosion craters:** these are expressions of generally small, but always short lived, explosions that excavate a crater and shower the surrounding landscape in an apron of ejecta. They may be formed by gas trapped in water/steam under a lava flow, or by rising steam/gas trapped in layers within soils or shallow rock/sediment layers. They do not involve the ejection of new magma.

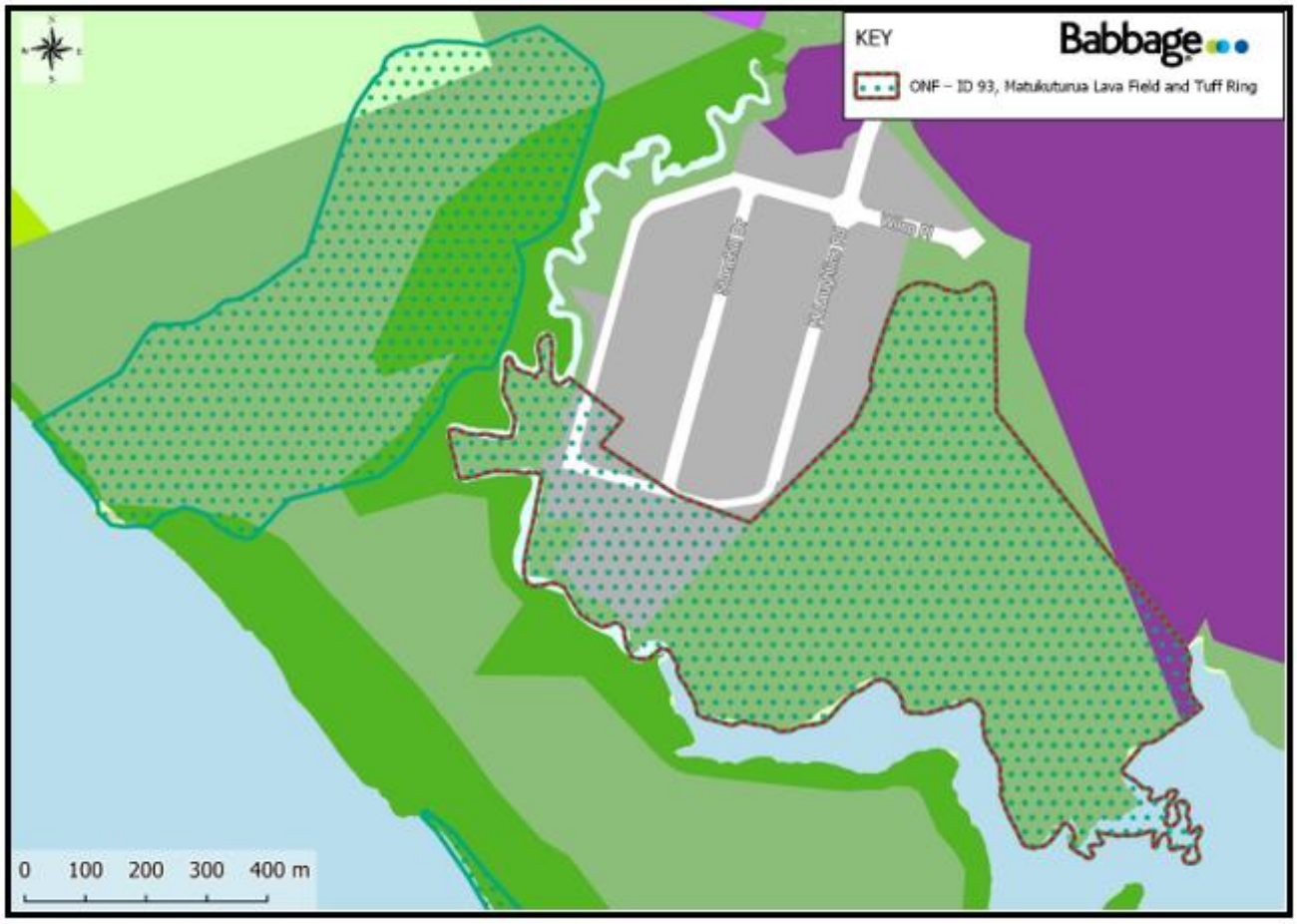
- **Lava fields**: these are areas covered by one or more flows of lava. Lava is the surface expression of molten rock (magma). It is erupted from spatter vents (or fire-fountains) under high pressures, or is gently leaked from the base of scoria cones. As lava emerges it flows down slope, with flows cooling to form distinctive shapes. Often several lava flows form over long eruptions, piling up beside and on top of each other to form a lava field. An example of this is the Matukuturua lava field.

3.0 OUTSTANDING NATURAL FEATURES OVERLAY IN THE AUP(OP)

3.1 The AUP(OP) seeks to identify and protect Outstanding Natural Features (ONF) from inappropriate subdivision, use and development. The maunga and other geological and landform features that are deemed to have "outstanding natural feature values" are identified in Schedule 6: Outstanding Natural Features Overlay Schedule in the AUP(OP).

3.2 The AUP(OP) Maps identify ONF 93 (Matukutūreia and Matukuturua lava field and tuff ring) as being located within the Plan Change area (Figure 3).

Figure 3: Mapped extent of ONF 93 in the AUP(OP)



3.3 Schedule 6 contains the following information with respect to ONF 93:

- ***Item****: 93*
- ***Name****: Matukutūreia and Matukuturua lava field and tuff ring*

- ***Location:*** *Wiri*

- ***Site type:*** *V (Large volcanic landforms)*

- ***Description:*** *The Matukuturua lava field is one of the best preserved lava fields remaining in the Auckland volcanic field and is an important representative example of the volcanic lava terrain that underlies much of the city. The lava field erupted from McLaughlins Mountain (Matukutūreia) volcano. Most of the original scoria cone and a section of the lava field in the north have been quarried away. Associated with the lava field is a section of tuff ring remaining from the early phases of the eruption. A small wetland has formed behind the ridge of tuff.*

- ***Unitary Plan criteria met for scheduling set out in Chapter B4.2.2(4):*** *a, c, d, e, g, h, i.*

3.4 Introduction to Chapter D10 (Outstanding Natural Features Overlay and Outstanding Natural Landscapes) of the AUP(OP) states that factors set out in Policy B4.2.2(4) have been used to determine the features that have outstanding natural feature values. Schedule 6 identifies ONF 93 as meeting the following factors set out in Policy B4.2.2(4):

(a) *the extent to which the landform, feature or geological site contributes to the understanding of the geology or evolution of the biota in the region, New Zealand or the earth, including type localities of rock formations, minerals and fossils;*

(c) the extent to which the feature is an outstanding representative example of the diversity of Auckland's natural landforms and geological features;

(d) the extent to which the landform, geological feature or site is part of a recognisable group of features;

(e) the extent to which the landform, geological feature or site contributes to the value of the wider landscape;

(g) the potential value of the feature or site for public education;

(h) the potential value of the feature or site to provide additional understanding of the geological or biotic history;

(i) the state of preservation of the feature or site.

4.0 REVIEW OF THE AUCKLAND COUNCIL DOCUMENTS INFORMING THE MAPPED EXTENT OF THE ONF 93 AND ITS INCLUSION IN THE AUP(OP)

4.1 Prior to the notification of the Proposed Auckland Unitary Plan in September 2013, Auckland Council completed a report titled "*Landscape Evaluations of Geological Sites and Landforms of Auckland and the Identification of Outstanding Natural Features*", dated May 2012, prepared by Brown NZ Limited (hereon referred to as the Brown Report).

4.2 The Brown Report evaluates the landscape values of 270 sites and landforms that were identified as geologically significant by Auckland Council prior to the notification of the Proposed Auckland Unitary Plan. The purpose of the Brown Report was to identify and map areas that were regarded as ONF within the context of section 6(b) of the Resource Management Act 1991 (RMA). Of the 270 geological sites and landforms that were assessed, the Brown Report identified 70 sites as ONF.

4.3 The Brown Report sets out the methodology Brown NZ Limited used to evaluate the 270 geological sites and landforms:

- Step 1: Classification of all 270 geologically significant areas to distinguish geological "sites" (e.g. unique rock or fossil sites) from geological "landforms". The purpose of making this distinction was to recognise that many geological sites (e.g. rock outcrop), while representing high intrinsic geological value, may not necessarily be recognisable as a distinct landform feature.

- Step 2: If a geologically significant area was described as a recognisable landform, then it was further classified in terms of landscape values to identify those areas that could be identified as an ONF.

- Step 3: This resulted in the development of a landscape classification of each geological site and landform using four general categories: Sites of Geological Value, Notable Natural Features, Significant Natural Features, and Likely Outstanding Natural Features.

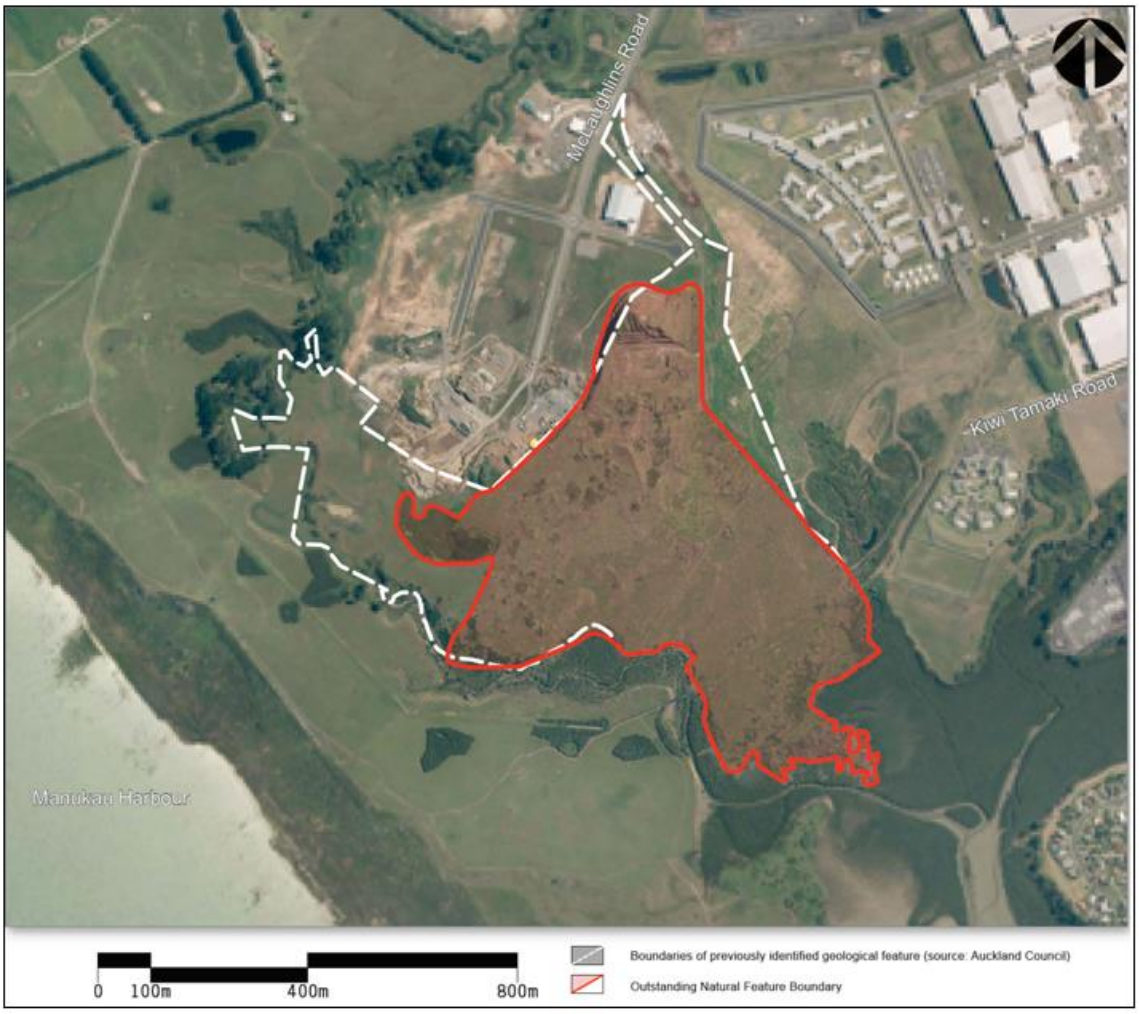
4.4 It is important to note that, in order for a geological feature to be classified as an "ONF", it had to meet the threshold for Outstanding Natural Feature within the context of Auckland Council's obligations for protection under section 6 of the RMA. In this regard, the Brown Report noted that "Likely Outstanding Natural Features" category included *"Areas likely to be prominent and conspicuous natural landform features that stand out amongst the natural features across Auckland"*, and included descriptions such as "conspicuous, eminent and remarkable".

4.5 Once a site was identified as a “likely ONF”, provisional site maps were developed using high-resolution aerial imagery from Auckland Council. These images were flown for rural areas in 2010/2011, and for urban areas in 2011.

4.6 The Brown Report contains worksheets on all 270 sites and landforms identified by Auckland Council, including maps of areas meeting the threshold for ONF. The worksheets contained an evaluation of intrinsic geological values (geophysical) and landscape values (perceptual and associative values), with a combined overall landscape evaluation for each individual site and landform.

4.7 Worksheet 138 sets out the overall landscape evaluation for Matukutūreia Lava Field. It contains the map shown in Figure 4 below, illustrating the geological feature boundary previously identified by Auckland Council (area within the white line), and the ONF boundary recommended in the Brown Report (area within the red line).

Figure 4: Map as contained in Worksheet 138 of the Brown Report.



4.8 The recommended ONF boundary in the Brown Report includes the intact Matukutūreia Lava Field (similar to Area 3 in Figure 2) and the small segment of explosion crater (similar to Area 2 in Figure 2).

4.9 The findings of the Brown Report illustrate that appropriate evaluation and evidence was available to Auckland Council prior to the notification of the Proposed Auckland Unitary Plan to accurately identify the extent of the area that met the criteria/values for inclusion as an ONF and to accurately map the extent of ONF 93. However, it remains unclear as to why the boundary for ONF 93 as recommended by the Brown Report was not used in the notified Proposed Auckland Unitary Plan. It is also not clear as to the rational for mapping a larger area for ONF 93, which extended entirely on to the site at 79 McLaughlins Road and beyond.

5.0 EVALUATION OF GEOLOGICAL LITERATURE PERTAINING TO ONF 93

5.1 Matukutūreia (McLaughlins Mountain) is a scoria cone, originally approximately 60m high (Firth, 1930; Searle, 1961). Its original form preserved a crater open to the south, as seen by the direction of the Matukuturua lava flows that form a steep stepped flow field that terminates at Puhinui Creek (Kermode, 1992).

5.2 Matukutūreia is thought to be older than nearby Wiri Mountain (~25,000 years B.P.; Searle, 1981) and was recently dated at 48,000 ± 3000 years old (Leonard et al., 2017). Gravity and aeromagnetic studies (Rout et al., 1993) showed that it is "essentially devoid" of any subsurface bodies below the cone and lava flows of Matukutūreia/Matukuturua. A tuff-ring remnant was referred to in Rout et al. (1993), but the geophysical study showed no subsurface lava body.

5.3 Horrocks et al., (2007) identified a wetland ~70m across and ~20m above sea level, approximately 500m south west of Matukutūreia, and noted that it lay adjacent to a crescent-shaped low landform, interpreted to be the remnant of a tuff ring. This was thought to be produced in the early, explosive stages of the Matukutūreia eruption. Later, Hayward (2009) described this feature as a "100 m long x 10 m high arc remnant of the original tuff ring built up by the early phreatomagmatic eruptions at this centre". The feature crosses the eastern boundary of 79 McLaughlins Road (see Figure 5).

5.4 A drill core through the centre of the wetland encountered approximately 90cm of peat above beds containing volcanic particles and fragmented non-volcanic sediments recognized from deeper units (Horrocks et al., 2007). The deepest peat yielded a radiocarbon age of approximately 15,000 years old, which provides a minimum age for the crater.

5.5 Within approximately 1 km west and southwest of Matukutūreia and within the Puhinui Reserve are three further small craters, described by Hayward (2012). These features are low, sub-circular features, with shallow craters, low rims of inferred tuff. No exposures through these have been described. A drill core through one of the Puhinui craters revealed at least 3m of mud and peat sediment. Based on geophysical evidence (Govind, 2013), these craters were interpreted as tuff rings.

5.6 From the review of the geological literature studies, it is concluded that:

- Matukutūreia and the Matukuturua lava field were erupted likely at approximately 48,000 years ago. The major volume of the eruption was focused at Matukutūreia forming a spatter-cone and a lava field expanding initially to the west and then south once the spatter cone breached.

- An arcuate crater occurs at the southwest margin of the Matukuturua lava flow (straddling the boundary of 79 McLaughlins Road). This has been attributed to:

  (a) part of an earlier large tuff ring that has since been buried by lavas elsewhere (Rout et al., 1993; Hayward, 2009), or

  (b) a possible fourth crater associated with the Puhinui Craters nearby (Hayward, 2012). The age/origin of the Puhinui Craters is unclear, and they may also be associated with the Matukutūreia/Matukuturua eruption.

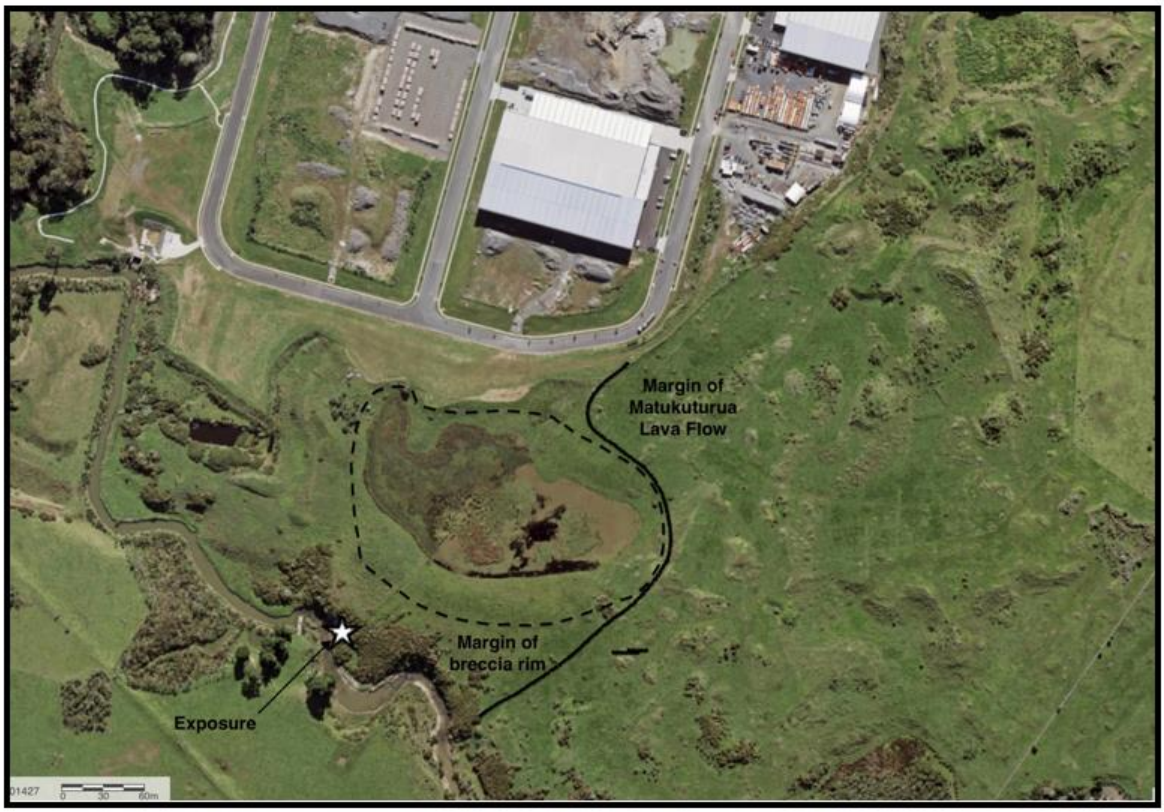
6.0 FINDINGS AND CONCLUSIONS OF FIELD GEOLOGY SURVEY OF THE PLAN CHANGE AREA

6.1 Three site visits to the Plan Change area were conducted between September and November 2018. The third visit was also attended by Associate Professor Ian Smith (University of Auckland) and Dr Marco Brenna (Otago University).

6.2 The lava flow field of Matukuturua (Area 3 in Figure 2), shows obvious surface features of lava flow lobes, rough surface textures, known as A'a and an overall distinct slope descending from Matukutūreia.

6.3 The area recommended for ONF protection in the Brown Report (red line in Figure 4), includes a lobe that protrudes into the 79 McLaughlins Road property. This lobe, includes a peat and water-filled volcanic crater, with a rim of ejecta (material explosively expelled from the crater), mainly on the outside southern margin of the crater (see Figure 5).

Figure 5: Annotated 2017 Aerial Photo (from Auckland Council Map Viewer), showing the outer margin of deposits from the Matukuturua Crater, with crater itself below swamp/water.



6.4 One exposure of volcanic material was found in a recent landslide scarp on the banks of the Puhinui Creek (Figure 5). This exposes a poorly sorted deposit with no bedding. It comprises variable-sized blocks (0.05-0.5 m in diameter) of sedimentary rock along with rare dense basaltic lava blocks (making up ~5% of the deposit) set within a matrix of mud-sand. The bulk of the materials within this are derived from non-volcanic shallow sediments/rock characteristic common to this general area. The basaltic lava blocks are fresh and dense, consistent with derivation from a lava flow. There are no scoria-like fragments present. The deposit is not continuous, but occurs in lobes and lenses, because appears to have infilled small erosional valleys in the surrounding, pre-event topography.

6.5 The deposit represents ejecta from a single explosion, similar in character to “steam-driven” explosions seen at many volcanoes around the world. The lava appears to be derived from the Matukuturua lava flow (chemical analysis may help confirm this). The explosion crater has broken through the edge of the lava field and represents a later event.

***Figure 6**:* Exposure of breccia from Matukuturua crater. This is a single explosion breccia unit, that contains rare large fresh dense lava clasts, amid >90% of disrupted sedimentary material. The lack of bedding and the single unit indicates that it was produced by a brief, one-off explosion of trapped gas/steam.

6.6 The Crater/ring feature has been earlier incorrectly identified as a tuff ring (i.e. a site of new magma eruption *sensu stricto*). Factors counting against this identification are the deposit being of a single, one-off explosion, no evidence of new magma being erupted (the lava blocks are from the adjacent Matukuturua lava flow), nor any geophysical evidence for a magmatic feeding dyke. Instead, this feature is a volcanic explosion crater, driven by expanding gas/water near the margins of the Matukuturua lava flow. This gives rise to its unusual shape and explains why the crater is not surrounded by a fully circular ring of ejected materials.

6.7 Formation of this crater could be the result of any of the following scenarios:

- Scenario 1: Water within sediment/soil beneath the actively moving lava flow being heated to gas-state and trapped, resulting in pressure build up and an explosion. This is common in areas where lavas flow over wet sediments/coastal areas.
- Scenario 2: Hot steam rising and being entrappedt within shallow sediments as magma rises near to the surface, but not erupting (a so-called phreatic eruption).

6.8 Scenario 2 is common in geothermal areas of New Zealand, and often unusual shaped craters form in relation to this mechanism (e.g. 2006 Raoul Island). Scenario 2 is also consistent with the formation mechanism of the nearby Puhinui Craters, and the Matukuturua crater could have formed at the same time as the three Puhinui examples. Scenario 2 could have occurred at any time after emplacement of the Matukuturua lava at 48,000 yrs. The sediment within the Matukuturua crater includes a minimum age estimate of 15,000 years B.P.

6.9 The remainder of the 79 McLaughlins Road site was examined and test pits dug in several locations to investigate whether original volcanic deposits are present. Aside from the area outlined in Figure 5, no further undisturbed volcanic deposits were found.

6.10 Conclusions from the field studies:

- The tuff ring identified should be re-classified as an explosion crater, probably driven by a single, one-off steam-driven eruption during rise of magma during or following the Matukuturua Lava flow eruption (at least >15,000 years old).
- Deposits of materials ejected from the subject crater lie primarily adjacent to it and are well described by the mapped extent of the ONF proposed by the Brown Report (see Figure 4).
- The remaining portion of the site at 79 McLaughlins Road (Area 1 in Figure 2) does not include primary volcanic deposits in place.

7.0 GEOLOGICAL VALUES ASSESSMENT OF ONF 93 WITHIN THE PLAN CHANGE AREA, APPLYING FACTORS SPECIFIED IN POLICY B4.2.2(4) OF THE AUP(OP)

7.1 This part of the report assesses the geological values of ONF 93 as mapped in the AUP(OP), in accordance with the factors set out in Policy B4.2.2(4). The evaluation of ONF 93 contains two discrete sub-areas:

- Area 1 (see Figure 2): This is the western part of ONF 93, located on the site at 79 McLaughlins Road, outside the Matukuturua crater. This is the area located outside the red line area in the Brown Report (i.e. the area not recommended for inclusion as an ONF). Area 1 includes small areas of lava flow that have been levelled and graded, but much of the area is not covered by volcanic deposits. Further, much of the area has been heavily modified by earthworks, and stormwater drainage works.

- Area 2 (see Figure 2): This is the eastern portion of the site at 79 McLaughlins Road that contains a portion of the Matukuturua crater. Area 2 forms part of the ONF 93 area recommended in the Brown Report (i.e. area within the red lines in Figure 4).

Table 1: *ONF 93 and Evaluation Factors in Policy B4.2.2(4)*

Evaluation Factors: Policy B4.2.2(4)		**Area 1**	**Area 2**
a	*The extent to which the landform, feature or geological site contributes to the understanding of the geology or evolution of the biota in the region, New Zealand or the earth, including type localities of rock formations, minerals and fossils.*	No contribution is possible because the area was not covered by volcanic deposits, or if it was, they have subsequently been removed/quarried.	This site represents a phreatic eruption crater – also known as a steam-driven explosion. It is likely representative of a type of "near-miss" eruption, where magma rises close to the surface but does not break through. This feature is very similar in character to the nearby Puhunui craters and they may be related. The feature thus contributes new insights to the understanding of the Auckland Volcanic Field.
b	*The rarity or unusual nature of the site or feature.*	Not applicable – there are no unusual features of this area.	The feature is one of four known features in this general vicinity (including the three Puhinui craters), and there are other similar features associated with some of the larger volcanoes of the field (e.g., around the One Tree Hill complex).
c	*The extent to which the feature is an outstanding representative example*	Not applicable – there are no original surfaces or deposits	The feature is one of four similar explosion craters in the vicinity (including the Puhunui Craters). It is

Evaluation Factors: Policy B4.2.2(4)		Area 1	Area 2
	of the diversity of Auckland's natural landforms and geological features.	representative of the volcanic history.	well preserved, and therefore has value as an example site of the diversity of Auckland's natural geological features.
d	*The extent to which the landform, geological feature or site is part of a recognisable group of features.*	The area lies adjacent to the Matukuturua Lava flow and crater and thus allows viewshafts to these.	This crater is associated with the Matukuturua Lava flow and is possibly also associated with the Puhinui craters.
e	*The extent to which the landform, geological feature or site contributes to the value of the wider landscape.*	The wider landscape includes industrial estate and reserve land. This forms a boundary between the two areas and an open green area. The Landscape Assessment Report also addresses this matter. I concur with the findings of the Landscape Assessment Report.	The crater is well preserved, particularly its eastern and southern margins. It is currently readily observed from McLaughlins Road, but is poorly visible from the Puhinui reserve to the south. Its unmodified parts (east and south rims) are valuable components of the wider landscape. The Landscape Assessment Report also addresses this matter. I concur with the findings of the Landscape Assessment Report.
f	*The extent of community association with, or public appreciation of, the values of the feature or site.*	There is currently no public access to this site, but a public walkway adjoins part of the area and it is visible from the Puhinui reserve. It currently allows viewshafts to the Matukuturua Lava flow and Matukutūreia cone.	There is currently very little community association or public appreciation of the values of this particular site, outside a few specialist geologists. It has mainly been overlooked, with the main values associated with the unmodified Matukuturua lava field to the east of the site.
g	*The potential value of the feature or site for public education.*	There is no potential value identified that could be explained to the public.	This site has some potential value for description as an aspect of the volcanic history of Auckland, but would require substantial documentation and development because, in its current state, the unique features of the site are very difficult to observe and explain to the non-specialist. Exposure of some of the deposits could add value to public explanation efforts. In its current form, the crater is unappreciated and, from a public/non expert perspective, non-unique. There

Evaluation Factors: Policy B4.2.2(4)		Area 1	Area 2
			are ways in which development could actually enhance this feature. Some ideas include the following, ranging from passive to invasive options: • Relocating the property boundary (with compensation to land owner) to encompass the crater margin and removing the fence line through the crater. • Return of vegetation to natural state on the site. • Exposure of part of the breccia rim (e.g., during adjacent development) to preserve an outcrop of the breccia – along with providing public access/visibility. This is essentially the only way in which the unique features of the site can be explained/demonstrated to the public.
h	*The potential value of the feature or site to provide additional understanding of the geological or biotic history.*	No potential – there are no volcanic history features. There are no unique sedimentary geology features, which can be better viewed at other localities.	It is unlikely that this site will provide more information on the history of the Auckland Volcanic Field because it appears that no fresh magma has erupted here. Only with invasive investigation (drilling, excavation) could there be any potential for geological investigation. With crater-fill drilling there could be possible biotic history additions to the Horrocks et al., 2007 study from crater-fill sediment.
i	*The state of preservation of the feature or site.*	This site is completely disturbed.	The site is largely unmodified on its eastern and southern margins, with the western margin modified by earthworks and quarry spoil, and parts of the north modified by earthworks.
j	*The extent to which a feature or site is associated with an historically important natural event, geologically related industry, or individual*	There are no famous geologists nor geological industries associated with this site.	There are no associations of this type for this site.

Evaluation Factors: Policy B4.2.2(4)		Area 1	Area 2
	involved in earth science research.		
k	*The importance of the feature or site to Mana Whenua.*	It is for mana whenua to comment.	It is for mana whenua to comment.

8.0 CONCLUSIONS

8.1 Area 1 (in Figure 2), which is currently included in ONF 93 in the AUP(OP), has no direct value as a primary geological feature, because this area either had no original volcanic cover, or those parts of it that did are highly modified, with much of the material removed. Although this area is identified as part of the ONF 93 in the AUP(OP), its relative value as a geological feature area is not supported. Overall, this area contains no value as a geological feature characteristic of the Auckland's Volcanic Field. It is not a prominent and conspicuous natural landform feature that stands out amongst the natural features across Auckland, nor can it be described as being "conspicuous, eminent and remarkable".

8.2 Area 2 (in Figure 2), encompasses the main geological value of ONF 93, which is restricted to the areas of the wetland (formed within the explosion crater) and the lava flow area that remains unmodified.

8.3 It is recommended that the property boundary should be relocated to encompass the margins of the wetland (Area 2) (with compensation to land owner) and to join this to the existing lava field area under protection.

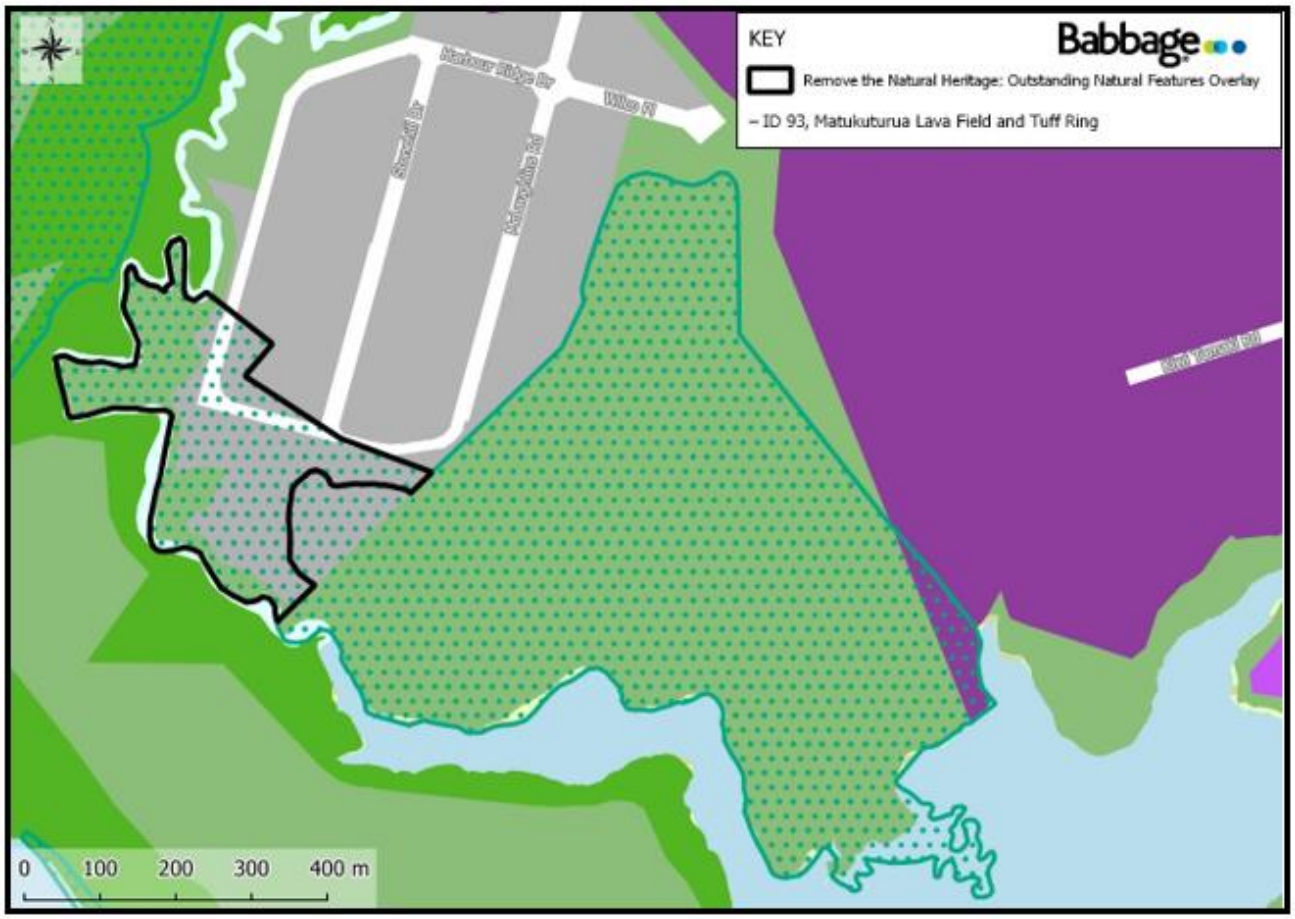
8.4 It is further recommended that there be a return of vegetation to natural state on the lava flow and the wetland site.

9.0 RECOMMENDATIONS

9.1 Based on the conclusions in section 8.0 of this report, the following amendments are recommended to the AUP(OP)

- **Amend the mapped extent of ONF 93 in the AUP(OP) as set out in Figure 7:**

Figure 7*: Part of ONF 93 recommended to be removed*



- **Amend the name and description of ONF 93 in Schedule 6: Outstanding Natural Features Overlay Schedule in the AUP (OP) as set out below.**

Item	Name	Location	Site Type	Description	Unitary Plan criteria met for scheduling set out in Chapter B4.2.2(4)
93	Matukutūreia and Matukuturua lava field and ~~tuff ring~~ explosion crater	Wiri	V (Large volcanic landforms)	The Matukuturua lava field is one of the best preserved lava fields remaining in the Auckland volcanic field and is an important representative example of the volcanic lava terrain that underlies much of the city. The lava field erupted from McLaughlins Mountain (Matukutūreia) volcano. Most of the original scoria cone and a section of the lava field in the north have been quarried away. Associated with the lava field is a section of ~~tuff ring~~ an explosion crater remaining from the early phases of the eruption. A small wetland has formed within the explosion crater ~~behind the ridge of tuff~~.	a, c, d, e, g, h, i

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