In the matter of Plan Change 69, of Selwyn District Council

Evidence of Associate Professor Peter Almond (Versatile soils)

Dated: November 9, 2021

## STATEMENT OF EVIDENCE OF PETER ALMOND

## INTRODUCTION

1. My name is Peter Craig Almond.
2. I am an Associate Professor at Lincoln University who has been engaged in teaching, research and administration for 30 years. I have a B.Sc. (Hons) from Massey University and a PhD in Soil Science from Lincoln University. I am a member and past President of the Australasian Quaternary Association, and a member of the New Zealand and American Societies of Soil Science and Geosciences New Zealand. I am a past Head of the Department of Soil and Physical Sciences at Lincoln University (2012-2017). Before my employment at Lincoln University I worked for DSIR Soil Bureau and the NZ Forest Service as a soil surveyor.
3. My research and teaching experience is in the areas of pedology, geomorphology, Quaternary geology and natural hazards. My specialty is in deciphering the patterns and properties of the soil in the landscape, both natural and agricultural; I have researched and published in the area of soil physics as well. I was involved in Canterbury Earthquake science response and recovery, focusing on ameliorating and understanding earthquake induced liquefaction. In 2019 I was lead author of a report to the Canterbury Regional Council reviewing their soil quality monitoring programme.

## CODE OF CONDUCT

4. I have read and am familiar with the Environment Court's Code of Conduct for Expert Witnesses, contained in the Environment Court Practice Note 2014, and agree to comply with it. My qualifications as an expert are set out above. Other than where I state that I am relying on the advice of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

## SCOPE OF EVIDENCE

5. I have been requested by Dr Timothy Curran to provide expert commentary on his submission.
6. Dr Curran's submission speaks to the need to prevent the loss of versatile soils that PC69 would cause if approved, both from a perspective of maintaining strategic food-growing resources and providing options in the landscape for protection of biodiversity. He argues that sustainable land use should entail land being used for its best available purpose, suggesting that on the Canterbury Plains this means that versatile soils should either be used for food production, or for the conservation and restoration of already highly-depleted indigenous biodiversity. The loss of versatile to urban development means that such land cannot be used for either highly productive agricultural activities or ecological restoration. My area of expertise does not reach to ecological restoration, so my evidence will be restricted to the matter of the versatility of soils in the boundary of PC69, and adjacent areas. Much of my evidence references the submission on *Versatile soils* of Katherine Ms

McCusker, acting for Rolleston Industrial Developments, who concludes that the area of "better soil for agricultural production is 4.6 ha (2%) of the soils" and "The remaining 189 ha (98% of the property) are imperfectly or poorly drained soils. The imperfectly or poorly drained nature of these soils provides limitations for land use.".

7. In preparing my evidence I have reviewed information on soils provided by:

    i. Manaaki Whenua Landcare Research's (MWLCR) S-Map spatial database;

    ii. Personal communication with MWLCR scientists;

    iii. The EM (apparent electrical conductivity) maps and soil map of Katherine Ms McCusker;

    iv. Personal communication with Associate Professor Alan Palmer of Massey University;

    v. Google Earth historical imagery;

    vi. Lidar elevation information;

    vii. The Land Use Capability (LUC) Survey Handbook (Lynn, 2009) and LUC maps.

8. In the first part of my evidence, I review the data available for assessing the versatility of soils. In the second part, I consider recent historical evidence for the intensity of land use that reflects on the versatility of soils.

## EVIDENCE

9. Dr Curran contends that if approved, PC69 would represent a loss of 190 ha of highly productive land (HPL) according to the definition of HPL in Draft National Policy Statement for Highly Productive Land. That definition (Ministry for the Environment, 2019) recommends interim adoption of Land Use Capability (LUC) classes 1-3 as the default for HPL. The land within the PC69 boundary is mapped according to the LUC mapping (Figure 1) as classes 1-3, and ostensibly Dr Curran is correct. I note in reproducing essentially the same map as in my Figure 1, Katherine Ms McCusker's report incorrectly assigns the area of LUC 3s (soil limitation) in Fig. 1 as 3w (wetness limitation). This error is significant because Ms McCusker argues that wetness significantly detracts from the versatility of the land in PC69. This error may have clouded her view.


*Figure 1. LUC mapping for PC69 area. Data from MWLCR LRIS portal.*

10. Ms McCusker argues that the LUC mapping is obsolete in this area as a means of assessing soil versatility, having been superseded by more recent soil mapping delivered via MWLCR's S-Map spatial database (Lilburne et al., 2012). Furthermore, she claims to have more refined soil mapping developed from an auger survey conducted by Aaron Stafford, whom Ms McCusker incorrectly describes as a Lincoln University student, and an apparent soil conductivity (EMa) survey conducted by Agri Optics Ltd in July 2014.

11. I concur with Ms McCusker that S-Map is a more reliable database than the LUC mapping. However, a limitation of S-Map as it is currently configured is that it does not allocate soils to LUC classes and therefore cannot be used "off the shelf" to determine land parcel LUC. Another limitation of S-Map is that is derived from an intensity of soil survey that is designed for 1:50,000 scale mapping (Lilburne et al., 2012) and consequently it is not optimized for land management at farm and paddock scales. In response to the limitations of the precision of S-Map, Ms Ms McCusker used the higher resolution map she developed as described above as the basis of her conclusions. The map was originally constructed by Assoc. Prof Alan Palmer of Massey University with whom I have been in contact. He noted the poor correspondence of the EMa data and the soil types observed from the auger survey, which suggests either unsuitability of EMa data for soil survey in this area, or a misrepresentation of the soil pattern from the auger data, referring me to a paper he co-authored on the matter at a Soil Science conference in 2016 (Palmer and Manderson, 2016). It is my view that the soil map Ms Ms McCusker has used, despite being of greater precision, is not more accurate than S-Map (here I draw distinction between precision and accuracy) and my interpretations of the areas of the versatility of soils is based on S-Map delineations (Figure 2). See Appendix 1 for my justification.

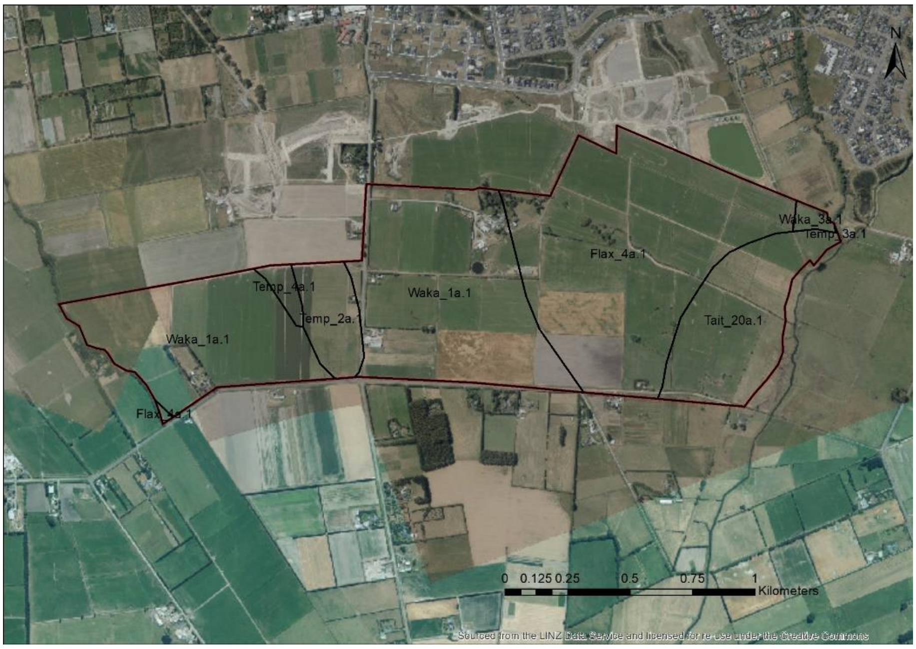


*Figure 2. S-Map soil mapping units. Data from MWLCR LRIS portal.*

12. As part of recent research comparing S-Map data with older data (Lilburne et al., 2020), scientists at MWLCR have developed automated routines to convert S-Map data into LUC classes. They have provided me with this unpublished dataset (Ian Lynn *pes. comm.;* MWLCR). S-Map maps a category of soil called soil siblings. Map units include multiple soil siblings, but the symbol on a map unit shows the dominant sibling only. Appendix 2 shows the correspondence between siblings within map units and their LUC classification. I have adopted the LUC class of the dominant sibling in a map unit to develop Figure 3. For the Flax_4a unit siblings Flax_4 and Temu_18 have equal abundance. In this case, I have adopted the higher LUC class (3w for Flax_4 versus 4w for Temu_18).

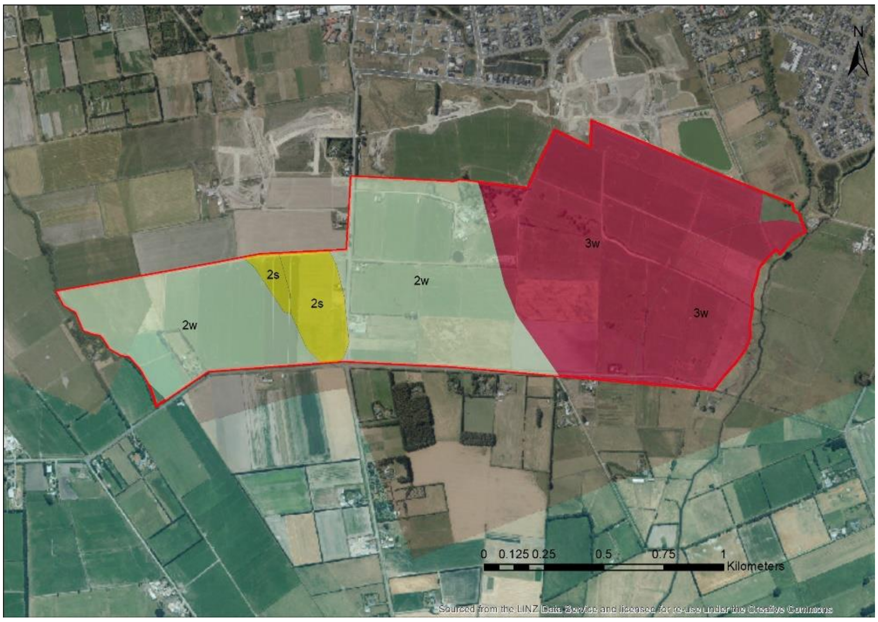


*Figure 3. LUC units derived from S-Map.*

13. Areas of class 2s land (11.5 ha) correspond with moderately well-drained Templeton soils and have a limitation related to soil depth. Areas of class 2w land relate to imperfectly drained Wakanui soils (88.2 ha), which have an identified limitation of soil wetness. Areas of class 3w land (97.7 ha) include poorly drained Flaxmere and Taitapu soils, which have a dominant limitation of soil wetness. A soil drainage map derived from S-Map is provided in Figure 4 as a complement to Figure 3

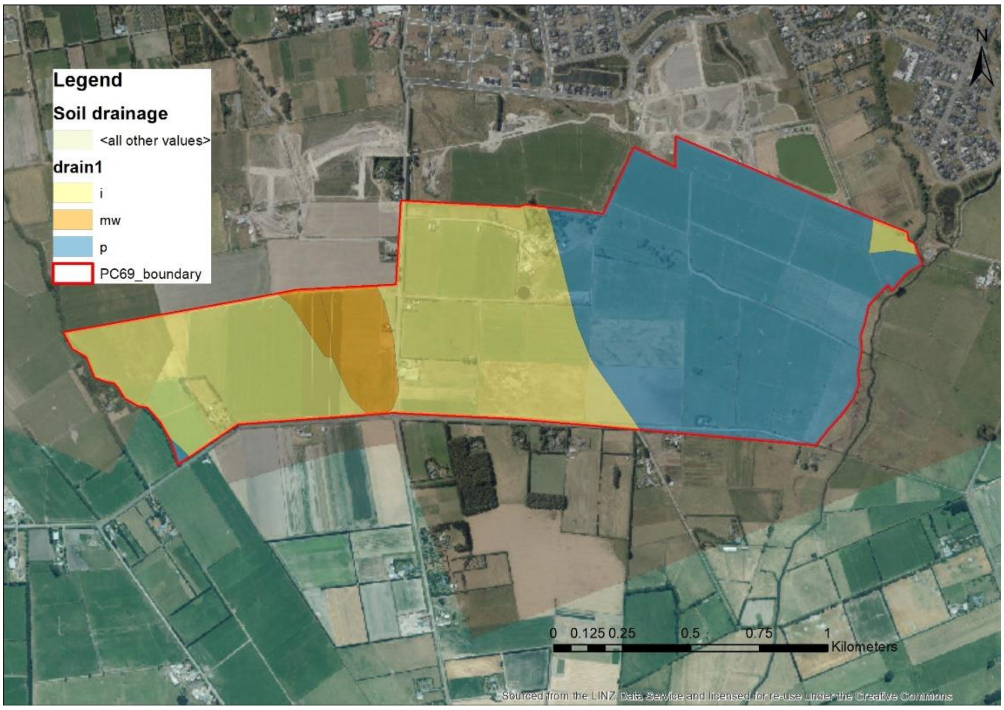


*Figure 4. Soil drainage derived from S-Map. i = imperfect, mw = moderately well, p = poor.*

14. Ms Ms McCusker argues that only the area corresponding to Templeton soils (4.6 ha on her map) are multiple-use soils (11.5 ha on S-Map), and thus PC69 represents an insignificant loss of versatile soils. Her analysis discounts the LUC class 2 Wakanui soils on the basis of anecdotal evidence that being imperfectly drained they are often too wet to be of high value.

15. To address the versatility of Wakanui soils I have considered historical imagery available via Google Earth of the frequency of cultivation as a proxy for versatility of land. Ms Ms McCusker contends that the wetness of the Wakanui soils is a limitation to the ability to cultivate. Historical imagery covering PC69 is available for the dates Nov-20, Nov-19, Feb-19, Aug-18, Nov-17, Apr-17, Nov-16, Jul-16, Nov-15, Jul-15, Apr-15, Jul-14, Jan-14, Aug-13, Mar-13, Jun-12, Feb-11. The frequency of cultivation is shown in Figure 5 below. Defining culitvation events was restricted as best as possible to those that involved ploughing, though it is possible, owing to the resolution of the satellite images, that some events may have been limited to spraying out and drilling. In the 10 years of imagery, paddocks in the area of Wakanui soils (LUC class 2w) have been cultivated up to three times, and no less frequently than the Templeton soils (LUC class 2s). An area of Wakanui soils immediately south of PC69 on the other side of Collins Rd used for market gardening (see Market Garden in Figure 5) has been cultivated 16 times. The cultivation proxy alongside the LUC classification of the Wakanui soils is strong evidence that they are versatile and highly productive soils. The different frequency of cultivation between the Wakanui soils within and outside of the

boundary of PC69 is attributable to contrasting current land uses rather than inherent land use capability: predominantly pastoral farming involving phases of pasture renewal and winter feed crops within, and market gardening without.

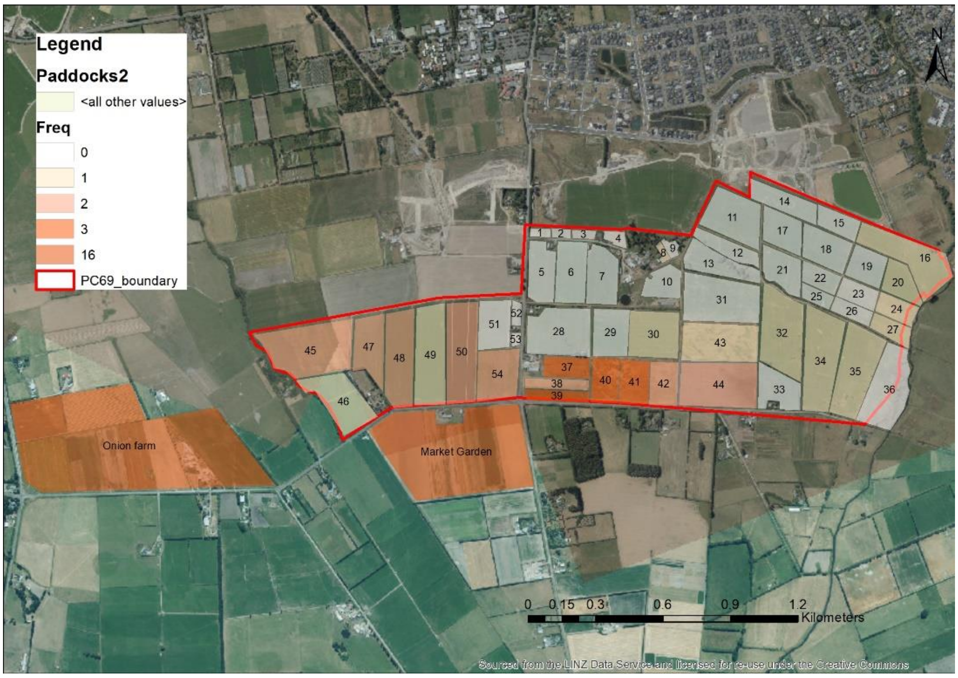


*Figure 5. Frequency of cultivation of paddocks in and adjacent to PC69. Shading and numbers in the legend refer to the number of times paddocks have been cultivated in the 10 years between February 2011 to November 2020 based on archived imagery in Google Earth.*

16. Turning attention to the c. 98 ha of poorly drained Flaxmere and Taitapu soils, paddocks have been cultivated no more than once, with a single exception (Paddock 44), which most likely reflects the limitations of high water content at critical times of year. Nonetheless, I note that Roper's onion farm less than 1 km west of the boundary of PC69 on Flaxmere soils (identical map unit) has been cultivated 16 times in the 10 years from 2011 to 2020 (Figure 5).

## ANCILLARY INFORMATION

17. From my experience of liquefaction mapping and research after the Christchurch Earthquake Sequence of 2010-2014 I am aware of effects of cyclic (earthquake induced) stresses on land with shallow groundwater near Lincoln and elsewhere. I include mapping of liquefaction-related effects on PC69 in Figure 6. It is clear the areas of poorly drained Flaxmere and Taitapu soils suffered significant ejection of pressurized groundwater to the surface in both earthquakes. Although I disagree with Nick Boyes' (Consultant Planner) conclusions in his submission about losses of versatile soils (see below), I concur with him that wetness in the area of poorly drained soils poses multiple limitations to housing.

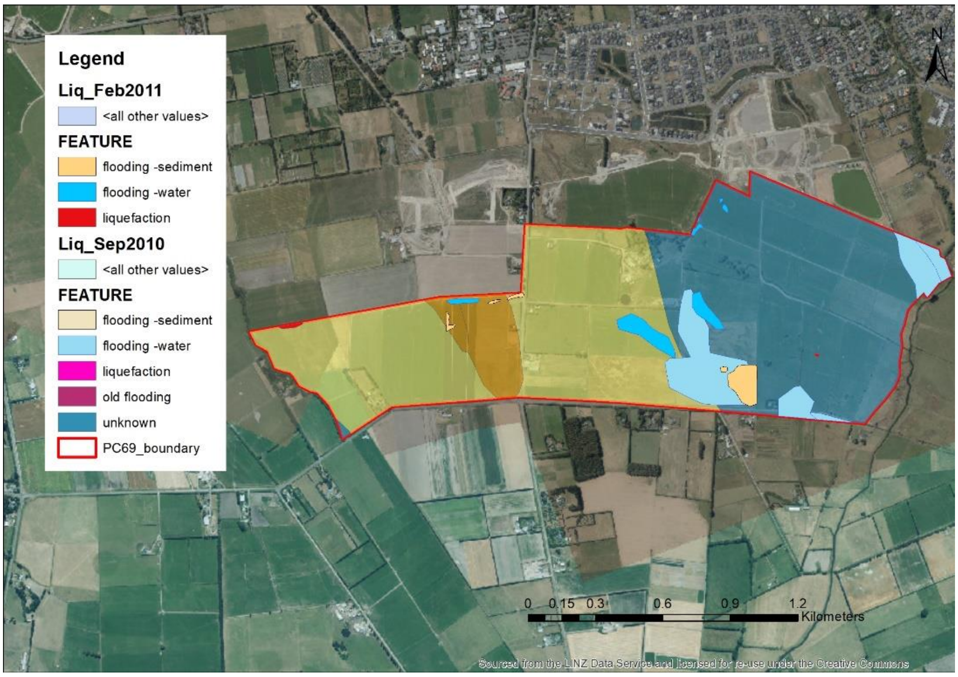


*Figure 6 Liquefaction mapping in PC69 for the September 2010 and February 2011 earthquakes of the Canterbury Earthquake Sequence (Townsend et al., 2016)*

## FINAL OBSERVATION AND PERSONAL COMMENT

18. Nick Boyes in paragraph 64 of his submission states "I consider that PC69 would represent a moderate loss of the overall Class 1 and Class 2 versatile soil resource within the region. This is mitigated to some extent by the soils within PC69 area being heavier and poorly drained when compared to other areas containing Class 1 and 2 soils around Lincoln, including those to the northwest which have recently been developed for urban purposes. I find the implication that a potential future loss of versatile soils is somehow mitigated by a previous loss to be bewildering. Extrapolating this reasoning to the climate crisis where inherent limits also apply, we would consider the mass of coal previously burnt as a mitigating circumstance for burning more coal.

## CONCLUSION

19. The land within the PC69 boundary is dominated by soils that are considered HPL (LUC classes 2-3) within both older LUC mapping and a LUC classification derived from more recent S-Map soil data.

20. LUC class 2 land in and around PC69, both technically and empirically, satisfies criteria for versatile, highly productive land. If PC69 is approved there would be, conservatively, a loss of c. 100 ha of HPL.

21. Less conservatively, if LUC class 3 Flaxmere soils in PC69 were considered HPL (as demonstrated by nearby farming activities and its LUC 3 classification) the loss of HPL would amount to 170 ha.

22. The poorly drained land of PC69 poses liquefaction-related hazards for residential development. These hazards would require mitigation.

23. The submission by Katherine Ms McCusker is flawed in my opinion having not considered obvious evidence of the versatility of LUC class 2w land in PC69 and significantly under-estimates the area of HPL.

## REFERENCES


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## APPENDIX 1 THE SOIL PATTERN IN THE LINCOLN AREA

1. The soil pattern in the area of Lincoln is largely determined by the interaction of the deposition of river sediment (alluvium) from distributory channels of the Waimakariri about 3,000 to 6,000 years ago (Templeton age, Cox and Mead, 1963) and local groundwater conditions.
    - The distributory channels themselves are associated with well-drained, stony Eyre soils formed in channel gravels with a thin fine-textured veneer;
    - The levees on the margins of these channels are associated with deep, fine sandy, moderately well-drained Templeton soils;
    - The zones outboard of the levees breached by past floodwaters have imperfectly drained Wakanui soils formed in a mix of silt and sand;
    - In the flood basins away from the former channels where the groundwater is relatively high, the finest sediment settled to form silty to clayey textured poorly drained (Flaxmere and Temuka) soils
    - On the lowest part of the floodplains where naturally the water table was at or above the surface (back swamps), very poorly drained organic (peaty Waimairi) soils formed. More recent (< 600 years) deposition from a distributary lobe of the Waimakariri river occupying what is now the Halswell river deposited silts and clays to form the recent gley Taitapu soils which bury peats in places.

The broad correspondence of the S-Map soil map with the landforms of the area Fig. A1 A and B contrasts with the poor alignment with the Ms McCusker map (Fig. A1 C).

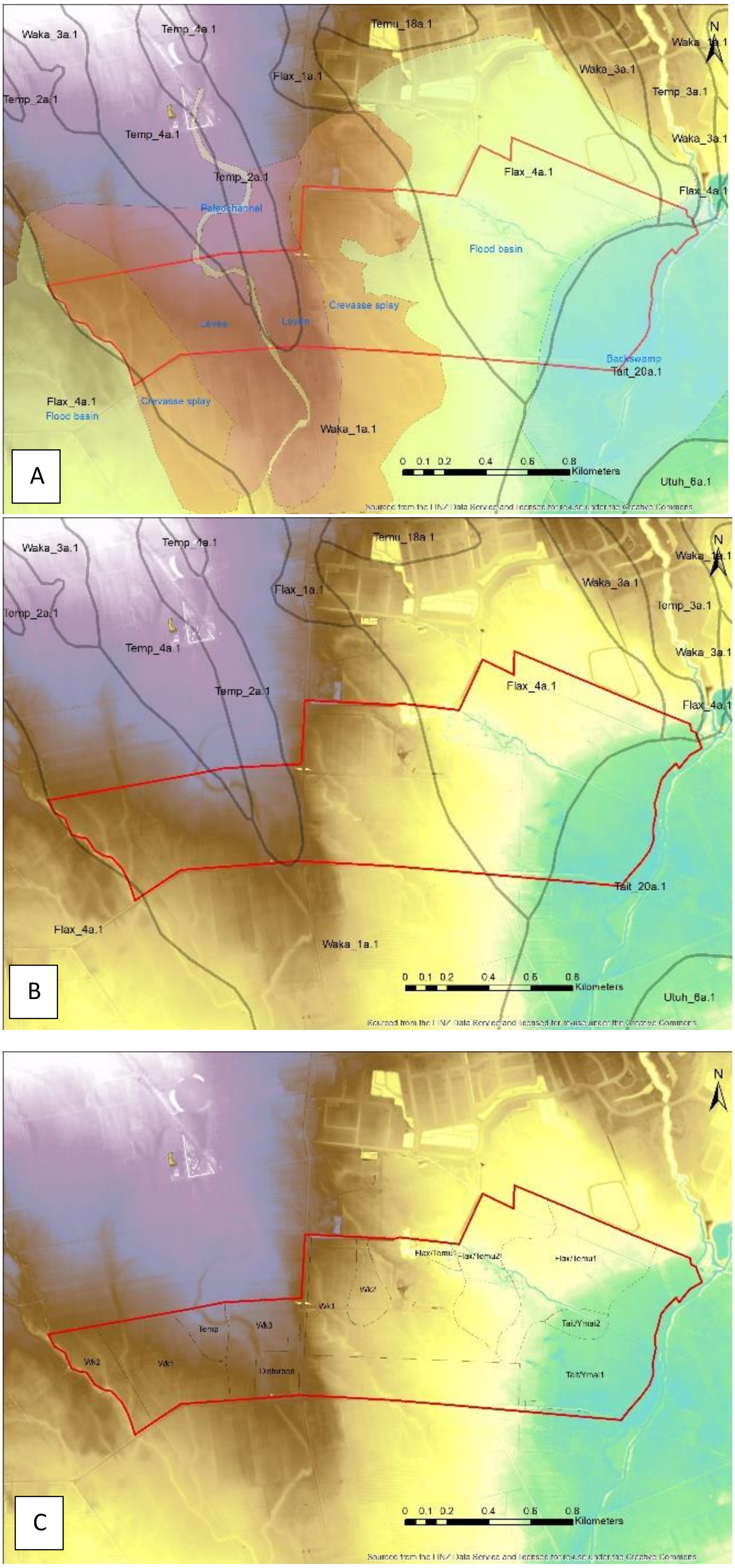


*Figure A 1. Soil patterns depicted in relation to lidar elevation data and landforms: A and B S-Map soil data; C Ms McCusker soil map. Lidar data downloaded from LINZ Spatial Data Portal.*

## APPENDIX 2

Table A1. Translation of S-Map soil siblings to LUC class (Ian Lynn, MWLCR *pers. comm.)*

| Map unit code | S map siblings | % | LUC Class (@ best) |
|---|---|---|---|
| Waka_1 | | | |
| | Waka_1 | 80 | 2w |
| | Waka_3 | 20 | 2w |
| Temp_4 | | | |
| | Temp_4 | 50 | 2s |
| | Temp_3 | 30 | 2s |
| | Temp_2 | 20 | 2s |
| Temp_2 | | | |
| | Temp_2 | 60 | 2s |
| | Eyre_1 | 20 | 3s |
| | Eyre_3 | 10 | 3s |
| Flax_4 | Flax_4 | 50 | 3w |
| | Temu_18 | 50 | 4w |
| Tait_20 | Tait_20 | 50 | 3w |
| | Ymai_16 | 25 | 4w |
| | Tait_16 | 25 | 2w |