Evaluation of soils for the PNCC Residential Growth Review

Soils and Land Use Capability of the Kelvin Grove, Anders Road and Race Course Growth Options

July 2010

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Evaluation of soils for the PNCC Residential Growth Review: Soils and Land Use Capability of the Kelvin Grove, Anders Road and Race Course Growth Options

AgResearch

July 2010

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1. Executive summary

- The Palmerston North City Council (PNCC) Residential Growth Review is currently examining options for urban growth out to 2029. One of the more important Review requirements (weighted with high priority) is to avoid urban growth into areas that will result in a significant loss of high class soils.

- AgResearch has been contracted by PNCC to investigate high class soils of three preferred Review growth options (Racecourse, Anders Road, and Kelvin Grove).

- Soils have been surveyed at a 1:8,000 scale for the Racecourse (110 ha), Anders Road (233 ha), and the Whakarongo sub-block (43 ha) of the Kelvin Grove growth option. Somewhat more predictable soils of the Kelvin Grove high terraces (155 ha) have been verified at a 1:15,840 scale.

- Land Use Capability (LUC) has been classified at the same scale. LUC classes 1 and 2 are used to define 'high class soils'. Maps of soils and LUC are used to report the distribution of high class soils across each of the three growth options.

- Land use and land cover has been mapped at a detailed scale to examine peri-urban fragmentation and the availability of high class soils for commercial cropping uses.

1.1 Conclusions: Racecourse growth option

- Rezoning the Racecourse block for urban development would result in the loss of significant areas of high class soils. Over 90% of the area (101 ha) has either elite LUC 1 soils (56% of block area) or high capability LUC 2 soils (36%) (Map A).

- Extensive peri-urban fragmentation is already evident for much of the Racecourse block. 90% of land use parcels are smaller than 5 ha. Lifestyle blocks* account for 45% of parcels and 24% of land area. Only 43% of high class soils are considered available to commercial cropping in a practical sense (Map B). This suggests that previous policies have been less than successful in avoiding the loss of significant areas of high class soils.

- Despite this, the remaining soils are dominated by agriculturally elite and scarce LUC 1 soils. If soils are to be protected for future uses, then it is these soils that should be afforded greatest protection.

* The term 'lifestyle block' is used in this report to refer to smaller parcels of land that include a residence and one or more (often small) paddocks. Use is primarily residential and it is highly unlikely that agriculture represents a significant source of income.
1.2 Conclusions: Anders Road growth option

- Rezoning the Anders Road block for urban development would result in the loss of significant areas of high class soils. Almost 90% of the area (208 ha) qualifies as LUC classes 1 and 2 (Map A).

- Extensive peri-urban fragmentation is also evident. 95% of land use parcels are smaller than 5 ha. Lifestyle blocks represent 74% of parcel count and 40% of land area. Only 49% of high class soils are considered available to commercial cropping (Map B). Again, previous policy appears to have been unsuccessful in protecting the high class soils of this block.

- Available high class soils of the Anders Road growth option comprise elite LUC 1 soils (9%), good LUC class 2 soils that respond well to first order drainage (34%), and a balance of LUC 2w02b soils that require second order drainage (57%).

- LUC 2w02b soils are poorly drained and tend to have finer subsoil textures that make them less responsive to first order drainage. Wetness is generally moderate but this can be reduced to slight under second order drainage.
(hence 2w rather than 3w). However, second order drainage may not be feasible for some properties due to drainage network issues, or because of pocket inclusions of 3w soils that can have a disproportionate influence on how paddocks are managed.

1.3 Conclusion: Kelvin Grove growth option

- Rezoning the Kelvin Grove high terraces for urban development would not result in the loss of significant areas of high class soils. LUC class 3 soils dominate (Marton and Milson silt loams). It is not considered feasible to modify the clayey textures and fragipans that attribute these soils with a moderate degree of limitation.

- Rezoning the Kelvin Grove Whakarongo block for urban development would result in the loss of significant areas of high class soils. Approximately half
the area has LUC 2 class soils (21 ha). However, if this block is considered as part of the full Kelvin Grove growth option, then the area of high class land might be interpreted as being of less significance.

- Parcel fragmentation is evident, but less so relative to the other growth options. Only 25% of land use parcels are smaller than 5 ha (for both the high terraces and Whakarongo sub-blocks). Lifestyle blocks account for 55% of parcel count, but the prevalence of large farming parcels (10 parcels covering 126 ha or 65% of total block area) means lifestyle-block area is relatively small (17% of total area). For the area of high class soils (21 ha), 67% (14 ha) is considered available for commercial cropping purposes.

- From a high class soils perspective, the Kelvin Grove block is the most suitable growth option of the three considered. However, expansion would result in the further loss of 14 ha (21 ha in total) of high class soils.
2. Introduction

The Palmerston North City Council (PNCC) Residential Growth Review is looking to identify areas suitable for residential expansion and growth out to 2029. Eighteen potential expansion areas around the City have been considered (see PNCC, 2009), three of which have been nominated for further investigation.

AgResearch have been contracted to undertake a detailed investigation of the three nominated areas in terms of soils, land capability (high class vs. low class soils), and existing land use.

2.1 Residential Growth Review criteria regarding soils

One of the Growth Review’s highest priorities is to avoid residential expansion into areas that would result in the loss of significant areas of high class (1 and 2) soils (PNCC, 2009., p.17). How this is meant to be interpreted is made explicit:

*Urban growth should mainly occur on high terrace soils... [such as] Marton, Milson and/or Tokomaru soils... urban growth should not normally occur on “recent soils of the river flats” or on “gleyed recent and gley soils of the river flats”* (p. 18).

2.2 What are high class (1 and 2) soils?

The Land Use Capability (LUC) system (Lynn et al., 2009) is used in this study to differentiate ‘high class soils’ from other soils (as requested by PNCC). Specifically, LUC classes 1 and 2 are used to represent ‘high class soils’ (Fig. 1), or more correctly, as land with soils rated as having a high value for food production.

![Diagram of LUC classes](image)

**Figure 1:** LUC classes 1 and 2 are used in this study to represent ‘high class soils’ (diagram adapted from Lynn et al., 2009).
2.3 Study locations

PNCC required three locations to be examined as part of this study (Map 1).

2.3.1 Racecourse growth option
Approximately 110 hectares of land along the City’s eastern edge, bounded by Pioneer Highway, Shiffiffs Road, and the Mangaone Stream.

2.3.2 Anders Road growth option
Approximately 233 hectares of land located adjacent to the north of the Racecourse growth option, bounded by Rongotea Road, No.1 Line (Longburn), and the Mangaone Stream.

2.3.3 Kelvin Grove growth option
Approximately 197 hectares of land located between James Line, Stoney Creek Road, Napier Road (SH3), and just to the north of Kelvin Grove Road. This includes the Whakarongo subblock (42 ha between Napier Rd/SH3 and the railway line).

Map 1: Study site locations (map contains Crown copyright data).
2.4 Study objectives

- Undertake detailed soil mapping and Land Use Capability classification of the Racecourse, Anders Road and part Kelvin Grove (Whakarongo subblock) Growth Options.

- Validate existing soil map and Land Use Capability classifications for part Kelvin Grove (upper terraces) Growth Option.

- Evaluate current land use and land cover for the three growth option areas.

- Produce a report that presents survey results and a commentary regarding the availability of high class soils across the three growth option areas.
3. Method

3.1 Soil survey

Preliminary work involved reviewing soil reports, maps and recognised soil distribution models (Cowie, 1974; Cowie & Rijkse, 1977; Cowie & Osborn, 1977; Cowie, 1978). Fieldwork involved detailed survey, observations and descriptions based on national guidelines and methods (Taylor and Pohlen, 1970; Milne et al., 1995).

PNCC circulated a letter prior to fieldwork to inform residents that a soil survey was to be undertaken. Where possible, residents were engaged before a property was entered. Not all properties were entered because of dogs, security, obvious extensive soil disturbance, or a confident understanding of soil type distribution had already been gained from mapping the surrounding area.

3.1.1 How soils were mapped

By their nature soils are hidden from view and are therefore difficult to map. Conventional soil survey involves making a number of soil observations by digging or augering a hole, and then relating those observations to more readily discernable landscape features such as changes in elevation, landform, or proximity to landscape forming features (e.g. rivers). Specialist tools and technologies are used to help with this process.

A minimum of 718 soil profile observations were made for the Anders Road, Racecourse and Whakarongo blocks (Map 2), mostly as dutch auger samples and soil profile pits. This equates to a mapping scale of approximately 1:6,300 to 1:7,900 (Table 1). Other observations were made, especially when determining the extent of a given soil, but were not described or recorded.

Table 1: Survey intensity and equivalent survey scale.

<table>
<thead>
<tr>
<th>Block</th>
<th>Area (ha)</th>
<th># observations</th>
<th>Intensity (obs/ha)</th>
<th>Equiv. scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whakarongo</td>
<td>42.5</td>
<td>88</td>
<td>2.1</td>
<td>1:6,900</td>
</tr>
<tr>
<td>Anders Road</td>
<td>233</td>
<td>361</td>
<td>1.5</td>
<td>1:7,900</td>
</tr>
<tr>
<td>Racecourse</td>
<td>110</td>
<td>269</td>
<td>2.5</td>
<td>1:6,300</td>
</tr>
</tbody>
</table>
Map 2: Minimum of 718 soil profile observations were recorded for the survey.

Soil boundaries were delineated using a combination of intense localised augering (for disturbed soils, or soils that related poorly to landscape features) and landscape interpretation, both visually (i.e. in the field and mapped onto aerial photography) and in the office using historical photography and high resolution elevation data supplied by PNCC (Table 2). A3 size aerial photo images printed at a 1:3,000 scale were used to initially record soil boundaries.

Table 2: Spatial data and resources used to assist the survey.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural city wide aerial photos</td>
<td>0.5m resolution colour orthophotos captured 2009.</td>
<td>PNCC</td>
</tr>
<tr>
<td>Urban city wide aerial photos</td>
<td>0.125m resolution colour orthophotos captured 2007 (90% of study area).</td>
<td>PNCC</td>
</tr>
<tr>
<td>Rural infrared imagery</td>
<td>0.5m resolution infrared orthophoto imagery captured 2009.</td>
<td>PNCC</td>
</tr>
<tr>
<td>LiDAR elevation data</td>
<td>Cleaned point elevations from PNCC’s 2005 LiDAR survey (sub-meter horizontal and sub-centimetre vertical resolution).</td>
<td>PNCC</td>
</tr>
<tr>
<td>LINZ orthophotos</td>
<td>2.5m greyscale orthophotos captured 2001.</td>
<td>LINZ</td>
</tr>
<tr>
<td>NZLRI soils</td>
<td>1:50,000 scale database of land resources including soils.</td>
<td>AgR</td>
</tr>
<tr>
<td>1:63k soils</td>
<td>Soil map of Kairanga County (Cowie, 1978) at 1:63,360 scale.</td>
<td>AgR</td>
</tr>
<tr>
<td>1:15k soils</td>
<td>Soil map of Palmerston City and Environ (Cowie, 1974) at 1:15,840 scale.</td>
<td>AgR</td>
</tr>
</tbody>
</table>
For areas of limited access, disturbed soils, and/or difficult soils, interpretations were aided by Des Cowie’s original soils maps (Table 2). Cowie was an excellent soil surveyor and it is likely he had access to resources and knowledge we no longer have (e.g. historical flooding patterns, soil profiles exposed by our then well maintained drainage networks, less disturbed soils, and farmers who knew their soils and land development history).

3.1.2 Reference profiles

Soils are rarely, if ever, the discrete entities represented as delineated units on soil maps. Rather, they are a complex continuum resulting from many soil forming factors interacting together over extended periods of time. Most ‘soils’ gradually transition from one to another, and a mapped soil boundary is more an acknowledgement of change rather than an absolute line of change. Similarly, depending on survey scale and the nature of the soil being examined, a given soil unit can contain many smaller inclusions of different soils that are otherwise too complex, or too small to map using conventional techniques.

Reference profiles are used to describe the most representative soil encountered within a mapped soil unit. They typify the most common, dominant or characteristic soil found within the unit.

Twenty-nine reference profiles have been prepared for the soils of Anders Road, Racecourse and Whakarongo blocks (Appendix 1). Most refer to dominant soil types and phases, but several double-ups are included to show the type of variation encountered with more difficult soils.

3.1.3 Verification of Kelvin Grove soils (upper terraces)

Soils of the upper Kelvin Grove block terraces were mapped by Cowie (1974) as Marton and Milson silt loams. The continuous layer of loess these soils have formed from means they tend to be more predicatable and exhibit less soil type variation than soils found on the flood plains. It is therefore unlikely that resurveying the area would have resulted in any significant improvement in Cowie’s original 1:15,840 soil map.

A verification exercise was undertaken to confirm Cowie’s original observations. This involved reviewing Marton and Milson reference profiles (Cowie, 1978), and walking a south-north transect across the block making soil profile observations at points where the landscape was least affected by erosion or fluvial processes.
3.2 Land use survey

The opportunity was taken to map land use and cover during the soil survey. Initially the land use component was mapped using cadastral parcels from the Core Record System (CRS) as the base mapping unit. However, a proportion of parcels within the study area are leased as standalone units (especially company or corporate owned land associated with the equine industry) and are operated as separate enterprises with their own facilities and often with one or more residences. Conversely, some farming enterprises comprise two or more legal parcels.

Land use categories (Table 3) were allocated to parcels according observations made during the survey. The survey represents a snapshot in time based on our interpretation. Land use classifications for large agricultural blocks were checked against AsureQuality’s AgriBase database. Not all properties on the high terraces of the Kelvin Grove block were visited; classifications were made remotely using orthophotography.

Table 3: Land use classifications.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock farming</td>
<td>Beef, sheep, deer and grazing operations (generally larger scale commercial operations). Includes mixed arable operations.</td>
</tr>
<tr>
<td>School</td>
<td>Whakarongo primary school and grounds.</td>
</tr>
<tr>
<td>Cemetery</td>
<td>Kelvin Grove Cemetery.</td>
</tr>
<tr>
<td>Equestrian</td>
<td>Horses, including horse cells, grazed paddocks, and practice areas.</td>
</tr>
<tr>
<td>Horticulture</td>
<td>Wide definition: flowers, vegetable growing, orchard trees, nurseries.</td>
</tr>
<tr>
<td>Lifestyle block</td>
<td>Where the primary use is residential but includes one or more small lightly-used paddocks (often grazed by one or two horses or cattle, or a handful of sheep). Highly unlikely that farming is the primary income.</td>
</tr>
<tr>
<td>Commercial</td>
<td>Engineering, transport, veterinary establishment.</td>
</tr>
<tr>
<td>Residential</td>
<td>Use is wholly domestic and generally includes curtilage, gardens, residential buildings and structures, and occasionally sizeable paddocks that are regularly mown rather than grazed.</td>
</tr>
<tr>
<td>Public</td>
<td>River, stream, roads, road edges, waste land, railway land.</td>
</tr>
</tbody>
</table>
Land cover was mapped using a combination of detailed aerial photography and field observation. Primary purpose was to identify land still available for commercial agricultural applications. Many of the land cover categories (Table 3) are considered semipermanent; that is, it is unlikely they will be removed in the foreseeable future (e.g. structures, facilities and hard surfaces).

Table 4: Land cover classifications.

<table>
<thead>
<tr>
<th>Land cover</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>Buildings, water tanks, sheds and other structures.</td>
</tr>
<tr>
<td>Crop</td>
<td>Food or fodder crop at the time of survey.</td>
</tr>
<tr>
<td>Farm curtilage</td>
<td>Yards, wasteland, service areas, areas around sheds, farm tracks.</td>
</tr>
<tr>
<td>Residential curtilage</td>
<td>Lawns, gardens, etc.</td>
</tr>
<tr>
<td>Horse cells</td>
<td>Holding pens or very small horse paddocks.</td>
</tr>
<tr>
<td>Horticulture</td>
<td>Orchards, commercial flower beds or vegetable plots</td>
</tr>
<tr>
<td>Hard surfaces</td>
<td>Roads, driveways, patios, car parks, any other concrete, paved or bitumen</td>
</tr>
<tr>
<td>Open water</td>
<td>Ponds, river, streams.</td>
</tr>
<tr>
<td>Pasture</td>
<td>High and low quality pasture.</td>
</tr>
<tr>
<td>Woody vegetation</td>
<td>Trees, shelterbelts.</td>
</tr>
</tbody>
</table>

Lastly, both land cover and use were used to produce a final classification of land that is no longer considered readily available for commercial farming purposes. This interpretation is based on observed current use, ownership, subdivision intensity, and semipermanent land cover, all relative to the practicalities and requirements of a commercially viable cropping operation.

For simplicity, lifestyle block land is not considered to be available for commercial farming activities.
3.3 Land Use Capability (LUC) Classification

Land Use Capability (LUC) is a rating of land quality for agriculture. It is defined as a systematic arrangement of different kinds of land according to those properties that determine its capacity for long-term production (Lynn et al., 2009, p.8), whereby ‘capability’ refers to suitability for productive uses.

The classification has an extensive history of use (developed in 1930s; now used in over 60 countries; used widely in NZ since late 1940s), including its consistent use as a tool to help inform the urban expansion and high class soils debate.

The LUC classification is applied in two stages. Firstly, fieldwork is undertaken to describe units of land in terms of petrology, edaphology, topography and biotic features (rock type, soils, erosion type and severity, slope and vegetation). This is a factual description of the land (referred to as Land Resource Inventory or LRI) and is undertaken according to national standards (i.e. Lynn et al., 2009).

Secondly, LRI is used with other information to rank land into one of eight capability classes (Fig. 2). LUC Class 1 represents prime agricultural land, while LUC Class 8 land effectively has no agricultural value whatsoever. Classes 1-4 are considered suitable for commercial cropping purposes (see previous Fig. 1) while Classes 1 and 2 are used in this project to represent ‘high class soils’.

Each LUC Class can be further categorised into subclasses according to the dominant physical factor limiting production (excessive wetness, soil limitations in the root zone, erodibility or climate). Each subclass can be further subcategorised into LUC units that indicate a fine degree of limitation, and/or different management requirements necessary to achieve the most sustainable productive use. Classifications are made according to national standards and regional standards particularly at the LUC unit level.

Figure 2: Structure of the LUC classification (adapted from Lynn et al., 2009).
Land Resource Inventory was not prepared for this project on the basis that soils were the dominant inventory factor that would decide LUC. Put another way, other inventory factors were largely constant. For example, rock type across the study area was either alluvium or loess; slope was generally flat (0-3\(^{\circ}\)); erosion was mostly negligible; and pasture was by far the dominant vegetation cover. The limited variations encountered (e.g. some rolling to steep slopes on terrace scarps) were readily accounted for in the soil descriptions.

A provisional LUC classification was made based on national standards at the LUC class and subclass level. Of note was our initial classification of some fine textured Kairanga and Te Arakura soils (Racecourse and Anders Road blocks). These soils were provisionally classed as LUC 3w because they exhibit seasonal wetness or waterlogging after drainage, to levels that definitely restrict the choice of crops and the intensity of cultivation under an arable use (italics are part criteria for LUC 3 land – see Lynn et al., 2009, p.56).

We did not immediately consider these soils to have only a slight wetness after drainage that posed only slight physical limitations to arable use, readily controlled by management and suitable for many cultivated crops (italics are part criteria for LUC 2 land – ibid. p.53). Rather, we considered the seasonal wetness of these soils as a significant management issue that restricts the crop choice, growing season, crop yield, and in worst cases, the ability to physically harvest the crop (evidence of harvesters getting bogged).

However, it needs to be stressed that the LUC classification criteria for wetness and arable use are very subjective (see italics in previous paragraph). Further, these particular soils are generally rated more highly within regional LUC classifications (e.g. Fletcher, 1987; Page, 1995; Harmsworth, 2009), by soil experts (e.g. Cowie, 1974; Cowie, 1978; Cowie & Osbourne, 1977; Cowie & Rijkse, 1977; Wilde, 2003; Wilde, 2009), and even by Council itself (PNCC, 2008: Clause 163-08 resolution implies ‘gleyed recent and gley soils of the river flats’, which include Te Arakura and Kairanga soils, are high class soils that should be protected).

Obstinately, however, this support does not make the distinction between a ‘slight wetness limitation’ (LUC 2w) and a ‘moderate wetness limitation’ (LUC 3w) any clearer. Neither does the classification of LUC by profile hydromorphic features (Lynn et al., 2009, p.78) as these soils retain poor and very poorly drained morphological characteristics for decades after they have been artificially drained.

Areas of concern were revisited to examine soil profiles in more detail (especially in regard to slow permeability and the potential for water table perching), to gauge land
holder experience, and to further map select areas of poor to very poorly drained soils at very localised and detailed scales.

LUC classifications were correlated with the most up-to-date regional classification for the Manawatu-Wanganui (Harmsworth, 2009). An additional suffix code (e.g. 2w02a) has been added in some cases to explain a finer degree of limitation not described at the regional unit level.

### 3.4 Map and database outputs

All survey data was digitised into ESRI’s ArcGIS (v.9.3.1) geographic information system as geodatabases. Metadata was prepared for each, and these files are to be supplied to PNCC.

Base maps of soils, land use and LUC were prepared in ArcGIS, and finalised cartographically in Adobe’s CS2 Illustrator (v.12.1) and Photoshop (v. 9.0) applications.

Map publication scale used in this report is 1:10,000 to accommodate easily managed page sizes (ISO A4 and A3). However, map data for Anders Road, Racecourse and Whakarongo blocks is designed for a publication scale of 1:8,000, although the smallest soil polygon of 31m² is considerably smaller than the recommended ~1500m² minimal legible area (MLA) for a 1:8,000 paper map (using 0.25cm² as the smallest delineation on a map that can be legibly labelled). This excessive level of detail was captured to help understand patterns of LUC 2w and 3w observed in some Kairanga soils (see discussion in Section 3.3).

Map data-scale for the greater Kelvin Grove area (the mid and high terraces) is 1:15,840 because it is still largely based on the observations of Cowie (1974).
4. Results and discussion

4.1 Soils

Eight soils series with twenty-nine variants (soil phases) were mapped for the study area. Several unpublished soil phases have been identified, mostly arising from the detailed survey scale (e.g. terrace edges mapped as Manawatu hill phases) and mappable differences in drainage class (e.g. Kairanga silt loam is mapped here as having an imperfect, poor, and very poorly drained phase).

A brief description of each soil is provided below. Soil distribution is presented as maps 3 and 4 (full size maps included as Appendix 1). Detailed descriptions of reference profiles are provided as Appendix 2.

4.1.1 Manawatu soil series

Manawatu soils are agriculturally elite and versatile soils with a high actual value for food production. They have a distinctive rich brown colouration with generally deep profiles and only minor drainage limitations (well and moderately well drained).

Manawatu soils are mapped extensively on the Racecourse block (73 ha or 66% of the block) where they associate mostly with levees created by the historical meanderings of the Manawatu River (Mangaone Stream up to Pioneer Highway is a former river bed). Somewhat less common is 23 ha of Manawatu soils on the Anders Road block (10% of block area) found along a narrow band of former stream and spring channels.
Three soil types and two phases are mapped. Localised areas of Manawatu silt loam (Mzl1) occur in the more settled deposition zones of former river levees and terrace remnants (Racecourse) and in narrow levee associations on the Anders Road block. Profiles are deep, richly coloured (brown and olive brown), slightly firm, and well drained. A moderately well drained mottled phase (Mzl2) is mapped as a transition to Kairanga silt loam. Profiles are readily differentiated by dulled colouration (greyish brown) and the presence of mottling.

Manawatu fine sandy loam (Mfs1) is mapped extensively across the broader levee areas of former river channels (Racecourse) and locally as narrow levee associations (Anders Road). This soil has a fine sandy loam texture with a definite silty influence, overlying a distinctively soft but cohesive sandy loam. Texture imparts a relatively greater drought risk (considered well to somewhat excessively drained). A mottled phase (Mfs2) is mapped as a transition to Kairanga fine sandy loam, and along the back-tilting swale areas of low terraces bordering the Mangaone Stream. A slightly shallower and less developed hill phase (Mfs3) is mapped for 8-20° slopes found along older terrace edges.

Manawatu sandy loam (Ms1) is mapped on levee crests and low river terraces of the Racecourse block. The small localised area found on the Anders Road block is suspected to have developed from sandy fill associated with the levelling of the old Pioneer Highway railway berm. The soil itself is characterised by its coarse sandy loam texture and raw non-cohesive sand at depth (often densely packed; difficult to make an auger bite), both of which contribute to somewhat excessive drainage and a tendency to dry out in summer. A hill phase (Ms2) is mapped for river terrace edges.

Manawatu soils are classed by Cowie (1978) as slowly accumulating recent soils, meaning they are, or have in recent times, received alluvial deposition from flooding on an infrequent basis. Sufficient time passes between flooding for the alluvium to be incorporated into the soil. Most can be classed as Weathered Fluvial Recent Soils under the NZ Soil Classification (Hewitt, 1998).

4.1.2 Kairanga soil series

Kairanga soils are found extensively on the flood plains subject to infrequent flooding (under natural conditions), and at localised low points or depressions where the water table is nearer the surface (e.g. former river bends and beds, channels, swales). They are considered to have high natural fertility relative to soils found on the higher terraces.
These soils have distinctive dark grey-brown coloured topsoils and light grey subsoils with yellow brown mottling. They have formed under high water tables and associated low-oxygen conditions (swamp and semi-swamp). Natural drainage is poor, very poor, and imperfect. Extensive drainage networks and schemes throughout the Manawatu have lowered original soil-forming water tables considerably, but some of these soils still retain a notable wetness limitation that requires careful management.

Cowie (1978) describes the Kairanga series as slowly accumulating soils that are, or have been in recent times, subject to infrequent flooding and small depositions of fine alluvium (up to 25mm). Under the NZ Soil Classification they are classed as Recent Gley Soils.

The Kairanga series represent a significant area of Racecourse block soils (36 ha or 33% of block), and they dominate the Anders Road block (135 ha or 58%). Soil texture and drainage are used to differentiate two soil types and six phases.

*Kairanga silt loam* (Kz12) is mapped where natural drainage is generally poor. A gley horizon appears within 40 cm of the surface, indicating that the original water table was quite high. The profile is predominantly silt loam throughout, sometimes grading to clay loam at depth.

This soil type represents a large area of the Anders Road block grading into Te Arakura soils. It was not uncommon to encounter localised areas where profile features leaned heavily towards those more commonly encountered within the Te Arakura series, even near Pioneer Highway. Also, the area contains very low relief channels or swales with heavier soils (*Kairanga heavy silt loam*, Kz13),
distinguished by gleying in the topsoil (historical water table at or near surface for extended periods). Mapping this level of micro topography was difficult (compounded by levelling and damaged soils by over-cultivation) so it was only undertaken for a small area. However, it was deemed necessary to help explain why some areas appeared to have stunted or dead shelterbelt trees, heavy pugging, tractor rutting, and/or crop failure (Fig. 3). *Kairanga heavy silt loam* (KzI₂) was mapped elsewhere also, particularly around springs and in deeper channels or depressions, including the large oxbow bend on the Racecourse block.

*Kairanga light silt loam* (Kzl) is mapped for a confined area near Pioneer Highway, where it associates with a flat topography punctuated with moderately distinct small channels (readily mapped where earthworks have been minimal). Topsoil is similar to that of a Manawatu soil, but a gley horizon is apparent at 40 cm making this an imperfectly drained soil.

Figure 3: Crop failure on localised patches of very poorly drained *Kairanga heavy silt loam*. Note that degree of failure may also be related to sowing too early for the soil type (or conversely, a wet season), or compounded soil aeration/drainage problems associated with cultivation damage. These are more delicate soils requiring more careful management.

The coarser textured *Kairanga fine sandy loam* (KfsI₃) is mapped either side of Pioneer Highway. While it qualifies as being poorly drained, this soil as far better subsoil permeability than its silt loam counterpart. The same degree of
artificial drainage will generally be more effective, attributing this soil with only a minor wetness limitation after drainage. However, as with all Kairanga series soils, special care is required after periods of rainfall to avoid accelerated soil structure damage.

A somewhat unusual *Kairanga fine sandy loam light* (KfsL) phase is mapped just north of Pioneer Highway. This soil associates with the same flat + moderately channelled topography of Kairanga light silt loam. However, historical earthworks have made this soil difficult to isolate and describe (especially earthworks associated with the infilling of channels and levelling with sand from the former Pioneer highway railway line). A general profile is similar to that of Manawatu fine sandy loam, particularly on slightly higher (unmodified) berm areas, with a gley horizon appearing at 40-50 cm. Old persistent root shells were commonly found at the same depth (manuka?). Another Karapoti similarity is occasional dark brown to black topsoils, although this may be associated with tar, oil or diesel from old railway spoil.

*Kairanga fine sandy loam heavy* (KfsH) is a very poorly drained soil that occurs in lower channel areas and wet patches. This phase is readily distinguishable by localised heavy pugging, wet pasture species (e.g. creeping buttercup), and occasionally by stunted shelterbelts (Fig. 4). Examples that have been under pasture for several decades have developed a thatched Ah horizon (almost organic).

![Figure 4: Shelterbelt stuntng and localised pugging associated with a transition to Kairanga heavy fine sandy loam.](image-url)
A large continuous area of Kairanga fine sandy loam heavy has been mapped on the Racecourse block. This is distinguished as a soft fine sandy loam over a heavy silt loam to clay loam, grading into a proper Kairanga silt loam nearer to Pioneer Highway. The area for the most part is badly pugged (high risk of twisting an ankle), despite crossing different land parcels and patterns of land use. Second order drainage is evident in places (i.e. novaflow, tile drainage), but continued wetness suggests the drainage design is inadequate. This soil is not as challenged as Kairanga heavy silt loam, and we would expect a considerably more effective response with an agriculturally designed and installed second order drainage system.

4.1.3 Te Arakura soil series

Te Arakura soils are mapped across former flood plains no longer considered to be subject to flooding (or perhaps subject to flooding over millennia rather than centuries). Extended periods between flood depictions mean these soils are more weathered relative to their lower elevation Kairanga-series counterparts. They are classified as Typic Orthic Gley Soils under the NZ Soil Classification.

Te Arakura soils are mapped at the northern edge of the Anders Road block were they associate with old stream or spring channelling and narrow levees (75 ha or 32% of the block). These were by far the most confusing soils to map due to variations in textural layering, similarities with Kairanga soils, and the inconsistent occurrence of distinguishing features. Likewise, weathering (perhaps) and/or very fine original alluvial deposits, introduce slightly finer texture classes than those used to describe other soil series (Cowie, 1978, alludes to this also).
Distinguishing features include light grey ('bleached') Bg horizons (compared to the darker grey subsoils of Kairanga soils), very fine and distinctive 'sugary coatings' on aggregates in the upper subsoil, and a 'rusty matrix' horizon that ranges from very heavy reddish brown mottling where concretions are beginning to form, through to a crumbly and gritty Bgc horizon with abundant and sometimes quite large (>5mm) concretions. Elsewhere this horizon can grade into an iron pan (not encountered in this survey).

Three soil types are mapped by texture, with the silt loam type further differentiated into three phases according to drainage. The most common, poorly drained *Te Arakura silt loam* (Tz1), is found on the gently down-sloping plain areas that extend away the Mangaone Stream and the old channel/spring networks. In this area the soil has a variable depth of silt loam over a light sandy clay loam to a fine sandy silt loam (subsoil was never particularly sticky as would be expected with a higher clay content).

![Figure 5: Drain exposure of Te Arakura silt loam. This example shows 50cm of silt loam over a sandy clay loam.](image)

*Te Arakura silt loam is recognised as being wetter, slightly less fertile, and more difficult to drain relative to Kairanga silt loam (Cowie, 1978). Water tends to perch somewhat after heavy or persistent rain, suggesting that the finer textures result in the slow downwards movement of drainage water. Walking across this soil type after rain can be likened to walking across a wet firm sponge. As with*
the Kairanga heavy phases, Te Arakura silt loam requires correctly designed second order drainage to be effective.

However, we believe the opportunity for installing better drainage is limited for the Te Arakura silt loams found in this area. Firstly, many of the existing open drains are shallow, and it would be difficult to achieve sufficient fall on some properties. Secondly, drainage network effectiveness is dependent on neighbours. Poorly maintained drains were common; some connecting drains have been filled in; and there was at least one case of open connecting drains being replaced with low volume novaflow pipe (meaning drainage of the preceding property was severely compromised).

Very poorly drained Te Arakura heavy silt loam (Tz3) is mapped within the same area as localised wet patches. It was also mapped along channel low points, sometimes with the sporadic inclusion of gravels. A well developed rusty matrix horizon, with many concretions high in the profile, was common (sometimes appearing just below the topsoil).

Te Arakura light silt loam (Tz1) is mapped across the narrow levee areas. The slight elevation difference means the gley horizon appears further down the profile, but not so far as to qualify as imperfectly drained. The key reason for differentiating this soil is the relatively shallower silt loam layer overlying a very fine sandy loam (cf. clay loam), with less ‘bleaching’ in the upper subsoil, and the presence of a heavily mottled (red brown) horizon in lieu of a rusty matrix horizon with concretions. While a degree permeability impediment persists, these soils would likely respond better to drainage relative to their silt loam counterparts.

Te Arakura fine sandy loam (Tfsl) is mapped where the silt loam layer becomes least influencing, most notably alongside the Mangaone Stream, in association with Te Arakura light silt loam on the narrow levees, and at the northern most end of Anders Road. Drainage class is still poor, but these soils have been far more responsive to first order drainage and are less likely to perch after heavy or persistent rain.

Te Arakura sandy loam (Tsl) is mapped only where a distinctive coarse sandy loam texture was encountered. This confines the soil to occasional patches along the narrow levee areas, and on the stream-ward side of the Mangaone stopbank (with some flood deposition influence). It is an imperfectly drained soil with relatively less pronounced Te Arakura features, overlying coarse sand at depth.
Note: After reviewing reference profiles and site descriptions while preparing this report, we now have a suspicion that Te Arakura silt loam may extend slightly further south in the north east corner of the Anders Road block.

4.1.4 Karapoti soil series

Karapoti soils (Weathered Recent Fluvial Soils) are formed on older stream channel levees, and are more extensively found to the north of Palmerston North. A very limited area was mapped at the top of the Anders Road block (<1ha). A well drained example of Karapoti brown sandy loam (Kp1) was mapped across an old sand bar, and an even smaller area of excessively drained Karapoti brown sandy loam gravelly phase (Kp2) was mapped adjacent to a now dry spring hollow.

4.1.5 Ashhurst soil series

Ashhurst soils are well to excessively drained soils that have formed on older river terrace remnants slightly above the present day flood plain. They are readily distinguished by their friable dark brown topsoils and light olive brown subsoils. Other features include an abundance of earthworm activity, a tendency to dry out in summer, and a variable depth to gravel that makes these soils difficult to map as individual units. They are classified as Typic Orthic Brown Soils.
A sizeable area is mapped on the Whakarongo sub-block (13 ha or 30% of sub-block area) along the inward side of an oxbow (former river channel curve). One soil type and one phase are recognised.

\[\text{Ashhurst series}\]

\[\text{Kelvin Grove}\]

\[\text{Anders Road}\]

\[\text{Racecourse}\]

*Ashhurst silt loam* (Ash₁) is mapped where fine alluvial deposits are deepest, particularly towards the back of the terrace where soils grade to Ohakea silt loam. A typical profile has a friable silt loam topsoil with a definite fine sandy grit, over fine sandy loam with a few yellow brown mottles (increasing towards the terrace back). Occasionally this would grade into a proper fine sandy loam soil, especially along channel edges. Depth to gravels is 70-90 cm.

*Ashhurst silt loam gravely phase* (Ash₂) is mapped where fine alluvial deposits are shallowest, and gravels have a definite influence on making these soils droughty. For this area a 45-50cm depth to gravels was reasonably consistent, although this decreased to <30cm on some berm areas and towards the front of the terrace.

While natural fertility is lower than that of Manawatu soils (Cowie, 1978), we rate the Ashhurst soils in this location has having a high value for food production, albeit with a recognition that droughtiness limits the choice of summer crops and/or necessitates irrigation.

### 4.1.6 Ohakea soil series

Ohakea soils are wetter soils that occur in association with the Ashhurst series on the same low terrace. They have formed in the low channels where fine alluvial material is deep, and towards the back of the terrace across fans of colluvial outwash from the high terraces above.
Under the NZ Soil Classification Ohakea soils are categorised as Typic Orthic Gley Soils, although elsewhere Cowie (1978) considered them to be transitional or young expressions of the Pallic Soils found on the higher terraces (perhaps Immature Pallic Soils).

Approximately 20 ha (48%) of the Whakarongo subblock is dominated by Ohakea soils mapped as one soil type and two phases. **Ohakea light silt loam** (Oh₁) is mapped immediately alongside the distribution of Ashhurst soils (along channels and towards the back of the terrace). Profiles have deep friable topsoils and coarse textured subsoils (silty fine sandy loams over loamy sand) and high chroma yellowish brown mottles. They are imperfect to poorly drained under natural conditions, but respond well to drainage.

Poorly drained **Ohakea silt loam** (Oh₂) is mapped across colluvial fan outwashes. It exhibits a distinctively compact light gley subsoil, sharp reddish brown mottling, and finer texture at depth (clay loam that is distinctively sticky).

**Ohakea heavy silt loam** (Oh₃) is mapped within grassed ephemeral channels that loosely bisect the colluvial and alluvial terrace components. At the time of inspection the channels were flowing slowly (i.e. water on top) but the subsoil was dry, and no water table was evident at 100 cm even after waiting 15 minutes. This soil is distinguished by heavy motting throughout the subsoil; presence of a rusty matrix (Bgc horizon) with concretions just below the topsoil; white grey gleying; and the appearance of a proper Cr horizon at depth (heavily reduced slightly sticky sandy loam with no motting).
4.1.7 Milson soil series

Milson soils are formed from moderately thick loess deposited on an intermediate terrace (Milson Terrace). They are classified as Perch Gley Pallic Soils with a significant wetness limitation during winter, and a propensity to dry out and crack during the summer months.

Approximately 57 ha of Milson soils were mapped by Cowie (1974) across the mid terrace of the Kelvin Grove block (29% of total area). We can confirm that these soils are mapped correctly at the 1:15,840 scale.

Milson silt loam (Mils₁) is mapped across the majority of the terrace. It is a distinctly wet and sticky soil dominated by fine textures (clay loam and silty clay loam subsoils), heavy mottling, and water perching in a Btg horizon over a dense fragipan at ~80 cm (Bx horizon). The Aokautere Ash marker bed is commonly encountered just below this horizon. Drainage is poor and natural fertility is relatively low.

Milson silt loam hill phase (Mils₂) is mapped on the Whakarongo sub-block to distinguish the moderately steep scarp (20-25°) that divides the Milson and Ohakea Terraces. In hindsight it perhaps better mapped as a Halcombe hill soil due to natural disturbance (minor soil slip erosion was noted) and shallow profiles over a range of loess and gravel material.
4.1.8 Marton soil series

Marton soils are formed from thinner deposits of fine textured loess across the higher terrace areas (Tokomaru Terrace). Like Milson soils they are classified as Perch Gley Pallic Soils. However, subsoils tend to be denser and more clayey, increasing the extremity of winter-wet and summer-dry conditions by an order of magnitude.

Cowie (1974) mapped 106 ha of Marton soils on the Kelvin Grove block (54% of total area). We agree with this classification at the 1:15,840 scale, but a degree of drainage variability was encountered, such that we suspect that a light and heavy phase could be mapped at a more detailed scale.

![Map of Marton series](image)

Poorly drained Marton silt loam (Mart₁) is mapped across the flat to undulating areas of the terrace. We did not encounter the Aokautere Ash marker bed. Marton silt loam rolling phase (Mart₂) is mapped along the terrace edge and along the sides of the large channels/small valleys that dissect the area (slopes 7-15°).
4.2 Land Use Capability classification results

Land Use Capability (LUC) has been classified according to national standards (Lynn et al., 2009), local LUC unit descriptions (Fletcher, 1987), and according to recently updated regional classification criteria developed for Horizons Regional Council (Harmsworth, 2009). Important variation not captured within regional units is accommodated by using a differentiating suffix (e.g., 2w02a, 2w02b).

4.2.1 LUC Class 1 land

This is prime agricultural land with a high actual value for food production. Includes Manawatu soils that are deep, well drained, have high natural fertility, and respond well to fertilisers. This land is highly versatile for a wide range of uses, including vegetable growing, flower production, grain crops, viticulture and horticulture. Production under these and other uses is generally high. LUC class 1 land is suitable for growing a diverse range of crops.

Two units are mapped. **LUC 1s01** is mapped for the Manawatu fine sandy loams and sandy loams that have a slight risk of drying out in summer. **LUC 1w01** is mapped for Manawatu silt loam, mottled silt loam, and mottled fine sandy loam (moderately well drained). In this case the mottled phases are considered to have only a minor wetness limitation that is readily managed and/or easily removed by drainage (see Wilde 2003 for discussion regarding the allocation of Manawatu mottled silt loam).

LUC class 1 is elite agricultural land that, in our view, should be regarded as being a significant natural resource for Palmerston North and one that is well worth protecting for future uses.

4.2.2 LUC Class 2 land

LUC Class 2 is very good agricultural land with a high potential or actual (i.e. potential has been realised) value for food production. Physical limitations are slight and readily overcome through management. However, the magnitude of limitation is sufficient to reduce the number of crop types that can be grown. Similarly, while land use versatility can still be high, more intense levels of land development and management are required. With good management and development, production levels from Class 2 land can still be high.

Extensive grain (maize, barley, wheat) and fodder cropping is common in the Manawatu. Orchards, nurseries, and flower growing operations have also been observed. Cowie considered that cropping potatoes, peas and other such cash crops were also viable.
Map 5: LUC map of Anders Road and Racecourse Growth Options

Legend

Class 1 land with minimal limitations for food production and suitable for a diverse range of crops:
- Flat land with deep, well drained and fertile soils. Very slight droughtiness limitation.
- Flat land with deep fertile soils that are either well drained or moderately well drained, sandy loams, very slight wetness limitation.

Class 2 land with slight limitations for food production and suitable for many crop types:
- Flat land with deep, well drained to somewhat excessively drained sandy loam soils. Slight droughtiness limitation.
- Flat land with deep, moderately well drained and fertile fine sandy loams. Slight wetness limitation due to drainage and risk of occasional flooding.
- Flat land with deep, fertile soils with a slight wetness limitation. Includes imperfectly drained silt loams and poorly drained soils with permeable subsoils (sandy loams and fine sandy loams) under first order drainage.
- Flat land with deep fertile soils with a moderate wetness limitation under first order drainage, but a slight wetness limitation under second order drainage. Includes poorly drained silt loams and heavy B loams.

Class 3 land with moderate limitations for food production. Crop choices are restricted and careful management is required:
- Flat land with deep fertile soils with a moderate wetness limitation caused either by shallow or very poorly drained soil types, or the area could be poorly drained.

Class 4 and 5 land unsuitable for arable food production:
- Semi-swamp areas in deep depressions with very poorly drained soils that cannot be readily drained.
- Steep river terraces, scarps and stream banks with excessively drained coarse textured soils.

See Appendix 1 for full size maps.

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Five Class 2 units are recognised. **LUC 2s02a** is mapped for a limited area of Manawatu sandy loams along the higher berms of the Mangaone Stream. These are infrequently flooded soils with a slight to moderate soil limitation (droughtiness).

**LUC 2s02b** is mapped for Ashhurst soils. While these soils are often classified as LUC 3s, in this location they have a moderate to deep soil depth (45-90 cm) that qualifies them as LUC 2s soils. While being droughty, we view the droughtiness limitation as being of a similar order of magnitude to the wetness limitation exhibited by some LUC 2w soils. Irrigation would be necessary in some years to fully realise the food production potential of this land.

**LUC 2w01** is mapped on the infrequently flooded low terraces bordering the Mangaone Stream. In having moderately well drained Manawatu fine sandy loams, these areas would qualify as 1s01 land if the flooding risk could be permanently removed (unlikely).

**LUC 2w02a** is mapped for land that has a slight wetness limitation under first order drainage*. Soils are either imperfectly drained, or poorly drained but with good profile-permeability characteristics that facilitate the quick movement of water to drainage channels. Some of these soils approach the lower end of LUC 1w01 under second-order drainage systems*.

**LUC 2w02b** is mapped for land with a moderate wetness limitation under first order drainage, but this limitation reduces to slight under well designed second order drainage systems. This applies to the poorly drained Gley Soils that have slow draining profiles (namely Te Arakura, Kairanga and Ohakea silt loams).

This distinction highlights a necessary peculiarity of the LUC system. If it is feasible to remove a limitation, then land must be assessed as if that limitation has already been removed (Lynn et al., 2009). Put another way, if it is feasible to drain a soil then the land should be assessed as if that soil has already been drained. The degree of feasibility depends on economics and availability of appropriate technology relative to the degree of limitation.

Second order drainage for these soils is entirely feasible, as these soils are regarded as being capable of returning high production under cropping (Cowie, 1974; Cowie, 1978; Cowie & Osbourne, 1977; Cowie & Rijkse, 1977).

*First order drainage refers to the Manawatu’s extensive network of drains which have effectively lowered the originally high water tables of Kairanga and Te Arakura soils permanently. Second order drainage refers to more intensive within-paddock drainage systems such as gravelled novalflow, tile drains or mole ploughing.
However, these LUC 2w02b soils definitely lean towards the lower end of the LUC class 2. From a management perspective, areas of 2w soils with appreciable pockets of 3w soils should perhaps be managed according the class 3 magnitude of limitation. However, we have viewed maize cropping operations successfully managing patches of 3w separately (e.g. not cultivating, not sowing, or resowing slightly later in the season if first attempts fail).

4.2.3   LUC Class 3 land

LUC Class 3 is regarded as good agricultural land with a moderate potential value for food production. Physical limitations to arable uses are moderately high. While the land can still be cultivated and fair levels of production can still be achieved, the magnitude of limitation restricts crop choice (mainly to fodder and perhaps grain crops) and length of growing season, and careful management is necessary to avoid soil damage and suppressed crop yields (Fig. 6).

![Figure 6: LUC 3w01 land that requires careful management to avoid cultivation damage. Inset shows a dense, structureless and heavily gleyed (light blue gley 10B 7/1) clump from the topsoil, indicative of ponding and extended anaerobic conditions caused by not-so-careful cultivation-related soil damage.](image)

Two LUC class 3 units are recognised. **LUC 3w01** is mapped where drainage is either infeasible or unlikely to reduce wetness to a slight limitation. This includes small pockets of heavy Kairanga soils found within slight depressions and channels across the wider flood plain (Fig. 5); heavy Kairanga soils at the base...
of a deep oxbow channel; and Ohakea silt loam soils formed from colluvial outwash (which also have moderately low natural fertility). It should be noted that Fletcher (1987) only describes this unit for Kairanga soils subject to ponding and flood inundation, yet the NZ Land Resource Inventory applies the unit more widely across a range of soils and conditions.

**LUC 3s04** is mapped extensively across the intermediate and high terraces of Kelvin Grove (Marton and Milson soils). Soils are sticky and wet during winter, dry and hard during summer, and natural fertility is low.

Historically these soils were incorrectly classified as LUC class 2 soils (i.e. Fletcher, 1987), despite having somewhat permanent soil limitations that are not readily changed (it is not particularly feasibly to remove or modify the underlying fine soil textures or fragipans). Considerable argument has been put forward to support their redesignation as LUC class 3 soils (e.g. see Wilde, 1995), which has been accepted and consolidated with the recent update of the Manawatu-Wanganui classification (Harmsworth, 2009). We fully support this improvement.

### 4.2.4 LUC Class 4 land

LUC Class 4 is at the upper end of what is considered suitable for arable. Limitations are generally severe, but occasional fodder and (perhaps) some cash crops are possible under very careful management and/or seasonally fortuitous growing conditions.

LUC 4e04 is mapped on the rolling and strongly rolling areas of the high terrace (Kelvin Grove). This land retains the same soil limitations of 3s04, with the additional limitations of slope and an associated risk of severe sheet and rill erosion when cultivated (Fletcher, 1987).

### 4.2.5 LUC Classes 5 and 6

LUC Classes 5 and 6 are not suitable for arable food production. One classification is made for LUC 5 and two for LUC 6. Both 5w and 6s are the mapped solely because of detailed scale; equivalent classifications to the unit level are not recognised within regional classifications.

Very localised areas of **LUC 5w** are mapped for deep wet depressions or gully areas that will never be drained. From a land development perspective it is far more feasible to fill and level these areas through earthworks. **LUC 6s** is
mapped for the narrow terrace scarps and stopbank areas found on the floodplains. LUC 6e01 is mapped for the moderately steep terrace scarps associated with the high and intermediate terraces of the Kelvin Grove block.

4.2.6 Summary of LUC ‘high class soils’

LUC high class soils are found extensively across most of the study area (Tables 5 and 6). Approximately 92% of the Racecourse block area has high class soils. Prime LUC 1 soils dominate (56% of the block). The area of least-capable high class soils (LUC 2w02b) is small (10% of the block).

Anders Road has a similar predominance of high class soils (89% of the block) although the area of LUC 1 is less (10% of the block) and the area of LUC 2w02b is greater (48% of the block).

Approximately half of the Whakarongo block has high class soils (49%), while the high Kelvin Grove terraces have no soils that qualify as being high class. If these two areas are to be considered together, then the percentage of high class soils found on the greater Kelvin Grove area is 11%.

Table 5: Hectares of LUC high class soils by growth option.

<table>
<thead>
<tr>
<th>Block</th>
<th>High class soils (ha)</th>
<th>Other soils (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racecourse</td>
<td>101</td>
<td>9</td>
</tr>
<tr>
<td>Anders Road</td>
<td>208</td>
<td>25</td>
</tr>
<tr>
<td>Kelvin Grove (Whakarongo)</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Kelvin Grove (high terraces)</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td></td>
<td>330</td>
<td>210</td>
</tr>
</tbody>
</table>

Table 6: Percentage of LUC high class soils for each growth option.

<table>
<thead>
<tr>
<th>Block</th>
<th>High class soils (%)</th>
<th>Other soils (%)</th>
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</thead>
<tbody>
<tr>
<td>Racecourse</td>
<td>92%</td>
<td>8%</td>
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<tr>
<td>Anders Road</td>
<td>89%</td>
<td>11%</td>
</tr>
<tr>
<td>Kelvin Grove (Whakarongo)</td>
<td>49%</td>
<td>51%</td>
</tr>
<tr>
<td>Kelvin Grove (high terraces)</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>61%</td>
<td>39%</td>
</tr>
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</table>
4.3  Land use and cover

Land use and cover results are presented as Maps 7 to 9 and Tables 7 to 8. Classifications are constructed through field observation and orthophotography interpretation. *Land use parcels* are areas of land that appeared to be under the same management system, and are not necessarily synonymous with land ownership.

4.3.1 Land use

A total of 150 land use parcels were mapped across the three study areas. Parcels are predominantly small in size, with the majority being less than 5ha (Fig. 7). Almost 90% of the parcels are smaller than 5ha. Small parcels associate with lifestyle blocks, non-agricultural uses (school, commercial), and very intense uses such as horticulture and some equestrian.

![Figure 7: Histogram of parcel size across all three growth options.](image)

Map 7: Summary map of land use across all three growth options.
Large parcels associate mostly with livestock enterprises (some cropping) and larger equestrian operations. While the number of large parcels is small (~10%), they represent the largest area (55% of the total study area). Lifestyle blocks are a particular feature of the Anders Road block (Table 7), while equestrian enterprises are notably high on the Racecourse block. Large-parcel livestock grazing and occasional cropping is a feature of the high Kelvin Grove terraces and part of the Anders Road block.

Table 7: Summary of land use area and parcel count by growth option.

<table>
<thead>
<tr>
<th>Block</th>
<th>Area (ha)</th>
<th>Percent of area</th>
<th>No. parcels</th>
<th>Mean parcel size (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anders Road</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>0.4</td>
<td>&lt;1%</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Equestrian and grazing</td>
<td>10.5</td>
<td>5%</td>
<td>2</td>
<td>5.3</td>
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<tr>
<td>Equestrian</td>
<td>4.1</td>
<td>2%</td>
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<td>Horticulture</td>
<td>4.0</td>
<td>2%</td>
<td>1</td>
<td>4.0</td>
</tr>
<tr>
<td>Lifestyle block</td>
<td>90.2</td>
<td>40%</td>
<td>48</td>
<td>1.9</td>
</tr>
<tr>
<td>Livestock grazing</td>
<td>116.2</td>
<td>51%</td>
<td>10</td>
<td>11.6</td>
</tr>
<tr>
<td>Residential</td>
<td>0.3</td>
<td>&lt;1%</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>225.7</td>
<td></td>
<td>65</td>
<td></td>
</tr>
<tr>
<td><strong>High terraces</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cemetery</td>
<td>23.1</td>
<td>14%</td>
<td>1</td>
<td>23.1</td>
</tr>
<tr>
<td>Commercial</td>
<td>1.4</td>
<td>1%</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>Forestry</td>
<td>7.2</td>
<td>5%</td>
<td>1</td>
<td>7.2</td>
</tr>
<tr>
<td>Lifestyle block</td>
<td>27.2</td>
<td>17%</td>
<td>18</td>
<td>1.5</td>
</tr>
<tr>
<td>Livestock grazing</td>
<td>100.3</td>
<td>63%</td>
<td>7</td>
<td>14.3</td>
</tr>
<tr>
<td>Residential</td>
<td>0.5</td>
<td>&lt;1%</td>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>159.7</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>Racecourse</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>1.1</td>
<td>1%</td>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>Equestrian and grazing</td>
<td>30.1</td>
<td>28%</td>
<td>2</td>
<td>15.1</td>
</tr>
<tr>
<td>Equestrian</td>
<td>40.1</td>
<td>38%</td>
<td>10</td>
<td>4.0</td>
</tr>
<tr>
<td>Lifestyle block</td>
<td>25.8</td>
<td>24%</td>
<td>17</td>
<td>1.5</td>
</tr>
<tr>
<td>Livestock grazing</td>
<td>6.6</td>
<td>6%</td>
<td>2</td>
<td>3.3</td>
</tr>
<tr>
<td>Residential</td>
<td>2.2</td>
<td>2%</td>
<td>9</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>106.0</td>
<td></td>
<td>41</td>
<td></td>
</tr>
<tr>
<td><strong>Whakarongo</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifestyle block</td>
<td>5.7</td>
<td>17%</td>
<td>6</td>
<td>0.9</td>
</tr>
<tr>
<td>Livestock grazing</td>
<td>25.3</td>
<td>75%</td>
<td>3</td>
<td>8.4</td>
</tr>
<tr>
<td>Residential</td>
<td>0.5</td>
<td>1%</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>School</td>
<td>2.3</td>
<td>7%</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>33.7</td>
<td></td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Fragmentation and land use type has a significant impact on the area of soils that can be considered available to commercial cropping. Effectively only larger parcels with livestock grazing and perhaps some of the equestrian could be considered available for large scale cropping. Dominant land use over all is livestock grazing, followed by lifestyle blocks (Table 8).
Table 8: Summary of land use by combined study area (525 ha).

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Hectares</th>
<th>Percent of total study area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cemetery</td>
<td>23</td>
<td>4%</td>
</tr>
<tr>
<td>Commercial + school</td>
<td>5</td>
<td>1%</td>
</tr>
<tr>
<td>Equestrian and grazing</td>
<td>41</td>
<td>8%</td>
</tr>
<tr>
<td>Equestrian</td>
<td>44</td>
<td>8%</td>
</tr>
<tr>
<td>Forestry</td>
<td>7</td>
<td>1%</td>
</tr>
<tr>
<td>Horticulture</td>
<td>4</td>
<td>1%</td>
</tr>
<tr>
<td>Lifestyle block</td>
<td>149</td>
<td>28%</td>
</tr>
<tr>
<td>Livestock grazing</td>
<td>248</td>
<td>47%</td>
</tr>
<tr>
<td>Residential</td>
<td>4</td>
<td>1%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>525</td>
<td></td>
</tr>
</tbody>
</table>

4.3.2 Land cover

Land cover is a snapshot in time. Land cover across all blocks is dominated by pasture and crop (Table 9; Maps 7 and 8), accounting for 76% of the total area. This includes general farming pasture and lifestyle paddocks, but excludes lawns and grassland not grazed by animals. Pasture/crop is considered to be a land cover that is readily amenable to commercial cropping applications.

Peripheral covers (trees, shelterbelts, horse cells, farm curtilage like yards and tracks) account for 10% of total area, and are considered to be less amenable to change (or more correctly, less likely to be changed in the immediate future).

Permanent or semi-permeant covers are least amenable to change (highly unlikely that they will change in the immediate future). They account for 15% of total area, and include buildings, structures, water, residential curtilage, and hard surfaces such as roads, pathways and driveways. The entire cemetery area is also included in this category.

Table 9: Summary of land covers by growth option.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Anders Road (ha)</th>
<th>High terraces (ha)</th>
<th>Race course (ha)</th>
<th>Whakarongo (ha)</th>
<th>Total (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cemetery</td>
<td>27.4</td>
<td>19.6</td>
<td></td>
<td></td>
<td>19.6</td>
</tr>
<tr>
<td>Crop</td>
<td>5.0</td>
<td>6.6</td>
<td>12.5</td>
<td></td>
<td>49.6</td>
</tr>
<tr>
<td>Farm curtilage</td>
<td>7.3</td>
<td>4.5</td>
<td>4.5</td>
<td>0.7</td>
<td>18.2</td>
</tr>
<tr>
<td>Hard surface</td>
<td>0.4</td>
<td>12.4</td>
<td>12.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horse cells</td>
<td>2.9</td>
<td>2.9</td>
<td></td>
<td></td>
<td>2.9</td>
</tr>
<tr>
<td>Horticulture</td>
<td>0.2</td>
<td>1.1</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open water</td>
<td>160.8</td>
<td>94.5</td>
<td>68.4</td>
<td>34.4</td>
<td>358.1</td>
</tr>
<tr>
<td>Pasture</td>
<td>16.6</td>
<td>5.0</td>
<td>4.8</td>
<td>2.1</td>
<td>28.5</td>
</tr>
<tr>
<td>Residential curtilage</td>
<td>4.8</td>
<td>1.4</td>
<td>2.7</td>
<td>0.8</td>
<td>9.7</td>
</tr>
<tr>
<td>Structures</td>
<td>7.6</td>
<td>12.8</td>
<td>3.4</td>
<td>2.6</td>
<td>26.4</td>
</tr>
<tr>
<td>Total</td>
<td><strong>233.0</strong></td>
<td><strong>154.6</strong></td>
<td><strong>109.8</strong></td>
<td><strong>42.5</strong></td>
<td><strong>539.9</strong></td>
</tr>
</tbody>
</table>
4.4 Land use implications for the availability of high class soils

Analysis of land use and land cover suggests that the first phase of urbanisation has already claimed large tracts of the study area. This is part of an incremental and cyclic process of peri-urban fragmentation and urban infilling. As a generalisation (after Molloy 1980, Cowie & Osborn, 1977):

- Close proximity of rural land to urban boundaries increases land value potential. Urban wealth allows those who wish to work in an urban area but live on a rural small holding to realise the ‘lifestyle dream’. Demand from lifestyles, speculators and developers puts pressure on local authorities to allow more intense rural subdivision. The area becomes increasingly fragmented. Land values increase while parcel size decreases; conventional agriculture is increasingly less viable, and gets pushed further out.

- Demand for urban housing grows. Speculators and developers see increasing opportunity with peri-urban land. Housing development represents a significant opportunity for local businesses and economic growth. Lobbying increases pressure on local authorities to allow further rezoning. Remaining farmers limit reinvestment, capital expenditure, and maintenance expenditure; some become speculators themselves. Arguments against urban expansion are eroded as commercial agriculture becomes less viable. Eventually infill housing is permitted. Existing lifestyles are increasingly crowded and/or undertake their own subdivision. Speculators, developers and lifestyles look further a-field to begin the process anew on the next block of peri-urban rural land.

This is neither a good or bad process, but rather a slow underlying transition that takes place over decades as a result of population growth and city expansion. To some it is an insidious creep that occurs over timeframes too long for the prevalent planning models to accommodate (e.g. compared to say, greenbelt models).

This peri-urban process is particularly evident for the Racecourse and Anders Road growth options; less so for the Kelvin Grove block, but not far behind. Fragmentation is approaching a tipping point (lifestyle blocks are the second dominant land use accounting for 28% of land area across all study blocks); land speculation interests are common (including expressions from long-term land holders); and conventional farming operations are less prevalent.

This has serious implications regarding the protection of high class soils on these blocks. For example, while an extensive area of high class soils has been mapped as part of this study, a significant proportion has already been lost under permanent or semi-permanent covers, or have come under land uses that are less suitable for high value food production (Maps 9 and 10).
Map 10: Availability of high class soils, Kelvin Grove Growth Option

Legend
- Land with limited availability for commercial cropping
  - Land with lower capability soils and/or a non-complementary land use or cover (hard-surfaced, agricultural, very intensive utilization).
  - High class soils under lifestyle or other uses or farm outbuildings.

- Land with high availability for commercial cropping
  - Agriculturally other high class soils with a high actual value for food production (LUCC 11).
  - High class soils with a high potential or actual value for food production (LUCC 21).
  - High class soils with a high potential value for food production (LUCC 24W25).

Disclaimer: While this map has been prepared with all reasonable skill and care, AgResearch accepts no responsibility for any action taken by any individual or agency based on the information presented on this map.

See Appendix 1 for full size maps.
The result is that less than half (48%) the 330 hectares of high class soils may be available for commercial cropping purposes (Table 10).

While availability may be low for the Racecourse block (43% availability), this should be tempered against recognition that the remaining high class soils are agriculturally elite with a high actual value for food production. In contrast, while the Anders Road block has slightly higher availability (49%), the high class soils are of slightly lower capability, especially in regard to soils that require second order drainage necessary to realise their food production potential (LUC 2w02b).

Table 10: Summary of high class soils that may be available to commercial cropping operations.

<table>
<thead>
<tr>
<th>Block</th>
<th>Total HCS* (ha)</th>
<th>HCS* available (ha)</th>
<th>Percent availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anders Road</td>
<td>208</td>
<td>101</td>
<td>49%</td>
</tr>
<tr>
<td>Kelvin Grove (high terraces)</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Racecourse</td>
<td>101</td>
<td>43</td>
<td>43%</td>
</tr>
<tr>
<td>Kelvin Grove (Whakarongo)</td>
<td>21</td>
<td>14</td>
<td>69%</td>
</tr>
<tr>
<td>Total</td>
<td>330</td>
<td>159</td>
<td>48%</td>
</tr>
</tbody>
</table>

* HCS = High Class Soils
5. Conclusions

5.1 Racecourse growth option

- Rezoning the Racecourse block for urban development would result in the loss of significant areas of high class soils. Over 90% of the area has either elite LUC 1 soils (56% of block area) or high capability LUC 2 soils (36%).
- Extensive peri-urban fragmentation is already evident for much of the Racecourse block. 90% of land use parcels are smaller than 5 ha. Lifestyle blocks account for 45% of parcels and 24% of land area. Only 43% of the high class soils are considered available to commercial cropping in a practical sense. This suggests that previous policies have been less than successful in avoiding the loss of significant areas of high class soils.
- Despite this, the remaining soils are dominated by agriculturally elite and scarce LUC 1 soils*. If soils are to be protected for future uses, then it is these soils that should be afforded greatest protection.

*A quick analysis of the updated HRC NZLRI dataset (Harmsworth, 2009) indicates that only 1.5% of the Manawatu-Wanganui Region and only 4% of the Palmerston North territorial authority is classified as being agriculturally elite (LUC 1). In practice these percentages will be a lot smaller because the dataset does not account for urban expansion after 1980, nor does it account for fragmentation of land into lifestyle blocks.

5.2 Anders Road growth option

- Rezoning the Anders Road block for urban development would result in the loss of significant areas of high class soils. Almost 90% of the area qualifies as LUC classes 1 and 2.
- Extensive peri-urban fragmentation is also evident for this block. 95% of land use parcels are smaller than 5 ha. Lifestyle blocks represent 74% of parcel count and 40% of land area. Only 49% of high class soils are considered available to commercial cropping. Again, previous policy appears to have been unsuccessful in protecting the high class soils of this block.
- Available high class soils of the Anders Road growth option comprise elite LUC 1 soils (9%), good LUC class 2 soils that respond well to first order drainage (34%), and a balance of LUC 2w02b soils that require second order drainage (57%).
- It is the predominance of LUC 2w02b soils that, in our view, lends this block a relatively lower actual value for food production. These are poorly drained soils with heavier fine-textured subsoils. The wetness limitation is moderate
but can be reduced to slight under intense second order drainage (novaflow, tile drains). This intensity of drainage is deemed feasible because soils have high natural fertility, a relative ease of drainage (cf. high terrace soils), and the potential for high levels of production (hence 2w rather than 3w). However, second order drainage may be difficult to achieve in some areas either because of drainage network issues (compounded by the level of parcel fragmentation), or because of pocket inclusions of 3w soils that influence over-all soil management.

5.3 Kelvin Grove growth option

- Rezoning the Kelvin Grove high terraces for urban development would not result in the loss of significant areas of high class soils. LUC class 3 soils dominate (Marton and Milson silt loams). It is not considered feasible to modify the clayey textures and fragipans that attribute these soils with a moderate degree of limitation.
- Rezoning the Kelvin Grove Whakarongo block for urban development might result in the loss of significant areas of high class soils. Around half the area has LUC 2 class soils (21 ha). However, if this block is considered as part of the full Kelvin Grove growth option, then the area of high class land might be interpreted as being of less significance.
- Parcel fragmentation is evident, but less so relative to the other growth options. Only 25% of land use parcels are smaller than 5 ha (for both the high terraces and Whakarongo sub-blocks). Lifestyle blocks account for 55% of parcel count, but the prevalence of large farming parcels (10 parcels covering 126 ha or 65% of total block area) means lifestyle block area is relatively small (17% of total area). For the area of high class soils (21 ha), 67% (14 ha) is considered available for commercial cropping purposes.
- From a high class soils perspective, the Kelvin Grove block is the most suitable growth option of the three considered. However, expansion would result in the further loss of 14 ha (21 ha in total) of high class soils.
6. References


Palmerston North City Council (PNCC). 2008. Minutes of the Council meeting (Part 1 public), held in the council chamber, civic administration building, Palmerston North, on Wednesday 17 December 2008. Section 163-08.


7. Appendices

7.1 Full size maps
7.2 Soil record: Reference profile descriptions

Please note that soil profile photos are provided as a visual representation. Angle of the photo plus soil compression associated with augering the subsoil, has in several cases distorted the representation of depth suggested by the backing board.

Likewise, photo representation of soil colour is variable and inconsistent – photos for different profiles were captured under widely different lighting conditions (early morning, dusk, cloudy conditions, blue sky conditions).