Soils of the Waimea Plains: Lower Queen Street area

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Introduction

The Waimea Plains is a small geomorphic entity that extends from Wakefield north-eastward to the Waimea Inlet and covers approximately 7,500 ha. It is an invaluable land resource for the Nelson region in that it comprises about one third of the provinces most versatile arable land, the other areas being the alluvial Motueka Plains and the Takaka Valley lowlands. Largely under intensive horticultural use, the area available for intensive use on the Waimea Plains is probably less than 6,000 ha with may be 20% or more already lost from productive use through urban development and infrastructure etc. Compared with other places in New Zealand such as Canterbury or Southland, the total area of potentially high producing arable land in Nelson is extremely small, yet these three small areas provide the mainstay for intensive agricultural production for the Nelson region. Conservation and efficient utilisation of this limited resource is essential for the long term economic prosperity of the Nelson region.

Soils of the Waimea Plains were first mapped and described in a report published in 1966 (Soils and Agriculture of the Waimea Plains, Chittenden, Hodgson and Dodson 1966, *New Zealand Soil Bureau Bulletin 30*). Both the soil map at a scale of 1:126,720 (two miles to the inch) and the accompanying report are generalised and provided a broad picture of the existing soil pattern and the soil properties with only three distinct soil families being recognised in this part of the Waimea plains. Further, given the inherent soil variations found on fluvial and floodplain surfaces, that report provided little indication of significant differences in key properties such as soil depth, soil stoniness or soil drainage a scale useful for individual farm and specific crop management or for planning purposes.

The soil survey of the Waimea Plains that commenced in 2011 covered five areas, the Appleby, Waimea West, Brightwater and Hope districts and concluded in 2016 with the final lower-lying area of the plains between the Appleby Highway and Lower Queen Street being examined. This detailed soil mapping has resulted in the identification of eleven soil families separated on the bases of soil properties that reflect landscape differences, alluvial sediment deposition patterns, flood history and drainage characteristics as well as soil stoniness and soil depth distinctions.

The area between Appleby Highway and Lower Queen Street differs from the rest of the Waimea Plains in that it is low lying, mostly below 4-6 metres above sea level, with sediment deposition in part influenced by delta like conditions associated with the Waimea River and in the older fluvial sediments, by the influence of high ground water. In places, deep drainage, has lowered the groundwater table and significantly increased the productive capacity for some of the soils.

Survey Methods

Field work within the Appleby Highway-Lower Queen Street area (824ha) was carried out over 50 days between June and November 2016. Old aerial photographs were used to help identify land surface features showing natural sedimentation and drainage features likely to be associated with the pattern of soil distribution. LIDAR maps with a contour interval of 50cm and up to date satellite images were used to assist the plotting of soil boundaries and the identification of subtle soil related landscape features. Soil observations were made mainly from auger borings, up to 1 metre depth where possible, along transect lines within individual properties, with additional observations from soil profile pits and exposures in drainage sections. The auger observations provided the basis for assessments of soil depth to gravel, soil horizon formation, soil texture and soil drainage characteristics while the observations from the pits and sections allowed soil structure, soil strength, plant root distribution and nature of underlying materials to be assessed. A total of 769 observations were made with an observation frequency of approximately 1/ha.

The soil description criteria used are those prescribed in the Soil Description Handbook (Milne et al. 1995) which gives the official standards for description of New Zealand soils. Additional and updated criteria are given in Clayden and Webb (1994) and Webb and Lilburne (2011). For the soils that were mapped, subdivisions within soil families were made largely on the basis of the stoniness, depth and drainage classes given in the Soil description handbook. Periodic checks of surface stone content were made by sieving to determine the >2mm proportion of the soil. Field soil data were electronically recorded and included a digital image for the soil at each observation site. Each observation site was located and recorded using GPS and marked on 1:4000 colour photo field sheets onto which soil boundaries were plotted. The field sheets had contours at half-meter intervals and these were useful in assisting with the plotting of small topographic differences associated with the soil patter. The soil boundaries were later transferred by TDC staff onto a photogrammetric base for final map compilation. The field data for each soil that was recognised were analysed in respect of the variation in properties for each of the recognized soil types (horizon sequences and thicknesses, colour, texture, drainage, soil depth, stoniness etc.) and the information was used in determining the properties for each soil as well as the variability within the map units. The soil land use ratings (Table 2) are derived from assessments of a range of soil and land attributes as outlined by Webb and Wilson (1995) in a manual of land characteristics for evaluation of rural land. A similar system was previously used by Agriculture New Zealand in the 1994 Classification System for Productive Land in the Tasman District.

The Soil Landscape Environment

The soil landscape of the Appleby Highway-Lower Queen Street area is a low-lying surface which, at the north-western end has formed from sediments from the Waimea River (Appleby Formation) and at the south-eastern end adjacent to Richmond from the Hope Gravel Formation (stony Ranzau gravel from the Wairoa River) (Johnston 1979, 1982). River terrace formation, which was clearly recognisable in the Waimea-Wai-iti River systems further south, is indistinct in this area, as the present gradient of the Waimea River intersects the former slightly steeper surface gradients of the Waimea River, resulting in more extensive deposition of younger river sediments (Appleby Gravel Formation) in the lower plains. Adjacent to Richmond, the Hope Gravel Formation extends to Queen Street, the surface being recognisable by the distinctive crenulated contour pattern that is evident further to the south. This lower margin of plains surface had a ground watertable at the time of early European settlement that was near the surface but is now at a greater depth due to subsequent deep

drainage. Some lower lying areas within this zone were earlier distinguished by peaty soils but the land drainage has resulted in decomposition of the peat with only residual organic accumulations remaining.

Although the survey area borders the marine Waimea Estuary environment, no deposits were observed that might have resulted from a catastrophic event such as a tsunami.

Soils of Lower Queen Street area

In this section, the soils of the lower Waimea Plains area are described according to their landscape position and drainage class in the order as set out in Table 1.

Table 1
Soils of the Appleby Highway-Lower Queen Street District

Estuarine Margin		
Poorly drained soils	Motukarara soils	(Mo)
Recent River Floodplain and low surfaces		
Well drained soils	Wai-iti soils	(Wamd, Wash, Wast)
Moderately well to imperfectly drained soils	Appleby soils	(Ap)
Low Terrace and Older floodplain Surfaces		
Well drained soils	Waimea soils	(Wm, Wmmd, Wmsh)
Moderately well to imperfectly drained soils	Cotterell soils	(Ct, Ctmd)
Older fan surface		
Well drained	Ranzau soils	(Rzmst, Rzvst)
Moderately well to imperfectly drained soils	Richmond soils	(Rmmd, Rmsh, Rmst, Rmpty)
Disturbed soils		
From gravel extraction or landfills	Anthropic soils	(An)

Soil name and map symbol: Motukarara soils (Mo)

Concept and overview

Motukarara soils cover 27ha and occur in several small areas on the lowest lying part of the plains surface adjacent to the Waimea inlet. They are poorly drained soils formed from alluvial sediments that have been modified by fluvial action in an estuarine environment. Their poor drainage is due to high groundwater conditions consequent upon their proximity to the Waimea Estuary.

Relationship to previously named soils

Motukarara soils were mapped by Chittenden et al. (1966) to the north of Nelson at Wakapuaka but were not identified in areas around the margin of the Waimea estuary. These poorly drained estuary margin soils were included within the Waimea soil map unit in the Waimea County Survey. Motukarara soils occur elsewhere in the South Island (Soil Bureau Staff 1968, Ward et al. 1964, Kear et al. 1967) and are separated as the soils on low lying land around the margins of estuaries, typically with slight to moderate salt concentrations due to their proximity to saline water. Tamutu soils (Gibbs et al. 1953 and Ward et al.1964) were associated with Motukarara soils being soils on slightly higher ground that was better drained.

Landform origin and history

The alluvial materials on the low-lying land adjacent to the Waimea estuary were deposited as part of the Holocene construction of the Waimea Plain and the low lying delta area. Subsequent to the deposition of the sediments, a small Late Holocene sea level rise may have reworked the sediments adjacent to the coast. Shallow channels, indicate the position of former estuarine leads, but since stopbanks have been constructed periodic inundation during extreme high tides has been restricted. One of the initial characteristics of Motukarara soils was elevated salinity levels but after drainage, stopbank construction and restricted inundation by sea water, salts appear to have been flushed from the soil.

Key features and physical properties

Motukarara soils are shallow and moderately deep poorly drained soils with weakly developed horizons and gravelly subsoils. The topsoil averages 16cm in thickness, is brown to dark brown coloured and has dominantly silt loam texture. The depth of fine material over gravel averaged 47cm with half of the observations classed as shallow soils (<45cm over gravel) and half being moderately deep (45-100cm). The subsoils are predominantly olive to blueish greyish coloured with mottle colours that vary from yellowish red to greenish grey. A watertable, was sometimes present between 30-50cm depth lies at the surface in ground surface channels.

Soil Variability

Topsoils vary in thickness (5-40cm) and there is a wide range of variation in soil colours and mottle patterns depending on the degree of wetness. The depth to gravel ranges from 18-100cm with 55% of profiles moderately deep (45-100cm) and 45% deep (>100cm). The soil drainage in the lowest lying areas is poor but improves to imperfectly drained with increasing distance away from the coast.

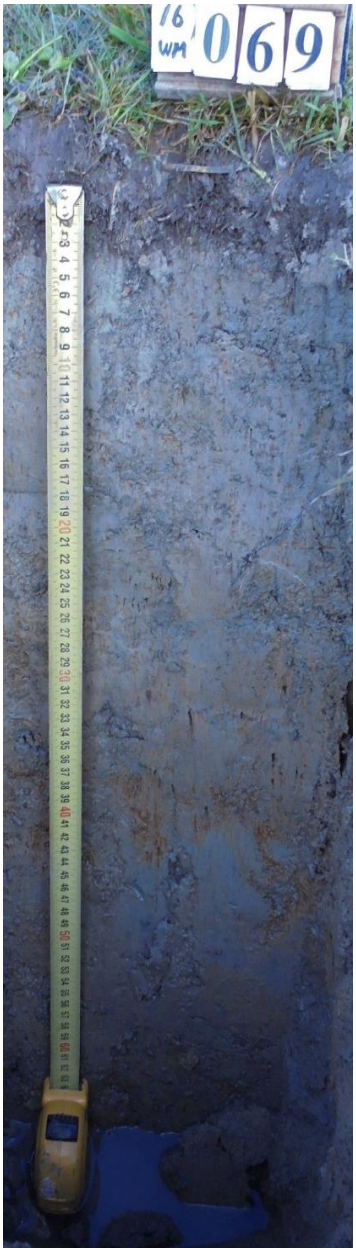
Associated and similar soils

Motukarara soils have similarities with Appleby soils (imperfectly drained soils from recent river alluvial deposits) and also with Cotterell soils (imperfectly drained soils from deeper river alluvium) with which they grade into. A few small areas of sandy textured well drained

soils (Taumutu soils) are present. In some places, areas of Motukarara soils have been modified by extensive additions of fill materials, including wood wastes and hard fill and are now classed as Anthropic soils.

Versatility and land use rating

Motukarara soils have a low versatility (average 3.6 Table 2) with significant limitations to intensive use. These include poor drainage with significant seasonal wetness, shallow to moderately deep soils with low available water capacity, restricted rooting depth, weakly developed soil structure and susceptibility to flooding. They are included in class F of the Tasman District Council classification system for land management.



Motukarara moderately deep silt loam

Horizon	Depth	Description
A	0-7cm	brown to dark brown (10YR 4/3) silt loam; weakly developed fine blocky structure; very weak soil strength; brittle failure; compact; abundant roots;
BCg	7-23cm	light grey to grey (10YR 6/1) silt loam; 15% yellowish red (5YR 6/1) coarse distinct mottles; weakly developed medium blocky structure; weak soil strength; brittle failure; compact; few fine roots
Cg1	23-45cm	light brownish grey (2.5Y 6/2) silt loam; 30% yellowish brown (10YR 5/6) coarse distinct mottles; weakly developed coarse to very coarse blocky structure; weak soil strength; brittle failure; compact; very few fine roots
Cg2	45-60cm	olive grey (2.5Y 5/2) silt loam; 20% yellowish red (5YR 5/6) coarse mottles; apedal; brittle failure; compact
Cg3	60-75cm	olive grey (2.5Y 5/2) sandy silt loam; 15% yellowish red (5YR 5/6) coarse mottles; apedal; brittle failure; compact
	on	gravel, with water at 75cm

Soil name and map symbol; Wai-iti soils (Wa, Wamd, Wash, Wast,)

Concept and overview

Wai-iti soils cover 102ha adjacent to the Waimea River on the lowest terrace levels and river floodplain and overflow surfaces. They are soils that have minimal soil profile development due to the very recent age of the alluvium and often have buried topsoils that represent the land surface prior to deposition of younger flood sediments. They are well drained soils, sometimes very stony along old channel surfaces and vary in depth and degree of stoniness over short distances. Some of the surfaces on which Wai-iti soils occur were river flood channels up until the 1930's before management of the river systems took place. Wai-iti soils are now largely protected from occasional flooding by the stopbank system, which was constructed in the late 1950's and early 1960's.

Relationship to previously named soils

Wai-iti soils were not identified in the earlier surveys (Chittenden et al. 1966) but were included within the Waimea soil family (Waimea silt loam and sandy loam) without being separated on the soil map. In the recent soil surveys of the Waimea Plains, Wai-iti soils have been mapped as the recent well drained soils on the floodplain and lowest surfaces of the Wairoa and Waimea Rivers.

Landform origin and history

Within the present survey area, Wai-iti soils occur mostly below 4m above sea level in old river meander scrolls which marked the former river flood plain and also in areas where more recent flood overflows have occurred. The sediments are part of the Appleby Gravel Formation (Johnston 1979, 1982) with the basal sediments dated at around 4000yrs but with the upper layers recent and largely resulting from sedimentation changes that followed human settlement within the region. Buried soils are found in 11% of the observations of Wai-iti soils and record evidence of past flooding and sediment deposition. The expected rise in sea level due to global climate change together with the likelihood of more extreme storm events will impact on the Wai-iti soils in this lower part of the river system with floods likely to exceed the design limits of the stopbank system.

Key features and physical properties

Wai-iti soils are weakly developed with a dark brown to brown or dark yellowish brown silt loam or sandy loam A horizon that averages 15cm thick. The upper subsoil displays little indication of soil weathering and commonly merges into unaltered olive brown C horizon sandy loam or sandy soil material at around 30cm depth. Stones may be present at various depths ranging from ground surface to greater than 1m but with the depth to underlying gravel averaging about 45cm.

Identified variants

Wai-iti soils vary over short distances because of the sedimentation differences resulting from flood flow processes with stony soils passing into deeper soils over a few metres distance. The mapped units include a small area of Wai-iti soils (Wa) which are deep soils (100cm+ over gravel) but they also occur sporadically elsewhere (13% of observations). Moderately deep Wai-iti soils (Wamd) have a depth to gravel of between 45-100cm, with the average depth being 61cm. Wai-iti shallow soils (Wash) have a depth to gravel of <45cm and

commonly merge with Wai-iti stony soils (Wast). which were noted in 42% of the observations. The percentage of surface stones varied from slightly stony (<5%, 18% of observations) and moderately stony (5-35%, 20% of observations) to very stony (>70% surface stones, 5% of observations.

Associated and similar soils

Wai-iti soils are associated with Appleby soils which are also soils formed on recent flood deposited alluvium, but Appleby soils have impeded drainage. Subsoil mottles are sometimes present in Wai-iti soils where they merge with Appleby soils as drainage conditions change. Wai-iti soils are similar to Eves soils from young secondary alluvial deposits which were mapped previously.

Versatility and land use rating

Wai-iti deep soils have a moderate to high versatility (1.4 Table 2) while the shallow and very stony soils have a moderate to low versatility owing to stoniness, somewhat excessive drainage, and lower available water capacity. Both the deep soils and also the stony soils are successfully used for horticulture. These soils are included in class B of the Tasman District Council system for land management.

Wai-iti moderately deep sandy loam

Horizon	Depth	Description
A	0-12cm	brown to dark brown (10YR 4/3) sandy loam; weakly developed fine polyhedral structure; weak soil strength; very friable; compact, few medium roots
(B)	12-36cm	light olive brown (2.5Y 5/4) sandy loam; apedal; 5% fine stones; weak soil strength; very friable; compact; few fine and medium roots
C	36-60cm	olive brown (2.5Y 4/4) fine sand; apedal; loose; very few fine roots
C	60-65+	olive (5Y 5/4) sand; apedal; 65% medium to large stones; loose

Soil name and map symbol: Appleby soils (Ap, Apmd, Apst)

Concept and overview

Appleby soils cover 31ha and occur in association with Wai-iti soils on recent alluvial deposits the Waimea River. They occur in places where soil drainage is impeded, essentially in the lower lying delta like area of the Waimea River. They are also mapped in narrow former river overflow channels where transient water flows may be present along with narrow strips of wet soils. Like Wai-iti soils, they are now largely protected from river overflows during flood events but owing to their low lying position, the soils are imperfectly and at times poorly drained.

Relationship to previously named soils

Appleby soils were not identified or separated in the previous soil survey of Waimea County (Chittenden et al. 1966) and were included within the Waimea silt loam to sandy loam mapping unit. They were recognised and mapped in the 2011 soil survey of the Appleby district (Campbell unpublished) and were found in isolated patches in other places on the Waimea Plains in poorly drained overflow channels.

Landform origin and history

Appleby soils have formed in a similar fluvial environment as Wai-iti soils on sediments from recent overflows of the Waimea River but in areas with less turbulent river flow, consequently they are seldom gravelly. The deposits are part of the Appleby Gravel Formation with the basal sediments around 4000yr BP (Johnstone 1979, 1982) but with the upper sediments recent and still accumulating in major flood events. Appleby soils occur on land mostly below 3m above sea level and because of their low lying position, soil drainage is impeded.

Key features and physical properties

Appleby soils have dark greyish brown to dark yellowish brown topsoils that are shallow (average 16cm) with predominantly silt loam texture, overlying olive brown or olive coloured subsoils with distinct reddish and grey or sometimes bluish coloured mottles. The soil drainage is dominantly imperfect and sometimes poor but as Appleby soils merge with Wai-iti soils, they become moderately well drained with a thin brown B horizon present. Appleby soils are mainly moderately deep, are seldom stony and sometimes have water present in lower horizons during winter months.

Identified variants

Appleby soils (Ap) are deep soils with >100cm of fine material over gravel (found in 35% of field observations) while Appleby moderately deep soils (Apmd) were recorded in 55% of the observations. Appleby stony soils (Apst) are separated in one small area. In the narrow drainage channels, the soils are highly variable and range from poorly drained and shallow to moderately deep and deep soils.

Associated and similar soils

Appleby soil are associated with Wai-iti soils and merge as soil drainage changes from well drained to imperfectly drained. Richmond soils occur on low lying land to the southeast of Appleby soils in the present survey area and are also imperfectly drained but they have clayey textures and are at in places slightly times slightly peaty.

Soil versatility and landuse

Appleby soils have a moderate to low versatility (average 2.6 Table 2), the principal limitations being their imperfect drainage, restricted trafficability, workability and rooting depth caused by soil wetness and periodic surface flooding at times of significant rainfall events. Areas of this soil type occurring in narrow overflow channels are of low versatility due to topography and drainage restrictions and would be included in class H of the Tasman District Council classification system for land management.

Appleby silt loam

Horizon	Depth	Description
A	0-10cm	brown to dark brown (10YR 4/3) silt loam; weakly developed fine polyhedral structure; weak soil strength; compact; friable
BC	10-25cm	olive brown (2.5Y 4/4) silt loam; 5% reddish brown (5YR 4/6) fine mottles; weakly developed fine polyhedral and medium blocky structure; weak soil strength; compact; friable; <5% fine stones; few fine roots
C(g)	25-42cm	olive brown (2.5Y 4/4) silt loam; 35% reddish brown (5YR 4/6) and 35% light brownish grey (2.5Y 6/2) medium to coarse mottles; weakly developed medium blocky structure; weak soil strength; brittle failure; compact
Cg	42-75	olive brown (2.5Y 4/4) heavy silt loam; 10% reddish brown (5YR 4/6) fine mottles; apedal; weak soil strength; compact; brittle failure

Soil name and map symbol **Waimea soils (Wm, Wmmd, Wmsh)**

Concept and overview

Waimea soils cover 67ha and in the present survey and are found in the northwest part of the survey area on lower lying land in close proximity to the Waimea River. Waimea soils are formed on land that is by and large above contemporary flood level, although recent overflows have cut some shallow depressions on the ground surface. Waimea soils are characterised by predominantly deep profiles, with silt loam textures and good drainage and are formed from alluvium derived from the Wairoa and Wai-iti river systems.

Relationship to previously named soils

Waimea soils of the present survey are similar to soils mapped by Chittenden et al. (1966) as Waimea silt loam and sandy loam. They have been identified and mapped in the other recent soil survey on the Waimea Plains as the deep to moderately deep well drained soils on the uppermost river terrace.

Landform origin and history

In the present survey area, the land surfaces on which Waimea soils occur are relatively uniform low elevation surfaces at about 4m above sea level. In the northern reaches of the Waimea River, Waimea soils are spread out in a delta like configuration, extending to about 1km east of the river. The soil materials were probably deposited in a low energy fluvial environment which allowed accumulation of fine sediment to over 1m. Near Landsdown Road, Waimea soils occur on an indistinct terrace surface about 1m above the floodplain. The soil materials form part of the Appleby Gravel Formation (Johnstone 1979, 1982) and judged by the absence of significant morphological development, are probably of late Holocene age.

Key features and physical properties

Waimea soils have a dark greyish brown or brown to dark brown coloured silt loam topsoil (average 24.5cm thick) that overlies a dark yellowish brown heavy silt loam to clay loam textured B horizon (average thickness 32.5cm) with moderately developed structure. This passes into light olive brown then olive brown BC and C horizons with predominantly clay loam textures. Waimea soils are well drained but some subsoil mottles may be present as Waimea soils pass into Cotterell soils, which are formed in a similar environment and on similar materials.

In 35% of the observations, fine and medium gravel was noted to be present in the A horizons but not the subsoil and it is believed that this material was added to the soil in the pre-European times of Maori cultivation.

Identified variants

The predominant unit of the Waimea soil family is Waimea deep silt loam (Wm) which was noted in 59% of the observations. Waimea moderately deep soils (Wamd) were found in 23% of the observations with the average depth to gravel being approximately 50cm. Waimea shallow soils (Wmsh) comprised approximately 17% of the observations with surface stoniness varying from slightly stony to moderately stony. In some places, the soils are moderately well drained (not mapped separately) more especially in places where they pass into Cotterell soils. In 35% of the observations, fine and medium gravel was noted to be present in the A horizons but not the subsoil and it is believed that this material was added to

the soil in pre-European times of Maori cultivation. The anthropic addition of gravelly material to the surface is generally less than about 20% coarse fragments.

Associated and similar soils

Waimea soils are associated with Cotterell soils (imperfectly drained to moderately well drained) with which they grade into as land elevation decreases and the groundwater table is closer to the surface. Redwood soils, not mapped in the present survey area, have similarities with Waimea soils but are generally shallower with weaker profile development. Motupiko soils also have similarities with Waimea soils but are formed from reworked Moutere Gravel materials.

Soil versatility and landuse

Waimea soils have a moderate to high versatility rating (average 1.8) for intensive use and are used predominantly for orchard, horticulture and nursery crops. Their moderately slow permeability gives rise to ponding in heavy rainfall events with restricted workability and trafficability, Waimea soils are included in class B of the Tasman District Council Classification system for productive land.

Waimea moderately deep silt loam

Horizon	Depth	Description
A	0-33cm	dark yellowish brown (10YR 4/4) silt loam; strongly developed fine and medium polyhedral structure; weak soil strength; friable; compact; common fine roots
B	35-55cm	dark yellowish brown (10YR 4/6) heavy silt loam; moderately developed medium polyhedral and blocky structure; weak soil strength; friable; compact; few fine roots
BC	55-76cm	light olive brown (2.5Y 5/6) sandy silt loam; weakly developed fine polyhedral structure; weak soil strength; friable; compact; 25% fine to medium stones; few fine roots
BC	76-90cm+	olive brown (2.5Y 5/6) sand; compact; 65% fine and medium stones; very few fine roots

Soil name and map symbol **Cotterell soils (Ct, Ctmd)**

Concept and overview

Cotterell soils cover 149ha and occur in the northwest part of the present survey area on low lying land. They are formed from similar alluvial materials as Waimea soils, have moderately deep silt loam to clay loam textures, deep soil profiles over gravel and are for the most part imperfectly drained. The subsoils are marked by prominent reddish and grey coloured mottles.

Relationship to previously named soils

Cotterell soils were not mapped in the previous soil survey of Waimea County (Chittenden 1966) and within the Waimea Plains area and were included within the Waimea silt loam and clay loam map units. They have been mapped elsewhere in the recent soil surveys of the Waimea Plains (Campbell, unpublished).

Landform origin and history

Cotterell soils are formed from sediments of the Appleby Formation (Johnstone 1979, 1982) the basal sediments dating from around 4000y BP. The upper fine textured sediment appears to thicken towards the north and possibly reflects deposition in a deltaic type of environment in the absence of river flows transporting gravelly alluvium. The land surface on which Cotterell soils occur is flattish and lies between 2-4m above sea level and the subsoil drainage is probably influenced by proximity to the watertable. The land surface on which Cotterell soils occur may be an extension of the river terraces that are present in the Waimea, Wairoa and Wai-iti river systems to the South.

Key features and physical properties

Cotterell soils have moderately deep (average 24cm) dark brown to brown topsoils, predominantly with silt loam or clay loam texture and an upper B horizon of about 23cm with brown to olive colour and silt loam or clay loam texture and with reddish brown and grey mottles. Below is a BCg horizon, commonly dominated by olive grey or light brown colours along with distinct reddish brown mottles. Underlying C horizons are again dominated by grey colours but with fewer reddish brown mottles. Subsoil structure is blocky or prismatic and the soil strength is firm. Drainage in Cotterell soils ranges from moderately well drained to imperfectly drained and a watertable is sometimes present within the soil observation profile.

Identified variants

The main variations in Cotterell soils are in respect of their depth and drainage with Cotterell deep soils (Ct) comprising 1m or more of imperfectly drained clay loam over gravel and Cotterell moderately deep soils (Ctmd) consisting of moderately well drained to imperfectly drained silt loam or clay loam over gravel, which was found at an average depth of 62cm. In some places, subsoils are dominated by greyish and reddish colours and the soil drainage is poor.

Associated and similar soils

Cotterell soils are associated with Waimea soils, the two merging as drainage changes from imperfectly or moderately well drained to well drained. Richmond soils (Richmond clay loam) has similarities with Cotterell soils but have heavier texture and a more intense subsoil mottle pattern.

Soil versatility and landuse

Cotterell soils have a moderate to low versatility (2.2 Table 2) with moderate limitations for intensive use. Their heavier texture and drainage impediment restricts trafficability and workability and restricts the range of horticultural crops that can be grown. In places they are used for market gardens and nursery crops and they are also used for dairying. They are included in Class 3 of the Tasman District Council Classification system for productive land.

Cotterell moderately deep heavy silt loam

Horizon	Depth	Description
A	0-28cm	brown to dark brown (10YR 4/3) heavy silt loam; strongly developed fine polyhedral structure; weak to slightly firm soil strength; friable; compact; many fine roots
B(g)	28-39cm	light yellowish brown (10YR 6/4) heavy silt loam; 15% yellowish red (5YR 5/6) and 15% light grey (10YR 7/2) heavy silt loam; moderately developed medium polyhedral structure; weak soil strength; friable; compact; many fine roots
B	39-57cm	light yellowish brown (10YR 6/4) silt loam; 10% strong brown (7.5YR 5/6) fine mottles; weakly developed fine strength; polyhedral structure; friable; weak soil strength; compact; 25% fine to medium stones; few fine roots
Cg	57-90cm+	light olive grey (2.5Y 6/2) sand; 10% strong brown (7.5YR 5/6) mottles; apedal; 55% fine and medium stones; compact

Soil name and map symbol **Richmond soils (Rmmd, Rmsh, Rmst, Rmpty)**

Concept and overview

Richmond soils occupy 354 ha and occur extensively in the southeast portion of the survey area. They are soils that have formed under the influence of impeded drainage, largely as a result of high ground water conditions that existed in this portion of the Waimea plains. They occur on somewhat older sediments and at a slightly higher elevation than the soils on the floodplain deposits to the northwest. They include a range of soils from moderately deep to shallow and stony, but also include areas of slightly peaty soils. Deep drainage has lowered the watertable and improved the soil drainage status.

Relationship to previously named soils

Richmond soils were mapped by Chittenden et al. (1966) in the survey of the soils of Waimea County with three units being separated, Richmond clay loam, Richmond peaty clay loam and Richmond silt loam and they are restricted to this north-eastern portion of the Waimea Plains.

Landform origin and history

The greater part of the eastern Waimea Plains consists of an extensive gravel fan (Hope Gravel Formation Johnstone 1982) which accumulated through the later part of the Late Otirian cold climate phase of the last glacial period. This extensive outpouring of sediment derived from the catchments of the Lee and Wairoa Rivers distributed poorly sorted stony gravel across the whole of this fan, but left a thin intermittent veneer of silty material at the surface. The fan surface is distinguished from other parts of the Waimea Plains in having a crenulated pattern of contours (as shown by a 0.5m contour interval) suggesting that deposition resulted from overland rather than channelized water flows. Near the northern end of Swamp Road, the gravels are overlain by a layer of fine textured sediment, which thins and becomes intermittent to the southeast. At the time of deposition of the Hope Gravel Formation, the fan sediments would have extended further north because of a lower sea level. With the Holocene rise in sea level, drainage within the gravels has been impeded and given rise to the poorer drainage conditions of the Richmond soils. This resulted in the formation of peaty deposits in the wetter areas. Subsequent deep drainage and lowering of the watertable has changed and improved the original drainage status of these soils. The original peaty soils are no longer recognisable, as discrete organic matter accumulation has disappeared through decomposition, although some of the characteristics of the original soil (deeper A horizons with dark and reddish colours) are present. The designation, ‘slightly peaty’ is retained to distinguish these soils from other Richmond soils.

Key features and physical properties

Richmond moderately deep, soils have brown to dark yellowish brown A horizons (average 22cm thick) with clay to silt loam texture, overlying mottled clayey textured subsoils over gravel, while the Richmond stony soils have stony upper horizons with mottled gravelly sandy clay loam subsoils. The slightly peaty soils are distinguished by darker brown A horizons with somewhat higher levels of organic carbon content overlying clay loam or gravelly clay loam at shallow depths.

Identified variants

Richmond moderately deep soils (Rmmd) have brown to dark yellowish brown topsoils with clay or clay loam texture overlying strongly mottled clay or clay loam have an average depth to gravel of 60cm but sometimes in excess of 100cm and are imperfectly to moderately well drained. Richmond shallow soils (Rmsh) are similar to Richmond moderately deep soils but subsoil mottling is less intense, underlying gravel occurred at an average depth of 39cm with mottling also present within the gravels and they are moderately well drained. Richmond stony soils (Rmst) have stones present in the surface horizon with the stone content varying. Slightly stony soils (<5% stones), comprised 24% of observations in Richmond soils, moderately stony soils (5-35% stones) were 50% of the observations and very stony soils (>35% stones) were 26%of the observations. Areas of soils with differing degrees of surface stoniness were not mapped separately. Although some subsoil mottles are present, the Richmond stony soils are now probably well drained as a result of deep drainage that has lowered the watertable. Richmond slightly peaty (Rmpty) soils have a dark brown friable silt loam to clay loam textured A horizon that is sometimes stony or slightly stony, overlying a clay or clay loam textured subsoil with an average depth to gravel of 31cm. The subsoil has distinct reddish or dark red and grey coloured mottles. An analysis of Richmond peaty clay loam at Richmond (Chittenden et al 1966) showed that the organic C% of the surface horizon was 20.2%, but since deep land drainage in this area, it is likely that the organic C content has appreciably decreased (no undecomposed fibres were observed) and this soil no longer qualifies as being classed as a peaty soil.

The Richmond soils have been assessed as being imperfectly and moderately well drained (occasionally poorly drained) on the basis of the observed mottle patterns. These may however reflect the soil conditions that occurred prior to land drainage and it is likely that the Richmond shallow and stony soils now resemble the highly productive Ranzau soils in respect of their drainage attributes.

Associated and similar soils

Richmond soils are associated with Ranzau soils, which are formed on similar materials and with which they merge as the natural subsurface drainage conditions improve. Richmond moderately deep soils have similarities with Cotterell soils but clay texture is more common in the Richmond soil and mottling generally more intense often with reddish colours.

Soil versatility and landuse

Richmond moderately deep and the slightly peaty soils are classed having a moderate to low versatility for intensive use (2.5 table 2) as a result of heavy soil texture, restricted drainage, workability and trafficability. Drainage improvements have allowed their use for horticulture. Richmond shallow and stony soils are classed as having a moderate to high versatility for intensive use (1.9 table 2) their main limitations being lower levels of plant available water and stoniness. They are included in class B of the Tasman District Council Classification system for productive land.

Richmond moderately deep clay loam

Horizon	Depth	Description
A	0-22cm	very dark greyish brown (10YR 3/2) clay loam; moderately developed fine and medium polyhedral structure; weak soil strength; friable; compact; many fine roots
B(g)	22-45cm	strong brown and yellowish red (7.5YR 5/8 + 5YR 5/8 50%) and light brownish grey (10YR 6/2 35%) mottled clay; strongly developed coarse blocky structure; slightly firm soil strength; semi deformable failure; few fine roots
Bg	45-65cm	yellowish red (5YR 5/8 and red (2.5YR 2.5Y% 4/8 55%) and light brownish grey mottled clay; strongly developed coarse blocky structure; firm soil strength; semi deformable failure; compact; very few fine roots;
Cg	65cm+	light brownish grey (2.5Y 6/2) clay loam; 60% medium stones; apedal; compact

Richmond slightly peaty sandy silt loam

Horizon	Depth	Description
A	0-28cm	dark brown (7.5YR 3/2) sandy silt loam; 1% fine and coarse stones; weakly developed fine polyhedral structure; weak soil strength; very friable; compact; stones; abundant fine roots
B(g)	28-50cm	strong brown (7.5YR 5/8 20%) and light brownish grey (10YR 6/2 50%) sandy silt loam; 40% fine to coarse stones; weakly developed coarse blocky structure; friable; compact; few fine roots
BCg	50-70cm	very pale brown (10YR 7/4) sandy silt loam; 65% fine to coarse stones; 5% yellowish red (5YR 5/6) mottles; apedal; compact

Richmond moderately stony sandy clay loam

Horizon	Depth	Description
A	0-23cm	dark brown (10YR 3/3) sandy clay loam; 25% fine to very coarse stones; weakly developed medium polyhedral structure; weak soil strength; friable; compact; many fine roots
B	23-50cm	dark yellowish brown (10YR 4/4) sandy clay loam; 5% reddish brown (5YR 5/8) medium to coarse mottles; 65% fine to very coarse stones; weakly developed medium blocky structure; friable; compact; common fine roots
BC	50-65cm+	yellowish brown (10YR 5/4) sand; 70% fine to very coarse stones;

Soil name and map symbol **Ranzau soils (Rzmst, Rzvst)**

Concept and overview

Ranzau soils occupy 71ha in the southeast part of the current survey area and are distinguished by their predominantly stony soil profiles. They have formed from alluvium that was deposited by the Wairoa River as an extensive gravel fan and soil weathering occurs to a greater depth than elsewhere in other soils of the Waimea Plains, signifying an appreciably greater land surface age.

Relationship to previously named soils

Ranzau soils were first identified and mapped in the survey of the soils of Waimea County (Chittenden et al. 1966) as Ranzau stony clay loam and Ranzau gravelly silt loam in the smaller areas on fan deposits originating in the hillside valleys between Hope and Stoke.

Landform origin and history

The fluvial deposits on which Ranzau soils are formed were derived from extensive outflows from the Wairoa River towards the end of the Last Glacial period when cold climate conditions provided an abundance of coarse sediments from hills within the Richmond Range. Adjacent to Richmond, the ground surface on which Ranzau soils occur is an extension of the low angle fan that was constructed by the Wairoa River and which extended from the Wairoa Gorge northwards to beyond the present sea coast. The crenulated 50cm contour pattern is indicative of gravel deposition by extensive overland flow and the persistence of this contour pattern to the edge of the Waimea Estuary suggests a lack of land surface modification by coastal processes. The Ranzau soils in the present survey area are at greater than 10m above sea level and have remained uninfluenced by the high groundwater levels as seen in the adjacent Richmond soils to the north.

Key features and physical properties

Ranzau soils are predominantly very stony (35-75% stones in the surface horizon) with a smaller proportion (25% of observations) moderately stony (<35% surface stones). The topsoils comprise brown to dark brown silt loam to clay loam with an average depth of 25cm and overlie dark yellowish brown stony sandy clay loam or sandy silt loam

Identified variants

Ranzau very stony soils and Ranzau moderately stony soils were the main soil units identified and separated. In a few places, Ranzau moderately deep soils were identified, the topsoil and upper subsoil being stone free to between 45cm and 60cm of underlying gravel.

Associated and similar soils

Brightwater soils, identified within the Brightwater survey area, are formed on Wairoa River alluvium that is younger than the Ranzau outwash alluvium and have soil profiles that are less deeply weathered. Barnicoat soils (formerly Ranzau silt loam) are from small gravelly fan alluvial deposits in small valleys that lie within the hills adjacent to the Waimea Plain. Richmond soils are associated with Ranzau soils occurring on the lower part of the plains surface where the watertable was close to the ground surface because of proximity to the sea.

Soil versatility and land use rating

Ranzau soils have a moderate to high soil versatility rating (1.8 Table 2) the main limitations being stoniness and low profile available water. They are included in Class A of the Tasman District Council system for land management.

Ranzau very stony clay loam

Horizon	Depth	Description
A	0-30cm	dark yellowish brown (10YR 4/4) silt loam; strongly developed fine polyhedral structure; weak soil strength friable; compact; 50% fine to coarse stones many fine roots
AB	30-40cm	dark yellowish brown (10YR 4/4-4/6) silt loam; moderately developed fine polyhedral structure; weak soil strength; compact; friable; 40% fine to coarse stones; many fine roots
B	40-52cm	dark yellowish brown (10YR 4/6) silt loam; few fine strong brown (7.5YR 5/8) mottles; weakly developed fine blocky structure; slightly firm soil strength; friable; compact; <5% fine stones; few fine roots
B	52-70cm	dark yellowish brown (10YR 4/6) sandy silt loam; few fine strong brown (7.5YR 5/8) mottles; weakly develop compact; 65% fine to coarse stones; few fine roots
BC	70-95cm+	light yellowish brown (2.5Y 6/4) sandy loam; few fine strong brown (7.5YR 5/8) mottles; apedal; 65% fine to coarse stones; loose; very few fine roots

Soil name and map symbol **Anthropic soils (An)**

Concept and overview

Anthropic soils are the soils that are found on soil materials that have been significantly disturbed and altered by human activities and they cover 23ha within the present survey area. They are mainly of two types, anthropic soils that are formed after extraction of subsurface gravel with some overburden and topsoil replacement and anthropic soils that are formed on materials used for infilling and building up the ground surface in low lying, poorly drained areas. Areas of soils (Waimea soils) which had gravel added under early Maori cultivation could perhaps be regarded as anthropic soils, but the degree of alteration is relatively insignificant compared with the disturbances resulting from large scale removal or additions of soil materials by mechanical activities.

Relationship to previously named soils

No anthropic soils were identified in the earlier surveys of the Waimea Plains (Chittenden et al. 1966) apart from the areas of soils identified as having gravel added to the topsoil under the period of Maori cultivation.

Landform origin and history

Soils in which the ground surface was lowered by gravel extraction were noted in an area of approximately 4.5ha to the west of Landsdown Road. Previously, Wai-iti soils, this area of anthropic soils was probably created in the 1970's. Soils in which the ground surface has been raised by infilling cover approximately 18ha and occur mainly on land adjacent to Lower Queen Street. This infilling has taken place predominantly on Motukarara soils in an attempt to alleviate the problem of poor drainage due to high ground water. In some places, extensive dumping of wood wastes took place before being covered with hard fill materials with predominantly clayey texture. A few areas of ground infilling to alleviate poor drainage conditions were also noted elsewhere.

Key features and physical properties

The anthropic soils are extremely variable because of the non-uniform manner in which materials for restoration or backfilling are applied. Topsoil (A horizon material) is commonly lacking while in some areas groundwater may be at or near the surface creating poor drainage conditions. The use of organic material such as wood waste is unlikely to provide a long term solution for poor land drainage as decomposition will lower the ground surface and also supply organic residues into ground waters. In areas where the ground surface has been raised by dumping soil materials profile drainage is often significantly impeded due to the addition of clayey material and compaction during soil spreading.

Associated and similar soils

Wai-iti soils are associated with one area of anthropic soils where gravel removal took place while Motukarara soils are associated with areas of anthropic soils where land filling has occurred to alleviate poor surface drainage.

Soil versatility and land use

Anthropic soils within the present survey area have a low versatility for intensive use (3.3 Table 2).

Anthropic soil

Horizon	Depth	Description
An1	0-19cm	dusky red (2.5YR 2/2) mixed peaty and silty refuse material; apedal; very weak soil strength; loose; very friable; few fine roots
An2	19-24cm	pale olive (5Y 6/4) silty fill; 20% fine stones; apedal; weak Soil strength; compact; friable
An3	24-27cm	very dark grey (5Y 3/1) organic refuse material; apedal; loose; very friable
An4	27-40cm	pale olive (5Y 6/4) clay loam; weakly developed medium blocky structure; slightly firm soil strength; friable
		water at 45cm

These layers of soil material do not conform with standard definitions of soil horizons and are here designated An (Anthropic) with the numbers indicating differing layers of fill materials.

Table 2

Soil Versatility Ratings

Soil Name	Motukarara	Wai-iti#	Appleby	Waimea	Cottrell	Richmond	Ranzau	Anthropic
Topography	1	1	1	1	1	1	1	1
Drainage	4	1	3	1	3	2	1	4
PAW*	4	2	2	1	1	3	3	3
Stoniness	2	2	2	1	1	4	4	2
Permeability	4	3	3	3	3	2	2	4
Nutrients	4	2	2	3	3	3	3	4
Trafficability	4	2	3	3	3	1	1	4
Workability	4	2	3	2	3	1	1	4
ERD*	4	2	3	1	2	2	2	4
EF*	4	3	3	1	1	1	1	2
Waterlogging	3	1	3	2	3	1	1	3
Average	3.5	1.9	2.5	1.7	2.2	1.9	1.8	3.3

PAW* Profile available water
ERD* Effective rooting depth
EF* Erosion/flooding

0-1	highly versatile	few limitations
1-2	moderate to high versatility	slight limitations
2-3	moderate to low versatility	moderate limitations
3-4	low versatility	significant limitations
>4	non versatile	severe limitations

Wai-iti moderately deep

References

Agriculture New Zealand 1994. Classification System for Productive Land in the Tasman District. *Agriculture New Zealand, Richmond*.

Chittenden, ET, Hodgson, L, Dodson, KJ. 1996. Soils and Agriculture of Waimea County New Zealand. Soil Bureau Bulletin 50. *New Zealand Department of Scientific and Industrial Research*

Clayden, B, Webb TH. 1994. Criteria for defining the soilform – the fourth category of the New Zealand soil classification. Landcare Research Science Series 3. *Manaaki Whenua Press. Lincoln, Canterbury, 36p.*

Johnston, MR 1982. Part sheet N27-Richmond. Geological Map of New Zealand 1:50 000. Map (1 sheet) and notes (32p). Wellington, *NZ Department of Scientific and Industrial Research.*

Milne, JDG, Clayden B, Singleton PL, Wilson AD. 1995. Soil Description Handbook. *Manaaki Whenua Press Lincoln, Canterbury, New Zealand*

Soil Bureau Staff 1968. General Survey of the Soils of South Island, New Zealand. Soil Bureau Bulletin 27. *New Zealand Department of Scientific and Industrial Research.*

Webb, TH, Lilburne, LR. 2011. Criteria for defining the soil family and soil sibling the fourth and fifth categories of the New Zealand Soil Classification. Landcare Research Science Series 3. *Manaaki Whenua Press. Lincoln, Canterbury, 38p.*